Submission by Land & Water Australia

to the

House of Representatives

Standing Committee on Science and Innovation

Inquiry into Pathways to Technological Innovation

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Executive Summary

Land & Water Australia (Land and Water Resources Research and Development Corporation, hereafter LWA) is a Statutory Corporation established under the Primary Industries and Energy Research and Development Act of 1989. It is one of 14 Research and Development Corporations and has a lead research funding and brokering role in Natural Resource Management.

Land & Water Australia's key stakeholders include both dryland and irrigation farmers, private companies, public land and water (authority) managers across Australia and policy makers at all levels of government. Uptake and adoption of knowledge and innovation by this diverse range of stakeholders may be motivated by a range of factors. Pathways to adoption often reflect these motivations and the success of innovations may depend on the ways in which they are presented, demonstrated and information on the innovation disseminated.

In this context, LWA considers commercialisation to be only one route to innovation and only part of the process of adoption of the results of research. Much of LWA's research is directed at improved natural resource management through generating returns to farmers. In this sense the innovation process is focussed on the adoption of a technology because it provides a commercial improvement in profitability for the primary producer, rather than a commercial return to Land & Water Australia. In other cases LWA's research has a clear public benefit focus where commercialisation is not a primary focus but which can result in efficiency gains and associated cost-savings in government program funding.

LWA has an ongoing commitment to research the impediments to adoption and factors that promote innovation in NRM. Land & Water Australia has found that information, knowledge and the infrastructure that support them are only some of the factors that contribute to, or inhibit, practice change in natural resource management. These factors sit within a larger context of social, cultural, political and economic factors that have significant influences upon practice change.

In recognition of the human factors involved in technological innovation LWA now invests almost 20% of its funds in knowledge and adoption activities (cf ~ 5% in 2000) to improve rates of adoption and better return on investments. The case studies presented in this submission show different examples of successful pathways to innovation, both on-ground and at policy levels. They demonstrate ways technological innovation can be supported and provide transferable models for pathways to innovation that include commercialisation.

Introduction

This submission is made in response to the public invitation for individuals and organisations to contribute to the inquiry into pathways to technological innovation by the House of Representatives Standing Committee on Science and Innovation. The Inquiry for the Committee to examine Australian technological innovations and their pathways to commercialisation has been referred by the Minister for Science, the Honourable Brendan Nelson MP.

Land & Water Australia (LWA) is a Statutory Corporation established under the Primary Industries and Energy Research and Development Act of 1989. The Corporation's mission is 'to provide national leadership in generating knowledge, informing debate and inspiring innovation and action in sustainable natural resource management'.

Since its establishment as LWRRDC in 1989, Land & Water Australia has been an active investor, broker and manager of research and development into critical Australian natural resource management and sustainable agriculture issues. Research and development activity is defined by the PIERD Act to include the training of people to undertake R&D, the dissemination of information, the publication of reports and the provision of advice or assistance to enable the adoption of technical developments. The outputs of the Corporation's activities are detailed in annual reports to Parliament and also the Corporation's industry stakeholders, which include the National Farmer's Federation and the Australian Conservation Foundation. The Corporation and its staff do not undertake technological research *per se* but have a key role in the organisation and funding of research activities, managing the knowledge and promoting the adoption of the results of that research.

The end-users of Land & Water Australia research include: on-ground managers of natural resources such as dryland and irrigation farmers; organisations such as catchment and water authorities and river managers; local and state government agencies; and policy makers at all levels. LWA's strategic approach to innovations considers the economic, environmental and social aspects (similar to triple bottom line accounting) and uses diverse pathways to achieve adoption of innovations both on-ground and at policy levels.

Commercialisation is one pathway to adoption whereas LWA uses a variety of means to influence uptake and adoption of knowledge and technology derived from research it funds. It is not LWA's primary objective to derive financial returns for the Corporation from innovations, rather that the Corporation's outputs lead to improved sustainability and profitability of primary producers and increase in wealth of the Nation. However, the successful uptake and adoption experience of LWA provides valuable lessons for technological innovation and commercialisation which will assist the Committee.

Innovation and Commercialisation

The Committee has appropriately taken a broad perspective on 'pathways to commercialisation'. Within the Australian community, and across the various agencies of Australian Government, there is broad acceptance that technological innovation does mean the commercialisation of the results of research but also includes innovation 'the introduction of new things or methods' or 'to make changes'.

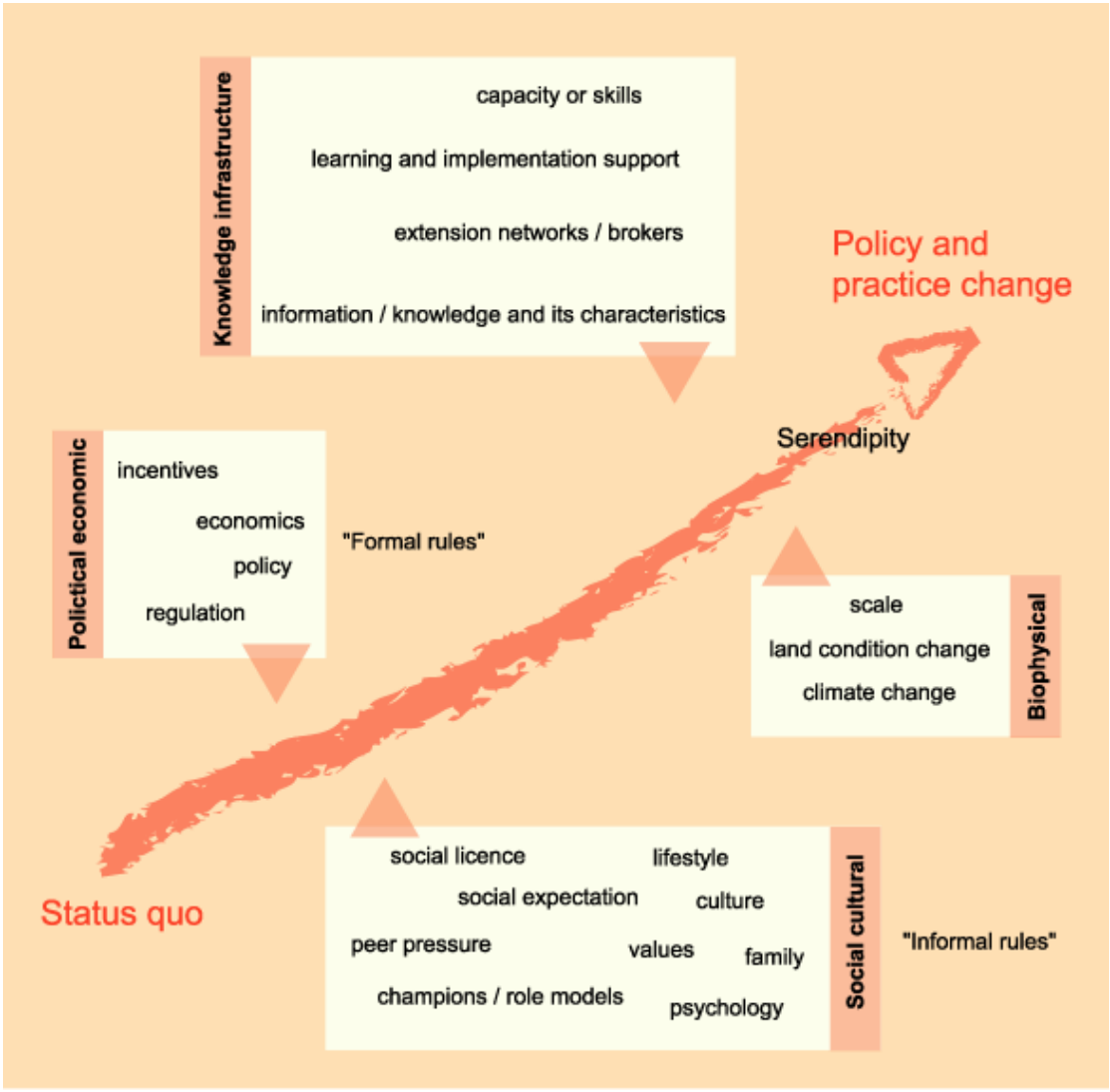
Some innovations suit commercialisation but others add value to capital that is not in a conventional market. For example, a farmer's growing knowledge and wisdom (intellectual capital) is an intangible that adds value but cannot itself be readily commercialised. The commercial value comes from improved production or profitability of their enterprise. Value is also generated in other forms including public benefits or in cost-savings or more efficient use of public funding. Although LWA has completed research into the valuing of intangibles such as biodiversity, it is premature to expect market operation around some innovations such as growing intellectual capital or knowledge. The difficulty in readily 'capturing' direct

financial gain from some research and innovation in natural resource management (NRM) or long lead times for returns demonstrates a market-failure where private investment in such R&D is not made. This is one reason for the Australian Government's investment in these activities through LWA. However, this does not mean that economic returns are not generated from the research, nor that commercialisation of some research outputs is not possible.

LWA may offer different perspectives to innovation and commercialisation pathways than organisations such as AusTrade or The Department of Industry Tourism and Resources and committee reports such as The Muir Committee's Final Report 'Metrics for Research Commercialisation' to the Coordination Committee on Science and Technology. There is however growing consensus that commercial innovation does not occur in a simple linear way but instead technology and knowledge-based firms have customer-led processes in which knowledge of markets, customer preferences and demands to develop new concepts for products and services is the competitive advantage. This reflects the need for other conditions to be favourable before commercialisation can be effective. These broader adoption issues are where LWA's experience may assist the Committee's deliberations.

LWA has brokered research projects that find out why successful uptake or adoption of new technology is not automatic. There are four major groups of factors (Figure 1) that influence the adoption of changes or innovation. These factors need to be deliberately aligned in policy, planning and practice innovation pathways to ensure optimum results.

Figure 1- Factors that influence innovation (shown as policy and practice change on the figure) in natural resource management (LWA Knowledge & Adoption Strategy 2005)



Australia's unique natural resources have demanded innovative solutions including agricultural production systems that innovate to achieve comparable levels of profitability with our international competitors who enjoy younger, richer, more forgiving soils with more reliable climates. A key contributor to successful R&D investments by LWA is getting the research questions right through good scanning, stakeholder consultation and working out the desired deliverables early in the process so that the outputs are more readily adoptable by the end users.

Governments and other institutions have also come under pressure to innovate. In response to the challenge of balancing the various demands on rural landscapes, governments across Australia have fostered the development of new organisations at catchment and regional scales, some funded by Natural Heritage Trust (NHT), the National Action Plan for Salinity and Water Quality (NAP), the National Water Initiative (NWI) and complementary programs at State and Territory level. The efficacy of the Australian Government's major public investments, in collaboration with State and Territory Governments, including a natural resource management budget exceeding $3 billion over the next five years, rests on good program implementation. This demands the application of new ways of working and the use of new technology and institutional innovations to communicate NRM knowledge to and between regions. LWA has been in a position to foster this development process and is developing new ways to facilitate this exchange.

Inquiry Specific Issues

Issue 1 Pathways to commercialisation

LWA's experience in natural resource management is that commercialisation is not the only or best pathway to adoption. However that experience does provide transferable lessons for commercialisation of innovation. LWA has a detailed strategic plan to increase adoption of innovation including:

- **Designing research** in collaboration with rural industries and other stakeholders and agreeing on the pathways for delivering research knowledge;
- **Synthesising** knowledge into forms suitable for uptake by policy, management and practitioner audiences and tailored to its scale of application;
- **Managing NRM knowledge** at a national level and communicating to government and the wider community on substantive NRM research issues;
- **Targeting** NRM/Landcare facilitator networks and catchment/regional bodies to include good science in planning and implementation;
- **Facilitating** knowledge exchange processes across levels of government, communities and rural industries;
- **Building capacity** in all sectors to access and interpret NRM information for their local situation or specific needs;
- **Documenting local knowledge** and promoting practical sustainability achievements of community members such as through our Community Fellowships;
- Assessing **research on adoption** and taking on and promoting its key messages.

Issue 2 Intellectual property and patents

LWA's primary role is to capture and exploit the benefits of R&D to achieve more sustainable agriculture and natural resource management in Australia. It recognises that the management and appropriate protection of IP is critical in the process of adoption of research and development, particularly for commercialisation.

1. **Protection of intellectual property:** Not withstanding the significant 'public good' and 'public domain' nature of IP arising from most of our investments, R&D must be managed on the basis that it may generate valuable intellectual property. That is, appropriate arrangements need to be made to ensure that the research is placed in a format so that it is capable of being protected if necessary. In some cases the intent and form of the protection will be directed to allow ready access to the IP by a wide audience so that one user cannot control or block its use**.**
2. **Assessment and use of prior intellectual property:** LWA has procedures in place to guide researchers in assessing the existing (or prior) intellectual property in the field that is likely to affect their research in order to determine, as appropriate, their freedom to operate in that field of research. All existing IP is made available to the contracted project.
3. **Identification & ownership of intellectual property:** As a default position LWA maximises the ownership of all of its funded R&D. Ownership will be based on level of prior IP and level of investment provided by each of the parties to the contracted project, while limiting ownership to no more than four parties. We assign our intellectual property rights through the Executive Director and only where there is a justified reason.
4. **Commercialisation**: Commercialisation is chosen as the adoption path when it clearly provides a cost effective, faster, more sustainable or more practical avenue for making products or services available to stakeholders. LWA assesses the commercialisation potential of projects.
5. **Transparency and Reporting**: Management reports to the Board regularly on all significant adoption and commercialisation activities.
6. **Risk management:** In accord with the Corporation's risk management framework, LWA has procedures that identify and manage the risks in the release and exploitation of intellectual property including the management of potential conflicts of interest, management of liability and effective due-diligence processes.
7. **Acknowledgment in the release of RDC generated IP:** LWA requires research providers and users to acknowledge the support by the Corporation & other key funders in the generation and development of the IP and will try to ensure that such acknowledgment continues into the future.

IP protection and commercial exploitation has not been a major route for the successful exploitation and adoption of the results of LWA funded research to date. LWA's research focus is on the critical knowledge needs for the future of Australian natural resource management which is in the main 'public good, public domain' but which assists the overall profitability of the primary production sector.

Issue 3 Skills and business knowledge

LWA, in its submission to the House of Representatives Standing Committee on Agriculture, Fisheries and Forestry Inquiry into Rural Skills Training and Research, asserts that the job of achieving landscape-scale adoption of more sustainable land management practices and other innovations requires highly skilled intermediaries between science and practice.

Like other R&D funders and providers in Australia, Land & Water Australia can no longer assume that the outputs of its research investments will be picked up by a well-structured, well-organised, well-trained and resourced rural extension system. In production agriculture, the decline in state-funded extension services has largely been offset by private advisory services through consultants and agribusiness firms. However in natural resource management, public funding remains dominant and there has not been a similar emergence of private service providers. This also reflects the market-failure raised earlier in this submission, where governments enter the 'market' to fund the research that would not otherwise be funded by private individuals or firms. Once funded there is still a market-failure in promotion for adoption of the results. LWA believes that this will not be

undertaken to a significant extent by private commercial interests if based purely on the improvement of sustainability, but that uptake of NRM innovation can be enhanced by embedding it in activities with more commercial drivers (for example soil health within advice on higher production farming systems). This concept is also supported by experience of the Australian Government's FARMBIS program which found that NRM training was more likely to be accessed by primary producers when embedded in production and commercially-oriented training activities.

A key issue for future dissemination and uptake of NRM knowledge and innovation will be effectively generating demand for NRM advice that will allow entrepreneurial providers to establish themselves.

In 2002 LWA commissioned a review of the skill and training needs of regional groups responsible for developing Integrated Natural Resource Management (INRM) plans under the National Action Plan for Salinity and Water Quality and the extension of the Natural Heritage Trust. The subsequent report also considered the broader issues related to capacity building for INRM.

The environmental education sector has evolved significantly in recent years. There has been substantial growth in programs, projects and resource materials, as well as significant increases in environmental and NRM degrees offered by the tertiary sector. In addition to degree courses on offer in the tertiary sector, there are some short courses and training packages offered through the VET sector and other providers.

However, it is unlikely that many of these educational systems provide any significant skills and business knowledge that then generates entrepreneurialism in the NRM knowledge and adoption sector.

Issue 7 Factors determining success

LWA research has identified the following factors as critical to the successful adoption of the results of natural resource management research:

- The relative "adoptability" of the information, ideas, technologies or new knowledge. Factors that determine adoptability include credibility, relevance, timing, trial-ability, accessibility, level of complexity, flexibility, compatibility to existing practices and values, the level of additional learning and capital outlay required, and the level of risk and uncertainty involved.
- Consultation with key clients/customers and focusing the research effort on their strategic opportunities and/or critical problems;
- Consideration of end user adoption/commercialisation and communication strategies up front so that they can be initiated alongside the final stages of the research effort (rather than after finalisation) to reduce the uptake lag period and to maximise returns on investment;
- Collaboration to address the big national issues that exceed the capacity of any one funding agency or research team; and
- Choosing research teams with the right mix of skills and a willingness to involve end users from the outset.

Issue 8 Strategies in other countries that may be instructive for Australia

In July 2004, the Program Coordinator for Land & Water Australia's Riparian Lands program Dr Siwan Lovett, investigated 'capacity building' and 'knowledge exchange' techniques in Canada, with particular emphasis on how science was used in community based decision making and river management. Dr Lovett concluded that Canada's relative strengths were in

engaging communities, initiating action, celebrating, using art, culture, history and drama as ways of 'knowing' a river. In contrast, Australia's comparative strengths appear to be technical rigor, a greater level of institutional coordination, and the involvement of communities who are building capacity to make long-term decisions about the future sustainability of their river and environs. She contends that Australia may need to rethink some of the technical demands being placed on community groups, and complement them with ways to celebrate and encourage involvement at a range of different levels, not just in formal committee structures. Ideally, river restoration needs to be inclusive, celebratory and stable, yet also institutionally cooperative and scientifically rigorous.

Case Studies in Technological Innovation

Land & Water Australia's pathways to innovation have included 'life of project' and triple bottom line (social, economic and environmental) evaluations of its research and development projects since 1992/93. More recently, the combined group of rural R&D Corporations developed a system of triple bottom line reporting, through which the Corporations agreed on a broad set of economic, environmental and social performance measures and on which they report annually to the Minister, to the Parliament and to industry and community stakeholders. This new 'outcomes' based reporting framework provides for reporting on:

- Economic outcomes that are based on adoption, industry productivity, and investment analysis, including benefit-cost ratios and internal rates of return;
- Environmental outcomes that are focused on water quality, environmental flows, water use efficiency, salinity, biodiversity, and sustainable resource management; and
- Social outcomes that are based on occupational health and safety, human resource capacity and capability development, development of the capacity to accept and adjust to change, and contributions to the development of viable rural and regional communities.

Triple bottom line accountability was incorporated into Land & Water Australia's R&D portfolio investment assessment in 2002/2003. The following case studies have been selected to illustrate good approaches and are summarised from external independent evaluations of selected LWA research projects and programs, some of which were initiated under earlier management regimes in the 1980's and 1990's. The full reports of the respective evaluations can be made available to the committee on request.

1. AussieGrass

The climatic environment in Australia for sheep and cattle grazing is highly uncertain and producers face high levels of variability in grass growth and hence grazing pressure. Livestock numbers can be adjusted but have to be kept at a sufficiently high level in order to make profits from given land areas and chosen enterprises. Agricultural policy settings have meant that Australian governments have had to decide from time to time whether to support, by way of drought assistance, graziers in particular regions suffering from exceptional circumstances in relation to climatic variability.

The concept behind AussieGRASS (Australian Grassland and Rangeland Assessment by Spatial Simulation) was developed as far back as 1988 at which time there was considerable controversy about drought funding by the Commonwealth and States. It was recognised that greater objectivity was needed in drought assessment and the system for distributing drought assistance. This controversy arose with accusations of rorting of government monies and governments providing assistance to poor managers. The controversy was set in the context of the general issue debated constantly in Australian agricultural policy over whether drought assistance is an efficient and effective policy given the frequency of drought in Australian agriculture and the farmer's role in managing the effect of drought.

Queensland researchers saw that a modelling framework could contribute to drought assessments by cost effectively providing greater objectivity and accountability for deciding whether a region was or was not in drought. AussieGRASS is a simulation model developed to predict and monitor historical grass production and land cover in all Australian regions. Principal inputs to the AussieGRASS model are past daily rainfall and other historical climatic data, soil type, tree density, stocking rate, and seasonal climate forecasts. By taking account of livestock numbers the model can also assess grazing pressure and therefore be used to assess degradation risk and identify opportunities for improved management. A central feature of the model is the GRASP pasture production model developed by QDNR and QDPI in the late 1980s. The model estimates surface runoff and soil moisture components, the latter being a key driver of pasture growth. Other pasture growth models are being used as well where they are better suited to the southern areas of Australia. As AussieGRASS can be used to monitor pasture growth nationally, it can therefore provide alerts or commentaries on both current and predicted ground cover. Hence it can produce benefits at the enterprise and regional scale as well as provide an equitable and objective assessment of pasture status in different Australian regions.

The original R&D investment in AussieGRASS built on an original Queensland Department of Primary Industries (QDPI) initiative in drought modelling for Queensland in the early 1990s, supported by the Rural Industries R&D Corporation. This model was then enhanced by a project in the National Climate Variability Program (NCVP) from 1992 to 1996 led by Land and Water Australia (LWA). Other States invested in AussieGRASS during that period, although outputs from the model were still limited to Queensland regions.

In this period from 1990 to 1996 there was considerable controversy concerning the importance of drought, support for landholders affected by drought, drought declarations for specific regions, and who would get Commonwealth and State assistance. This stimulated the Bureau of Meteorology (BOM) to provide advice on drought and the Commonwealth advice compared results with the Bureau of Resource Sciences models. The approach was extended to Western Australia showing the value-adding power of freely sharing innovations in NRM.

The Queensland model was extended in the first phase of the Climate Variability in Agriculture Program (CVAP) from 1997 to 2001. CVAP was also supported and managed by LWA. It was during this phase of the investment by LWA that more substantial interest and investment by additional States to Queensland and Western Australia further supported the development of the model through the Managing Climate Variability Program (MCVP) and the modelling in a number of projects funded under the more recent joint AWI and LWA initiative entitled "Land Water and Wool". Over the past few years, the regular operations and reports, together with the maintenance and updating of AussieGRASS, have been supported by the States with Queensland Department of Natural Resources, Mines and Energy (QDNRME) the most prominent funding source. This support is expected to continue in future.

Adding value to seasonal climate forecasting is an important output from AussieGRASS as predictions of rainfall alone are more powerful if the history leading up to the present time is recognised, for example, allowing for current soil moisture status, pasture growth, and land cover status (the more cover the more quickly a growth response is observed).

A range of products have emerged from AussieGRASS. Products relevant to Queensland have been delivered operationally since November 1991. The team at DNRME maintain the model and continue to produce and make available its products. Products include:

- Various maps for each State showing information for recent past periods and expected in the next three months, relative to the long-term averages; maps include those for rainfall, pasture biomass, and pasture growth;
- Queensland monthly report of seasonal conditions in Queensland where model outputs are presented in conjunction with recorded and forecast rainfall, satellite imagery, SOI

and current and drought declarations to build a comparative picture of the current and future seasonal conditions;
- A 4 page colour leaflet mailed out each month to subscribers; and
- Reports on land cover status now and likely in the future.

Uses of these products include:
- A land degradation alert that identifies areas where the resource base is at risk eg. low rainfall, low pasture availability and high stocking rates;
- Seasonal condition assessment for drought analyses; and
- An environmental calculator, such as predicting methane emissions from predictions of pasture growth and quality, and numbers of animals.

In the early stages of AussieGRASS, the main focus was on use by policy makers and analysts in government, both State and Commonwealth. Use has extended to inform individual producers, extension agents, stock inspectors, local drought committees, agribusiness, and rural fire Boards. This pathway has been an example of the kind of technological innovation that will help meet the need for smarter and more competitive agricultural systems in Australia.

2. Incentive Payments to Conserve Remnant Vegetation

Native vegetation protection is a significant issue in the conservation of Australia's biodiversity. Native vegetation and biodiversity provide a diverse range of benefits from nutrient cycling and pollination to aesthetics, recreation, and habitat for Australia's unique flora and fauna. However, there are a number of threatening processes including underlying institutional causes such as lack of information, market failure and policy failure. In addition, these threatening processes apply across different land-use tenures from national parks and other public lands, through to leasehold and privately owned land. In recent years there has been an increasing focus on protecting biodiversity and native vegetation on private land in contrast to the previous emphasis on public lands. As part of this, it has been recognized that private lands contain many of Australia's most threatened ecological communities.

In response to these issues, a three year project was undertaken from 1996 to 1999 by CSIRO Wildlife and Ecology (now CSIRO Sustainable Ecosystems) and funded by LWRRDC (now Land & Water Australia (LWA)) and Environment Australia (now Department of Environment and Heritage). The aim of the project was to address the issue of conserving native vegetation in a way that is relevant to the non-government sector and all three spheres of government (local, state and commonwealth).

The principal output of the project was a series of publications. The titles of these reports as well as brief descriptions of their content (as described by the authors) follows:

- *"Beyond roads, rate and rubbish: opportunities for local government to conserve native vegetation"* – evaluates the role of local government by identifying strategies for working with local government, the tools they can use, the issues that need to be addressed to raise their capacity, and how natural resource management institutions can more effectively engage local government.

- *"Motivating People – Using Management Agreements to Conserve Remnant Vegetation"* – addresses the role of financial incentives and legally binding management agreements in promoting the conservation of native vegetation on private land. It develops a conceptual framework for the project by identifying the situations in which different types of financial incentive can be most effectively used to conserve native vegetation.

- *"Conservation hindered: The impact of local government rates and State land taxes on the conservation of native vegetation"* – evaluates existing exemptions from these taxes and the impact of different methods of land valuation. State and local taxes are shown to have widely varying impacts on conservation activities.

- *"Opportunity denied: review of legislative ability of local governments to conserve native vegetation"* – evaluates impediments to local governments using a range of incentive-based instruments. A number of important legislative barriers to local government playing an effective role in native vegetation management are identified.

- *"Talking to the Taxman about Nature Conservation: Proposals for the introduction of tax incentives for the protection of high conservation value native vegetation"* – reviews the impact of Commonwealth taxes on the conservation of native vegetation. It is found that conservation activities can in certain circumstances be highly taxed. The report put forward proposals to address these situations.

- *"Landscape Conservation and the Non-Government Sector"* – identifies opportunities for the community sector, philanthropists, businesses and governments to conserve native vegetation through the creation of markets for environmental services.

The most notable policy changes which built on the recommendations of the research were changes to tax incentives for conservation which were legislated in May 2000. Specifically,

- an income tax deduction for gifts of property, made on or after 1 July 1999, valued at more than $5,000; and

- an income tax deduction for any decrease in land value as a result of entering into a conservation covenant (provided the landowner receives no payment for entering into it).

- any taxpayer (for example, an individual, trust or company) can claim a deduction for a donation of property and seek apportionment of tax deductions. Property is defined as land, buildings, shares, vehicles, machinery etc valued at over $5,000 by the Commissioner of Taxation.

In addition to the above changes to the Tax Act, the publications produced from the research have been widely distributed and many of the recommendations and policy tools in those reports have been adopted by various levels of government and non-government organisations, including:

- Principles for the design of regional and catchment institutions and application of management systems for NRM have been adopted in the development of the National Policy for Managing Natural Resources in Rural Australia. This document has directly drawn on research findings relating to regional planning, local government and philanthropic sectors (AFFA discussion paper December 1999).

- Analysis of impacts of taxation on the capacity of non-primary producers to invest in biodiversity conservation contributed to broadening the Prime Minister's 1999 commitment of a $51 million package of taxation measures to encourage private and corporate philanthropy to include measures for donation of land to environmental organisations.

- The roles of incentives, local government and tax reform in vegetation management have been formally recognized in the ANZECC National Guidelines for Vegetation Management and Monitoring. These outputs from the project played a central role in developing these guidelines and subsequently reviewing state and commonwealth performance in collaboration with Griffin NRM.

- The analysis of the role of local government in natural resource management established the conceptual framework for the Development of the National Local Government Biodiversity Strategy through the Biodiversity Advisory Council and the Australian Local Government Association.
- Western Australia, New South Wales and Queensland have adopted the model proposed for the establishment of independent Conservation Trusts with capacity to enter into conservation covenants.
- Commonwealth funding was secured for the establishment of independent Conservation Trusts with capacity to enter into conservation covenants.
- Commonwealth funding was secured for the establishment of non-government revolving funds and Land for Wildlife programs in all states and territories.
- Land tax and local government rate exemptions adopted for private conservation reserves as part of Western Australia's Salinity Strategy.
- Design and drafting of an implementation strategy for Lower Hunter and Central Coast Biodiversity Strategy.
- Advice to governments on the establishment of incentive and regulatory frameworks for regulating land clearing and developing sound vegetation management policy in NSW and Queensland.

3. Indian Ocean Information to Climate Forecasting in Australia

Australian rainfall is low and variable so agricultural production systems are strongly influenced by climate. Understanding this variability and improving weather and climate forecasting is critical in Australia where the outcomes of land and irrigation water management decisions are strongly influenced by the variable climate.

Many of Australia's weather systems originate in the Indian Ocean, yet compared to ENSO (the El Nino Southern Oscillation Index), very little was known on how they influenced Australian climate and weather.

Three projects funded by the LWA-managed Climate Variability Program used technological innovation to develop a seasonal outlook by incorporating Indian Ocean temperatures into the forecasting method. The new seasonal outlook provided by the Bureau of Meteorology complements the SOI phase forecast from the Queensland Centre for Climate (QCCA) applications that captures the ENSO (El Nino Southern Oscillation). Both QCCA and BOM forecasts are statistical forecasts as opposed to atmospheric and ocean modelling aids to forecasting.

Before these projects, little attention had been given to the Indian Ocean as a source of climate variation by other countries and researchers around the world. These ocean and atmosphere coupled models improved longer term forecasts, contributed to understanding of climate change and explained unusual trends such as the continued warming of the Indian Ocean (White, *pers comm* 2003). These projects were carried out by CSIRO (Marine Research and Atmospheric Research Divisions) and the Bureau of Meteorology Research Centre (BMRC) and culminated in POAMA (Predictive Ocean Atmosphere Model for Australia), a coupled model of the ocean and atmosphere. It has been run operationally by BOM since 1 October 2002 and gives predictions for rainfall 3 months ahead. Also, forecasts can now be provided at least two weeks prior to the start of the target season, rather than during the target season. The system is also claimed to be more robust than the SOI and outperforms the previous SOI system particularly in Southern Australia (eg South west WA) for the autumn period.

The principal outputs from the investment were

- the improved statistical input to seasonal outlook forecasts made by the BOM,
- a world-class coupled ocean–atmosphere model (POAMA) for prediction of ENSO, together with the enhanced understanding of the influences of Indian Ocean and northern oceans on the Australian climate, as captured by the POAMA model.

Benefits from the improved seasonal outlook statements focus mainly on seasonal outlook for rainfall, rather than temperature or cyclone or frost incidence prediction. The sector using seasonal forecasts most appear to be the rural sector, although other sectors also may benefits (e.g. tourism, emergency services, electricity generation, insurance, and mining). The benefit derived would be from improved decision making by those who have previously used seasonal forecasting. In turn this implies benefits such as higher average profitability via crop yields, lowered drought management costs, water savings, or less financial risk.

4. Managing Riparian Lands

A knowledge gap for riparian lands (any land which adjoins, directly influences, or is influenced by, a body of water) was identified by LWA in the early 1990s. This led to the development of the Riparian Lands R&D Program that commenced in 1993/94. The program aimed to develop guidelines and principles for sound and economic management of riparian lands to contribute to the condition and value of waterways in terms of channel stability, water quality, biodiversity and in-stream ecological systems.

The program has been a highly successful LWA integrated investment where scientific research results produced in the early stage of the program have been extended successfully to users principally through a series of technical guidelines and fact sheets. They have been utilised throughout Australia by a range of users since they were released and are strongly linked to adoption of improved management practices associated with riparian areas on private land.

Over the last three years, industry-specific riparian management guidelines have been developed for, and promoted by, the cotton, wool, sugar and dairy industries in partnership with their respective R&D corporations.

The program operated through a series of selected sites across Australia that were established with State Agencies and other regional and catchment groups. Much of the scientific research focused on understanding of processes that operated within riparian areas. A series of more applied research investments focused on testing and evaluating principles of management.

A range of communication activities and products disseminated findings from the program including:

- fact sheets – demonstration projects
- technical and industry-specific guidelines
- a web site;
- various workshops;
- a newsletter (RIP-RAP); and
- scientific, technical and extension writings.

The fact sheets and technical guidelines are the principal extension products that have emerged from the program.

Phase 1 of the program covered seven years finishing at the end of 1999/2000. Phase 2 of the program finishes in June 2005. The program was largely funded by LWA. Co-lead R&D agencies were the CRC for Catchment Hydrology and the Centre for Catchment and In-Stream Research (Griffith University). No other partners committed to the program on a continuing basis, but many research organisations contributed funding in-kind. As well,

financial contributions were forthcoming from commodity specific R&D Corporations, on a specific project basis, in the last few years of the program (eg SRDC, DRDC and CRDC). Many of these shared projects were related to interpreting the knowledge produced in relation to particular industry circumstances.

The fact sheets and the technical guidelines were the vehicle for integrating and communicating the scientific knowledge produced in the program. Without the fact sheets and guidelines this knowledge would have been transferred by other means, perhaps less effectively and slower. However, the outputs for the innovation should be seen as both the scientific knowledge generated and the communication products emanating from the program.

The R&D findings included:

- the role of vegetation roots in reinforcing and stabilising streambanks;
- the minor contribution of trees to streambank slippage, contrary to previous positions;
- the effectiveness of grass strips leading to riparian zones in trapping nutrients and sediment;
- identifying the sources of sediments in streams and designing management responses;
- design guidelines for laneways and tracks to minimise sediment release;
- in-stream productivity of streams is low under natural conditions due to low light, temperature and nutrient availability;
- identifying nitrogen as the limiting factor of in-stream growth;
- the role of shade in controlling growth of nuisance aquatic plants in waterways;
- a canopy cover of about 70% is usually required to prevent growth by aquatic plants; decision rules were developed to relate catchment area (stream width), latitude, orientation and percentage cover to control in-stream productivity;
- the necessity to replant streambanks in the north with native species since aquatic organisms can not utilise C4 sources of carbon such as para grass and sugar cane;
- showing the importance of in-stream habitats such as woody debris and root armouring of banks;
- the deleterious nature of stock access to streams through urine and dung deposition, trampling and bank pugging;
- strategic management of grazing can be used to improve productivity and recoup fencing and watering costs while improving environmental management;
- improved livestock management can lead to natural revegetation and cost-effective direct seeding approaches are available;
- practical methods developed for riparian fencing, alternative water point development, replanting and reseeding, rearmouring etc

The first set of fact sheets was produced in 1995/96 and has been reprinted three times (more than 5,000 copies). The fact sheets are designed to link the above scientific knowledge with practical management issues. They were designed as a first step in raising knowledge and interest in managing riparian areas more effectively. The set of fact sheets is being revised over time and extended to cover more management issues. The second set of fact sheets was produced in May 2002 and included scientific knowledge generated from 1996 to 2000. These latter fact sheets are now going into a second reprint. The guidelines are user friendly but are strongly underpinned by science that has emerged from the R&D program investment.

Volume 1 of the Technical Guidelines presents principles of sound management, whereas Volume 2 provides on-ground tools and techniques to better manage riparian lands. A large proportion of the 2,500 copies were sold and others were given to community groups and others who promote riparian area management. The information produced from this investment has filled a knowledge gap in the area of riparian land management. The

information has reached a wide range of target audiences. Most importantly, the information is being used in practice. Some land managers were commencing to adopt improved riparian management practices, often facilitated by government grants. Interest by landcare groups and community projects was strong as was the inclusion of riparian issues in catchment plans and in NHT funding applications and uptake of grants. The number of projects that had riparian management as a key focus in Natural Heritage Trust projects under Bushcare, MDB 2000, the National Landcare Program, and the National Rivercare Programs was 530. This indicated not only a high level of awareness of the importance of riparian lands among those land managers but also active implementation of innovative riparian practices.

5. Sustainable Grazing Systems including PROGRAZE

The Sustainable Grazing Systems Program (SGS) was a Meat & Livestock Australia (MLA) initiative together with several partners including LWA, MDBC, State agencies and several universities. Large numbers of producers also contributed to the program.

SGS commenced in July 1996 to look at declining pasture productivity and sustainability in grazing systems of the higher rainfall sheep and cattle producers in southern Australia (>600mm annual rainfall). A 1994 producer survey had revealed mixed and varied levels of understanding among many southern high rainfall graziers about what constituted efficient and sustainable grazing management. Fertilizer applications were being reduced, pastures were becoming less persistent, pasture quality was declining, and in general a planned approach to grazing management was lacking on many farms. Advice on what was good pasture management was often divorced from what constituted good animal management and the integration between the two objectives was lacking.

SGS was developed in a cooperative framework between researchers, producers and extension personnel. The framework for SGS was developed by a producer planning group in order to maintain producer ownership of the program.

There were four components of SGS:

- the National Experiment on principles, tools and indicators
- a regional producer network with regional committees prioritising issues and managing responses
- PROGRAZE, a training course for producers on sustainable grazing management
- integration and management of the program, including the development of products such as Prograzier, Tips and Tools and benchmarking surveys to monitor changes in practices. The surveys were undertaken 1994, 1998 and 2001.

The research or national experiment component spanned a range of sites across the high rainfall zone of Australia including Western Australia. It was a knowledge seeking scientific approach to quantify the relationships between management actions and production and sustainability outcomes, as well as to develop more profitable and sustainable production systems.

PROGRAZE had originally been developed by NSW Agriculture extension personnel with its application commencing in April 1994. It was adopted and adapted by other states in following years and was strengthened scientifically by SGS information.

The eight segment course was delivered concurrently with the SGS R&D program - the idea was to prime producers with skills and knowledge likely to be produced from the research and provide producers with the confidence and language needed to actively participate in the producer networks. The course was based on the principles behind pasture and livestock management and stressed:

- pasture and animal assessment (eg fat scoring)
- on farm grazing decisions and the integration of pasture and animal needs

- matching feed requirements to pasture production
- seeking profitable and efficient outcomes
- water management (introduced as a result of the LWA investment)

The National Experiment produced final reports for each of the six sites (Albany, Hamilton, Rutherglen, Wagga, Orange and Tamworth), and for each of the five themes (water, nutrients, pastures, animals and biodiversity). The reports provide relationships between the production and sustainability variables. An SGS database now holds data for all of the sites in a common format. As well, an SGS computer model was developed that incorporates the elements of high rainfall grazing systems. The outputs from the National Experiment contributed to further development of the PROGRAZE course in terms of both new knowledge and giving further confidence to principles being taught.

The PROGRAZE course provided technical information and assessment skills, used discussion groups, visits and revisits to grazing properties, and provided takeaway manuals and guidelines for use after the course. The course was based on learning from others, solution seeking and active learning with emphasis on building the capacity to make changes. It consisted of eight half-day segments each 2-4 weeks apart with about 15 producers in each course. This allowed various seasons of the year to be covered in the 8 month course.

As research had identified the key role of water management in both production and sustainability outcomes, the revised course incorporated these key water management and sustainability messages. PROGRAZE Update was also developed later for delivering the new water messages to past PROGRAZE participants. This involved specific LWA funding via the National Dryland Salinity Program.

By the end of 1996 nearly 4,000 producers had undertaken the course. By 2002, some 8,500 producers had undertaken the course. These 8,500 (6,400 businesses) were all from the high rainfall zone of southern Australia.

Communication outputs included the production and distribution of the quarterly Prograzier magazine to over 12,000 producers with special editions of such titles as "water" and "biodiversity", particularly relevant to NRM. Other communication products included a special series of SGS "Tips and Tools", sent to 11,000 producers.

Outcomes included:

- A 2001 survey showed that 9,839 producers had engaged with or participated in some way with SGS. This represented 42% of the 23,688 producers in the southern high rainfall zone across Australia. A higher proportion of producers (60%) were aware of SGS.
- The 1998 and 2001 surveys reported producers making changes and reporting more confidence in decisions as a result of SGS.
- Participants in SGS were more likely than non-participants to rotationally graze; have higher stocking rates; more perennial pasture; assess their pasture, dry matter and digestibility value; calculate a fodder budget, weight and fat scores for livestock; soil test and apply fertiliser and lime; and focus on specific markets.
- Among participants in SGS, 81% and 85% respectively stated that the changes they had implemented would increase profitability and sustainability.
- Producers said their involvement in SGS had assisted them in their management of animal, pastures, nutrients and water as well as sharing information among their peers.
- Producers who had participated in SGS were found to more likely recognise environmental issues or problems on their properties and to adopt best practice. A high proportion of producers said it helped then to understand and manage water and nutrients (75%) and environmental issues in general (80%).

6. Pathways to innovative effluent re-use

The discharge of effluent into rivers leads to an over-abundance of nutrients, particularly phosphorus and nitrogen, which are major contributors to the growth of toxic blue-green algae. So research into alternative options to river discharge for the disposal of effluent (both from sewage treatment plants (STPs) and from animal production and processing enterprises) was done. All States have effluent-reuse guidelines produced by their respective environmental protection agencies that specify the level of reuse that should be obtained within a scheme and management procedures that should be followed. They are designed to guide schemes to be sustainable over the long-term so that land will not suffer from overwatering with adverse consequences for soil or groundwater. The State guidelines are updated regularly as new knowledge becomes available.

Land & Water Australia funded eight research projects from 1993-2000 to develop water and nutrient balance models as a key tool for linking the guideline requirements to the local soil and climate conditions in designing reuse schemes. The 'Flushing Meadows' integrated research projects at Wagga Wagga over the period made a seminal contribution to the use of forestry in reuse schemes. Radcliffe (2004) lists 385 reuse projects throughout Australia, of which 14% included forestry as the reuse crop. The Wagga Wagga results have been very useful for evaluating forestry as an option – even in projects where forestry was rejected in favour of another crop in the final design.

The guidelines are designed to assist a range of decision makers including councils, industry managers and their advisers. They assist council engineers, environmental engineering consultants and regulatory authorities with site and species selection and other technical details and helps managers and operators of plantations including councils, private consultants, foresters or farmers to establish plantations and manage their daily operations including irrigation scheduling and silvicultural practices in an environmentally sustainable way. Over 300 copies have been sold throughout Australia and NZ. CSIRO Forestry and Forest Products reports that copies of the guidelines are still being ordered and CSIRO continues to undertake 5-10 consultancies per year on effluent irrigated tree plantations for organisations ranging from Councils, private land owners and water authorities (Tivi Theiveyanathan, *pers comm* 2004).

Two years ago Victorian DNRE requested CSIRO to provide a detailed study on effluent irrigation and to further develop the guidelines by increasing the number of reference sites so that the models predictions are more accurate and reliable across Victoria.

The MEDLI model was developed in Queensland through a concurrent project and has been used more broadly than the Wagga Wagga models and guidelines because it addresses a range of crops and calculates some important design parameters such as the size of the irrigation area and the capacity of the wet weather storage. It is widely used in Queensland where it is recommended as a design tool in the Queensland effluent reuse guidelines for both STPs and animal industry enterprises. To date over 100 copies have been sold with 75% to consultants and 15% to government. Current pricing is $1130 per copy (Gardner, *pers comm*, 2004).

The LWA project reviewers noted that MEDLI, like many other complex biophysical models, has a limited niche market. MEDLI is used in 80-90% of the investigations regarding feedlots for beef cattle in northern NSW and Queensland, and in abattoirs and piggeries in Queensland.

Appendix

Terms of Reference

The House of Representatives Standing Committee on Science and Innovation is to inquire into Australian technological innovation and pathways to commercialisation, with particular reference to examples of successful Australian technological innovations that demonstrate strategies to overcome potential impediments and factors determining success.

To assist in its inquiry, the Committee seeks to compile a series of case studies of successful technological innovations, and the pathways to commercialisation. Submissions are sought detailing successful examples of Australian technological innovations.

Submissions are also sought with particular reference to successful innovations, on issues such as:

- pathways to commercialisation;
- intellectual property and patents;
- skills and business knowledge;
- capital and risk investment;
- business and scientific regulatory issues;
- research and market linkages;
- factors determining success; and
- strategies in other countries that may be of instruction to Australia.