Managing the bush:

Recent research findings from the EA/LWRRDC National Remnant Vegetation R&D Program

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National Research and Development Program on Rehabilitation, Management and Conservation of Remnant Vegetation

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Foreword

Jann Williams' highly readable and useful report summarises the outputs of the first five years of a remarkable program of research and development focused on the conservation and management of Australia's remnant native vegetation.

Australia's native vegetation cover is extraordinarily diverse, rich in species and complexity, with a very high degree of endemism. It is a priceless element of our natural heritage. It plays a crucial role in sustaining ecosystem function and processes, and consequently the productive capacity of our relatively old and infertile soils and scarce freshwater resources. It buffers the impact of harsh and extremely variable climates, binds and nourishes skeletal soils, and filters streams and wetlands. The condition and extent of native vegetation communities are inextricably entwined with the future of the birds, animals and invertebrates depending upon them for food and shelter.

The distinctive character of Australian landscapes and their iconic images are also bound up with the nature of 'the bush': the grey-green mantle clothing vast horizons; the tough dry foliage; the innovative adaptations to cope with drought and fire; the subtle, delicate beauty of stems, flowers, bark and leaves; and the invigorating scent of volatile oils, often the first evocative welcome for Australians returning from overseas.

Each generation of Australians has defined its relationship with the bush consistent with its own aspirations, understandings and technologies. For the first European settlers, Australian native vegetation was unfamiliar, even bizarre, and was often seen as something to be fought, tamed and displaced in order to 'civilise' landscapes into something more familiar and hence more productive. For the current generation, the challenge is to develop more sustainable ways of managing the native vegetation that remains, and of enhancing and augmenting it where appropriate.

Remarkably, it took more than 200 years after the arrival of the first fleet for Europeans in Australia to think in a concerted way at a national scale about how to manage one of the most extraordinary botanical heritages on earth. This far-sighted program was initiated and funded by Environment Australia and the Land and Water Resources Research and Development Corporation. I have been fortunate to be involved with the program through roles with each of these organisations over the last five years.

Many of the insights and principles developed through this R&D program and summarised in Jann's report will, in my view, be seen as of lasting significance in the management of Australia's unique native vegetation communities.

A vision for the bush

To put the program in an historical context, I want first to 'fast forward' about one human generation, say twenty-five years, sketching a vision around how we manage 'the bush'. This vision assumes that native vegetation has, and is seen to have, intrinsic values in addition to ecological and utilitarian values. It envisages Australian landscapes in which native vegetation is conserved for its ecological values, celebrated for its intrinsic values and enhanced for sustainable production.

The concept of 'landscape' is the background to these images. Landscape is an integrating term encompassing the biophysical elements of the countryside, and the people and communities who live in and depend upon that countryside. Landscape is an inherently subjective concept — interpreted differently by different people in different places at different times. Landscape connotes spatial scales that are necessarily fuzzy and fluid, but generally bigger than individual properties. Thus, managing landscapes implies social processes. Further, the concept of landscape should not imply a static snapshot, a visual image, but rather an evolving context shaped by ecological and climatic processes and human activities. These human, spatial and temporal dimensions are fundamental to the challenge of trying to manage the countryside to achieve individual, community and national goals.

Within a generation, the current tendency to see conservation of biodiversity and agricultural productivity as competing objectives to be 'balanced' and 'traded off' will be much less pervasive. Natural resources — land, water, vegetation and animals — are the life-blood of agriculture. Our attitude to natural resources and how we manage them will determine the capacity of primary industries to produce, and ultimately survive. Conservation of biodiversity and sustainable agriculture are inextricably linked. A healthy natural environment is crucial for primary producers, who depend on clean and plentiful water supplies, fertile soils and other ecosystem services such as pollination, for their income. Conservative management is an investment in natural capital, which underwrites material wealth. Conservation of biodiversity means much more than just protecting wildlife and their habitats in nature reserves. Conservation of native species and ecosystems, and the processes they support — the flows and quality of rivers, wetlands and groundwater; and soil structure and landscapes — is crucial to the long-term sustainability of all primary industries.

Biodiversity conservation is about being able to foresee and understand the consequences of human actions on the natural environment. It is about keeping options open. Within a generation, biodiversity conservation will be accepted in Australia as economically rational.

Many of the land degradation issues and processes in Australian rural landscapes stem from the ongoing attempt to adapt European agricultural systems to Australian landforms, climates, soils, fauna and hydrology. The vision sketched here does not for a moment assume a return to some pre-European Arcadia and/or the replacement of all the native vegetation that has been cleared or modified since European settlement. However, it implies that restoring some hydrological balance, enhancing habitat for wildlife, protecting freshwater resources and rehabilitating degraded lands will require the development of land-use systems which are more distinctively Australian. Such systems — in their structural and functional composition; in their cycling of water, energy and nutrients; and in their resilience in the face of climatic variability — will draw inspiration from the ecosystems which evolved in situ.

The ecological disturbance that has already taken place in many areas means that there is little point being purist about endemic or even indigenous species in these regions. Introduced species of plants and animals will continue to play a role, but within farming systems, much more structurally and functionally analogous to undisturbed ecosystems (for example, based on perennials rather than annuals, and soft-footed browsing rather than cloven-hoofed grazing animals). Over time, more sustainable land-use systems are likely to make much more use of native Australian species than conventional agriculture as practised today.

One can imagine farming systems in which a significant portion of the landscape is occupied by native perennials, some of which form the basis of grazing systems, and others generating a range of products including landscape amenity, carbon sequestration, plant water use, timber, fuelwood, craftwood and pulp, cut flowers, essential oils, herbs, solvents and pharmaceuticals. The configuration of the vegetation at a landscape scale — the matrix of patch and corridor — would be based on design principles informed by both catchment hydrology and bioregional biodiversity conservation principles.

Revegetation of rural landscapes would also be informed by less tangible considerations such as an acceptance of the need to 'put something back' into the rural landscapes which have generated so much wealth for the country, and the desire to rejuvenate landscapes in ecological decline. The powerful symbolism of the stark skeletons of once majestic paddock trees, or the pathetic, threadbare remnants of once vast woodlands and forests, would be offset by equally potent images of community-based revegetation and regeneration on an unprecedented scale.

Such revegetation and regeneration activities would be underpinned by a thriving native vegetation industry, and associated infrastructure for native vegetation management. Activities would include: landscape design; habitat management; indigenous seed collection and storage; seedling propagation; site preparation; direct seeding; large-scale planting; bushland regeneration; management of weeds and feral animals; farm bushland silviculture; plantation pruning, thinning, and local processing; harvesting, transport and marketing of herbs, oils and flowers; and natural resource inventory, mapping and monitoring.

Infrastructure required would include: regional facilities and services to support ecological inventory, mapping and monitoring activities; local and regional seed banks and nurseries stocking the full range of locally-indigenous flora, by provenance; equipment such as seed harvesters, direct seeding machines, mechanical planters, sprayers, pruners and weeders — all adapted to local/regional needs and conditions; and the knowledge base, training capacities and people required to apply and refine best-practice techniques at appropriate scales.

These activities would be delivered (and the infrastructure managed) by various combinations of specialist consultants and contractors, community groups and grower cooperatives, local government, catchment bodies and regional organisations; with various degrees of public support according to the wider public benefit and the potential for commercial returns.

The 'wider public benefit' would be understood in reference to robust, regionally specific articulations of the 'duty of care' of land users not to degrade natural resources. Duty of care would be widely accepted and understood as setting out the responsibilities which are inseparable from the privilege of managing land, regardless of its tenure. It would be internalised in social norms, reinforced by peer pressure, rather than the letter of the law. Duty of care would be defined in regulation where appropriate, but would be more commonly used in industry codes of practice, industry-based environmental management systems, and voluntary incentive programs. Land uses generating insufficient returns to enable land users to fulfil their duty of care would, by definition, be unsustainable and hence unsuitable uses of land.

Markets would be informed and constrained by the understanding that the human economy is a subset of human society, which in turn is a subset of, and utterly dependent upon, the biosphere. Market forces would work to use natural resources more efficiently, discriminating against products, production systems and processes that degrade or deplete natural resources unsustainably. Linkages between well-informed consumers and all stages of production cycles would be fostered and direct feedback encouraged. Environmental externalities (positive and negative) would be internalised in market prices wherever possible. National accounts would account for natural capital stocks, as well as flows, offering a truer reflection of the relative sustainability of apparent economic performance. The role and limitations of market forces in questions of long-term sustainability would be well understood, and the conditions under which intervention in markets is justified, well accepted.

Comprehensive incentive regimes would complement markets in encouraging and delivering more sustainable approaches. Management actions seen to be in the public interest, for example through positive externalities, and which are clearly over and above what would be expected under duty of care, would be supported by a wide range of direct and indirect incentives and disincentives. Such incentives would be derived and delivered at a range of scales: for example, nationally through the taxation system and major targeted grants for national priorities; sub-nationally through property rights reform, revolving funds, tradeable credits, industry codes of practice, accreditation systems and regulatory approaches; and regionally through regional grants, stewardship payments, planning, zoning and rating systems.

The incentives regime would be designed to attract private-sector funding into nature conservation at property and landscape scales through: tax measures encouraging philanthropy; rewards at an industry-level for best-practice and corporate citizenship; and tax and other incentives for the individual or firm to go above and beyond their duty of care in managing for long-term conservation in the public interest. The general principles informing the design and delivery of incentives would include the principle that natural resource management and resource allocation decisions should be made at the lowest practicable level — that systems should connect people as directly as possible with the consequences of their actions; and that local ownership of problems and solutions is most likely to be genuine when revenue-raising and resource allocation operate at the same level.

This is far from a depiction of current reality in many regions of Australia. The first step towards making this picture more real in most places is to improve our knowledge base, in both theoretical and practical terms, on how to conserve, manage, enhance and re-establish native vegetation for various combinations of objectives at various scales.

The program of research and development described in this report has done just that. It has invested in ground-breaking work on the development of incentives for nature conservation on private land. It has generated important insights into how Australians perceive native bush and what this means for the design of incentive and extension programs. It has substantially increased our understanding of the ecology of remnant vegetation in rural landscapes — a fundamental prerequisite for better management. It has taken the next step of developing practical guidelines and toolkits in some landscapes to help farmers and others to look after their bush. It has pioneered the incorporation of social and institutional research into natural resource management, and successfully brought together ecologists and social scientists.

Of course many gaps in our understanding remain. The gains made through this program over the last five years provide great encouragement, however, that these gaps can and will be filled over time. The Board of the Land and Water Resources Research and Development Corporation has approved funding for a second five-year phase of this program, to which all States, Greening Australia and CSIRO have committed funding.

Our challenge now is to ensure that the lessons encapsulated in Jann Williams' lucid report and the detailed research papers to which it refers, reach a wide audience among those with an interest in the management of Australia's extraordinary native vegetation.

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Executive Director
Land and Water Resources Research and
Development Corporation.

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This report was written in my capacity as the part-time coordinator of the EA/LWRRDC National Remnant Vegetation R&D Program between May 1998 to June 2000. The content has been considerably improved by comments from Phil Price, Peter Lyon, Charles Willcocks, Neil MacLeod, Judy Lambert, Carl Binning, Sue McIntyre, Tony Norton and Richard Hobbs. They all took time out of their busy schedules to provide feedback, and their efforts were very much appreciated. However, the responsibility for the final wording is all my own.

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This position was based in Canberra, but wouldn't you know it — my permanent home is in Melbourne. So I'd also like to thank Ian Lunt and Gill Earle for the use of their Holden Drover to get around while I was Canberra and to Isobel Crawford for her wonderful hospitality on my monthly visits. At LWRRDC Siwan Lovett, Joy Sutton and Janice Oliver, who are my nearest neighbours, have provided much stimulating discussion and laughter, and Karen Donovan and Gill Whiting have given excellent Program support. And thanks to all of the other people at LWRRDC and in the National Land and Water Resources Audit that have made my visits to Canberra most enjoyable (these acknowledgments are long enough without listing names — but they know who they are). Last but not least, I'd like to acknowledge my husband, Tony Norton, who has unstintingly supported my involvement in the Program, even though it meant that I was away from our home for around half of the year.

Executive summary

In 1994 a national program of research and development was established by the Australian Nature Conservation Agency, now part of the Biodiversity Group of Environment Australia (EA), and the Land and Water Resources Research and Development Corporation (LWRRDC) to devise improved methods of managing bushland. Native vegetation provides many benefits and services to agriculture, helps maintain the health of land and water, and provides a home for Australia's unique biodiversity. Given the integral role of native vegetation in sustainable land management, it is important to understand the ecological, social and economic factors that have an impact on the conservation and management of this increasingly scarce resource. With this in mind, the EA/ LWRRDC National Remnant Vegetation R&D Program (hereinafter called 'the Program') has focused on tree-dominated ecosystems on the highly cleared regions of southern Australia, where private land ownership and management occurs across much of the landscape. When the Program started, pressing needs for R&D were identified in these regions.

The major goal of the Program is:

> to assist government agencies, community groups and landholders to better manage and protect remnant native vegetation through the application of improved knowledge and understanding gained from research, with a strong emphasis on practical outcomes.

To help achieve this goal, the Program focused on three major aspects — ecological research, socio-economic research and six, State-based regional pilot planning projects. Several important insights into the conservation and management of remnant native vegetation have arisen from research undertaken in the Program — and the range of communication activities at the project level has been varied and extensive. This publication focuses on the Program level, synthesising the key findings and messages across the broad range of projects, and setting them in the wider context of other research undertaken on these topics.

Key findings from the ecological projects — a summary

Many of the ecological projects funded in the Program are relatively long-term and large-scale, and they have produced a number of key findings that relate to both the ecology of the systems and their management. They are listed below. In many cases, similar results have been learnt from other research, reinforcing these messages.

Ecology

- "What we've got is all we've got" — once the original vegetation disappears from a site, then it is very difficult to create the same system.
- All remnant vegetation has some value, even individual trees.
- For ecological sustainability, a *minimum* of 30% of a landscape or property must be under woodland or forest.
- Vegetation along rivers and creeks provides critical habitat and needs special management attention.
- Small and isolated remnants can make an important contribution to biodiversity conservation.
- Site preparation is very important for successful plant regeneration.
- Identifying appropriate disturbance regimes for native vegetation, such as fire, flood and grazing, is critical for its long-term maintenance.
- The capacity of a plant to recover from natural disturbances can be used to guide the type and degree of interventions needed to 'kick-start' natural recovery.
- Smoke can be an important cue for plant germination, but does not trigger all species.
- Successful regeneration/restoration is highly dependent on water availability, and management must meet this need.
- The use of indicator species requires further investigation.

Management

- Management is required at the site, region and landscape scale.
- Management goals need to be clearly stated, so that progress can be measured.
- Adaptive management allows the effects of particular practices to be evaluated — monitoring is the key to 'knowing if you're winning'.
- If it ain't broke, don't fix it — in other words, don't change current management practices unless there is an obvious reason to do so.
- Fencing is only the first step in a management program for native vegetation.
- Strategic and controlled grazing of native vegetation is possible, and sometimes even essential.
- Caution must be taken when transferring results — what works in one place, might not in another.
- Obtain and use local knowledge wherever possible.

Key findings from the socio-economic projects — a summary

The range of key findings identified in the socio-economic projects, and listed below, illustrates the importance of the broader socio-economic context for the sustainable management of natural resources.

- The future of native vegetation is tied up with the future of the farm itself.
- Capacity building is needed for a range of stakeholders.
- Cost-sharing incentives are a critical component of improved vegetation management on private land — but a mix of incentives is needed, including legal instruments.
- There are several examples of highly successful incentives programs that should now be taken up more widely.
- Current institutional arrangements are impeding effective conservation and are in need of major reform.
- Partnerships that include all interested stakeholders are needed at the regional level.
- The non-government sector could play a much greater role in nature conservation.
- Reform to the tax system is needed to encourage philanthropy.
- Understanding the value systems and perceptions of different stakeholders can lead to more targeted and effective approaches to management and education.
- Written materials on their own are not sufficient to change attitudes and behaviour.
- The 'personal approach' to extension services — face-to-face communication and discussion — is the most effective.
- There is an urgent need to retain, expand and redirect extension services.
- There is considerable evidence that locally employed extension officers, and particularly farmers, will be more effective — highlighting opportunities for government investment in employment in rural Australia.
- A range of management agreements for native vegetation should be made available.

Pilot planning projects

The pilot planning projects funded by the Program reinforced the value of planning at a regional scale. Just as importantly, they helped identify the critical success factors and weaknesses of particular approaches. An integrated, accessible and consistent database on natural and other resources was seen as an integral part of regional plans. Developing useful goals, and implementing them at an appropriate scale, are also critical. Involvement of community groups was a key factor underlying the eventual adoption of the plans. Consequently, adequate time needs to be built into the planning process to allow for this. Collaboration both within and between agencies was also identified as critical for the successful implementation of the plans.

The importance of developing robust and durable regional structures for natural resources management is a consistent theme throughout the

Program. To be successful, however, they must be allocated adequate human and financial resources.

Conclusions

While the impact of the Program has been significant, and much has been learnt from this and other research about native vegetation management, there are still several priority areas that warrant future investigation. These include developing the skills and capacity needed to integrate native vegetation management with sustainable agriculture and building more effective incentive and program structures to promote sound management practice. The implementation of new research models is also a priority, with a more learning-based and participatory approach being widely advocated. One message is particularly loud and clear though. Only by considering the multiple elements of natural resource management — ecological, social, economic and institutional — is a sustainable future possible.

1 Introduction

Australians strongly identify with the bush, but many parts of the rural landscape will lose their native vegetation if better management approaches are not developed and adopted. Native vegetation provides many benefits and services to agriculture, helps maintain the health of the country's land and water, and provides a home for Australia's unique biodiversity. Given the integral role of native vegetation in sustainable land management, it is important to understand the ecological, social and economic factors that affect the conservation and management of this increasingly scarce resource. With this in mind, a national program of research and development was established in 1994 by the Australian Nature Conservation Agency, now part of the Biodiversity Group of Environment Australia (EA), and the Land and Water Resources Research and Development Corporation (LWRRDC) to devise improved methods of managing bushland. The Program has focused on tree-dominated ecosystems in the highly cleared regions of southern Australia (Figure 1) where private land ownership and management occurs across much of the landscape. When the Program started, pressing needs for R&D were identified in these regions.

The major goal of the Program is to assist government agencies, community groups and landholders to better manage and protect remnant native vegetation, through the application of improved knowledge and understanding gained from research, with a strong emphasis on practical outcomes. To achieve this the Program focused on three major areas:

- ecological research — aimed at identifying the processes of degradation and extinction operating in remnant vegetation and at developing practical management methods to overcome and reverse them, and delivering these through active participation by landholders and rural groups;
- socio-economic research — to support the development of policies and programs to help manage remnant vegetation, including the development of incentives and conservation management structures by organisations and individuals involved in remnant vegetation management; and
- regional pilot planning projects — to develop and test methods for planning and implementing vegetation management at catchment or regional scales.

Throughout this review the projects in these three categories will be referred to by their project codes (ie. CTC9 or Project CTC9), which are listed in Tables A1–3 in the Appendix.

Before discussing the facts and figures from the Program, and how these can be best applied to improving land management, it is worth stopping to reflect for a moment. To do this, I invite you to read Box 1, which comes from the *Save the Bush Toolkit* (Goldney and Wakefield 1997). If you are not a farmer, imagine being in their shoes and dealing with the many competing demands they face. It is important to remember that successfully managing remnant vegetation and protecting plants and animals is strongly influenced by people's understanding and motivation, and the encouragement they receive. It is also important to have a vision for management at the farm, catchment and regional level — something which is discussed later on in the review. One of the strengths of the National Remnant Vegetation R&D Program is that it has addressed the ecological, social, economic and institutional elements of managing native vegetation. Only by considering these multiple elements of natural resource management is a sustainable future possible.

Communication of results is a critical aspect of the Program, as there is often a significant gap between the level of knowledge and understanding held by scientists and researchers, and that available to community groups and landholders actively engaged in on-ground management of native vegetation. The range of communication activities at the project level has been varied and extensive. For more information on the outputs of the separate projects and their communication activities, LWRRDC (1999a) is recommended. In contrast, this publication synthesises the key findings and messages from the broad range of projects in the National Remnant Vegetation R&D Program and sets them in the wider context of other research undertaken on these topics. It concludes with recommended future directions for R&D into the conservation and sustainable management of remnant vegetation. These were based on discussions with a wide range of stakeholders.

It should be kept in mind that this is not a review of all of the issues related to remnant vegetation conservation and management — which would be another book in itself. Rather, the discussion is limited to the issues identified as priorities in the Program. For those interested in pursuing the complexities of remnant vegetation conservation and management further, a range of complementary publications is available eg. Saunders *et al.* (1986, 1987), Saunders and Hobbs (1991), Bennett *et al.* (1995), Hale and Lamb (1997), Bennett (1999) and Hobbs and Yates (2000) provide comprehensive overviews and are recommended reading.

1.1 What is remnant vegetation?

At the broadest level, the National Remnant Vegetation R&D Program has been concerned with the impacts of agricultural development on native vegetation. A common definition of remnant vegetation is "native vegetation occurring within fragmented landscapes", with the ultimate remnant described as an individual tree (LWRRDC 1999b). Remnants are mostly associated with patches of woodland of limited size, but they can also include other native ecosystems such as grasslands and wetlands. These patches of vegetation are surrounded by crops or sown pastures and are often viewed as relatively discrete and readily definable (Figure 2).

As our understanding of landscape ecology has developed, it has become evident that this concept of remnant vegetation does not encompass the

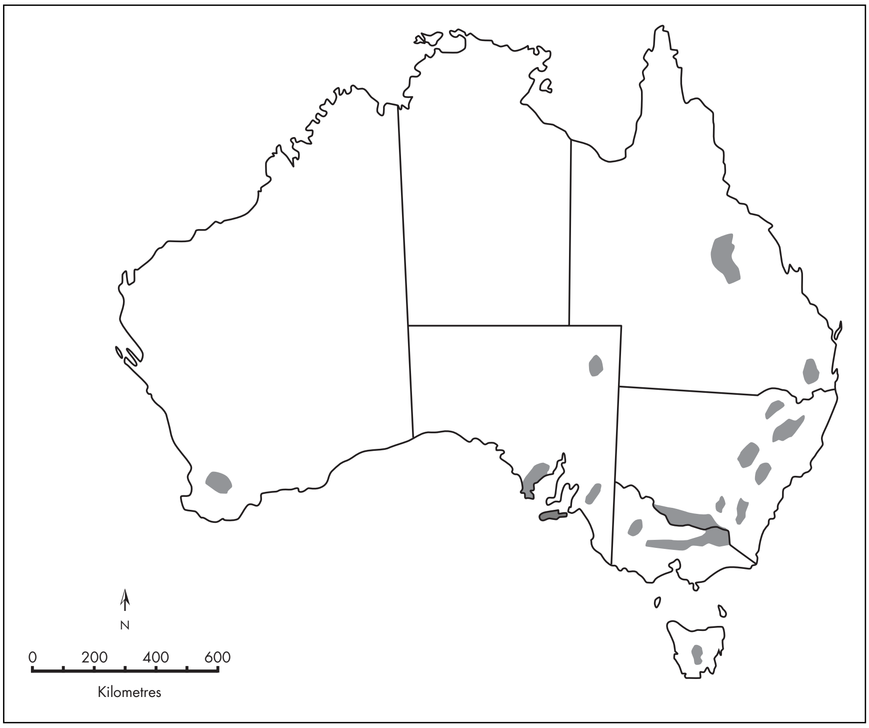

Figure 1. The broad geographic locations of projects funded through the National Remnant Vegetation R&D Program. Some projects, such as CWE 13 (see Appendix, Table A2), were undertaken at the national level.

diversity of situations in which we need to manage native vegetation. For example, native grassland may grade imperceptibly into exotic sown pasture within a paddock. In other words, the boundaries between native vegetation and the surrounding agricultural lands are not always clear-cut and obvious to the human eye. It is also important to realise that a human view of agricultural impacts does not necessarily mirror that of the plants and animals living in the landscape. For example, a landscape dominated by native pasture with small patches of eucalypts may not be fragmented from the point of view of grassland fauna species, but birds dependent on the woodland may find the same landscape fragmented and difficult to survive in. Preliminary work by Driscoll (1999) also suggested that linear remnants of mallee vegetation in the NSW wheat/ sheep belt that appear to the human eye to be interconnected, might be quite different from the perspective of reptiles. His initial work demonstrated that the grazed strips of mallee vegetation could not be used by reptiles, hence ungrazed remnants may be isolated rather than part of an interconnecting network. Clearly, defining remnants is not at all straightforward. Even so, the important task of sustaining healthy native vegetation in agricultural landscapes remains.

Another way of viewing remnant vegetation is as a product of existing land uses and management practices. This view places remnant vegetation in a historical and economic context. In many cases, it is useful to recall that a remnant exists only because of decisions made by the landholder. Often remnants occur on land that is unproductive for agriculture or is held by a landholder with a strong commitment to conservation. Indeed, remnant vegetation might be thought of as a stand of native vegetation that reflects current and past management practices and opportunities. For this reason, good quality remnants are often associated with capable and sympathetic landholders. This is an important factor for developing policies for engaging landholders in the conservation and management of remnant vegetation.

1.2 Another way of looking at remnant vegetation

To capture the variation in Australian rural landscapes, McIntyre and Hobbs (1999) have developed a framework describing the range of landscape alteration 'states'. This describes the landscape context in which remnant native vegetation must be managed, and uses two concepts: *habitat destruction* (complete removal of vegetation) and *habitat modification* (change in the structure, composition or function of vegetation as a result of exogenous disturbance). Four landscape alteration states are recognised: intact, variegated, fragmented and relictual. These are associated with increasing amount of habitat destruction and decreasing levels of habitat connectivity (Table 1). In intact landscapes (eg. arid rangelands), less than 10% of the vegetation is destroyed and the landscape mosaic is therefore 'habitat' in various states of modification. At the other extreme are relictual landscapes (eg. cropping or urban areas) where over 90% of the vegetation is destroyed and small areas must survive in a landscape matrix which may be hostile to the continued persistence of the vegetation.

It is useful to consider remnant vegetation in the context of the landscape matrix, as there are important implications for management objectives and priorities. For example, where the surrounding land use is 'hostile' (eg. urbanisation as a source of exotic species and nutrients) and the habitat patches are small, it will be necessary to actively manage remnants to avoid degradation. In grazing lands where the landscape is variegated, there may be more to be gained by a strategy of maintaining the vegetated matrix and buffering the most intact remnant vegetation with less hostile land uses (eg. grazing rather than cropping). The significance of this alternative framework, is that it makes us consider more carefully what is habitat and non-habitat, not just from a human perspective, but from the point of view of the plants and animals living in the landscape (McIntyre and Hobbs 1999). For example, even the extreme land uses that are associated with native vegetation destruction such as

Box 1 – Understanding your farm landscape

Go to one of your favourite places on the farm with your family; it may be up the hill, behind the house, it might be the front gate or down by the creek.

Just stand and look at the landscape, the scattered trees and bushland. What is it that you admire and enjoy about the landscape? Is it the green of the trees contrasting with the golden brown colour of the late summer pasture and stubble, or the colour and texture of the bark? Is it the branches of the trees silhouetted against the evening sky? Perhaps it is the age and sense of permanence or timelessness in the landscape?

Maybe you enjoy looking at groups of trees scattered across the farm? Or is it the stock lying in the shade on a hot still afternoon or a flash of colour as birds dart through the farm?

As you admire your bushland, listen to the sounds of your farm. This may be best done either in the early morning or evening. What are the sounds you hear and miss when you go to the city? The call of the birds or the croak of the frogs in the dam?

You may be fortunate and have an area of remnant bushland on your farm, where you have noticed lizards running along rocks and logs or maybe an echidna fossicking amongst native grasses. Perhaps you are lucky enough to have some sugar gliders climbing and gliding in your trees as they search for insects, particularly Christmas beetles.

Enjoy your farm as a family and compare notes. What is it that each one of you sees, hears and smells that delights you?

Now blot out the bushland and trees from the landscape and what do you see? Just bare land rolling to the horizon. No place for protection from the heat or the sun and nowhere to shelter from the rain being driven by a cold south wind. The birds and the animals have gone. They rely on bushland for food and shelter, so the landscape is now silent. You and your stock are alone.

Is this the world you want for your future and the future of your kids? Do you want to just be able to show them photos in books of what the farm used to look like? Would you not want them to experience the pleasures of our flora and fauna for themselves?

If you and your neighbours take no action to nurture your bushland and other natural areas, you will not only lose these small but important pleasures in life, but you will also have a less valuable and less productive farm in years to come.

Develop a vision and actions for nurturing your bushland and wildlife, so it will not be lost from your farmland and lost to future generations.

From Kit 9 of the 'Save the Bush Toolkit' (Goldney and Wakefield 1997).

Figure 2. Two perspectives of fragmented vegetation in south-eastern Australia. Left: Aerial view near Armidale, New South Wales, illustrating the range of shapes, sizes and connectivity of remnant vegetation. Right: Farmland near Whipstick State Forest, Bendigo, Victoria, showing the abrupt boundaries often associated with remnant vegetation.

cropping in the Western Australian wheat belt support some native invertebrates, while suburbs and plantation forests provide habitat for the breeding and dispersal of some native fauna.

If this framework were widely adopted, it could be easier to identify which part of the continuum was relevant to the specific regions or ecosystems in which people work. Thus, the term remnant vegetation may be replaced over time by the more informative concept of landscape states defined by McIntyre and Hobbs (1999). This system also associates remnant vegetation more closely with the surrounding matrix, drawing attention to the potential interactions between the different elements in the landscape. For this review, however, the term 'remnant' is used to describe the range of fragmented native vegetation — from 'relictual' to 'variegated'.

1.3 *Why is so much of this vegetation fragmented?*

Broad-scale clearing in Australia of the original native vegetation has led to the creation of remnant vegetation in nearly 40% of Australia, mostly in south-western and south-eastern Australia, as well as parts of central and eastern Queensland (Figure 3). This change has been particularly marked in the forests and woodlands of the tablelands, slopes and plains, which now constitute our most important agricultural areas. But even in those areas, there is considerable variation within regions and landscapes in the extent of clearing, depending on the suitability of land for cropping and/or grazing. So, as a result of land-use changes that have occurred since European settlement, in some areas less than 5% of the original vegetation remains, but even where the figure is higher (at 20–30%), there are signs of continued and increasing vegetation decline and dieback. The loss of vegetation has many flow on effects to both the fauna that use the vegetation (Recher 1999; Reid 1999) and the physical environment, but these issues are covered in greater detail below.

Figures on rates of clearing at the national level have become available (Box 2) only very recently. The stimulus for developing these estimates was to provide an accurate assessment of the rates of land cover change across the Australian continent for the National Greenhouse Gas Inventory, with land cover change including tree clearing and replanting/ regrowth of trees. Although most States and Territories in Australia have implemented, or are considering, some form of land-clearing controls, this study showed that substantial areas are still being cleared for cropping, grazing and urban development. For example, a recent study released by the Bureau of Rural Sciences estimates that, between 1990 and 1995, approximately 1.2 million hectares of native woody vegetation (trees > 2 m height and > 20% canopy cover, including regrowth) had been cleared in the intensive land-use zones of Australia. At the time of the study, this vegetation form covered around 40% of the country and is located principally in southern and eastern Australia (Figure 3). Not all this clearing will necessarily result in permanent loss of woody vegetation, but it does give an indication of recent broad-scale activities which will lead to the creation of more fragmented vegetation.

Queensland is a hot-spot, with high rates of land clearance currently occurring. The continued high level of clearing is reflected in the State Land and Tree Study (www.dnr.qld.gov.au/resourcenet/veg/slats) that identified an average annual rate of 340,000 ha being cleared in Queensland over the period 1995–97. This is 18% higher than the 1991–95 rate, estimated to be 289,000 ha per year. In other parts of Australia, clearing is at present less extensive, but horticultural and agricultural ventures in areas such as the east Kimberley (the Ord Irrigation Scheme) and the Douglas Daly region near Katherine are planned.

There is now widespread debate about the long-term environmental impacts of broad-scale clearing, the role of legislation in controlling such actions and the provision of incentives for landowners to implement the clearing regulations. With accelerating rates of clearing in northern Australia, there is an opportunity to ensure the maintenance of landscape function and health, based on lessons learnt from poorly planned and excessive clearing in other parts of the country.

Box 2 – Mean annual rates of clearing in Australia between 1991 and 1995

Queensland	262,000 ha
New South Wales	150,000 ha
Victoria	1,828 ha
Tasmania	4,000 ha
Western Australia	8,000 ha
South Australia	trace levels (already extensively cleared)
Northern Territory	trace levels (potential for extensive clearing)

(Source: National Greenhouse Gas Inventory 1995 with Methodology Supplement; modified for Queensland according to the Statewide Landcover and Trees Study Interim Report 1997.)

Table 1. Four landscape alteration states defined by the degree of habitat destruction. Characteristic connectivity (Pearson et al.) and degree and patterns of modification associated with each state are also given. After McIntyre and Hobbs (1999).

Type of landscape alteration	Degree of destruction of habitat (% remaining)	Remaining habitat – connectivity	Remaining habitat – degree of modification	Remaining habitat – pattern of modification
Intact	Little or none (> 90%)	High	Generally low	Mosaic with gradients
Variegated	Moderate (60–90%)	Generally high but lower for species sensitive to habitat modification	Low to high	Mosaic which may have both gradients and abrupt boundaries
Fragmented	High (10–60%)	Generally low but varies with mobility of species and arrangement on landscape	Low to high	Gradients within fragments less evident
Relictual	Extreme (<10%)	None	Generally highly modified	Generally uniform

1.4 Benefits associated with remnant vegetation

The destruction and modification of habitat described earlier has left a legacy of patches of native vegetation of various sizes, shapes, connectivity and condition. Many of the benefits associated with native vegetation (Box 3; Lambeck 1997; Williams 1998; Kirkpatrick and Gilfedder 1999) relate to medium to larger patches, although all native vegetation plays some role in the landscape. For example, individual trees provide shade for stock, nesting and foraging sites for wildlife, cycle nutrients, act as a source of seeds and may help to reduce groundwater recharge and to recycle cations from depth (DLWC VegNote 2.11, Project CSU6, Project ANU6, Reid and Landsberg 2000). In addition to the conservation of biodiversity, native vegetation provides many benefits and free services to agriculture and is invaluable in maintaining the health of land and water (DLWC 1998). Sustainable agricultural production is dependent on farms being part of a healthy functioning environment, and it is becoming increasingly clear that native vegetation plays a crucial role in maintaining landscape function and productivity (Lambeck 1998a; Walpole 1999).

Larger and more intact patches of native vegetation, or in some cases small, degraded patches, may be the only remaining examples of particular ecosystems and serve as a reference point for revegetation activities (Stelling 1998) and ecosystem function. Once the original vegetation disappears from a site, then it is difficult, if not impossible, to recreate it. And while revegetation projects are becoming increasingly sophisticated, it will take decades to develop the characteristics of the original vegetation (ie. being self-sustaining), especially those provided by large trees (Project DUV2). This means that *what we've got is all we've got.* Consequently, there is general agreement that the first step to sustainable management is to retain existing native vegetation where possible. The next steps are to protect and manage that vegetation and then, where appropriate, to revegetate cleared areas.

Box 3 – Benefits associated with remnant vegetation in rural areas of Australia

- Aesthetics/heritage and cultural values
- Personal well being (existence value)
- Biodiversity conservation
- Recreation (especially riparian zones)
- Nutrient and water cycling for landscape health
- Soil conservation (protection from water and wind erosion)
- Shelter for stock from wind and sun
- Windbreaks for crops and pastures
- Pest control by native birds and animals
- Wood production for poles, posts and sawn timber
- Source of firewood
- Source of honey, flowers, specialty timbers, foliage and oils
- Genetic resources for a wide range of potential products
- Sources of seed for revegetation

Box 4 – Perceived problems with remnant vegetation in rural areas of Australia

- Haven for feral animals, weeds and diseases
- Increases fire risk to crops, plantations and pastures
- Takes up land that could be used for productive purposes
- Difficulty in mustering stock
- Cost of fencing and maintenance to control stock access

Perceived problems with remnant vegetation are listed in Box 4. These have been identified in a number of projects in the Program (eg. Projects FAS1, USA2 and VAC1) and elsewhere (Middleton

Figure 3. The intensive land-use zone (after Graetz et al. 1995), which covers approximately 40% of Australia, is the region where most broadscale clearing has and is occurring.

et al. 1999). Interestingly, Project UME28 (Cary and Williams 2000), a study of the perceptions of native vegetation in urban and rural residents, found that the association between native vegetation and pest plants and animals was relatively weak. However, the researchers stressed the importance of assessing these results in the context of studies that overtly measure concern for pest plants and animals, where landholders often consider pest plants and animals to be a problem. At least one of these studies (Miles *et al.* 1998) found that concern over pest animals was balanced out by the presence in native vegetation of native animals that helped control pests.

In order to address the actual extent of these problems, systematic studies are needed. For example, to my knowledge, there have been no published studies that document the fire risk posed by native vegetation to surrounding land uses such as cropping and plantation forestry. Indeed, a recent study in urban areas in Tasmania found that fires burnt into native vegetation from the lands surrounding the remnant, rather than the reverse. Clearly, more thorough documentation is required.

1.5 Processes threatening remnant vegetation

Agriculture is a significant contributor to the national economy and, over the long term, has maintained a strong performance (Industry Commission 1998). However, it is clear that many agricultural practices have led to considerable natural resource and environmental degradation (Yates and Hobbs 1997a; Walker *et al.* 1999). By and large, this has not been deliberate. People have done what they believed was right or best at the time and, in many cases, governments either promoted the activity or penalised its non-pursuit. At later dates, of course, what were thought to be solutions have proved to be the source of problems. For example, the broad-scale clearing of native vegetation and its replacement with shallow-rooted crops and pastures has contributed significantly to rising water tables, mobilisation of salt, and other hydrological changes. Thus, vegetation clearance has led to landscape salinisation, increased sediment, nutrient and salt loads in rivers and streams, loss of habitat and a decline in biodiversity. The associated costs have been substantial for agricultural production, infrastructure, local communities and the environment.

Consequently, a number of ecological (Box 5) and societal (Box 5a) processes threaten the native vegetation remaining in highly cleared rural landscapes. Multiple threats can occur at the one site, making management even more complex. There is also no room for complacency that all threatening processes have been identified. This is highlighted by the pervasive threat posed by Mundulla Yellows, which causes the yellowing of foliage on native trees and shrubs and ultimately could lead to their death. While the symptoms were first observed in the late 1970s, it has only recently been recognised that Mundulla Yellows has the potential to devastate the native vegetation of South Australia (Paton and Cutten 2000).

Another threatening process that is receiving increasing attention is the impact of firewood harvesting on remnant native vegetation. It is clear from the examples in Box 5 that the harvesting of firewood from native vegetation requires urgent attention. The 1999 ACT Solid Fuel Strategy is thought to be a good first step in the move towards an ecologically sustainable firewood industry, but it is also thought that much more needs to be done by government, industry and consumers (Maxwell 1999). At the national level, a major advance has been the first national conference on firewood held in Bendigo, Victoria on 8–9 June 2000. This was organised by the Victorian National Parks Association and examined what could be done about developing a sustainable firewood industry. It should help set research, management and policy directions for some time to come.

Many of the threatening ecological processes are considered in greater detail in LWRRDC (1999b) and elsewhere, and some will also be revisited later in this paper. The societal processes (Box 5a) that threaten remnant vegetation require as much attention as the ecological threats. For example, remnants can be placed at great risk from land-use change when markets shift, new technologies emerge or land ownership changes and new economic opportunities are revealed. Examples include loss of native grasslands in south-eastern Australia, because of poor wool prices or through urban encroachment on the coastal zone. Issues such as these will be discussed in greater detail later in the report. The aim of this brief section is to show the range of processes threatening native remnant vegetation and to demonstrate the clear need for effective policies and active on-ground management.

1.6 Key findings arising from the Program

More and more attention is being paid to the fragmented landscapes of Australia as the magnitude of the environmental problems associated with over-clearing becomes apparent. For example, recent meetings of the Australian Network for Plant Conservation and the Ecological Society of Australia have highlighted ecological research on the conservation and management of remnant vegetation (ESA 1999). This is complemented by work being undertaken in the areas of social science and ecological economics. As noted, one of the strengths of the National Remnant Vegetation R&D Program has been to bring together researchers from these different disciplines before the need for a multi-disciplinary approach was more widely appreciated. Another has been the involvement of landholders in the design and implementation of many of the projects, an approach that usually engenders increased ownership of the results.

The next section gives the key findings from the three different priority themes funded through the Program, then examines issues that cut across these themes. Where time permitted, material from other research projects is also considered. If results from the projects have been published in the Bushcare publication series associated with the Program (for example, Elix and Lambert 1998) the publication is listed in Appendix A. The contact details for project leaders can also be found in Appendix A if readers are interested in finding out more about each project.

2 Ecological projects in the Program

The National Remnant Vegetation R&D Program began with a call for projects in the ecological/ management area. Eight projects were funded in this initial round (Table A, Appendix A). They generally had a strong field-based component. One of the socio-economic projects (CTC9 — see Table B, Appendix A) also has a strong field-based component and so will be referred to in this section, and there are brief references to other projects where relevant. Most projects funded in this call for projects have developed management guidelines as a key product, and these are covered in greater detail later in this review.

As the Program focuses on practical outcomes, four priorities were initially set for the ecological projects (LWRRDC 1999a), based on major issues that had been identified as requiring further research. The main priorities addressed in this part of the Program are:

- developing methods for determining appropriate size, configuration and location of native vegetation patches;
- identifying characteristics important for ecosystem function, or as indicators of the health of remnants;
- assessing key processes influencing the long-term maintenance and conservation value of remnant vegetation; and
- formulating measures to reconstruct, rehabilitate or manage remnant vegetation in highly degraded or altered landscapes.
- formulating measures to reconstruct, rehabilitate or manage remnant vegetation in highly degraded or altered landscapes.

2.1 Methods for determining appropriate size, configuration and location of patches of native vegetation

Three projects explicitly examined this priority, which emphasises the role of native vegetation for maintaining ecosystem function and conserving biological diversity within agricultural landscapes. Two of the projects studied the use of remnant vegetation by fauna (Projects ANU6, DUV2), and the third, vascular plant species (UTA4). Project CTC9 also addresses this priority, as part of its focus on whole-property management (see Table B, Appendix A). These studies cover a range of environments from Tasmania to south-eastern Queensland and are examining multiple sites at the landscape scale.

2.1.1 Thresholds of forest and woodland cover

In many areas of southern Australia less than 10% of the original native vegetation cover is left. This dramatic reduction in area has had a major impact on native plants and animals, as well as on water and nutrient fluxes. For example, Bennett and Ford (1997) showed that bird species diversity declines drastically when tree cover drops below 10%, and the Salinity Audit recently released by the Murray Darling Basin Commission (MDBC 1999) had some sobering statistics on the impacts of widespread clearing of trees. Project ANU6 has also identified that approximately 10% native vegetation is the minimum threshold for the persistence of many species of indigenous fauna within the boundaries of a radiata pine (*Pinus radiata*) forest, although many taxa were found to require a greater area than this. It is not surprising that 10% of the original vegetation cover is pushing systems to the limit and beyond, and at this level many elements of the biota would have already been lost. In areas where widespread clearing has already occurred, questions are therefore now being asked about how much vegetation needs to be put back into the landscape. And where vegetation is still being cleared, the question being asked is, "How much vegetation should be left in the landscape?".

Box 5 – Current ecological processes threatening remnant vegetation in rural areas of Australia

- Continued vegetation clearance and fragmentation
- 'Tidying up'
- Poorly managed grazing
- Dieback
- Lack of regeneration, especially of trees
- Invasive plants and animals, resulting in predation, competition and habitat loss
- Altered disturbance regimes including the frequency, intensity, season and type (eg. fire, floods, grazing by native animals)
- Disease eg. Mundulla yellows, Phytophthora
- Salinity
- Waterlogging
- Climate change
- Movement of nutrients, water and energy from adjacent lands to the bush
- Disruption of food webs (loss of native predators)
- Rubbish dumping
- Firewood collection — a more detailed example of a threatening process

Firewood is currently the third largest source of energy used in Australia after electricity and gas, and much of the annual firewood supply is removed from remnant vegetation stands (Wall 2000b). Overall, the harvesting of wood for domestic and industrial heaters means that around 6 million tonnes of timber a year goes up in smoke. To put this in perspective, a similar amount of eucalypt woodchips is exported annually.

At a regional level, Project UOC7 (Table 2, Appendix A) showed that to service the demand for firewood in the Canberra market, the 'catchment' for firewood harvesting has expanded to include areas approximately 500 km towards the north-west, into the cropping zone of the central west of New South Wales. Almost all of the firewood was sourced from remnant vegetation, with particular demand for timber from box and ironbark eucalypts (Treweek 1997). To reduce the impact of harvesting on native plants and animals, Project UOC7 examined alternative sources of firewood such as farm forestry. This research demonstrated that the formation of farmer cooperatives and farm forestry networks made the firewood markets economically feasible, especially when tree plantations could be used for a range of purposes.

Box 5a – Current societal processes threatening remnant vegetation in rural areas of Australia

- Limited financial and human resources for the scale of the task
- Lack of management experience and confidence
- Information delivery of limited effectiveness, little person-to-person communication or interpretation
- Lack of institutional reform and political will to tackle the issues over the required time scale
- Pressure on landholders to maximise production and recognise returns

Based on our current level of understanding it appears that *a minimum* of 30% woodland or forest cover is needed to avoid serious ecological damage (Barrett 2000). This figure has been recommended by a range of different sources from southern and eastern Australia, including some projects funded through the Program. For example, Project CTC9 recommended that, in south-eastern Queensland, 30% of a landscape or property should be under woodland or forest, at whatever density is appropriate for the vegetation types under consideration (McIntyre *et al.* 2000). Project ANU6 also recommended that, for extensive developments (eg. > 1000 ha) of the softwood plantation estate in south-eastern Australia, the aim should be to contain *at least* 30% of remnant or re-established native vegetation within the boundaries of the plantation. It was also suggested that an increase in the area of native forest and woodland contained within the plantation estate should be a criterion for sustainability of these areas. Restoring native vegetation cover to *a minimum* of 30% of the landscape at regional levels has also been recommended to arrest the serious declines in bird numbers witnessed across southern Australia (Recher 1999).

This level of native vegetation cover also makes sense from an economic perspective, with Walpole (1999) showing that gross value of pasture output near Gunnedah (northern NSW) was at its highest level when the proportion of tree area across the farm was 34%. Interestingly, the figure of around 30% native vegetation cover is now working its way into policy documents. For example, the discussion paper on natural resource management released by AFFA (1999) states that regions with less than 30% cover will lose biodiversity and have dryland salinity problems.

There is also a growing understanding of the importance of understorey for both conservation and production values (Anon. 1992; Lambeck 1999; Martin 1999), so maintaining the indigenous understorey is a critical consideration. It is also important that the figure of 30% not be taken as an absolute, or the maximum level of revegetation/ native vegetation retention required at the landscape/regional scale. In some cases, greater areas of native vegetation may be needed, for example to combat dryland salinity. As stressed by McIntyre *et al.* (2000) for eucalypt woodlands in south-eastern Queensland, 30% represents the lowest level needed for landscape functioning, not a desirable level. There is still much to be learnt about the role of native vegetation in the landscape, but the value of 30% cover gives land managers a minimum to work with. Questions about the wider applicability of work undertaken in southern and eastern Australia on thresholds for vegetation cover have also been raised. As clearing increases in other parts of Australia, this question becomes of increasing relevance. While further field-based studies are needed in these regions, retaining a minimum of 30% vegetation cover is a conservative target and leaves a greater range of options open as the understanding of these systems improves.

How can the message about minimum levels of forest and woodland cover be effectively communicated? Project CTC9, which is examining the production–conservation trade-offs in variegated landscapes, has developed a board game to illustrate why various thresholds, like a minimum of 30% woodland cover, have been set. The game demonstrates the importance of landscape planning and the detrimental effect that clearing vegetation has on the animals and plants which live there. Given the interest in this approach, there is the potential for it to be more widely adopted and communicated in workshops, schools and other arenas.

2.1.2 The importance of gully and stream areas

Gully and stream areas were found to be critical for biodiversity conservation in all of the projects where it was studied, despite these being in quite different environments: Project DUV2 in the box–ironbark woodlands of Victoria, surrounded by agricultural land; Project ANU6 in the higher altitude forests near Tumut, NSW, surrounded by *Pinus radiata* plantation; and Project CTC9 in the variegated landscapes of south-eastern Queensland. As well as often having different suites of plant species than those in surrounding land, gullies and stream areas are a relatively rich habitat for a range of fauna. This is related to greater availability of moisture and probably nutrients — leading to greater productivity. Where the original vegetation remains, there is also a greater structural complexity of vegetation (eg. taller, larger trees). Riparian corridors can also be a key feature for dispersal of at least the smaller mammals such as the bush rat, as identified in Project ANU6. That study found that native vegetation in gully and stream areas (that are not available for timber harvesting), if maintained or restored was likely to make a significant contribution to biodiversity conservation. Fisher and Goldney (1998) found similar results in the pine plantations of central-western NSW. Their study focused at the landscape scale, concluding that, in general, native vegetation was critical for birds and that vegetation along drainage lines in particular should be maintained and extended.

These and other studies (Bennett *et al.* 1998; Reid 1999) emphasise the importance of retaining and restoring gully and stream areas in the landscape. They can have an impact way above the area they occupy — for example, wooded gullies occupy only about 2% of the box–ironbark estate in Victoria. However, they are also targeted for a range of other uses, the most destructive perhaps being alluvial gold mining. Native vegetation in other parts of the landscape also plays a critical role in biodiversity conservation and landscape function, but the relative importance of gullies and streams has been recognised only recently.

Watercourses are also important for farming enterprises, so their management is a particularly good example of trying to balance the objectives of both conservation and production. Project CTC9 in south-eastern Queensland has identified key principles for managing watercourses in this region, as they are particularly important to the ecosystem and grazing enterprises (McIntyre *et al.* 2000). As a general principle, it was recommended that: livestock should be excluded from watercourses to reduce soil erosion and maintain the quality of water; vegetation should not be cleared right to the edges of watercourses; and the control of exotic species in riparian zones was important. Project ANU6 has also recommended that grazing be excluded from native vegetation along creeks and gullies in a pine forest matrix for at least 5 years. However, in some cases the total exclusion of stock may not be required. Access of stock to watercourses and other remnant vegetation is discussed further in section 2.4.3.

2.1.3 Is bigger really better?

How big should a patch of native vegetation be? This has been the subject of considerable interest as questions are asked about the amount of management effort that should be put into different sized remnants. As already noted, all native vegetation has some value and provides the building blocks of the Australian landscape, especially for revegetation programs. Where the effort should be targeted depends on the objectives of management and the nature of the patches found in an area. For example, in Tasmania >90% of remnants are 1–5 ha in area and Project UTA4 is studying the viability of very small remnants to identify under what conditions it is worth trying to maintain them. Even if only small remnants remain, at least there is something to work with and build on — and they can provide a source of information on the composition of native vegetation as well as supply seed for restoration efforts. And if they are of a vegetation type that has been extensively cleared from its former extent, they are significant even if their current condition is degraded. Small remnants can also serve an aesthetic or spiritual purpose. It must also be remembered that even individual trees may provide habitat/resources for some fauna such as bats (Lumsden and Bennett 2000). These trees may also serve many other functions (Reid and Landsberg 2000; Project ANU6).

The comments about remnant size and configuration also need to be considered in the context of the broader landscape and the amount of vegetation cover needed overall to avoid ecological degradation. Based on previous discussions, there should be a *minimum* of 30% tree cover, emphasising the need to remember the 'big picture'. The management history of an area can also have a bearing on the relationship between remnant size and the resources it provides. In northern Victoria, woodland remnants on private land have greater numbers of large, hollow trees than those on public land (because of less intensive logging) but proportionately fewer dead trees (a result of farmers cleaning-up) (Bennett *et al.* 1994). So in this region, remnants of equivalent size but on different tenures would provide quite different habitat. This illustrates that bold statements like "only put your efforts into patches larger than 100 ha" need to be rethought — generalisations such as these will be further discussed later in this section.

The reasons for managing and conserving remnants (ie. the management objectives) — such as maintaining certain plants or animals — can also have a bearing on the importance of the size of a patch. For example, there appears to be a much greater capacity for plants to persist in small remnants that have received sympathetic management (Project UTA4). And while bigger remnants are generally better for vertebrate fauna (see below), in the Tumut region at least, Project ANU6 has shown that patches of remnant woodland and forest vegetation as small as 0.5 ha can be valuable habitat for wildlife, especially for birds and reptiles. In the grassy woodlands of south-eastern Queensland (Project CTC9), clumps of trees of at least 5–10 ha have been recommended as the minimum size to provide birds with habitat and allow them to keep trees and pastures healthy by eating insect pests (Martin 1999; McIntyre *et al.* 2000). Freudenberger (1999) also recommended that vegetation patches at least 10 ha and with at least a 20% shrub cover were required for many bird species in the ACT region.

For most species of vertebrates, however, the larger the remnant, the more 'value' it is likely to have. Project DUV2 found that, in general, remnants of about 80 ha had a similar bird community to larger reference areas in contiguous forest. Larger remnants in a pine forest matrix (Project ANU6) also had bird communities more reminiscent of continuous eucalypt forest, whereas the smaller remnants supported a bird community more similar to that in the radiata pine. However, even the radiata pine provided habitat for native birds, with significantly more species being found than was expected.

These projects are supported by studies such as Freudenberger (1999) who demonstrated that, while woodland birds were found in a range of patch sizes, conservation of large (> 100 ha) and structurally diverse woodland remnants was a high priority, at least for vulnerable woodland birds. Project ANU7, which was also conducted in the ACT region, likewise recommended that woodland remnants of high conservation value (in this case to maximise bird species diversity) should be greater than 150 ha. For remnants less than 150 ha, further assessment based on habitat complexity was recommended when prioritising the management of remnants. So, native vegetation patches of 80 ha or greater — and particularly those with structural diversity in the understorey — have been identified as important for bird species diversity in southern Australia at least. In contrast, the managers of the company Earth Sanctuaries Pty Ltd, whose mission is to save Australia's wildlife before any more species become extinct, recently stated that areas less than 1000 ha were not viable in the longer term. Once again, this demonstrates the importance of clearly stating the objectives of the area being managed — in this instance the conservation of a range of fauna species and particularly mammals.

It can be seen from these few examples that remnant patches of all shapes and sizes provide a range of benefits and that it is difficult, if not impossible, to prescribe a particular formula. Larger remnants are important, especially for vertebrates, but smaller remnants and even individual trees can be a critical part of the overall landscape used by fauna. Interestingly, one of the socio-economic projects funded through the Program (Project UME28) recommended that educational strategies should place greater emphasis on the values and management of relatively small areas of remnant vegetation. The project suggested that landholders place relatively little value on fencing small areas of vegetation, probably because they do not appreciate the importance of careful management of all remnants, regardless of size. This once again emphasises the contribution to biodiversity and wildlife protection of small remnants across a landscape.

Overseas studies are beginning to demonstrate that caution is needed when using generalisations such as what size of remnant is the 'best'. A recent study on the effect of fragmentation on vertebrates in the Florida scrub (McCoy and Mushinsky 1999) found that the benefits gained for certain species from focusing on the preservation of larger scrub fragments could be offset by harm done to other species, especially rare ones. The authors concluded that when a habitat has declined to a state where large fragments are, at best, extremely rare, then smaller fragments are likely to be of considerable value, no matter how they compare to larger fragments.

2.1.4 Configuration of remnants

The configuration of remnants — how they are arranged in relationship to each other — has also been a topic of widespread interest. In particular, the advantages and disadvantages of corridors in agricultural and other landscapes have received considerable attention (Breckwoldt and others 1990; Wilson and Lindenmayer 1995; Bennett 1999). The importance of maintaining the original native vegetation as linkages in the landscape has been reinforced by Projects DUV2 and ANU6. Networks of roadside and streamside vegetation were found to play a critical role in maintaining habitat connectivity among remnants in the box–ironbark woodlands in Victoria. As noted, corridors of native vegetation along riparian zones within a pine forest matrix (Project ANU6) also play a key role in the dispersal of some of the small mammals. Thus, while CIE (1998) found that there was no unequivocal evidence to show whether the creation of corridors by *revegetation* will bring significant benefits to nature conservation, research on corridors already existing in the landscape has demonstrated that they can have significant ecological value for the maintenance and dispersal of some biota.

Studies in the wheatbelt of Western Australia have recommended that the distance between remnants should not exceed two kilometres for birds and that vegetation linking habitats occupied by dispersal-limited birds should be approximately 50 m wide (Lambeck 1999). In eastern Australia, it was found that many bird species were likely to occupy patches that were within 500–1000 m of other remnants (Freudenberger 1999). Project ANU6 found that areas of radiata pine 50–100 m wide were not significant barriers to the movement of small mammals such as the brown antechinus but those exceeding 500 m limited dispersal between patches of remnant eucalypt forest. These results reinforce the general principle that areas of remnant vegetation should not be too widely dispersed or isolated, especially for less mobile species like small mammals and arboreal marsupials (Bennett 1999). Nevertheless, Project ANU6 has found that isolated patches can still have significant conservation value for many species (eg. birds) and should not be cleared or ignored simply because they are isolated. Even when isolated remnants are small, they should not be ignored as candidates for active conservation management.

The configuration of remnants is also important because of the spatial and temporal availability of resources that fauna rely on. For example, it was found that nectar feeders in the box–ironbark woodlands use different floral resources in different seasons and at different locations in the landscape (Project DUV2). This is necessary because plant species do not always flower consistently from year to year or place to place. Project ANU7 (Er and

Tidemann 1996) also demonstrated that yellow box (*Eucalyptus melliodora*)–Blakely's red gum (*E. blakelyi*) woodland remnants in the ACT were critical wintering sites to partial migrant and resident bird species and breeding sites for both residents and summer migrants. This study demonstrated that birds respond differently to their habitats at different times of year and also emphasised the importance of basing management decisions on information from more than one season. The mobility of fauna also means that the type of land use or source of disturbance in the matrix can influence the composition and abundance of wildlife populations in remnant patches (Wilson and Lindenmayer 1995; Bennett 1999).

2.1.5 Remnant condition

It is not only the size of the remnant that is relevant, but also its condition. This can relate to measures such as tree health, understorey diversity, structural diversity, the number of tree hollows and weediness. There would be little argument that remnants in good condition should be a high priority for conservation. But what of those that aren't? Once again, the results from Project UTA4 in Tasmania are proving interesting. This research has shown that condition and rare or threatened species (ROTS) occurrences are not correlated, with ROTS generally occurring in poorer quality remnants in terms of exotic species cover and richness. It has also shown that the correlates with condition and ROTS occurrence vary quite markedly between environments and vegetation types.

For animals in the box–ironbark woodlands, the most useful indicators of remnant quality were found to be measures of the remnant itself, including the level of disturbance to on-site resources (Project DUV2). This includes the availability of habitat resources such as ground layer cover and shelter, logs and woody debris, and large trees for hollows and nectar production. As discussed under the section on remnant size, even a degraded remnant can be significant if it represents an extensively cleared vegetation type or is the habitat of rare species. An example given by Kirkpatrick and Gilfedder (1999) is the lowland silver tussock grasslands in Tasmania. This vegetation community is almost extinct and is often represented by badly degraded remnants, but the remnants are essential habitat for the threatened Ptunarra brown butterfly. Criteria for assessing the health of a remnant are discussed further under the second priority for ecological projects funded through the program. The assessment of vegetation condition is also being addressed as part of the National Vegetation Information System, which will be examining the issue at a number of scales. This is being conducted as part of Theme 3 of the National Land and Water Resources Audit, with more information available on the Audit web site (http://www.nlwra.gov.au).

2.1.6 Conclusions

The hope of many conservation managers is that it will be possible to identify a limited set of landscape variables which, if present, will ensure the retention of all of the biota in the landscape that they are managing (Lambeck 1999). In other words, a relatively simple template is sought that specifies a proportion of the landscape that should be allocated to native vegetation (original and planted) to ensure the persistence of the native biota. Unfortunately, such a 'recipe' does not exist, although there are some general rules of thumb that can be applied if little information is available for the landscape being managed and it is in urgent need of remedial action.

Overall though, decisions about the 'optimal' size, shape, connectivity or condition of remnants to conserve biodiversity will depend to a large degree on which element of biodiversity is being targeted and the specific management objectives to be met. Even when the one group such as birds is being targeted, projects such as ANU7 (Er and Tidemann 1996) have demonstrated the complexities of managing remnant vegetation. This study showed that patch size, 'connectedness', distance to other remnants and the vertical/horizontal complexity of vegetation are important factors for different species of birds during different seasons.

In order to help systematically address such complexity, an explicit methodology has recently been developed — the focal species approach — for identifying the most appropriate size and spatial configuration of native vegetation and/or areas to be revegetated (Lambeck 1997, 1999). This approach is receiving increasing attention as a planning and management tool. For example, it was used in the Western Australian pilot planning project funded through the Program (Project CCM4, Table C in Appendix A), to guide revegetation activities around Canberra (Freudenberger 1999; Elvin 2000) and is being considered by government agencies in Victoria and Tasmania. To identify priority areas for native vegetation management this approach uses 'indicator' species, birds in particular. While the focal species methodology offers a pragmatic approach to landscape design, it is important that it undergoes further testing and refinement and that monitoring is a key part of the project design — as discussed in greater detail in section 2.2.1.

While bigger is generally better, certainly where fauna is concerned, research conducted within the Program and elsewhere indicates that all native vegetation has a role to play. For example, small, weed-infested remnants can be important habitat for rare or threatened plant species, so should not automatically be discounted — especially when they are all that remains. These areas can be used as a starting point to enhance the long-term viability of remnants — the building blocks of the Australian landscape (Campbell 1999). However, when areas are being revegetated, it is better to plant larger areas and wider corridors than dotting the landscape with tiny patches and thin strips — these will support faunal communities that are only simple when compared with those in large natural areas (Project DUV2). Gully and stream areas have a particularly important role to play for both biodiversity conservation and farming enterprises, which is often disproportionate to the area they occupy.

Remnant characteristics like size, shape and connectivity are no doubt important, but other considerations are sometimes necessary when determining which remnants should be the highest priority for on-ground management. A stark reminder of this is the threat that rising groundwater and salinity poses to an increasing number of remnants. Initiatives to incorporate this additional threat in establishing priorities are under way in both eastern and western Australia. For example, in the Goulburn–Broken catchment in north-eastern Victoria (Project VCE13, Table C in Appendix A), when remnants are prioritised for resource allocation, the depth of the watertable is considered in addition to the size of the remnant and proximity to other native vegetation. As already discussed, the management history of an area can also have a bearing on the relationship between remnant size and the resources it provides. These examples emphasise the importance of understanding the range of factors influencing the nature and condition of the native vegetation.

What these and other projects also demonstrate is the need to consider remnant vegetation at a number of scales, from the site to the region. A summary of the usefulness of these different scales for vegetation management in the box–ironbark region is provided in Box 6 and discussed in greater detail in the overall summary for the ecological projects. The principles outlined in this approach can be applied generally, although the detail will differ depending on the region in question. The different scales of action required in relation to management goals are also addressed in one of the pilot planning projects funded through the Program (Project CCM4, Table C, Appendix A). And the importance of viewing the bush from a broader perspective than individual patches is also emphasised in Project UTA4 (Kit 2 in Kirkpatrick and Gilfedder 1999). These examples further support the need to carefully consider the issue of scale when managing native vegetation.

2.2 Identifying characteristics important for ecosystem function, or as indicators of the health of remnants

There has been an ongoing debate about the best attributes to measure in order to determine the health or quality of remnants. But based on research in the Program and studies elsewhere, assessment of characteristics of the remnant itself, rather than particular 'indicator' species such as birds or mammals, appears to be the most effective approach. Two projects in the Program focused specifically on characteristics of remnants that are important for animals (Projects ANU6 and DUV2) and one on plants (Project CWE10). Projects CSU6 and UTA4 consider the broader range of attributes that are needed to assess remnant condition, addressing the needs of both animals and plants, as well as attributes that contribute to ecosystem function. These projects developed toolkits as simple and cost-effective methods for assessing the health of remnants at the site level (Goldney and Wakefield 1997; Kirkpatrick and Gilfedder 1999).

Project ANU6 identified several limitations associated with the use of indicator species, which were broadly supported by Project DUV2 — even though the studies were undertaken in quite different regions. The results from ANU6 showed that each animal species responded differently to landscape fragmentation and remnant characteristics. Consequently, no single species or group of species was thought to be a good indicator for the response of other taxa, even closely related ones. Complementary work in Project DUV2 found that trying to predict remnant quality based on the ecology of animal species sensitive to fragmentation was unsuccessful. This was thought to be due to the many flow-on or secondary effects of fragmentation, such as changes to microclimate and invasion of pest species at the edges. Also, these effects were not consistent between ecosystems and varied between remnants within ecosystems, making reliable predictions based on bioindicators extremely difficult.

For animals in box–ironbark woodlands (Project DUV2), the most useful indicators of remnant quality were measures such as the size of remnants, level of disturbance to on-site resources and where the remnant occurred in the landscape. These results are similar to ANU6, where it was found that the most robust ecological principles for promoting biodiversity conservation in fragmented landscapes included establishing, maintaining or enhancing landscape connectivity, stand complexity, plant species composition and landscape heterogeneity. Using these characteristics, a high quality remnant for vertebrate fauna in box–ironbark woodlands would be large in area, include a gully or stream and have lots of big trees, litter and downed woody material. But based on the work in Project DUV2, it would not be possible to say that, because a particular species that was sensitive to fragmentation was present at a site, that the area was high quality habitat for other species.

Project CWE10 focused on the condition of remnants from the perspective of a plant and used habitat value and the potential for regeneration to assess salmon gum (*Eucalyptus salmonophloia*) woodlands in the south-west of Western Australia. This was based on survey and experimental work that confirmed the existence of restoration thresholds, caused by changes in soil structure and lack of soil- or canopy-stored seed. Project USH3 also examined restoration of a range of vegetation communities, and is covered in greater depth in section 2.4.1. Experimental work in Project CWE10 reinforced the importance of weed control in facilitating establishment of native species, and indicated that survival and growth of native species could be enhanced with management intervention such as soil ripping and/or creating a 'gap' by ringbarking individual adult trees. Salmon gum woodlands were considered to represent a 'worst-case', and it was felt that other woodland types would require varying degrees of management intervention, perhaps involving only the removal of stock for a limited period.

The results from Project CWE10, as well as research conducted in Projects UNE21, KPB1 and CSU6, reinforce the importance of plant regeneration for the long-term maintenance of native vegetation (also see section 2.4.1). This was not explicitly addressed in Projects DUV2 and ANU6, but is critical for providing fauna habitat in the longer term.

In addition, characteristics like the presence of feral predators and the amount of fertiliser drift can influence remnant quality. These are included in the assessment of the health and sustainability of bushland patches in Kit 1 of the "Save the Bush Toolkit" (Goldney and Wakefield 1997). By scoring 20 different characteristics of the bushland remnant, a

Box 6 – Managing remnants at different scales — general implications from the box–ironbark forests (Project DUV2)

Site level: management at the site level is important for the provision and maintenance of the habitat resources that species use on a regular basis. Research in the box–ironbark woodlands recognised the importance of ground-layer attributes, such as logs, leaf litter and low shrubs; diversity of vegetation structure; and the values of large old trees for hollows, foraging substrates and nectar production. It is at the site level that management must control the disturbance processes that have an impact on such habitat resources. Consequently, a key element of managing remnant vegetation is ensuring that land uses such as grazing, timber harvesting and gold mining do not deplete resources.

Landscape level: at this level, attention must be given to the types of habitats and the spatial pattern of habitats that are managed for the conservation of biodiversity. The following aspects have been highlighted by research in this project:

- Conservation and management of forest remnants has an important role in retaining fauna in rural landscapes. In general, the larger the remnant, the greater its value for faunal communities. Remnants of about 80 ha had a similar avifauna to larger reference areas in contiguous forest.
- Networks of roadside and streamside vegetation, already present in many areas, have a critical role in maintaining habitat connectivity among remnants as well as providing further habitat, often of high quality.
- Gullies and streams are key parts of the landscape to protect and manage for faunal conservation.
- Maintaining a diversity of forest types close to one another is valuable for species that move between habitat types to obtain resources (such as nectar).

Regional level: management of natural environments at a regional scale is essential:

- to provide representation of the range of different habitats required by the fauna (eg. between the east and the west of the box–ironbark woodlands);
- to provide sufficient habitat for wide-ranging species such as large predators (eg. powerful owl);
- because some species move widely within the region seasonally or annually (eg. the threatened swift parrot); and
- because a substantial proportion of the bird community migrate in/out of the region as a whole each year.

It is at a regional level that a comprehensive system of conservation reserves needs to be established to provide protection of suitably large areas of forest that are representative of vegetation types and geographically spread across the region. It is also at the regional and landscape scale that planning is required to integrate management of remnants on private land with the remnant forest system on public land.

health rating is developed which gives an indication of the amount of management intervention needed. An important element of this assessment is the use of aerial photographs or property maps to identify patches of bushland. Another project in the Program (Project VCA2) has emphasised the importance of easy and inexpensive access to aerial photographs, which allow landholders to see the amount and location of vegetation on their properties.

Project UTA4 (see Kit 1 in Kirkpatrick and Gilfedder 1999) took a different approach to assessing the condition of bushland, describing what should be expected in bush that was in excellent, good and poor condition. The description of bush in excellent condition, which is something to aspire to, is reproduced in Box 7. Interestingly, the description does not explicitly include attributes identified as important for fauna in other projects in the program, such as hollow trees and downed woody material. However, these are likely to be present if bushland includes the other attributes referred to in Box 7.

Box 7 – A description of Tasmanian bush in excellent condition

Bush in excellent condition is entirely or almost entirely composed of native species in all its layers. There may be occasional exotic grasses such as hair grass (*Aira* species) or quivery grass (*Briza* species), or exotic herbs such as flatweed (*Hypochoeris* species and *Leontodon* species). However, exotic shrubs such as gorse or broom are absent or rare. Woodlands and forests in excellent condition have a healthy tree layer, a healthy understorey, and some evidence of younger trees emerging in the gaps. Treeless vegetation in excellent condition has sufficient spaces between the tussocks or shrubs to allow smaller species to survive.

From Kit 1 (Bush on your Farm), Kirkpatrick and Gilfedder (1999)

These research results provide firm support for a range of attributes being used for bushland assessment (see DLWC 1998 — VegNotes 1.3 for a NSW example). So the message is that there is a strong scientific basis underpinning much of the current practice in this area. Research in the Program also suggests that the use of bioindicators such as birds may have limited applicability when assessing remnant quality. This conclusion is supported by a major review on indicators for biodiversity in forest ecosystems to be published soon (Lindenmayer *et al.* 2000) which advocates the use of stand and landscape (spatial) attributes as potential indicators for biodiversity, and hence ecosystem health. The Lindenmayer *et al.* review concluded that characteristics such as stand structural complexity, plant species composition, connectivity and heterogeneity were preferable to the more commonly used indicator species (generally animals) where robust linkages had not been well established with other organisms or conditions. The next section examines how such statements sit with approaches that use ‘indicator’ species as an umbrella for other plants and animals.

2.2.1 Designing landscapes to meet biodiversity objectives — the focal species approach revisited

With continued emphasis on the restoration and revegetation of the highly cleared landscapes of southern Australia, increasing efforts are being made to identify the most appropriate size, configuration and location of native vegetation patches required to maintain ecosystem function and conserve biological diversity in agricultural landscapes. Because the remaining native vegetation in many parts of southern Australia will be insufficient to maintain viable faunal and plant populations in the long term (eg. Saunders and Ingram 1995; Bennett *et al.* 1998), there is a need to expand existing areas to meet biodiversity conservation and other objectives such as combating salinity, waterlogging and erosion, and to provide sinks for carbon to meet Australia’s greenhouse commitments. The complex models needed to examine these multiple objectives are under development. An integrated approach to land management should help achieve goals in both nature conservation and sustainable land use. But the objectives of programs such as Bush for Greenhouse, which hopes to provide funds for planting trees to preserve biodiversity and achieve sustainable land management, are thought to be difficult to achieve (Hassall and Associates 1999). For the purposes of this review, the focus is on designing landscapes for biodiversity objectives, but there is obviously still considerable work to be done on designing landscapes to meet multiple objectives.

A regional-level approach that has gained considerable attention is the use of focal species to specify conservation targets and determine the actions required to meet those targets (see Lambeck (1999) for a detailed review). The focal species approach is based on knowledge of the fauna of a particular study area and the identification of species potentially at risk in that area if no management action takes place. For those species, attention is given to identifying factors that limit their distribution and abundance, such as the minimum patch sizes needed and the distance required between patches so species can still disperse. Species that are limited by habitat size or isolation, or by insufficient resources, will require reconstructed habitats in the landscape — as recommended for the Wallatin Creek catchment in the Western Australian (Lambeck 1999) south-west. For example, in this region it was recommended that the minimum size for habitat patches be 25 ha, the distance between remnants should not exceed two kilometres and that vegetation linking habitats occupied by dispersal limited birds should be approximately 50 m wide (Bennett *et al.* 1999). Importantly, the nature of revegetation was also specified, with a recommendation for revegetation to contain clumps of dense understorey vegetation for some invertebrates and small mammals and the use of plant species that produce nectar during summer and autumn. For species limited by factors such as predators, stock grazing or inappropriate fire regimes, improved management of threatening processes was recommended as the main action required.

The emphasis of the focal species approach on planning at a landscape scale is a major step forward and the technique is thought to show considerable promise (Bennett *et al.* 1999; Reid 1999). One of its strong points is that it provides a pragmatic and explicit approach to landscape design that managers can use now. It is also underpinned by a number of assumptions, the key one being that designing landscapes to meet the spatial needs of the most sensitive species will meet the requirements of other, less sensitive species (Wallace 1998). However, the results from Projects ANU6 and DUV2 suggest that using one species (which is usually an animal) as an indicator for remnant quality, or as an umbrella for other plants and animals, may have limited application. It is important therefore that the focal species approach be further tested and refined, especially as it is being considered for adoption in several eastern States. A good opportunity to examine some of these issues is presented by the "Vegetation Investment Project" (Freudenberger 1999; Elvin 2000), which has used the focal species approach to guide revegetation activities around the ACT. As noted by Lambeck (1999) the establishment of monitoring programs is critically important to learn from such actions.

2.3 Assessing key processes influencing the long-term maintenance and conservation value of remnant vegetation

2.3.1 Invasive plants and animals

Invasive plant and animal species pose a serious threat to both species diversity and ecosystem function, as reported in many publications (eg. Humphries *et al.* 1991; Low 1999). This is no different in remnant vegetation, and invaders may pose a more serious threat in systems that are already under pressure from other factors. While introduced species such as the fox and cat can be a major problem, native species that have increased in numbers, usually because of environmental changes, can also cause considerable damage. Two examples of this phenomenon have been highlighted by projects funded through the Program — the brushtail possum (*Trichorus vulpecula*) in Tasmania (UTA4) and the noisy miner (*Manorina melanocephala*) in Tasmania (Project UTA4) and Victoria (Project DUV2).

In subhumid Tasmania, it was demonstrated that the exclusion of possums will improve tree health at some sites, and that the presence or absence of noisy miners had a major influence on the assemblage of birds present in remnant patches. Noisy miners were also found to have a negative impact on bird assemblages in the box–ironbark woodlands of Victoria, especially on small insectivorous birds. The noisy miners aggressively excluded other birds and depressed the diversity and abundance of native species (Grey *et al.* 1998). Interestingly, in the absence of noisy miners, a range of bird species was able to use even small, degraded remnants. The removal of noisy miners in Project DUV2 also significantly reduced insect damage on eucalypt leaves at most sites (because the number of insectivorous birds increased and hence the numbers of insects fell) and there was an overall improvement in tree health. This is the first time that a link between noisy miners and tree health has been demonstrated and illustrates the flow-on effects that changes in even one species can have to the dynamics of these systems.

Because the habitat for native fauna has become so reduced in area and simplified in structure, it is not surprising that disruptions such as these will occur. The question is, how can they be managed? The removal of noisy miners in the box–ironbark woodlands was found to be difficult, destructive and time consuming. As noisy miners are an open country species, habitat manipulation, such as increasing the size of the remnant or promoting a shrub layer, is being investigated as an alternative. By paying attention to good habitat in planning and managing a property (Dorricott *et al.* 1998), then there is also a greater chance that these problems can be avoided in the first place.

The problems caused by invasive plant species in bushland patches are well known, and several techniques have been developed to control them (Buchanan 1989; Davies 1997). Weeds compete for space and resources such as nutrients and water, and can alter the dynamics of a system, for example, by changing the fuel available for fires (Fensham *et al.* 1994). There are also a few anecdotal examples of environmental weeds providing food and protection for native animals. Consequently, some thought needs to be given to the role weeds play in a system before they are removed. Overall, however, quantitative measures of the impacts of environmental weeds on natural systems are still relatively rare (Adair and Groves 1998). This situation is gradually improving with a recent review describing the impacts of several terrestrial weeds at the species and ecosystem level in Australia (Groves and Willis 1999).

At a national level, the impact of environmental weeds has been recognised in both the National Weeds Strategy (Commonwealth of Australia 1999a) and the CRC for Weed Management Systems which has a program on weeds in natural ecosystems. Also, a review of the toolkit of measures needed to manage environmental weeds in Australia and New Zealand can be found in a special issue of *Austral Ecology* (Williams and West 2000). This outlines the considerable advances made over the last decade, but also notes the magnitude of the problems facing both countries. The recent proceedings of the Australian Weeds Conference (Bishop *et al.* 1999) also illustrates the increasing prominence being given to environmental weeds.

The management of environmental weeds was a component of several of the ecological projects in the Program. A common message was that weed control is an essential element of site preparation when aiming to regenerate or rehabilitate a site. However, as weeds are often associated with the disturbance caused by such preparation, it is important to monitor the potential invasion or re-invasion of sites by weedy species.

Project ANU6 reinforced the importance of hygiene practices when managing native vegetation. The highly modified landscapes that often surround remnant vegetation can act as a source of weed propagules. Therefore, vigilance is needed to help ensure weedy plants do not spread into native vegetation. This has been noted as a particularly serious problem in pine plantations where blackberries and other weeds are spreading into the small remnants of native vegetation remaining in the broader pine forest matrix (Project ANU6; Lindenmayer and McCarthy 2000). As blackberries are often spread by birds, this represents a real challenge for managers. Pine wildlings also threaten the long-term integrity of remnant vegetation, and Project ANU6 recommend that efforts should be made to further develop and use reproductively sterile radiata pine trees for softwood plantation establishment. For areas already invaded by pines, Gill and Williams (1996) reviewed the use of fire as a management tool. Not all native vegetation communities, however, have the same susceptibility to weed invasion, with Project UTA4 showing that there was little penetration of exotics into the heathland. This led to the conclusion that small heath remnants in agricultural landscapes may therefore have greater resistance to change than was previously thought.

In order to encompass the broad range of issues associated with weed management, including those identified above, a weed management plan is required. Kit 3 in Kirkpatrick and Gilfedder (1999) recommends five steps in such a plan:

1. define the problem;
2. plan an integrated weed management strategy;
3. develop a works program;
4. implement the strategy; and
5. monitor and review the process annually.

These steps provide a framework that presents options to help decision-making, rather than providing a simple set of prescriptions. This is important because the best methods for weed control will vary depending on the plant species present and the history and environmental sensitivity of a site (Kirkpatrick and Gilfedder 1999). Similar approaches to managing weeds have been recommended elsewhere eg. see Blood *et al.* (1996).

2.3.2 Conclusions

Invasive species can be both introduced and indigenous, and are a major degrading process in remnant vegetation. Identifying what is the problem is an important first step, which must include consideration of the potential benefits the weeds may provide and how these could be maintained if the weeds are removed. For some fauna species, habitat modification may be the only cost-effective way of managing invasive species. Awareness of the impact of invasive species is increasing, and integrated plans appear to be the key to their successful management.

2.4 Formulating measures to reconstruct, rehabilitate or manage remnant vegetation in highly degraded or altered landscapes

It is clear from work within the Program and other studies that active management of remnant vegetation is required to manage degrading processes such as weed invasion, rising groundwater, modified fire regimes, and changed site conditions leading to lack of recruitment and regeneration. It has also been noted that there is a need to increase the extent of existing areas of native vegetation to meet biodiversity conservation and other objectives such as combating salinity, waterlogging or erosion, and to provide sinks for carbon to meet the country's greenhouse commitments. The projects in the National Remnant Vegetation R&D Program have focused on existing vegetation, but there are clear links between maintaining what we already have and enhancing these areas with revegetation.

The long-term viability and self-regeneration of plant populations in remnant woodland vegetation is a pressing issue because active management may be required for many of these remnants to remain viable. Four projects in the Program examined the regeneration response of plants in detail, to try to enhance our understanding of these processes — and each took a quite different approach. Project UNE21 in the woodlands of the New England Tablelands investigated the response of numerous native plants to factors such as rainfall, fire, grazing, ant predation and soil disturbance. In contrast, Project KPB1 examined the germination response of plant species in south-western Australia to one factor — smoke. Another Western Australian study (Project CWE10) examined the measures needed to rehabilitate the highly degraded salmon gum woodlands of the wheatbelt of that State. And in the Central Tablelands of NSW, Project CSU6 investigated the recruitment of the dominant tree species in agricultural landscapes. These projects are discussed in greater detail below.

2.4.1 Restoration/rehabilitation of remnant vegetation

The processes required to restore/rehabilitate remnant native vegetation have been investigated at a range of different scales in the Program — from broad vegetation types (Project USH3) to individual plant species (Projects KPB1 and UNE21). Project USH3 examined ecosystem resilience and the restoration of damaged plant communities using case studies in sclerophyll and grassland communities in Sydney and rainforest sites near Lismore. In addition, it reviewed wetland resilience and restoration. This research indicated that the capacity of plant species to recover after natural disturbances such as fire, can play an important role in their recovery after human-induced impacts. In a similar vein, plant species with different functional responses to disturbance were grouped together in Project UNE21 as an aid to managing remnant vegetation in north-eastern New South Wales.

These and other studies suggest that the recovery capacity of plant species can be used by managers to help predict the type and degree of human intervention needed to restore a damaged plant community. Project USH3 concluded that an important first step was to consider the natural stresses to which a particular plant community (whether sclerophyll, rainforest, grassland or wetland etc.) has been exposed to over evolutionary time frames and the degree to which these stresses are similar to (or different from) the human-induced stresses which have caused the degradation. Identifying these evolutionary stresses can also provide clues to the type and degree of interventions needed to kick-start (or even supplement) natural recovery potential (Project USH3). Some sites, for instance, may need only small interventions because they have residual plant populations (even if only buried seed) or because plant species can migrate from sites within dispersal distance. In other, more highly damaged sites, however, this resilience may be lost and species may not recover unless higher levels of intervention (such as extensive reintroductions and substrate reconstruction — see Project CWE10, section 2.2) are carried out.

There is still much to be understood about the recovery capacity of plant species. For example, it has been only a relatively recent discovery that smoke can be an important factor in the germination of many native plant species. The aim of Project KPB1, therefore, was to further the understanding of this process and to develop practical methods for large-scale use in the rehabilitation of remnant bushland. This work was extremely successful and the technique is now part of mainstream practice, resulting in considerable savings in establishment costs. A very important aspect of this project was the application of aerosol smoke to the margin between remnant vegetation and abandoned pasture. Minimal recruitment was observed after this treatment, suggesting that in many instances there may be limited opportunities for long range (>5 m) natural dispersal of seed or establishment of seedlings from bushland into alienated margins. This means that it cannot always be assumed that remnant vegetation will be able to reclaim cleared land, and in many cases seed collection from local remnants and broadcast of this seed into a prepared bed must be undertaken along with a weed control program.

It is interesting to note, however, that smoke was not an important factor in the germination of plant species in remnant woodlands on the New England Tablelands of New South Wales (Project UNE21) highlighting the importance, once again, of being cautious when transferring results from one place to another (section 5.2). Project UNE21 identified the critical cues (ie. rainfall) and thresholds (ie. fire, grazing) that influence plant regeneration, then made linkages between different processes influencing the decline, maintenance or increase in population numbers. The results were written up as a series of practical measures in the booklet *"Your Bushland: Tips for Managing Native Bush Plants in the New England Region"*, which has recently been published by the University of New England (Clarke 1998). Some of the key results were that the main germination cue for most species in the New England region was rainfall; that there appears to be some window for limited grazing, but not fire in the first years after a recruitment event; but also that the combined effects of set stock grazing and other grazing (rabbits and kangaroos) reduces survival of most species. The subject of grazing in remnants is covered in greater detail later in this review. Most species also did not persist for long periods as soil-stored seed and required some form of disturbance to provide the appropriate conditions for establishment — this result could pose a challenge for managers because soil disturbance can also encourage weed invasion.

Major disturbance such as soil ripping or ringbarking was recommended to encourage regeneration in the highly degraded salmon gum woodlands of south-western Australia (Project CWE10), demonstrating that in some cases quite drastic intervention may be required to maintain remnant systems. In this instance, serious soil compaction and competition for limited soil moisture by adult eucalypts meant that plants had little opportunity for successful establishment — but this really was considered a worst case scenario and in some cases natural regeneration from seed fall may be all that is needed. For example, in some areas of south-western Australia, sites that have been cleared, or abandoned soon after clearing were shown to yield useful conservation benefits with relatively little input (Arnold *et al.* 1999). To recognise these potential differences, Project USH3 recommended a 'resilience analysis' before deciding appropriate treatments for any site. This would need to take into account 'migratory' and 'in situ' resilience potential which arises from two factors:

- the intrinsic attributes of the pre-existing species (which is often different between 'resprouters' and 'obligate seeders'); and
- the spatial layout of a site (ie. whether patchy or diffuse impact patterns).

Even if plant propagules are available at the site or can be dispersed from nearby, other factors come into play. In many instances, the areas that are the target for recovery have a long history of intensive land use — so how does one try to regenerate these landscapes? This question was addressed in the Central Tablelands of NSW (Project CSU6; Windsor 1998) where the optimal conditions for the recruitment by seed of two eucalypt species and one wattle were studied in highly modified agricultural landscapes. The aim was to identify cost-effective alternatives to tree planting that could be readily implemented by landholders. While a range of factors was important for the success of regeneration from seed, such as the dispersal of eucalypt seed by wind and the degree of agricultural disturbance, soil moisture was found to be critical for seeding establishment, with the timing of the restoration effort significantly influencing the recruitment outcomes. For sites that are highly modified, this means waiting until favourable seasonal conditions and canopy stored seed are available, then using a combination of scalping and scarifying to prepare the site. In some instances, however, it was found that tree planting rather than recruitment from seed may be the only viable option. Yates and Hobbs (1997b) have also developed a model to help land managers identify areas where further information is needed for the restoration of woodlands.

The projects in the Program focusing on plant regeneration have delivered some useful insights. The discovery of the importance of smoke as a germination cue, which was developed in Project KPB1, took many people by surprise. The rapid and widespread adoption of the results of research such as this are encouraging. Other important messages are that site preparation is a key to successful establishment to reduce the impact of competition from other plants, that some sort of disturbance is generally needed and that soil moisture is a critical factor in plant regeneration. In hindsight, it could be said that many of these results are common sense. So the question is — why isn't more of this knowledge being put into practice? Presumably because the human and financial resources are not currently available. And while generalisations such as 'disturbance is an important factor' can be made, a very important result from these and other projects is the variable nature of plant responses and management requirements. Project UTA4 in Tasmania demonstrated this particularly well, concluding that the management of rare or threatened plant species for conservation should be undertaken on an individual species basis.

2.4.2 Using research to develop management guidelines

Guidelines for the management of native vegetation communities can help identify priority issues, and several have been developed in the Program, principally those funded under the banner of ecological projects' (CWE10, DUV2, CTC9, ANU6, UNE21, CSU6, UTA4 — see Table 2). Several of these have included landholder involvement to ensure that their content and language meets the needs of the primary audience. Rather than being prescriptive about managing remnant woodlands, an adaptive management approach is encouraged where ongoing monitoring is a key factor. And when it comes to specific management guidelines, nothing can match local knowledge about the systems involved. While technical knowledge about ecological patterns and processes varies among individual landholders, this source of information has often been overlooked. The topic of management guidelines is covered in greater detail in a later section: 'Across Program issues'.

2.4.3 Grazing impacts and the role of fencing

There has been considerable emphasis on fencing remnant vegetation as the first and critical management step. 'Virtual fencing', which uses remotely transmitted signals to discourage domesticated animals from venturing into or out of an area, is currently in the developmental stage (Rouda 1999). Until this has been shown to be a cost-effective and simple technique, wire fencing (both electric and other) will continue to be the most commonly used method, with variations such as flood-resistant laydown fencing near streams (Askey-Doran 1999).

Both the Natural Heritage Trust (NHT) and Greening Australia have funded numerous fencing initiatives that provide the fencing materials for landholders, who then provide the labour to put up the fences. In this regard, a project hailed as a model for the NHT has been the Fencing Incentives Program in the Riverina district of NSW (Driver *et al.* 2000). In this region, the need for fencing has been identified as a prerequisite for implementing appropriate and ongoing vegetation management. However, a significant impediment in bringing about changed vegetation management was the cost of fencing. Provision of funding assistance for fencing was also identified as a priority by landholders interviewed in Projects FAS1 and CSO2 (Slee and Associates 1998; Elix and Lambert 1998). These and other incentives for managing vegetation on private land will be dealt with later in this report.

The main aim of fencing remnant vegetation is to exclude large grazing animals, although rabbits can also be a problem (Project UTA4). Inappropriate levels of grazing can cause compaction of the soil, increase the amount of nutrients at a site, introduce weed propagules, reduce invertebrate biodiversity (Bromham *et al.* 1999) and adversely affect particular plant species that are selectively grazed. Project CWE10 also found that heavy livestock grazing in salmon gum woodlands in Western Australia was associated with a decline in native perennial cover, an increase in exotic annual cover, reduced litter cover, reduced soil cryptogam cover, loss of surface soil microtopography, increased erosion, changes in the concentration of soil nutrients, degradation of surface soil structure, reduced soil water infiltration rates and changes in near ground and soil microclimate. Driver *et al.* (2000) also reported that 24 of 26 overstorey species showed regeneration after the removal of stock from remnant vegetation in the Riverina.

It is now relatively widely accepted that certain grazing regimes can be detrimental to both the conservation and production values of native vegetation, particularly continuous heavy grazing in riparian areas (Askey-Doran 1999). However, under certain circumstances these impacts can be managed so that grazing animals do not have to be totally excluded from native vegetation. As the Tasmanian Bushcare Toolkit advises, stock is not necessarily bad for native bush (Kirkpatrick and Gilfedder 1999). Reid and Landsberg (2000) also list a range of studies linking the regeneration of farm eucalypts at least, with certain kinds of grazing. In addition, it has been suggested that even riparian vegetation can be used as an emergency store of feed as long as the frequency of use and stocking rates are adjusted to suit the sensitive nature of the land (Askey-Doran 1999). And in some instances the presence of grazing has been associated with the maintenance of high conservation values at a site, which is discussed further below. The key point is that *fencing allows total grazing pressure to be controlled.* It can also facilitate improved and differentiated management by zoning land both conceptually and physically. The physical power of erecting a fence to change management should not be underestimated.

The occasional use of remnant vegetation for grazing or stock shelter may alleviate some of the concerns of some land managers that fencing off remnants reduces the utility of the native vegetation (Slee and Associates 1998 — Project FAS1). In the past the focus has been on the adverse environmental impacts of grazing, but there is growing interest in the strategic use of grazing to develop conservation outcomes. For example, the results from Project UNE21 demonstrated that *limited* periods of sheep grazing on the Northern Tablelands of New South Wales could help preserve native plant species. This was because natural grazers such as kangaroos were no longer active in

Table 2. Detailed management guidelines or principles developed for particular native vegetation communities by projects in the EA/LWRRDC National Remnant Vegetation R&D Program.

Project	Region	Output
UNE21	NE NSW	Your bushland: tips for managing native bush plants in the New England region (see Clarke 1998)
UTA4	Tasmania	Tasmanian Bushcare toolkita. (see Kirkpatrick and Gilfedder 1999).
DUV2	Box–ironbark woodlands Victoria	Wildlife in box–ironbark forests: linking research and biodiversity management. Information sheets 1999.
CSU6	Central–west NSW	Save the Bush Toolkit (see Goldney and Wakefield 1997)
CWE10	Temperate woodlands	Guidelines for managing remnant woodland (see Hobbs and Yates 1997, 1998)
CTC9	Sub-tropical woodlands	General principles for the sustainable management of grazed woodlands. (see McIntyre et al. 2000)
ANU6	SE Australia	Guidelines for biodiversity conservation in new and existing softwood plantations. (see RIRDC 2000b)
UME28	Southern Australia	Guidelines for promoting native vegetation protection. (see Cary et al. 1999)

[a] This toolkit was the result of a major collaboration between several agencies to which the LWRRDC project UTA4 contributed significantly.

much on-farm remnant vegetation and *controlled* grazing with sheep opened up the ground cover and allowed seed stored in the soil or falling from the tree canopy space to germinate. Without this disturbance, natural and introduced grass species smothered smaller understorey plants where a lot of the biodiversity is found. The recommendation from this project was therefore to cease continuous stock grazing and implement intermittent grazing regimes with long rest periods (Clarke 1998). Preliminary results from Project UTA4 found that low levels of grazing in several vegetation types in Tasmania were not associated with a loss of conservation values. It was even found that in a small remnant of *Eucalyptus tenuiramis* inland forest on mudstone, sheep grazing reduced the cover of exotic plants, and, with burning, promoted the abundance of at least one threatened plant species. The interaction between fire and grazing is a critical one, but has received relatively little attention to date.

Outside of the Program (see Lunt and Morgan 2001 for research in temperate grasslands), increasing attention is also being paid to the tactical use of grazing in native vegetation. For example, several reviews of grazing impacts, with a view to developing grazing guidelines, have also recently been completed or are under way in Queensland, New South Wales and Victoria (David Leslie, pers. comm.). Also, a workshop titled "Is a fence enough? A workshop on managing your grassy woodland" was held in Cumnock, NSW in March 2000. The fact that this workshop is assessing whether excluding stock will help achieve conservation aims in grassy woodlands is a sign of the growing appreciation of this issue.

Continued grazing of sites such as travelling stock routes may also be important as a form of disturbance, especially in the absence of fire. In many areas, Travelling Stock Routes and Reserves are the only remaining tracts of native vegetation and therefore play a vital role in providing habitat for a range of flora and fauna, including many threatened species (Nowland 1997). This means that the grazing practices used in the past must have been relatively benign and maintained a number of native species — although this may reflect the intermittent usage of these reserves. The current high conservation status of grasslands at the newly established Terrick Terrick National Park in Victoria is also believed to be predominantly a result of the grazing history.

In instances where remnants are in good condition, such as at Terrick Terrick, it has been recommended that major long term changes to the historical grazing regime should occur only after investigation of the impact of such changes on environmental values. This was the conclusion of Project UTA4 in Tasmania — that is, where remnants appear to be in reasonable condition, *if it ain't broke, don't fix it.* In other words, don't change management practices unless there is an obvious reason to do so (Kirkpatrick and Gilfedder 1999). So, if grazing has been part of the management of a site and the site is assessed to be in good condition, then the advice points to maintaining those practices but also to trying to determine what elements of the grazing regime are important. Grazing management that maintains appropriate levels of groundcover, provides breaks based on seasonal conditions and allows for seed set, germination and establishment should help ensure the protection of both the resource for stock and the remnant vegetation that sustains them.

These examples demonstrate that while fencing is often the critical first step, better management of native vegetation is not always as simple as excluding all grazing animals. This is being increasingly recognised in fencing schemes (eg. Driver *et al.* 2000) where it is being noted that some fenced sites will require weed management, either by physical, chemical or grazing manipulations. Where appropriate, the use of *controlled* grazing in native vegetation may mean putting gates in the fences that are constructed around remnants, and providing alternative water sources if fences exclude stock from streams (Askey-Doran 1999). This may seem a small price to pay if it means greater acceptance of fencing as a management tool, but the practical implications of isolating remnants from grazing need to be considered. For example, Project CTC9 has identified that in south-eastern Queensland, concern over the resources needed to manage weeds, fire and pests — which are associated with fenced vegetation in this region — can be real barriers to action.

So what type of grazing is appropriate where? While there is considerable anecdotal information available on the best time and place to minimise the impacts of grazing animals on native vegetation, there is a need for more experimental evidence to be collected and made widely available. This will begin to happen as more projects are set up like the grazing experiment established at Bala Travelling Stock Reserve, north-east of Boroowa, New South Wales (Walker 1999). Ungrazed vegetation will be compared with that under controlled grazing to give some clues about the regeneration of vegetation under the different treatments. Only with this sort of information can informed decisions be made about the value of fencing and strategic grazing and a more adaptive and proactive management system designed.

Increasingly, fences are also being erected to exclude vertebrate predators, such as at Genaren in central NSW where a 390 ha remnant has been fenced (Sutherland 1997) and the brush-tailed bettong reintroduced to part of its former range. Project VCA2 is using the Genaren Hill Landcare Group as a case study for evaluating farmer involvement in off-reserve conservation — this will be covered later in this report. Fences for predator exclusion are much more expensive than regular fencing, and need continuous maintenance to make sure that the predators have not been able to breech the boundary — one dog or cat can do a lot of damage in a short space of time. However, in special cases this may be the only option where species re-introduction is desired. Research on 'sterile ferals' which aims to sterilise foxes at least, still has a considerable way to go, so baiting, shooting and fencing are the main strategies available. While talking about animals, a potential drawback with fencing that is rarely mentioned, is the potential for barbed wire to entangle native fauna. A study being undertaken through Deakin University aims to determine the extent of the problem.

In summary, fencing is unlikely on its own to maintain remnants in the long-term because of the many processes that continue to threaten the vegetation, such as environmental weeds and changes to the patterns of disturbance by fire and native grazing animals. Indeed, in some instances, the total exclusion of grazing by fencing out areas could lead to detrimental changes in the vegetation and its associated fauna. Therefore, the controlled use of grazing can be both useful for maintaining conservation and production values and can be used alongside other forms of management such as the control of pest plants and animals. The trick is knowing when and where grazing is an option, which can only be determined by a process of adaptive management.

2.5 Key findings from the ecological projects — a summary

The relatively long-term and large-scale nature of many of the ecological projects funded in Program has produced several important insights. In terms of a general framework for addressing ecological questions in fragmented landscapes, Project DUV2 highlighted the need for the conservation and management of remnant vegetation at the site, landscape and regional level, as summarised in Box 6. While the detail in this example would not be applicable to all circumstances, the need to examine remnants at the site, landscape and regional scales is readily apparent. The key messages that have arisen from ecological research funded in the Program — listed below — relate to both the ecology of the systems and their management. In many cases similar results have been identified in other research projects, which reinforces the messages.

Ecology

- "What we've got is all we've got" — once the original vegetation disappears from a site, then it is very difficult to create the same system.
- All remnant vegetation has some value, even individual trees.
- For ecological sustainability, there must be a *minimum* of 30% of a landscape or property under woodland or forest.
- Vegetation along rivers and creeks provides critical habitat and needs special management attention.
- Small and isolated remnants can make an important contribution to biodiversity conservation.
- Site preparation really is important for successful plant regeneration.
- Identifying appropriate disturbance regimes for native vegetation, such as fire, flood and grazing, is a critical for its long-term maintenance.
- The capacity of a plant to recover from natural disturbances can be used to guide the type and degree of interventions needed to kick-start natural recovery.
- Smoke can be an important cue for plant germination, but doesn't trigger all species.
- Successful regeneration/restoration is highly dependent on water availability, and management must be based on meeting this need.
- The use of indicator species requires further investigation.

Management

- Management is required at the site, region and landscape scale
- Management goals need to be clearly stated, so that progress can be measured
- Adaptive management allows the effects of particular practices to be evaluated — monitoring is the key to 'knowing if you're winning'.
- If it ain't broke, don't fix it (or, don't change current management practices unless there is an obvious reason to do so).
- Fencing is only the first step in a management program for native vegetation.
- Strategic and controlled grazing of native vegetation is possible, and sometimes even essential.
- Be cautious about transferring results — what works in one place, may not in another.
- Obtain and use local knowledge wherever possible.

3 Socio-economic projects in the Program

Understanding the ecology of native vegetation is a critical, but not the only, element of sustainable management. There are clearly economic, social and perhaps cultural barriers that present landholders applying current scientific knowledge. In 1995 LWRRDC held a socio-economic workshop to explore this topic further. As a result of the workshop, a call was made for projects and a second group funded through the Program (Table B, Appendix A). These were orientated towards methods to define values of remnant native vegetation and the development of public policies that might encourage adoption of practices to protect and manage such vegetation. As with the ecological projects, objectives were developed for these projects (LWRRDC 1999a):

- clarify the roles, rights and responsibilities of different stakeholder groups;
- identify and measure the costs and benefits of managing remnant native vegetation;
- identify effective market and non-market mechanisms to help retain native vegetation on private land;
- clarify the role and importance of intrinsic values of remnant native vegetation in the retention and management of that vegetation; and
- identify how information can be packaged and extended to stakeholders.

These are discussed in detail in the sections to follow.

3.1 *The roles, rights and responsibilities of different stakeholder groups*

There is a large number of agencies, organisations and individuals with a stake in the management of remnant native vegetation. To illustrate this, Box 8 lists the agencies and authorities involved in the New South Wales study region of Project CSU10 (Lockwood *et al.* 1999). This is indicative of one area, and it would be easy to imagine the list growing longer — for example Rural Land Protection Boards and equivalent groups have responsibility for a large amount of native vegetation in rural Australia (see eg. Nowland 1997 for New South Wales information). Non-government organisations such as the World Wide Fund for Nature (WWF) (True 1999; Frost 2000 *et al.*) and Birds Australia are

Box 8 – Agencies, organisations and individuals with a stake in the management of remnant native vegetation in the Murray Catchment of New South Wales (Lockwood et al. 1999)

• Private landholders	Individuals
• Environment Australia	Commonwealth Government
• Department of Land and Water Conservation	State government
• NSW National Parks and Wildlife Service	State government
• Murray Catchment Management Committee	Regional body
• Regional Vegetation Committees	Regional body
• 14 shires	Local government
• Community groups such as Landcare	Community group
• Greening Australia	Non-government

also increasingly becoming involved in nature conservation in rural Australia (Fendley 1999). WWF, for example, is involved in the Woodlands Biodiversity Project in south-western Western Australia that promotes conservation of key areas and salinity control. Interestingly, the list does not include research scientists, who are also stakeholders because their work is used to help improve the management of native vegetation. The roles of a number of these groups were examined in detail by projects CWE13 and CSU10, with the focus of this priority being how to develop partnerships and build the capacity of the different stakeholders.

3.1.1 Landholders

Much has been said about landholders' attitudes towards native vegetation. Some of the perceptions held by, and about, landholders are reflected in media reports, as shown in Box 9. However, it is not possible, or desirable, to pigeon-hole landholders into one particular category. There are landholders who earn their income off-farm and buy properties because of the native vegetation and the experience it brings, so-called 'lifestyle' owners; then there are many farmers who are making a living off their farms, and are prepared to cover the costs of native vegetation management from their own pockets if needed. However, other landholders see vegetation as a source of weeds, vermin and fire and consider that it should be removed because this increases the land available for commercial crop or animal production (Project FAS1; Slee and Associates 1998). And there is the minority of people who will clear native vegetation because they think someone else is going to tell them what to do with it. The diversity of circumstances experienced by landholders is aptly illustrated in the recently released social atlas of rural and regional Australia (Haberkorn *et al.* 1999). Several projects in the Program have also examined the perceptions and attitudes towards native vegetation held by landholders, using a combination of surveys, interviews and photographs. These will be revisited in section 3.4.

Box 9 – Media reporting in 1997–1998 on native vegetation management (from Project UNE26)

"Talk about hypocrites! These people who are now stopping us clearing our land, land that we once used to think we owned, are the very same people we have been feeding and clothing all these years."

– A frustrated farmer

"Leave it to farmers and they will respond in a short term profit maximising way."

– An environmental expert

"We are not the rapists nor are we the environmental vandals that some press and the green movement like to make us out to be."

– A primary producer

"Mr Yeadon* has irresponsibly caved in to the NSW Farmers Association which seems to think that any attempt to rein in the unsustainable clearance of native vegetation is an impertinent trespass on their rights."

- A representative of a conservation group

* At the time, Mr Yeadon was the NSW Minister for Land and Water Conservation

One thing that applies to all land in private ownership, however, is the need to clearly define property rights and associated entitlements and obligations tied to land ownership. Because much of the remnant vegetation in Australia is on private land, this an essential starting point for addressing vegetation issues and has been investigated in the Program by Binning and Young (1997) (Project CWE13). They distinguished between the *duty of care* for sustainable land management faced by the landholder and the provision of non-marketable *public conservation service* by landholders managing vegetation to meet conservation objectives. They concluded that a public conservation service is provided when management practices are required to achieve land-use objectives at a regional scale or when any additional practices are required to sustain sites of unique conservation value. In these cases, economic incentives to encourage, assist or reward landholder action were considered appropriate.

Project CSU10 (Lockwood *et al.* 1999) also addressed the circumstances where the costs of remnant native vegetation conservation should be regarded as part of the normal costs of production. For their study region, where the native vegetation is extensively cleared, they concluded that the duty of care applied to landholders retaining existing remnant native vegetation, whereas improving the remnant native vegetation management involved provision of public conservation services. Based on this definition, it was considered neither practical nor appropriate to compensate landholders for the opportunity costs of being prohibited from clearing, but that incentives should be based on costs to landholders associated with: (i) loss of productivity arising from a reduction in grazing and timber products extracted from the vegetation, and (ii) the costs of improved remnant native vegetation management associated with fencing, weed control and feral animal management. If implemented, this approach would meet the concerns of farmers surveyed across a number of regions in southern Australia (ie. Projects FAS1, CCM3, CSO2) where it was felt that financial assistance should be provided for fencing and management practices such as pest plant and animal control.

In any discussion of the duty of care, it should be noted that this is an evolutionary concept (Binning and Young 1997) and that the expectation placed on landholders will shift over time as scientific understanding and community expectations change. A powerful example is the debate surrounding the introduction of clearing controls in New South Wales and Queensland in recent years. The challenge is to develop regulations, policies and incentives that are capable of adapting and facilitating transition from one standard to a new one. It is hoped that the Commonwealth House of Representatives Standing Committee on Environment and Heritage will address some of these issues in its inquiry into public good conservation and the impact of environmental measures imposed on landholders. Submissions closed in mid-May 2000. This Committee will make recommendations that will include potential legislative and constitutional means to ensure that costs associated with public-good conservation measures are shared equitably by all members of the community. The report from this inquiry is awaited with interest.

3.1.2 Government sector

Australia has three tiers of government — local, State and Commonwealth. The final report into ecologically sustainable land management in Australia (Industry Commission 1998) described the role of government as follows:

> Governments have a responsibility to ensure that environmental outcomes are compatible with the interests of the community as a whole. However, intervention is not costless, and in every case where governments could intervene to improve outcome, there is a significant risk of making things worse. Indeed, well meaning but poorly designed and executed interventions have contributed to many of our environmental problems.
>
> Where intervention is warranted it is likely to be to provide well-defined and enforceable property rights; ensure that decisions by individual landholders take account of any costs their actions have on others; provide mechanisms for the provision of public goods; and promote production and dissemination of relevant information.

This description builds very well on the previous section about the roles and responsibilities of landholders, where property rights and the provision of public goods were also highlighted. The government sector has played, and will continue to play, a critical role in planning for and achieving conservation outcomes. For example, where markets fail to adequately recognise conservation as a public good, governments must establish the institutional structures that correct it (CSIRO and the Ian Potter Foundation, 1999). The following section will touch on aspects of the role of governments in the management of native vegetation. For further information, readers can consult the Industry Commission report on sustainable land management (Industry Commission 1998).

A major focus of Project CWE13 in the Program has been the role of local government — the level of government closest to the community — in the management of native vegetation (Binning *et al.* 1999; Cripps *et al.* 1999; Binning and Young 1999). The roles of Commonwealth and State governments, and in particular the impact of their taxes on native vegetation management, have also been examined (Binning *et al.* 1999; Binning and Young 1999). Local governments can make a significant contribution to the conservation of native vegetation because they are able to translate the policies of Commonwealth and State governments into on-ground projects. They are also responsible for regulating a wide range of activities that may impact on native vegetation, from the use of by-laws to control land clearing, to the management of roadsides and town reserves. Local governments can also play a lead role in dealing with the loss of biodiversity, as recently recognised at the national level with the release of a Biodiversity Strategy (Berwick and Thorman 1999). However, given that there are around 700 local governments in Australia — there is great variation in their capacity to undertake, and interest in, the management of biodiversity in general and native vegetation in particular.

The development of regional partnerships that involve local government and other organisations with an interest in vegetation management, has been identified as an urgent need (Binning *et al.* 1999). A minimum Commonwealth Government commitment of $100 million over the next three to five years was deemed necessary to adequately engage and build these partnerships, which at around $200,000 per local government is a modest investment. This also has to be considered in the context that the Commonwealth Government currently provides more than two billion dollars per year in grants to local governments. Complementary strategies for building the capacity of local government range from the provision of data, information and expertise, to the design of institutional arrangements for more effectively working with local government to develop and deliver regional natural resource management strategies (Binning *et al.* 1999).

The bulk of land and resource management powers in Australia reside with the eight States and Territories which each have their own sets of policies and legislation applying to native vegetation management on both public and private land. These different mechanisms can lead to complex and often inconsistent approaches, such as the systems for classifying and listing noxious weeds, many of which can become problems in remnant vegetation. This has led to a call for nationally consistent, transparent and simple regulatory controls for noxious weeds across the States and Territories (Thorp and Lynch 1999), but could also be applied to a range of policies relevant to vegetation management. In addition, numerous agencies within a State can have responsibilities for various aspects of vegetation management which can also lead to overlapping and poor coordination of functions. These issues have been identified by the Industry Commission (1998) as a significant problem across all levels of government, in addition to the fragmentation of responsibilities and the requirement for some bodies to not only regulate but also manage and provide services. As already noted, regional partnerships are being recommended as a way to encourage greater cooperation and coordination (AFFA 1999) and are discussed in greater detail in section 3.1.4.

The Commonwealth Government has responsibilities for Australia's international obligations, coordinating responses across all levels of government, leadership in issues of national significance (including national programs and strategies) and managing its own land (Industry Commission 1998). The Commonwealth Government is also a major funder of environmental programs, currently under the banner of the Natural Heritage Trust. Of particular relevance is the Bushcare Program, whose overall goal is to achieve a net gain in the quality and extent of Australia's native vegetation (Commonwealth of Australia 1999b; also see the independent Mid-Term Review of the Bushcare Program at http://www.nht.gov.au/review/index.html). The first two years of the Bushcare Program have strongly emphasised injecting direct capital in on-ground vegetation projects, and also the fundamental role of the community in managing native vegetation. The need for continuing institutional reform has been identified (Commonwealth of Australia 1999b) so that complete integration is achieved across natural resource and environmental management objectives and so the community have the strong support and engagement of governments at all levels in the form of resources and authority. This is a very worthy goal, but will be a considerable challenge given the issues involved.

The National Reserve System program, which is part of the Natural Heritage Trust, purchases areas with high conservation values to add to the conservation estate. This is an important if modest initiative, but many of Australia's most vulnerable ecosystems are found predominantly on private land, near urban centres and within agricultural regions, where public acquisition and management are not feasible. All levels of government have the potential to use tax incentives to secure investment by private landholders, companies and the general public in the conservation of native vegetation. Project CWE13 argues that a strong market for private investment in nature conservation can be created if similar taxation arrangements currently applied to primary producers and social charities are also applied to land that is purchased and managed for conservation. One of the proposals put forward by CWE13 that has been adopted by the Commonwealth Government is to allow a tax deduction for land valued over $5,000 that is gifted to conservation organisations. Other recommendations being considered include the ability to apportion donations over 5 years and the exemption of donated land from capital gains tax.

3.1.3 Non-government sector

There are several important drivers for more active involvement of the non-government sector in Australia to conserve native vegetation (CSIRO and the Ian Potter Foundation 1999). The non-government sector is free of the bureaucratic process of government organisations, has greater scope to be innovative and to develop pragmatic solutions that are often outside the political reach of government institutions. A demonstration of these benefits is the ability of the Trust for Nature in Victoria to react quickly when high value conservation properties come up for sale (Anon. 1997). Because the Trust is not bound by the usual government and ministerial approval process for land acquisition, it can make relatively rapid purchases through its revolving fund and buy above the valuation price, which is sometimes necessary.

Already there is a large and growing number of non-government organisations actively promoting the protection of bushland outside of the formal reserves system. Theses include the World Wide Fund for Nature, the Australian Bush Heritage Fund and the Trust for Nature, Victoria. However, the non-government sector would likely become much more involved if the policy and tax changes recommended in a recent briefing paper were adopted by government (Ian Potter Foundation 1999). The three main recommendations were to legislate to enable the establishment of private conservation trusts, change the tax laws for donations of property to conservation trusts (this is being considered by the Commonwealth Government) and tax incentives for land covered by conservation covenants. It is thought that such changes might lead to a strong and vibrant market for private investment and philanthropic donations. The two reports referred to in this section were based on the work of Project CWE13 in the Remnant Vegetation R&D Program, which has already had considerable influence on government policy.

3.1.4 Partnerships for natural resource management

Regional partnerships have been widely recommended as the most suitable focal point for dealing with natural resource and related industry and community matters (Dale and Bellamy 1998; Slee and Associates 1998; AFFA 1999). This is supported by Binning *et al.* (1999) (Project CWE13) who strongly supported the development of robust and durable regional structures. Other projects in the Program that focused on planning and partnerships at the regional level were the series of six pilot planning projects (Table C, Appendix A) and Lockwood *et al.* (1999) (Project CSU10). The latter recommended that all institutional stakeholders jointly develop and enter into a Cooperative Agreement for the conservation of remnant native vegetation.

As noted by Lockwood *et al.* (1999) (Project CSU10) and others, attempts to establish an effective approach to remnant native vegetation conservation at the regional scale is being hampered by the difficulty of coordinating effort across the large number of stakeholders involved. Consequently, a clear understanding of the roles of the partners is required and these should build on the existing strengths of the partner organisations. Partnerships also need adequate resourcing, but as outlined in section 3.1.2 the amount needed across the country to underpin regional partnerships is relatively modest compared with other government expenditure. In addition to the direct funding required to build these partnerships, the ability to independently raise revenue, as well as access to technical expertise and data, are important components in the long-term development of best practice strategies.

It is likely that different models for regional planning and delivery will be required depending on the capacity and willingness of local institutions and landholders (Binning *et al.* 1999). But there are still key features that are relevant across all models. For example, a workshop held in November 1999 at the Ian Potter Foundation in Melbourne identified the characteristics of a successful partnership for nature conservation at a landscape/regional scale (Box 10). Just as important if the need to build partnerships on mutual trust, respect and understanding, along with an equality of power within relationships (Lambert and Elix 2000). There is also strong evidence that regional structures will succeed only if they are stable and have a secure planning environment over at least a 5–10 year time frame (Binning, pers. comm.). Not surprisingly, these partnerships will take time and understanding to develop.

Box 10 – Characteristics of successful partnerships for nature conservation identified at a workshop held in November 1999 at the Ian Potter Foundation, Melbourne

- The collaboration of several non-government organisations, businesses and government working in partnership to achieve conservation outcomes at a landscape/ regional scale;
- an appropriate balance struck between engagement of local communities and their aspirations for land management and leadership in natural resource management through provision of information, identification of conservation priorities, funding and organisational support;
- acceptance that different organisations have different strengths and weaknesses and hence different niches within which they can effectively contribute in partnership; and
- active promotion of successes and collaboration that secures ongoing community and political support including funding from both the public and private sector.

3.2 Identifying and measuring the costs and benefits of managing remnant native vegetation

The protection and management of remnant vegetation in agricultural areas is often cited as a component of 'ecologically sustainable agriculture' and to achieve this future, three elements of the rural environment that need to be sustained have been identified (Box 11). Some benefits of native vegetation are listed in Box 3. Many of them direct and indirect income to landholders, with new ideas and opportunities continually presenting themselves. Even so, some farmers consider that the economic benefits derived from native bush (eg. Driver 1998) would not bring the same returns as clearing the area (Slee and Associates 1998). Getting the appropriate balance between conservation and production in these environments is, of course, one of the major challenges faced in the management of natural resources.

Box 11 – Three elements of the rural environment that need to be sustained to achieve 'ecologically sustainable agriculture' (Driver 1998; DLWC 1998)

1. The diversity of indigenous life forms (biodiversity) and the ecological processes that sustain them;

2. the protection and maintenance of land and water resources and the balance of hydrological and physical processes that assist in land health; and

3. the direct and indirect supply of income and wealth to individual landholders and the nation as a whole.

So what is a patch of remnant vegetation worth? Some would say that this question should not be asked, as it is difficult to put a price on many of the benefits (Box 3) associated with remnant vegetation. However, there are techniques called 'stated preference methods' that allow some determination of the market and non-market values of native vegetation; these were used in Projects CSU10 and UNS19 (Lockwood *et al.* 1999). By improving our understanding of the costs and benefits of the conservation of remnant native vegetation it is much easier to determine the types of incentives that could be offered to landholders and whether they are economically justified. It can also help target information where a lack of awareness about the benefits of native vegetation has been identified.

To give some idea of the type of 'values' that can be assessed for remnant vegetation, Box 12 lists the costs and benefits assessed in Project CSU10 (Lockwood *et al.* 1999). It can be seen that calculating the benefits provided by native vegetation is quite complex and the techniques being used to 'value' them are under constant development. 'Choice modelling' has become more widely adopted in the past few years and its usefulness as a technique has been investigated by Project UNS19 in the program. Choice modelling allows policy makers to estimate the values of different environmental changes associated with a range of resource-use options. The research conducted on the strengths and weaknesses of this technique has developed it to the point where agencies are confident to see it employed as a policy tool. The research has also identified the range of applications over which choice modelling results can be considered valid.

Project CSU10 surveyed landholders to measure the costs and benefits they incur to conserve remnant native vegetation. They also surveyed representative samples of New South Wales and Victorian voters to determine their willingness to pay for remnant native vegetation conservation in the two study areas. Under most conditions the aggregate benefits of conserving remnant native vegetation were greater than the aggregate costs if a conservation scenario was adopted. Consequently, under most conditions, there was a net economic benefit in conserving remnant native vegetation in the areas studied. This led to a recommendation that publicly funded incentives should be made available to allow farmers to retain and manage native vegetation for its conservation value.

Box 12 – Costs and benefits assessed for remnant vegetation in Project CSU10 (see Lockwood et al. 1999)

- Benefits to landholders arising from uses such as unimproved grazing, timber products and stock shelter
- Costs to landholders arising from management activities such as weed control, pest control, fence maintenance, and fire management
- Opportunity costs to landholders if the land could otherwise be cleared and used as improved pasture, pine plantation, or some other enterprise
- The contribution, positive or negative, of RNV to the resale value of properties
- Benefits to the productivity of downstream properties
- Avoidance of costs associated with salinity and emission of greenhouse gases
- Benefits to the wider community arising from scenic amenity and biodiversity conservation.

3.2.1 Does remnant vegetation increase property values?

One of the values examined by Project CSU10 was the impact of remnant vegetation on property prices. There has been interest in the results of such research, because if a positive value were found, it could be used as a marketing tool. If only life were that simple. Like many other relationships, the one between property value and remnant native vegetation is influenced by many factors.

For example, Project CSU10 (Lockwood *et al.* 1999) found that, in the catchments studied in southern New South Wales and north-eastern Victoria, the area of remnant vegetation on a property had no influence on the value where it covered up to 50% of a property. When native vegetation covered more than 50%, it had a negative influence on property price. In a study of the impact of heritage agreements on the value of farms in four regions of South Australia, the results were quite complex (Project USA2). In some regions the presence of native vegetation with a heritage agreement had a negative influence on property price, but in other regions the relationship was not significant.

For properties that didn't have a heritage agreement, Project USA2 found that the presence of remnant vegetation had a positive influence on the price paid for a farm in some regions. The differences were attributed to different uses of the native vegetation (grazing compared with recreation) and socio-economic differences between the regions. This project considered only properties where all of the owners income came from the farm, so the results could have been different again for 'lifestyle' properties where having bush on a property is a major attraction. There was also concern, in Project CSU10 at least, that given the costs and benefits associated with remnant native vegetation, the property market was not a good measure of the economic value of the vegetation. This was thought to reflect a lack of information and awareness on the part of both buyers and sellers (Lockwood *et al.* 1999).

3.2.2 Relief from rates and land taxes

Land is also 'valued' to calculate property rates levied by local governments and State-based land taxes. Project CWE10 examined the impacts of these policies and taxes on the ability of landholders to conserve native vegetation. It concluded that the current rate and land tax structures are hindering vegetation conservation, particularly where development pressures were high (Binning and Young 1999). This sends a negative price signal to landholders seeking to conserve native vegetation, and a national program was recommended that would deliver, for a modest cost, rate and land tax concessions. In regions where rates were relatively low, rate relief would be largely symbolic and act as a catalyst to reinforce existing motivations of landholders. In other areas, however, especially along the coastal zone, rate and tax relief would be a major incentive for greater investment in nature conservation. Rate relief, funded by State and Commonwealth governments, was also recommended in the package of measures for delivering improved remnant conservation in Project CSU10 (Lockwood *et al.* 1999). However, for properties covered by heritage agreements in South Australia (Project USA2), rate relief was not promoted as a useful incentive. This was because, in some regions, remnant vegetation did not add value to properties where the owners were deriving their full income from the farm. However, even in this instance, rate relief could play a symbolic role.

3.3 Identifying effective market and non-market mechanisms to help retain native vegetation on private land

The previous section focused on measuring the costs and benefits of managing native vegetation, and identified that economic incentives were appropriate measures in certain circumstances. One of those touched on above was rate and tax relief. It is now commonly recognised that a mix of incentives is required, with different situations requiring different approaches. Further, the requirement is for a suite of instruments covering social processes (motivation, extension and education), environmental security (regulations, codes of practice, environmental management systems and property agreements) and financial incentives (grants, taxes and environmental markets).

Improving incentives to encourage landholders to conserve and manage remnants was also identified as the most important strategy by a range of stakeholders surveyed to assess the impact of the National Remnant Vegetation R&D Program (LWRRDC 1999a). As illustrated in Project CWE13, incentives can be small or large, varying from the provision of management advice, to funding for fencing remnant vegetation, to the payment of annual stewardship fees for conservation management (Binning and Young 1997). Binning and Young (1997) also considered that the size of the incentive payment should depend on the landholder's commitment to conservation and their willingness to enter into a binding management agreement that secures public investment in on-ground conservation works.

The use of management agreements to conserve native vegetation is becoming increasingly popular. Anon. (1997) reviewed a range of 'best practice' initiatives for nature conservation on private land, focusing at the State level, describes a number of the different management agreements available across Australia. They range from the *Land for Wildlife* scheme, which is a voluntary program that encourages and helps private landholders to provide habitats for wildlife on their properties (Larsen 1999), to the legally binding conservation covenants of the *Trust for Nature* in Victoria that are attached to property titles (Todd 1997; Whelan 1997). Because of the different needs and aspirations of landholders, a choice of the type of management agreement entered into should be available, with landowners potentially making greater commitments as they become more comfortable with the process. A group called the Interstate Management Agreement Network has been formed so that there is a national focus for such initiatives. Also at a national level, the *Bush for Wildlife* scheme has been set up to provide a stronger focus on wildlife conservation through Natural Heritage Trust programs and to support State-based *Land for Wildlife* schemes.

For management agreements to be effective, they have to be well resourced and as free from bureaucracy as possible. For example, Project VCA2 noted the persistence of a farmer when a Voluntary Conservation Agreement in New South Wales took nearly two years to finalise. Only the most dedicated individuals would have continued with this process, so it should be streamlined as far as is possible. Changes in the management of voluntary conservation agreements (see previous paragraph) were also recommended in Project CSO2 which examined incentives and barriers to conservation, using the grassy white box woodlands of eastern Australia as a model (Elix and Lambert 1998). Based on discussions with a range of stakeholders, this study recommended a package of measures for remnants on private and public land which included provision of technical information and advice, financial incentives, property based incentives (eg. provision of fencing subsidies contingent on entering into management agreements), legislative protection, development of a ‘stewardship’ scheme and importantly, working in the local community. Ross (1999) also indicated that a similar ‘toolkit’ of incentives was required for best practice in grassland conservation, so there appears to be increasing agreement about what steps are required.

The role of legal instruments in this toolkit has been widely debated with some players, eg. Slee and Associates (1998) — Project FAS1, suggesting that the current legislation is not effective in protecting or enhancing conservation values. Project UTA4 concluded that legal measures to prevent clearance or degradation of native vegetation were required if it was to persist in the longer term. Legislative frameworks at the State government level, which are supported and given effect through regional planning processes, were considered the most suitable vehicle in Project CWE13 for clearly defining the rights and responsibilities of landholders (Binning and Young 1997). Having these underpin management agreements and other incentive-based instruments was felt to be the most effective approach. So while it is considered that legislation could be less adversarial (Project FAS1), it has an important role to play in the conservation and management of remnant native vegetation.

An interesting perspective on the role of incentives was provided by Project UME25. It concluded that failure to consider the future of farm business in policy approaches to conservation and land management would have major consequences for the management of native vegetation. This approach is supported by Ross (1999) who identifies that, in many circumstances where grassland conservation is being considered, incentives that consider the whole farm situation will be most appropriate. The researchers associated with project UME25 recognised that short-term gains would arise from the range of incentives described above. But they also suggested that remnant vegetation will decline in quality or be lost on many such properties over the long-term if farmers are not also assisted in developing sound strategies for achieving their farm business goals and in enhancing their capabilities for carrying them out. This approach recognises that the future of remnant vegetation is tied up with the future of the farm itself and that assistance with the farm business might avoid more costly intervention in future years when farmers find that their private interests are even further removed from the public interest. If alternative sources of income, on or off-farm, are identified, the cost to government of incentives, management agreements or covenants might be significantly lower. Consequently, tools that can assist farm businesses weigh up the costs and benefits of different management scenarios (Crosthwaite 1998) could become increasingly important.

3.4 The role and importance of intrinsic values of remnant native vegetation in its retention and management

Several projects in the Program have examined, using a combination of surveys, interviews and photographs, the perceptions and attitudes held by landholders towards native vegetation. As already noted, visual aids such as aerial photos and maps of landholders’ properties which show the amount and condition of native vegetation can be a motivating factor for changed behaviour (Projects CSU6, VCA2). Project CSU10 reported that the aesthetic qualities of native vegetation were considered the most important benefit by landholders in the two areas surveyed (Miles *et al.* 1998), with around 90% of respondents giving a positive response. Project UME28 also found that generally there was a preference for some remnant native vegetation in the landscape rather than none. An interesting follow-up question would be to ask — does this apply to vegetation on your own property or others? As noted at the start of this review, native vegetation can also be seen as a source of pest plants, diseases, vermin and feral animals, as demonstrated by surveys conducted in Projects FAS1 and USA2. The latter project found that over 60% of survey respondents in the Eyre Peninsula and Murray Mallee in South Australia viewed native vegetation in this way. In contrast, many of the landholders surveyed in Miles *et al.* (1998) commented that having pest animals was balanced by the presence of animals that helped control pests.

By understanding the perceptions held about native vegetation in rural landscapes, it should be possible to more carefully target policies, on-ground management programs and extension material. To help address this, Project UME28 used images of rural landscapes to examine the attitudes of rural landholders and the urban community to develop guidelines for promoting native vegetation protection (Cary *et al.* 1999). Based on the range of landscapes captured in these images, landholders considered farmland with a large area of fenced remnant vegetation to have the highest agricultural, ecological and aesthetic value. Results also showed that particular plant species such as eucalypts were preferred over others such as bull-oak (*Allocasuarina verticillata*). While the research was exploratory, it suggested that the perceived agricultural value is the primary criterion for landholder assessment of native vegetation on rural properties. It was recommended therefore that educational programs should first highlight the value of remnant vegetation for shelter and prevention of soil degradation and salinity, and once the agricultural benefits had been established, landholders would be more likely to appreciate the ecological values.

This conclusion could well apply to property owners where the production benefit of remnants is the major concern. However, Project VCA1 in Victoria demonstrated that landholders with properties of less than 150 ha were more concerned about their recreation, aesthetic and habitat values, with the owners of these properties generally not reliant on farming as a primary source of income. It was therefore recommended (Hamilton *et al.* 2000) that different strategies be developed when providing information and incentives to these landholders compared with those with properties greater than 150 ha who were concerned more about the production aspects. Gilfedder and Kirkpatrick (1997) also identified a number of different types of managers responsible for native grasslands in Tasmania, noting that different educational and other approaches were needed for each group. So it is apparent that different ways of developing educational and other forms of intervention are needed not only for rural and urban residents, but also for different landholder groups within the rural community. Urban communities are an important stakeholder, as their cooperation is critical to ensure financial and moral support for those who must directly manage remnant vegetation in rural landscapes (Cary *et al.* 1999).

Even if farmers are aware of the production benefits of remnant vegetation, there are other considerations that come into play when management decisions are being made. As an example, Project FAS1 (Slee and Associates 1998) examined the attitudes of farmers in New South Wales, South Australia and Victoria and found that most farmers were unconvinced that the retention of larger areas of remnant native vegetation on their farms would add to annual farm income. As such, it was concluded that the majority of landholders are likely to remain uninterested in the protection and management of remnant vegetation on their properties unless financial incentives are offered. However, another survey in Western Australia (Project CCM3) found that a majority of farmers replanted or fenced their bush with no financial assistance, when time and money allowed. And the majority of farmers surveyed in Tasmania (Project UTA4) had undertaken conservation work without any monetary incentive. This is not to say that the landholders did not think incentives were needed, but that it was not the sole driving force for managing native vegetation. Once again, this demonstrates the diversity of views in the farming community.

But attitudes can and do change. Raising awareness about the issues involved in native vegetation conservation and management is one of the first steps in changing behaviour. For example, Project (CCM3) examined how attitudes had changed in southern Western Australia over time, by asking the same questions as a survey conducted 10 years previously (Jenkins 1998). This demonstrated a change in both attitude and behaviour as farmers gained a greater knowledge of the problems caused by overclearing, and because the problems were so extensive and obvious that they were prompted to seek information to address them.

3.5 Identifying how information can be packaged and extended to stakeholders

As well as funding research and planning projects (Tables A–C, Appendix A), the National Remnant Vegetation R&D Program funded a foresighting exercise that examined the future requirements for managing Australia's remnant vegetation (LWRRDC 1999b). As part of this exercise, Morton (1999) investigated the availability of information for landholders on methods for protecting and enhancing remnant vegetation and the associated costs, and the methods for revegetation and associated costs. The conclusion was that the amount of material available appeared 'huge', comprising pamphlets, leaflets, booklets, guidebooks and toolkits that covered everything from local, on-farm activities to regional planning guides. Another example of the amount of material available, but this time in urban areas, comes from a bibliography of works that relate to biodiversity in the Melbourne–Geelong metropolitan area (McDonnell *et al.* 1999). The search for unpublished and published literature uncovered around 1200 citations ranging over a 100-year time frame. Many of these might be useful material for managing the fragmented vegetation found in urban systems.

3.5.1 Packaging and extending information to stakeholders

Despite the seemingly vast amount of information available, around 50% of farmers surveyed in Project FAS1 (Slee and Associates 1998) said that information and advice was lacking, while the other 50% felt that there was plenty of information and advice but a lack of means to implement it. This response was thought to reflect differences between regions, which may indicate an absence in certain areas of both information and the extension services to promote it. Likewise, in Western Australia, landholders noted a lack of available information on bushland management (Project CCM3; Jenkins 1998). The need for information and advice to come in practical and implementable forms to assist conservation management was also stressed by landholders associated with Project CSO2 (Elix and Lambert 1998).

So what is it that makes this vast array of information seem less than adequate? Four main attributes were identified by Morton (1999):

- Much of the material is fairly shallow, offering advice only in a generalised and non-specific manner.
- Information in the area of 'associated costs' appears to be much thinner than it is in the area of technical information on carrying out vegetation management.
- The range of information available to urban landholders and groups is narrower than that accessible to farming communities.
- The backup support required to enhance the full use of the vast array of printed material available on vegetation management is lacking.

The final point is a critical one — as identified by Morton (1999) a major impediment to better vegetation management lies in putting a human face to the provision of integrated extension support. Projects DUV2, CTC9, VCA2 and FAS1 noted in particular that the most effective form of communication was getting out and talking to people. So while printed material is commonly used as a form of communication (LWRRDC 1999a), there is overwhelming evidence that written materials on their own are not sufficient to change attitudes and behaviour. A key finding from projects CCM3, CSU6 and others was that while printed/ electronic information is an essential component for any extension program, it must be promoted and interpreted to the particular situation of the landholder if it is to be effective. Lack of confidence that management actions would obtain the desired outcome was a common theme from landholder surveys. Incorporating sound management principles for remnant native vegetation into extension materials and processes, including those of agribusiness, will be a priority if native vegetation is not to disappear from large tracts of Australia.

With around 100,000 farmers managing most of the remnant vegetation in Australia, however, the effective extension of information represents a major task and continues to pose serious problems for on-ground action. Extension of information is also considered one of the weakest links, and in need of the greatest attention, in the agricultural sector more broadly (RIRDC 2000a). As a consequence, a project on how to create a lifelong culture of learning in farmers and their service providers was implemented (scheduled for completion in July 2000). This represents an important opportunity for integrating the range of extension material relevant to farming enterprises. It also points, as a priority, to the training agricultural extension officers in the management of native vegetation, so that they are able to identify management strategies for landholders. This action would support the conclusions of Project VCA2 that noted the imbalance between 'normal' agricultural and other extension programs. This project is examining what 'biodiversity extension' provided by management agencies means in community-driven projects, compared with local agents with expertise in flora and fauna. If this expertise could be combined, then more consistent advice might be available for managing the range of resources on a property.

The need to integrate nature conservation into the agricultural landscape is, however, being increasingly recognised (Dorricott *et al.* 1998; Lambeck 1998b; Barlow and Thorburn 2000). For example, the third National Property Management Planning (PMP) Forum, held in 1999, included sessions on "nature conservation within PMP" and "how to engage/ integrate Farm$mart (PMP) with existing extension and R&D programs" (http://www.soil-water.org.au/pmp/proceedings/index.htm). The success of using property plans as a vehicle for integration will depend on how many farmers have them (see section 4.1) and how rigorously they are implemented, but the important first steps are being taken. At the State/regional level, a range of approaches is being used to integrate conservation and production on farms (see Box 13), some in existing programs, others not. Considerable potential also exists to reach a wide audience by building native vegetation management into industry codes of practice and best management practice programs such as TOPCROP for the grain industries and PROGRAZE for grazing industries (ANZECC 2000).

Other initiatives such as local farmers acting as liaison officers (see case study "Farmers learning from farmers") and the potential to use information technology as a tool, demonstrate that there is considerable room for improvement in packaging and extending information to stakeholders. The use of information technology as a tool, which touches on the issue of access to information, is as critical as having extension personnel out and about. Their task will be made much less effective if they are unaware of what information is available. However, increasing use of the Internet by farmers (RIRDC 1999), especially by groups and agencies associated with

Landcare (Anon. 1999), is helping make information more accessible.

In order to get the most out of the resources that are already being put into education and extension, it is important to understand how effective they have been in improving the management of native vegetation. This was assessed in Project UTA4, which tested whether incentives, education and extension, in the absence of regulation, were effective means of conserving significant vegetation on private land. The conclusion was that in around 80% of cases they were not, and that the long-term conservation of vegetation remnants requires legal measures to prevent clearance or degradation. These results were based on survey data that examined changes in the condition, management and ownership of 100 remnants in Tasmania over the period 1993–1999. They reinforce the need for a mix of measures to help improve the on-ground management of remnant native vegetation.

3.6 Key findings from the socio-economic projects — a summary

It has been said that natural resource management should be the realm of biophysical scientists, not social scientists (in the broadest sense of the term), but both are needed of course. The range of issues identified in the socio-economic projects, and listed below, illustrates the importance of the broader socio-economic context for the sustainable management of natural resources.

- The future of native vegetation is linked to the future of the farm itself.
- Capacity building is needed for a range of stakeholders.
- Cost-sharing incentives are a critical component of improved vegetation management on private land — but a mix of incentives is needed, including legal instruments.
- There are several examples of highly successful incentives programs that should now be taken up more widely.
- Current institutional arrangements are impeding effective conservation and are in need of major reform.
- Partnerships that include all interested stakeholders are needed at the regional level.
- The non-government sector could play a much greater role in nature conservation.
- Reform to the tax system is needed to encourage philanthropy.
- Understanding the value systems and perceptions of different stakeholders can lead to more targeted and effective approaches to management and education.
- Written materials on their own are not sufficient to change attitudes and behaviours.
- The 'personal approach' to extension services — face-to-face communication and discussion — is the most effective.
- There is an urgent need to retain, expand and redirect extension services.
- There is considerable evidence that locally employed extension officers, and particularly farmers, will be more effective — highlighting opportunities for government investment in employment in rural Australia.
- A range of management agreements for native vegetation should be made available.

4 Pilot planning projects in the Program

The third and final round of funding in the National Remnant Vegetation R&D Program was for a set of pilot planning projects (Table C, Appendix A) which aimed to develop and test methods for planning and implementing vegetation management at the catchment or regional scale and to provide documented case studies that could be used in preparing regional vegetation plans.

The pilot planning projects were successful in demonstrating both the effectiveness of particular approaches, and their weaknesses, and the value of planning at a regional scale. For example, a vegetation management strategy was developed for the pilot project in Victoria (Project VCE13), which focused on 'priority action zones' to increase the nature conservation values of the catchment. The study area was in the Goulburn–Broken catchment in north-eastern Victoria and the project led to the publication of a draft Native Vegetation Management Strategy (Goulburn Broken Catchment Management Authority 1999). The three main action areas identified in this region were:

- to adopt participative decision-making;
- to target investments so that the maximum conservation benefit was provided for the resources invested; and
- the need for ongoing improvement.

The pilot planning project in the Dongolocking region of Western Australia (Project CCM3) took quite a different approach, producing a generic framework for planning that integrates land-use goals and management at the landscape scale (Wallace 1998). This project identified some of the limitations of planning at regional scale, such as the difficulty of developing useful goals and planning their implementation at the appropriate scale.

Several of these regional planning projects have also identified difficulties with data availability, accessibility, integration and consistency. Also,

Case study: Farmers learning from farmers

The importance of involving the local community in vegetation management was highlighted in Project CSO2 (Elix and Lambert 1997) and further developed by this group and others through a Natural Heritage Trust funded project. Called the 'Grassy white box woodlands taking action now' project, local farmers have been employed as 'action liaison officers' to provide advice on the conservation and management of remnant vegetation. The employment of local landholders as extension officers is proving to be highly successful, as it has been in other conservation programs. For example, the 'Managing vegetation — learning from farmers' project provides an opportunity for farmers, and others, to learn from farmers who have successfully used native vegetation as an integral part of their overall management (Wall 2000a). Started in the Murray Catchment in southern New South Wales, it is envisaged that the concept will expand across the State, resulting in a network of farmers providing information exchange and support. So where people with the expertise and time are available, this represents a new and exciting model for extension of information in regional Australia. This approach also addresses the concerns of many farmers surveyed in project FAS1 (Slee and Associates 1998) who felt that not enough is being done to access and use their intimate knowledge of native plants and animals.

regional communities involved needed considerable time to understand the purpose of regional-scale vegetation planning and management, to identify priorities and to then develop a management plan that has broad agreement across stakeholder groups. Involvement of these groups is a key factor underlying the eventual adoption of these plans and adequate time needs to be built into their development. The importance of inter-agency and institutional collaboration was also highlighted in the pilot projects: the broader community can soon tire of getting mixed messages from different groups.

Box 13 – Examples of State/regional approaches to integrating nature conservation and production

In New South Wales, *Farming for the Future* is a partnership between the NSW National Parks and Wildlife Service, NSW Agriculture and NSW Department of Land and Water Conservation. The delivery of the program is facilitated by the National Parks and Wildlife Service which also provides specific information and advice on how biodiversity conservation measures can be incorporated into property management. The overall aim is to contribute to the maintenance or enhancement of productivity while improving the property's biodiversity.

In Victoria, the *Living Systems Project* is promoting the inclusion of biodiversity in Property Management Planning. By doing so, it is aiming to help landholders benefit from the contribution biodiversity (plants, animals and the systems they form) makes towards the sustainability of their property, industry and lifestyle (Richards and Platt 2000). The Living Systems Project, has three main components — an education and training program, an industry support program and a community planning program — which will help address such questions as "How should I manage for the sort of natural environment I want to leave future generations of my family?" and "How can my family and industry benefit from increased buyer demand for 'green' products?" This will be achieved through an already existing Property Management Program – Farm$mart.

In south-west Western Australia, *Living Landscapes* is a pilot planning process that considers both agricultural production and broader landscape issues such as nature conservation and ecological health (Frost et al. 2000). The aim is to assist community groups to develop landscape management practices that protect biological diversity within an ecologically viable and sustainable land-use system. The *Living Landscapes* project involved an interdisciplinary team that used experiential learning as an overarching process (Frost et al. 2000). The other key process used was the focal species approach (Lambeck 1997) — by combining these two approaches, *Living Landscapes* has developed a set of guiding principles for nature conservation planning in the context of sustainable land management.

Many important lessons have been learnt through this exercise about what planning approaches do and don't work at the regional level. A measure of their impact is that several of the pilot projects have been the catalyst for large, vegetation management initiatives funded either through the Bushcare Program or under State legislation. These include the establishment of a protected area network for grassy whitebox woodlands in New South Wales, targeted revegetation in parts of the Western Australian wheatbelt, and landholders applying new management practices in the midlands of Tasmania, the upper south-east of South Australia, the Brigalow region of Queensland and the Lachlan catchment of New South Wales.

The importance of developing robust and durable regional structures for natural resources management is a consistent theme throughout the Program (see section 3.1.4 in particular). To be successful, however, they must be allocated adequate human and financial resources.

4.1 Other planning issues

Planning and management at the property level has the potential to lead to a greater appreciation by farmers of the need to protect and manage remnant native vegetation on farms (Slee and Associates 1998 — Project FAS1). But while the incorporation of biodiversity conservation into the whole farm perspective is starting to be taken up (see discussion above and Box 13), relatively few landholders have sound plans in place for active management of native vegetation. At the property and regional level, integrated planning and management are being promoted by Project CTC9, which is examining the sustainable management of grazed woodlands in south-eastern Queensland. This project emphasises in particular that farmers should have a long-term vision that considers the whole property and its place in the catchment. The results from this project should improve our understanding of how a balance between conservation and production objectives can be achieved. The need for an increase in whole-farm planning has also been recognised at a national level (AFFA 1999). One of the indicators of progress in the recent discussion paper on natural resource management in rural Australia was that "by 2010 operations on a majority of farms should be based on whole-farm plans that are consistent with regional strategies". The implementation of such research and policy initiatives should encourage a more integrated and widely used approach to planning.

As noted earlier in the report, managing native vegetation at the appropriate scale is critical. The issue of scale also applies equally to planning. Briggs (2000), focusing on central NSW, identified that the lack of a formal relationship between planning at large, catchment scales and implementation at local scales made undertaking effective rehabilitation of habitats and landscapes at the appropriate scales very difficult. This was compounded by the lack of regional integration between the work of Landcare groups and other managers operating at local scales. These comments illustrate the importance of planning in the overall management of remnant vegetation, and the need to link catchment-scale plans with the correct scales for the rehabilitation of landscapes.

5 Across Program issues

As demonstrated in the previous sections, only by considering the multiple elements of natural resource management — ecological, social, economic and institutional — is a sustainable future possible. Thus, making decisions based on any of these factors in isolation is likely to fail. As well as recognising the interdependence of these factors, several other issues are relevant across the broad range of projects funded in the Program.

5.1 Developing management guidelines and principles

Several of the projects have developed detailed management guidelines or principles for particular native vegetation communities. These are listed in Table 2. All of them relate to the on-ground management of vegetation and its associated fauna, apart from Cary *et al.* (1999) which aims to assist individuals and agencies seeking to promote the importance of protecting remnant native vegetation to urban and rural communities. These guidelines aim to synthesise the research undertaken in the various projects, or current ecological research in general, and produce it in a form that is accessible to land managers and demythologises the approach of researchers.

Perhaps one of the better known products from the Program is the 'Save the Bush Toolkit' (Project CSU6; Goldney and Wakefield 1997) which has become the primary reference document on remnant management in the central west of New South Wales, both for land managers and extension personnel. The toolkit consists of a series of nine kits that enable landholders to assess their farm's natural resources and to develop appropriate management strategies. Several hundred kits have been sold, numerous workshops and field days held, a hotline set up for farmers to access and an extensive extension program run focusing on agency personnel, landholders and Landcare groups. The model used in this project is also being considered elsewhere.

Interestingly, despite the intense effort put into the extension of the 'Save the Bush Toolkit', a survey showed that only a very small percentage of the toolkits sold had actually been used in the field. This is not because the information was not considered useful, as it was developed with extensive consultation and based on current ecological understanding. Part of the lack of use may be related to landholders not having the time, resources or confidence. But it also suggests that nothing beats someone with acknowledged technical and practical expertise going out in the bush with a landholder to assess the condition and management needs of the native vegetation on their properties (see section 3.5 for further discussion). Given the number of farmers in rural Australia, however, this would represent a major undertaking.

The approach to developing management principles taken in Project CWE10 was quite different from that for the Save the Bush Toolkit. In Project CWE10, landholders were given a three-step process to identify the actions needed to reverse degradation in their remnants (Hobbs and Yates 1997, 1998). The first step is to assess the condition of the remnant, the second is to decide whether plant species reintroduction will be necessary and the third is to see if some form of site amelioration will be needed to re-establish species. The guidelines focus on plant species regeneration in salmon gum woodlands in south-western Western Australia, but include information that can be applied more generally. However, the results of the assessment are specific to the location being assessed and will lead to specific management actions. They also require knowledge of the local biota and its requirements. Project UNE21 took a different approach again, encouraging land managers to learn more about the biology of the plants they are working with by understanding their response to a variety of cues and thresholds (Clarke 1998). This is done within an adaptive management framework, where monitoring is the key to 'knowing if you're winning'.

Several times in this review, the need for a range of management guidelines, or 'toolkits', has been emphasised, so different situations can be catered for. These are needed to cover the diversity of circumstances associated with native vegetation management in rural Australia. However, as discussed in the next section, caution needs to be taken when transferring such guidelines from one place to another. To help overcome that problem, it would be especially valuable to:

- develop a list of toolkits etc.;
- develop criteria on how to select the ones that are likely to be most use in any particular situation; and
- monitor and evaluate the impact of the toolkits, with further adaptive management.

5.2 Transferability of results

Earlier in the report, it was acknowledged that a simple 'recipe' for designing landscapes for biodiversity conservation does not exist. The fact that a solution generated in one part of the landscape cannot be transported to another is likely to concern conservation managers (Lambeck 1999). However, it is critical that this fact be acknowledged, as any attempts to take solutions from one location and apply them to others may produce results that will be inadequate or fail in some areas and excessive in others. So, while general approaches and principles such as those advocated in Lambeck (1999) and Hobbs and Yates (1997) are useful at a broad level, they need to be adopted, interpreted and tested at the local level. It is critical that detailed management prescriptions are not exported out of the environments/vegetation types from which they were derived and used elsewhere without some prior testing and/or incorporation within an adaptive management approach.

The limitations of transporting solutions generated in one region to another, one site to another, or even one species to another, arose in many projects in the Program. For example, Project UTA4 has shown that vegetation condition and rare or threatened species (ROTS) occurrences are not correlated, with ROTS generally occurring in poorer quality remnants in terms of exotic species cover and richness. It has also shown that the correlates with condition and ROTS occurrence vary quite markedly between environments/vegetation types. Projects KPB1 and UNE26 also demonstrate that smoke is not the universal germination cue that some might have thought.

The need for care when making generalisations is also relevant to the size of a remnant. Bigger remnants are generally more important for vertebrates than for many plants species and probably invertebrates (see section 2.1.3). Some of the issues related to the 'portability of prescription' and the use of fire as a management tool have also been considered in Williams *et al.* (1994). While this focuses on temperate forests rather than woodlands, there are many similar matters involved.

Examples from the socio-economic projects include CSU10, which identified the need for different incentives in the two regions studied because of the different legislative, environmental and social circumstances. Likewise, institutions for regional partnerships will vary with leadership required by Commonwealth, State and local government in different situations (Project CWE13). In other cases the non-government sector may lead. In the case of individual policies and programs, their applicability may also be context-specific, as is the case with rates rebates that are more effective where land values and development pressures are highest.

These examples demonstrate that being cautious about transporting solutions between sites or regions is relevant not only to the on-ground management of remnants, but also to broader social and economic issues.

5.3 Research models

One of the interesting developments over the last decade or so has been the change in the way research is conducted — a topic of particular relevance to a national research and development program. Past research models are being increasingly questioned in the agricultural sector more generally, and a more learning based and participatory approach advocated (AFFA 1999; Bullen and Woods 1999). This calls on a greater involvement of the people who will be using the research in the research activity itself, rather than just being presented with an end product. For example, greater involvement of landholders in research such as weed, rabbit and fox control and fuel reduction processes, was recommended in Project FAS1. Such an approach would help address the gap between the level of knowledge and understanding held by scientists and researchers, and that available to community groups and landholders actively engaged in on-ground management of native vegetation.

Several of the projects funded through the National Remnant Vegetation R&D Program formed partnerships with land managers from the outset of their projects. Clarke and Davison (1997) provide an interesting perspective on the linkages formed between field practitioners and academic ecologists in Project UNE21. Landholders and property managers have also played an integral role in Project CTC9 which is using four case study cattle properties in south-eastern Queensland to examine the nature and scope of potential trade-offs between production and conservation objectives (McIntyre *et al.* 2000). The difference with this project is that it is examining the management of the entire property (as also recommended by Project UME25), rather than focusing principally on the conservation of native vegetation. Comparisons are being drawn between the performance of present management strategies and what might be expected for alternative strategies that specifically aim to optimise resource conservation. The level of involvement of the case study property owners and other landholders in this project has been both extensive and intensive. One measure of success of this approach that is being tested in the project is the translation of management *principles* (McIntyre *et al.* 2000) to practical management *strategies*. So far this has been limited, but the barriers and opportunities to the adoption of the alternative management strategies are being identified and will act as focal points for an innovative extension campaign in the target region.

An important issue that needs to be addressed in order to encourage further partnerships between researchers and landholders is the assessment and reward system under which scientists operate, and the need to make funding for such projects easier to apply for and administer (Briggs 2000). In many institutions, the promotion and funding of scientists are based primarily on publishing in refereed journals. Understandably this system does not encourage the devotion of time and resources needed to work with community groups and landholders, although the involvement of scientists in research of this nature is changing (Recher 1998).

Interdisciplinary approaches that identify and take into account the social, educational, institutional and economic factors affecting the adoption of management techniques are also being advocated (AFFA 1999). As noted earlier in this review, one of the strengths of the Remnant Vegetation R&D Program was the range of projects it funded across these disciplines, and the importance placed on the involvement of on-ground users. But this is a relatively new and evolving model and everyone is learning the best way to undertake such research, including the researchers. The yearly review and coordination meetings of the leaders of all the projects were an aspect of the Program that encouraged such interactions and stimulated cross-fertilisation between the different disciplines.

6 The impact of the National Remnant Vegetation R&D Program on the conservation and management of native vegetation

An independent evaluation of the impact and effectiveness of the Program was undertaken in the second half of 1998 (LWRRDC 1999a). While the authors of the evaluation believed that it was too early to assess the full impact of the Program, they concluded that the R&D work being done was of high quality and was already:

- making a strong contribution to policy development associated with the scope and nature of incentives for improved management of remnant vegetation;
- providing improved understanding of the ecology of native vegetation through practical management guidelines for regional plant communities;
- playing a significant role in focusing and coordinating the overall national R&D effort on remnant vegetation; and
- providing good 'value for money'. This was exemplified by three detailed case studies of projects funded within the Program that demonstrated that the net benefits were significant and that the rates of return on R&D were likely to be positive.

The issues covered in this review highlight the quality and scope of the projects in the Program. The measure of the success of the Program, however, will be the uptake of the results by government and non-government institutions, other researchers and the people who manage the vegetation on the ground. This is already happening to various degrees. But given that it can take several years for new knowledge to be adopted, it would be instructive to review the projects and their impacts in a few years time.

7 Future directions for the conservation and management of remnant vegetation and for associated R&D

Considerable attention is being paid to the management of natural resources in general and native vegetation in particular. For example, ANZECC has developed a *National Framework for the Management and Monitoring of Australia's Native Vegetation* (ANZECC 2000) that identifies best-practice attributes of native vegetation management and monitoring mechanisms. The review of Natural Heritage Trust programs has just been completed (see http://www.nht.gov.au/review/index.html), a Regional Australia Summit has been held, a discussion paper for developing a national policy on managing natural resources in rural Australia was released (AFFA 1999) and the Prime Minister has asked ministers Truss, Hill, Costello and Anderson to jointly present goals for natural resource management policy development to Cabinet in mid 2000. In addition, a conference entitled "Visions of Future Landscapes" was held in May 1999, and in March 2000 the International Landcare 2000 conference took place (Anon. 2000). So there is a lot of attention on the bush, and this is just a brief list of activities at the national level.

But the question is, where is it all heading? A vision for rural industries built on sustainable natural resource management is reproduced in Box 14. While each of us might have a slightly different vision, this example illustrates the range of issues that farmers of the future are going to have to handle, and the range of skills they will need in order to cope. It also emphasises the need to maintain the integrity of soils, water, vegetation and healthy ecosystems. But it is the on-ground implementation that is going to be the key to success.

The importance of sustainable management of natural resources, and its pervasive influence on the future of Australia's agricultural industries and regions is a message also stressed by Price (1999). What is clear is that there is going to be considerable change in the agricultural and other sectors in the coming years, which will have major implications for the management of native vegetation. To help capture the dynamics of change, the Program funded a foresighting exercise (LWRRDC 1999b) which examined three scenarios that are relevant to future vegetation management in Australia — 'economic growth', 'conservative development' and 'post-materialism'. Each of these was considered to represent a realistic possible future, and was used to help identify the type of strategies and R&D priorities required to provide an appropriate knowledge base for future directions and investments. The scenario planning approach, which was designed around two workshops that drew on the insights and experience of a wide range of stakeholders, was seen to be an effective tool for generating new possibilities for the future. LWRRDC (1999b) gives full details.

Another way of examining the impact of changes in the agricultural sector is through studies that revisit areas over time. For example, in Project UTA4 it was observed that, over a six-year period, a quarter of the 88 remnants on private land being studied in Tasmania had changed ownership. This led to a greater chance of deterioration or destruction of remnants, with the replacement of a conservative older generation by either the younger generation or new owners who need to develop the land to service their debt. Project UME28 also noted that young landholders were more vulnerable to financial instability and so must place greater importance on agricultural production in rural landscapes. Not all young landholders will fall into this category, but it is interesting that two quite disparate projects identified similar patterns. Dealing with such change will become an increasingly important issue for both urban and regional Australia.

As noted in AFFA (1999), research and innovation should continue to be a foundation for sustainable agricultural production and natural resource management. For example, the most effective way of dealing with the rapid changes identified above could be a research topic in itself. The National Remnant Vegetation R&D Program supported a number of initiatives in the last two years that identified future research needs for managing Australia's remnant vegetation (LWWRDC 1999a,b). These were encapsulated in the seven priority areas identified as critical knowledge gaps for funding by LWRRDC and others in the area of native vegetation management:

- developing skills and capacity to design sustainable landscapes that integrate native vegetation with sustainable agriculture;
- developing simple but effective methods to assess the significance, status and trends of existing native vegetation in order to identify priorities for restoration and management;
- developing methods to assess and rank threatening processes, and the development and testing of practical management techniques that will be most effective in preventing or overcoming them;

Box 14 – A vision of rural industries built on sustainable natural resource management

The productive and profitable farming and grazing enterprises of the future will be those that are innovative and are based on internationally competitive and environmentally sustainable production systems. Informed landholders will use modern technologies and will actively seek and adopt new and innovative production techniques. Some will obtain market information and sell into the global marketplace via the Internet. They will respond to market signals, data and research findings by adjusting management practices to maintain the integrity of soils, water, vegetation and healthy ecosystems on their properties and across the region.

Some farmers will have re-focused their operations on new or other market opportunities or will be managing their properties for other values. There will be changes in land use to more intensive forms of production — horticulture, viticulture, crops, feedlots, increased rotation — as well as tourism, conservation and new commercial opportunities.

The profile of farmers will also change because of retirement, the entry of younger people with new skills, a new business focus and different expectations, and through the increasing role of women.

Significantly, the innovative landholders of the future will be fully integrating environmental outcomes, including biodiversity protection, into their business operations to complement public conservation reserve management.

These are the enterprises that will provide a foundation for rural economies and for wealthy and vibrant rural communities.

From Managing Natural Resources in Rural Australia for a Sustainable Future (AFFA 1999)

- developing methods to integrate management of native vegetation into whole-property planning and management;
- building on work that quantifies the direct and indirect benefits of native vegetation, and developing more-effective incentive and program structures based on these to promote sound management practice. Identification of benefits and beneficiaries, and thence of agreed cost-sharing arrangements;
- creating a suite of activities ranging from awareness-raising to inclusion of sound vegetation management in best practice and environmental accreditation, so that there are a whole series of drivers that promote vegetation management at all levels and aspects of agriculture and resource management; and
- achieving a closer integration between scientists and researchers and the agencies, groups and individuals involved in resource management to promote an adaptive management approach and transfer of knowledge in both directions.

Integration is a strong theme, and the need for greater linkages between individuals and institutions is readily apparent — but the best way to achieve this is not always so clear. Many of the research priorities focus on socio-economic issues, but considerable ecological research is still needed, such the role of remnant vegetation in landscape health and function (ie. landscape focus/off-site impacts), the most effective way to reconstruct fragmented ecosystems at a number of scales, and identifying the most appropriate disturbance regimes in native vegetation (Project USH3). There is also still much to learn about the role of non-vascular plants and invertebrates in these systems (Majer and Brandenburg 1995) as well as the impact of diseases and other threats. Developing appropriate models to effectively communicate this and other research is another challenge we all face.

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Appendix

Table A1. Ecological research projects (publications listed under 'Title of project' are part of the publication series associated with the Program and are listed in the reference list)

Project code	Project leaders	Title of project	Broad geographic location of projects
ANU6	Dr David Lindenmayer The Australian National University Ph: 02 6249 0645; Email: davidl@cres.anu.edu.au	The role of corridors and retained vegetation in biodiversity conservation * Lindenmayer (2000)	Tumut, New South Wales (this project focuses on fauna in remnants in a pine plantation matrix)
CSU6	Assoc. Prof. David Goldney, Charles Sturt University Ph: 02 6338 4386; Email: dgoldney@csu.edu.au	Further development of a socio-ecology extension program as an Australian model	Central Western New South Wales (this project resulted in the publication of The Bush Tool Kit)
CWE10	Prof. Richard Hobbs, Murdoch University Ph: 08 9360 2191 Email: rhobbs@essun1.murdoch.edu.au	Practical solutions for the rehabilitation of degraded remnant woodland	Western Australian wheatbelt; a book on the temperate woodlands of southern Australia, arising from a workshop funded by LWRRDC has also be published (Hobbs and Yates 2000)
DUV2	Dr Andrew Bennett Deakin University Ph: 03 9244 7511; Email: bennetta@deakin.edu.au	Extinction processes and fauna conservation in remnant box–ironbark woodlands	North-central Victoria
KPB1	Dr Kingsley Dixon Kings Park & Botanic Gardens Ph: 08 9321 7332; Email: kdixon@kpbg.wa.gov.au	Guidelines and methods for the practical use of smoke-induced germination for bushland restoration	South-western Western Australia
UNE21	Dr Peter Clarke University of New England Ph: 02 6773 3712; Email: pclarke1@metz.une.edu.au	Native plant regeneration processes in remnant woodland vegetation	New England Tablelands
USH3	Tein McDonald – PhD Thesis, UNSW Ph: 02 6682 2885; Email: teinm@ozemail.com.au	Ecosystem resilience and the restoration of damaged plant communities	Case studies in sclerophyll and grassland communities in Sydney, rainforest sites near Lismore and a review of wetland resilience and restoration.
UTA4	Prof. Jamie Kirkpatrick University of Tasmania Ph: 03 6226 2460; Email: J.Kirkpatrick@utas.edu.au	Guidelines for the maintenance and improvement of remnant bush in Tasmania	Tasmania – low and high rainfall area

Table A2. Socio-economic research projects (publications listed under 'Title of project' are part of the publication series associated with the Program and are listed in the reference list)

Project code	Project leaders	Title of project	Broad geographic location of projects
CCM3	Suzanne Jenkins/Penny Hussey Ph: 08 9334 0530	Effectiveness of incentives in changing landholder attitudes towards remnant vegetation. * Jenkins (1998)	Western Australian wheatbelt
CSO2	Jane Elix/Judy Lambert Community Solutions Ph: 02 9948 7862; Email: comsols@peg.apc.org.au	Grassy white box woodlands: incentives and barriers to rural conservation * Elix and Lambert (1997)	Wagga Wagga; Bathurst/ Orange/Cowra; Tamworth
CSU10	Dr Michael Lockwood, Charles Sturt University Ph: 02 6051 9884; Email: mlockwood@csu.edu.au	Economics of remnant native vegetation conservation on private property * Lockwood et al. (2000)	NE Victoria; Murray Catchment, NSW
CTC9	Neil MacLeod CSIRO Tropical Agriculture, Ph: 07 3214 2270; Email: neil.macleod@tag.csiro.au	Applying management principles in variegated landscapes: identifying production-conservation trade-offs	South-central Queensland (Burnett and Brisbane River catchments)
CWE13	Mike Young/Carl Binning CSIRO Wildlife and Ecology Ph: 02 6242 1671 (CB), Email: c.binning@dwe.csiro.au	Opportunities for the use of incentive payments to conserve remnant vegetation * Binning and Young (1997, 1999); Binning et al. (1999); Cripps et al. (1999)	Mostly national (depending on which phase of the project is considered)
FAS1	South Australian Farmers Federation Ph: 08 8232 5555; Email: pday@saff.com.au	Model native vegetation legislation and policies * Slee and Associates (1998)	All mainland States
UME25	Jim Crosthwaite University of Melbourne Ph: 03 9344 5008; Email: j.crosthwaite@landfood unimelb.edu.au	Improving market outcomes: the case of native grasslands Crosthwaite and Malcolm (2000)	NE Victoria; Central Tablelands, NSW; Riverine Plains (Victoria and NSW)
UME28	John Cary/Kath Williams Ph: 03 9344 5016 (KW); Email: k.williams@landfood unimelb.edu.au	Perceptual attributes contributing to maintaining native vegetation: a market study. * Cary and Williams (2000)	Wimmera, Victoria; upper SE SA; Tasmanian Midlands
UNS19	Prof. Jeff Bennett The Australian National University Ph 02 6249 0154, Email: jeff.bennett@anu.edu.au	Use of choice modelling to estimate non-market values	Desert Uplands, Central Queensland
USA2	Wayne Marano, University of South Australia Ph; 08 8302 0523; Email: wayne.marano@unisa.edu.au	Factors influencing the market value of remnant native vegetation in South Australia, 1982–1994	SE South Australia; Murray Mallee; Kangaroo Island; Eyre Peninsula

Table A2. Socio-economic research projects (publications listed under 'Title of project' are part of the publication series associated with the Program and are listed in the reference list)

Project code	Project leaders	Title of project	Broad geographic location of projects
UNE26	Geoff Kaine/Jean Sandall University of New England Ph: 02 6773 2220; Email: gkainejo@metz.une.edu.au	Building conservation strategies from stakeholder's intrinsic and social values	NE NSW (near Moree) and SE Queensland (near Toowoomba)
UOC7	Alison Treweek University of Canberra (now with DLWC, NSW) Ph: 02 6297 6472	Identifying alternatives to using remnant eucalypt vegetation for firewood in the ACT region through consultation with residents and farmers	ACT
VCA1	Steve Hamilton University of Melbourne Ph: 03 5833 9240; Email: s.hamilton@landfood.unimelb.edu.au	Landholder perceptions of remnant vegetation in the box–ironbark woodlands of northern Victoria * Hamilton et al. (2000)	Northern Victoria
VCA2	Chris Williams, PhD Scholar, University of Melbourne Ph: 03 9250 6800; Email: c.williams1@pgrad.unimelb.edu.au	Evaluating farmer involvement in off-reserve conservation projects: the case of the Genaren Hill Landcare Group	Peak Hill, Central West NSW

Table A3. Pilot planning projects

Project code	Project leaders	Title of project	Broad geographic location of projects
CCM4	Ken Wallace Department of Conservation and Land Management, WA	Remnant native vegetation management in Dongolocking, Western Australia	South-western Western Australia
DEP4	Lindsay Best/Bob Inns Department of Environment, Heritage and Aboriginal Affairs,	Remnant native vegetation management in regions of South Australia	South-eastern South Australia
NDW18	Richard Papis DLWC	Remnant native vegetation management in the Lachlan region of NSW	Lachlan region, central west of New South Wales
PWT3	Louise Gilfedder, Department of Primary Industries, Water and Environment Tasmania	Remnant native vegetation management in the Northern Midlands of Tasmania	North-central Tasmania
Q1202/QEH1	Juliana McCosker Department of Natural Resources	Regional vegetation strategy — Brigalow Belt	Central Queensland
VCE13	Caroline Douglas Department of Natural Resources and Environment, Victoria	Remnant native vegetation management in the Goulburn–Broken catchment of Victoria	North-Eastern Victoria