

**SCIENCE AND INFORMATION
TO SUPPORT THE
NATIONAL ACTION PLAN
FOR SALINITY AND WATER QUALITY
AND THE
NATURAL HERITAGE TRUST

POSITION PAPER**

JUNE 2003

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1. EXECUTIVE SUMMARY

There remain some serious knowledge gaps affecting all or most jurisdictions and regions which have the potential to limit the return on investment from the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust (NHT).

The purpose of this discussion paper is to propose priorities for targeted investment in science and information to overcome these impediments. These priorities were developed under the aegis of the Science and Information Working Group (SIWG) of the Standing Committee to the Australian Ministerial Council on Natural Resource Management. The SIWG identified four research themes (sustainable land use, biodiversity conservation, climate variability & change, and monitoring and indicators) as being of high national significance, relevant across several jurisdictions, and poorly addressed through other means. These priorities were developed by State/Commonwealth writing teams and refined by the SIWG with the assistance of Land & Water Australia and a national workshop. See Appendices 7.1, 7.2 & 7.3 for background information.

The five strategic areas agreed by the Science and Information Working Group are:

- *Sustainable Agriculture and Land Use*: methods and tools to link on-property, industry and regional sustainability targets, strategies and planning;
- *Biodiversity Conservation*: methods and tools to assess the relative impacts and potential interactions of a range of threats to biodiversity and assess the potential benefits to biodiversity of a range of management intervention measures;
- *Climate Variability and Change*: a) methods and tools to better account for climate variability and change in regional/catchment strategies and targets; and b) assess the potential impacts and costs of climate variability and change on biodiversity, agricultural productivity, water quality and quantity, vegetation and soil health;
- *Monitoring and Indicators*: practical methods and tools to assess and monitor resource condition, assess trends and predict the outcomes of management interventions.
- *Managing Knowledge for Change*: Systems and tools for improved access by decision makers to and use of the best available data, information and knowledge to deliver the objectives of the NAP and NHT

The Commonwealth/State partnership under the NAP offers a unique opportunity to deliver a coordinated investment on science and information and capitalise on science that is funded outside the NAP. Collaboration through a State/Commonwealth partnership will:

- Avoid duplication of effort;
 - Make best use of limited R&D capacity on some key issues;
 - Maximise leverage from existing science investments;
-

- Enable testing of approaches and sharing of lessons across regions and jurisdictions; and
- Share the risks in undertaking R&D.

This paper outlines priorities for investment in science and information to tackle knowledge gaps that affect all or most regions and that are significant impediments to the achievement of NAP and NHT objectives. It has been designed to maximise linkages with the substantial body of existing research and development effort funded by State and Commonwealth agencies, R&D Corporations, Cooperative Research Centres, CSIRO and Universities. It is also structured with a view to making it much easier for regional bodies, industries and policy agencies to tap into and apply science outputs from across Australia. The science and information initiatives proposed here will add value to other bilateral activities, and to the Monitoring and Evaluation, and Capacity Building components of the NAP. It will improve NAP efficiency and effectiveness, generating substantial gains in our collective understanding of catchment processes, and practical tools for catchment managers and decision makers.

1.1 Program Design

This paper focuses on issues common to most regions. It proposes investment in an integrated program with two main components:

- **Methods & Tools for Action;** To assist NAP participants to draw upon the best available science (and to fill critical NAP-related knowledge gaps) on generic issues such as sustainable agriculture and land use; biodiversity; climate; monitoring and indicators; and to apply this knowledge to maximise return on NAP investments.
- **Delivery Systems;** Integrated and efficient delivery of these tools, methodologies and indicators, along with other relevant knowledge, to regions in a way that complements State/Territory processes, optimises use of national R&D resources, and ensures that knowledge-based work within the NAP is easily accessible to all players;

The program framework is outlined in Figure 1 and 2 below. The five strategic research areas form the main thrust of this proposal, attracting the majority of investment. The “Monitoring and Indicators” strategy links and applies the outputs from the “Sustainable Industries”, “Biodiversity Conservation” and “Climate Variability & Change” strategies. Some outputs from the “Climate” strategy will inform the “Sustainable Industries” and “Biodiversity” strategies. The five strategies also lend themselves to strong linkages with other participative research programs, especially those that are industry-based. Some of the many relevant national and state-based R&D programs that need to be linked with the NAP are listed in the Appendices. The core strategies and their objectives are also summarised in Figure 2.

Figure 1. The Science and Information Framework

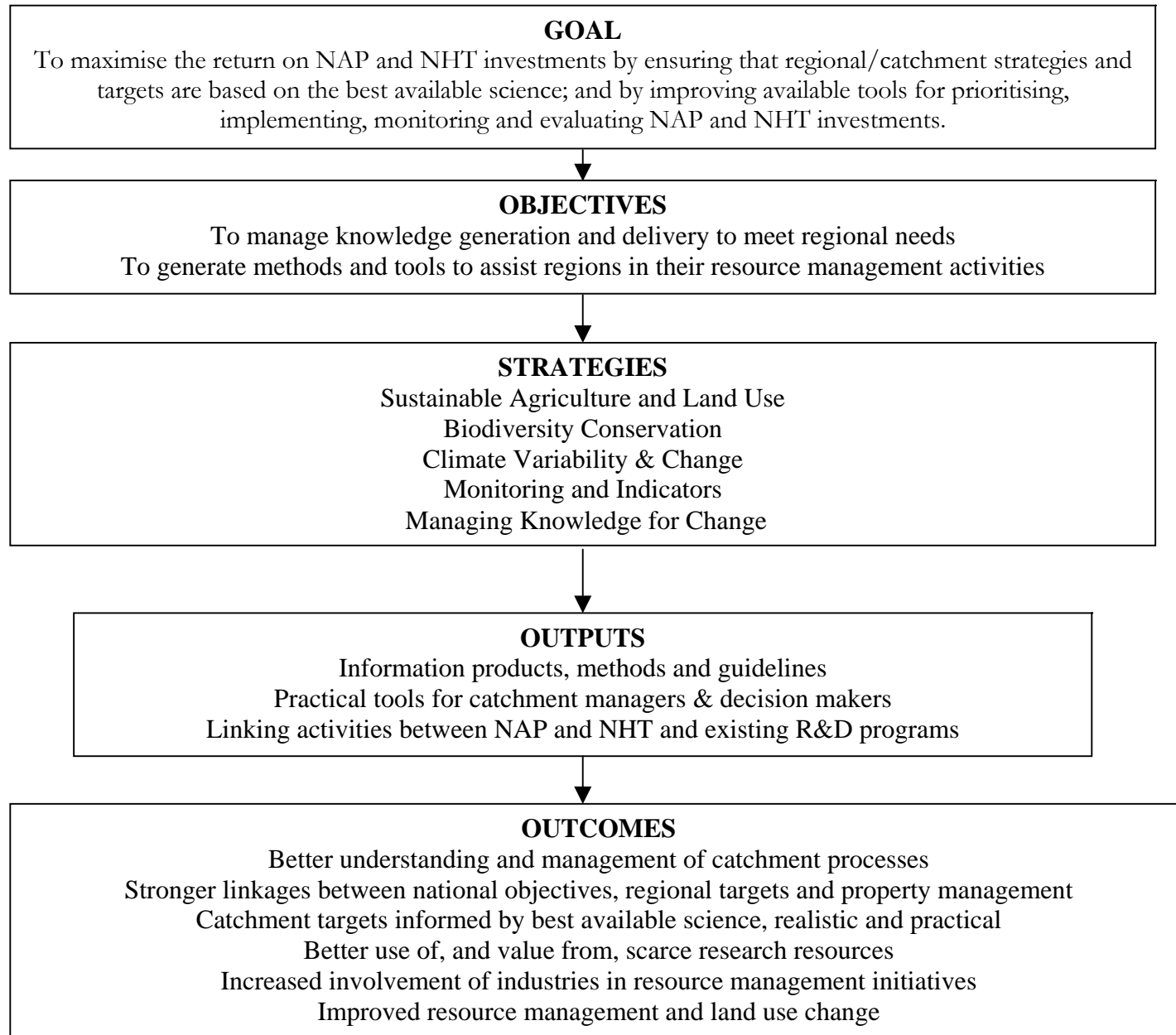
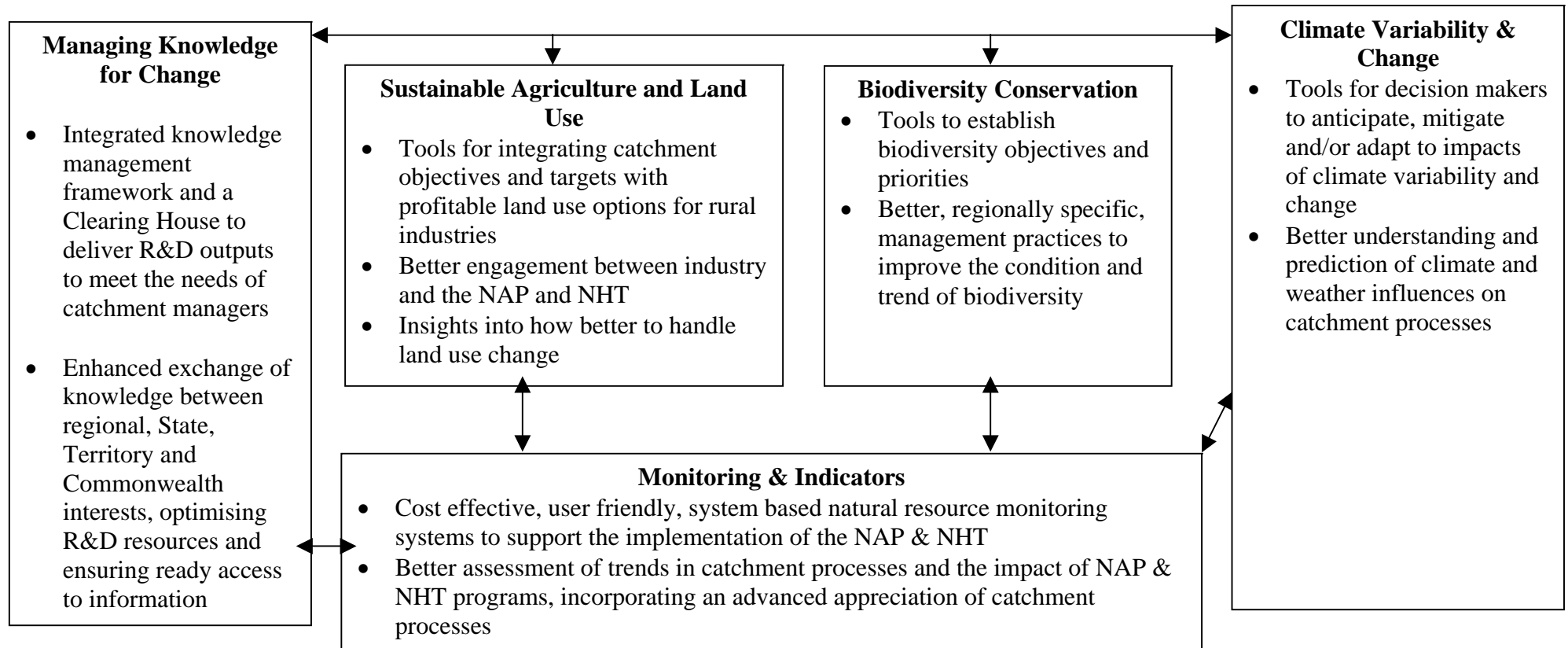


Figure 2. Key Strategies, Objectives and Outputs



1.2 Key deliverables

1.2.1 Sustainable Agriculture and Land Use

OUTPUTS

Tools, models, software, processes, protocols and data-bases such as:

- Infrastructure to support effective and efficient collaboration and communication between catchment bodies and industry networks;
- Systems analysis of land use, farming and catchments in test catchments;
- Information packages for integrating catchment objectives and targets with profitable land use options for farmers;
- Maps identifying areas of selected “test” catchments that have high environmental hazard. The major focus would be on salinity issues and the identification of areas in which deep drainage is high and has a high probability of reaching saline groundwater, and a flow path that indicates it will cause deterioration in river or high quality groundwater salinity levels;
- Farm/small catchment idealised land use plans (scenarios) that identify more appropriate land uses for the “leaky” areas and options for intensification on less leaky parts of the landscape;
- Linkages and support for delivering research findings through extension networks.

OUTCOMES

- Knowledge and application gaps identified in terms of the impact of current farming practices on salinity and water quality targets
- On-property, industry and region-wide sustainability activities informing each other and better coordinated around common catchment salinity and water quality targets
- Greater attention within the diverse range of industry sustainability and adoption activities towards meeting catchment salinity and water quality targets
- Development of key on-farm decision support tools to assist in promoting more efficient on-farm management of climate variability

1.2.2 Biodiversity Conservation

OUTPUTS

Tools, approaches, and data sets that help NAP partners:

- Effectively and efficiently utilise the various information sets to create regional investment strategies, trading off values and determining cost effective and achievable activities to improve productivity and environmental quality of landscapes;
- Identify priority bioregions, sub-regions, ecosystems and species;

- Identify cost-effective and achievable actions to protect and improve the condition and trends in biodiversity, and
- Integrate biodiversity conservation sympathetically with other priorities for land use under the NAP and NHT.

OUTCOMES

- Better planning capability within regions and regional plans that maximise effectiveness of investment in sustaining biodiversity while considering the interrelationships between biodiversity and other priorities.

1.2.3 Climate Variability and Change

OUTPUTS

- Climate indicators that monitor the major factors that moderate regional climate variability and change
- Assessment of regional climate trends on a variety of timescales i.e. annual decadal and multi-decadal
- Assessment of the interaction between regional climate variability and anthropogenic climate change in order to provide more accurate shorter-term climate change scenarios (5 to 15 years)
- Regionally specific climate variability and change scenarios and assessments of current and future regional vulnerabilities
- Extension of historical climate records through support of existing initiatives such as SILO and CLIMARC
- Information on the implications of climate variability and change for NAP and NHT priorities including salinity, water quality and biodiversity and their targets
- Assessment of optimal interventions to mitigate and adapt to climate variability and change in priority regions and the consequent development of decision aids for risk management
- Training programs on existing tools (eg RAINMAN, RAINMAN-STREAMFLOW, Flowcast, AussieGRASS) and their applicability to regional/catchment planning
- Application of tools that provide a national focus (e.g. AussieGRASS) to address the integration of climate change, climate variability, CO₂ fertilisation, and land use change to provide insights into the changes in NAP and NHT priorities such as salinity, soil hydrology, surface water flows, quality of subsurface and surface waters, and biodiversity
- Biophysical, economic and social assessment tools enhanced to explicitly account for climate variability and climate change as they affect NAP and NHT priorities

OUTCOMES

- Improved catchment management practices that take into consideration the possible impacts of climate variability and change on catchment processes and key NAP and NHT priorities at regional and catchment levels across Australia

- Intervention at regional and catchment levels that reduce the adverse impacts of climate variability and change on key NAP and NHT priorities
- Improved regional seasonal climate risk assessments/outlooks
- Improved understanding of the interaction of climate variability and change on regional scales
- Greater network of long-term climate station data
- Enhanced delivery of NAP and NHT objectives at regional and catchment levels within a variable and changing climate

1.2.4 Monitoring and Indicators

OUTPUTS

- User-friendly tools and models, and supportive data access protocols, that capitalise on access to existing National Land and Water Resources Audit style data
- User-friendly tools and models that integrate the outputs from sustainable industries, climate and biodiversity strategies so decision makers may plan and assess integrated resource management activities
- Tools to evaluate and monitor changes in resource condition over time against catchment goals and targets

OUTCOMES

Monitoring the condition of Australia's natural resources and their productivity provides the information basis for:

- Continuous improvement in investment strategies;
- Evaluating program delivery, especially NAP, NHT and related State activities.

This information also provides key inputs to:

- Policy formulation and modification;
- Program development and revision;
- Improved community understanding and action.

1.2.5 Managing Knowledge for Change

OUTPUTS

- Analysis of end user requirements and definition of R&D outputs in terms of end users' needs
- Mapping of pathways to adoption relevant to NAP and NHT activities, including where appropriate the involvement of industry and end users in the R&D process
- A program-level knowledge management and communication strategy structured variously depending on investment level
- Strategies and capacity to facilitate integration and sharing of lessons within the program, and to resource a comprehensive outreach capacity

- A clearinghouse that provides a ‘first stop shop’ for finding out what is happening where, what lessons have been learned, who are the key research contacts etc; and for running processes that make it efficient for researchers to interact with each other and with end-users across project and program boundaries
- A ‘virtual knowledge team’ (based on existing expertise) for each NAP region, responsible for leading regional efforts to get a handle on the best available knowledge to meet regional needs and to pin down key gaps.
- Integration with research and development information and programs across States, Territories and the Commonwealth

OUTCOMES

Knowledge is managed in the NAP and NHT via a framework that:

- Maximises learning across and between activities within each of the four R&D priorities;
- Sets out options for enhancing uptake of NAP-funded R&D by catchments/regions, policy clients and industry;
- Optimises linkages with other areas of NAP investment and with relevant R&D occurring outside the NAP, in particular through industry and state and national programs.

2 SUSTAINABLE AGRICULTURE AND LAND USE

Currently a wide range of work on sustainable agriculture is happening. There is a gap however on scale issues around the reconciliation between public-good oriented catchment-level plans, and targets; and farm and paddock scale action for commercial purposes.

Catchment targets, particularly those monitored at end of catchment, average out contributions in flow, salts and nutrients from what may often be thousands of square kilometres. The challenge with respect to sustainable agriculture is to develop methods and tools to tease out the relationships between on-farm actions and catchment-level impacts.

Linking catchment targets with the impacts of individuals is highly problematic.

Current technologies do enable the identification of ‘hotspots’, both in terms of vulnerable parts of the landscape and farming practices, which contribute disproportionately to processes such as deep drainage, nutrient export and erosion. Climate influences both the spatial distribution of landscape vulnerability, and the impact of particular farming practices, which underlines the importance of the work identified in Section 5. Practices that may be benign in good seasons can be quite inappropriate in drought seasons. Soil types or slopes that would normally sustain particular farming practices with little risk may be at an elevated level of risk as drought deepens or even when it breaks. Thus this work is not just about producing maps – it is about developing tools to capture the dynamic interplay between landscapes, climate and human activity. It is about doing the “right thing” in the “right place” at the “right time”; and how this can be integrated in catchment planning and management.

2.1 At a Glance

2.1.1 Goal

On-property, industry and regional sustainability activities, strategies and planning better linked with national natural resource management objectives.

2.1.2 Application

Networks will be fostered within all priority investment regions of the NAP creating opportunities for existing and new agribusiness, industry, RDC, MDBC and CSIRO initiatives to link with NAP salinity and water quality objectives. Translation between catchment level targets and on-farm action will be facilitated, in some cases through new R&D and in collaboration with industry partners.

2.1.3 Outcomes

1. Knowledge and application gaps identified in terms of the impact of current farming practices on landscape processes and natural resource condition

2. On-property, industry and region-wide sustainability activities informing each other and better coordinated around common catchment natural resource management objectives
3. Greater attention within the diverse range of industry sustainability and adoption activities towards meeting catchment natural resource management objectives
4. Better planning and management of land use change

2.1.4 Key Participants

Catchment bodies, agribusiness, industry groups (eg Fertiliser Industry Association), RDCs, farmer groups and networks (including Landcare, Top Crop, ProGraze, Bestwool 2010) MDBC, CSIRO, state agencies.

2.2 Program Detail

2.2.1 Key Issues

The challenge with sustainable agriculture is to develop methods and tools to link on-property, industry and regional sustainability targets, actions, strategies and planning.

The program would have a strong focus on developing tools and methods and on managing the exchange of knowledge to promote their adoption; achieving results within the time-frame of the NAP, while preparing Australia for the major challenges likely to develop into the future.

The approach will be to better enable existing and new activities in sustainable agriculture in NAP catchments to contribute to meeting natural resource objectives and to draw from and build on their existing capacity. R&D will be required to address issues of scale and translation of information between catchment targets and on-farm activities. Where land use change appears to be unavoidable, work is needed on the best tools and processes (social, economic and technical) to facilitate land use change towards more desirable uses.

Issues/tasks requiring investment include:

- Integration of research being undertaken at all scales and by a variety of groups into profitable land use options and communicating this knowledge rapidly to stakeholders;
- Identifying profitable land use and management options and making them accessible to extension/adoption support networks;
- Alignment of industry and regional research needs;
- The development of methodologies that identify and prioritise areas of catchments that have a high salt or other environmental hazard (e.g. erosion, biodiversity

loss) and which, in addition, have a high probability under current management practices of the hazard becoming a definable risk to catchment targets;

- Testing and evaluation of methods and tools in selected regions in conjunction with key stakeholders and evaluating the results of testing using modelling scenarios (e.g. what would the catchment look like if a target of 50% decrease in salt exported was to be met?);
- The impact of structural issues on the adoption of profitable land use and management options;
- Enhanced monitoring (and achievement) of targets;
- Enhanced capacity to support community decision-making where trade-offs may be required between land-use and management and catchment objectives;
- Identification of appropriate institutional frameworks to most effectively support drivers of land use change toward sustainability, including market-based instruments and ecosystem services;
- Assessment of relevance and potential role of EMS in supporting catchments and producers to meet natural resource management targets.

2.2.2 Objectives

- To foster opportunities for networks to establish within catchments involving industry, agribusiness, RDC, MDBC, CSIRO and catchment bodies which facilitate the exchange and translation of information about natural resource management objectives and how they relate to sustainable agriculture initiatives
- To develop methods and tools that identify, assess and prioritise areas of high hazard in terms of natural resource risk within catchments, and high-risk activities (management practices in given circumstances)
- To maximise the relevance of catchment targets to inform on-farm and industry wide adoption of current and new practices which bring about land-use change toward reduction of on-farm drivers of natural resource degradation
- To enable the assessment of the sustainability of current farming systems and their on-farm and off-site impacts in terms of their influence on district salinity and water quality hotspots and catchment targets

2.2.3 Activities

- Development of 'hooks' and participative processes to get industry more engaged (at R&D, policy and local group levels) in the NAP and NHT, especially around the interface (and occasional tensions) between catchment/regional planning and industry programs developing and extending best practice on-farm. This would also benefit catchments through enhancing access to state of the art agricultural productivity R&D in partnerships with industry; eg including phase farming and high input agriculture
- Identifying key issues in study areas and assessing hazards and risks
- Enhancing the useability of and integrating existing (and when necessary developing new) models of catchment processes. Eg assessing the impact of land

use or management changes (under alternative climatic scenarios) on catchment outcomes, measuring and modelling deep drainage under different cropping and grazing regimes and applying groundwater flow systems technology as developed by the National Land and Water Resources Audit and conventional groundwater flow modelling

- Measuring and modelling runoff and erosion under different cropping and grazing regimes
- Establishing and applying alternative landscape scenarios including definition of trade-offs and information on catchment consequences of on-farm management changes
- Involvement in decision making by catchment managers and farmers using adaptive catchment management strategies based on integrated catchment modelling.

2.2.4 Outputs

Tools, models, software, processes, protocols and data-bases (and their outputs) such as:

- Infrastructure to support effective and efficient collaboration and communication between catchment bodies and relevant industries;
- Systems analysis of land use, farming and catchments in test catchments;
- Information packages for integrating catchment objectives and targets with profitable land use options for farmers;
- Maps identifying areas of selected “test” catchments that have high environmental hazard. The major focus would be on salinity issues and the identification of areas in which deep drainage is high and has a high probability of reaching saline groundwater, and a flow path that indicates it will cause a deterioration in river or high quality groundwater salinity levels. There may be need for a multi-criteria assessment matrix of some sort as in some areas the issues will be the impact of salinity on surface water flows and therefore flooding, public infrastructure and biodiversity - all of which are high level public interest considerations. Also may need some cost benefit analysis to determine whether it is worth doing anything much about the impacts;
- Farm/small catchment idealised land use plans (scenarios) that identify more appropriate land uses for the “leaky” areas and options for intensification on less leaky parts of the landscape;
- Economic assessments of the impacts of land use change on affected farms;
- Assessments of the impact of land use changes on catchment targets;
- Evaluation of the impacts that the methods and tools are having on decision making;
- Linkages and support for delivering research findings through extension networks.

2.2.5 Key Links

Effective and efficient relationships between the key participants will need to be fostered and actively supported. Previous and current initiatives and strategic partnerships should be identified and used as the basis to inform the development of NAP activities. Some of these are listed more fully in Appendix 7.4, but some prominent examples include:

- National Land and Water Resources Audit I: the “Way Forward” Chapters in theme reports, with particular reference to agriculture, salinity and water quality assessments and industry case studies, provide significant direction;
- MDBC; Landmark;
- CSIRO; Heartlands, Healthy Country
- MLA; Sustainable Grazing Systems (with LWA);
- GRDC; Farming Systems projects and groups;
- AWI; Land, Water and Wool (with LWA);
- LWA; National Dryland Salinity Program, Redesigning Agriculture for Australian Landscapes, Social and Institutional Research Program, National Rivers Consortium, Managing Climate Variability;
- RIRDC; Joint Venture Agroforestry Program, Cooperative Venture for Capacity Building for Innovation in Rural Industries; Resilient Agriculture;
- Agribusiness support services and advisers (eg Pivot, Elders);
- MLA, GRDC, LWA; Mixed farming systems program under development.

3 BIODIVERSITY CONSERVATION

3.1 At a Glance

3.1.1 Immediate Goal

Cost-effective investment that systematically and strategically addresses key threats to biodiversity (including priority knowledge gaps) and key opportunities for salinity and water quality benefits from biodiversity; - within a broader framework for research and development that integrates NAP and NHT biodiversity goals with broader natural resource management goals for Australia.

3.1.2 Application

The research and development will be applied in NAP and NHT regions identified as priorities with respect to their species, ecological communities, landscapes, threatening processes, interactions among threats, opportunities for effective intervention to manage threats and/or provide salinity and water quality outcomes, and the economic, social and ecological trade-offs associated with interventions.

3.1.3 Outcomes

Enhanced ability to prioritise investments in biodiversity and to take tangible action on-ground, based on not only ecological but also economic and social considerations. Increased capacity within regions will lead to regional plans that maximise effectiveness of investment in sustaining biodiversity while considering the interrelationships between biodiversity and other priorities.

3.1.4 Key Participants

State, Territory and Commonwealth conservation and natural resource management agencies, research institutions with strong capability in biodiversity and land management disciplines, National Land & Water Resources Audit II.

3.2 Program Detail

3.2.1 Key issues

For any NAP region or catchment, approaches to dealing with biodiversity fall into three broad categories, roughly in order from cheapest, simplest and fastest (and arguably most effective?) to most expensive, complex and time-consuming:

- Protection: actions to protect remaining biodiversity (including consolidation of protected area networks and the minimisation of deleterious on-site and off-site impacts of land management practices);
- Restoration: actions to improve the condition of biodiversity (including but not restricted to endangered species and ecosystems);

- New systems: land uses, management actions, policies and other institutional changes to recognise, develop and encourage approaches to integrated natural resource management that consider biodiversity conservation sympathetically along with the range of other priorities for land use.

Each of these approaches needs to be underpinned by good science. For example, development of cost-effective investment strategies for conserving biodiversity and/or gaining maximum benefits from biodiversity for other natural resource management objectives like those related to salinity and water quality is often constrained by inadequate information and understanding in the following:

- The components of biodiversity that are targets for management intervention, being those species, ecological communities and landscapes identified as being of national and regional significance;
- The nature and relative importance of the threats to those defined components of Australia's biodiversity;
- The significance of the interactions between those threats;
- The effectiveness of interventions aimed at managing those threats including the costs and benefits of proposed interventions;
- The management of trade-offs that result from interventions aimed at managing threats to defined components of Australia's biodiversity;
- The benefits coming from biodiversity with respect to other components of natural resource management,
- The relative contributions from natural and developed landscapes to the survival of species that range across both.

The costs and achievability of answers to these questions varies considerably from place to place and issue to issue. Much of the necessary science is beyond the limited budget and timeframe of the NAP, but it is important that R&D supported by the NAP is integrated with the much larger investment expected in the NHT and other processes.

In the past few decades, various initiatives by State, Territory and Commonwealth agencies and research institutions (such as the Audit, the Review of the National Strategy for the Conservation of Australia's Biodiversity, preparation of Biodiversity Conservation Research Priorities and Sustaining Our Natural Systems and Biodiversity) have been completed, which herald an era of great opportunity for progress with respect to biodiversity management. These initiatives provide a solid platform for assessing priorities with respect to species, ecological communities and landscapes. This, in turn, provides the basis for developing practical and effective approaches to identifying and prioritising threats and for investigating opportunities for, and implications of, interventions.

The major challenges for the regions are:

- Utilising the various information sets to establish objectives, create regional investment strategies, manage trade-offs and determine cost effective and achievable activities to improve productivity and environmental quality;

- Providing practical advice to land managers about actions they can take to meet biodiversity goals within their broader commercial objectives.

There remain some important information gaps, deficiencies in analytical and decision-support tools, and inadequacies in regional capacity and resourcing across large parts of Australia to achieve effective biodiversity outcomes. For example, despite considerable investment in salinity research, remarkably little work has been done on the impacts of salinity on terrestrial, wetland and in-stream biodiversity and ecosystems.

The specific issue mentioned above is being partly taken up within the CRC for Plant-based Management of Dryland Salinity and to a lesser extent through the National Dryland Salinity Program and the National River Contaminants Program. Significant knowledge gaps remain. Salinity mapping and prediction modelling more generally should provide information that can be used to investigate impacts of salinity on biodiversity, but this is far from the case at present. The R&D proposed below takes account of these limitations as well as other processes that are expected to complement the NAP and run over different timeframes.

3.2.2 Objectives

Develop and make available tools and approaches that:

- Help NAP partners identify priority bioregions, sub-regions, ecosystems and species, and to identify and prioritise threats to biodiversity;
- Help regional planners establish objectives and identify cost-effective and achievable actions to protect and improve the condition and trends in biodiversity, based on an analysis of interactions among threats and the benefits, costs and trade-offs of possible interventions;
- Integrate biodiversity conservation sympathetically with other priorities for land use under the NAP;
- Provide the research and development that will allow managers within regions to give practical advice to land managers about achievable on-ground actions to achieve regional objectives.

3.2.3 Activities

3.2.3.1 *Identifying priority bioregions, sub-regions, ecosystems and species*

The National Land and Water Resources Audit and the various initiatives by State, Territory and Commonwealth agencies that preceded and contributed to it, has provided a solid basis for meeting this objective by developing an agreed hierarchy of bioregions, sub-regions, and ecosystems and standardising some of the classifications of components of biodiversity.

These initiatives have trialed some approaches to identifying geographic priorities for biodiversity conservation based on multiple criteria including richness, endemism, irreplaceability, rarity and the concentration of threatened species and ecosystems. While further development of the information systems supporting these prioritisation approaches would be expected under Audit II, further development of the

prioritisation tools and analyses would need to be funded under NAP and build on considerable progress in this area already made by State, Territory and Commonwealth agencies. Rapid progress could be expected in this area with adequate funding.

Integral to the prioritisation process is a need for further information and analysis of threatening processes and actions that can be taken to address these cost effectively. The National Land and Water Resources Audit identified some priorities in this regard and could be built on to provide outcomes within an acceptable timeframe.

3.2.3.2 Assess the adequacy of protected area networks in the light of the prioritisation process

Considerable activity has been undertaken and is ongoing at State, Territory and Commonwealth levels with respect to protected area networks, including Representative Areas, Coastal & Marine, Rivers and Estuaries. There will be a need to assess the adequacy of these networks in relation to the priorities that are identified; and this will require cross-jurisdictional cooperation.

3.2.3.3 Identify and implement cost-effective and achievable strategies to reduce key threats and enhance the condition of priority ecosystems

There will be a need to bring together the considerable experience and expertise of State, Territory and Commonwealth agencies and researchers to identify where investment in threat-mitigation could be cost-effective and where R&D is indicated within the constraints of the NAP. Key threats relevant to the NAP obviously include salinity, declining water quality and land clearing.

Key components of the science needed here include:

- Defining where, with what severity and over what time scale, human activities are impacting on species, ecological communities and landscapes. The National Land and Water Resources Audit has recently analysed threatening processes for biodiversity at a subregional scale. This project would build on the Audit analysis to identify the most significant threats at the national and regional scales with respect to the components of interest, working with selected regions to identify the most significant threats across a range of climatic and vegetation zones. Such an analysis would need to include assessment of the following threatening processes:
 - land clearing;
 - weeds and feral animals;
 - salinity;
 - climate variability and change;
 - changed land use;
 - changed water flow regimes;
 - changed water quality;
 - chemicals in the environment;
 - grazing;
 - pests and diseases;
 - changed fire regimes;
 - firewood collection;
 - disruption and removal of other limited habitat components (eg bushrock, water snags, mature paddock trees, rainforest remnants);

- over-harvesting of native species (eg grass trees, orchids, parrot and raptor nests).
- Describe interactions between threats and identify the most significant interactions on the basis of their impact, tractability and potential to respond to management interventions, stratified by broad climatic and vegetation zones;
- Design and report on adaptive management experiments to test responses to management interventions that are currently being applied under regional natural resource management plans, in all jurisdictions. For example, most information about vegetation management and revegetation and its use to achieve biodiversity goals is anecdotal. Very little research has been undertaken on methods for regenerating trees and shrubs; managing grazing or fire for biodiversity in woodlands; adapting techniques for bush regeneration from urban areas to agricultural landscapes; scales at which vegetation enhancement and revegetation should be undertaken; how to restore functioning ecosystems; how to mimic natural succession in revegetation; the role of soil fauna in vegetation management and revegetation; relationships between overall vegetation cover, connectivity and biodiversity; and colonisation and use of revegetated areas by native plants and animals. Techniques for integrated landscape rehabilitation await development. Research and extension equivalent to that undertaken for agricultural production in the last 50 years in Australia, which provided understanding about legumes, super phosphate, the role of trace elements in plant growth, soil structure and fertility, crop and pasture diseases, etc., are urgently needed to develop and communicate information about how to manage and re-establish native vegetation for biodiversity. Significant steps could be taken to address these issues in priority areas;
- This information will be used to establish benchmarks to measure the impacts of future investment in management interventions. The interactions between threats are likely to require some form of modelling before they can be tested in practical studies;
- Identify the relative costs and benefits of management interventions as a way of prioritising investment by building on the methodology described in the Appendix to the PMSEIC report *Sustaining our Natural Systems and Biodiversity*;
- Identify the trade-offs that are likely to result from proposed management interventions and identify alternative strategies for their management. Where the management of trade-offs involves quantifiable costs, this step should be repeated to incorporate trade-offs in the benefit-cost analyses.

3.2.3.4 *Develop tools to allow biodiversity issues to be considered sympathetically in integrated natural resource planning and management*

One key to integrating biodiversity conservation with other land-use priorities is to consider not only the ethical imperative for biodiversity conservation but the economic and other benefits (sometimes called “ecosystem services”) that biodiversity provides for humans. Research is needed to quantify the relationship between the condition of ecosystems and the quality of ecosystem services delivered.

This research should be focussed by analyses, in priority areas, of which services are likely to be most limiting given the needs of human communities.

Research also is needed to provide decision support systems that integrate social, ecological and economic aspects of catchment management, so that regional planners can anticipate the full implications of proposed actions.

Of vital importance to implementation of NAP objectives, is research on alternative institutional arrangements that encourage individual behaviours and market activities consistent with desired NAP outcomes. Major components of this research are occurring with the Market-Based Instruments (MBI) initiative under NAP, but consideration needs to be given to policy and institutional research that is vital to achieving biodiversity objectives but which falls outside the scope of MBI.

3.2.3.5 Develop and implement tools for monitoring and evaluation of interventions designed to meet biodiversity goals

A major recommendation of the Terrestrial Biodiversity Report of Audit was the implementation of an integrated and coordinated monitoring and assessment program, building on State and Territory activities, which tracks changes in species, populations and ecosystems, assesses impacts of threatening processes, details management activities, and draws attention to opportunities for improved management. Assessing the effectiveness of actions taken as part of the NAP is essential for both the integrity of the program and to enable adaptive learning from the investments made. Monitoring and evaluation of NAP investments generally is considered in the Monitoring & Indicators section of this document and is core business for the Monitoring and Evaluation Working Group.

3.2.4 Outputs

Tools, approaches, and data sets that help the NAP partners:

- Effectively and efficiently utilise the various information sets to create regional investment strategies, trading off values and determining cost effective and achievable activities to improve productivity and environmental quality of landscapes;
- Identify priority bioregions, sub-regions, ecosystems and species and priority threats and combinations of threats to be addressed;
- Identify cost-effective and achievable actions to protect and improve the condition and trends in biodiversity;
- Integrate biodiversity conservation sympathetically with other priorities for land use under the NAP and NHT;
- Provide practical advice to land managers about achievable on-ground actions.

3.2.5 Key Links

Key sources of information and expertise include:

- Monitoring and Evaluation Working Group findings;
- State of Environment reporting;

- Ways Forward Chapters in each of the National Land & Water Resources Audit I theme reports [and as broadly summarised in the Audit's Final Report Recommendations], especially the biodiversity report;
- State, Territory and Commonwealth monitoring and data collection, collation, assessment, interpretation and planning activities, eg National Strategy for Biodiversity, Threatened Species Scientific Committee etc;
- Research publications and data from institutions engaged in biodiversity research, including CSIRO, universities and State and Territory agencies.

3.2.6 Next Steps

The considerable progress made in research and planning for biodiversity protection by State, Territory and Commonwealth agencies and researchers makes it highly likely that progress will have been made towards sustainable management of biodiversity. However, there will still be a long way to go. The research and development proposed here needs to be guided by representatives from key State, Territory and Commonwealth initiatives and advisory committees, so that maximum benefit is derived from other initiatives and continuity is maintained; ensuring ongoing attention to these bigger issues. It will be important within the NAP to ensure that investments are made in ways that allow learning and thereby increase the efficiency and effectiveness of future expenditure.

4 CLIMATE VARIABILITY AND CHANGE

The severity of the 2002-03 drought that affected much of Australia was exacerbated throughout much of 2002 by higher than “normal” maximum temperatures, which may be a consequence of global climate change. Early estimates are that the increased temperatures associated with an El Niño induced drought and the existing global and regional maximum temperature trends since the mid-twentieth century combined to increase temperature anomalies in 2002 to record levels (i.e. +1.22°C above normal compared with the previous highest anomaly of +0.91°C in 1980).¹

Global and national climate projections based on IPCC² greenhouse gas scenarios indicate the following possible changes in climate:

- Average temperature increases between 0.4°C and 2.0°C by 2030 for continental Australia and increasing rates of temperature rises thereafter;
- Increased frequency of extreme hot days, and decreased frequency of extreme cold days;
- Overall drying trends in some areas of continental Australia due to a combination of decreases in rainfall and increases in potential evaporation; and
- Possible changes to the frequency of extreme events such as extreme rainfalls.

The changes would vary from region to region, influencing the capacity of the National Action Plan to deliver the NAP objectives across the different NAP regions and catchments. Changes in water availability and temperature associated with climate change, and their consequent biophysical impacts, could influence areas for optimal cost-effective NRM interventions at the national, regional, and catchment scales.

Australia has a high year-to-year variability in climate, but it is now well established that the projected changes in climate would exacerbate both the frequency and magnitude of some weather and climate extremes (although this is clearly less likely with respect to cold extremes), thus compounding risks in effective management of natural resources. The areas of increased risk include those identified as key priorities of the NAP: salinity, soil hydrology, surface water flows, quality of subsurface and surface waters, and biodiversity.

An inevitable and major consequence of high climate variability is the difficulties it imposes in separating the climate signal from the influence of management interventions when tracking resource condition indicators in climate-driven systems. This is a critical issue for the NAP, as many catchment strategies are likely to set targets for parameters such as groundwater levels, recharge, streamflow etc, all of which are strongly climate-driven. Data obtained over several decades are essential to discriminate with confidence between changes in natural resources due to climate trends and those due to management change.

² Intergovernmental Panel on Climate Change

Freshwater resource degradation, in terms of both supply and quality, was identified by the IPCC Third Assessment Report as the most significant potential impact of climate change on Australia. Decreases in stream flow are probable for southern Australia based on projections that indicate reductions in rainfall and increased evaporation. Estimated possible changes in stream flow in the east-central Murray-Darling Basin range as low as –20% in 2030, and to –45% in 2070 (considering a range of possible future greenhouse gas emissions). This would exacerbate shortages in meeting existing needs, particularly for winter rain fed systems that are already under stress.

4.1 At a Glance

4.1.1 Goal

Improved understanding of climate variability and change, along with better tools and mechanisms that:

- Enhance predictions of impacts of both climate change and climate variability on salinity, water quality, agriculture, biodiversity and other land uses; and hence
- Enable intervention at regional and catchment levels that enhance delivery of NAP objectives.

4.1.2 Application

Applications of the science will involve all Regions of the NAP, linking existing and new initiatives, in particular the Climate Variability in Agriculture Program (CVAP), the initiatives of the Australian Greenhouse Office, research conducted by CSIRO and the Bureau of Meteorology (BOM), and activities under way in each State and Territory.

4.1.3 Outcomes

1. Improved catchment management practices that take into consideration the possible impacts of climate variability and climate change on catchment processes and key NAP and NHT priorities at national, regional and catchment levels across Australia
2. Intervention at regional and catchment levels that reduce the adverse impacts of climate variability and climate change on key NAP and NHT priorities, while ensuring broader national requirements are met
3. Enhanced delivery of NAP and NHT objectives at regional and catchment levels

4.1.4 Key Participants

Catchment bodies, the Climate Variability in Agriculture Program (CVAP), the Australian Greenhouse Office, CSIRO, BOM, State and Territory agencies.

4.2 Program Detail

4.2.1 Key Issues

Nationally:

- How do we accurately assess current climate trends and determine the level of attribution to climate change?
- How do we identify the regions where climate change and climate variability will have significant effects?
- How should we prioritise for interventions and funding allocations when taking into account climate change and climate variability?
- How do we adequately identify areas, communities and enterprises that might be vulnerable to climate change?
- How do we encourage climate change impact assessment across a range of NAP and NHT issues that is consistent and allows direct inter-comparison?
- How do we assist in the development of high-resolution scenarios appropriate for use in environmental modelling?
- How do we encourage governments, industry and the community to begin to utilise this information more effectively?
- How do we assess impacts of climate change and variability and develop responses in NAP regions for: catchment salt and water balances; biodiversity; sustainable production (including existing and potential production systems and products); tree establishment, survival and growth, trees versus grass competition (recognising the major role of revegetation and forestry in achieving NAP outcomes).

Regionally:

- How do we improve understanding and communicate the broad implications of climate variability and change for our region?
- What do we need to do now to be able to respond (mitigate and/or adapt) more effectively to future challenges?
- What core obligations in respect of protecting environmental assets and natural resources are likely to be impacted by climate variability or change?
- How do we assess impacts on our industries and communities?
- What new opportunities might arise for our region?
- What existing tools can we use and what new ones do we need to develop?

4.2.2 Objectives

- To identify the impact of recent climate trends on NAP and NHT priorities

- To improve understanding of the impacts of climate variability on key NAP priorities
- To improve the precision of climate change scenarios at regional and catchment levels
- To improve understanding of impacts of climate variability and change on catchment processes and key NAP priorities at regional and catchment levels across Australia
- To identify opportunities for intervention at regional and catchment levels to reduce the adverse impacts of climate variability and change on key NAP priorities; through improved anticipation and adaptation
- To provide tools and mechanisms to enhance delivery of NAP objectives at regional and catchment levels within a variable and changing climate - through improved anticipation, mitigation and adaptation

4.2.3 Activities

- Assessment of current climate trends at a regional scale consistent with NAP focus regions
- Improving the precision of climate change projections at regional and catchment levels, and the impact on climate variability
- Improving understanding of the impacts of climate change on key NAP priorities at a regional and catchment level, in particular impacts on salinity, soil hydrology, surface water flows, quality of subsurface and surface waters, and biodiversity
- Assessments of vulnerabilities of NAP regions to the impacts of climate change on the key NAP priorities
- Assessment of the capacity of possible intervention measures to minimise the adverse effects of climate change on key NAP priorities
- Development of relevant intervention measures for more effective delivery of key NAP priorities at regional and catchment levels

4.2.4 Outputs

- Climate indicators that accurately monitor the drivers that moderate current regional climate variability
- Regional climate trends on a variety of timescales i.e. annual, decadal and multi-decadal
- Regionally specific climate variability and change projections
- Focused information on the implications of climate variability and change for NAP and NHT priorities including salinity, water quality, sustainable land use and biodiversity and their targets
- Current and future regional vulnerabilities within a range of key environmental, economic and social contexts

- Optimal intervention strategies to mitigate and adapt to climate variability and change in priority regions and the consequent development of decision aids for risk management
- Training programs on existing tools (eg RAINMAN, RAINMAN-STREAMFLOW, AussieGRASS, Flowcast) and their applicability to regional/catchment planning
- Tools that provide a national focus (e.g. AussieGRASS) to address the integration of climate change, climate variability, CO₂ fertilisation, and land use change to provide insights into the changes in NAP and NHT priorities such as salinity, soil hydrology, surface water flows, quality of subsurface and surface waters, and biodiversity
- Biophysical, economic and social assessment tools enhanced to explicitly account for climate variability and climate change as they affect NAP and NHT priorities

4.2.5 Key Links

It is important to recognise that climate variability and change (particularly in Australia) cannot be isolated from other NRM issues. They permeate all activity within landscapes. Climate will become an increasingly important factor in making assessments of biodiversity, water resources, salinity, fire, production systems and human health and demographics. Climate must be factored into all aspects of regional planning and for this reason we must seek methods that integrate all these issues. The sustainable land use and biodiversity conservation strategies will act as clients and help define the specific climate tools required by catchment managers and planners and will also provide a testing ground for new products.

It is important conceptually to distinguish between Australia's very high natural year-to-year climate variability and long term changes in underlying climate patterns that may be coming about due to human influence on the global environment. However for catchment management practitioners, it is reasonable to focus on climate variability, accepting that it is possible that climate change may already be exacerbating climate variability. Natural resource management systems that are robust and resilient in the face of extreme annual variations in climate are best placed to cope with changes in underlying trends. However, while natural resources may be resilient to extreme year-to-year changes, they may be less able to cope with sustained trends that increase the frequency of climate extremes – for example the apparent drying of southwest Western Australia that has occurred over the last 25 years.

New R&D on climate variability and change needs to be cognisant of previous and current activities. The research proposed here is a modest applied effort focused on immediate NAP needs. It should link with more comprehensive, longer-term approaches (not developed further here) involving;

- Improved coupled ocean – atmosphere climate models,
- Improved methods for downscaling global climate model results,
- Enhanced measurement and monitoring of the climate system,
- Systematic validation of model results and verification of predictions whenever they are feasible,

- Improved decision support tools, applying models and scenarios,
- Improved understanding of relationships between land use change and climate change,
- Improved understanding of links between climate change and variability and landscape processes (eg erosion and salinity).

4.2.6 Next Steps

Key participants in climate research should be approached and invited to contribute to the refinement of this proposal and to identify existing, new and proposed activities that could support achievement of NAP objectives. Consultation is also required with leaders of the sustainable land use and biodiversity conservation strategies to assess their likely requirements in terms of climate outputs.

5 MONITORING AND INDICATORS

As with the other priority areas of R&D identified by the Science and Information Working Group, R&D on monitoring and indicators needs to complement, link with and build upon the significantly larger body of work already underway. Whilst some indicators and monitoring needs may be peculiar to the NAP, if they are to be of lasting value they need to be useful beyond its scope and the timeframe. Various projects and programs in different Australian agencies are involved in developing broader sustainability indices, generally at an early stage of development. In effect, we need to be considering the architecture of a national system for tracking the condition and productive capacity of our natural resources and targeting relevant projects within that.

5.1 At a Glance

5.1.1 Goal

To contribute to the research, development, design and implementation of a natural resources monitoring system for Australia

5.1.2 Application

The system will be applied within all Regions of NAP and NHT, ensuring an Australia-wide consistent approach to natural resources information and underpinning data collection. At the same time, components of the system will be given varying levels of emphasis within the context of the natural features and needs of each region.

5.1.3 Outcomes

Monitoring the condition of Australia's natural resources and their productivity provides the information basis for:

- Continuous improvement in investment strategies;
- Evaluating program delivery, especially NAP, NHT and related State activities.

This information also provides key inputs to:

- Policy formulation and modification;
- Program development and revision;
- Improved community understanding and action.

It provides a "bottom line" input to assessments of, and plans for, sustainability.

5.1.4 Key Participants

National Land & Water Resources Audit II in close cooperation (through the Advisory Council) with all States and Territories, the Monitoring and Evaluation Working Group, and all the data provision groups such as NVIS and ACLEP.

5.2 Program Detail

Three key considerations inform this section:

- The cost of monitoring. To be effective, monitoring of natural resource condition must continue over the long term, allowing us to track progress, explore emerging issues and evaluate management and policy interventions;
- Explicit links between monitored data and management response. Monitoring must not only track changes in condition but also provide insight into any causes of problems and opportunities for improvement in management and land use practice;
- Application of monitoring to program delivery and finetuning. Monitoring needs to explicitly link to natural resources policies and programs, providing information to progressively improve their focus and activities.

5.2.1 Objectives

Taking these factors into account, the objectives are:

1. To research and design a cost-effective natural resources monitoring system that will provide relevant information sufficient to directly evaluate progress towards improved natural resource management outcomes under the NAP and NHT;
2. To research and design an ecosystem process-based natural resources monitoring system that assists in understanding the causal factors affecting resource condition and the opportunities to improve or maintain resource condition;
3. To research and design a natural resources monitoring system to support the implementation of key Commonwealth, State and Territory programs, particularly the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust.

5.2.2 Activities & Conceptual Framework

Key steps in designing a rigorous natural resources monitoring and information provision system for Australia (and indications of more specific activities relevant to the NAP and NHT) include:

- Determination of key attributes and assessment methods that will link resource condition and trend with resource management opportunities (including the development, with industries, of key indicators of sustainable management practices);
- Collection and collation of geo-referenced data sets to agreed standards (based on protocols and standards agreed for catchment monitoring);
- Integrated and accessible data management and reporting systems building on and linking with the Australian Natural Resources Data Library and related data access systems in States and Territories (including protocols for monitoring vegetation condition across catchments);
- Application of assessment tools that use various data sets to provide information upon which to base management responses and priority setting (via user friendly

models developed to meet the needs and capacity of catchment planners and managers);

- Information presentation, using tools including the Australian Natural Resources Atlas and related, but not yet linked Internet Atlases in States, Territories and regions (and models and tools designed for regional application);
- Decision support, providing various tools that can be applied across information sets to determine, based on community values and needs, opportunities for investment and to assist groups in setting their priorities by presenting various scenarios (including socio-economic aspects).

Schematically and conceptually, within a region the application of this Australia-wide system might look like:

Regional Goal:.....		
Integrated Targets		
Target 1:.....	Target 2:.....	Target 3:.....
Benchmarks		
Eg: Audit Estuary Condition	Eg: State Salinity Extent Mapping	Eg: Regional assessment of agricultural production returns
Decision Support Tools		
Tool 1: eg Landscape Health	Tool 2: eg AEAM	etc
Information presentation, including trends		
Regional profile on Australian Natural Resources Atlas, or State Atlas, or Regional Atlas linked to the others		
Integrated Assessment Tools		
Eg method to use various data sets to determine estuary condition and trends	Eg methods to track improvements in water balance through changes in land use and practice	Eg methods to analyse ABS, ABARE and regional data on crop production and profitability
Data Management		
Data Systems such as the Australian Natural Resources Data Library and related State or Agency systems		
Data Collection		
Key contributing data sets and specifications [data quality, standards, timing of monitoring, responsibility, applications etc]		
<ul style="list-style-type: none"> ▪ Data Set 1 ▪ Data Set 2 ▪ etc 		

For the NAP, the system will draw together information needs highlighted by the sustainable agriculture and land use and biodiversity conservation strategies and also incorporate any relevant outputs from the Climate strategy.

5.2.3 Outputs

- User friendly tools and models, and supportive data access protocols, that capitalise on access to existing Audit style data
- User friendly tools and models that integrate the outputs from sustainable industries, climate and biodiversity strategies so decision makers may plan and assess integrated resource management activities
- Tools to evaluate and monitor changes in resource condition over time against catchment goals and targets

5.2.4 Key Links

Key sources of information on which to research and then build the monitoring framework in a systematic and cost-effective manner include:

- Monitoring and Evaluation Working Group;
- State of Environment indicators;
- Ways Forward Chapters in each of the National Land & Water Resources Audit I theme reports [and as broadly summarised in the Audit's Final Report Recommendations] and work plans for the Audit II;
- State and Territory monitoring and data collection, collation, assessment and interpretation activities;
- Other strategies within this program (eg Sustainable Agriculture, Biodiversity and Knowledge Delivery).

The Monitoring and Evaluation Working Group (MEWG) is developing a practical set of natural resource condition indicators to meet the needs outlined in the National Monitoring and Evaluation Framework.

The resource condition indicator headings identified by MEWG so far include:

- Area of land threatened by shallow or rising water tables;
- Soil condition;
- Native vegetation extent, distribution and condition;
- River condition;
- Wetland ecosystem extent, distribution and condition;
- Estuarine, coastal and marine habitat extent, distribution and condition;
- Nitrogen and Phosphorus in aquatic environments;
- Turbidity / suspended solids;
- In-stream salinity;
- The extent and conservation status of selected significant native species and ecological communities;
- The extent and impact of selected ecologically significant invasive species.

The MEWG has sought technical and scientific advice from multi-jurisdictional expert groups such as the Working Group on Land Resource Assessment on the methods to monitor the indicators. Ongoing links with MEWG (a key "client") and the Audit II (potential strategy manager) will be essential for the success of this strategy.

5.2.5 Next Steps

Much has been done towards establishing a natural resources monitoring process for Australia. An essential part of this initiative is to build upon these various inputs and design the implementation of it from a rigorous systems approach. The systems

approach is essential and recognises that the outcome is more likely to be a finetuning and re-focusing of existing investments in monitoring rather than additional investment. For example, the Audit found that Australia already expends in excess of \$100M in monitoring water quality annually. Maximising returns from existing investment is a major part of the research challenge.

The next steps are therefore about integration across jurisdictions, disciplines, agencies and institutions, building a shared and agreed strategy within the context of the three objectives. This requires the active involvement and commitment from all players in a nationally coordinated approach, presumably through the National Land & Water Resources Audit II working closely with the Monitoring and Evaluation Working Group. From this base a detailed research strategy can be prepared and implemented.

6 MANAGING KNOWLEDGE FOR CHANGE

6.1 At a Glance

6.1.1 Goal

To define the needs of clients (catchment and regional planners and managers, industries and policy advisers) and to improve their access to and use of the best available data, information and knowledge to deliver the objectives of the NAP and NHT.

6.1.2 Application

Existing regional networks will be able to tap into and interrogate a Clearing House that will access and package relevant information coming from across the Methods and Tools for Action strategies, and from other natural resource research initiatives. The strategy will be developed in a staged manner commencing with a user needs analysis and design phase – that establishes close connections with the client base and existing networks.

6.1.3 Outcomes

The integrated knowledge management framework will result in better exchange of information between regions, between researchers and catchments, and between industries and other sectors. By adding value to existing structures and networks, service delivery will be more effective and efficient – enabling the relatively small investment in science within the NAP and NHT to capitalise on the much larger investment in science external to these programs.

6.1.4 Key Participants

Existing State, Territory and Commonwealth agencies and networks will underpin this strategy. Links to a wide range of research organisations and to clients (catchments and industries) will be other critical partnerships.

6.2 Program Detail

6.2.1 Key Issues

This strategy is based on some fundamental assumptions:

- The primary purpose of the National Action Plan is to invest in on-ground actions *supported by sound science*. Accordingly, R&D is eligible to be funded where it is on the critical path to implementation of measures to meet the core objectives of the NAP;
- It follows then that NAP-funded R&D must deliver outputs within a timeframe that will support on-ground, policy and institutional investments through the NAP (generally 18 months to three years);

- And that NAP-funded R&D must deliver outputs that meet the needs of intended end-users within their adoption context;
- The proportion of total NAP investment allocated to R&D is likely to be modest, and the bulk of that is likely to flow through bilateral agreements between individual jurisdictions and the Commonwealth;
- NAP-funded R&D must build on, link with and add value to relevant existing R&D efforts at all levels, as well as to other enabling components of the NAP including Monitoring and Evaluation, and Capacity Building.

NAP-funded R&D, whether developed through bilateral agreements between particular jurisdictions and the Commonwealth, or through this multilateral process, must be tightly focused on meeting NAP objectives and must be very applied in nature, informed by an acute awareness of the specific needs of end users. It needs to answer real questions that key NAP stakeholders are asking, in a NAP timeframe. The pathways to adoption need to be very clearly mapped and understood by all players including R&D providers. The timeframes alone dictate a high level of end-user involvement in the R&D to increase the likelihood of adoption.

The 21 NAP regions, and the 40 or so other catchments/regions to which funding is likely to be directed through the Natural Heritage Trust (NHT) are at various stages of planning and implementation and accordingly, of defining their information needs. Participants at a catchment level are often able to identify information and knowledge needs in broad terms, but are rarely equipped to translate these into specific research questions. Nor is it realistic to expect them (even those working in full-time research or extension roles) to be aware of all R&D, surveys, investigations, mapping and monitoring, relevant to their needs, that may have been done, is in progress or is planned.

The people involved in planning and implementing NAP investments are the primary audience for the outputs of NAP-funded R&D. Many of these people are engaged at a catchment/regional level in voluntary and paid capacities, employed by catchment bodies or state agencies. State agency personnel operating in management and policy roles at a state level are an important audience, as are policy makers at a national level. Industry leaders, involved in both policy and R&D roles, are also a critical audience for the important challenge of reconciling farm-scale activities and practices with catchment-scale plans and targets (and vice versa).

A critical design and management issue for any NAP-funded R&D is the interface with the delivery context, which is overwhelmingly at catchment and regional level, or at a policy level aimed at assisting implementation at the catchment/regional level. It is assumed implicitly here that farm or paddock scale R&D is unlikely to be funded through this process (and modest at best through any NAP process), so linkages between the NAP and industry- and state agency-based on-farm R&D programs are essential.

Adoption requires careful attention to managing knowledge generated through each of the four Methods & Tools for Action strategies in an integrated way, closely coupled with the delivery context.

Other factors, including efficiency and effectiveness, also dictate such an approach. Resources are limited in terms of the likely funding available, the number and capacity of the R&D providers on each priority, and the time that stakeholders at catchment, policy and on-ground levels have available for participating in R&D. Duplication of effort must be avoided. We cannot afford to repeat each bit of R&D in each catchment/region; and do not have sufficient research capacity to attempt it. Regions need to share information and learn from each other, and any NAP-funded R&D projects need to do likewise.

Understanding the needs of catchment managers, appreciating and packaging the wealth of information available and being generated, and exchanging information effectively will require close linkages between Managing Knowledge for Change strategy and the Capacity Building, and Monitoring and Evaluation initiatives.

6.2.2 Objectives

- To establish a knowledge management framework that maximises learning across and between activities within each of the four Methods & Tools for Action strategies
- To set out options for enhancing uptake of NAP-funded R&D by catchments/regions, policy clients and industry
- To optimise linkages with other areas of NAP investment and with relevant R&D occurring outside the NAP, in particular through industry and state and national programs

6.2.3 Activities

6.2.3.1 *Delivery Options*

There are several broad options for trying to ensure that NAP-funded R&D projects learn from each other, make sense as a whole, can be easily accessed and interpreted from outside, and have the appropriate level of involvement from different kinds of stakeholders.

Option 1: Focal Regions

One option is a focal region approach, where R&D activity is concentrated in particular locales; projects on each R&D priority are delivered (and hopefully integrated) within each site; local stakeholders are intimately involved in planning and implementing the R&D; and presumably adopting R&D outputs as they are generated. There are many examples around of this approach. For instance, Land & Water Australia has applied this approach within the National Dryland Salinity Program, the Remnant Vegetation R&D Program, the National Rangelands R&D Program and the Ord-Bonaparte Program.

This option has the advantages of mirroring the regional approach of the NAP, and of putting the R&D within a delivery context, at least in the focal regions. It does facilitate active participation of key stakeholders within the focal region.

However it also has disadvantages. The concentration of resources within priority regions necessarily leaves out other regions. This means that picking the focal regions often becomes a political exercise. The quality of work done within the focal

region, and in particular the extent to which it is adopted, often depends critically on the existence of committed and talented local champions. Such people tend to live (not coincidentally) in regions that are already relatively well resourced. The sharing of lessons from one region where lots of R&D has occurred to another where very little has occurred is problematic. The best R&D providers do not necessarily want to work in the focal regions. Sharing a geographic focus does not automatically lead to better integration across R&D projects, or between the R&D and its application.

Option 2: Fund the arrows

An alternative approach is to ‘fund the arrows’. Science and information programs, like other funding programs, are typically represented by diagrams like that in Figures 1 & 2 at the beginning of this document, consisting of project activities in boxes joined by lines or arrows purporting to represent some form of connection, linkage or interdependence. Typically, most funding sits within the boxes (projects) and little is left over to resource the arrows – the activities and processes that connect them and make them into a whole (eg forums, workshops, active regional interpretation of distant findings, and packaging information from disparate sources).

Even with a focal region approach, it is important to fund the arrows – too often it is assumed implicitly that co-location will deliver communication and integration. This is far from inevitable.

If the linkages between science project activities; between the overall program and its intended beneficiaries; and between the program and the outside world are sufficiently well resourced, then the geographic location of project level activities can be determined by criteria other than co-location. From an R&D perspective, it is critical to be able to run contestable processes to determine the best provider, and to locate the R&D where it can best explore the issue in question. Some projects may need to be in regions where little work has been done in the past and where champions are scarce.

Finally, if the linkages and interfaces are sufficiently funded, there is a good chance that the overall program will be better integrated, that the whole will be greater than the sum of the parts, and that interested parties will be more easily able to find out what has been achieved and what’s in it for them.

This proposal by definition focuses on science and information that should be relevant to most jurisdictions and most regions. Therefore it needs to be structured so that all jurisdictions and regions can easily access research outputs and synthesis products, and so that linkages with related activities within and external to the NAP are excellent. So the arrows (between ‘boxes’ and between this initiative and the outside world) will have to be funded in any case. Option 2 is thus preferred.

6.2.3.2 A knowledge management framework

The proposed knowledge management framework to add value to NAP-funded science will need to be resourced at project, program, catchment/regional, State/Territory and national levels.

At the project level, for any applied research it is always important to identify the end users, to define R&D outputs in terms of end users' needs, and to map out pathways to adoption including where appropriate the involvement of end users in the R&D process. These steps will be particularly critical for NAP-funded science and particular discipline will be required to ensure that they are integral to project design and implementation.

Having good communication, participation and outside linkages at a **project** level is a necessary but not sufficient condition to ensure good knowledge management at a **program** level. Development of a program-level knowledge management and communication strategy would be an important early priority action. For this proposal, capacity is required to facilitate integration and sharing of lessons within the program, and to resource a comprehensive outreach capacity, given the number, diversity and geographical spread of intended end users.

Some form of Clearinghouse model that provides a 'first stop shop' for finding out what is happening where, what lessons have been learned, who are the key research contacts etc; and for running processes that make it efficient for researchers to interact with each other and with end-users across project and program boundaries, would seem most appropriate. The Clearinghouse would require skilled individuals with high-level process expertise and interpersonal skills, an excellent web-based interface, and sufficient resources to run some extension/outreach activities tailored to the needs of particular stakeholders, jurisdictions, industries or regions. It would also require sufficient expertise to play a coordination and oversight role for project-level communication activities.

All NAP **regions** are wrestling with the challenge of working out what data, information and knowledge they need for what purposes, how to get it, and how to resource it. Consultants are flourishing and the risk of duplication and wasted effort is enormous.

It would be extremely beneficial for the effectiveness of this proposed program, and probably for a range of other NAP purposes, if each NAP region were to form a 'virtual knowledge team' of designated people responsible for leading regional efforts to get a handle on the best available knowledge to meet regional needs and to pin down key gaps. These people already exist across state and catchment agencies and NGOs, but are not necessarily set up this way. They would ideally comprise people having a good overview of the regional knowledge base and research happening within the region, regional extension leaders (public and private) and senior catchment managers with a strong policy/planning perspective. Such teams would be the key point of contact between this NAP-funded R&D and the regions, and they would be important contributors to refining R&D priorities and getting key end-users involved in R&D projects as appropriate. The interface/overlap between such people and the regional/catchment facilitators and community-based coordinators funded by NAP and NHT is obviously important, underlining the need for this program to be developed in concert with the Capacity Building Working Group.

At the national level there is already a considerable investment in natural resource management R&D outside the NAP/NHT framework. Appendix 7.4 summarises some of this activity across the more than 20 relevant Cooperative Research Centres;

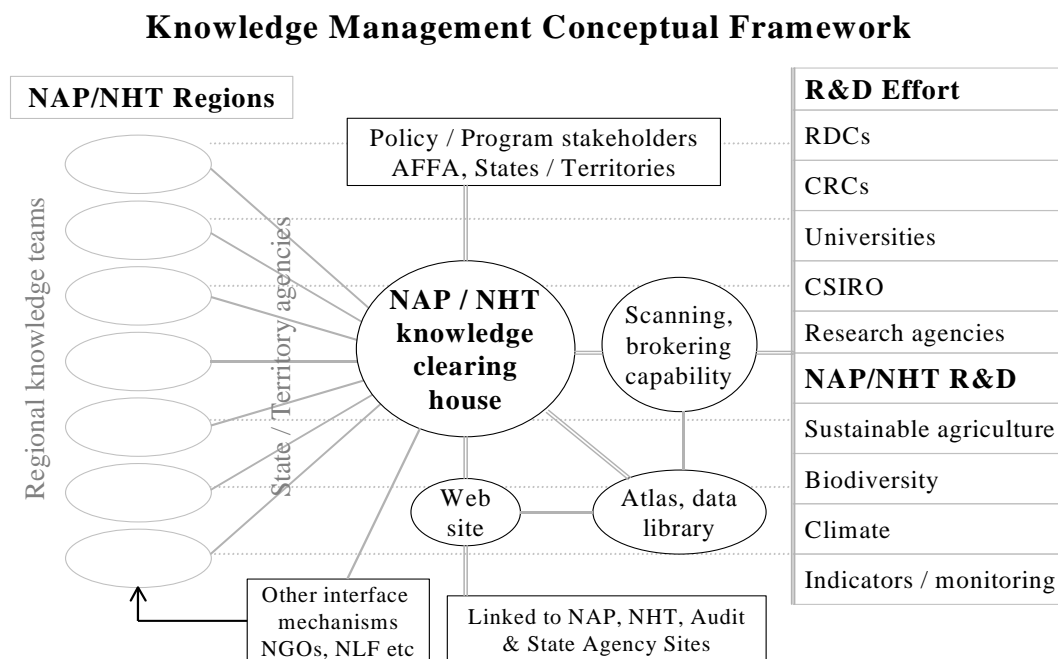
14 R&D Corporations; several divisions and major initiatives of CSIRO; universities; and the research activities and agencies of the Murray Darling Basin Commission; AFFA (BRS, ABARE, Geoscience Australia, AQIS); Australian Greenhouse Office; EA (Bureau of Meteorology, ABRS, GBRMPA); and DoTARS (Bureau of Transport and Regional Economics).

Similarly, there are various equivalents in the States and Territories, where considerable applied R&D into sustainable agriculture and natural resource management is carried out; and where institutions provide support of varied nature to catchment / regional resource management planners. These existing State and regional resources provide a foundation for regional knowledge teams. Their operation would be enhanced by the additional (targeted) services and networks provided via a national Clearinghouse. They would also help feed information on regional needs (and new knowledge generated by regions and States) into the knowledge management network.

6.2.3.3 *Resourcing Knowledge Management*

Figure 3 below outlines the conceptual framework for better achieving a linkage between the policy and program investments of the NAP and NHT on the one hand, and the R&D investments of a wide range of organisations across government and industry at national, state and regional levels on the other.

Figure 3.



At its heart is a Clearinghouse that would ideally have a very close relationship with the National Land and Water Resources Audit, and the associated Atlas and Data Library. The Clearinghouse would have a scanning, linking, broking and synthesis role, and would be a ‘first stop shop’ for anyone involved in the NAP wanting to find out what is happening where in terms of science and who to contact for more detailed

information on a given issue. It would ideally comprise 3-6 people with a mix of skills including high level broad understanding of NRM science and information, expertise in interactive web-based information management, and high level facilitation and process expertise.

The Clearinghouse would have close regular contact with knowledge teams and existing research and extension providers in each region and with the key policy, program and science coordination sections of relevant state agencies, comprising the key end-user market for NAP-funded and other relevant R&D. It would also scan across the full range of R&D providers and be a useful link for them into NAP catchments and regions.

Figure 3 should be seen as a conceptual framework, not as a wiring diagram – the lines represent virtual linkages and information connections rather than any structural relationship. The web site is not necessarily a new one – it could easily build on an existing site.

6.2.4 Outputs

- Analysis of end users and definition of science outputs in terms of end users' needs;
- Mapping of pathways to adoption relevant to NAP and NHT activities, including where appropriate the involvement of industry and end users in the R&D process
- A program-level knowledge management and communication strategy structured variously depending on investment level
- Strategies and capacity to facilitate integration and sharing of lessons within the program, and to resource a comprehensive outreach capacity
- A Clearinghouse that provides a 'first stop shop' for finding out what is happening where, what lessons have been learned, who are the key research contacts etc; and for running processes that make it efficient for researchers to interact with each other and with end-users across project and program boundaries
- A 'virtual knowledge team' (based on existing expertise) for each NAP region, based upon existing expertise and networks, responsible for leading regional efforts to get a handle on the best available knowledge to meet regional needs and to pin down key gaps
- Integration with research and development information and programs across States, Territories and the Commonwealth

7 APPENDICES

7.1 National Action Plan Outcomes

The National Action Plan for Salinity and Water Quality (NAP) was endorsed by the Prime Minister, Premiers and Chief Ministers at the Council of Australian Governments on 3 November 2000. It involves a funding package of \$1.4 billion from the Commonwealth, States and Territories over a seven year period, complementing the \$1.5 billion Natural Heritage Trust (NHT).

The goal of the National Action Plan is to motivate and enable regional communities to use coordinated and targeted action to:

- Prevent, stabilise and reverse trends in salinity, particularly dryland salinity, affecting the sustainability of production, the conservation of biological diversity and the viability of our infrastructure;
- Improve water quality and secure reliable allocations for human uses, industry and the environment.

7.2 Science and Information Working Group

The Science and Information Working Group reports to the Programs Committee of the Natural Resource Management Standing Committee. Its membership comprises representatives from each jurisdiction, plus CSIRO. Land & Water Australia participates as an observer.

The Terms of Reference of the Working Group are as follows:

- Report on critical NAP and NHT priority research issues and directions (taking into account the “Priority National Research and Development” Discussion Paper and the “Proposal for a Commonwealth/State Research and Development Partnership” Paper (critical within six months);
- Identify and report on critical priority research issues and issues associated with the collection and management of information related to NAP and NHT on an ongoing basis;
- Be a forum to bring jurisdictions together for discussions on NRM science and information collection and management to facilitate:
 - Exploration of opportunities for co-investment and collaboration;
 - Workshops for sharing information and experience;
 - Efficiencies and directions in activities and investments.
 - Ensure lasting value by identifying and reporting on science/information management governance issues related to NRM.
 - Science coordination
 - Data management
 - Standards
 - Linkages between R&DC, policy, community providers;

- Recommend mechanisms and proposals which lead to multi-jurisdictional, national R&D activities;
- Recommend mechanisms and proposals which maximise the outcomes of national and multi-jurisdictional NRM programs through the uptake of Science and Information by investors and NRM practitioners.

7.3 Development of the R&D priorities

The Science and Information Working Group prepared a discussion paper titled “National Research and Development Priorities for Natural Resource Management”, in October 2002. The discussion paper identified six research and development themes identified as being of the highest national priority for supporting natural resource management programs:

- Sustainable and economically viable agriculture and land use;
- Biodiversity conservation;
- Integrated catchment management;
- Economic drivers of sustainable natural resource management and the trade-offs that may be associated with these;
- Managing the impacts of climate variability and change; and
- Expanding community capacity building for planning and implementing sustainable natural resource management.

The Programs Committee of the Natural Resources Management Standing Committee directed the Science and Information Working Group to:

- Identify highest priority research activities from the discussion paper and develop them into investment proposals for consideration by the Programs Committee at its February 2003 meeting, with an aim to submit a final Investment Program to the Standing Committee at its March 2003 meeting;
- Develop an understanding for each jurisdiction of precisely what research activities are already underway or planned under the identified priority themes. The objective of this process is to identify gaps in research and the most suitable activities for cooperative/collaborative research in the future.

The Science and Information Working Group implemented a rapid process at its October 2002 meeting to select the highest priority research activities based on the following criteria:

- The issue was a high priority for more than two jurisdictions;
- The research activity was poorly addressed by other programs, mechanisms and institutions (CRCs, RDCs, state agencies, CSIRO etc);
- It was appropriate to address the issue at a national scale (this does not preclude the issue being addressed at different scales as well).

Four key research activities were identified as being of high national significance, and poorly addressed through alternative mechanisms:

- Sustainable Agriculture and Land Use: developing methods and tools to link on-property, industry and regional sustainability targets and strategies and planning;
- Biodiversity Conservation: develop and apply methodologies to assess the relative impacts and potential interactions of a range of threats to biodiversity and assess the potential benefits to biodiversity of a range of management intervention measures that address threats;
- Impacts of climate variability and change: a) Identify priorities for long term investment in R&D and b) assess the potential impacts and costs of climate variability and change on biodiversity, agricultural productivity, water quality and quantity, vegetation and soil health;
- Developing Indicators and Tools: to monitor resource condition, assess trends and predict the outcomes of management interventions – interacting with the Monitoring and Evaluation Working Group who will have identified R&D priorities in early December.

Writing teams were formed to develop work programs/proposals on each of these four priorities, and these teams reported back to the Working Group on Monday 2nd December. With the timeline imposed by Programs Committee, the Working Group agree that a dedicated team needs to be established to complete full drafts by the end of 2002. It was also agreed that the Working Group would seek a suitable external service provider to coordinate and facilitate the development of a final draft Program.

The Working Group invited Land & Water Australia to consider taking on the role of coordinating a writing team that includes a representative from each jurisdiction, to deliver a first draft of the Program description by the end of 2002. It was agreed that the Working Group would act as a Steering Committee to this writing team.

Explanations of the acronyms used in the following tables can be found in the Glossary at the end of this document.

7.4 Other Relevant Research Initiatives

7.4.1 MDBC

INITIATIVE	FUNDING PARTNERS	FOCUS
E-Flows	150m/7 years	<ul style="list-style-type: none"> - improved floodplain health; - better management for fish; and - better management of the Murray mouth, Coorong and the Lower Lakes
Landmark	3 years	To identify, assess and map current land use and current recommended management practices for dryland agriculture against a range of sustainability criteria in dryland agricultural regions of the Basin.

7.4.2 CSIRO

INITIATIVE	FUNDING/PARTNERS	FOCUS
Heartlands	MDBC	This initiative aims to design and achieve sustainable land use change in selected catchments in the Murray-Darling Basin and to monitor its effectiveness in alleviating environmental degradation.
Healthy Country		As a result of Healthy Country, Australia will have an increased capacity to deliver sustainable systems; better manage risks to their implementation; and have a suite of metrics for assessing progress.

7.4.3 R&D Corporations

INITIATIVE	FUNDING/PARTNERS	FOCUS
Land & Water Australia National Dryland Salinity Program	12m/11 years GRDC, AFFA, MDBC, RIRDC, All States	Research, develop and extend practical approaches to effectively manage dryland salinity across Australia.
National Program for Irrigation R&D	27.3m/15 years GMW, MIL, PIRSA, QDNRM, SunWater, CSIRO, Sunraysia, Horticulture Australia, CRDC, DRDC, GWRDC.	Water use efficiency, water services, inter-relationships between irrigation and wider catchment processes, adoption of innovations and best practice guidelines
National Rivers Consortium	5.9m/7 years CSIRO, MDBC, NSW DLWC, WA WRC, SA Catchment & Water Boards.	The Consortium coordinates and plays a leadership role in river restoration and protection, through sharing and enhancing the skills and knowledge of

INITIATIVE	FUNDING/PARTNERS	FOCUS
		its members
National River Contaminants Program	3.9m/5 years MDBC	Management of key contaminants with a focus on salinity, sediments and nutrients.
National Riparian Lands R&D program	8.9m/12 years All States & Territories	Facilitating communities to implement, monitor and evaluate practices for ecologically sound, effective and economic management of riparian lands
National Groundwater R&D	2.8m/9 years	Management and policy information and tools to assist in the sustainable use of groundwater resources and the protection of groundwater quality.
Native Vegetation R&D	10.8m/12 years CSIRO, EA, MDBC	To assist government agencies, community groups and landholders to better manage and conserve native vegetation and its associated biodiversity in rural landscapes
Climate Variability in Agriculture Program	13.3m/14 years AFFA, GRDC, RIRDC, SRDC, CRDC, MLA, AWI, DRDC	To develop products for improved management of the major opportunities and risks arising from climate variability.
Social & Institutional Research Program	8m/11 years	The program has a broad mandate to encompass social, economic, legal, institutional and policy-related disciplines.
MLA Prograze Commenced in 1996	Ongoing. All States.	PROGRAZE provides training and skills development for producers. It develops participants' pasture and animal assessment skills and, importantly, shows producers how to confidently use these skills to improve on-farm grazing decisions.
Sustainable Grazing Systems Commenced 1996	5 years LWA	Addresses the issues of declining pasture productivity and sustainability of the grazing systems in the high rainfall zone of southern Australia.
RIRDC JVAP	10m (1993-) RIRDC, LWA, FWPRDC, MDBC, AFFA	Development of agroforestry options, in particular for mid-low rainfall regions.
Resilient Agriculture	5 years	Investigating alternative production systems including organic farming. Developing agri-industry systems that have sufficient diversity, integration, flexibility and robustness to respond opportunistically to continued change.
AWI		

INITIATIVE	FUNDING/PARTNERS	FOCUS
Land Water & Wool	20.8m/5 years LWA	Sustainable wool production in Australia
GRDC Environmental Analysis	2.6m/7 years	To assess the environmental impacts of dryland and irrigated grain production and storage and processing techniques.
Soil & Water Management	45.2m/7 years	To advance the knowledge base on the principles and processes of managing soil water and nutrient resources within productive, profitable, sustainable grain farming systems.
Sustainable Rotations	46.8m/7 years	To develop, validate and demonstrate improved farming systems appropriate to distinct agroecological zones optimising both economic and ecological sustainability.

7.4.4 CRCs

INITIATIVE	FUNDING/PARTNERS	FOCUS
CRC for Plant Based Management of Dryland Salinity Commenced: 7/01	22.0m/7 years GRDC, CSIRO, Uni. of Adelaide. States: Qld, WA, NSW, Victoria	Management of dryland salinity through the use of profitable, perennial plant-based farming systems.
CRC for Freshwater Ecology Commenced: 7/99	14.0m/7 years CSIRO, ANU, UWA; Unis: Adelaide & Sydney. State: WA	River system ecology, river restoration and sustainable river management - ecological knowledge to manage rivers in a sustainable way
CRC for Catchment Hydrology Commenced: 7/99	16.2m/7 years CSIRO, MDB, BOM. States: Qld, Vic & NSW and Industry Unis: Monash, Griffith & Melbourne	To provide land and water managers with the capability to predict the hydrologic impacts of catchment management.
CRC for Irrigation Futures New – 2002	16.0m/7 years CSIRO, GMW, PIRSA, States: Qld, Vic, SA & NSW and Industry Unis: Adelaide, Sthn Qld & Melbourne	To deliver the science to make it feasible to double productivity while halving water use from irrigated lands within Australia and endeavour to define sustainable irrigation areas and practices.
CRC for Biological Control of Pest Animals Commenced: 7/99	13.9m/7 years CSIRO, MDB; Industry; States: Qld, Vic, NSW & ACT; Unis: Canberra, Monash, Griffith, LaTrobe & Adelaide.	To reducing the devastating environmental and economic impact of introduced pest animals.
CRC for Coastal Zone, Estuary and	14.7m/7 years CSIRO, Geoscience Aust.	Identify decision-making tools and knowledge necessary for the effective

INITIATIVE	FUNDING/PARTNERS	FOCUS
Waterway Management Commenced: 7/99	State: Qld Unis: Qld., Central Qld, Griffith & James Cook	management and ecosystem health of the coastal zone, estuaries and waterways.
CRC for Landscape Environments and Mineral Exploration Commenced: 7/01	20.2m/7 years CSIRO, Geoscience Aust. & BRS Industry States: SA & NSW Unis: ANU, Curtin, Adelaide & Canberra	Breakthroughs in mineral exploration in areas characterised by substantial cover (>100m), with flow-ons of airborne geophysical methods and regolith knowledge to environmental studies, particularly addressing dryland salinity
CRC for Tropical Savannas Management Commenced: 7/01	18.2m/7 years CSIRO, NPWS Industry: MLA States: Qld, NT & WA Unis: Qld, NT & James Cook	Information to underpin management of the tropical savannas for sustainable use and conservation.
CRC for Australian Weed Management Commenced: 7/01	20.3m /7 years CSIRO, GRDC States: Qld, WA, Vic & NSW Uni: Adelaide	To reduce the risks facing the environment, agricultural and rural sectors across all of Australia from current weeds and an increasing number of weed incursions from overseas.
CRC for Water Quality and Treatment Commenced: 7/01	16.8m/7 years CSIRO Industry States: Qld, SA, NSW & Vic. Unis: Curtin, RMIT, Griffith, Monash, SA, NSW, Qld, Adelaide.	Research and knowledge management capability to support the Australian water industry in its role of providing safe and aesthetically pleasing water supplies
CRC for Greenhouse Accounting Commenced: 7/99	15.4m/ 7 years AGO, BRS, CSIRO States: WA, Qld & NSW Uni: ANU	To ensure that Australia is in the strongest position possible to argue internationally for a comprehensive system of accounting for carbon emissions and sinks.
CRC for Conservation Management of Marsupials Commenced: 7/95	13.8m/8 years NZ Manaski Whenua Landcare Research States: Qld, WA Unis: Macquarie & Newcastle	To improve the understanding of fundamental aspects of marsupial reproduction and genetics strategic to the development of practical conservation and management tools and policies.

Glossary

SILO This is a web site service provided by the Bureau of Meteorology (see www.bom.gov.au/silo)
CLIMARC Computerising the Australian Climate Archives (a project run by the Bureau of Meteorology - see <http://www.bom.gov.au/climate/how/climarc.shtml>)

RAINMAN a seasonal rainfall forecasting software tool developed by the Queensland Department of Primary Industries and Fisheries

RAINMAN-STREAMFLOW extension of above for managing seasonal variability (see <http://www.dpi.qld.gov.au/rainman/>)

Flowcast A time series analysis tool – originally for hydrological data (see <http://www.ncea.org.au/QCCAWater/Flowcast/>)

AussieGRASS A spatial modelling software tool for estimating pasture growth (see <http://www.longpaddock.qld.gov.au/AboutUs/ResearchProjects/AussieGRASS/>)

ABARE Australian Bureau of Agricultural and Resource Economics

ABRS Australian Biological Resources Survey

ACLEP Australian Collaborative Land Evaluation Program.

AGO Australian Greenhouse Office

AFFA Agriculture, Fisheries and Forestry Australia (now Department of Agriculture, Fisheries and Forestry)

AQIS Australian Quarantine and Inspection Service

ANU Australian National University

AWI Australian Wool Innovation

BOM Bureau of Meteorology

BRS Bureau of Rural Sciences

CRDC Cotton Research and Development Corporation

CSIRO Commonwealth Scientific and Industrial Research Organisation

CVAP Climate Variability in Agriculture Program

DoTARS Department of Transport and Regional Services (Bureau of Transport and Regional Economics).

DRDC Dairy Research and Development Corporation

EA Environment Australia now Department of the Environment and Heritage

FWPRDC Forests and Wood Products Research and Development Corporation

GBRMPA Great Barrier Reef Marine Park Authority

GMW Goulburn-Murray Water

GRDC Grains Research and Development Corporation

GWRDC Grape and Wine Research and Development Corporation

IPCC Intergovernmental Panel on Climate Change

LWA Land and Water Australia

MBI Market based instruments

MDBC Murray Darling Basin Commission

MEWG Monitoring and Evaluation Working Group - a State and Australian Government officials group (since disbanded) that oversaw implementation of the National Natural Resource Management Monitoring and Evaluation Framework

MLA Meat and Livestock Australia,

NAP National Action Plan on Salinity and Water Quality

NHT Natural Heritage Trust

NSW DLWC formerly the New South Wales Department of Land and Water Conservaton but now the Department of Infrastructure, Planning and Natural Resources (DIPNR)

NVIS National Vegetation Information System

PIRSA Department of Primary Industries and Resources South Australia

PMSEIC Prime Minister's Science and Engineering and Innovation Council

QDNRM Queensland Department of Natural Resources and Mines

R&DC Research and Development Corporations

RIRDC Rural Industries Research and Development Corporation

SRDC Sugar Research and Development Corporation

UWA University of Western Australia

WA WRC Western Australia Water Resources Commission