



Implementation Plan for Climate Change Adaptation Research: Terrestrial Biodiversity

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1. Purpose of Implementation Plan

This Implementation Plan for Terrestrial Biodiversity (2012) outlines implementation directions for the updated priority research questions for climate change adaptation and terrestrial biodiversity, as stated in the *Update Report: National Climate Change Adaptation Research Plan for Terrestrial Biodiversity (2012)* (Update Report; Kitching et al., 2012).

The purpose of this Implementation Plan is to define the most effective way to build (and in some cases initiate) national investments to address the updated priority research questions. The focus is on:

- delivering research to address the objectives of the Terrestrial Biodiversity NARP and the updated priority research questions for terrestrial biodiversity;
- facilitating collaborative arrangements;
- maximising resources for priority research; and

- optimising the timing of research investments.

Implementation Plans consider opportunities for implementing research at a specific time, and so are not static documents. NCCARF updates Implementation Plans periodically to ensure that new opportunities are continually identified, developed and harnessed over time. This implementation plan was revisited and updated during using information from relevant organisations and after discussions with and input from key stakeholders.

This Implementation Plan will be further updated to reflect additional research investment that may arise in a next Phase of NCCARF.

2. Background

2.1 The Terrestrial Biodiversity NARP

The National Climate Change Adaptation Research Facility (NCCARF) developed the *National Climate Change Adaptation Research Plan for Terrestrial Biodiversity* (Terrestrial Biodiversity NARP; Hughes et al., 2010) in 2010 to identify high priority research questions to guide research investment and activity for a five to seven year period. The Terrestrial Biodiversity NARP is one of nine NARPs that address issues arising from the impacts of climate change on key theme areas.

In 2012 NCCARF revisited the Terrestrial Biodiversity NARP to take account of developments after the NARP was completed, including:

- research published since 2010,
- changes to stakeholder information needs since 2010, and
- research commissioned after the NARP was completed.

The revisit process resulted in the preparation of an Update Report (Kitching et al. 2012) that sets out amendments to the list of priority research questions identified in 2010. The new list of high priority research questions is provided in Appendix 1.

2.2 Preparation of the Implementation Plan

NCCARF has updated the Terrestrial Biodiversity Implementation Plan in 2012 to take account of changes in:

- the capacity of Australian researchers to undertake climate change adaptation research for terrestrial biodiversity and
- the capacity of key potential research funding organisations to invest in research to address the updated research priorities in the terrestrial biodiversity research theme.

Australia has a long history of high-quality research that addresses terrestrial biodiversity, funded by both the public and private sectors. This research provides a good platform for a national focus on climate change adaptation research that addresses the updated priority research questions for terrestrial biodiversity.

3. Potential Sources of Research Funding

This section outlines potential sources of funding to support research aimed at supporting sound decisions about climate change adaptation and terrestrial biodiversity.

3.1 Key changes since 2010

Since the first Implementation Plan (2011) for the Terrestrial Biodiversity NARP was completed, several developments have affected funding for climate change adaptation for terrestrial biodiversity.

- Ten research projects directly relevant to the priority research questions in the Terrestrial Biodiversity NARP have been commissioned under the Adaptation Research Grants Program (ARGP) (see Section 3.2).
- NCCARF has commissioned seven research projects under the Synthesis and Integrative Research (SIR) program that are also relevant to climate change adaptation and terrestrial biodiversity (see Box 4 in Kitching et al., 2012).
- All ARGP funding has been allocated (see Section 3.3.2).
- Griffith University, NCCARF and DCCEE are investigating options for further research funding for this theme and for an extension of NCCARF (see Section 3.3.2).
- Over 30 research projects concerned with climate change adaptation and terrestrial biodiversity have been commissioned by other research investors (see Box 5 in Kitching et al., 2012).
- The Commonwealth government has initiated several major programs through the Clean Energy Future package that are relevant to climate change adaptation for terrestrial biodiversity;
 - the Biodiversity Fund,
 - the Carbon Farming Initiative,
 - the Regional Natural Resource Management Planning for Climate Change Fund,
 - Indigenous Carbon Farming Fund and
 - other programs implemented through DAFF.

3.2 Current NCCARF (ARGP) Research Program for Terrestrial Biodiversity

In 2010, the Department of Climate Change and Energy Efficiency (DCCEE) agreed to provide Adaptation Research Grants Program (ARGP) funds to support climate change adaptation research that addressed priority research questions identified in the original Terrestrial Biodiversity NARP. Ten research projects have been commissioned using the NCCARF (ARGP) funding that address the priority research questions in the original Terrestrial Biodiversity NARP. The total value of this research portfolio, including ARGP funds, other funding and in-kind from researchers and other parties, is about \$6,600,000. The projects are listed in Appendix 2. A further five ARGP research projects commissioned under other themes are also relevant to climate change adaptation and terrestrial biodiversity. Reports for these projects will be available by June 2013.

All ARGP funds have been allocated.

3.3 Australian Government

3.3.1 *Regional Natural Resource Management Planning for Climate Change Fund*

The Regional Natural Resource Management Planning for Climate Change Fund has been established to support the updating of existing regional NRM plans to guide planning for climate change impacts on the land and to maximise the environmental benefits of carbon farming projects. The key goal is to guide where biosequestration projects should be located in the landscape to maximise the benefits for biodiversity, water and agricultural production. Around \$44m over five years will be available from the Regional Natural Resource Management Planning for Climate Change Fund through two streams: Stream 1 will enable regional NRM organisations revise existing regional NRM plans (see Section 3.3.3); Stream 2 will support development of regional-level information in the form of scenarios about the impacts of climate change (see Section 3.3.2).

3.3.2 *Department of Climate Change and Energy Efficiency*

Adaptation Research Grants Program

The Department of Climate Change and Energy Efficiency (DCCEE) provided \$27 million over 2008-2013 for the Adaptation Research Grants Program (ARGP), managed as seed funding for research to address the priority research questions identified in the nine themes of the NCCARF program.

As noted in Section 3.2, DCCEE allocated ARGP funds for research focussed on priority research questions in the original Terrestrial Biodiversity NARP, and all of this funding has been allocated. However, DCCEE retains an interest in promoting further research about this and other NARP themes.

Griffith University, NCCARF, the NCCARF Board and DCCEE are looking at options for an extension of NCCARF. No funding for further terrestrial biodiversity research will be available from an extension of the ARGP until decisions are made about the future of NCCARF.

Regional Natural Resource Management Planning for Climate Change Fund

DCCEE administers Stream 2 of the Regional Natural Resource Management Planning for Climate Change Fund that will provide \$15m over five years from 2012 to support development of regional-level information in the form of scenarios about the impacts of climate change (water, temperature, storms) which can be used for medium term regional natural resources management (NRM) land use planning.

3.3.3 *Department of Sustainability, Environment, Water, Population and Communities*

The Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) has primary responsibility for national environmental policy and programs, and supports research to enable it to meet its responsibility through evidence-based policy.

Regional Natural Resource Management Planning for Climate Change Fund

SEWPaC administers Stream 1 of the Regional Natural Resource Management Planning for Climate Change Fund that will provide \$28.9m over five years from 2012 to support the 56 regional NRM organisations to revise existing regional NRM plans to help identify where in the landscape adaptation and mitigation activities should be undertaken. Stream 1 will provide assistance to regional NRM organisations to incorporate climate change mitigation and adaptation into existing regional NRM plans.

National Environmental Research Program

SEWPaC implements the National Environmental Research Program (NERP) that provides around \$20 million each year to five NERP Hubs to support public good environmental research to improve Australia's capacity to understand, manage and conserve the nation's unique biodiversity and ecosystems. This funding is used for world-class research, and its delivery to Australian environmental decision makers and other stakeholders. Four of the five NERP hubs are conducting research that is potentially relevant to climate change adaptation and terrestrial biodiversity.

- The **NERP Environmental Decision** hub carries out multidisciplinary, applied research in decision science for biodiversity conservation. The research will result in new tools, data, models and syntheses to enable Australian governments to make evidence-based decisions that protect biodiversity. The research program is structured around delivering outcomes on each of the five NERP research priorities: values, ecosystems, threats, sustainable use and markets."

- The **NERP Tropical Ecosystems Hub** has twelve programs in three themes, all of which are potentially relevant to climate change adaptation. Two programs have an explicit reference to climate change and terrestrial biodiversity:
 - Condition and trends of North Queensland Rainforests;
 - Threats to rainforest health.
- The **NERP Northern Australia Hub** focuses on the terrestrial, freshwater and estuarine ecosystems of the northern savanna landscapes. The Hub's research program is concerned with :
 - gaps in understanding of biodiversity patterns;
 - adaptive planning to respond to current and emerging threats;
 - effective methods for monitoring and reporting on biodiversity and ecosystem health;
 - benefits derived from community-based natural resource management; and
 - opportunities to support Indigenous livelihoods.
- The mission of the **NERP Landscapes and Policy Hub** is to bring consideration of biodiversity into mainstream planning processes by fostering an interdisciplinary approach that (i) incorporates integrated assessment of social, institutional, economic and biophysical attributes and (ii) is capable of examining the likely consequences of alternative biodiversity policies, planning instruments and institutional arrangements. This Hub has three research themes:
 - Communication
 - Social and Economic Futures
 - Ecological Futures

Caring for our Country

Caring for our Country is an ongoing program of the Australian Government that works towards achieving an environment that is healthier, better protected, well-managed and resilient, and provides essential ecosystem services in a changing climate. It will be delivered over the period 2013-18 through a Sustainable Environment stream, delivered by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and a Sustainable Agriculture stream, delivered by the Department of Agriculture, Fisheries and Forestry. In December 2012 the Australian Government released its prospectus "One Land – Many Stories" for investment in national biodiversity. The Prospectus joins the Sustainable Environment stream of Caring for our Country with the parts of the Land Sector Package (including the Biodiversity Fund) that are administered by DSEWPaC. It sets out the Government's priorities for funding conservation and improving natural resource management in 2013–14. The framework specifies the target areas, national priorities (investment themes) and the available grant funding to guide development of project proposals in the 2013–14 round of biodiversity conservation and natural resource management investment. While climate change is an important theme within the document, the Department's support for biodiversity-related research is provided mainly through the National Environmental Research Program.

Terrestrial Ecosystem Research Network

The Terrestrial Ecosystem Research Network (TERN) builds on significant past investments by scientists and governments to understand Australian ecosystems by focussing on collating, calibrating, validating and standardising existing data sets. TERN also funds new research infrastructure and collection systems, expanding observation and monitoring programs into unrepresented ecosystems, and building digital infrastructure to store and publish this information in a form that can be searched and accessed freely under licenses that acknowledge the data provider(s) and build collaborative research.

TERN also creates a network for sharing ideas and is able to support high-level analysis and synthesis of complex ecosystem data across the science-policy-management continuum. TERN thus encourages an open and collaborative approach to ecosystem science in Australia.

Australian Centre for Ecological Analysis and Synthesis

The Australian Centre for Ecological Analysis and Synthesis (ACEAS) within TERN is designed to link ecosystem scientists and environmental managers to improve our understanding and management of Australian ecosystems. ACEAS activities support multi-disciplinary integration, synthesis and modelling of ecosystem data. ACEAS' support is specifically directed to facilitate the development of evidence-based environmental management strategies and policy at regional, state, and continental scales.

3.3.3 Department of Agriculture, Fisheries and Forestry (DAFF)

DAFF implements several climate change adaptation research programs that are focussed on primary industries or rural communities and businesses, but that may be relevant to terrestrial biodiversity. They include a new research investment program for climate change adaptation and mitigation (*Climate Change Research Program (CCRP)*) that was introduced in 2012 to augment and extend two previous research programs having a similar focus (*Australia's Farming Future (AFF)*, and the *Forest Industries Climate Change Research Fund (FICCRF)*).

The Adaptation Research Program (ARP) component of the CCRP was established to help farmers develop strategies and practices to manage the effects of climate change. Projects commissioned under the ARP aim to help land managers adapt to a changing climate while increasing productivity. The ARP includes funding from the CCRP, state departments and industry and research bodies.

Australia's Farming Future (AFF) made \$46 million available for research projects and on-farm demonstration activities that focus on reducing greenhouse gas pollution, improving soil management and adapting to climate change impacts. The program goals of the Forest Industries Climate Change Research Fund (FICCRF) relate to supporting climate change adaptation by forest industry stakeholders.

While all of these research programs have a clear industry or commodity focus, some of the research may also help inform climate change adaptation for terrestrial biodiversity.

All DAFF funds available through these programs have been fully allocated at present. There may be a further round for the CCRP, but there will be no further investments through the AFF and FICCRF.

3.3.4 Other Australian Government Departments

Some other Australian Government Departments, or Divisions within Departments, appear to have a direct or indirect interest in climate change adaptation for terrestrial biodiversity. However, no investment for research that addresses the updated priority research questions for terrestrial biodiversity has been identified at present. The most relevant department is:

- Department of Innovation, Industry, Science and Research (www.innovation.gov.au) administers several key programs that support research in Australia.
 - The mission of the Australian Research Council (ARC) mission is to deliver policy and programs that advance Australian research and innovation globally and benefit the community. The ARC provides advice to the Government on research matters, manages the National Competitive Grants Program and other research support and investment programs (see Section 3.5).
 - The Cooperative Research Centre (CRC) program supports end user driven research collaborations to address major challenges facing Australia. CRCs pursue solutions to these challenges that are innovative, of high impact and capable of being effectively deployed by the end users (see Section 4.8).

3.4 State and Territory Government Organisations

For many decades state and territory governments have strongly supported terrestrial biodiversity research. Climate change responses (both mitigation and adaptation) are progressively being built into strategic planning and operations of relevant state government organisations, including into research programs.

State and territory governments have both departmental administrative arrangements, including on-ground conservation and other management activities, and research capacity in terrestrial biodiversity. A strength of state and territory research arrangements is that departments are able to respond to external research initiatives that align with existing research objectives by contributing state-based resources and support on a project-by-project basis, within a long term policy context.

Collaborative arrangements between state and territory government agencies and other research investors are thus important elements of Australia's national research effort on terrestrial biodiversity. NCCARF will continue to explore possible opportunities for collaboration on research investment with state, territory, and local governments.

3.5 Australian Research Council (ARC)

The Australian Research Council is often the first port of call for many researchers and research institutions seeking additional support for research. Grants offered by the ARC under its National Competitive Grants Program (NCGP) include Discovery Project and Linkage Project grants. Through the NCGP, the ARC aims to support research and research training of national benefit. Responding to climate change and variability is identified as a priority goal under the national research priority of *An Environmentally Sustainable Australia*.

Another ARC scheme, ARC Future Fellowships, promotes research in areas of critical national importance by giving outstanding researchers incentives to conduct their research in Australia. The aim of ARC Future Fellowships is to attract and retain the best and brightest mid-career researchers and significantly boost Australia's research and innovation capacity in areas of national importance. Preference is given to those researchers who can demonstrate a capacity to build collaborations across industry, research institutions and other disciplines.

Over a five-year period (2009-2013), ARC Future Fellowships offer four-year fellowships to 1,000 outstanding Australian and international researchers. In addition, each researcher's administering organisation receives funding of up to \$50,000 per year to support related infrastructure, equipment, travel and relocation costs. About 800 Future Fellowships have been announced so far (2009 to 2012).

Opportunities for funding climate research adaptation research for terrestrial biodiversity also exist within the ARC Centres of Excellence scheme. The main existing Centre with relevance to the Terrestrial Biodiversity NARP is the ARC Centre of Excellence in Plant Energy Biology that focuses on better understanding the way in which plants produce and use their energy systems in response to environmental change. The ARC Centre of Excellence in Plant Energy Biology has received extension funding until 2013. The ARC Centre of Excellence for Environmental Decisions will generate knowledge and tools needed to support effective conservation investments, including those made at a catchment scale in mixed use landscapes. The ARC Centre of Excellence for Climate System Science is seeking to transform the foundation for impacts and adaptation research in Australia by improving advice to all levels of Government and the broader community on the scale, speed and timing of regional climate change. The information generated will minimize threats and maximize opportunities in regional climate science and can be integrated into national frameworks, yielding direct economic, social and environmental benefits.

3.6 Private Sector and Community

A wide range of peak bodies for industry sectors, non-government organisations and advisory bodies are aware of the need to adapt to climate change. They may either have access to funds or are able to lobby and leverage funds across a range of program areas.

Collectively, these and similar bodies are able to influence and contribute to the adaptation research agenda through various innovative funding arrangements. NCCARF will continue to explore future funding opportunities in this area.

3.7 Summary

Funds to support projects focussed on the updated priority research questions for terrestrial biodiversity are potentially available from a number of sources, subject to the proposed research meeting their individual guidelines. Potential sources include SEWPaC, DAFF and other Commonwealth government agencies, and state and territory government agencies. In many cases these organisations are keen to co-invest through partnerships in ARC, CRC or similar research collaborative arrangements.

4. Potential Sources of Research Delivery

Australia has a long history of ecological research aimed at understanding and conserving the nation's biodiversity. Groups with an existing focus on terrestrial biodiversity research provide a strong research platform to address the updated priority research questions.

This section describes the main research organisations able to deliver research focussed on the updated priority research questions for terrestrial biodiversity. In many cases, these research organisations have access to resources that might help fund the research.

4.1 Key changes since 2010

- Australia's research capacity for climate change and terrestrial biodiversity has a greater focus on adaptation options, as opposed to understanding the impacts of climate change on terrestrial biodiversity.
- The membership of the Adaptation Research Network for Terrestrial Biodiversity has increased from about 480 members to about 1030 members and now comprises almost equal membership of research providers and research users (see Section 4.6).

4.2 State Departments and Agencies

Every state and territory government in Australia has a long history of delivering research to conserve its terrestrial biodiversity. In many cases research findings at the state or territory level can also contribute to conservation in other jurisdictions.

Research undertaken by state and territory agencies may be directly funded by the relevant department, or jointly funded such as through a CRC program, an ARC-supported project, or CSIRO activity. Joint funding and research arrangements are highly valuable, as they ensure potential users of the research findings are involved in a research project, and so understand the potential application and limits of its findings. Jointly generated research outputs are thus more likely to be effectively communicated, understood and used.

State departments and research agencies are likely to support partnership arrangements on a project-by-project basis to address the updated priority research questions for terrestrial biodiversity where the priorities align with their own strategic and operational plans and where the project meets the competitive funding arrangements in the department/agency.

4.3 Universities

Universities employ researchers with wide-ranging capabilities for research across disciplines relevant to terrestrial biodiversity - from highly theoretical approaches which challenge the ways

we frame problems through to practical problem solving. Most university-based researchers collaborate closely with research clients such as RDCs, government departments, catchment management groups, CSIRO or industry.

Universities offer the opportunity to assemble large groups of researchers from diverse disciplines, frequently across several universities, to tackle complex multi-faceted problems. Universities generally welcome partnership arrangements such as those with CRCs, other research groups (including those overseas) and agencies, but need to consider carefully costs and benefits on a case-by-case basis.

4.4 Commonwealth Scientific and Industrial Research Organisation (CSIRO)

The Climate Adaptation Flagship provides the primary CSIRO focus for climate change adaptation research. Research related to the Terrestrial Biodiversity NARP and the updated priority research questions for terrestrial biodiversity is implemented mainly through CSIRO's Species and Ecosystems theme. Within this theme, CSIRO is developing and delivering adaptation options to protect Australia's marine and terrestrial species, ecosystems and the services they provide.

To identify and manage the threats facing our biodiversity and ecosystems Flagship researchers work in two key areas:

1. Predicting the responses of natural ecosystems to climate change, and developing adaptation options to improve their resilience;
2. Reducing the threats posed by invasive species, bushfires and habitat loss through development of well prioritised response strategies

The Climate Adaptation Flagship provides information for ecosystem managers and policy makers, and helps to improve how climate change adaptation is embedded into policy, by responding to requests from policy agencies.

CSIRO considers partnerships in research investment on a project-by-project basis depending on the mutual alignment of interests. Examples include long-term partnerships in CRCs and other research ventures where the prospects of end-user engagement and research effectiveness are likely to be increased by partnering. CSIRO is not a funding agency *per se* but does co-invest from time to time when there are distinct opportunities to align its research interests with those of partner organisations.

4.5 Centre for Australian Weather and Climate Research

The Centre for Australian Weather and Climate Research (CAWCR) is a partnership between Australia's leading atmospheric and oceanographic research agencies - the Bureau of Meteorology and CSIRO. CAWCR was established in 2007 to ensure that Australia remains a world leader in climate, weather and oceans research, and thus able to meet the changing weather and climatic challenges that continue to confront the nation. The centre has five research programs:

1. Atmosphere and land observation and assessment;
2. Ocean observation, assessment and prediction;
3. Coupled earth system modelling;
4. Weather and environmental prediction;
5. Seasonal prediction, climate variability and change.

These research activities will improve observational databases, improve understanding of observed climate variability, and deliver climate predictions (seasonal to decadal) for use in risk assessments. Improved accuracy and resolution of the prediction of future climate are particularly relevant for adaptation responses in Australia's terrestrial biodiversity.

CAWCR could provide contextual climate change information to underpin research projects that address priorities in the NARP, in particular outputs from the physical models used to make future climate projections.

4.6 Adaptation Research Network for Terrestrial Biodiversity

The NCCARF *Terrestrial Biodiversity Adaptation Research Network (TBARN)*, hosted by James Cook University, has a membership of about 1030 members, comprising researchers from universities, government research institutions, and industry and research-using decision-makers or policy analysts from government, business and the producer community. Collectively, the members have access to a wide range of field and laboratory research facilities and have knowledge of the pathways to public and private sector research investment funds.

The primary goal of The Terrestrial Biodiversity Adaptation Research Network is to develop explicit and practical strategies that increase the resilience of terrestrial ecosystems and maximise their adaptive potential under climate change. The research priorities of this network are to collate knowledge, co-ordinate expertise and synthesise these inputs into recommendations and frameworks that will guide the way forward for Australia to adapt to global climate change.

The philosophy of the network is to have a truly national focus, and thus to distribute both activities and funding opportunities across all states and territories, and amongst as broad a range of researchers, institutions, and stakeholder organisations as possible.

The Network plays a key role in building national consortia to address research priorities for terrestrial biodiversity, and it supports the NCCARF knowledge adoption team's efforts to communicate the outputs of research to end users.

4.7 Cooperative Research Centres

Cooperative Research Centres (CRCs) bring together researchers from universities, CSIRO, other Australian and state government research organisations, private industry, and/or public sector agencies in long-term collaborative research arrangements. CRCs are funded to support research, development and education activities to achieve real outcomes of national economic and social importance.

The following is a listing of the CRCs most directly and immediately relevant to the updated priority research questions for terrestrial biodiversity.

- CRC for Forestry (2013)
- Future Farm Industries CRC (2015)
- Invasive Animals CRC (2013)
- Bushfire CRC (Funded until 2014)

Two applications for new CRCs invited to stage two consideration in early 2013 are potentially relevant to climate change adaptation and terrestrial biodiversity. These are concerned with resilient communities and with safeguarding biodiversity.

Opportunities for collaboration with these CRCs to deliver and potentially fund national level research into climate change and terrestrial biodiversity need to be explored on an ongoing basis. Opportunities are likely to exist on a project-by-project basis.

4.8 Geoscience Australia

Geoscience Australia (GA) is a prescribed agency within the Australian Government Department of Resources, Energy and Tourism. It conducts geoscience research to inform government policy, including development of fundamental data and information products needed for climate change adaptation.

GA provides a national dynamic mapping system that places current land cover status and changes into a historical context at a national, regional and local scale. This mapping system is designed to support and facilitate natural resource management decision-making, and to act as a national standard baseline for change detection and environmental reporting. Other important services include estimating ground water recharge and discharge, supporting hazard analysis and emergency management and supporting navigation systems.

GA's research and policy advice is supported in large part through the agency's appropriated budget, and through collaborative or co-funded projects with the Australian, state and local governments, CRCs, universities, and industry partnerships. GA seeks partnerships to develop, maintain, and value-add to geoscience information to inform government policy and the public with an emphasis on resilience. GA is not a funding agency, but does co-invest in areas of interest to the Department's resources, energy and tourism portfolio – including in terrestrial biodiversity where geospatial and geoscience information underpins vulnerability and risk analysis.

4.9 Regional and local partnerships

Terrestrial biodiversity is a valuable resource for regional and local residents for active recreation, landscapes, or other purposes and values. Many regional and local partnerships have developed across Australia between universities and other research organisations and state agencies, regional organisations, and local groups that are interested in climate change adaptation options for terrestrial biodiversity. Some of these partnerships include local residents who support or conduct research. Combining the management support of institutions, professional knowledge of scientists and local knowledge of residents creates a valuable research resource. In addition to the many informal or purpose-driven partnerships having a broad interest in terrestrial biodiversity, there are two formally organized groups of partnerships that are well placed to support climate change adaptation research for terrestrial biodiversity.

Regional Natural Resource Management (NRM) organisations

The 56 Regional Natural Resource Management (NRM) organisations (see <http://www.nrm.gov.au/about/nrm/regions/index.html>) are being supported to update existing regional NRM plans to guide planning for climate change impacts on the land and to maximise the environmental benefits of carbon farming projects, especially to guide where biosequestration projects should be located in the landscape to maximise the benefits for biodiversity, water and agricultural production (see Section 3.3.1).

Regional Development Australia

Regional Development Australia (RDA) is an Australian Government initiative that brings together all levels of government to enhance the development of Australia's regions. A national network of 55 RDA committees, based on local government areas, has been established to achieve this objective and develop local solutions to local issues.

4.10 Private sector and commercial research organisations

Private sector and commercial organisations may also be interested in undertaking research where the topic is relevant to their objectives. Research collaborations with commercial entities are likely to arise both through targeted programs and opportunistically.

4.11 Summary

Research capacity to undertake projects focussed on the priority research questions in the Terrestrial Biodiversity NARP is available from a wide range of providers, including state agencies, universities, CSIRO and CRCs. Many community members are also keen to and able to contribute to conservation research activities. Many professional research providers are members of TBARN, and are well placed to participate in the type of integrated research consortia that are necessary to

meet the challenges of climate change adaptation research for terrestrial biodiversity. However, as some research providers may not be members of TBARN, it will also be necessary to ensure that any call for research proposals is widely publicised in the relevant media.

5. Strategy for National Coordination

There is a broad recognition by government, industry, business, communities and individuals that adaptation to climate change will become an increasingly important factor for decisions about conservation of terrestrial biodiversity. Research commissioned since the original Terrestrial Biodiversity NARP was completed will contribute to sound decisions about climate change adaptation. This includes ten NCCARF-funded research projects focused on high priority research questions in the Terrestrial Biodiversity NARP (see Section 3.2 and Appendix 2) that will report by June 2013, and a further 12 NCCARF-managed research projects that are relevant to this theme. Additional research is being funded and / or conducted by a variety of other research investors (e.g., ARC, RDCs), research organisations (e.g., CSIRO), and Commonwealth and state agencies.

The long history of high-quality Australian research and coordinated research delivery in terrestrial biodiversity, at national, regional, and local levels, provides a good platform for developing research in this area. The updated priority research questions for the Terrestrial Biodiversity NARP provide guidance for research and development agendas for terrestrial biodiversity for the coming five to seven years.

5.1 Immediate investment

The Australian Government's *Climate Change Adaptation Research Grants Program (ARGP)* funding is now fully allocated. No further funding for climate change adaptation research is currently available from this source during the present phase of NCCARF.

Some Australian Government departments have an interest in climate change adaptation research for terrestrial biodiversity. For instance, SEWPaC may be in a position to invest in research that is relevant to updated priority research questions, especially those that help inform national policy. DAFF may be interested in investing in research that supports effective adaptation in multiple use landscapes involving both primary industries and conservation objectives. State and territory agencies are likely to invest in research that is germane to their priority interests.

The ARC has regular calls for research, including research relating to climate change adaptation. There is every reason to presume that sound research proposals are likely to be successful.

CSIRO and CRCs undertake research relevant to the Terrestrial Biodiversity NARP research priorities.

NCCARF will continue to investigate the availability of additional resources for new research programs that will advance Australia's climate change adaptation knowledge base for the terrestrial biodiversity theme.

NCCARF is also developing an on-line hyperlinked source-page of potential climate change adaptation funding sources available to Australian researchers. When this page is live it will be announced at www.nccarf.edu.au and all Adaptation Research Network members will be advised.

5.2 Building the Program

A next Phase of NCCARF is being proposed to commence from 2013. NCCARF is seeking to establish a new round of core funding for further climate change adaptation research, with additional funds available for the terrestrial biodiversity theme.

NCCARF will continue to investigate with all potential research investors, especially SEWPaC and other government agencies, how further coordinated research programs could be developed to advance Australia's capacity to respond effectively to climate change adaptation challenges and opportunities.

NCCARF will continue to monitor the interests of stakeholders with a view to developing and enhancing opportunities for research investment and collaboration.

6. IMPEDIMENTS AND RISKS

6.1 Impediments

Australia's terrestrial biodiversity research community is now more focussed on and experienced with climate change adaptation research than it was when the original Terrestrial Biodiversity NARP was completed in 2010. Nevertheless, the challenges of building and delivering a national research program to address the priorities in the Terrestrial Biodiversity NARP will require several research phases.

Implementing the research agenda will therefore take time. A key focus will need to be on increasing the size of the research funding directed to this research agenda – across a wide variety of organisations and stakeholder groups - while at the same time utilizing the resources available immediately for carefully targeted and effective research.

6.2 Risks

NCCARF has invested \$3,200,000 of ARGP funds in ten projects commissioned for the terrestrial biodiversity theme, having a total research value of about \$6,600,000 (cash and in-kind). NCCARF has also invested in 12 other research projects relevant to the research priorities for this theme. In addition to NCCARF's investment, many other research investors are supporting climate change adaptation research relevant to this sector. NCCARF will continue to collaborate with other relevant organisations to ensure the outcomes from research activities relevant to the priority research questions are available to support sound decisions about climate change adaptation for terrestrial biodiversity.

7. Monitoring

NCCARF will continue to monitor the progress of research commissioned under the NCCARF research program, and will ensure delivery of the findings of these research activities by June 2013. NCCARF also identifies other research being conducted across Australia that implements the priority research questions in the Terrestrial Biodiversity NARP to identify emerging gaps and further research needs. NCCARF will also continue dialogue with key stakeholders and the research community.

The Terrestrial Biodiversity NARP and Implementation Plan will be updated periodically to take account of changes in the information base available, current research being undertaken and changes in stakeholder information needs. NCCARF, through a dedicated research program, also synthesises research outcomes as these evolve.

NCCARF undertakes a yearly survey of stakeholders which obtains feedback about a variety of issues including stakeholder engagement in projects and the delivery of useful information to end users.

8. Communication and Engagement

The communication of research outcomes will take into account the information needs of end users and an appreciation of the most appropriate mechanisms to deliver that information. In order to better understand the information needs of end users, NCCARF and its Adaptation Research Networks have established a number of mechanisms for engaging with key stakeholders, for example by including end users in the research planning process, and through symposia and stakeholder workshops. NCCARF, through a dedicated program, will also synthesise research outcomes as they are completed.

9. Acronyms

AFF	Australia's Farming Future.
ARC	Australian Research Council
ARN	Adaptation Research Network
CSIRO	Commonwealth Scientific, Industrial and Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DCCEE	Department of Climate Change and Energy Efficiency
GA	Geoscience Australia
NARP	National Climate Change Adaptation Research Plan
NCCARF	National Climate Change Adaptation Research Facility
NRM	Natural resource management
RDC	Research and Development Corporations
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities
TBARN	Terrestrial Biodiversity Adaptation Research Network

10. References

- Hughes, L., Hobbs, R., Hopkins, A., McDonald, J., Stafford Smith, M., Steffen, W., Williams, S. (2010) National Climate Change Adaptation Research Facility, Gold Coast.
- Kitching R, Boulter S, Hobbs R, Mansergh I, McKellar R, Stafford Smith M, Wardrop M, 2012: Update Report: National Climate Change Adaptation Research Plan for Terrestrial Biodiversity, *National Climate Change Adaptation Research Facility*, Gold Coast.

Appendix 1: Updated Priority Research Questions for Terrestrial Biodiversity (2012)

High priority research questions (2012)
1. National- / continental scale issues
1.1 How will climate change affect existing conservation goals and how should changed conservation goals be promoted and achieved?
1.2 How can the existing Australian legal, policy and institutional architecture for land management and biodiversity conservation respond to changes in conservation goals caused by climate change?
1.3 What conceptual models and long-term observation systems are needed to support the design, analysis and assessment of active adaptive management and policy experiments at regional and national scales under climate change?
2. Regional issues
2.1 What principles should guide ecosystem-based adaptation in Australia and the design of landscapes to support ecosystem resilience?
2.2 How will climate change interact with other key stressors such as fire, invasive species, salinity, disease, changes to water availability, grazing and clearing, and what are the integrated implications for ecosystem structure and functioning?
2.3 How can Australia's land-based carbon mitigation initiatives be designed to enhance ecosystem services, ensure appropriate ecological connectivity, deliver biodiversity conservation benefits and avoid adverse impacts on biodiversity?
2.4 How can the major socio-economic trends occurring in many regions of Australia contribute to effective climate change biodiversity adaptation responses?
3. Local land management issues
3.1 What are the costs and benefits of different climate change adaptation measures in vulnerable ecological communities and ecosystems?
3.2 How should fire management adapt to climate change?
3.3 How can management of local protected areas incorporate and adapt to climate change?
3.4 How can we better integrate conservation plans and actions across landscapes, incorporating protected area management, off-reserve conservation measures and other land uses, in order to maximise biodiversity conservation benefits / outcomes under a changing climate?
4. Managing key species and communities
4.1 How can investment in climate change adaptation measures to conserve species and communities be prioritised?
4.2 How will climate change affect current management actions for protecting priority species and communities, and what management changes will be required?
4.3 How will climate change affect current or potential problem species and what management responses will be required?

Appendix 2: Current NCCARF (ARGP) Research for Terrestrial Biodiversity

Project Title and Description	Principal Investigator and Institution
<p>TB1101 The architecture of resilient landscapes: scenario modelling to reveal best-practice design principles for climate adaptation</p> <p>One of the most cost-effective ways to help Australia's native species survive climate change is to ensure their populations are as large and connected as possible. This means that management to protect Australia's biodiversity will need to happen over whole landscapes, not just in national parks. So do we need lots of corridors or more habitats? This project will evaluate different approaches to managing biodiversity across landscapes and calculate how likely they are to improve the resilience of native species.</p>	<p>Veronica Doerr CSIRO</p>
<p>TB1102 Optimal habitat protection and restoration for climate adaptation</p> <p>Research has shown that many species are likely to go extinct because of climate change, but which species these will be, and what we can do to prevent these extinctions remain uncertain. This project will predict how species and habitats will move in response to climate change over the next century, then work out how much it will cost to protect existing habitat and restore new habitat where this would help species survive.</p>	<p>Richard Fuller University of Queensland</p>
<p>TB1103 Climate-resilient vegetation of multi-use landscapes: exploiting genetic variability in widespread species.</p> <p>Multi-million dollar investments in ecosystem maintenance through restoring Australia's degraded landscapes currently take little account of climate change. Until recently there has been a strong focus on maintaining local genetic patterns for optimal restoration. In a changing climate this paradigm will no longer be relevant. This project will undertake pioneering research at the interface between molecular genetics, plant physiology and climate adaptation, targeting the question 'What new genetic frameworks can facilitate adaptive restoration in changing environments?' Addressing this question will ensure optimal outcomes for Australia-wide investment in ecological restoration and provide solutions to ecosystem adaptation in changing environments.</p>	<p>Margaret Byrne Department of Environment and Conservation, WA</p>
<p>TB1104 Adaptation strategies for Australian birds</p> <p>Climate is likely to change so much that many birds may need human help to survive. For some, dispersal corridors may be needed. Others may need help to cross barriers as their favoured habitat shifts across the landscape. Some may even need to be taken into captivity. This project will identify what needs to be done in the next 20-50 years to enable our children to appreciate the same birds that we inherited.</p>	<p>Stephen Garnett Charles Darwin University</p>
<p>TB1105 Determining future invasive plant threats under climate change: an interactive decision tool for managers</p>	<p>Lesley Hughes Macquarie University</p>

<p>This project will provide the first comprehensive, national assessment of the risks of weeds emerging from naturalised plants. In Australia, invasive plants cost the economy at least \$4 billion annually, not including the cost to terrestrial biodiversity. As many invasive species may be advantaged by climate change, this figure will increase significantly. Of the 29,000 introduced plant species in Australia, approximately 400 have become significant weeds and a further 2,700 have become 'naturalised' - established self-sustaining populations in the wild. With around 15 species added to this list each year, these species represent a ticking time bomb of future weed problems.</p>	
<p>TB1106 Developing management strategies to combat increased co-extinction rates of plant dwelling insects through global climate change</p> <p>Co-extinction occurs when a species goes extinct as a result of the extinction of the species it depends on. As 30-40% of plant-dwelling insects and other species depend on a host, losses to biodiversity may be extremely high if host species disappear.</p> <p>Climate change is predicted to reduce the population size and range of many plants, so there is the potential for climate-induced co-extinction to threaten Australia's biodiversity. This project will develop indicators of the degree to which insect species might be prone to co-extinction across Australia and identify cost-effective conservation strategies to combat this.</p>	<p>Melinda Moir University of Melbourne</p>
<p>TB1107 Determining high risk vegetation communities and plant species in relation to climate change in the Australian alpine region</p> <p>The Australian Alps are one of the three most vulnerable ecosystems to climate change in Australia. It's an important biodiversity ark with more than 400 species of plants, 25 of which occur nowhere else.</p> <p>Snow cover is already 30% less than in the 1950s. With longer, warmer, summers come other threats including bushfires, weeds and feral animals. There is nowhere higher for Australian alpine plants to go – how can we conserve them in a warmer world?</p> <p>This project will prioritise strategies to increase the resilience of plants to these threats. It will assess the characteristics of plants such as their height, leaf size and shape and how they reproduce to determine which will decline with less snow and which will move in. This will enable resource allocation to maintain key refuges, control weeds and feral animals, and manage increased recreational use of the area.</p>	<p>Catherine Pickering Griffith University</p>
<p>TB1108 The role of refugia in ecosystem resilience and maintenance of terrestrial biodiversity in the face of global climate change</p> <p>This research will maximise the protection of Australia's terrestrial biodiversity by improving our understanding of what parts of the landscape provide natural refugia from the impacts of global climate change. Researchers will assess, map and quantify the vegetation types and species associated with each refugium and assess their relative vulnerability and likelihood of persistence across a range of future climate scenarios. This research will form the basis for systematic conservation planning, enabling management actions to be prioritised to ensure cost-efficient</p>	<p>Stephen Williams James Cook University</p>

allocation of resources.	
<p>TB1109 Adapted future landscapes – from aspiration to implementation</p> <p>Regional adaptation to climate, market and social changes is possible by changing what we do and where we do it on the land. Both productivity and conservation goals can be achieved by farming to land capability, changing land use to capitalise on the emerging carbon market and identifying land use practices that provide a mosaic of production and conservation uses. This project will work with two regions in South Australia to develop an experimental process that uses future land use projections to assess different policy and guidance incentives. If the experimental process is successful, it could be adopted for land use planning in other regions in Australia.</p>	<p>Wayne Meyer University of Adelaide</p>
<p>FW1109 Contributing to a sustainable future for Australia's biodiversity under climate change: conservation goals for dynamic management of ecosystems.</p> <p>Likely changes in climate and ecological processes due to climate change mean it may not be possible to retain biodiversity and ecosystems in the same form or place. This project seeks to establish a broadened set of goals and objectives for NRM management that will accommodate these inevitable changes of biodiversity in response to climate change and other pressures.</p>	<p>Michael Dunlop CSIRO Climate Adaptation Flagship</p>