knowledge for managing Australian landscapes

The Australian Natural Resource Management Knowledge System

Knowledge Generation and Management

R&D Corporations
- Cotton
- Fisheries
- Forest and Wood Products
- Grains
- Grape and Wine
- Land & Water Australia
- Rural Industries
- Sugar

Cooperative Research Centres
- E-Water
- Plant based Management of Dryland Salinity
- Irrigation Futures
- Weed Management
- Tropical Savannas Management
- Australasian Invasive Animals
- Coastal Zone, Estuary & Waterway Management
- Cotton Catchment Communities
- Desert Knowledge
- Greenhouse Accounting
- Sustainable Forest Landscapes
- Landscape Environments & Mineral Exploration

Australian Greenhouse Office

Australian Bureau of Statistics

CSIRO   ANU

Geoscience Australia

Universities

Horticulture Australia

Australian Wool Innovation

Meat and Livestock Australia

Australian Pork Limited

National Land and Water Resources Audit

Dairy Australia

Bureau of Rural Sciences

Community Landcare groups

Regional NRM Bodies

Indigenous communities

Water Authorities

Commercial Advisory Services

Commercial Farmers

Australian Govt NRM Facilitators

NGOs

Adoption

Hobby Farmers

Indigenous Land Corporation

Local Governments

Rural residential

State NRM Agencies

Department of Agriculture Fisheries and Forestry

National Water Commission

Department of Environment and Heritage

Productivity Commission

Community Water Grants

National Landcare Program

Envirofund

Natural Heritage Trust

Policy and Programmes

National Water Initiative

National Action Plan for Salinity and Water Quality

Coastcare

Bushcare

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Preface

This document is the product of a one month 'writing sabbatical' undertaken in June and July 2005. It attempts to describe and analyse the knowledge system for natural resource management in Australia – how we as a nation learn our way to more sustainable systems of land and water use and management.

This analysis concludes that, while there are many inspiring and innovative things happening in natural resource management – in science and on the ground – we are not putting it all together at the national level as well as we could or should be. In the days of 'team Australia' and 'joined up government' the NRM knowledge scene remains highly fragmented, with its many parts rarely in symphony. The paper identifies areas we can focus on to improve the system as a whole.
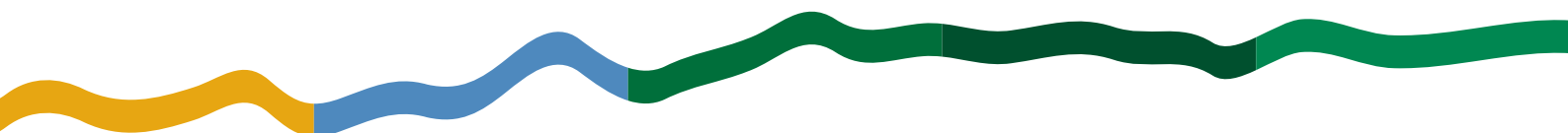
Acknowledgements

This document summarises a larger body of work generated through the Land & Water Australia sabbatical, which contains more detailed explanations and refers to a wider range of literature. Readers interested in digging deeper into this material can request a copy of the larger document from LWA on 02 62636000.

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GLOSSARY OF ACRONYMS

AANRO	Australian Agriculture and Natural Resources Online
ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AKIS	Agricultural Knowledge and Information System
ANU	Australian National University
ANZLIC	Australia New Zealand Land Information Council
APEN	Australasia Pacific Extension Network
ARC	Australian Research Council
ASDD	Australian Spatial Data Directory
ASHEN	Artifacts, Skills, Heuristics, Experience and Natural talent
AWI	Australian Wool Innovation Limited
BMP	Best Management Practice
BRS	Bureau of Rural Sciences
CMA	Catchment Management Authority
CoAG	Council of Australian Governments
CRC	Co-operative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture Fisheries and Forestry
DEH	Department of Environment and Heritage
DEST	Department of Education Science and Training
GRDC	Grains Research and Development Corporation
KM	Knowledge Management
LWA	Land & Water Australia
MDBC	Murray Darling Basin Commission
MLA	Meat & Livestock Australia
NAP	National Action Plan for Salinity and Water Quality
NFF	National Farmers' Federation
NGO	Non Government Organisation
NHT	Natural Heritage Trust
NLP	National Landcare Program
NLWRA	National Land & Water Resources Audit
NRM	Natural Resource Management
NRMSC	Standing Committee of the Natural Resource Management Ministerial Council
NRP	National Research Priorities
NWC	National Water Commission
NWI	National Water Initiative
PIERD	Primary Industries and Energy Research & Development Act 1989
PISC	Standing Committee of the Primary Industries Ministerial Council
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
PPM	Purchaser-Provider Model
R&D	Research and Development
RDC	Research and Development Corporation
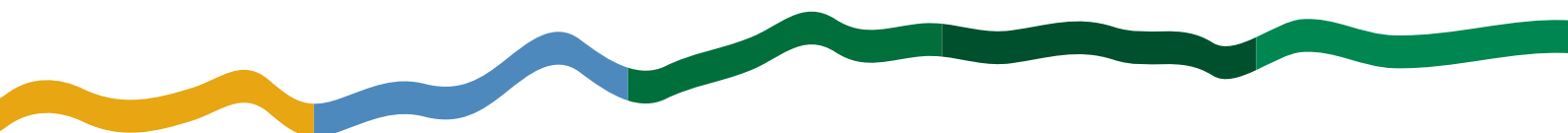
Executive summary

Three key ingredients are needed for more sustainable management of natural resources. People need to know what to do and how to do it; they must want to do it; and they need to be able to do it. Knowledge, commitment and capacity are essential to underpin changes towards more sustainable systems of land, water and vegetation management at all scales.

This paper analyses Australian progress on the knowledge component of the sustainability equation. It contends that there are many areas of genuine innovation and pockets of excellence, but that overall we are not putting it all together as well as we might. We need to invest in new knowledge and in making better use of what we know already:

1. to help people, businesses, industries and governments make better decisions at all levels of management and policy;

2. to energise the innovation process so that we can develop more sustainable land use and management systems and technologies; and

3. to help communities and the nation as a whole to learn as we go along, so that we make best use of existing knowledge and past experience.

Australia currently invests several billion dollars per year on national natural resource management (NRM) programmes. We also invest significant sums in NRM and agricultural science – at least a billion dollars per year just in publicly funded research. Notwithstanding these large public investments, most NRM knowledge exists in the experience, skills and know how of the tens of thousands of people actively involved in managing natural resources every day.

Our challenge is to get the best performance we can from this overall knowledge 'system' – formal and informal, public and private, at all scales – so that Australia is doing the best job it can on the knowledge component of the

sustainability equation. While we did not set out to design an NRM knowledge system, there is value in thinking about the current aggregation of players, organisations, institutions and activities as a system, in order to identify ways to make the whole work better – more appropriately, effectively and more efficiently.

This analysis proposes three key analytical lenses for the NRM knowledge system – purpose, cohesion and function – and it works through current issues and potential system improvements for each. It concludes that the system could and should be working much better than it is, but there are no magic bullets that will deliver dramatic improvements across the whole system immediately. Rather it identifies a range of measures that together would make a big difference over time.

Several measures would make the system more **purposeful**:

- Establish a high level capacity to set priorities and review progress, without implying a centralised, command and control model or an overarching NRM knowledge agency.

- Develop an overall NRM knowledge strategy, preferably consistent with a new national framework for agricultural and NRM research, development and extension – but not constrained to only those activities within the NRM knowledge system, nor to just the formal scientific knowledge domain.

- Strategic direction requires the ability to comprehend the whole system, which means developing at least core elements of a common reporting framework. Incentives would need to be built-in so that there is a sound business case for agencies to meet national reporting requirements.

Complementary measures would make the system more **cohesive**:

- The most important need is to ensure that knowledge assets and knowledge-rich activities are transparent and accessible across the whole system, so that people in any part of the system can more easily find out what has happened and been learned in the past and/or in other places.

- Thinking of a typical system or organisational diagram represented by boxes connected by arrows, it is critical for overall system cohesion to allocate resources explicitly and specifically to the arrows – the linkage and communication mechanisms – not just the boxes. For the NRM knowledge system, this means looking at the boundaries between knowledge sectors such as management, research, extension, policy and evaluation. It also requires attention to the boundaries between knowledge domains such as local, indigenous, organisational and scientific knowledge. Potential mechanisms include brokers dedicated to specific boundary issues, and applying new technologies to better connect (and make searchable) existing information databases that are currently constrained by state or organisational boundaries. There is great scope to re-orient existing publicly funded extension positions.

- From a funders' perspective, we need to think about extending ways to reward collaborative behaviour. We have some successful models such as funding for landcare groups and Cooperative Research Centres. We now need to think about how to better reward knowledge sharing, particularly between different knowledge sectors and knowledge domains. Existing policy settings such as the purchaser-provider model actively impede such knowledge sharing.

There are two key dimensions to system **function**: the decision-making dimension (point 1 above) and the learning and innovation dimension (points 2 and 3). As well as the aforementioned, further measures would improve the **learning** dimension of system function:

- When we have made knowledge assets easier to find and access, it is then important to build in memory aids so that wheels are not reinvented unnecessarily. Monitoring and evaluation tools should pull out and underline the lessons learned from both successes and failures. There are hundreds of potential case studies happening every day in NRM at present, but few are known well beyond their immediate participants.

- We need to do better in honouring, retaining and tapping into elders – people with rich experience and deep knowledge – and helping them to make their insights more accessible and enduring. At present the system appears to be better at forgetting than remembering. Amnesia is systemic, exacerbated by de-skilling of state agencies, high levels of staff turnover, short-term contracts and insufficient attention to career paths, induction or long term skills development.

- One means of both honouring elders and countering systemic amnesia is through centres of excellence. Such centres (which could be virtual) would celebrate and foster deeper learning, and provide opportunities for people at all levels within the system to sharpen their skills, be exposed to wider perspectives, and share their learnings more widely.

- In terms of fostering innovation to achieve quantum improvements in our capacity to manage resources more sustainably, the paper identifies several areas worth exploring: improving the linkages between the 'public' knowledge system of formal research-driven science and the private knowledge system of the leading edge farmers and their consultants and suppliers; perhaps shifting the balance in NRM research to either directly fund more basic science or establish better links into areas such as nanotechnology, photonics, experimental economics, artificial intelligence and genomics; and paying more attention in NRM science to the development and marketing of practical technologies that are able to be adopted on a widespread scale by resource managers.
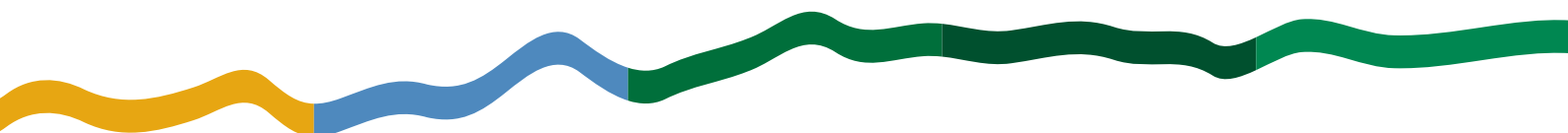
- We need to lift our game on monitoring & evaluation – perhaps the biggest weakness in the NRM knowledge system at present. As well as reinvesting (using latest technology) in the collection and analysis of primary data on resource condition and management practices, we should be looking at the value other countries are deriving from long term research and monitoring sites, with a view to expanding on and enriching the few we have already.

All of the above would also help to improve the **decision-making** dimension of system performance. Additional measures include:

- For each knowledge sector – planning, extension, regulation, incentives, markets and so on – we need to articulate how and where knowledge services the main objective. This means identifying the decisions that need to be informed – by scale, type of decision maker, preferred learning styles and so on. This then feeds into the design and application of knowledge management tools.

- For example, from a research perspective, too many current research outputs aimed at farmers and other resource managers are not adoptable from the users' perspective. We need to better define adoption pathways for research outputs and work to ensure that knowledge assets are synthesised and packaged accordingly. A redesigned NRM extension system would help.

A specific subset of the overall NRM knowledge system that needs urgent attention is the 'regional model' of NRM programme delivery for the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust (NHT). The regional model is a world-leading effort to implement sustainable NRM at a landscape scale. It has huge potential through its capacity to devolve decision making & resource allocation to appropriate scales; to tap into and build on deep local knowledge and connection to place; and to work across issues and industries in an integrated way. It is also a grand experiment, so the need to learn as we go

and apply the lessons learned is critical.

Research funded jointly by Land & Water Australia and the NHT has found that although the knowledge needs of the 57 regional bodies are varied, there is lots of scope for learning across regional and state boundaries. Land & Water Australia is currently managing an NHT-funded project called Knowledge for Regional NRM that is exploring ways of improving knowledge management and knowledge exchange among regional bodies, and improving the way the overall system serves those regional bodies from a knowledge perspective. Areas of concern identified by regional bodies to date about information include fragmentation, volume, relevance, accessibility, the need for two-way exchange, and the need for sharing across regions and up to the Commonwealth level and back.

All of the foregoing measures would help the regional model and make life easier for regional bodies. Moreover, dedicated measures being canvassed in active collaboration with regional bodies include:

- A 'First Stop Knowledge Shop' (face to face and web-based) for the regional model that would guide regional bodies in working out how to best meet their own knowledge needs – not to spoon feed them but to help them navigate what can appear to be an intimidating and intractable information mountain. Such a service would assist intermediaries (facilitators, coordinators, advisers, consultants etc) to tap into the best available people & information for their situation.

- Mechanisms that explicitly 'fund the arrows' by targeting knowledge flow: between regions, and from regional to national and back again.

- Building communities of practice among NRM Knowledge Brokers.

This analysis concludes that in many aspects of natural resource management, Australia is at the leading edge of international efforts to develop and implement more sustainable ways of managing land, water and biodiversity resources. Innovation and rich insights are sparking in many places, organisations and people across the NRM knowledge system.

However at present we are not pulling all of this together as well as we could or should. It is too hard for people in any part of the system to find out what is happening and what is being learned elsewhere – or has been learned already. Consequently decisions may not always be based on the best available information, past mistakes may be being repeated, and we are probably not getting the best possible return on investment of public and private funds and effort.

This paper argues that there is value in thinking about the overall aggregation of knowledge-based activities, organisations and institutions as a knowledge system, in order to illuminate ways of improving the performance of the system as a whole. Measures that would improve system performance are identified.

Renovating the NRM knowledge system would be a great investment for Australia.
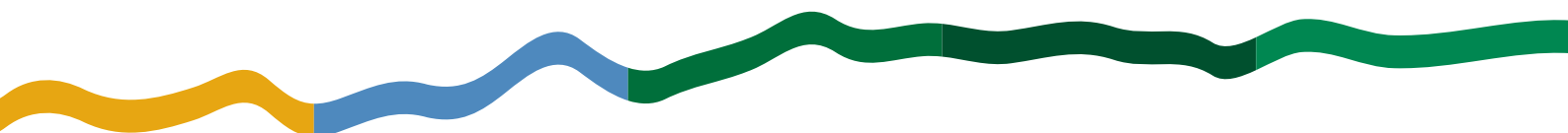
Introduction

The management of Australia's rich endowment of natural resources is a national priority.

Water resources – both surface water and groundwater – are under extreme pressure, and many ingrained habits in water use and management are under question. Australia has long had to deal with extreme climate variability, but it is now clear that each drought is hotter than the last, and we seem to be in a more profound drying cycle, especially in south-western and south-eastern Australia. The management of vegetation is critical in achieving an appropriate hydrological balance, in managing carbon emissions, in conserving biodiversity and in sustaining grazing systems. Invasive species, both plants and animals, continue to impose significant costs on agricultural production, and fierce competition and predation pressures on native species. Soils are the engine room of agricultural productivity and we have much still to learn about managing soil health in Australia. Fire management is a complex sustainability challenge, especially in the north.

The role of knowledge in the Australian sustainability agenda is critical.

There is much to admire about Australia's current approach to natural resource management.

There is an unprecedented level of agreement between Australian governments about the big issues and the need for coordinated, 'joined up government' approaches.

There is an unprecedented level of commitment from the Prime Minister down, reflected in CoAG discussions and resolutions, and Australian government funding commitments.

Australia's primary industries are increasingly seeing natural resource management as core business and are investing accordingly.

The extent of grassroots farmer and community participation through Landcare and 'buy in' to practical local environmental initiatives is without parallel in other countries, and a wonderful platform for long term reform.

The regional delivery model based on new catchment/regional institutions is a bold national experiment that creates the potential for problems to be understood, decisions to be made, resources allocated, capacity developed and solutions implemented at a more appropriate scale for some issues.

Australia has put some of the hard issues like property rights on the table. There is real innovation in measures being canvassed and piloted to work out new ways of making and implementing resource allocation decisions.

Australia has long since left behind notions that conservation is something that only happens on protected areas, and is leading the world in new approaches to landscape ecology that recognise that landscapes are socially constructed and people are integral.

The NRM research scene in Australia is underpinned by a highly successful rural R&D model through R&D Corporations, some exciting Cooperative Research Centres and some outstanding researchers.

We need to develop systems of land and water use and management that meet our changing lifestyle and livelihood needs profitably, while sustaining the long term productive capacity of the resource base and looking after our unique natural heritage for future generations. The sheer uniqueness of our biota, climates and landscapes means that in the main our natural resource management know-how has to be home grown – made in Australia.

We need uniquely Australian knowledge to improve Australian farming systems and consequent profitability. We need better knowledge to manage our natural resources more sustainably. We need better knowledge to be able to target, manage and evaluate large public investments in natural capital. We need better knowledge to help governments balance competing demands on natural resources and rural landscapes on behalf of Australian citizens.

Australian Governments have agreed on major public investments in natural resource management exceeding five billion dollars over the next five years. Chief among these are the National Action Plan for Salinity and Water Quality (NAP), the Natural Heritage Trust (NHT) and more recently the National Water Initiative (NWI). These programmes are generating new questions related to prioritising investment, working out appropriate interventions and monitoring and evaluating progress.

This paper attempts to analyse the Australian natural resource management (NRM) knowledge system and its performance in serving the policy and programme goals of Australian Governments, and the knowledge needs of resource managers. The focus here is predominantly rural and agricultural – not because other land uses are unimportant, but for pragmatic reasons of space and time.

The issues we are tackling are enormous, intractable and complex. They won't be fixed overnight. We are on a long journey, and our rate of progress will be determined to a large degree by how smart we are in working together at appropriate scales and learning from each other and from experience. Our natural resource management knowledge system plays a critical role.

Analytical framework

No-one set out to build an NRM knowledge system *per se*, and thus it could be argued that it is invalid or unfair to analyse a disparate suite of organisations and activities as if they were a system. This paper starts from the premise that it doesn't matter whether or not we intended to build an NRM knowledge system – we have one by default and we need it to start working better as a whole. Australia has committed billions of dollars to improving the NRM knowledge base, and to major programmes aiming to improve management of natural resources. It is valid to ask how well 'the system' (whether or not we set out to build it as such) is meeting the needs of its users. Systems concepts are used here to explore ideas that could make the whole work better, delivering a better return on public and private investment.

The key analytical lenses applied here can be summarised as **Purpose, Function** and **Cohesion**. They are captured in the following questions:

1. How well does the system as a whole perform as an innovation and learning system for Australia?
   This is the big overarching question, teased out by examining two subsidiary questions:

2. How well does the system respond to and meet the needs of its users – in particular to help make better decisions about management of natural resources?

3. How well do the components of the system work together as a whole?
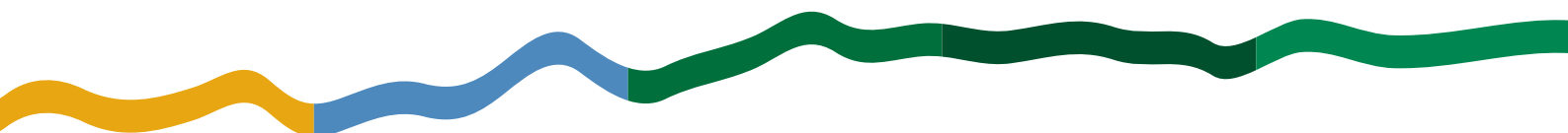
The exploration of these questions is intended to pinpoint areas where we can focus constructively to improve the performance of the system. The paper concludes with some suggested next steps that might progress such improvements.

Before considering system performance issues, it is important to touch briefly on the concept of knowledge itself, and that of a knowledge system.

Knowledge and learning

Knowledge happens between the ears. It arises through individual cognitive processes that enable people to make sense of the world. This is a critical point: knowledge is not an abstract, tangible thing that can be exchanged between people without any mediation, transformation or interpretation. All knowledge is generated in the human head, and shaped by the cultural and physical context of the time.

For the purpose of this analysis, learning is a broad term for the cognitive processes of processing data and information and building knowledge. Individuals see the reality they experience through their own world view, something which is changed rarely and with difficulty. We each have particular styles of learning, of which it is important to be aware, especially in working with other people. Professionals in agriculture and NRM need to be technically competent to deal with specific issues, but they also need to learn how to learn, as do their organisations at a higher level, and the system as a whole comprising multiple organisations across eight jurisdictions.

This paper draws on discussions of knowledge and learning in the systems and management literature. Dave Snowden[1] contends that knowledge is the means by which we inform, not a higher order of information, and it is always influenced by its context – in fact dependent on it. As Snowden says, "*I only know what I know when I need to know it*" observing after Michael Polanyi that we always know more than we can say, and we will always say more than we can write down. Knowledge is revealed more reliably through action or reaction than verbal or written explanation.

Dave Snowden developed the ASHEN model to describe the different ways in which knowledge is revealed or disclosed[2]:

Artefacts: anything made by people, processes, documents, tools in which knowledge is embedded;

Skills: abilities that can be trained and measured without ambiguity (over time);

Heuristics: rules of thumb, the outcome of experience, the main repository of knowledge mostly unarticulated;

Experience: accumulated experience of failure and success which allows the right pattern to be triggered in the right context;

Natural Talent: some people are just better at doing things than other people – and they are often not the people you expect.

It is worth dwelling briefly on knowledge and the different forms it can take – the different epistemologies or 'ways of knowing'. The most common categorisation of ways of knowing in the NRM context is the distinction between formal, expert, scientific knowledge; experiential or tacit knowledge; local knowledge; and indigenous knowledge. This is a useful distinction because it relates well to how people get an understanding of the land, water, vegetation or 'country' they are living in and managing – and consequently how they might relate to the NRM knowledge system.[3]

Val Brown[4] makes the point that the individual and social construction of **ignorance** is as important as the way what she calls knowledge 'cultures' construct knowledge:

Each knowledge culture has developed effective boundary-riding techniques through allocating ignorance... Individual knowledge is consistently rejected as prejudiced; local knowledge as gossip; specialised knowledge as jargon; strategic

knowledge as corrupt and holistic knowledge as impractical. Familiar accusations from their fellow knowledges are that specialist knowledge is too abstract to be useful. Community knowledge is irrelevant since it can only refer to one case. Strategic knowledge of organisations is distorted, since it seeks to influence reality, not merely to observe it.

This implies that for any knowledge system to be effective in reaching a wide cross section of people and stakeholder groups and contexts, it needs to recognise the different knowledges and the diverse ways knowledge and ignorance are constructed and interpreted across society as a whole. It is particularly pertinent in thinking about the interface between formal, scientific knowledge and the knowledge cultures of those who manage most natural resources in Australia – farmers, pastoralists and indigenous communities.

From an NRM perspective, it is also useful to think about the interface between scientific knowledge and the 'strategic' knowledge domain of administration, governance and policy. Scientists are often frustrated that big public policy decisions are at best imperfectly informed by the best available science. Policy makers are often frustrated that scientists rarely have useful 'answers' at the right time – and usually respond with a request for more money to do more research over a longer time, delivering results long after the politically opportune moment has passed.

A well-designed NRM knowledge system would focus on these interfaces, with mechanisms designed to ensure fruitful interaction between different knowledge domains and value systems[5] rather than mutual frustration and misinterpretation.

The final distinction between different types of knowledge here is that between 'tacit' and 'explicit' knowledge. This is particularly important from a knowledge management perspective. Tacit or experiential knowledge – personal knowledge rooted in individual experience and involving personal beliefs, perspectives and values – is inherently personal and tends not to be recorded systematically, and thus is not easily explicit or

accessible to other people. The recognition of tacit knowledge is important in NRM, because it is probably the case that most knowledge about the management of Australia's natural resources resides in the heads of farmers, pastoralists and indigenous communities. The NRM knowledge system needs to recognise this, value it and work with it, seeking ways to share tacit knowledge more widely (where appropriate), and to minimise its inexorable erosion as people with a wealth of experience die, leave the land or change jobs.

The NRM knowledge system needs to work on the assumption that for most of its users, seeking knowledge is a means to an end, rarely an end in itself. We do know about the knowledge seeking behaviour of professionals – they need focused information quickly, they often don't know what they need until they need it, and they are likely to default to a trusted source rather than search systematically for the best possible advice. The same probably holds for most people.

Maybe thinking is uncomfortable. Maybe we are biologically programmed to want to 'complete' our thinking as soon as possible.[6]

Table 1 below[7] summarises the findings of a number of studies into how policy and decision makers try to inform themselves. The implications of this for the NRM knowledge system are significant. As for farmers and catchment managers, policy makers need the whole picture, not just little bits. So the knowledge system needs to be able to anticipate, respond to and meet this need, without crossing the line into trying to write the policy. The ability to sort and synthesise the most relevant information in a timely way is crucial for policy makers – and if the best information is not available in a useable form exactly when it needs to feed into the policy environment, then it won't be used[8].
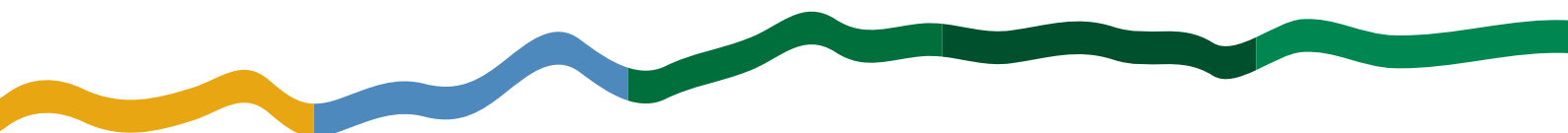
Table 1. Common characteristics of and motivations for knowledge seeking behaviour in decision makers

Decision confidence or social behaviours
• They prefer to solicit information from someone they trust rather than a recognised authority in the field.   • The more experienced, educated and knowledgeable the Decision Maker the wider the range of information sources and networks both inside and outside their organisation they are likely to utilise.   • They are likely to accept an idea if the sources are consistent — regardless of the authority of the source.   • They are unlikely to search for new information about a topic upon which they feel knowledgeable.
Time management behaviours
• They seek up-to-date, concise overviews of current understandings in a particular area. They do not see the individual research project as the appropriate unit of knowledge transfer.   • They avoid time consuming active information 'search' behaviours (e.g. libraries, searching for expert opinion) over more passive knowledge transfer behaviours (e.g. call a professional colleague).   • They seek until they find the first acceptable answer.   • They seek information that does not require significant analysis.   • They give up searching for the knowledge relativity quickly and rarely keep searching for the 'best' answer - They tend to go back to past sources of information rather than seek out new ones, even if the information they get is not as useful as other information sources could provide to this particular problem.   • They tend to seek knowledge from someone who is easily accessible and will accept inferior information as an acceptable outcome of this behaviour.   • They follow habitual patterns in their information seeking. They fall into a pattern of information seeking on particular topics, especially with other people.

[Barchiesi 2003, from Pollitt 2001; Alcock, 2002; Cullen et al 2001; Hansen, 2002; Sudiono, 2002.]

Knowledge management

Knowledge Management exploded in the management literature and the business schools during the 1990s, in parallel with notions of 'the knowledge economy' and catalysed by the exponential growth in the ICT sector and its ever more powerful, accessible and affordable technologies. A key focus of the early knowledge management push was to try to capture tacit knowledge and codify it into explicit knowledge, within organisations or more broadly. Many organisations use knowledge management tools to try to minimise the erosion of corporate

memory that occurs when experienced people leave an organisation, and to try to capture some of the skills, heuristics and experience of their people in ways that feed into broader organisational learning.

In my view the Australian NRM knowledge system would benefit from more systematic application of these tools. However Dave Snowden[9] argues that such approaches are somewhat simplistic, and based on the false premise that knowledge can be converted from tacit to explicit and back again without losing meaning. Snowden contends that *"properly understood, knowledge is paradoxically both a **thing** and a **flow**..."*

This distinction between knowledge management as 'content management' and knowledge management as 'learning management' (my interpretation) is subtle but important. Both are needed in the Australian NRM knowledge system. We have much to do simply to get our house in order in managing content – knowledge artifacts reflected in data, information, maps, reports of all descriptions and so on. We need to do more to make other expressions of knowledge – skills, heuristics, experience and natural talent – more transparent, tractable and accessible so that we can more easily bring it to bear on relevant problems.

However we also have much to gain from considering how better to manage knowledge as a flow – as context and narrative, not just content. This would mean paying more attention to the local and regional contexts in which learning takes place, and much more explicitly seeking to draw out and incorporate local knowledge in NRM planning, extension, implementation, monitoring and evaluation. For Indigenous communities in particular, knowledge is deeply embedded in its local context, and struggles for meaning when abstracted from that context. In the wider NRM scene we already have some crucial planks in place in terms of community participation in landcare and land literacy programmes, in vibrant farmer groups runs by farm management consultants and in the regional/catchment management apparatus through catchment management organisations.

In an Indigenous context, we are still in the early stages of developing ways to get the most appropriate mix of knowledges to bring to bear on the sustainability challenges on the 20% of the continent managed by Aboriginal people.[10]

Knowledge systems

Professor Niels Röling at Wageningen Agricultural University in the Netherlands started developing the concept of Agricultural Knowledge and Information Systems (AKIS) in the 1980s. Niels Röling responded to what he saw as the failings (particularly in a sustainability context) of the Transfer of Technology paradigm of agricultural research and extension[11] – the so-called 'linear model' arising from diffusion theory in which knowledge is assumed to diffuse from science through extension to leading farmers and then eventually 'trickle down' to the rest.

The AKIS concept recognises that there are many more players in agricultural development than just researchers, extension officers and farmers. Further, AKIS assumes that almost everyone is engaged in all of the generation, transformation, transfer and use of information and knowledge, and it acknowledges that formal, scientific knowledge is only one of many forms of knowledge relevant to the improvement of farming systems. Perhaps the most important feature of the AKIS concept however, is its proposition that research, extension and farmers potentially form **systems**— wholes with emergent properties over and above the sum of their individual capacities—and that such **synergy**, particularly if it fosters innovation and improves access to relevant information and technology, is one characteristic of an effective knowledge system.

In the Australian NRM knowledge system, we are interested in knowledge for innovation and knowledge to influence behaviour change towards more sustainable management practices. This means that a key diagnostic for the NRM knowledge system is how well it helps people to make better decisions about changing management practices and policies. Figure 1, from Land & Water Australia's Knowledge and Adoption Strategy, presents a conceptual model
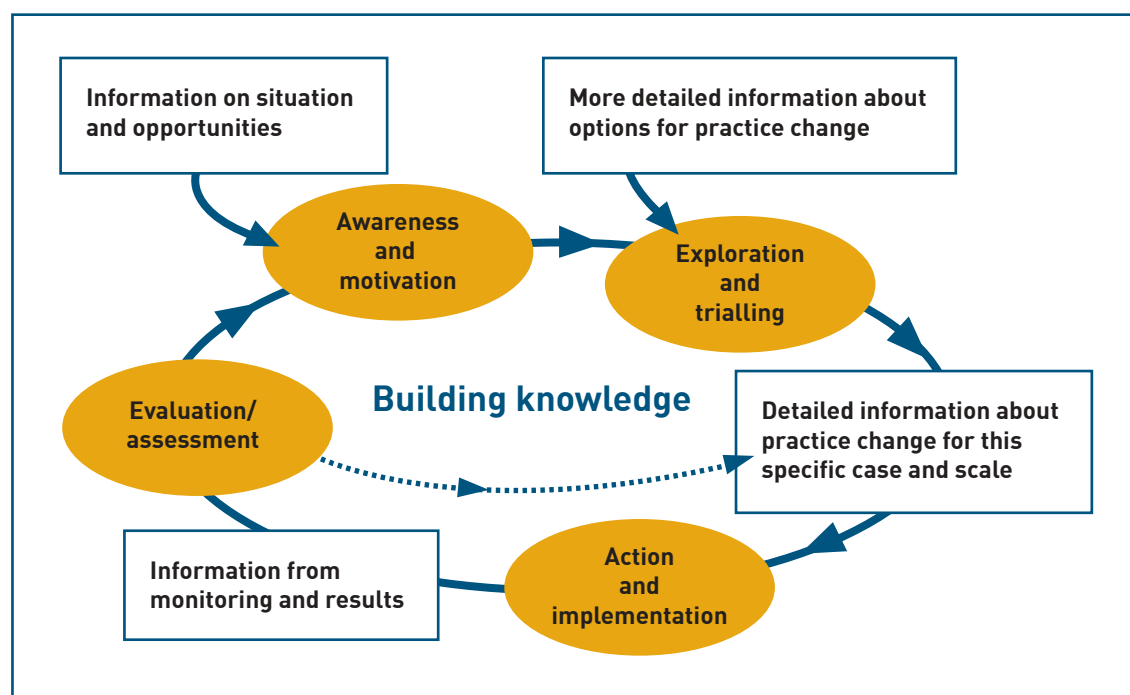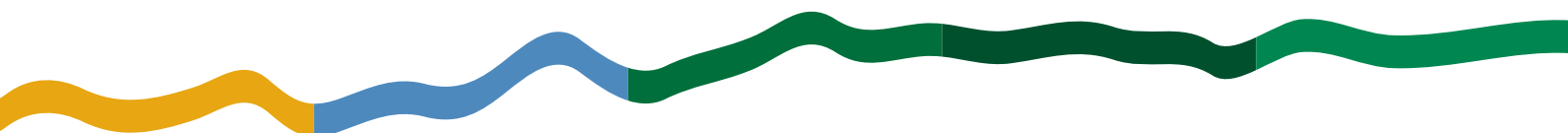
Figure 1. Information and the practice change cycle

[LWA (2005a) Knowledge and Adoption Strategy.]

for practice change at a farm scale, identifying the points at which different types of information are required.

Different types of decisions generate different knowledge needs for sustainable NRM at the national and landscape scales respectively. Together, these can be used to derive the questions to interrogate the performance of the Australian NRM knowledge system as a whole. But first, it is worth looking briefly at the processes aimed at increasing knowledge in the agricultural and NRM context in Australia.

Extension, capacity building and knowledge brokering

Extension for the purposes of this discussion is the process of engaging with individuals, groups and communities so that people are more able to deal with issues affecting them and opportunities open to them[12]. Extension is a non-coercive policy instrument that aims to foster learning to improve decision making, usually towards a specific objective expressed in terms of a desired change

in behaviour among a target group – often the adoption of a particular technology or practice. Jeff Coutts and colleagues, in a comprehensive review of extension in Australia commissioned by the cross-RDC Cooperative Venture for Capacity Building in Rural Innovation, developed a typology of extension models[13]:

- **Group facilitation/empowerment:** is based around helping people to define their own problems and opportunities and to develop their own ways of tackling them, using group learning to assist people to learn from and with each other, and to develop more collective approaches to common problems.

- **Programmed learning:** is based on the development and systematic delivery of workshops and/or courses applicable to a large number of diverse participants over a number of regions or even state boundaries – ideally linked into the National Training Framework with some possibility of accreditation.

- **Technology development:** assumes that new technologies and practices are rarely developed successfully in isolation and simply adopted on a widespread scale. Most technologies need some form of adaptation in context, and many need demonstration and facilitation to prove their relative advantage and to assist with trialling – giving people the confidence to have a go.

- **Information access:** recognises that people require different information at different stages of their learning and decision-making processes in forms that suit their individual learning styles. Projects of this type seek to make information available and accessible in a variety of ways, but usually not requiring direct mediation through an extension agent. Web-based applications obviously lend themselves to this model, but are not the only option.

- **Individual consultant/mentor:** is based on 'traditional' one-on-one extension, and is still in widespread use among leading farmers, primarily through the use of farm management and other consultants.

In the contemporary context of natural resource management in Australia, the more trendy term for these activities is 'capacity building'. Coutts et al[14] argue that these five models form the supports and rungs of a 'capacity building ladder' and all are complementary and necessary for the capacity building process. In my view it is unhelpful to conflate extension with capacity building. Extension is just one way of enhancing capacity, and other tools (including infrastructure development, structural adjustment, tax breaks, cash grants and R&D) may be more appropriate depending on context.[15]

A more recent development in thinking about knowledge management in an NRM context is the concept of **knowledge brokering**.

Knowledge brokering is typically used to refer to processes used by intermediaries (knowledge brokers) in mediating between sources of knowledge (usually science and research) and users of knowledge. Knowledge brokering is usually applied in an attempt to improve knowledge exchange in a specific context for the benefit of all parties.

Technical experts and people who need access to technical expertise are busy, and neither party has sufficient time or appropriate expertise to also be an expert in knowledge exchange. Knowledge brokers help people to ask the right questions, and to identify the best sources of the information they need, and work with the knowledge sources to get information into a form that will be most appropriate for end users. Skilled knowledge brokers facilitate feedback from both parties – feeding into researchers as much as to the users of research outputs, and potentially challenging the way research outputs are presented or even the research questions being explored. Expert knowledge brokers are typically 'multilingual' in being able to understand people at each end of the knowledge exchange equation. In the case of indigenous knowledge, it is an advantage to be literally multilingual in order to capture a fuller sense of a deeply contextual knowledge culture.

Essentially, knowledge brokering is a term for processes to facilitate learning, with the term 'brokering' implying an active form of facilitation that involves pro-active searching and synthesis from different information sources on the one hand, and active negotiation to get the questions and knowledge needs clear on the other hand. It is of particular use in mediating between different knowledge domains such as scientific and local knowledge or indigenous knowledge.

Servicing the knowledge needs of catchment and regional bodies under the National Action Plan and the Natural Heritage Trust is one of the biggest challenges in NRM today. With generous support from the NHT through DAFF, Land & Water Australia has embarked on a National Knowledge Brokering for Regional NRM project that is working with CMAs[16] to tease out their knowledge needs, and hopefully identifying some ways to get the system to work better. This project has also reviewed experiences with knowledge brokering in sectors other than NRM in Australia and internationally. Ideas that have
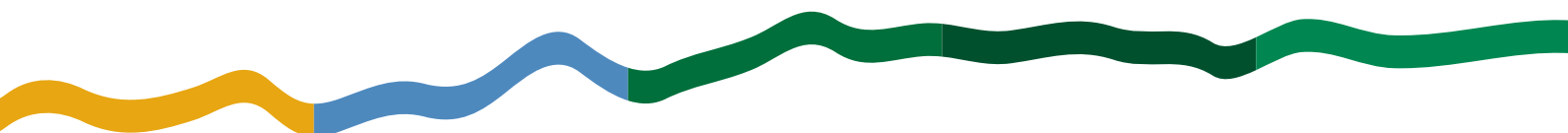
emerged from this project and its interactions with a range of catchment bodies are canvassed later in this paper. Drawing this discussion together, the diagram below attempts to relate the various categories of extension models to knowledge brokering and capacity building. Extension is one way, but not the only one, of building the capacity of people and communities to make better decisions and gain more control over their situation. Similarly, I see knowledge brokering as a subset of extension, although it cuts across Coutts' typology[17] of extension models. Knowledge brokering is easier if information is freely and easily accessible in appropriate forms.

repertoire of extension approaches, carefully chosen according to context. One-on-one technology transfer remains valid and will be the best available approach in certain situations. Knowledge brokering is equally valid in other situations. Landcare group facilitation remains appropriate for raising awareness, getting people involved, changing social norms and marshalling resources for problems that cross farm boundaries. There is a rich extension repertoire able to be employed by skilled and experienced extension professionals, drawing on the accumulated knowledge and wisdom of the extension profession to work out the best mix of approaches for the

Figure 2. Conceptual mud map of extension models
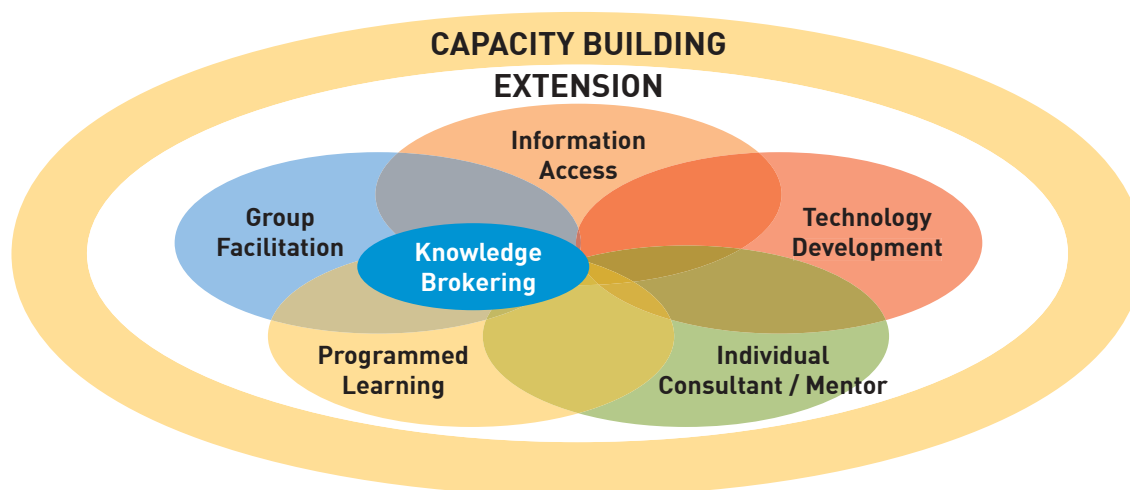
It can be achieved through programmed learning activities, group facilitation methods or one-on-one advisory models. Knowledge brokering can assist in technology development, in particular by brokering shared understandings between those developing technologies and the intended users of the technology. Similarly, there is considerable overlap or at least mutual reinforcement between the different extension models. Group facilitation, programmed learning and information access tools can be synergistic when used together – as can combinations of one-on-one work with group approaches, whether in a structured learning environment or in an open facilitation setting. The challenge of developing and implementing more sustainable systems of farming and land and water management in Australia demands the skilled and strategic application of the full

particular context, and enriched by contemporary concepts like knowledge management, knowledge brokering and social learning. That profession is admittedly threadbare in Australia at present, having lost much of its infrastructure over recent decades. But it still has an important role to play. The opportunity to reinvigorate it is there with the resources already being invested in thousands of projects through major public funding programmes including the NAP, NHT, NLP and NWI, drawing on the considerable expertise that still exists within industry-based programmes and in non-government organisations such as Greening Australia.

These possibilities are explored later – first an attempt to describe the Australian NRM knowledge system as it currently is, not what it could be.

The Australian NRM Knowledge System

This section attempts to examine the Australian NRM knowledge system in terms of its components, purpose and cohesion, and its performance as a learning system – both in helping to make better decisions on a daily basis, and in helping the system as a whole to learn and adapt through time. The lack of publicly and easily accessible data to support much of this analysis is itself an indicator of the current lack of system in our overall approach to NRM knowledge in Australia.

System boundaries

For the purposes of this analysis, the NRM knowledge system is the aggregation of measures that we have established over the years to generate, extend, transform, record, share and exchange knowledge about Australia's natural resources and their management. The focus here is on management of land, water and biodiversity in rural Australia. Urban, marine and atmospheric dimensions of NRM are not considered explicitly. The emphasis is also primarily on agriculture rather than mining, fisheries or forestry, and on private and leasehold land, rather than reserves such as National Parks and State Forests. Nevertheless, it is likely that many of the issues around knowledge and its management in the rural agricultural context are applicable to varying degrees in other sectors of NRM in Australia.

System components

The starting point for analysing an agricultural knowledge system is the actors within it.[18] These are the people, institutions and networks who comprise the system – and are engaged in generating, extending, transforming, recording, sharing, brokering and exchanging knowledge about Australia's natural resources and their management.

Figure 3 overleaf presents more than forty organisations and funding programmes established and funded by the Australian Government charged with purchasing, managing or delivering various aspects of NRM science. In the main, these organisations and programmes are operating in the formal scientific knowledge domain. Note that these are only those organisations operating at the national level,[19] directly relevant to a reasonably constrained definition of natural resource management. When the definition of NRM is expanded somewhat to include agricultural production aspects and some of the broader science coordination mechanisms – the list of national organisations doubles to more than eighty.

Organisations focused at the formal, scientific end of knowledge generation and management are only a small proportion of the total number of players and networks. Add in the non government organisations (NGOs) such as advocacy groups like the National Farmers' Federation and community-based organisations like Greening Australia, the Australian Conservation Foundation (ACF), WWF, the Australian Bush Heritage Fund and you could quickly exceed one hundred organisations at the national level alone. Superimpose the federal architecture on top of that by including all the NRM science players across the eight States and Territories, and intergovernmental coordination mechanisms like ANZLIC[20], and you would compile several hundred organisations managing formal, scientific NRM knowledge.

Include universities and TAFE providers and you double it again. The environmental education sector has evolved significantly in recent years. There has been substantial growth in programmes, projects and resource materials, as well as significant increases in environmental and NRM degrees offered by the tertiary sector.[21] There is a wide array of over 600 environmental and natural resource management courses on offer in the tertiary sector. In addition, the Vocational Education and Training sector has study courses and training programmes that cover natural resource management. Certificate and Diploma courses in Environmental Management and Natural Resource Management are offered through TAFE at various locations.
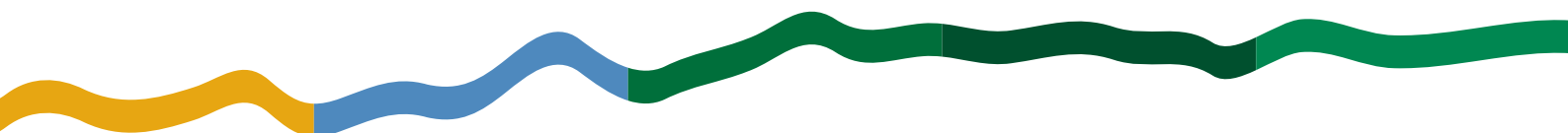
So there are several hundred organisations across Australia investing public monies in the generation and management of formal scientific knowledge in NRM. This can be seen as the supply side of the NRM knowledge system, but only in terms of publicly funded formal knowledge. There are several dozen consultancy firms (probably employing over one thousand consultants in total), from large multinationals to individual consultants, who also play an important role in generating NRM knowledge and undertaking research, especially at the agricultural production end of NRM.

Figure 3. Key components of the Australian NRM knowledge system

Knowledge Generation and Management

Australian Greenhouse Office
Australian Bureau of Statistics
CSIRO   ANU
Geoscience Australia
Universities
Horticulture Australia
Australian Wool Innovation

R&D Corporations
• Cotton
• Fisheries
• Forest and Wood Products
• Grains
• Grape and Wine
• Land & Water Australia
• Rural Industries
• Sugar

Cooperative Research Centres
• E-Water
• Plant based Management of Dryland Salinity
• Irrigation Futures
• Weed Management
• Tropical Savannas Management
• Australasian Invasive Animals
• Coastal Zone, Estuary & Waterway Management
• Cotton Catchment Communities
• Desert Knowledge
• Greenhouse Accounting
• Sustainable Forest Landscapes
• Landscape Environments & Mineral Exploration

Meat and Livestock Australia
Australian Pork Limited
National Land and Water Resources Audit
Dairy Australia
Bureau of Rural Sciences

Community Landcare groups
Regional NRM Bodies
Indigenous communities
Water Authorities
Commercial Farmers
Commercial Advisory Services
Australian Govt NRM Facilitators
NGOs

Adoption

Hobby Farmers
Indigenous Land Corporation
Local Governments
Rural residential

State NRM Agencies
Department of Agriculture Fisheries and Forestry
National Water Commission
Department of Environment and Heritage
Productivity Commission

Community Water Grants
National Landcare Program
Envirofund
Natural Heritage Trust

Policy and Programmes
National Water Initiative
National Action Plan for Salinity and Water Quality
Coastcare
Bushcare

Legend

Departments of State (FMA Act)
Statutory Agencies (FMA Act) within portfolios
Statutory Agencies (CAC Act) within portfolios
Corporatised R&D Corporations (Statutory Funding Agreement)
Department Programmes

As discussed earlier, formal scientific knowledge is but one domain of NRM knowledge. Generators, users and exchangers of informal, tacit and local knowledge include 80,000 farm businesses[22], 57 catchment bodies, several thousand landcare and other community groups, and many hundreds of indigenous communities. There are also a range of organisations who manage strategic knowledge in NRM, including all of those listed in Figure 3 above, 20-30 industry bodies, 57 catchment bodies, several dozen water authorities, 722 local governments and hundreds of state government agencies at all levels.

The managers of natural resources, the communities and industries they work in, and the agencies responsible for NRM policy and programme delivery at all levels of government are the key clients of the NRM knowledge system – they are the target audience for its outputs. So there are several hundred organisations across Australia needing to access the best available NRM knowledge to do their job properly. And there are many thousands of people, families, communities, businesses and organisations who contribute to and use NRM knowledge every day in various ways.

Knowledge markets

Another way of examining the NRM knowledge system is to consider its components and performance in conjunction with each other, from the perspective of particular client groups or knowledge 'markets':

- Resource Assessment, Mapping & Monitoring;

- Resource Use & Management Planning;

- Managing Natural Resources;

- Knowledge Generation (R&D);

- Extension and capacity building;

- Policy development & programme administration; and

- Monitoring and Evaluation.

System purpose

This analysis is predicated on the view that there are two key dimensions to the purpose of the Australian NRM Knowledge System – two key reasons why we have such a system and why we invest so much in it.

The first is to help all the players in the system, as listed above, to make better decisions about the management of natural resources as they go about their everyday business. Ideally, critical decisions at all levels should be based on the best available knowledge. In practice of course this is rarely the case, but it is nevertheless an appropriate yardstick by which we can judge how well the NRM knowledge system is performing.

The second is to help Australia as a whole learn its way to more sustainable systems of land use and management through time – so that we can innovate and develop more sustainable technologies and systems, so that we make best use of the talent and experience within the system, so that we learn from past mistakes, and so that we can track our progress and adapt accordingly.

In terms of both the decision-making dimension and the longer term learning and innovation dimension, Table 2 below attempts to break down the key knowledge needs at different scales. This sets up the evaluation frame for judging the performance of the system as a whole.

It is clear from this list that an effective NRM knowledge system means much more than just having good R&D. It requires excellent base data on natural resources and their condition, and the capacity to relate that to current and potential land uses and management practices. Both of these need to be tracked regularly through time, at an appropriate resolution, preferably close to the scale at which management decisions are made. They also need to be calibrated to account for climate variability (seasonal, inter-annual and decadal) which is more extreme in Australia than other continents. It requires an understanding of the effectiveness of different types of policy and programme interventions in different contexts, which means having a comprehensive evaluation
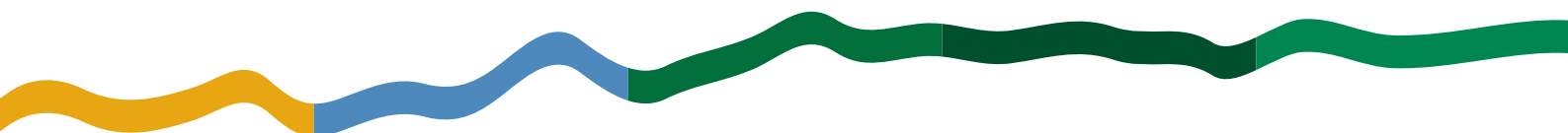
apparatus and a long memory. Finally, it requires an extensive advisory and facilitation capacity to support trialing, implementation and evaluation of new approaches and to ensure that lessons learned are captured and managed appropriately.

Table 2. Knowledge needs for Sustainable Natural Resource Management

| SCALE	KNOWLEDGE NEEDS for Sustainable Natural Resource Management
National	Mapping and monitoring of existing land & water uses and management practices
	Mapping and monitoring of existing natural resources and their condition
	Understanding the nature, causes and extent of sustainability problems and opportunities
	Understanding the likely impact of possible interventions
	Strategic basic and applied R&D on new NRM systems, technologies and practices
	Evaluation of policy and programme effectiveness, efficiency and appropriateness
	Research to inform the allocation of public investment at a national level
Landscape/ Catchment	Mapping and monitoring of existing land & water uses and management practices (fine scale, adjusted for seasonal conditions, understanding barriers to adoption)
	Mapping and monitoring of existing natural resources and their condition
	Understanding the nature, causes and extent of sustainability problems and opportunities – in particular the relative sustainability of different land use options
	Understanding catchment demography, lifestyles and livelihoods
	Identification of appropriate catchment-scale interventions and targets, and priorities for public investment
	Applied R&D and extension to refine and promote more sustainable management systems and practices – tools to reconcile catchment targets with farm practices
Farm/ paddock	Information on existing situation and opportunities
	More detailed information about options for practice change, encompassing adoptability issues
	New farming systems, technologies and practices that are practical and profitable to implement and much more sustainable
	Advisory services (private or public) to support trialling, implementation and evaluation

The next section summarises an analysis (the full detail of which is presented in the background document) of how well the NRM knowledge system is serving the needs tabulated on the page previous.

System function – how well is it performing?

As outlined in the introduction, Australia is performing very well in many aspects of natural resource management. In several areas – for example in community participation through landcare, in water policy, in the smart use of incentives, in multi-jurisdictional initiatives such as the MDBC and now the National Water Initiative – we are seen as among the leading and more innovative nations in developing more sustainable ways of using and managing natural resources.

Similarly, within the NRM knowledge system itself there are many bright sparks of innovation and genuine excellence that we should celebrate and of which we can be justly proud. Dozens of examples could be listed here, and it is always risky to single some out. But without casting any aspersions on worthy initiatives not mentioned here, I think there are positive elements within the NRM knowledge system worth recognising, both at a 'big picture' level and at the level of individual pixels. These include:

- 'Land literacy' programmes[23] such as Waterwatch, Saltwatch, Frogwatch and many others, involve tens of thousands of Australian students and citizens in practical activities that improve their skills in reading, listening and appreciating the signs of health (and ill-health) in a landscape, to understand the condition of and trends in the environment around them.

- Our rural R&D model – a partnership between government and industry that sees producer levies and public funds invested jointly through statutory independent R&D Corporations (RDCs) in programmes that have a strong record of adoption and return on investment.[24]

- The first phase of the National Land and Water Resources Audit[25] did a magnificent job pulling together the best of Australia's available data and presenting continental scale snapshots of Australia's natural re sources and where possible, their condition. The second phase is taking on the heroic task of coordinating a process across all jurisdictions that will enable on-going reporting against jointly agreed indicators on a consistent basis.

- A growing number of farmer groups, supported by a mix of private and public resources, are doing outstanding work in harvesting best available knowledge and applying it to drive innovation in their own sectors and regions – for example the Birchip Cropping Group, Mingenew-Irwin, Southern Farming Systems, Evergreen, Saltland Pastures and Traprock Wool.

- Several Cooperative Research Centres (CRCs) have done a great job pulling together a fragmented science effort and producing more integrated suites of research outputs tailored to specific management and policy priorities.

- **www.aanro.net** is a world class research database that presents key information and contacts for 6,000 current R&D projects, and provides access to the outputs from 150,000 completed projects.

- Industry-based research and extension programmes, often delivered through collaborations among the RDCs, are getting large numbers of producers involved in integrated programmes based on sophisticated research and extension models – including Sustainable Grazing Systems, Cotton BMP, Grain & Graze, DairyCatch and Land Water & Wool.

- Finally, we are fortunate to have some outstanding individual researchers working in NRM in Australia, notably in the areas of landscape ecology and economics.
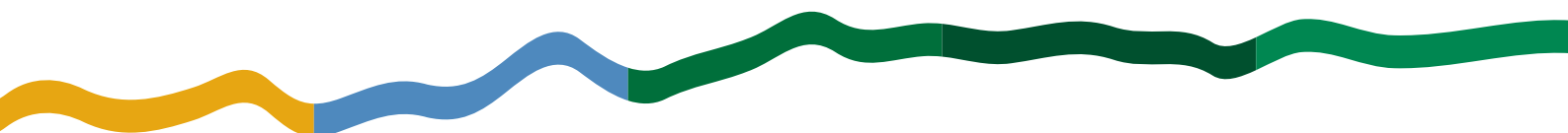
These are just a handful of many possible examples where individual elements of the NRM knowledge system are working well in their own context, and they serve to underline the point that there is lots of good stuff happening.

It is also valid to examine how well the various elements of the system are working together as a whole, and to look at areas where we could be doing better. That is the focus of the next sections in this paper.

The larger background document to this paper worked through each of the knowledge 'markets' listed above to explore in some detail how well the knowledge system is performing in meeting the needs outlined in Table 2. The following summarises that analysis.

How purposeful is the Australian NRM knowledge system?

The system as a whole does not currently appear to be purposeful.

This is understandable to the extent that we did not set out to build an NRM knowledge system. It has developed incrementally over several decades. The system we have now is the aggregate and cumulative result of lots of individual decisions, each with their own rationality in their own context – not the outcome of implementing coherent design principles consistently across different jurisdictions and multiple agencies through time.

This paper is not about a critique of past efforts, except to the extent that such analysis can generate ideas as to how to get the system to work better from today's starting point. It certainly does not assume or contend that there should be a 'super NRM knowledge agency' or centralised command and control of the NRM knowledge system – heaven forbid … one of the strengths of the Australian approach to most areas of public policy is the inherent pluralism conferred by the federal administrative structure, which enables different ideas to be tried out in a wide range of contexts. Conversely, one of its

inherent weaknesses is that we don't always pick up the best approach and implement it consistently, as quickly or thoroughly as we might.

Without advocating centralised command and control, it is nevertheless reasonable in my view to expect that there should be some capacity to first comprehend the whole system, and then to influence it strategically.

The Australian NRM knowledge system fails this test at present.

There are no data to support any serious quantitative or qualitative analyses (e.g. portfolio balance, or strategic vs applied R&D, or return on investment) or any synoptic overview of activities or quality. The ability for governments, industries or any sector to exert strategic influence on the system as a whole is very limited.

How functional is the Australian NRM knowledge system?

How well does the system as a whole meet and respond to the needs of its users? How does it help us to make better decisions and to innovate and learn our way to more sustainable NRM? In my view, the system is generally not performing as well as it could.

The analysis described in more detail in the background paper concludes that the system is doing a reasonable job defining the nature, cause and extent of environmental problems.

However it is performing poorly on predicting the impact of particular interventions – whether restoration efforts or alternative resource development options. It is also not doing as well as it should be on generating practical, profitable, adoptable solutions that can be implemented by resource managers on the necessary scale without extensive subsidies or intensive extension efforts. This is a crucial weakness on the innovation dimension of system function. Many of the options presented to farmers in particular are not sufficiently practical and profitable, and

hence are not adoptable on a widespread scale. Another key flaw is the generation of the basic data that underpins the rest of the system. Resource inventory, assessment and monitoring is probably the least sexy sector of the NRM knowledge system, but it supports everything else. It is often the last thing to get properly funded and the first to get cut when budgets are tight.

Governments, Ministers and Ministerial Councils and government agencies at all levels need good data and information to: assess status and trends in resource condition in order to set priorities and track progress; evaluate catchment plans and investment strategies; monitor compliance with legislation; and report against national priorities and targets. Regional and catchment bodies need good data and information to assist in the development of their catchment and investment plans; assist their communities to get a good understanding of problems and opportunities; and assess status and trends in resource condition in order to set priorities and track progress. Landholders and industries need good data and information to help work out their own investments and to track progress. Researchers need good data and information to: better understand ecosystem and landscape function; underpin the development, refinement, calibration and ground-truthing of their models; better understand and predict cause and effect relationships; and to measure status and trends in resource condition.

"On entering our duties we found ... that information available regarding our rivers was meagre and fragmentary..."[26]

This observation was made by the Royal Commission into Water Conservation in New South Wales in 1887. The following statement is a finding of the Australian Parliament's Inquiry into Catchment Management in 2001:

"...while there is an expanding body of information in this area, it is often inaccessible, patchy, uncoordinated and uncollated."[27]

According to the National Land and Water Resources Audit:[28]

"The messages about the availability and quality of natural resources information today are fundamentally the same as in 1887. In many cases there is already ample information to inform debate, but:
- data and information are often fragmented and difficult to find;
- some fundamental natural resource data are not being managed systematically; and
- coordinated programmes are needed to maintain and fill gaps in time series data."

Work done by the current phase of the National Land & Water Resources Audit suggests that we are going backwards in work on basic mapping and monitoring of resource extent and condition. Further, we are rarely monitoring management practices at scales appropriate for policy and management decisions, to identify and pinpoint the crucial intersections (spatially and temporally) between management practices and resource degradation.[29]

Consequently, the system is currently poor at servicing monitoring and evaluation needs.[30]

We are probably doing enough monitoring and evaluation work, and doing it well enough, to give investors (taxpayers, levy payers and resource managers) confidence at a macro level that the overall investment is a good one for Australia.

In the main, NRM investments are 'no regrets' measures that achieve positive results and are valued by their beneficiaries. At a national level, the various programme-level reviews are generally sufficient to give useful feedback and inputs to policy directions at a coarse-grained level. However our monitoring and evaluation effort is rarely sufficiently fine-grained to provide detailed feedback into management and/or policy to inform the design and tailoring of new programmes, or the adaptation of existing ones, to achieve the maximum possible impact and consequent return on investment for the resources invested.

Gaps in longitudinal data on resource condition are widening, so our ability even at the broadest national level to assess whether we are making a difference is on the whole getting weaker, despite the
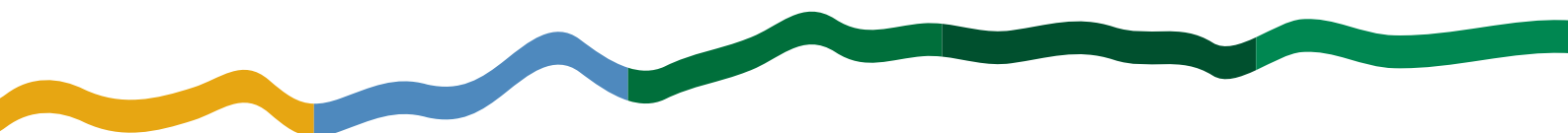
unprecedented overall levels of public investment.

Further, the system currently is not working well in sharing information on what is happening where and what lessons are being learned across the whole system – or what has happened in the past. Thousands of individual projects are being funded, but (with the notable exception of AANRO for R&D projects) there is no systemic attempt to make these projects and their findings widely accessible throughout the system. The tendency towards short-term contracts and project-based employment for many of the professionals within the system exacerbates this problem, because it is often the case that project officers, facilitators and coordinators commence their contracts after the departure of their predecessor. Proper transition, handover and induction processes are difficult to ensure within a system based on short-term contracts and project-based funding. The regional delivery model can potentially improve this situation, but we are a long way from that as yet.

At present, we have a system that seems better designed for forgetting, overlooking and ignoring than for remembering, learning and understanding. **Amnesia is systemic, built in, guaranteed...**

How cohesive is the Australian NRM knowledge system?

"...almost every time I talk with someone from an R&D Corp or CSIRO or a government agency, they tell me they take a 'helicopter' view. But from where I sit, all I can see is bloody helicopters buzzing round, getting in each others way and confusing us folk on the ground. I want to know who is doing air traffic control, and who is looking at the satellite picture?"[31]

A tenet of this paper is that cohesion is one of the key ingredients required to get the NRM knowledge system performing better as a whole. It is a means to an end, rather than an end in itself, but it is so important as to warrant specific attention.
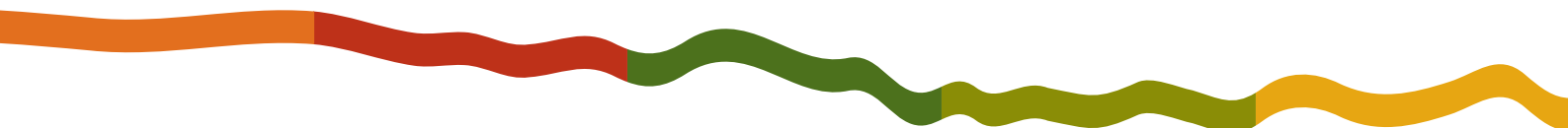The key question here is how well the various parts of the system work together. For the purposes of this discussion, we can consider several degrees of cohesion:

Communication. This is the most painless – it is basically about getting sufficient transparency in the system and sufficient consistency in reporting so that there is some capacity to develop a picture at a higher level of what is going on, and an explicit means of the left hand knowing what the right hand is doing.

Coordination. This next step takes the information generated by good communication and reporting, and uses it to identify obvious gaps where issues may fall through the cracks and also to identify and hopefully minimise unnecessary duplication.[32] It implies some degree of influence on the part of the institution(s) charged with the coordination role. We often default to interdepartmental committees or intergovernmental working groups in trying to deliver this function, with patchy results dependent on the commitment of the participants, the leadership, energy and resources of the secretariat and the incentives for collaboration. If you don't explicitly 'fund the arrows'[33] then linkage and coordination mechanisms tend to remain weak and ephemeral.

Synthesis. This goes beyond coordination as described above to generate new products or outcomes by combining elements across disparate parts of the system. It implies strategic design against identified needs, and it also implies that the institution doing the synthesising has some resources of its own. Delivering synthesis products just by combining some parts is extremely difficult without the lubrication and polishing that can be achieved with additional resources and deep expertise to bring to the exercise.[34]

There is a fourth level in this 'cohesion hierarchy', which goes beyond coordination and synthesis, and is the true indicator that the system is starting to function well, and that is **Synergy**. When disparate elements of the system interact to generate outcomes that would be impossible to achieve without that interaction, when the whole is more than the aggregate of its component activities, then the system as a whole is becoming more **integrated**.[35]
There are reasonable communication and coordination mechanisms <u>within</u> some sectors, such as R&D, where the National

Research Priorities process sets up a high level reporting framework, R&D Corporations play a leadership and coordination role within specific commodities, and Cooperative Research Centres (CRCs) can play a leadership and coordination role for some specific NRM issues. But even within R&D, there is much scope for better overall communication and coordination mechanisms across the NRM sector as a whole.

However the situation with respect to the linkages between sectors is much worse. Links between, for example, R&D; resource assessment & monitoring; catchment planning; catchment management; farm management; water supply management; policy at all levels; and monitoring and evaluation; are generally poor. Knowledge within each sector should inform the others, but that's rare. Further, the linkages are also poor between knowledge domains: local, indigenous, scientific and strategic knowledge for example.

Again, the regional delivery model offers a framework within which we should be able to engineer some multicultural approaches across the different knowledge cultures. But we have a long way to go in that regard, and such developments will need to be catalysed, fostered and nurtured.

At this stage there are no effective system-level communication or coordination mechanisms in the Australian NRM knowledge system.

Improving the Australian NRM Knowledge System

This section attempts to draw together the various threads of analysis to imagine what a more purposeful and functional NRM knowledge system might look like. The emphasis here is on trying to think through what needs to be done, not who should do it or how it should be done.

Design criteria for renovating the knowledge system

From the foregoing analysis, we can summarise some design criteria as follows.

- In terms of **purpose**, there should be some capacity first to comprehend the system as a whole, and then to influence it – to change course in response to changing needs and to shift resources to strategic priorities.

- In terms of **function**, the system should support and reinforce innovation and learning – making transparent and accessible the activities, actors, history and lessons – throughout the system. It should meet the knowledge needs – especially for decision-making – of its intended beneficiaries, summarised in Table 2 above, and it should be establishing a solid platform of basic data and information to support feedback through monitoring and evaluation so that progress can be tracked and strategy and management adapted accordingly.

- In terms of cohesion, the system should automatically achieve the 'communication' level; it should routinely achieve the 'coordination' level; it should regularly achieve the 'synthesis' level in meeting the knowledge needs of its intended beneficiaries; and it should be capable of rising to the level of more integrated approaches to deliver 'synergy', especially in generating and bringing to bear critical mass on the big priority issues.

Making the system more purposeful

The most important step in getting more clarity around the overall purpose of the system is to establish a high level capacity to set priorities and review progress.

This would be a precursor to the development of an overall NRM knowledge strategy. According to Peter Cullen,[36] a knowledge strategy should articulate: the overall mission and focus; the
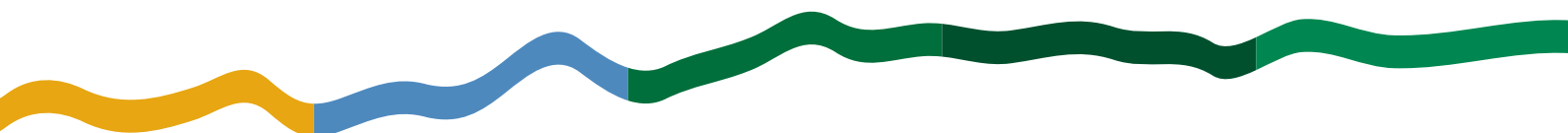
critical questions; the knowledge needs (data, synthesis or research); an audit of existing knowledge assets and their quality; and priority investments, including in new knowledge assets. Cullen observes that the type of knowledge required differs according to its use, whether day to day operations, longer term planning, developing new technologies & approaches, or identifying emerging issues.

Against this framework, several bits of such a strategy are already articulated in different places. The National Research Priorities set out high level research priorities. Various national strategies and resolutions of Ministerial Councils set out agreed goals and priorities for NRM as a whole, from the National Strategy for Ecologically Sustainable Development to the NAP, NHT and NWI agreements. There could be some rationalisation to make it a bit neater and sharpen the focus, but overall we are 'strategy rich' in terms of high level NRM mission. However the other elements of Cullen's strategic framework are missing: knowing what assets we already have; understanding the right balance required between data, synthesis and research; and using those to develop more detailed investment priorities.

A prerequisite for improving the sense of purpose and direction in the whole NRM knowledge system is to be able to comprehend what is going on, where and why, funded by whom, and preferably with what results. The first and most obvious finding awaiting anyone who sets out to develop such a strategy or to set even high level priorities will be the difficulty in comprehending the whole system – the lack of hard data in any reasonably accessible or coordinated form. Any attempt to make the system more purposeful must grapple with this issue.

I can see no alternative to the development of a standardised reporting framework, with consistency in at least core elements that can be reported nationally. Land & Water Australia is currently convening such an exercise across R&D Corporations on NRM research activities. It is a lot of work in the first year to get agreement on a common reporting framework and then within each agency to make any system changes

necessary to be able to extract and provide data in the right format. But in subsequent years it should get easier, and as the database builds, its analytical usefulness will increase.

In conjunction with the design of a reporting framework, it would be essential to identify the types of portfolio level analyses required, because this has an impact on the type of data needed and its format.

Consistent with the points about 'funding the arrows', it is critical in dealing with issues like an improved common reporting framework that there are built-in incentives and support for compliance. The business case needs to make sense at all levels in the system, or adherence to the new system will be patchy, which undermines the central purpose of the exercise. We have many examples of governments committing at high levels to lofty strategies and sound principles, only for the implementation detail to fall far short of agreed standards.[37]

Making the system more cohesive

Efforts to make the system more purposeful and more cohesive are likely to be highly complementary – they are two sides of the same coin, and both are critical to improving the overall performance of the system.

The first step in improving cohesion is to achieve the 'communication' level in the cohesion hierarchy outlined above. This starts with ensuring that knowledge rich activities and knowledge assets (including details of key contact people) are transparent and accessible across the whole system.

We also need to do a better job capturing and sharing where possible the findings and lessons generated from the great diversity of projects being funded by NAP, NHT, NLP and the NWI. This will require innovative combinations of hard systems – databases, websites, intranets and so on – and soft systems based around community leaders, facilitators, knowledge brokers, consultants and other extension professionals, education and training. Land & Water Australia is currently investigating the potential of distributed

networks, exploiting new web-based technologies that may prove more amenable to the Australian NRM scene than a more centralised 'hub and spoke' model. Whichever model is adopted, it needs to provide easily navigable pathways for people to find out who to talk to about what, and whether information appropriate to their needs exists, and if so how to get it – and then to help them get it and interpret it for their own situation.

Australian governments and industries are already funding many people (somewhere between two and four thousand[38]) with roles in delivering projects funded through NAP, NHT, NLP, NWI and the R&D Corporations and CRCs. Most of these people have roles defined in terms of specific projects or tasks, but not in relation to the broader knowledge system as a whole. It should be possible with a modest investment in training, for at least a portion of these people, to start to define and resource complementary activities directed to improving the performance of the wider knowledge system.

In particular, we need more consistent ways of capturing and managing knowledge assets that emerge through these major national programmes. Where does anyone go to access insights on what is working well where, and why – or perhaps more important – what is not working, and why not? There is lots of great stuff happening, but it's very hard to get a handle on and to track. We're not sharing lessons from the really good work. Equally, we're not selling the good news as proudly as we might if these stories were more accessible. Knowledge assets might be as simple as a good set of 'before and after' photos or the results of a detailed mapping project, or lessons from a failed project.

We also need to do better at identifying knowledge needs that can be fed back into the system as appropriate – for example gaps in data, mapping or monitoring, or research needs. Further, we need to give some professionals within the system a specific mandate to work across the different knowledge domains, to act as brokers and translators between for example local knowledge and science, to try to build better linkages between some existing silos of knowledge.
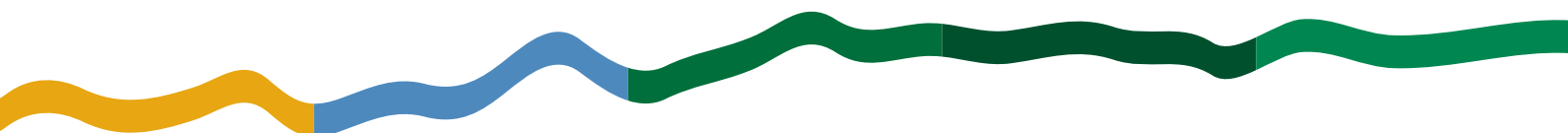
I don't believe that we need necessarily to be spending more money or employing more people. But we do need a clearer national framework for this total investment, and one that pays greater attention to some of the underlying knowledge system issues. As things stand currently, extension activity is being funded, but investment in extension infrastructure is limited and has probably declined. There is a predominance of project work done by people on short-term contracts – and the nature of the contract is usually linked to implementation of the project, not plugging into a more durable on-going programme grounded in and building institutional memory. It is very difficult for individuals to map out a career path in such a context, so we are losing lots of good people, often just as they have developed expertise, networks and insight.[39] It is very difficult to get recognition (or funding) for non-project work such as monitoring and evaluation, or professional development.[40]

I believe in NRM generally we are still trading on the intellectual capital of senior staff, consultants and researchers trained more than fifteen years ago, under very different funding regimes.

A national policy framework for extension?

Jeff Coutts, Jock Douglas and Andrew Campbell proposed the development of a national extension policy framework for Australia in 2001[41]. The key drivers include:

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

- the need to re-energise NRM professionals so that we are working from an ever-greater skills base, retaining and developing good people rather than churning through them and burning them out;

- the need to build a new knowledge infrastructure so that issues such as training, resourcing, centres of excellence and

the application of new technologies (for example in knowledge management and the internet) can be tackled systematically; and

- the need to sort out roles and responsibilities between different levels of government, and between government, the community, industry and individual landholders – especially to clarify who should pay for what.

The elements of a national extension policy framework, preferably set out at a high level under CoAG, start with the last point above – agreement on respective roles, responsibilities and funding, firstly across the public/private divide, then across government, industry and NGOs, then across tiers of government. The framework could then be fleshed out with agreed approaches and resourcing to deliver the other dot points above. Such an agreement could be specified separately or incorporated in schedules to, for example, the National Action Plan for Salinity and Water Quality (NAP), the Natural Heritage Trust (NHT), the National Water Initiative (NWI) and even the Murray-Darling Basin agreements[42].

Such a step would, over time, make a huge difference in the overall functioning of the NRM knowledge system in Australia.

Improving knowledge system function – making better decisions

Almost by definition in this paper, measures that would make the knowledge system more cohesive will also make it perform better. This and the following section outline other measures aimed at improving system performance on those two dimensions of its function – helping us to make better decisions, and helping us to innovate and learn as we go along.

A national policy framework for extension would be a key component of an overall NRM knowledge strategy. Such a strategy would articulate how knowledge fits into the policy instrument mix – the role of the knowledge base in serving NRM planning, extension, regulation, incentives, markets

and policy. It would identify the decisions that need to be informed in terms of the various types of decision maker operating at different scales and their preferred learning styles. This would then assist in the targeting of resources to those measures most likely to make a difference.

Another opportunity for improvement lies in the way we undertake R&D activities and in particular the way we manage and promote the outputs of research, especially to farmers.

At the farm level, the key criterion for evaluating the performance of the NRM knowledge system is how well it serves the overall objective of supporting the adoption of more sustainable management practices. While the environmental, social and economic context in which farming is played out may be subject to constant change, the fundamentals that influence farmer adoption appear to have changed little over recent decades[43]. Dave Pannell and colleagues point out that 'traditional' extension viewed the extension process as primarily a matter of communication, and consequently often focused on improving information delivery, presumably assuming that farmers lack information and are relatively passive recipients of knowledge.[44] However, like the rest of us, farmers are besieged with information (including from banks, accountants, consultants, agribusiness, the media, other farmers and community groups) and probably receive a similar quantum of unsolicited mail (electronic and paper).

Increased investment in improving information and knowledge management should not be undertaken lightly. If it is to be of any use, the investment needs to be carefully planned and delivered. Information 'dumping' will be of little use, and may well be counter-productive.

The NRM knowledge system must do far more to meet the needs of farmers than just furnish information. First and foremost, it needs to generate more sustainable farming systems, management practices and technologies that offer relative advantage against existing approaches, and preferably are trialable. Second, it needs to encourage and support participatory approaches to

farm-relevant research wherever practicable. This helps to ensure that the research is relevant to or at least cognisant of farmer goals, it increases farmer ownership of research results, and it has a better chance of incorporating local knowledge, skills and experience into the research process. Third, some innovation in ways of helping farmers to learn from trials in contexts where on-farm trials are not feasible or cost-effective would be worth exploring.

Finally, the 'formal' NRM knowledge system needs to do better in tapping into farmers' local knowledge and their own innovation networks. Science does not have a monopoly on innovation – far from it. Leading farmers are often trying out things that are well beyond where researchers have got to in their thinking or are tackling problems from different angles than scientists. Such innovations are often known to a few peers and maybe a farm management consultant. In the 'old' days, agricultural extension officers would keep close tabs on leading farmers and often assist in extending their ideas back into the research community as much as the other way around.[45] Farmers at the sharp end are mainly using private consultants.[46] In the public system, staffed more often by relatively inexperienced people on short-term contracts (especially within NRM), there is not often the time or the credibility necessary to form such relationships. So some of the most innovative work in NRM is essentially in the private domain – not because anyone is trying to keep it secret, but as a consequence of poor linkages with the more formal publicly-funded NRM knowledge system.[47]

Knowledge for the regional model

Land & Water Australia has identified that meeting the knowledge needs of catchment and regional bodies under the NAP and NHT is one of the biggest challenges in NRM today. Accordingly, it is one of three core strategies in the corporation's new Strategic R&D Plan 2005-10. With generous support from DAFF, the corporation is leading a National Knowledge Brokering for Regional NRM project that is working with CMAs[48] to tease out their knowledge needs, and hopefully identifying some ways to get the system to work better.

The knowledge needs of the regional bodies under the NAP and NHT vary widely according to their diverse physical contexts, their varying stages of maturity, and the stages of development and implementation of their regional strategies. Nevertheless, they have much in common in terms of their knowledge needs. Scoping work undertaken by the LWA project has revealed major concerns for CMAs in relation to information and knowledge in the regional NRM context. These are summarised in Table 3 on page 28.[49]

Further, there is lots of scope for regional bodies to learn from each other, both on how to undertake their core business of developing and implementing catchment strategies, and on how to make best use of the NRM knowledge system to support their core business.[50] If we don't assist CMAs with knowledge management infrastructure such as databases and other software we run the risk of allowing the development of dozens of different rail gauges, exacerbating the difficulties of developing any national assessment of progress and sharing lessons across the whole system.
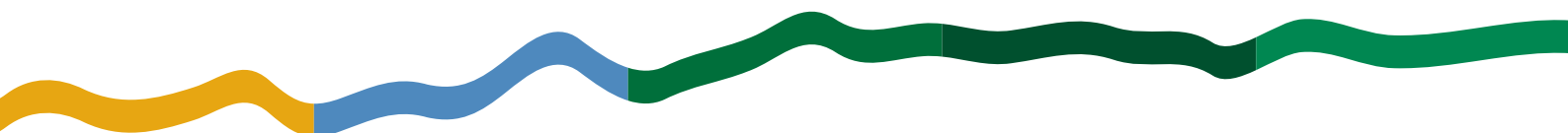
Table 3.   Knowledge concerns among regional NRM bodies and potential improvements

BROAD AREA OF CONCERN		POTENTIAL STRATEGIES
Fragmentation *'Where is it and how do we get to it?*	Impacts on capacity of regional body to find and incorporate research. Mixed messages coming from inconsistent sources creates confusion and lack of trust	Consolidated point of access – e.g. first-stop-shop including option for voice (person-to-person) interaction – web-based is not sufficient 'Database' of proposed, ongoing and completed research and other projects (e.g. like AANRO) Regional contact person(s) within national organisations – relationship building Knowledge brokers (regional and national) – with support for people acting in this role (e.g. through knowledge broker network)
Volume	The amount of information available can be overwhelming and information gathered gets 'lost' in drawers. Regional bodies have limited resources to sift through 'the deluge' and to assess what is important.	Classification system for research/information from national organisations Support (time/resources – such as training) in information literacy skills such as searching and assessing web-based sources Electronic prompts with updates on research/information resources relevant to the region Provide support for regional knowledge management systems
Relevance • Scale • Format • Research issue	'Generic' information is difficult to apply to specific regional contexts. Different preferences for information formats. Interpretation increases relevance. Regions want to be able to identify regional information needs.	Regional case studies to be built into national research Multiple formats necessary. Synthesised information reduces volume and increases relevance. Language to be simplified. Support is needed for regions to identify and address regional research questions
Two-way flow	How to get the regions' needs on the scientific agenda? How to communicate regional success stories? Lack of formal processes for flow of information from regions to national organisations.	Consolidated point of access (as in first point above) to be used for two-way flow (i.e. regions contribute) Regional contact person(s) in national organisations help relationship building and to report regional projects to central point National organisations to become familiar with regional plans
Information sharing across regions and with national organisations	Regions aren't talking to each other. Resulting duplication wastes limited resources. Lack of willingness to share data between national organisations and with regional organisations. Cost of some data is prohibitive for regional bodies.	Face-to-face interaction is preferred. Increase formal networking opportunities e.g. through a network of regional body CEOs and/or knowledge specialists; theme-based knowledge groups with members from all levels; web-based forums; establish a peak body for CMAs Establish formal links between State and Federal NRM agencies to commit to information partnerships and sharing Improved interoperability between datasets

[LWA (2005b) Knowledge for Regional NRM, Scoping Report.]

The Knowledge for Regional NRM project is working with CMAs to identify and trial measures that could tackle several of these issues and achieve a much better connect between 'the regional model' and the rest of the Australian NRM knowledge system. The table above summarises both the key areas of concern raised by CMA participants in relation to knowledge in the regional NRM context, and some early thinking about how these concerns could be tackled. There is a long way to go in this project, and it must be stressed that these are just preliminary ideas that have emerged from initial discussions with CMAs and our own analysis.

It is more difficult to implement and sustain such measures within a system dominated by staffing arrangements with short-term contracts, a fairly flat remuneration structure and consequently high turnover of people. Nevertheless it is not impossible, and these factors can be assumed and designed into the response, rather than wished away. The days of the permanent civil servant crafting a forty year career through patient incremental progression within one agency are long gone.

Assuming continued high rates of churn among staff in regional bodies, and in the government, industry and non-government bodies working with them, it is still possible to improve the system's capacity for learning, for adaptation and innovation. Some ways of doing so are canvassed below.

## Improving knowledge system function – fostering innovation and learning

We have a system where people don't necessarily stay for long in any one job or location, where agencies themselves are frequently restructuring and reforming, where in many regions the rate of turnover in land ownership is increasing and where most NRM funding is directed through projects with a finite life (usually several years). That system is tackling land degradation and resource management issues governed by climatic, hydrological and ecological processes that operate over decades, centuries and millennia.

We need a knowledge management infrastructure that helps us to bridge this temporal disjuncture. Possible elements of such an infrastructure are introduced here in terms of tools and aids that assist memory, learning and innovation respectively, although several of these measures would deliver more than one of these functions.

Improving memory aids

As outlined earlier, the NRM knowledge system is currently better at forgetting than it is at delivering memory aids. A key to building more memory into the system is to make information easier to find, to access, and to use. This means doing the unglamorous work of ensuring that basic information is gathered and stored and maintained in consistent ways – or at least in ways that enable information in any part of the system to be transparent and accessible across the whole system. Crucially, it also means maintaining such a capability through time, ensuring that metadata standards and protocols are followed, and that information recorded in 'old' formats (including maps, photos, anecdotes, oral histories and so on) does not become redundant and/or invisible through new technologies.

A key dimension of systemic memory – probably the most important – is the people dimension. We need to work harder at honouring, retaining and tapping into the elders within the system – the people with long experience and deep knowledge in management, science and policy. Land & Water Australia's Community Fellowships are one example of how to capture the individual stories and life-long lessons learned by people through personal experience in NRM. Building bridges between the knowledge domains of local knowledge, scientific knowledge and organisational knowledge is crucial here, as farmers in particular tend to move less often than the salaried players in the system. Local knowledge can often perform a long term memory function for some (but not all) aspects of the system, provided there are explicit means of recognising that and building it in to the
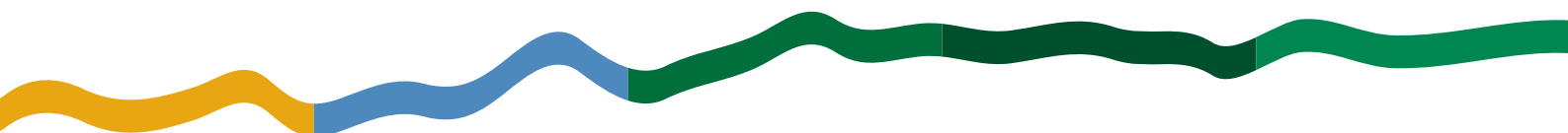
system. Notwithstanding the assumptions above about inevitable levels of staff turnover, we also could do better in enabling good people to stay in professional NRM roles for longer, by paying more attention to career paths, recognition and reward schemes, and provision of professional development opportunities.

Improving learning aids

The system would do a much better job in helping us to learn along the way, if it could do justice to the Monitoring & Evaluation frameworks that have already been designed. We have world leading data frameworks and standards. We need to ensure that they are populated with good data – especially on the condition of the resource base and on management practices – and that we use such data to feed back into policy and management. At present agencies at all levels are trying to derive reports against indicators and targets from generally old and patchy data that was often gathered for other purposes. Western Australia has had a comprehensive look at its data needs and the overall investment required is of the order of $20 million to be able to report and track progress in an authoritative way against agreed indicators and targets. This is a significant investment, but a crucial one given the billions (in public money alone) in the overall investment. This is an issue that needs to be resolved at a national level (States and the Commonwealth working together) rather than the regional level. Regions don't have the skills or the resources to do this work, and it is difficult enough getting a coherent picture across eight jurisdictions, let alone more than fifty.[51]

A comprehensive monitoring and evaluation framework is an essential underpinning platform for learning across the system and through time. The first phase of the National Land & Water Resources Audit produced a great set of snapshots of resource condition across the country with the best available data at the time, albeit identifying major holes and flaws in existing data sets. The second phase has worked to develop an agreed framework of indicators, standards and protocols across all jurisdictions that would enable consistent and

authoritative tracking and reporting of progress, were it populated with quality data. We need to be planning now for a third, on-going phase, focused on maintaining and improving the agreed data framework, and more importantly, funding the necessary data gathering to keep it up to date with high quality data. Ideally this activity should be undertaken within a durable institutional framework at arms' length from the everyday exigencies of policy and politics – performing a role that Morgan Williams[52] refers to as 'the keeper of the long view'. Without such a framework, regular reports such as the State of the Environment reports will be increasingly hollow, and evaluating the impact of major public and private investments will be increasingly difficult.

Just gathering the data consistently and managing it professionally is not sufficient. We then need to extract the full value from that investment by pinpointing and exploring in more depth some of the emerging insights and lessons, and making these more obvious and easily accessible. This can't be achieved just through smart satellites, databases and websites – it needs skilled people. We can build such skills at a number of levels, according to need. For example, regional bodies need to understand how to use the system in order to track the impact of and to prioritise their investments. The people advising farmers and other resource managers (facilitators, consultants and advisers) need to know where and how to tap into the best available people and information.

To develop a higher level learning capacity within the system, we need to invest more in centres of excellence in NRM knowledge.[53] Such centres (not necessarily a group of people sitting in a building somewhere – they could be 'virtual centres' or communities of practice[54]) would establish sufficient critical mass in learning, reflection and research to provide opportunities for in-service training, for sabbaticals, for research and for undertaking analytical work to feed into monitoring and evaluation activities. They would need to strike the right balance between being closely hooked into policy and programme development and implementation,

and being sufficiently independent to be open to new ideas and perspectives, including from sectors other than NRM – and crucially, to be able to criticise the status quo constructively without fear of losing resources.

Another tool to improve the long term learning capabilities within the system is the establishment of long term ecological research and monitoring sites. Such sites exist in the United States, the United Kingdom and several other countries, and are designed to enable tracking of particular ecosystem parameters over many decades and beyond. Given the variability inherent in Australian systems and the long term nature of many of the issues we are tackling, a national network of long term monitoring sites would ideally be one element of the overall NRM knowledge system. With new sensing and telemetry technologies, such a network would be cheaper and easier to establish now than ever before. Its design would ideally be driven by management and policy needs, rather than science push.

Improving innovation capacity

Many of the measures already discussed that could improve the NRM knowledge system's capacity to support memory and learning would also help innovation, as of course would measures to reinvigorate extension. We usually associate innovation with R&D, which is valid, but research is only one component of the mix that drives and supports innovation.

Much innovation at a management level happens on the ground through the sheer ingenuity, resourcefulness and opportunism of farmers and other resource managers. As discussed earlier, such work does not always make it into the formal or public knowledge domains. In agricultural production, linkages between the leading farmers and scientists in agribusiness or elsewhere are still in pretty good shape through the influence of market forces, the R&D Corporations, and the fact that agricultural production extension was coming off a much larger base than NRM extension. But in the NRM domain, with the possible exception of soil conservation, we have never had comprehensive

extension systems. Consequently, we've yet to develop reliable and extensive ways of identifying best practice and sharing it, or getting farmer innovation recognised and incorporated. Initiatives such as the Master Treegrowers Programme[55] (which has a focus on agroforestry and farm forestry) provide glimpses of ways in which we could foster innovation more broadly in NRM, across the public and private knowledge systems.

At the research and development end of the innovation system, it would be good to get a much better handle on portfolio balance, between investment and effort in basic and applied research, and between research, development and extension. With the exception of some fashionable areas such as molecular genetics in plant breeding, the national portfolio of NRM science in my view is not giving sufficient weight to strategic basic research[56] – either in funding terms or in forging the links with the labs in other sectors (for example nanotechnology, robotics, photonics and medical research) that are doing work that has potential application in NRM. In many areas of NRM we need technological breakthroughs – incremental adjustments to the status quo are not sufficient – and we may be more likely to source such breakthroughs outside the NRM sector. But data to test such an hypothesis are not readily available across the national science effort – which is itself a problem for any attempt to analyse or manage the performance of the system as a whole.

The other aspect of research that has an impact on innovation is the adoptability of R&D outputs, touched on earlier. Researchers, and especially managers and brokers of applied research, need to have a good grasp of the factors determining adoptability.[57] One way, but not the only one, of keeping researchers grounded in the realities of adoptability is to keep the intended end users of research outputs engaged in the research process throughout. There are many good examples across the rural R&D corporations of such programmes.[58]
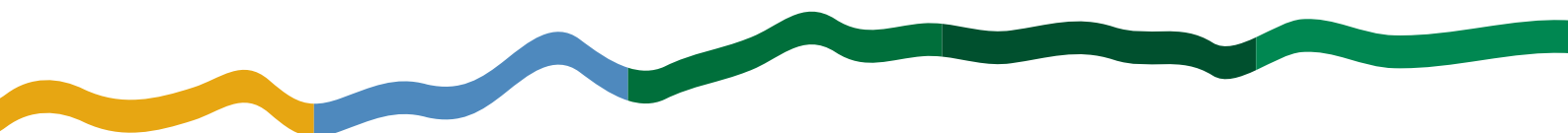
Next Steps

This section does not pretend to outline a detailed blueprint or dare to suggest who should do what to implement some of the ideas in this paper. Rather, it identifies some possible enabling measures that could help to bring about a better sense of the overall NRM knowledge system and how to improve its performance.

A fundamental problem that underlies much of the dysfunction in the NRM knowledge system is that we are trying to deal with very large, long term problems through what are essentially short-term programmes. The National Action Plan and the National Water Initiative, at seven years, are long programmes by contemporary standards. This is a credit to their planners and the governments that agreed them. But even seven years is a short timeframe given the sorts of issues we are tackling. The Decade of Landcare, in which all governments signed on to some broad principles in a bipartisan way for a decade of joint investment, provides a good example from which to learn. It is possible to imagine a longer bipartisan commitment (for example through CoAG) to an NRM framework that all governments of all political stripes could sign on to. We have surely reached the stage by now where NRM is seen as core business for governments at the same level as health, education, transport or defence.

Such a policy framework would set out some core guiding principles like those in Appendix B and some core elements of enabling infrastructure that would be required to support their implementation – such as a knowledge strategy and many of the measures canvassed in this paper. Such generic infrastructure is essential to support long term NRM programmes, that make maximum use of what we already know, and consequently are able to deliver top value for public and private investment.

In the shorter term, a range of processes already underway are considering, either as a central or peripheral issue, the issue of knowledge in NRM:

- The Standing Committee to the Primary Industries Ministerial Council (PISC) is developing a new national framework for research, development and extension;

- The Policy and Programmes Committee to the Natural Resource Management Ministerial Council (PPC) is also considering knowledge frameworks, especially with respect to the regional NRM delivery model;

- A Ministerial Reference Group is reviewing the regional NRM delivery model;

- The 'Corish Committee' is undertaking a stocktake of the Agriculture and Food Sector in Australia, with a view to developing a long term vision and direction for the sector, including research and innovation;

- There are Parliamentary Inquiries into Rural Skills, Training and Research; into Pathways to Technological Innovation; into the Extent and Economic Impact of Salinity; and into Sustaining our Resources – Resilient Outcomes, all of which have relevant terms of reference; and

- Australian Government agencies are developing options for Ministers to consider for the future of the Natural Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAP).

The moment is ripe for a more coherent knowledge strategy for natural resource management.
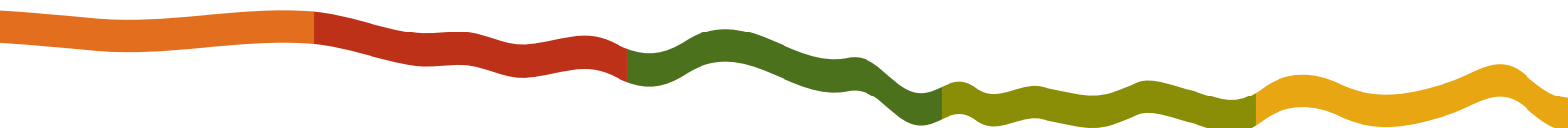
Conclusion

Australia is doing many things right in Natural Resource Management, but we could (and should) be doing better.

Better use of existing knowledge and a more systematic approach to learning and innovation across the whole knowledge system is a key opportunity. We are not learning from rich experience as well as we might, which means that decisions are not always as well founded as they should be. Further, innovations or insights from one part of the system are not necessarily evident or accessible elsewhere in the system, constraining the overall rate of innovation and learning.

The first step in delivering systemic improvements in the way we handle knowledge is to start thinking about the system as a whole, whether or not we set out to create it as such. It is a further shift in thinking to start to manage it as a whole system, but a shift we need to make.

The current NRM knowledge situation is the cumulative and aggregate result of the incremental, ad hoc evolution of Australia's overall approach to natural resource management over the last several decades. Those decades have seen huge increases in community engagement and the role of the Commonwealth, significant increases (with still some way to go) in industry involvement, and a marked decline in the role of state agencies in funding and delivering extension services and data collection in particular. There has been a tendency for NRM programmes to be seen and badged as 'special initiatives', usually issue-based, with defined timelines of less than ten years. The transition between programmes has rarely been smooth and never seamless.

This lumpy, jerky progress focused narrowly on specific issues with short-term horizons belies the nature of the NRM challenge and the sustainability journey more generally, where we are dealing with ecological and climatic processes over multiple issues and large scales in space and time.

In essence we are on a long journey, but we don't act like it.

We need to start thinking and acting in decades. This is particularly the case with the knowledge dimension of the sustainability equation. We need to be thinking about the NRM knowledge system as a crucial element of national infrastructure that will underpin future wealth, security and prosperity in the same way as health, defence, transport and education. It would be great to see a new bipartisan, federal commitment involving all jurisdictions and political parties – for say 25 years – to establish the right planning frame and security of funding for some of the basic elements underpinning our overall approach to NRM. This could build on the principles already agreed by all governments, and draw on the best elements and learnings from the Decade of Landcare, the Natural Heritage Trust, the National Action Plan and the National Water Initiative. It would need to engage industry, local governments and non-government organisations more formally than has been the case in the past.

That's the big picture within which a properly functioning NRM knowledge system would operate. This analysis has attempted to identify areas in which we could improve the performance of that system in order to derive greater value from current, past and future public and private NRM investments by fostering innovation and ensuring that decisions are based on best available knowledge. Such work is not so much about additional funding as it is about smarter use of existing resources.

Natural Resource Management is rightly a very high priority for all Australian governments, industries and citizens. A sound knowledge base is a fundamental plank for improving natural resource management. Improving the knowledge base, and improving the system for managing knowledge to assist decision-making, learning and innovation, is a great investment for Australia.
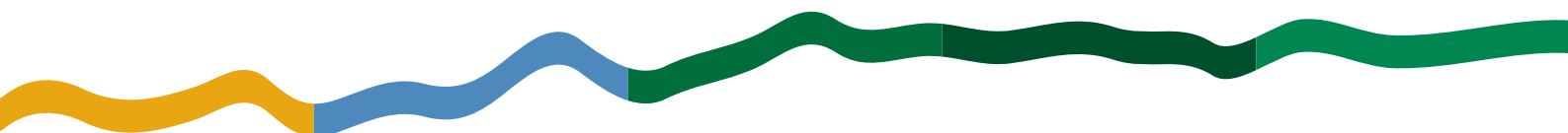
Appendices

APPENDIX A. References

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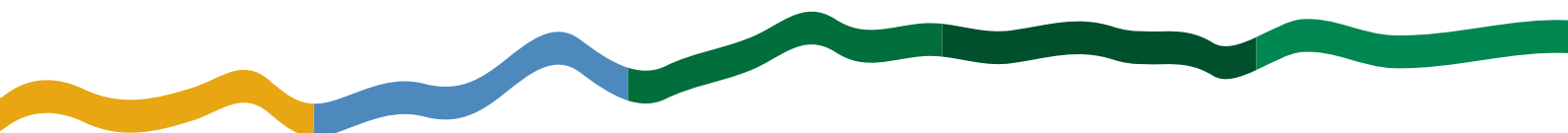
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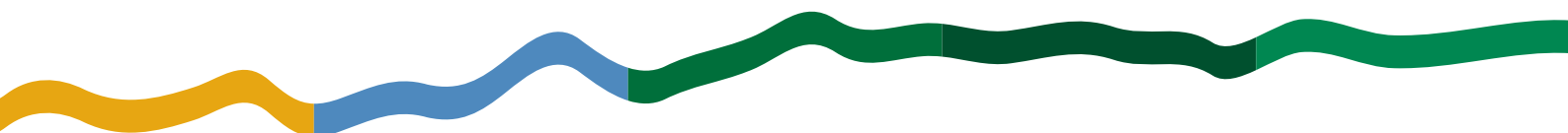
## APPENDIX B. Natural resource management principles

In August 1999, Ministers attending the sixteenth meeting of the Agricultural and Resource Management Council of Australia and New Zealand noted the following principles. The Council also noted that these principles might be amended in time to capture economic and regional issues, important changes in attitudes and behaviour, and findings from the monitoring and evaluation of progress. These are the sorts of principles that could form the basis for a new bipartisan 20 or 25 year framework for NRM, preferably agreed through CoAG.

1. Ecologically sustainable development is the framework for the management of our natural resources.

2. Natural resource management requires integrated management at the appropriate scale recognising ecosystem processes.

3. Natural resource management requires a partnership between government, communities, industry and individuals, with clear and agreed roles and responsibilities.

4. Relative contributions to the costs of natural resource management are to reflect the private and public costs incurred or benefits derived.

5. A mix of policy and delivery instruments is required for natural resource management outcomes.

6. Policy and programmes are to be consistent and aligned within and between all levels of government.

7. Natural resource management actions are to be based on best available science and experience and the principle of continuous improvement. New natural resource management requires a continued investment in science and innovation.

8. Capacity building, leadership and empowerment are fundamental to natural resource management.

9. Natural resource management requires a fundamental change in society's values, thinking and behaviour.

10. Natural resource management objectives are outcome focused and S.M.A.R.T. – simple, measurable, achievable, reasonable and time-bound.

11. Natural resource management recognises the rights and aspirations of Indigenous people and their connection to natural resources.

APPENDIX C. Notes

[1]   Dave Snowden is Director of IBM's Cynefin Centre for Organisational Complexity and formerly Director of IBM's Institute for Knowledge at Cambridge University. He introduced Land & Water Australia staff to his approach to knowledge management through practical workshops and 'story circles' (Snowden 2004b) in 2003, and is an insightful and accessible thinker, writer and practitioner in knowledge management.

[2]   Dave Snowden 2004a

[3]   This is a very brief excursion into the nature of knowledge, and it should not be inferred that any of these broad knowledge domains are homogeneous or straightforward. There are various types of science and modes of scientific inquiry for example, but insufficient space here to do them justice. The background paper goes into more depth. Indigenous knowledge merits particular attention, given the 20% of the continent managed by indigenous people, and is dealt with in more depth in the background paper.

[4]   Val Brown 2005

[5]   Michael Lockwood 2004

[6]   Edward De Bono 2000:166

[7]   Jan Tilden et al *in press*

[8]   ibid

[9]   Dave Snowden 2002

[10] Mark Stafford Smith (2005) in a fascinating and insightful Alfred Deakin Lecture, observes that there is much to be learned from Indigenous knowledge, but not in a starry-eyed way. Land & Water Australia currently has a suite of eleven research projects underway (with a total investment exceeding $2m) looking at various aspects of indigenous NRM in a cross-cultural, 'dual knowl edge' setting. Many of the key outputs arising from this body of research are focused on processes for better integrating Indigenous knowledge and Aboriginal peoples' aspirations into mainstream NRM (Susie Williams 2005, Kylie Pursche 2004).

[11] Niels Röling 1992

[12] Jeff Coutts et al 2004

[13] described in more detail by Coutts et al (2004) and in the background paper to this report

[14] ibid

[15] Bob Macadam and colleagues (2004) present an excellent overview of capacity building for the joint RDC Cooperative Venture on Capacity Building for Rural Innovation http://www.rirdc.gov.au/reports/HCC/04-034.pdf

[16] In this document the acronym CMA is shorthand for all catchment and regional bodies under NAP and NHT – not just those in NSW and Victoria officially titled Catchment Management Authorities.

[17] Jeff Coutts et al 2004

[18] Niels Röling 1992, Paul Engel and Monique Salomon 1996

[19] I have not attempted to repeat this analysis for the other eight jurisdictions in the Federation. That was done for the whole innovation system (not just NRM) by the then Industry Commission in 1994, in several volumes spanning several hundred pages, and again by DEST 2003.

[20] Australia New Zealand Land Information Council (ANZLIC) – Ministerial Council for spatial information

[21] Heather Aslin et al 2002

[22] The ABARE 2001-2 Resource Management Survey estimated there were 78,087 broadacre and dairy industry farms with an agricultural turnover greater than $22,500 per annum (Rohan Nelson et al 2004). If 'hobby farmers' and rural lifestyle blocks are included, then it seems safe to assume well over 100,000 families living on and managing rural and peri-urban properties in Australia.

[23] Andrew Campbell 1995, Jason Alexandra et al 1996

[24] DAFF 2005, CIE 2003

[25] National Land & Water Resources Audit 2002c

[26] Parliament of the Colony of New South Wales 1887, cited in NLWRA 2002

[27] Parliament of the Commonwealth of Australia 2001, cited in NLWRA 2002

[28] National Land and Water Resources Audit 2002

[29] We are not systematically monitoring probably the single most important factor affecting the condition of natural resources – management practices. This places lots of evaluation work in a fundamentally weak position because it is unable to answer with any authority the crunch questions about adoption of changed management practices on the ground, and subsequent impact on the condition of natural resources. Broadscale land use mapping, and national
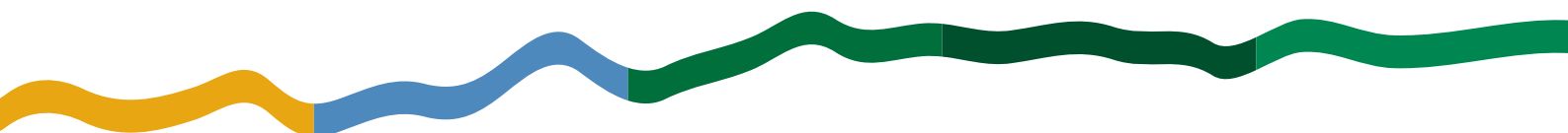
surveys of management practices carried out by ABARE (e.g. Nelson et al 2004) and the ABS Agricultural Census are useful. But we need to complement them with paddock-scale monitoring of management practices – especially in high priority areas like degradation hotspots or around particular ecological or infrastructure assets – to get a real feel for where behaviour change is needed, and to measure adoption of desirable practices. Mapping land use against land type can highlight risk areas up to a point, but a given land use on a given land type could be benign in the hands of a top manager, and a disaster for a poor manager. Management practices also need to be related to seasonal conditions – the same practice on a given land type could be OK in a good year and very risky in a poor season.

[30]   A good summary of the current status of monitoring and evaluation work in NRM can be found in National Land and Water Resources Audit (2005)

[31]   Mike Stephens (*pers comm*). Mike Stephens is an experienced agricultural consultant from near Ballarat who for many years has provided recruitment services in agriculture, and farm management consultancy and research services. His firm works for and with R&D corporations, state and federal agencies and hundreds of leading farmers. If it is difficult to get a handle on global R&D funding levels, it is even more difficult to build a picture of the content subject matter, or the research methods being employed, or how all the hundreds of agencies relate to each other. The most reasonable answer to Mike Stephens' rhetorical question is 'no-one'.

[32]   Note that duplication is not necessarily a bad thing. Sometimes it is a sensible strategy to have more than one group or agency tackling the same issue – we often do this by default given the vagaries of the Federation, whereby each jurisdiction develops its own approach to the same problem. The trick is to learn the lessons from such instances – an opportunity the federal system often misses.

[33]   Diagrams of organisations and other systems usually attach the dollars to the boxes, not to the arrows between them – an accurate reflection of reality. I'm indebted to Richard Price who first coined the 'funding the arrows' metaphor as a way of emphasising the need to identify and resource linkage mechanisms explicitly. Effective linkages across organisational, sectoral or jurisdictional boundaries can rarely be sustained in the absence of dedicated resources and expertise. This is not to assume however that all the knowledge within the boxes is sufficient or good enough, and that it is merely a matter of improving linkages – far from it.

[34]   A good example of this is the National Dryland Salinity Program (NDSP). After more than a decade of research and several hundred projects, the partners in the program decided to pull it all together into synthesis products designed around the needs of specific target audiences at farm, catchment and policy levels. A fantastic suite of synthesis products resulted (see www.lwa.gov.au) – at a cost of an additional million dollars.

[35]   This issue was discussed at some length at Land & Water Australia's integration symposium (LWA 2004), with insightful contributions including Gabriele Bammer, David Brunckhorst, Steve Cork, Allan Curtis, Steve Dovers, Gordon Duff, Gary Jones, Richard Price, Sarah Ryan, Geoff Syme, Lorrae van Kerkhoff, Bob Wasson and Lindsay White among others. For an excellent synthesis, see Bammer (2004) and the Volume 12 Supplementary issue of the *Australasian Journal of Environmental Management* (2005).

[36]   Peter Cullen 2005

[37]   Compliance with agreed standards and protocols for the Australian Spatial Data Directory (ASDD) is a classic example. The Australian Spatial Data Directory is the national directory of Australia's investment in map data. It enables users to find out what data is available, and provides 'metadata' describing the data. For each set of data, metadata available in the directory includes: a description of the data including scale; its location; its quality including accuracy and currency; how the data were developed (lineage); who to contact to obtain access to the data; and conditions of access (NLWRA 2002). The ASDD currently contains around 30,000 datasets.Given the number of players in the NRM knowledge system, the Australian Spatial Data Directory is clearly an essential tool to help organisations see what data has already been collected, to prevent duplication and to get maximum value from investments in data. But in practice, it is not reaching its potential. The National Land and Water Resources Audit (2002) found significant gaps in the ASDD including data generated under the Regional Forest Assessment program, the National Forest Inventory, the Agricultural Land Cover Change program, and the Resource Assessment Commission inquiries. It also found that many records in the ASDD *"are out of date, misleading or provide little information to help users determine whether data are suitable for a proposed purpose."* There is limited value in having a potentially valuable component of the NRM knowledge system like the ASDD if it is not used by key data custodians and/or if compliance with its standards and protocols is so patchy.

[38]   Jeff Coutts et al (2004) concluded that there are more than 4,000 extension positions across Australia, measured in Full Time Equivalents, of which more than 2,700 are in the public/community sectors. Given the number of part-time extension personnel, especially in landcare/NRM roles, Coutts et al estimate that perhaps half as many people again

are actually involved in extension work – so around 6,000 people in total. I believe it is reasonable to assume that the proportion of part-time work is higher in the public/community sector, so there are probably at least 4,000 people working in extension roles in that sector. Most of these positions are project-based and thus on fixed term contracts, mostly of three years or less.

39   A number of researchers have pointed to the impact of current working and funding arrangements – short-term contracts, poor training, limited career paths, inadequate support, institutional amnesia, churn, loss of good people etc – on professionals in extension. Mark Paine, Ruth Nettle and Steven Coats described dairy advisory staff as undergoing a crisis of identity (Paine et al 2004). Frank Vanclay (2002) contends that extension agencies have lost legitimacy. Allan Curtis documents 'burn-out' – emotional exhaustion, depersonalisation and a feeling of a lack of personal accomplishment among landcare leaders and professionals working with them (Curtis 1999).

40   It is no accident that the key principles of the Victorian LandCare program were developed by officers within the then Department of Conservation, Forests and Lands who had had the opportunity to undertake paid study leave to do post-graduate research in extension. LandCare was grounded in solid research evaluating the failures of previous approaches to soil conservation extension (Campbell 1994). Darrell Brewin's Masters thesis had evaluated department-led soil conservation catchment schemes and concluded that a lack of community and landholder ownership, stemming from a lack of engagement in planning and implementing on-ground works, was a key factor in the problematic durability of such schemes (Brewin 1980). Policy officers including Bryan O'Brien, Horrie Poussard and Rob Joy drew on this and other in-house extension research to propose the core principles of the LandCare program launched by Joan Kirner and Heather Mitchell in 1986.

41   Jeff Coutts, Jock Douglas and Andrew Campbell 2001. This is not a nostalgic call to reinstate the good old days of traditional extension services comprising state public servants driving around in government vehicles talking to the same small proportion of the farming community. Rather, it is about acknowledging and refining the role that extension plays within the NRM knowledge system, and resourcing it appropriately, making best possible use of new technologies, private consultants, NGOs, industry programmes and tools from contemporary knowledge management.

42   Andrew Campbell 2004

43   Dave Pannell, Graham Marshall, Neil Barr, Allan Curtis, Frank Vanclay and Roger Wilkinson have recently completed a comprehensive review of the literature and the issues relating to adoption of conservation technologies by rural landholders (Pannell et al *in press*). Their findings echo those of Don Burnside in reviewing research relevant to knowledge management at the catchment level for Land & Water Australia and the Glenelg and Corangamite CMAs (URS 2004). These findings are summarised below, drawing on both excellent sources. Adoption is a dynamic learning process, whereby landholders learn from experience, each other and external sources in adopting new practices, preferably with some form of trialling and evaluation along the way. Adoption is an inherently subjective, contextual process – highly dependent on individual perceptions and expectations. These perceptions are influenced by three factors: the learning process, the landholder's social and economic context, and the characteristics of the technology or innovation itself. People use information to test, adjust and reframe their understanding of the world and how best to operate in it. This costs them intellectual effort, time and money. It needs to generate benefits that exceed those costs. If the information is too far outside the receiver's frame of reference it will be rejected. Increasing doses of that information will reinforce the rejection.

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

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

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

With respect to NRM practices in particular, the evidence suggests that most farmers are unlikely to sacrifice self-interest to manage for the public good. At present, the relative advantage of many currently recommended NRM
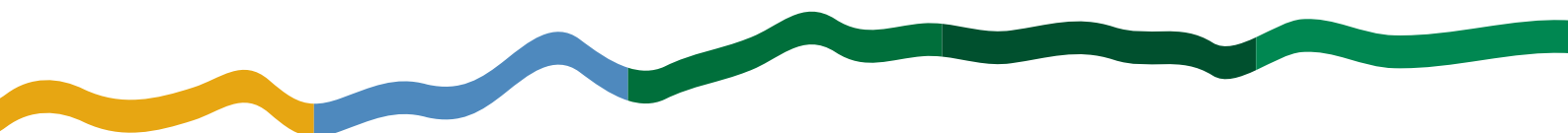
practices is perceived to be low by many landholders. Either there needs to be a closer alignment of self-interest with public interest, or practices need to be available and promoted that deliver both self-interest and public good outcomes. Appeals to stewardship values and management attitudes in the absence of adoptable practices will be effective for only a small minority of landholders. Creating the environment for desired change, and supporting that change will be more effective. The ability to access information, on its own, is a poor driver of change.

[44] Dave Pannell et al *in press*

[45] Professor Niels Röling from Wageningen University in The Netherlands, having studied extension in many countries, observes that top farmers and top extension agents seek each other out almost automatically.

[46] Gordon Stone 2005 (http://www.rirdc.gov.au/reports/HCC/05-086.pdf) analysed the role of agribusiness in provision of services in extension, education and training in southern Queensland and Northern NSW and found that it is generally doing a good job for the top 25% of farmers.

[47] Mike Logan *pers comm*

[48] In this document the acronym CMA is shorthand for all catchment and regional bodies under NAP and NHT – not just those in NSW and Victoria officially titled Catchment Management Authorities.

[49] This table is based on findings from the Knowledge for Regional NRM Scoping Report (LWA June 2005 p 30) prepared by Kate Andrews, Melissa Morley, Mat Silver, Camille McMahon, Belinda Lovell and Alice Renton. For more information see www.lwa.gov.au

[50] Associate Professor Janelle Allison is currently working on a joint LWA and NHT-funded research project looking at the capacity-building activities of a number of CMAs across several jurisdictions. She contrasts the situation of an embryonic regional body in north Queensland with an established CMA in Victoria, noting that if the CEO of the younger group has been able to spend even an hour talking with the CEO of the older group it could have saved months of hassles (Janelle Allison 2005 *pers comm*).

[51] This does not mean that regions should not be involved in M&E – far from it – just that we should not be asking regional bodies to be the data collectors to build a national picture. Regional bodies need to be very active in managing knowledge and information within their region, at the scale most relevant to the management and investment decisions they need to make. An excellent example of how a regional body can piggy-back on national systems to its own advantage is the Corangamite CMA in Victoria, which has built its own 'front end' (providing data on 600 local projects) onto the AANRO database (which references 150,000 completed projects and 6000 projects in progress nationally). This enables people accessing the CCMA website to search through both local material and national material in one seamless system, with powerful search facilities that would be very expensive for CCMA to build from scratch.

[52] Dr Morgan Williams is New Zealand's Parliamentary Commissioner for the Environment, an officer of the New Zealand Parliament (one of three including the Auditor General and the Ombudsman) reporting directly to the Parliament through the speaker rather than any Minister or portfolio. In this role he conducts inquiries into issues affecting the New Zealand environment, with a mandate to take a strategic, long term view. See www.pce.govt.nz for incisive, comprehensive analyses.

[53] The Centre for Resource and Environmental Studies at the ANU (CRES) is an excellent example of a university-based centre of excellence in sustainability research with a 30 year track record http://cres.anu.edu.au/ The Johnstone Centre at Charles Sturt University (http://www.csu.edu.au/research/jcentre/) has done very useful research on and with the landcare movement, and has built a critical mass in some of the social sciences. But there are many other possibilities that could more easily incorporate other knowledges along with western science. Wes Jackson's Land Institute in Kansas is a good example of a broader concept outside traditional academe that has been operating for almost 30 years. http://www.landinstitute.org/vnews/display.v The Centre for Rural and Regional Innovation at the University of Queensland, Gatton (CRRI-Q – formerly the Rural Extension Centre) http://www.crriq.edu.au/ is another model with strong links into government and a great track record in provision of in-service training and mid-career breaks for professionals to recharge their intellectual and professional batteries. It would be worth building on these and exploring models that combine elements of all of these, with a mandate to provide a memory function for the NRM knowledge system, and with sufficient critical mass to attract and invigorate the best people.

[54] Etienne Wenger 2004

[55] http://www.mtg.unimelb.edu.au/

[56] The ABS (1998) classifies research into four categories: pure basic research; strategic basic research; applied research; and experimental development, defined as follows.
Pure basic research is experimental and theoretical work undertaken to acquire new knowledge without looking for long term benefits other than the advancement of knowledge.

Strategic basic research is experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the solution of recognised practical problems.

Applied research is original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives.

Experimental development is systematic work, using existing knowledge gained from research or practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed (ABS 1998).

Across the whole Australian innovation system the split between these types of research in 2000-2001 is presented in figure 4.

Figure 4. R&D expenditure by type of activity, all sectors, 2000-01 (DEST 2003)
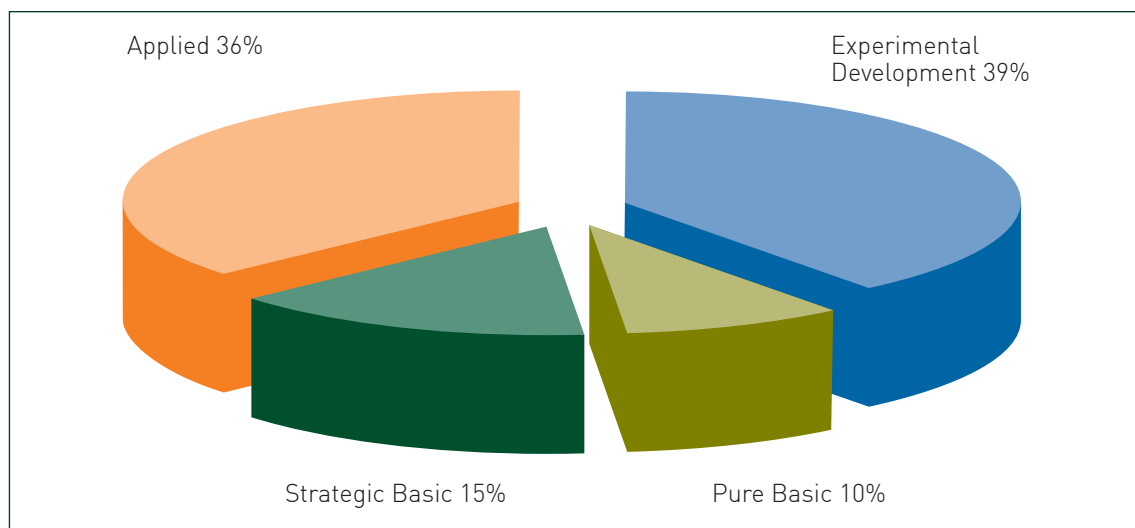
This shows that we invest about one quarter of total effort in basic research and three quarters in applied research and the 'D' part of R&D. There are no publicly available data to support a similar analysis in NRM. However almost by definition it is an applied field. My hunch is that the split in NRM would be closer to 90:10 applied R&D to strategic basic research, compared with 75:25 for the economy as a whole. It is worth thinking about how the NRM sector could build better linkages into strategic basic and pure basic research within universities of potential long term relevance to NRM.

ABS figures suggest that overall, the Australian Government is the major funder of R&D, especially basic research, through CSIRO, universities and medical research institutes. State Governments in total spend significantly less on R&D than the Commonwealth, and more than 80% of their research spend is in applied research and experimental development. Business spends more than the States, more than 90% of which is in applied research and experimental development.

[57]   Dave Pannell et al, in press

[58]   DAFF 2005, CIE 2003

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