Discussion Paper on Ecosystem Services for the Department of Agriculture, Fisheries and Forestry

Final Report

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Glossary of key terms and acronyms

DAFF Australian Government Department of Agriculture, Fisheries and Forestry

DSEWPaC Australian Government Department of Sustainability, Environment, Water, Population and Communities

Ecosystem A system in which a range of species interact with one another and with the non-living *environment*. Although ecosystems rarely have clearly defined boundaries and are constantly changing, this term is used to convey the fact that species often interact with one another in complex ways that result in processes that would not happen if individual species functioned in isolation from one another. This is an example of the total outcomes from ecosystems being more than the sum of the parts. Consequently, *ecosystem services* are services that could not be produced by individual species operating alone.

Ecosystem services Broadly, benefits to humans from ecosystems. More specifically, the latest thinking has tightened up the definitions used when strict accounting of ecosystem services is required (e.g., in economic valuation, environmental accounting, or planning decisions that involve tradeoffs between services and/or between environmental and other factors). Firstly, some have argued that the term 'ecosystem services' should be reserved for services that come from ecosystems without any human input (e.g., water filtration through native vegetation systems in catchments). Human inputs are often required to turn ecosystem services into benefits (e.g., ecosystems might make opportunities for angling possible but turning this into the benefit of recreation required the actions of the angler). This clearly separates some actions by land managers (e.g., planting exotic plants to stabilize soil or fight salinity) from ecosystem services (without denying the potential value of those actions). Where land managers recreate natural ecosystems (e.g., replanting riparian vegetation) it might be argued that ecosystem services are generated *after* the human actions have been completed.

Secondly, to avoid confusion and double-counting of benefits and to better align ecosystem services with theory in economics and ecology, the latest definitions distinguish between ecosystem services that can be turned directly into benefits (commonly called 'final ecosystem services') and those that support other services (commonly called 'intermediate ecosystem services'). A further extension is to identify the specific beneficiary of the benefit to assist with its valuation and the avoidance of double counting.

Ecosystem services have been classified under many different headings but the three most commonly used to encompass final ecosystem

services are: Provisioning services (e.g., provision of the conditions for food, fibre, water, natural medicine and genetic resources); Regulating services (e.g., regulation of climate, water flows, erosion and pollination); and Cultural services (e.g., recreation, ecotourism, aesthetic and heritage values). A further heading — Supporting services (e.g., soil formation, photosynthesis, water and nutrient cycling) — is commonly used to describe services that usually are intermediate. Some services can be final in some situations and to some beneficiaries but intermediate in other situations.

Ecosystem approach or ecosystem management

Broadly, environmental management at an ecosystem scale (i.e., a focus on ecosystems rather than individual species). An ecosystem approach usually includes a focus on ecosystem services. The UK Department for Environment, Food and Rural Affairs, for example, states:

> The ecosystems approach has been defined in various ways, but the core of the approach lies in integrating and managing the range of demands placed on the natural environment in such a way that it can indefinitely support essential services and provide benefits for all.[224]

The recent review of the *Environment Protection and Biodiversity Conservation Act 1999* [22] recommended that environmental management in Australia should adopt an ecosystem approach and defined that approach to include such elements as: management decentralised to the lowest appropriate level; considering the effects of management activities on adjacent and other ecosystems; where ecosystems are managed in an economic context, reducing market distortions that adversely affect biological diversity, aligning incentives to promote biodiversity conservation and sustainable use, and internalising costs and benefits in the given ecosystem to the extent feasible; conserving ecosystem structure and functioning in order to maintain ecosystem services; managing at appropriate spatial and temporal scales; setting objectives for the long term, recognising the varying temporal scales and lag- effects that characterise ecosystem processes; seeking an appropriate balance between conservation and use of biological diversity; considering all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices; and involving all relevant sectors of society and scientific disciplines.

When defined in this way, the ecosystem approach is virtually identical to an ecosystem stewardship approach.

Ecosystem services approach

An approach to considering the full range of potential benefits to humans from ecosystems in a strategic way using language and concepts that are understandable to a wide range of people. The essence of an ecosystem services approach is to engage specialists and stakeholders in identifying the nature of potential benefits and to consider the full suite of benefits and implications strategically before

	focusing on actions that might involve some stakeholders and some services. The intent is to avoid unintended consequences that often arise when only a narrow range of benefits and beneficiaries are considered. These unintended consequences range from inefficient and ineffective use of natural resources to undermining of biodiversity and/or human social and economic wellbeing. Economists call them 'externalities' – impacts that occur external to the scope of the transactions being considered. While a range of classifications of ecosystem services have been developed and approaches to assessing ecosystems services in monetary and other terms have been proposed, the essence of an ecosystem services approach is to not be wed to any established scheme but to consider the particular situation and apply the most appropriate methods from disciplines like economics, ecology, psychology and others. An ecosystem services approach, therefore, is not an alternative to economic, ecological or other disciplinary approaches, but rather an approach that seeks to integrate these disciplines to encourage strategic conversations about ecological, social and economic dimensions of complex issues facing society.
Ecosystem stewardship	Ecosystem scale management that also considers social and other factors relating to the resilience of coupled ecosystems and human social systems and the ability of those systems to adapt or transform in response to change — explored more fully in Chapter 6.
Stewardship	This is the concept of responsible caretaking or a duty of care. It is based on the premise that land managers have responsibilities to manage land and natural resources for future generations.
Environment	Used in this report to mean 'natural environment' unless indicated otherwise. This is intended to mean all aspects of climate, soils, water and biodiversity, including landscapes managed for agriculture and urban landscapes where native species are present and interact with one another to form *ecosystems.*
IPBES	IPBES stands for 'Intergovernmental Platform on Biodiversity and Ecosystem Services'. IPBES will be an interface between the scientific community and policy makers that aims to build capacity for and strengthen the use of science in policy making.[125] IPBES will be a mechanism that addresses the gaps in the science policy interface on biodiversity and ecosystem services globally. IPBES was formed in 2010 as a merging of the follow-up processes from the Millennium Ecosystem Assessment and the International Mechanism of Scientific Expertise on Biodiversity. The United Nations Environment Programme (UNEP)is cooperating with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Food and Agriculture Organisation of the United Nations (FAO), the United Nations Development Programme (UNDP) and other organizations to operationalise IPBES. Australia has been involved in the establishment

	of IPBES.[20]
Market	A market is any process by which things are traded between people. Markets develop when goods or services have clear value, it is clear who has rights to that value, and the conditions exist for those rights to be traded with others. Prices for goods and services are determined by what participants in markets are prepared to pay versus what those selling are prepared to accept. *Non-market values* are a reflection of the worth that people seem to place on things that don't pass through markets (e.g., rare species that no-one owns and no-one can sell).
Market-based instruments (MBI)	Ways of achieving policy outcomes by encouraging the development and/or direction of markets. In relation to ecosystem services, This usually involved use of regulations, caps on resource use and/or incentive payments to create demand for services that otherwise would not be traded in *markets* and/or to create a degree of temporary or permanent ownership of a natural resources so that trading in a market can occur (e.g., giving an investor the right to own and sell the carbon accumulated in trees under certain conditions).
Millennium Ecosystem Assessment	The Millennium Ecosystem Assessment (MA) was called for by the United Nations Secretary-General Kofi Annan in 2000. Initiated in 2001 and completed in 2005, the objective of the MA was to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being. The MA involved the work of more than 1,360 experts worldwide. Their findings, contained in five technical volumes and six synthesis reports, provide a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide (such as clean water, food, forest products, flood control, and natural resources) and the options to restore, conserve or enhance the sustainable use of ecosystems.[144]
National Environmental-Economic Accounts	As part of the System of National Accounts, the Australian Bureau of Statistics is exploring ways to improve collection of information on the environment[10]
National Plan for Environmental Information	On 11 May 2010 the Minister for Environment Protection, Heritage and the Arts announced a new initiative to address the environmental information needs of the nation. The National Plan for Environmental Information is the first step toward a long-term commitment to reform Australia's environmental information base and build this critical infrastructure for the future. The plan is a whole-of-government initiative implemented jointly by the Department of Sustainability, Environment, Water, Population and Communities and the Bureau of Meteorology.[19]

Natural resources	All resources that come from nature, including not only native genes, species and ecosystems but also soils and water that play a role in supporting industries and societies.
Natural resource management (NRM)	The management of natural resources, including management for conservation, agriculture, urban consumption and any other purposes. Note that some groups and agencies define NRM more narrowly to either mean conservation management or management for agricultural production but not both. In this paper we take the term at face value – to mean the management of all resources that are part of the natural *environment*.
Non-market values	Non-market values are a reflection of the worth that people seem to place on things that don't pass through markets (e.g., rare species that no-one owns and no-one can sell). Economists have devised a range of techniques to estimate what this worth is. These are all based on gauging what people would be willing to pay if there were a market or what tradeoffs they are willing to make in terms of *market*-based values (e.g., how much more they might pay for food or water to protect biodiversity or maintain soil health). There has been a long debate about how to use non-market values in decision-making (for example, how well do people's stated preferences match their actual behaviour and decisions?).
SEEA	The System of Environmental-Economic Accounts (SEEA) is the statistical framework that provides internationally agreed concepts, definitions, classifications, accounting rules and standard tables for producing internationally comparable statistics on the environment and its relationship with the economy. The SEEA approach is being revised under the guidance of the United Nations Statistics Division.[231] This revision is likely to include an ecosystem assessment approaches based on ecosystem services.[114]
Stewardship	This is the concept of responsible caretaking or a duty of care. It is based on the premise that land managers have responsibilities to manage land and natural resources for future generations.
WAVES	The Wealth Accounting and Valuation of Ecosystem Services (WAVES) programme (World Bank, United Nations Environment Programme and various partners) is the mechanism by which ways to include environmental information into SEEA are being investigated.[137]

Executive summary

Ecosystems are complex interactions among living and non-living components of the environment (e.g., forests, grasslands, riverine ecosystems, marine ecosystems). These interactions mediate processes that achieve major transformations of resources, many of which rival or exceed what can be achieved cost-effectively by humans (e.g., maintenance of atmospheric gases, large-scale filtration and purification of water, or widespread control of potential pest species). These transformations support and enrich human life, but are often overlooked and/or undervalued in decision-making because decision-makers lack relevant information about them and because they do not pass through markets and therefore do not have economic value attached to them.

The term 'ecosystem services' has been used to denote the transformations of resources that can be turned into benefits by humans (Box 1). A typical definition is "… the direct and indirect contributions of ecosystems to human well-being").

Box 1: Examples of ecosystem services (adapted from Maynard et al.[150])

Provision of:

- Food
- Water for Consumption
- Building and Fibre
- Fuel
- Genetic Resources
- Biochemicals, medicines and pharmaceuticals
- Ornamental Resources
- Transport Infrastructure

Regulation of:

- Air Quality
- Habitable Climate
- Water Quality
- Arable Land
- Buffering Against Extremes
- Pollination Pests and Diseases
- Productive Soils
- Noise Abatement

Support for human culture and social values by provision of:

- Iconic species
- Diverse environmental characteristics of cultural significance
- Support for spiritual and religious beliefs
- Systems from which humans can increase their knowledge
- Inspiration
- Aesthetically satisfying experiences
- Mediation of social interactions
- Sense of place
- Iconic landscapes
- Recreational opportunities
- Therapeutic landscapes

Since the late 1990s, a large body of literature has developed focusing on how to categorise and assess ecosystem services and how to integrate ecosystem services analyses with other approaches to planning and decision-making. An ecosystem services approach does not seek to replace other approaches or be a new discipline — it simply aims to name and categorise benefits from ecosystems, and the processes that lead to those benefits, in ways that enable diverse stakeholders to then apply the tools of ecology, economics and social science in an informed way and to interpret what those tools are telling them in straightforward language.

An ecosystem services approach is an integrative approach to analysing environmental benefits and beneficiaries. It draws on tools from diverse disciplines, including economics (e.g., benefit-cost analysis, total economic value, non-market valuation) and ecology (e.g., energy and material balances, resource utilisation analyses, population regulation) and social sciences (e.g., understanding of how interactions between people and the environment affect physical and mental health and wellbeing).

The key contributions of an ecosystem services approach are to provide an holistic framework for considering all benefits from the environment in an integrated way and to use language and concepts that allow stakeholders from across societies to take part in meaningful dialogue about environmental-social planning and policy. As such, the concept of ecosystem services it is potentially an important component of approaches taken by governments, non-government organisations, businesses and community groups for thinking strategically about investments in natural resource management. This is particularly important when dealing with complex, social-ecological issues like population, climate change, food security and water use, that have no easy solution and require collaborative dialogue among stakeholders to build understanding, trust and support for hard decisions.

The past decade has seen intense debate about how to characterise ecosystem services so that this style of thinking can be aligned with other approaches to assessing resource-use by humans. Most recent typologies have concentrated on:

- separating the contributions from ecosystems from those of humans (e.g., an ecosystem might provide clean water and fish but humans provide vehicles, boats, fishing lines and other inputs that lead to the benefits of commercial and recreational angling) (Figure 1)
- categorising ecosystem services and benefits in ways that avoid double-counting in environmental accounting and/or benefit-cost analyses (e.g., pollination of crops by native insects contributes to the value of those crops along with contributions from soil organisms that maintain soil fertility, so it is important that these two types of ecosystem services are considered as input to a 'final service' of 'support for crop production').

Ecosystem services assessments are an integral part of what has been termed 'the ecosystem approach' to natural resource management, which is now advocated by major governments around the world, including the UK, USA, Canada the EU, New Zealand and Australia. Recent approaches to ecosystem services assessments have incorporated advances in understanding resilience and adaptability of social and ecological systems – an approach sometimes called 'ecosystem stewardship'. Ecosystem services approaches are now making important

contributions internationally and within Australia to the development of environmental-economic accounts.

This report reviews recent developments in thinking about ecosystems services, in Australia and internationally, and considers how this concept can contribute to policy and management in relation to natural resources and human well being in Australia. It concludes that there are still issues to be addressed in relation to how an ecosystem services approaches might be put into practice, but that the concept already has several unique contributions to make.

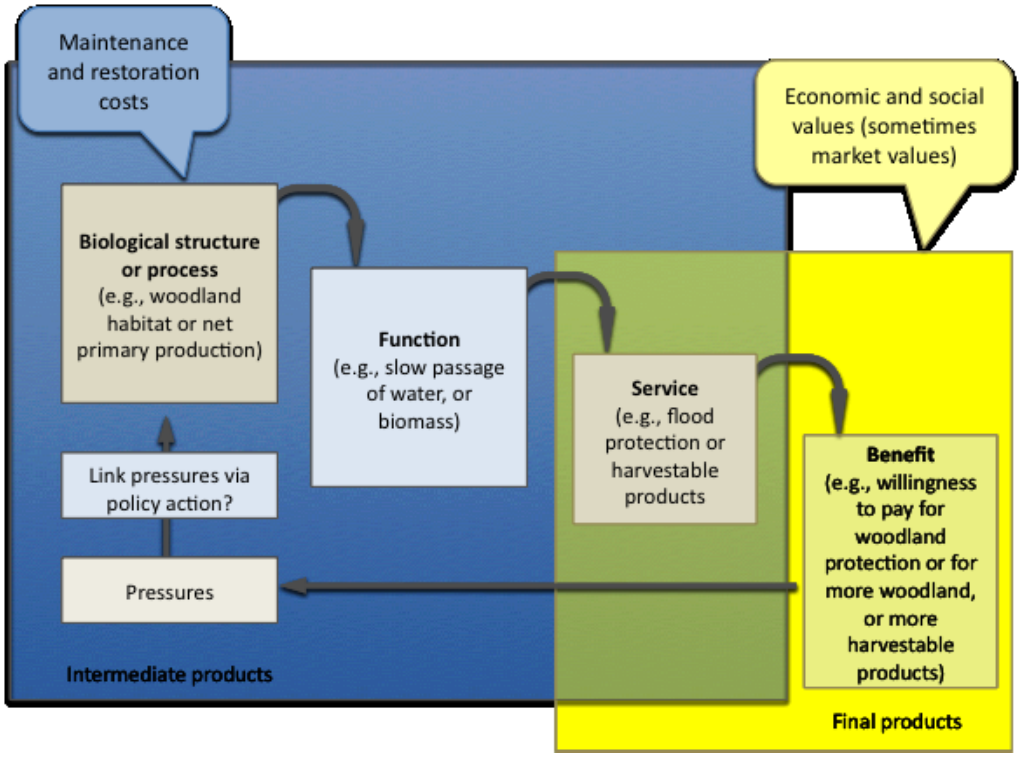

Figure 1: The conceptual framework used by The Economics and Ecosystems and Biodiversity project to link ecosystems and human wellbeing.[215]

The issues to be addressed include:

- there is still some disagreement among experts about defining and operationalising ecosystem services frameworks (although consensus is emerging that different definitions and approaches are probably needed for different situations and applications, and there are now numerous examples of successful applications around the world)
- methods for measuring the outputs from ecological systems in relation to human needs, and/or predicting the impacts of policies and management decisions on these outputs, are still not adequate for many purposes (although this is a problem common to all approaches to environmental policy and management and is not uniquely relevant to ecosystem services approaches)
- methods for assessing the economic implications of ecosystem services that do not pass directly through markets (e.g., cultural or spiritual values of landscapes or the influence of scenic views on where people live or how much they are prepared to pay for houses or for the right to visit remote places) are still not developed or accepted to the point that they carry weight in decision-making in Australia).

This report concludes that one powerful contribution of ecosystem services approaches is to cross-societal dialogue in relation to major, complex environmental-social challenges facing this country. People across Australian society are demanding greater involvement in decisions about such issues and they want to know that the different parts of governments are thinking strategically about the role of the environment in these issues. The language and concepts of ecosystem services offers a platform for this sort of dialogue, but it requires some steps to be taken by governments:

- developing and promoting a common understanding across governments and society about the nature of ecosystem services and the benefits that can be drawn from them
- using that understanding to promote strategic dialogue among disciplines, government departments and across society about priorities for managing human-environmental interactions in the short and longer-term future
- considering how responsibilities for management ecosystem services can be shared across society (i.e., moving away from the model of governments taking all of the responsibility).

Australia has a very good record of using ecosystem services as the focus for constructive dialogue between scientists, communities and government decision makers, which has led to tangible planning outcomes. Regional communities have shown they are able to consider sophisticated biophysical, economic and social information in these dialogues and to develop robust, defensible and monitorable plans as a result. This, together with moves to include this sort of information in national accounts, should give governments confidence that there are sufficient skills in communities, academia, non-government organisations and governments to support much better national strategic dialogue than has been had previously.

Recommendations

Further explanation of these recommendations can be found in Section 11.5 of the report.

Recommendation 1: Develop a process for strategic dialogue and planning within the Australian Government that considers the full range of potential benefits from ecosystems along with other information relevant to strategic decisions.

Recommendation 2: Explore improvements to governance arrangements to encourage appropriate sharing of responsibility for strategic alignment of human wellbeing and ecosystem management across society

Recommendation 3: To support all of the above, continue and enhance initiatives to establish an appropriate and accessible set of information capable of supporting strategic dialogue about ecosystem management and human wellbeing

Recommendation 4: Build on and enhance Australia's investments in innovative ways to link ecological and economic research with business to drive desirable environmental change

1 Introduction

The concept of ecosystem services has been gaining traction globally and in Australia for over a decade. The interest in the concept has generated many different interpretations and applications by government agencies and non-government organisations. Nowhere has the proliferation of opinions and ideas about ecosystem services been greater than in regard to agriculture and the management of mixed-use landscapes.

This discussion paper synthesises aspects of ecosystem services thinking and practices, in Australia and internationally, and considers how the concept could contribute more broadly to the policy imperatives of the Department of Agriculture, Fisheries and Forestry (DAFF).

Given that the concept of ecosystem services has been prominent in the scientific literature for over a decade and has been discussed both within government and among DAFF's stakeholders, one might ask why DAFF has commissioned this study now. Indeed, this question was asked by several of the stakeholders that we interviewed. There are two answers to this question.

Firstly, DAFF has been investing in thinking about ecosystem services for much of the past decade. It was Land & Water Australia, within the DAFF portfolio, that was one of the first agencies to fund a major ecosystem services project in Australia. [65] In addition to support for research on ecosystem services, DAFF's investment has included discussion papers to develop the concept and make it applicable to the practical issues faced by land managers. [146] Ecosystem services are in integral part of the Caring for Our Country program, jointly administered by DAFF and the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). That programme includes a number of strategies for improving ecosystem services outcomes from farm management, and especially soil management which has been poorly understood and underestimated until recently.[13]

Secondly, insights from research on ecosystem and community resilience, together with public service reform and attempts to link carbon emissions policy with broader environmental objectives have brought a new focus on strategic thinking about multiple social and economic benefits from the environment.

There has been growing interest in policy circles and the broader community in how to make Australian society more resilient and able to adapt to change.[18, 52, 59, 86, 149, 197, 240] Research in this area has shown that social and ecological systems cannot sensibly be considered in isolation from one another.

In the past, government departments tended to act as silos. More recently, however, the process of public service reform, in both the Australia Government and the states and territories, has emphasised the need for whole of government approaches to tackling major challenges. Examples of such challenges include changes in the state of Australia's natural resources, the demands that Australians place on those resources, and the local, national and global drivers of environmental, social and economic change.

In September 2011, the announcement of details of the Australian Government's policies to address carbon emissions included a Biodiversity Fund that aims to achieve multiple environmental, social and environmental benefits linked to carbon policy.

Together, these developments call for a framework that enables all Australians to engage in dialogue about the relationships between humans and the natural environments in which they live. The concept of ecosystem services is aimed at supporting this broad and open dialogue in ways that allow potential synergies and tradeoffs among social, economic and ecological objectives to be identified and addressed with due reference to the multiple perceptions that people have about benefits and beneficiaries from the environment.

Apart from these reasons for exploring the use of an ecosystem services framework and language in Australia, this approach is increasingly being used in international dialogue, in which Australia can, and should, be playing a key role. Major nongovernmental organizations (NGOs) and global intergovernmental agencies have been developing ecosystem services programs for several years now. These include The Nature Conservancy, the World Wildlife Fund, the World Resources Institute (WRI), the United Nations Development Program (UNDP) and the World Bank.[204]

DAFF's purpose in commissioning this paper is to assess whether the intentions of ecosystem services approaches are appropriate and can be put into practice in Australia and globally and to ask what steps might need to be taken to achieve these intentions.

2 Terms of Reference

The Terms of Reference for this project were to:

- Review current ecosystem services definitions and discuss their appropriateness for use in Australia
- Examine available conceptual frameworks for ecosystem services - is there a framework within which the impacts of multiple benefits on multiple ecological, social and economic processes can be considered that might be best suited for use in Australia?
- Briefly review activities currently underway in Australia and overseas that seek to incorporate ecosystem services approaches into the management of natural resources, and outline the reasons as to why this approach has not yet been more widely adopted in Australia
- Provide an example framework for the ecosystem services associated with rural lands using Australian examples
- Identify the likely nature of the costs and benefits of an ecosystem services approach for Australia, and the types and scales of supporting information needed to assist in developing an Ecosystem Services framework which could support analysis and discussion of tradeoffs; for example to inform the sustainable population debate.
- Discuss how an ecosystem services approach could be implemented with reference to associated policy measures such as regulation, legislation, market based instruments, codes of conduct, environmental management systems/certification schemes, environmental impact assessment to improve government and other decision-making.

This report in intended to be a key input to a multi-stakeholder workshop/ forum, which will aim to:

- establish an agreed definition and conceptual framework suitable for further consideration of an ecosystem services approach for Australia
- share experiences with implementing services approaches within government agencies and with key interested stakeholders
- discuss barriers to the wider adoption of ecosystem services within Australian government agencies and how this might be addressed
- provide recommendations for further work

3 Approach

The discussion paper was developed using the following approaches:

- A targeted review of the literature to develop a summary of how the concept of ecosystem services has evolved and been applied in Australia and around the world, and to identify how an ecosystem services approach compares and contrasts with alternative approaches to addressing similar policy issues
- Interviews with key policy makers, researchers and people who have been involved in developing and implementing ecosystems services approaches and/or alternative approaches to similar policy issues
- Development of a systems map of critical issues (driving, enabling, disabling factors, key organisations and their interactions)
- Regular dialogue with DAFF staff to review progress and emerging ideas and conclusions
- Two small working meetings with DAFF staff and selected key experts and stakeholders to develop and refine an example of how an ecosystem services approach might be applied in DAFF's policy environment
- Preparation of a detailed progress report and a final report.

The interviews were the key component of the project because much has been written in a range of literature and media but the attitudes and interpretations of key stakeholders, which ultimately affect what policies are developed and implemented, are usually not recorded explicitly and in detail. The interviews were carried out as free-ranging conversations aimed at establishing:

- What the interviewee understood about the concept of ecosystems services
- How useful they thought that concept was
- Whether it meets particular needs of decision makers at some or all levels of government and/or non-government decision-making in Australia
- Whether there are alternative and/or better ways to address those needs
- How those needs are currently being met and could be met better (considering the full range of roles government and non-government contributors but especially considering role of government agencies at all levels), including consideration of what barriers exist to meeting the needs and how those barriers might be overcome.

The interviews ranged in time and depth from a few minutes to an hour, depending on how much time an interviewee had available and how relevant their experiences were to the questions being addressed. As themes began to emerge, some interviews were focussed on obtaining views on only one or a few key issues.

As our focus was on assessing how well the concept of ecosystems services might help address the issues surrounding relationships between people and the environment, all of those chosen for interview were people who were expected to be familiar with these issues. To date over 50 people have been interviewed specifically for this project, as indicated in Table 1. Some of those interviewed have themselves conducted interviews with a range of stakeholders about their understanding of the concept of ecosystem services, so we have drawn on those processes indirectly as well. Two other important source of insights for this report were a two-day

workshop on ecosystem services convened by Charles Sturt University and CSIRO in August 2011 and a one-day forum on carbon policy at the Crawford School, ANU, both of which addressed a range of issues relevant to this project. The opportunity was taken to discuss aspects of the project with numerous participants in those workshops. Finally, we have drawn on a series of interviews conducted as part of a project for the Murray Darling Basin Authority (MDBA) in 2010,[61] which also asked people about aspects of the processes for management of natural resources that provide context for the current project. The numbers of these interviews are given in the 'indirect column in Table 1.

Table 1: Categories of people interviewed directly so far in this study or whose views have been captured indirectly through the MDBA study.

Characteristics	*Number of interviews*	
	Direct	*Indirect*
Australian government policy officers experienced in dealing with relationships between people and the environment	14	>20
State government policy officers experienced in dealing with relationships between people and the environment	6	>20
Local Government and catchment management bodies	4	>20
Farmers	1	>30
Private investors, investment brokers, business advisors	8	>20
Researchers who have been involved in developing ecosystem services approaches in collaboration with governments, regional bodies and other stakeholders (universities, CSIRO and other)	21	>30
Non-government environment and industry representative organisations	3	>10

4 Issues, origins and definitions

Key conclusions from this chapter:

- The concept of ecosystem services is now widely used by governments and non-government organisations around the world. The concept has evolved over the past four decades to facilitate dialogue about the relationships between humans and the natural environment, by describing the benefits that humans obtain from the environment in language that a wide range of stakeholders can understand
- The concept of ecosystem services is not intended to focus solely on economic assessments of worth. It is intended to provide a bridge between economic and ecological sciences and between land-use and land-protection interests
- Much of the development of the concept over the past decade has been aimed at improving its ability to be used along side theory and tools from ecology, economics and social sciences
- An ecosystem services classification should have the following elements: A definition of ecosystem services; a framework relating ecological processes to the benefits that flow to people and, broadly, who those people are; a list of services (often including a higher-level grouping of services based on broad types of services and/or the benefits they provide)
- Definitions of ecosystem services appear to be in a transition from ones that saw ecosystem services as 'benefits to people from ecosystems' to ones that define ecosystem services as ecological phenomena and benefits as things that flow from services as a result of human inputs
- To avoid problems of double counting in environmental-economic accounts, a distinction has been made in all recent major studies between 'final ecosystem services' — those that are directly used by people to provide benefits — and 'intermediate ecosystem services' — those that form part of a 'cascade of services' that support one another and underpin final services
- Although agreement on a common definition of ecosystem services is likely to be achievable in the near future, it is recommended by several experts that there should be different classifications of ecosystem services for different purposes (although those different classifications should be consistent with one another)

The concept of ecosystem services has been evolving since the 1970s (Figure 2). Its ultimate origins can be traced to the coining of the term 'ecosystem' in the 1930s or even to the origins of ecosystem ecology in the 1880s.[155]

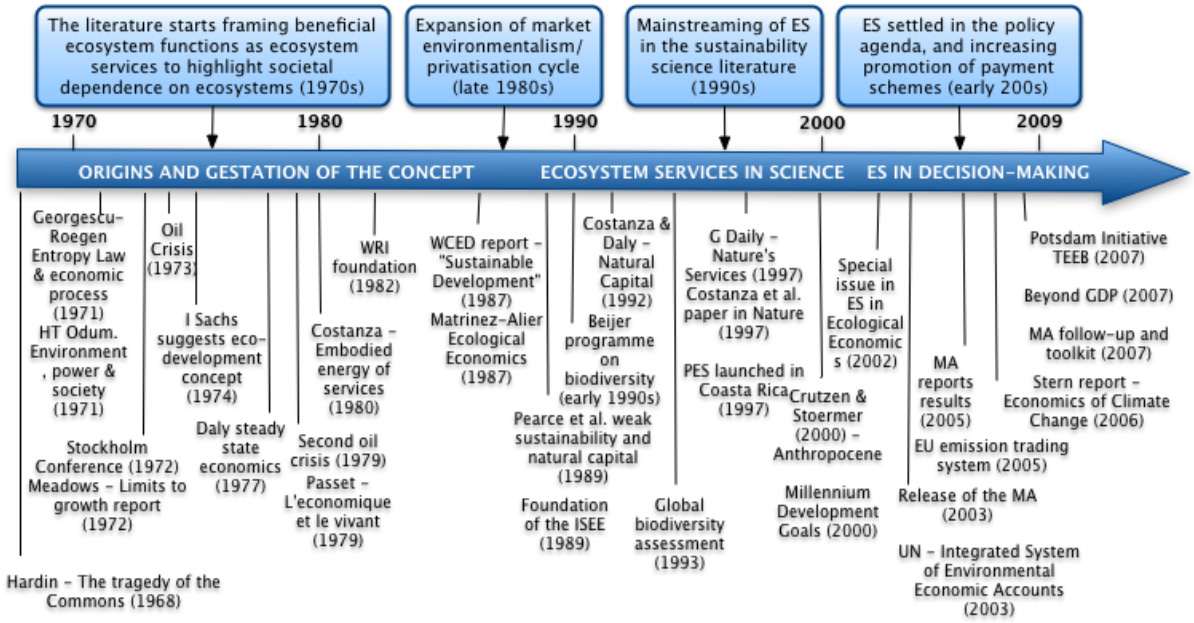

Figure 2: Stages in the modern history of ecosystem services.[109]

'Ecosystem services' is the term that has been used most frequently,[92; 69; 144] but various alternative have been suggested, including: 'environmental services';[201] 'public-service functions of the global environment';[118] 'public services of the global ecosystem';[91] and 'nature's services'.[242]

Widespread acceptance of the concept can be tracked to Daily's 1997 book 'Nature's Benefits'.[74] Since then the development of the concept has proceeded on four main fronts:

- Enumeration of examples of economic and other benefits to society of individual ecosystem services or some bundles of services
- Development of increasingly sophisticated quantitative and qualitative models of the interactions among social, economic and environmental systems
- Use of the concept, and often the models referred to above, as a tool to engage diverse stakeholders in dialogue about relationships between humans and the natural environment to support better planning and natural resource management
- Debate among ecologists and economists to try and harmonise typologies for ecosystem services with the ways in which these disciplines define 'functions', 'processes', 'services', 'benefits' and 'values.
- The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes.

4.1 Where an ecosystem services approach fits with other approaches

In Chapter 6, we discuss in detail what taking an 'ecosystem services approach' means. In summary, an ecosystem services approach is primarily an environmental benefits and beneficiaries analysis. Although such analysis can be put together using other tools, an

ecosystem services approach tries to do this more holistically and with more generally-understandable language than other approaches. As such it is potentially an important component of approaches taken by governments, non-government organisations, businesses and community groups in assessing the relative merits of current decisions and thinking strategically about future investments in natural resource management. To be useful it must be compatible with other frameworks and tools that support decision-making in natural resource management ( ). Much of the refinement in ecosystem services definitions and approaches over the past decade has aimed at achieving this compatibility.

Box 2: Examples of tools proposed by the US Environmental Protection Agency to support their sustainability framework. An ecosystem services approach should be seen as part of a set of mutually compatible approaches that support decision-making.

Risk Assessment	Integrated Assessment Models
Life-Cycle Assessment	Sustainability Impact Assessment
Benefit-Cost Analysis	Environmental Justice Tools
Ecosystem Services Valuation	Present and Future Scenario Tools

4.2 Issues that the concept addresses

The language and concepts of ecosystem services ('benefits to humans from ecosystems') emerged due to concern among leading ecologists and economists that, not only was the welfare of other species being given inadequate consideration in decisions by governments, businesses and communities, but benefits critical to human wellbeing were also being overlooked with potentially major, even disastrous, implications. It was argued that these benefits were overlooked due to at least three major 'failures' of decision-making:

- Lack of broad understanding about benefits from ecosystems within societies
- The absence of markets for many of these benefits because they are of mostly public rather than private benefit
- The tendency of decision makers at all levels of society to deal with complex issues, such as those relating to ecological or other complex systems, by reconceiving them as simple cause and effect problems and/or to deal with only small parts of a system issues rather than trying to understand and manage the system itself

These challenges have been recognised by economists for some time. They are elements of 'market failure' and are frequently referred to as 'information failure', 'institutional failure' and 'intervention failure'.

Ecologists have also recognised some of these issues, particularly the third, which is one reason that the term 'ecosystem' emerged in the 1930s — to emphasise that the interactions among species and between species and the non-living environment are complex and generate outcomes that are 'greater than the sum of the parts'.

Given this prior recognition of the issues, questions are often asked by economists, ecologists and policy makers like:

- Why is the concept of ecosystem services needed?

- What is the policy issue that the concept of ecosystem services is trying to address?

Below, we identify several major policy challenges that an ecosystem services approach can add considerable value to:

- Getting environmental issues heard in public decision-making
- Improving the quality and efficiency of public engagement in development and implementation of environmental policy
- Explaining and justifying environmental policies in the context of broader policy issues
- Developing whole of government understanding of, and strategic approaches to, the interrelationships between environmental, social and economic issues
- Mobilising non-government resources to complement government efforts to address public environmental issues
- Considering equity in decisions that involve multiple social, economic and environmental issues
- Maintaining conservation of biodiversity as a key societal goal

Proponents of an ecosystem services approach do not suggest that this approach should replace, or is even capable of replacing, other scientific and/or policy approaches to dealing with these issues. It is an overarching framework that potentially integrates other approaches in some circumstances. Ways to identify when an ecosystem services approach is most appropriate are discussed in Section 6.3.

4.2.1 Getting environmental issues heard in public decision-making

Although disciplines like economics have developed approaches to identifying and potentially dealing with benefits from the environment that are not captured by markets (so-called 'externalities'), economic arguments often do not carry sufficient weight with politicians for them to compete with the arguments of vested interests. The language of ecosystem services is becoming better known and is developing strong international credibility. It is language that politicians can use and be understood by their peers and their constituents. The essence of an ecosystem services approach is discussed further in Chapter 6.

4.2.2 Improving the quality and efficiency of public engagement in development and implementation of environmental policy

Because the benefits to humans from ecosystems are both public and private and the beneficiaries are many and varied across the whole of society, there is a need for language and concepts that potentially allow all stakeholders to both understand the benefits that they stand to gain or lose from landuse decisions and to engage in productive dialogue about those decisions. Although in theory governments represent public interests and often intervene to protect those interests in the face of market forces that favour private interests, it is difficult for governments to act if the public is unaware of the benefits that are possible and/or unable to articulate their preferences. As discussed in the subsection above, and further in Chapter 6, ecosystem services approaches have been shown to be powerful ways to generate productive dialogue among stakeholders.

From the point of view of governments, it is important that inputs to decision-making are supported by sound evidence about the nature of the issues (including pubic opinion about

them), the context and causes of those issues, the options for addressing the issues, the implications of different decision options, and adequate consultation with all stakeholders. In relation to environmental issues, it has been difficult to obtain informed views from the public because relationships between humans and the environment were often represented in narrow, stereotypic ways by competing interest groups and constructive consideration of tradeoffs between competing interests was difficult because there were few frameworks for considering aspects of environmental management, from conservation to production, together. Combining ecosystems services frameworks with scenario analysis, and consideration of emerging understanding of resilience, adaptability and transformability in ecosystems and societies, is an effective way to not only generate dialogue but enable critical consideration of evidence (Chapters 6 and 11).

4.2.3 Explaining and justifying environmental policies in the context of broader policy issues

Flowing from the previous point is the responsibility of governments to explain their decisions, which has often been difficult in relation to environmental decisions. A particular challenge is explaining the nature and consequences of tradeoffs between economic, social and environmental values or between competing environmental values. Approaches to assessing ecosystem services are focussing increasingly on trade-off analysis, which not only allows dialogue about those trade-offs but often reveals that what were expected to be trade-offs often do not need to be if alternative management options are considered. Approaches to ecosystem services analysis are discussed in detail in Chapter 8.

4.2.4 Developing whole of government understanding of, and strategic approaches to, the interrelationships between environmental, social and economic issues

Most government departments do not understand environmental issues and do not see the relevance of environmental policy to them. This has led to the environment struggling to be heard in budgetary debates within government and, arguably, to sometimes perverse environmental implications from decisions made in non-environment departments. Similarly, opportunities for synergies with environmental policies have likely been overlooked. In Chapter 11 we report strong opinions from interviewees that there is a need for better strategic consideration of environmental issues across government departments and we outline how steps towards this objective might be made by developing common language and concepts around the potential benefits from ecosystems and their implications for the business of government departments.

4.2.5 Mobilising non-government resources to complement government efforts to address public environmental issues

A further issue is the strong dependence of Australians on governments to solve society-wide problems, including environmental ones. It is becoming increasingly clear that the whole of society needs to contribute to solutions to Australia's environmental challenges, including the relationships between environmental management and other 'wicked' policy challenges like population policy, climate change and food security, but a framework for debating this issue has been lacking. In Chapter 11 we make recommendations about how the Australian Government might act to encourage and empower other sectors of society to play a greater role in strategic

dialogue and action to improve alignment between human wellbeing and environmental management.

4.2.6 Considering equity in decisions that involve multiple social, economic and environmental issues

In their review for the Natural Resource Management Standing Committee, Cork *et al.*[63] noted that:

> Conventional benefit-cost analysis does not deal well with ethical issues such as fair distribution or intergenerational equity. The validity of valuation techniques for non-market services, particularly intangible services such as 'aesthetics', is highly contestable. Many people consider the 'utilitarian' nature of benefit-cost analysis inappropriate for making decisions about environmental assets with 'intrinsic' value. An ecosystem services approach does not resolve these issues – in fact it can bring them to the fore – but it does provide a basis for dialogue about what the values are that are being contested. Often this debate occurs without such a framework so the potential for miscommunication is large.

This observation remains relevant today. Approaches such as that being pioneered by the USEPA,[160, 161, 194, 233] which focus on identifying not only the benefits from ecosystems but also the beneficiaries at a range of scales of space and time, provide important additional inputs to dialogue about equity issue that market signals or vote numbers in elections can convey.

4.2.7 Maintaining conservation of biodiversity as a key societal goal

Some conservation interests and government departments with responsibility for conserving biodiversity have expressed concern that a focus on ecosystem services might diminish the perceived importance of conserving other species for their intrinsic value and/or for moral and ethical reasons. While biodiversity is recognised as the key underpinning of ecosystem services in all widely accepted frameworks, there are differences in how conservation of biodiversity is dealt with in different frameworks. Some have argued that conservation should be considered as an ethical issue separate from the use-based considerations often emphasised in an ecosystem services approach. Others argue that biodiversity should have two key roles in an ecosystems services framework: Maintenance of biodiversity by ecosystem processes can be seen as a so-called 'intermediate service' (a service that helps to generate other services) and as a 'final service' (a service that is valued directly by people).[222] Whichever approach is taken, it can be argued that an ecosystem services approach can be a way to enhance rather than detract from the importance of human intervention to conserve biodiversity.[222] Concern remains high, however, because despite numerous demonstrations of the economic and social value of biodiversity conservation it is questionable how much people are really willing to pay when more tangible aspects of their wellbeing are perceived to be under threat.[176] Whether or not this is true, it makes sense to have an open and informed dialogue — in the words of the late David W. Pearce 'begin … with an honest appraisal of just how little we do [value biodiversity]'[176] — so that all stakeholders are aware of the short and long-term implications of decisions about biodiversity conservation.

4.3 Definitions

The literature on definitions and classifications of ecosystem services can be very confusing, not only to the uninitiated but also those who have been involved in ecosystem services research for many years (including the authors of this report). In Appendix I we give examples of a range of different definitions. In this section we explain the reasons for these differences.

We conclude that definitions of ecosystem services appear to be in a transition from ones that saw ecosystem services as 'benefits to people from ecosystems' to ones that define ecosystem services as ecological phenomena and benefits as things that flow from services as a result of human inputs. While some proponents of ecosystem services approaches still prefer the older 'benefits from ecosystems' definitions because of their simplicity and utility as communication tools (see also Section 4.4), four recent definitions that capture the latest thinking and are likely to be appropriate for use by the Australian Government for a range of purposes are:

> … [final ecosystem services are] the components of nature, directly enjoyed, consumed, or used to yield human well-being[42]
>
> … the direct and indirect contributions of ecosystems to human well-being[210]
>
> … the aspects of ecosystems utilized (actively or passively) to produce human well-being[102]
>
> … the contributions that ecosystems make to human wellbeing, and arise from the interaction of biotic and abiotic processes[114]

Further conclusions from our review (explained more fully in the rest of this subsection) include:

- Ecosystem services are so-named because they arise from the actions of suites of species interacting with one another and the non-living environment — things that might be valuable to people that arise from nature but do not require these interactions (e.g., minerals, sunlight, tidal energy) are not considered to be ecosystem services
- Ecological processes that require inputs from humans (e.g., processes occurring in agricultural systems) are not in themselves considered to be ecosystem services, although they are likely to have ecosystem service components and are examples of synergy between ecosystem and human processes
- To avoid problems of double counting in environmental-economic accounts, a distinction has been made in all recent major studies between 'final ecosystem services' — those that are directly used by people to provide benefits — and 'intermediate ecosystem services' — those that form part of a 'cascade of services' that support one another and underpin final services
- Some services can be intermediate in some circumstances and final in others, depending on the nature of human needs
- There is more disagreement about how to define ecosystem 'functions' and there is a lack of clarity about how to distinguish ecosystem services from assets such as stocks, capital, infrastructure and the like — this is not likely to be a major problem for the Australia Government as it easily addressed by defining services in terms of processes rather than assets, as done by most sectors of the economy

- As discussed in Section 4.4, although agreement on a common definition of ecosystem services is likely to be achievable in the near future, it is recommended by several experts that there should be different classifications of ecosystem services for different purposes (although those different classifications should be consistent with one another).

The debate about definitions revolves largely around the concept of 'benefits'.

Early definitions, such as those of Costanza and colleagues,[69] Daily[74] and the Millennium Ecosystem Assessment,[144] equated ecosystem services themselves with benefits:

> … the benefits human populations derive, directly or indirectly, from ecosystem functions[69]
>
> … conditions and processes through which natural ecosystems, and the species that are part of them, help sustain and fulfil human life[74]
>
> … benefits that people receive from ecosystems[143]

These definitions were deliberately broad and simple to help make the sometimes-complex issues associated with ecology and economics more easily digested by non-specialists.[67] They are still widely used. The Millennium Ecosystem Assessment definition has been used by the Australian Government,[21] presumably for the purposes of communication and education. Most successors of the Millennium Ecosystem Assessment — The Economics of Ecosystems and Biodiversity (TEEB) program,[210] the UK National Ecosystem Assessment[228] and the Global Partnership for Wealth Accounting and the Valuation of Ecosystem Services (WAVES)[137] — have also adopted the broad definition.

As explained further in Section 5.2, however, definitions have been reassessed in the past few years as the concept of ecosystem services has been applied more comprehensively to understanding and assessing the links between ecosystem processes and human wellbeing and, especially, in situations that require rigorous accounting for benefits. The debate began with concern that definitions of ecosystem processes, functions, services and benefits were not sufficiently clear or agreed and that some so-called services were being counted as both means for generating benefits and ends in their own right.[102, 241] The Millennium Ecosystem Assessment [143] brought a heightened focus on the benefits of ecosystem processes by more explicitly defining human wellbeing and the paths by which ecosystems might contribute to wellbeing. Binning *et al.*[34] suggested that services should be defined in terms of the transformations that they mediate (because in economics services are defined as transformations of one sort of capital into another), and Wallace argued that they should be defined in terms of the human needs that they meet.[241] While neither of these arguments has been taken up explicitly, the debate has moved to the point that recent publications have distinguished between 'final ecosystem services', which directly yield benefits to people, and 'intermediate ecosystems services', which are still beneficial to people but act to support other services that directly provide benefits.[42, 102]

The impetus for these more recent recommendations was the need to avoid double counting so that ecosystem services typologies could be better aligned with economic theory and practice. However, their effect was to also encourage further debate about the nature of 'processes',

'functions', 'services' and benefits. While there appears to be general agreement about what ecosystem *processes* are (i.e., all interactions among components of an ecosystem), there is disagreement about the use of the word *function*. Although this term is used routinely by ecologists to denote functions that maintain ecosystems, some commentators are concerned that its use in an ecosystem services context infers some sense of human-centric purpose that is unacceptable to some stakeholders.[102] This human-centric bias is apparent in the definition of ecosystem functions used by de Groot *et al.*[81] — 'the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly' — but not in the definition used by Maynard *et al.*,[150] — 'the biological, geochemical and physical processes and components that take place or occur within an ecosystem'.

Two key areas that remain unresolved (although they are moving towards resolution) are:

- exactly which *processes* can quality to be *ecosystem services*
- whether *services* and *benefits* should be separated.

One element of the debate about what an ecosystem services is relates to what a 'service' is. The debate about intermediate and final services and 'cascades of services' has helped to sort out previous concerns about mixing 'means' and 'ends' in ecosystem services approaches. However, the sense of the word 'service' seems to have been lost in recent literature. In older literature, it appears that the word 'service' was deliberately used to denote the same sort of process that is involved in a 'service economy' — that is, a 'transformation of capital' or 'performance of a process' to provide a benefit that would not otherwise be available.[34] In a recent paper that claims to sort out a lot of the confusion about definitions of ecosystem services, Fisher *et al.*[102] define ecosystem services as 'aspects of ecosystems utilized (actively or passively) to produce human well-being'. They argue that this definition includes: 'ecosystem organization or structure as well as process and/or functions if they are consumed or utilized by humanity either directly or indirectly'. Thus, they include stock, capital and infrastructure as services. This is a good definition of 'things that are important to humans from ecosystems', but it is not a definition that is consistent with definitions of 'services' on any other fields. It might seem pedantic to make this point, but a sure way to inhibit interdisciplinary dialogue is to use common terminology inconsistently. A solution might be to rephrase ecosystem services in ways that convey the transformation of process: for example, 'maintenance and renewal of natural capital' or 'generation of natural capital' in the example above.

A second element of the debate about what constitutes an ecosystem service is the distinction between services provided by ecosystems and those provided by humans. The intent of ecosystem services approaches from the beginning has been to recognise the benefits that come from systems of 'natural' species.[74] Several authors have argued that there is a need to distinguish between the inputs from humans and the inputs from ecosystems when considering benefits that have an ecosystem component.[42, 101, 102, 128] It is argued that ecosystem services should be considered to be ecological phenomena and that benefits to people usually require some human input. For example, ecosystems maintain soil fertility but humans plant the crops to produce food. This might seem to be a complicating factor but it makes dealing with multifunctional landscapes easier and clearer. For example, in their assessment of the inputs to human wellbeing from ecosystems in southeast Queensland, Maynard *et al.*[150] considered the contributions to food production of both from natural ecosystems and agricultural ecosystems that required input of materials and labour by humans. When considering the roles of

landowners and managers in delivering services such as water purification or natural pest control to the public[108] in the future, it will be useful to consider the overall social benefit and the contributions made by ecosystems and humans.

The debate about whether *services* and *benefits* should be separated has already been alluded to above. The argument for separating them is to recognise that human input is usually required to yield the benefit. For example, some ecosystem services studies identify 'delivery of water for drinking' as an ecosystem service. It can be argued that the ecosystem service is provision of clean water and the benefit is drinking water for domestic consumption, which requires both the demand from people to exist and some infrastructure to take the water to taps.[42, 102] This distinction also highlights the point made by several authors that while ecosystems might produce outcomes that could be beneficial to humans, they only become benefits when people want them. To take this into account, Maynard *et al.*[150] discuss the merits of estimating both actual and potential ecosystem services.

Table 2 illustrates the distinction between benefits and services according to some authors. There is variation and a certain lack of clarity among recent studies in how this is dealt with. In The Economics of Ecosystems and Biodiversity (TEEB)[215] and the UK National Ecosystem Assessment,[228] ecosystem services are defined as 'benefits from ecosystems' but it appears that services and benefits were identified separately. A recent consideration of soil ecosystem services in Australia[30] clearly delineated between services and benefit. The study by SEQ catchments in Australia[150] defines ecosystems services in terms of their benefits but considered the separate inputs from ecosystems and humans, as explained above.

Table 2: Examples of the distinction between ecosystems services and the benefits that flow from them with human inputs[42] (see also Section 5.1).

Illustrative benefits	*Illustrative ecosystem services*
Harvests	
Managed commercial	Pollinator populations, soil quality, shade and shelter, water availability
Subsistence	Target fish, crop populations
Unmanaged marine	Target marine populations
Pharmaceutical	Biodiversity
Amenities and fulfilment	
Aesthetic	Natural land cover in viewsheds
Bequest, spiritual, emotional	Wilderness, biodiversity, varied natural land cover
Existence benefits	Relevant species populations
Damage avoidance	
Health	Air quality, drinking water quality, land uses or predator populations hostile to disease transmission
Property	Wetlands, forests, natural land cover
Waste assimilation	
Avoided disposal cost	Surface and groundwater, open land
Drinking water provision	

Avoided treatment cost	Aquifer, surface water quality
Avoided pumping, transport cost	Aquifer availability
Recreation	
Birding	Relevant species population
Hiking	Natural land cover, vistas, surface waters
Angling	Surface water, target population, natural land cover
Swimming	Surface waters, beaches

Taking the above considerations into account, three definitions that are likely to be acceptable to most proponents of ecosystem services approaches (although some might prefer earlier definitions) are:

> … [final ecosystem services are] the components of nature, directly enjoyed, consumed, or used to yield human well-being[42]

> … the direct and indirect contributions of ecosystems to human well-being[210]

> … the aspects of ecosystems utilized (actively or passively) to produce human well-being[102]

We note here that, since this report was written, Nahlik *et al*. (2012)[160] have published a review of frameworks for ecosystem service analysis and have drawn essentially the same conclusions as this report. They concluded that separating services from benefits, and focussing on final ecosystem services, is not only consistent with the majority of recent discussions but is also a way to allow a range of disciplines to engage with the concept of ecosystem services. They propose a process the interdisciplinary refinement of definitions for ecosystem services and development of plans to see the concept implemented in policy. This type of approach is similar to hat we proposed in our recommendations arising from this report.

4.4 Different classifications are likely to be needed for different purposes

In response to a paper by Wallace (2008),[241] which questioned the vagueness of the definition of ecosystem services as 'benefits to people from ecosystems' and the inconsistency of existing classifications of ecosystem services, Robert Costanza, a pioneer of the concept, argued that such a definition is:

> … a good, appropriately broad and appropriately vague definition. This definition includes both the benefits people perceive, and those they do not. The conventional economic approach to 'benefits' is far too narrow in this regard, and tends to limit benefits only to those that people both perceive and are 'willing to pay' for in some real or contingent sense. But the general population's information about the world, especially when it comes to ecosystem services, is extremely limited.[67]

Costanza further argued that different definitions and classifications of ecosystem services might be needed for different purposes. Others[102] have agreed with him that different classifications may be needed (Table 3), although, as explained in the previous sub-section, many are arguing for a single definition of ecosystem services.

Table 3: It has been argued that different classifications of ecosystem services might be needed for different purposes but that a common definition should be sought.[102]

Purpose	*Characteristics of classifications*	*Implications for definition*
Understanding and education	Categories need to be expressed in plain language that is understandable to the target audience(s)	Broad definitions referring to 'benefits from nature' are successful at meeting this purpose, while more complex ones can confuse some stakeholders[67, 74, 150]
Environmental-economic accounting analysis	To allow the aggregated net benefits (be they measured in economic or other terms) of ecological systems to be assessed, it is important that classifications are based on discrete units so that benefits or costs are only counted once	This purpose has led to definitions that distinguish between 'intermediate' (which contribute to a 'cascade of services'[115] services and 'final' services (which are directly 'consumed or enjoyed' by humans)[42]
Landscape management	In landscape-scale analyses, there needs to be consideration of where benefits and beneficiaries are in relation to one another and how these arrangements might change through time. Approaches to date have relied on mapping aspects of ecosystem function (see Section 8.5). This requires classifications that explicitly link services, benefits and beneficiaries with the underpinning ecosystem processes and functions.[77, 150, 188]	For this purpose, definitions need to very clearly distinguish between processes, functions, services and benefits. This has been an area of considerable confusion in the literature.[30, 102]
Public policy and equity in human wellbeing	Public policy often deals with all aspects of ecosystem services considered in this table, but one particular concern of governments is ensuring that public goods and services are shared equitably. Classification for this purpose have focussed strongly on classifying beneficiaries and the links between ecosystem services and human wellbeing.[30, 42, 150, 194, 241]	Wallace[241] attempted to define ecosystem services directly in terms of human needs. This paper generated considerable useful discussion but the definition has not been adopted widely. Most existing definitions do refer to human wellbeing in terms of 'benefits to people from ecosystems' but the explicit consideration of public-private distinctions and equity issues is dealt with by drawing on the disciplines of economics and social sciences.
Meeting multiple objectives	For both policy and land management the major challenges are setting and achieving multiple environmental, social and economic objectives in an integrated way. This means that classifications of ecosystem services may need to include all of the elements	As mentioned above, the more technical and complex definitions can inhibit dialogue with some stakeholders but simpler definitions can hinder dialogue with others.

Purpose	Characteristics of classifications	Implications for definition
	considered above, possibly in a nested was that allows different aspects to be emphasised with different audiences.	

4.5 Alignment with economic approaches to benefits

The concept of total economic value (TEV) (Figure 3) addresses the same set of benefits to humans as ecosystem services but it not as explicit about what these benefits are and does not put an emphasis on engagement with stakeholders in identifying and understanding the benefits and beneficiaries. TEV is a framework for economic analysis while ecosystem services is primarily a communication device that focuses on identifying what the benefits are in language that engages a wide range of stakeholders in strategic dialogue that is usually not possible around economic analyses. The tools of TEV are necessary, but not sufficient, to support an ecosystem services approach.

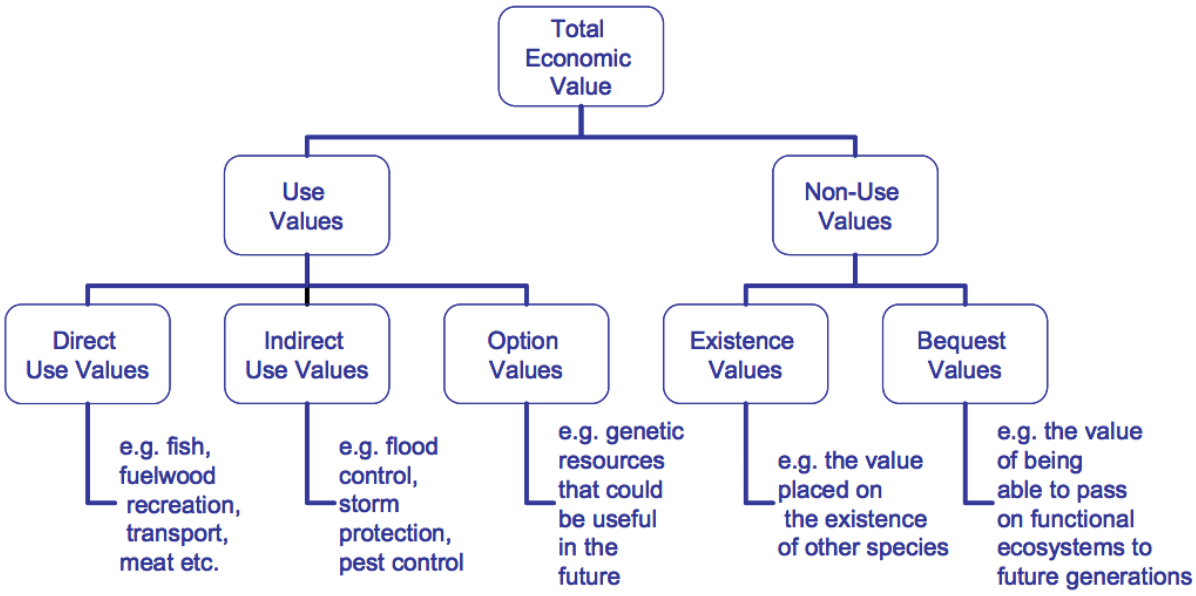

Figure 3: The concept of total economic value.[27, 170]

There have been some examples of misinterpretations of the relationships between ecosystem services and TEV. For example, in 2002 an OECD report [169] inferred that ecosystem services were equivalent to direct and indirect use values only. This misinterpretation was copied in some other publications and used by some representatives of Australian farmers for a few years [63] but appears no longer to be used in the literature or in practice.

A recent attempt to more explicitly align ecosystem services classifications with economic theory and practice is shown in Figure 4. As discussed in the previous sub-section, classifications

like this are useful when the purpose is to bring ecosystem services into an economic analysis, but they can be confusing for some other purposes.

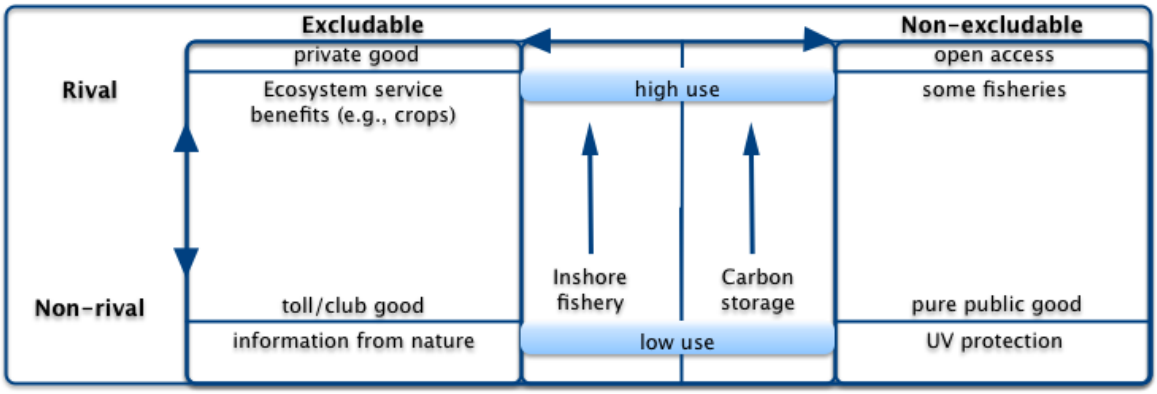

Figure 4: Goods and services can be characterized along a continuum from rival to non-rival and from excludable to non- excludable.

Some goods that are non-rival at low use levels (fisheries and CO2 storage) can move towards becoming rival goods with high use.[102]

4.6 Multifunctionality

In Europe and parts of Asia it has been popular until recently to use the terms 'multifunctionality' or 'multifunctional landscapes' to refer to landscapes managed for multiple market and non-market values.[2, 39, 49, 82, 99] This approach has been controversial as it became associated with payments to farmers to continue farming in traditional ways to maintain the cultural and tourism values of landscapes. This was interpreted as subsidisation of agriculture by some and challenged under World Trade Organisation regulations. Similar controversy has arisen in response to payments to rice farmers in Asia.[39]

5 Conceptual frameworks and typologies

Key conclusions from this chapter:

- Most recent typologies of ecosystem services have made the distinction between services that have indirect benefits to humans (often, but not always, called 'intermediate services') and services that have direct benefits (often called 'final services') — this has been an important advance to avoid double counting of benefits and to align ecosystem services approaches with theory in economics and ecology
- Most recent typologies refer to three categories of 'final' services: Provisioning services (e.g., provision of food, water, fibre and fuel); Regulating services (e.g., climate regulation, regulation of river flows, control of diseases); and Cultural services (e.g., spiritual, aesthetic, recreational and educational opportunities) (or equivalent names)
- Several high-profile projects have continued the Millennium Assessment practice of referring to a fourth category of services —Supporting services (e.g., primary production, soil formation) — but treating these as 'intermediate services' when assessing benefits (this can be confusing to readers not familiar with the origins of this fourth category in earlier typologies)
- Most recent typologies continue the practice adopted by the Millennium Ecosystem Assessment of being explicit about the presumed relationships between ecosystem services and human wellbeing (see also Appendix II).

5.1 Conceptual frameworks

The original conceptual frameworks for ecosystem services[69, 74] defined ecosystem processes, functions and services loosely. This has sometimes led to confusion, lack of uptake of the concept, and even strong opposition to its use, especially from some ecologists and economists. Research over the past 14 years has modified the original conceptual frameworks in several ways:[42, 77, 81, 101, 128, 241]

- Broad categories of ecosystem services have been identified (provisioning, regulating, cultural and supporting)
- Relationships between ecosystem services and human well being have been made explicit
- The concept of 'intermediate' and 'final' ecosystem services has been introduced to avoid the potential double counting of benefits
- In some conceptual frameworks the maintenance of biodiversity has been included as a service (e.g., 'habitat service') and in others it has been considered to be an underpinning enabler of other ecosystem services (in the most recent frameworks, habitat services have been considered to be 'intermediate', and therefore underpinning, services)

The following three figures illustrate the evolution of thinking about ecosystem services over the past 14 years. Figure 5 is the conceptual framework used in the Millennium Ecosystem

Assessment during 2000 to 2005. This framework built on the earlier definitions and typologies of ecosystem services such as those developed by Costanza *et al.*[69]and Daily[74] (see Appendices I and II). The dialogue associated with the Millennium Ecosystem Assessment revealed that neither the relationships between ecosystem services and human wellbeing nor the nature of wellbeing itself were well understood by the general public, policy makers or social and biophysical scientists. One major contribution of the Millennium Ecosystem Assessment conceptual framework, therefore, was to address these relationships explicitly.

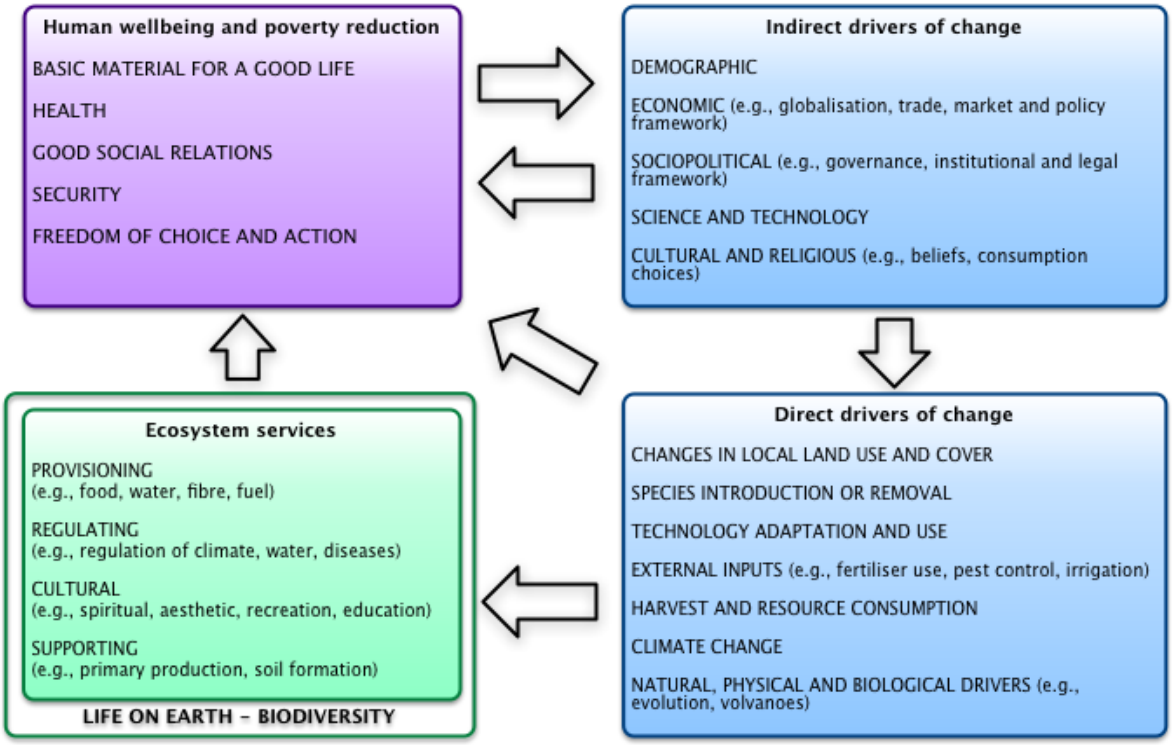

Figure 5: A simplified version of the conceptual framework relating drivers of change, ecosystem services and human wellbeing from the Millennium Ecosystem Assessment.[144]

The relationship between ecosystem services and human wellbeing was specified in more detail in other parts of the framework, as was the nature of potential policy and management interventions.

The Economics of Ecosystems and Biodiversity (TEEB) program built on the Millennium Ecosystem Assessment with a focus on developing the conceptual framework further so that it aligned better with economic valuation principles.[210] It was set up under the auspices of the United Nations Environment Program with a large number of international sponsors and partners (http://www.teebweb.org/Home/tabid/924/Default.aspx). One key advance in this framework is the explicit separation of ecosystem functions, services and benefits (Figure 6). This was a key step required to align ecosystem services thinking with economic theory and practice, which is addressed further in Figure 7.

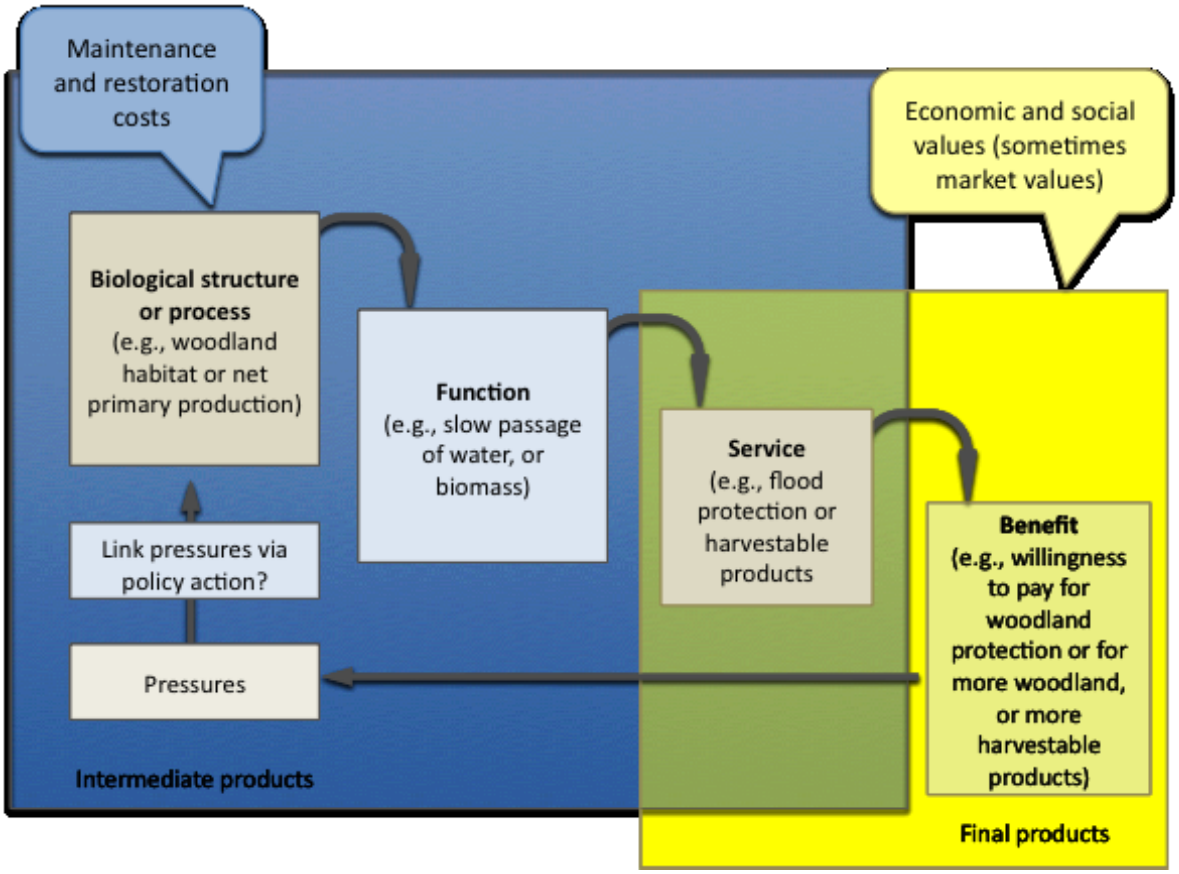

Figure 6: The conceptual framework used by The Economics and Ecosystems and Biodiversity project to link ecosystems and human wellbeing.[215]

Figure 7 shows the latest thinking about how to align ecosystem services frameworks and typologies with economic theory and practice. Progress towards this interpretation began with the typology developed by deGroot and colleagues[81] (see Appendix II) with major contributions to the debate from Boyd and Banzhaf[42], Wallace[241] and Fisher and colleagues.[101] It has been further elaborated on in the most recent TEEB foundations document [78] but retains the same key components.

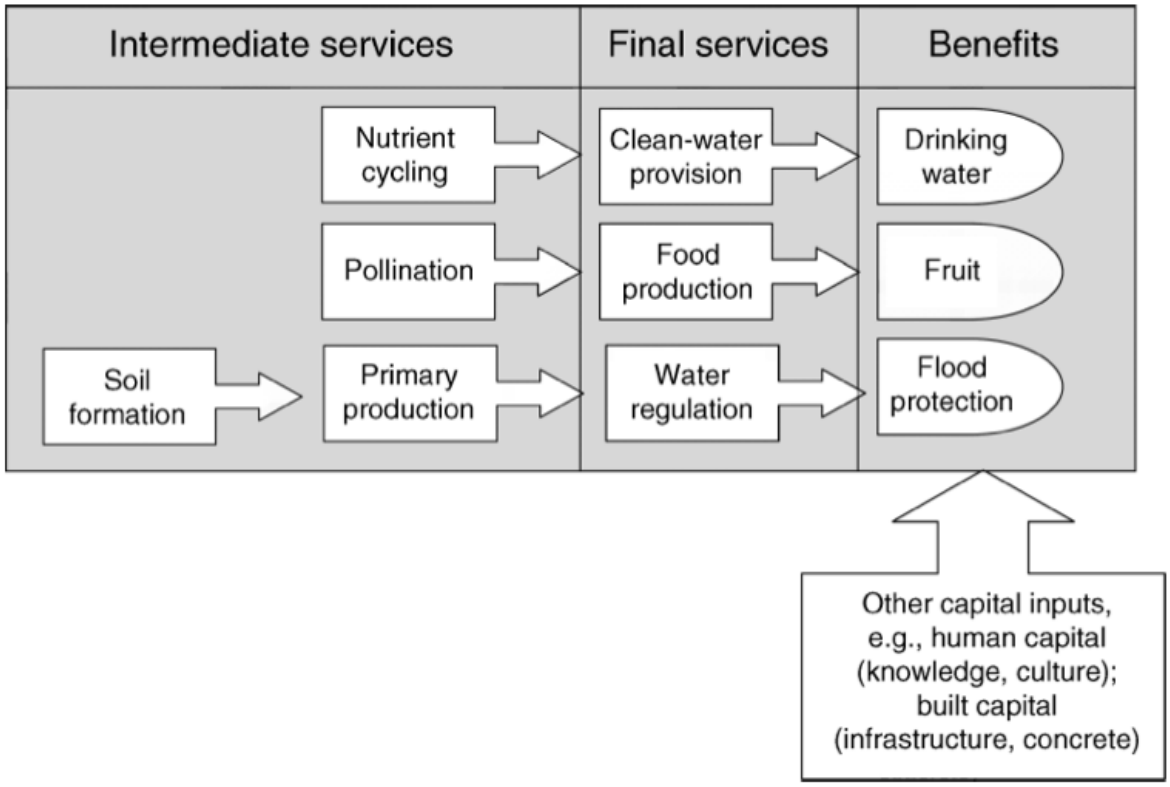

Figure 7: The conceptual relationships between intermediate and final ecosystem services and benefits.[101]

The key advance in these recent conceptual frameworks is that the possibility of multiple counting of benefits is reduced. By separating ecosystem services into intermediate and final services and benefits, the approach recognises that only the benefits generated by the final services can be aggregated. The contrast with previous approaches is illustrated in the following quote[101]:

> The Millennium Ecosystem Assessment divides ecosystem services into supporting, regulating, provisioning, and cultural services. While this typology is useful as a heuristic tool, it can lead to confusion when trying to assign economic values to ecosystem services. For example, in the Millennium Ecosystem Assessment, nutrient cycling is a supporting service, water flow regulation is a regulating service, and recreation is a cultural service. However, we see the first two as providing the same service, usable water, and the third (e.g., recreation on a clean, navigable river) turning the usable water into a human benefit (i.e., the endpoint that has a direct impact on human welfare). If all three Millennium Ecosystem Assessment services were to be individually valued and added to a cost–benefit analysis, we would commit the error of double counting, as the intermediate services are by default included in the value of the final service.

Similarly, food provision is seen as a final service in this approach, whereas pollination is an intermediate service. The benefit is food for consumption. The distinction between ecosystem services and benefits is important because the same service can generate multiple benefits (e.g., flood prevention, drinking water, and recreation), and these can be added together.

The scheme shown in Figure 7 is indicative and there are still challenges associated with putting it into practice. For example, delineation between intermediate service, final services, and benefits is not always clear-cut. The services identified are often a function of a beneficiary's

perspective. Maintenance of native vegetation might be seen as a final service to someone interested in conservation but it might be an intermediate service to someone interested in the role of vegetation in resulting water flows in landscapes. On the other hand, regulation of water flows might be seen as only an intermediate service to someone interested in a steady water supply. These complications are an inevitable reality of how humans perceive and value benefits, but at least the complication of multiple counting has been reduced in the latest approaches.

It should be noted that there are still some small differences of opinion in the use of terminology in ecosystem services frameworks. For example, in the framework and typology adopted by Maynard and colleagues [150] in southeast Queensland (Table 23 in Appendix II) components identified as 'ecosystem functions' appear to be similar to 'intermediate services' in Figure 7. The 'ecosystem services' identified by Maynard *et al.* would probably be classified as a mixture of 'final services' and 'benefits' by Fisher *et al.* Similarly, Balmford and colleagues,[25] use the terms 'core ecosystem processes' (e.g., production, decomposition, nutrient & water cycling), 'beneficial ecosystem processes' (e.g., biomass production, pollination, biological control, habitat and waste assimilation), and 'benefits' (e.g., food, fresh water, raw materials, energy and wellbeing).

Despite all of these unresolved issues, the concept of intermediate and final ecosystem services has been adopted in the most recent large scale application of ecosystem services analysis, the UK National Ecosystem Assessment.[228]

5.2 Typologies of ecosystem services

Since the 1990s there have been many attempts to develop and refine typologies (detailed and consistent classifications) of ecosystem services, building on the refined conceptual frameworks discussed above.[69, 74, 75, 79, 94, 143, 144, 213, 241] There appears to be emerging consensus that the categorisation of ecosystem services into Provisioning, Regulatory, and Cultural services, as done by the Millennium Ecosystem Assessment (Figure 5) is useful. However, the Millennium Ecosystem Assessment's fourth category – Supporting services – are better thought of as intermediate ecosystem services rather than final services. This development is illustrated in Figure 8.

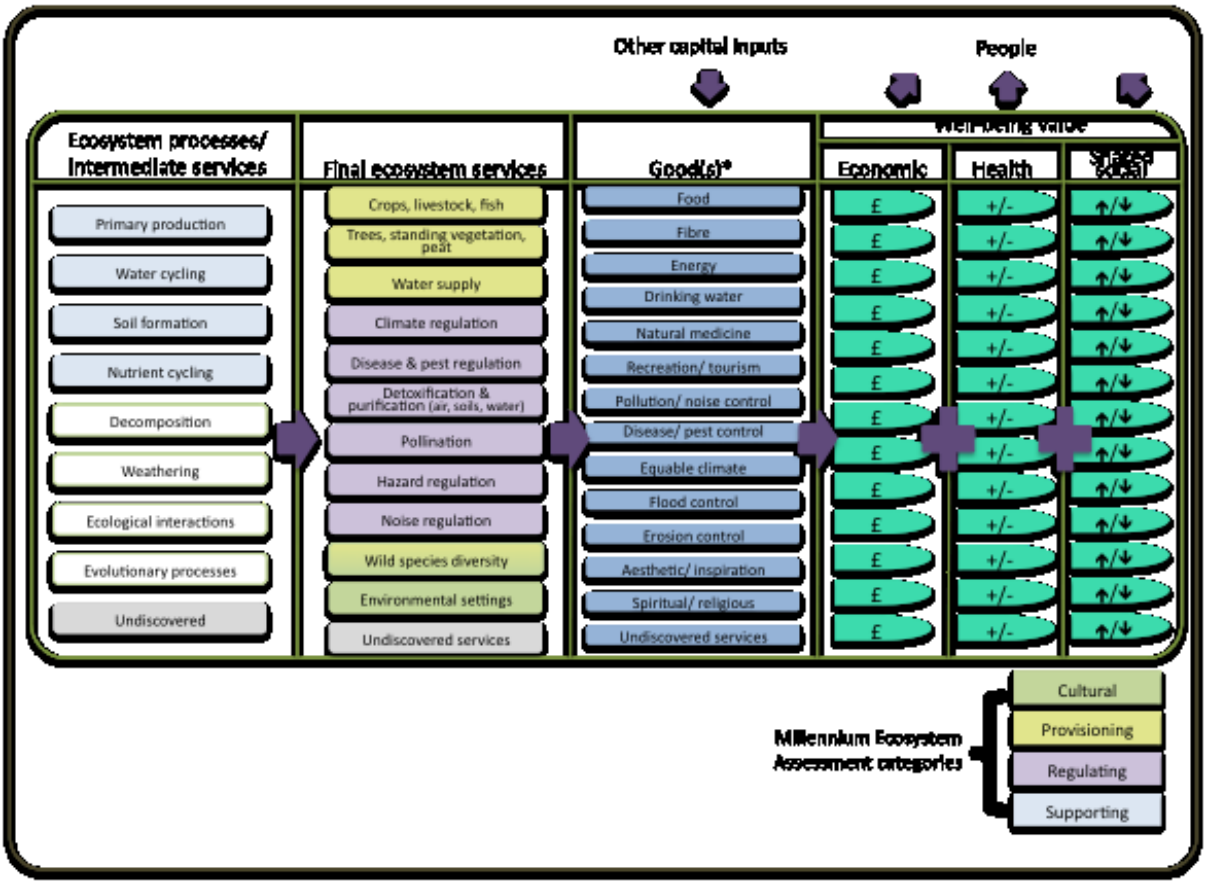

Figure 8: The conceptual framework for the UK National Ecosystem Assessment,[228] which was itself adapted from Fisher et al. (2008).[101]

This framework illustrates how the Millennium Ecosystem Assessment's four categories of ecosystem services — Cultural, Provisioning, Regulating and Supporting — have been recognized but only the first three are considered to be 'final' ecosystem services that lead directly to benefits. In the UK NEA report, this figure was accompanied by the following text: "Note that some ecosystem services can be both intermediate and final services. For simplicity, in this figure, services are shown only in the most final position that they occupy. Services such as pollination and climate regulation that also play important roles further back in the chain are not represented here. Cells with colour are ecosystem processes/services that were not in the Millennium Ecosystem Assessment classification. Note [also] that the term good(s) includes all use and non-use, material and non-material outputs from ecosystems that have value for people".

Several examples of typologies are given in Appendix II. As explained in the previous sub-section, not all recent typologies use the terms 'intermediate services' and 'final services' but they adopt the principal of separating services that had indirect benefits to humans to ones that have direct benefits.

Several research groups that have worked closely with stakeholders emphasise that it is important to retain flexibility for those stakeholders to identify which services and benefits are most relevant to them.[1, 34, 150, 190] As discussed previously, the challenge for future ecosystem services projects and programmes will be to encourage environmental-accounting best practice, as illustrated in Figure 6 and Figure 7, while allowing experiential learning to take place.

In response to this challenge, Johnston and Russell[128] developed a set of guiding questions to help workshop participants distinguish between benefits and intermediate and final ecosystem services. These rules are conceptually simple:

1. A fully informed, rational beneficiary would be willing to pay for increases in the service rather than go without it
2. The service must represent the output of an ecological system prior to any combination with human labour, capital or technology
3. Willingness to pay for the service cannot depend on other ecosystem outputs and conditions
4. An ecosystem outcome can simultaneously represent both a final service to some beneficiaries and an intermediate service to others — to avoid double counting, only benefits of final services (as identified by Rules 1-3) should be counted and aggregated.

Despite this apparent simplicity, application of these rules can be quite complicated, as discussed at length with examples by Johnston & Russell[128] (see also Appendix III). Rule 2, for example, considers whether an outcome is produced with or without human input. If there is human input then the outcome cannot be considered an ecosystem service by these rules. Johnston and Russell give the following example:

> For example, fishing – or a harvested fish in the boat – is not an ecosystem service to a recreational angler. Rather, the benefits of fishing result from the combination of the angler's time, fishing gear, and a set of final biophysical outcomes (or ecosystem services) consumed by the angler, including the presence of fish in the water. Once human labour or capital is applied to transform a biophysical output into something else, that "something else" is no longer an ecosystem service but rather the result of human production.

Although Johnston & Russell[128] argue that the production of ecosystem goods and services requires no inputs of labour or built capital, they acknowledge, after Fisher *et al.*[101], that '*benefits* are typically generated by ecosystem services in combination with other forms of capital like people, knowledge, or equipment'.

Rule 4 is especially complicated to apply, because it considers the fact that some outcomes will be final ecosystem services to some people, but not others, and that it is necessary to consider the different beneficiaries separately to avoid multiple counting. Johnston and Russell[128] illustrate this challenge using the example of water clarity. Water clarity is an ecological attribute that can be a final service to a lakeside home owner enjoying the view, but can also be an intermediate service to that same homeowner in their role as a recreational user wanting to catch fish that use submerged aquatic vegetation as habitat, given that such vegetation grows better in clear water where sunlight can penetrate. In this case, to avoid double counting of benefits from ecosystem services, it is important to consider only the final services and benefits when aggregating values or exploring tradeoffs.

5.3 Inclusion of ecosystem services in international environmental-economic accounts

At a theoretical level, Total Economic Value, a concept from the discipline of economics designed to include use and non-use value and market and non-market values, can be mapped closely to ecosystem services typologies (see a Section 4.5). The difference is that an ecosystem services

approaches seeks to be more explicit about identifying the services and benefits and to express them without the use of economic or ecological jargon as far as possible.

At a practical level, there are attempts under way internationally to develop ways to include assessments of ecosystems in the national accounts of nations. The System of Environmental-Economic Accounts (SEEA) is the statistical framework that provides internationally agreed concepts, definitions, classifications, accounting rules and standard tables for producing internationally comparable statistics on the environment and its relationship with the economy. The SEEA approach is being revised under the guidance of the United Nations Statistics Division. As part of this revision, a Common International Classification of Ecosystem Services for Integrated Environmental and Economic Accounting (CICES) is being considered.[114] Development of the CICES has been informed by several sources.[141, 232] First, discussions took place at two international workshops on CICES hosted by the EEA in Copenhagen, December 2008 and 2009. Second, an e- forum organised on behalf of the EEA ran from November 2009 to January 2010, which was designed to enable a wider international audience to comment on the issues relating to the CICES concept. Over 150 people registered for the forum; participants were invited members from the international community. In 2011, three key meetings were organized that brought together the experts and practitioners from some of the leading institutions in this field. The first was a meeting in March hosted by the World Bank in Washington D.C. to kick-off the Global Partnership for Wealth Accounting and the Valuation of Ecosystem Services (WAVES). The second was the meeting of experts hosted by the EEA in May 2011 to further a consensus on the conceptual framework for ecosystem accounts and the strategy for its development within the context of the revision process of the SEEA. A convergence emerged in both of these recent meetings on the general principles and elements of the conceptual framework for ecosystem accounting, the proposed outline and road map. A third meeting was held in London in December 2011, at which the proposed typology shown in Table 4 and Table 5 was discussed and supported, with input from several Australian individuals and agencies (including the Bureau of Meteorology and the Australian Bureau of Statistics, with papers authored by Richard Mount, Simone Maynard, Steven Cork and others).[141]

Table 4: Proposed structure for a Common International Classification of Ecosystem Services (CICES) for integrated environmental and economic accounting, and its relationship with ways in which natural capital is currently considered in the international System of Environmental Economic Accounts (SEEA).[114]

The SEEA is currently under review and the CICES is being considered as a way to report on ecosystems in national accounts.

CICES Theme	*CICES Class*	*Correspondence to SEEA 2003 'functions' of natural capital*
Provisioning	Nutrition	Resource function
	Materials	Resource function
	Energy	Resource function
Regulation and Maintenance	Regulation of wastes	Sink function
	Flow regulation	Service function (environmental quality)
	Regulation of physical environment	Service function (environmental quality)
	Regulation of biotic environment	Service function (environmental quality)

Cultural	Symbolic	Service function (amenity)
	Intellectual and experiential	Service function (amenity)

Table 5: Thematic, Class and Group structure proposed for the CICES.[114]

Theme	*Class*	*Group*
Provisioning	Nutrition	Terrestrial plant and animal foodstuffs
		Freshwater plant and animal foodstuffs
		Marine plant and animal foodstuffs
		Potable water
	Materials	Biotic materials
		Abiotic materials
	Energy	Renewable biofuels
		Renewable abiotic energy sources
Regulation and maintenance	Regulation of wastes	Bioremediation
		Dilution and sequestration
	Flow regulation	Air flow regulation
		Water flow regulation
		Mass flow regulation
	Regulation of physical environment	Atmospheric regulation
		Water quality regulation
		Pedogenesis and soil quality regulation
	Regulation of biotic environment	Lifecycle maintenance & habitat protection
		Pest and disease control
		Gene pool protection
Cultural	Symbolic	Aesthetic, Heritage
		Religious and spiritual
	Intellectual and Experiential	Recreation and community activities
		Information & knowledge

The typology proposed for the CICES is similar to those considered earlier in this chapter. The themes and classes are broad, as would be expected for national accounting. The classification has been cross-referenced to several other major UN standard classifications of environmental processes and benefits: International Standard Industrial Classification of All Economic Activities (ISIC V4); Central Products Classification (CPC); and Classification of Individual Consumption by Purpose (COICOP). It was found that some types of ecosystem outputs are accommodated in these existing classifications but that others are not and that 'a basis probably exists to propose a new standard in this important new area'.

If Australia decides to develop a national framework for ecosystem services, it should be consistent with the CICES as this, or something similar, is likely to become an important component of international environmental economic accounting in the future.

6 Application of an 'ecosystem services approach'

Key conclusions from this chapter:

- An ecosystem services approach is one that seeks to integrate the ecological, social and economic dimensions of NRM (including conservation as well as production objectives) at ecosystem scales and in language and concepts that engage a wide range of stakeholders
- Ideally, an ecosystem services approach will consider the full range of services strategically as focusing on one or a few services in ignorance of the others creates the risk of generating perverse societal outcome and even reducing human wellbeing
- Two other concepts that appear frequently in the literature and in policy documents are 'ecosystem management' (also called the 'ecosystem approach') and 'ecosystem stewardship'
- The ecosystem approach emphasizes the scale of environmental management (ecosystems rather than individual species) — the concept of ecosystem services is a key component of most ecosystem approaches
- Ecosystem stewardship emphasizes the need to consider social as well as ecological factors that affect the resilience of coupled ecological and social systems and their ability to adapt or transform as a response to change
- For an ecosystem services approach to be relevant and effective in natural resource policy and management, it must include the principles of ecosystem stewardship
- The ways in which an 'ecosystem approach' is described and recommended in the recent review of the *Environment Protection and Biodiversity Conservation Act 1999*[22] is consistent with ecosystem stewardship and is a good model for applying an ecosystem services approach

6.1 The essence of an ecosystem services approach

Seppelt *et al.* (2011)[205] recently reviewed literature on ecosystem services approaches. They concluded that the ecosystem service concept is intended to support the development of policies and instruments that integrate social, economic and ecological perspectives and has become the 'paradigm of ecosystem management'. They also concluded, however, that:

> The prolific use of the term 'ecosystem services' in scientific studies has given rise to concerns about its arbitrary application. A quantitative review of recent literature shows the diversity of approaches and uncovers a lack of consistent methodology.

Seppelt and colleagues distilled four core facets of an ecosystem services approach:

- biophysical realism of ecosystem data and models
- consideration of local trade-offs
- recognition of off-site effects
- comprehensive but critical involvement of stakeholders within assessment studies.

These core facets agree well with the ways in which an ecosystem services approach has been defined in the USA[204] and Australia ( ), where Cork *et al.* (1997)[63] suggested that the essential objective of an ecosystem services approach is to facilitate strategic dialogue and planning about multiple ecological processes and benefits.

Box 3: Essential features of an ecosystem services approach.[63]

An ecosystem services approach is one that seeks to integrate the ecological, social and economic dimensions of NRM (including conservation as well as production objectives) by:

- explicitly identifying and classifying the benefits that people derive from ecosystems, including market and non-market, use and non-use, tangible and intangible benefits
- describing and communicating these benefits in concepts and language that stakeholders and the public can understand
- posing and trying to answer a set of critical questions for sustainable management of ecosystems and human welfare, including:
  - Which services are provided by which ecosystems?
  - Who benefits from different services? How? What are the future needs of humans for these services?
  - What are the impacts of humans on different ecosystem services?
  - What is the role of biota and other natural assets?
  - How do different ecosystem services interact with one another?
  - What are the critical levels of ecosystem services for human welfare and survival?
  - What are the possibilities and implications of technological substitution for ecosystem services?

An ecosystem services approach focuses dialogue on a set of key integrative questions ( ). This set of questions is similar to those that underpin benefit-cost analyses in economics. The intention of an ecosystem services approach, however, is to engage a wider range of stakeholders in consideration of environmental and social benefits and costs using language and concepts that are more accessible than those of the discipline of economics.

There has been considerable debate over the past decade about whether the language and typologies of ecosystem services do achieve this objective, or whether there is a risk that they might confuse stakeholders if they are inconsistent. In our opinion, the following conclusions can be drawn from this debate:

- Diverse stakeholders react well to processes that allow them to 'discover' the ecosystem services that are important to them [1, 34, 150, 189, 190]
- Imposing a preformed typology too rigorously or early in an engagement process has the potential to inhibit engagement with stakeholders (Simone Maynard personal communication, August 2011)
- On the other hand, too little attention to what has been learned in ecology and economics about the need for clarity of definitions of terms like 'processes', 'functions', 'services', 'benefits' and 'value' can lead to confusion and biased conclusions.

6.2 Considering the full suite of services

The ideal application of an ecosystem services approach is to consider the full suite of services in one strategic analysis. This was the approach pioneered by the Millennium Ecosystem Assessment.[144] It has been described by the Natural Capital Project in the USA as 'Strategic Ecosystem Assessment'.[164-166] The UK National Ecosystem Assessment has applied a further refinement of this strategic approach.[228] These are not the only examples globally, and strategic approach to assessing the full range of services have been trialled in Australia as well.[1, 34, 190]

Although considerable progress has been made through studies focussing on a few ecosystem services — in terms of raising awareness of the benefits from ecosystems — concerns have been raised that such narrow studies might, in some cases, have counter-productive effects.[204] For example, prioritising a single service (e.g., carbon sequestration) or even a bundle of services (e.g., bundles associated with tree planting) can lead to significant trade-offs with other services (e.g., tree planting to manage water tables can affect water yield from a catchment. A recent study found that locations selected for conservation of ecosystem services globally would conserve only 22-35 percent as many species as locations selected for preservation of biodiversity.[162] Another concluded that only 16 percent of World Bank biodiversity-focused development projects resulted in a win-win for biodiversity and human well-being.[213] This is not to say that management for particular ecosystem services should not be done, as in many cases purpose managed ecosystems can produce more of desired services that native ones (e.g., monoclonal forest farms are reported to provide greater carbon sequestration than native forests as they can be maintained in rapid growth states[214]). It is, however, important to make such decisions in full knowledge of the implications for other services.

In relation to this issue of considering multiple services, a debate is emerging about the virtues of 'stacking' ecosystem services. This is the practice of allowing land managers to claim payments for several ecosystem services from the same piece of land.[87] The main benefits from stacking is that the overall payment becomes competitive with land development options. This is essentially the same as the approach to bundling ecosystem services proposed by Binning and others previously in Australia.[33] We mention stacking and bundling, together with other approaches to payments for ecosystem services, again in Section 8.7. The mention of them here is to reinforce the message that market-based mechanisms are emerging to deal with suites of ecosystem services but there is an urgent need for ecologists, economists and social scientists to develop the theory and frameworks so that markets can be guided towards suites of services that meet strategic societal objectives.

6.3 When an ecosystem services approach is most useful and the roles of ecological and economic analyses

As the professions of economics and ecology have increasingly interacted in the development of ecosystem services assessments over the past decade, more has been learned about how these disciplines can be integrated most effectively. Early research tended to focus either on ecological or economic approaches with the other as an add-on, but more recently strategic assessment approaches have emerged that start by considering the nature of the challenge and proceed to consider what balance of ecological and economic information and analysis is required.[70, 100, 130, 148, 164, 181, 183, 200, 216, 225, 228] Some of these approaches are discussed further in Chapter 7 of this

report. Table 6 illustrates a strategic consideration of whether an ecosystem services approach is likely to be appropriate for a particular challenge and how that approach might be developed. This table outlines the criteria desirable in the best-case but usually not all of these will be achievable or even always desirable. For example, it might not always be possible to achieve a short time from actions to delivery for ecosystem services that rely on ecosystem processes that might take years or decades to improve (e.g., regulation of water tables by deep-rooted vegetation). Similarly, the absence of a well established cause-effect relationship between actions and service delivery should not preclude taking an ecosystem services approach to exploring possible relationships, but it would suggest that research and a feasibility study be conducted before large investments are made.

Table 6: Framework for assessing the viability of an ecosystem services approach for meeting natural resource management (NRM) objectives (adapted from a framework developed specifically for achieving conservation objectives).[165]

Criteria	*Best-case*	*Some questions to consider*
1. Service delivery	• Clear evidence that feasible actions will increase services • Minimum time from actions to delivery • Delivery where demanded • Low variability in delivery	Is there clear evidence of a cause-effect relationship between proposed actions and service delivery? What are the current conditions and trends in service delivery? How long will it take for the intervention to result in service delivery? Will the services be delivered where they are demanded? Are there unacceptable trade-offs within/among services?
2. Measurability of service	• Clear units • Accurate/cost-effective measurement	How accurately and cost effectively can changes in the production of services be measured? Can the measurement be influenced by other factors? Is there a clear unit (e.g., carbon dioxide equivalent, nutrient credit) that adequately captures the attributes of the service delivered? If it is not possible to measure service delivery, can a closely linked activity be easily measured as a proxy?
3. NRM delivery	• Contributes to NRM objectives	Would proposed actions both increase services and advance NRM goals? Does the approach entail proven effective NRM strategies?
4. Scalable and replicable	• Supports NRM at scale	Will the proposed ecosystem services strategy deliver NRM benefits at scale? Is the approach likely to be replicable? If so, within what spatial area (e.g., same basin, region-wide, globally)?

Criteria	*Best-case*	*Some questions to consider*
5. Superior to alternatives	• Ecosystem services strategy is best available option compared to both technological substitutes and alternative NRM approaches	What are the possible alternatives to an ecosystem services-based strategy for delivering service benefits (e.g., infrastructure/technology)? Would other approaches (perhaps unrelated to NRM) produce service benefits more cost-effectively with less risk? Would other NRM approaches achieve conservation goals at less cost and risk?
6. Providers and beneficiaries	• Providers and beneficiaries exist that are not widely dispersed • Strong ongoing demand with beneficiaries willing to pay	Is there demand for services? How is it projected to change over time? Are there entities willing to pay for improvements in ecosystem services (public sector programme, institution, or constituency, private sector market or buyer)? Are there many potential providers and beneficiaries? Are they concentrated in a particular area or dispersed?
7. Benefits and costs	• High-value/important benefits with potential to translate into financial support for the project • Costs not prohibitive • Policy cost-effective for society and key stakeholders	Would proposed actions produce meaningful service benefits (that is, significant enough benefits to generate support/buyers for the actions)? What are the likely costs of proposed actions (implementation, monitoring, measurement, enforcement, transaction and opportunity costs)? Are costs potentially prohibitive (compared to the expected benefits)? If so, could they be reduced without compromising the approach? Can ecosystem service benefits be translated into financial returns for providers?
8. Legal context, institutional Enfield capacity	• Strong legal/regulatory framework • Supportive policies • Clear property rights • Strong institutions • Sufficient field capacity to implement project	Are there legal or regulatory drivers that support an ecosystem services approach? Are management and use rights clear for the services? Are property rights clear for the areas where the services are sourced and delivered? Is resource use effectively governed by informal rules (not captured in the current legal and regulatory framework)? Are there strong existing institutions that could support the ecosystem services strategy? Is there sufficient institutional and field capacity to use an ecosystem services approach (funding, technical skills, leadership)? Would an intermediary coordinating mechanism be required to facilitate exchange? Could any existing organisation potentially fill this role? Are there existing ecosystem services projects in the area? How successful have they been?

Criteria	*Best-case*	*Some questions to consider*
9. Stakeholders, equity and political viability	• Stakeholder support with local champion • Participation by and trust among stakeholders • No “big losers"; poor made better off or compensated • Approaches politically feasible; will not be blocked by adversely affected groups or powerful interests • Stakeholders support policies that enable ecosystem services approach	Are key stakeholders likely to be supportive? Are there local champions for taking the ecosystem services approach forward? Is there public understanding and support for ecosystem services provision? Are people concerned about degradation of ecosystem services? Are there existing mechanisms for participation in conflict resolution that would be useful for ecosystem services approach? Are they clear “winners and losers"? Are poor communities likely to be made better/worse off (both providers and non-providers of the service)? Would poor people be able to participate in the ecosystem services scheme? Is there political support/capital for solutions to preserve ecosystem services? Will the project adversely affect the interests of politically influential stakeholders? Are stakeholders sufficiently supportive of current or additional required policies that are needed for a ecosystem services approach?
10. Economic context	• Sufficient budget available • Current incentives favourite ecosystem services approach • Resilient to future changes in markets	Is there sufficient budget available to implementing ecosystem services approach? Are there existing subsidies or taxes that would undermine incentives to provide ecosystem services? Could an ecosystem services approach have secondary effects on prices, creating incentives that could undermine conservation? How would future predicted price changes affect the viability of the ecosystem services approach? Could other land uses soon become more financially attractive?

Several conclusions can be drawn from dialogue about integrating ecology and economics within an ecosystem services framework over the past decade:

- It is vital to be clear about the nature of the issues and the questions that need to be answered
- Often there will be critical gaps in ecological knowledge that need to be filled before accurate assessments of costs and benefits can be performed, but in many cases a coarse assessment of the full range of ecosystem benefits and beneficiaries, will be adequate to support decisions because the likely balance of benefits to costs is clear even when uncertainties in current ecological and economic understanding are considered (e.g., see Table 7 for an example of an analysis of the likely magnitudes of different ecosystem services, which allows additional research to be focussed where it is most critical)
- There is a need to include a much wider range of disciplines than ecology and economics in applying an ecosystem services approach, as issues such as legislative arrangements,

governance, equity and politics need to be taken into account[15, 44, 100, 105, 127, 130, 165, 181, 200, 225, 226, 248]

- When considering payments policies that encourage markets for ecosystem services, it is more important to focus on the mechanisms that allow stakeholders to negotiate market transactions that to attempt to calculate values accurately, as the latter are likely to be influenced by many variable factors. [15, 44, 100, 105, 127, 130, 165, 181, 200, 225, 226, 248]

Table 7: An example of a qualitative expert assessment of ecosystem services from inland wetland ecosystems (from the Millennium Ecosystem Assessment).[152] Increasing size of the filled circles denotes low, medium and high magnitude of services; not known = ?.

Services	*Components and examples*	*Permanent and temporary rivers and streams*	*Permanent Lakes, Reservoirs*	*Seasonal Lakes, Marshes, and Swamps, Including Floodplains*	*Forested Wetlands, Marshes, and Swamps, Including Floodplains*	*Alpine and Tundra Wetlands*	*Springs and Oases*	*Geothermal Wetlands*	*Underground Wetlands, Including Caves and Groundwater Systems*
Provisioning services									
Food	production of fish, wild game, fruits, grains, and so on	●	●	●	●	▪	▪		
Fresh water	storage and retention of water; water for irrigation and for drinking	●	●	●	▪	▪	▪		●
Fiber and fuel	production of timber, fuelwood, peat, fodder, aggregates	●	●	▪	●	●	▪	▪	
Bio-chemical products	extraction of materials from biota	▪	▪	?	?	?	?	?	?
Genetic materials	medicine; genes for resistance to plant pathogens, ornamental species, and so on	▪	▪	?	▪	?	?	?	?
Regulating services									
Climate regulation	regulation of greenhouse gases, temperature, precipitation, and other climatic processes; chemical composition of the atmosphere	▪	●	▪	●	▪	▪	▪	▪
Hydrological regimes	groundwater recharge and discharge; storage of water for agriculture or industry	●	●	●	●	▪	▪		▪
Pollution control	retention, recovery, and removal of excess nutrients and pollutants	●	●	▪	●	▪	▪		●
Erosion protection	retention of soils and prevention of structural change (such as coastal erosion, bank slumping, and so on)	●	▪	▪	●	?	▪		▪
Natural hazards	flood control; storm protection	●	●	●	●	●	▪		▪
Cultural services									
Spiritual & inspirational	personal feelings and well-being; religious significance	●	●	●	●	▪	●	▪	▪
Recreational	opportunities for tourism and recreational activities	●	●	●	▪	▪	▪	▪	▪
Aesthetic	appreciation of natural features	●	●	▪	●	▪	▪	▪	▪
Educational	opportunities for formal and informal education and training	●	●	●	●	▪	▪	▪	▪
Supporting services									
Biodiversity	habitats for resident or transient species	●	●	●	●	▪	▪	▪	▪
Soil	sediment retention and	●		●	●	▪	?	?	

formation	accumulation of organic matter	
Nutrient cycling	storage, recycling, processing, and acquisition of nutrients	
Pollination	support for pollinators	

6.4 'Ecosystems approach' and 'ecosystem stewardship'

Two other concepts that overlap strongly with an ecosystem services approach are 'ecosystem management' (also called 'the ecosystem approach') and 'ecosystem stewardship'. There have been suggestions that some ecosystem approaches retain undesirable elements of past 'steady state' approaches to resource management. We explore these suggestions below and conclude that application of an ecosystem services approach in natural resource policy and management in Australia must be embedded in an ecosystem stewardship approach to be relevant and effective in the world of the next few decades and beyond. We further conclude that at least some of the ways in which the Australia Government is proposing to implement ecosystem-scale policy and management recognises and incorporates the essential elements of ecosystem stewardship.

The ecosystem approach focuses on the scale of management (i.e., ecosystems rather than species). Proponents of an ecosystem stewardship approach suggest that an ecosystem focus is not sufficient to prepare coupled ecological and social systems for the sort of change likely in the next few decades and beyond (e.g., climate change and pressures on arable land for urban development, food production, energy production and other uses).[50] They argue that past, steady-state, approaches to resource management frequently failed because they applied limited understanding of how coupled ecological and social systems remain resilient, adapt or transform in the face of pressures and shocks (Table 8). In their view, an ecosystem-scale approach might not perform much better than previous approaches unless specific attention is paid to the interactions between social and ecological systems, including governance and other institutional components.

Table 8: Differences between steady-state resource management and ecosystem stewardship.[50]

Characteristic	*Steady-state management*	*Ecosystem stewardship*
Reference point	Historic condition	Trajectory of change
Central goal	Ecological integrity	Sustain social–ecological systems and delivery of ecosystem services
Predominant approach	Manage resource stocks and condition	Manage stabilising and amplifying feedbacks
Role of uncertainty	Reduce uncertainty before taking action	Embrace uncertainty: maximize flexibility to adapt to an uncertain future
Role of research	Researchers transfer findings to managers who take action	Researchers and managers collaborate through adaptive management to create continuous learning loops
Role of resource manager	Decision-maker who sets course for sustainable management	Facilitator who engages stakeholder groups to respond to, and shape, social–ecological change and nurture

		resilience
Response to disturbance	Minimize disturbance probability and impacts	Disturbance cycles used to provide windows of opportunity
Resources of primary concern	Species composition and ecosystem structure	Biodiversity, well-being and adaptive capacity

Some form of assessment of benefits to humans for ecosystems, who the beneficiaries are and how the dynamics of human-ecosystems are managed is central to an ecosystem stewardship approach. The essential difference between an ecosystem stewardship approach and the sorts of approaches that Chapin and colleagues are critical of is not whether ecosystems services are considered but what processes are used to anticipate and prepare for future needs for services and future ability of ecosystems to meet those needs.

These criticisms of past resource management, and especially ecosystem-scale approaches, are important to consider when thinking about how terms like 'ecosystem approach' and 'ecosystem services' are used and interpreted in policy and management. Governments around the world have been moving towards ecosystem-scale environmental management for much of the past decade,[174, 204] and ecosystem services is an integral component of most approaches to ecosystem management.[205] The recent review of the *Environment Protection and Biodiversity Conservation Act 1999* – one of the main instruments by which the Australian Government can bring about strategic thinking and planning about environmental issues – recommended that:[17]

> The Act should be amended to incorporate these principles of the ecosystems approach.

That review articulated the principles of an ecosystem approach, drawing on the Convention on Biodiversity ( ). This approach is far from being a steady-state approach and is consistent with an ecosystem stewardship approach.

Box 4: Principles of an ecosystem approach as articulated in the recent review of the Environment Protection and Biodiversity Conservation Act 1999.[17]

Principle 1: The objectives of management of land, water and living resources are a matter of societal choices

Principle 2: Management should be decentralised to the lowest appropriate level

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems

Principle 4: Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

- reduce those market distortions that adversely affect biological diversity
- align incentives to promote biodiversity conservation and sustainable use
- internalise costs and benefits in the given ecosystem to the extent feasible.

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach

Principle 6: Ecosystems must be managed within the limits of their functioning

Principle 7: The ecosystems approach should be undertaken at the appropriate spatial and temporal scales

Principle 8: Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term

Principle 9: Management must recognise the change is inevitable

Principle 10: The ecosystems approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity

Principle 11: The ecosystems approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices

Principle 12: The ecosystems approach should involve all relevant sectors of society and scientific disciplines

Ideally an ecosystem services approach would include both analysis of ecosystem benefits and beneficiaries and consideration of governance and other institutional requirements for achieving strategic objectives that allow for adaptation and transformation of ecological and social systems if necessary. Simply assessing ecosystem services without embedding that assessment within an ecosystem stewardship framework is simply 'ecosystem services evaluation' and not what we term an 'ecosystem services approach'. We argue, therefore, that our concept of an ecosystem services approach is virtually synonymous with ecosystem stewardship and that together they provide frameworks and language that should be an important component of both policy and management approaches. The approach outlined in reflects a desirable ecosystem approach, but we have not attempted to analyse application of ecosystem-scale policy and management across other state and federal government areas of interest.

7 Relationships between ecosystem services and biodiversity

7.1 The issues

The ecological underpinnings of most ecosystem services remain poorly understood.[24, 142, 172, 195] A central question is how the mix of species present in an ecosystem affects the nature of ecosystem functions and services at one point in time and through time in the face of environmental change. There has been a long debate about these relationships.[98, 120, 132, 154, 156, 158, 159, 203, 218-221, 245] Experimental work on the relationship between species mixes and ecosystem function has been almost entirely on artificial, simplified communities of organisms because of the difficulty manipulating naturally occurring ecosystems.[134]

An important reference point for this debate was the work of Vitousek & Hooper (1993),[237] who suggested three different possible relationships between plant diversity and ecosystem functions (Figure 9). On the basis of what was known at the time, they concluded that the asymptotic relationship, shown as Type 2 in Figure 9, was the most likely one. This relationship is expected to come about because the essential functions of an ecosystem, including nutrient cycling and decomposition processes, are provided at any point in time by a relatively small number of species and addition of more species primarily replicates these essential functions. In general the research cited above has supported this conclusion. Following sections of this chapter address some of the key questions that follow from this hypothesis, including:

- Do all ecosystems follow the relationship depicted in Type 2 of Figure 9?
- What significance do 'replicate' species have through time and space?
- What happens if ecosystems assemble or disassemble non-randomly?
- How does diversity of species and functions relate to production of ecosystem services?
- Can we identify ecosystem service providers and measure their efficiency?

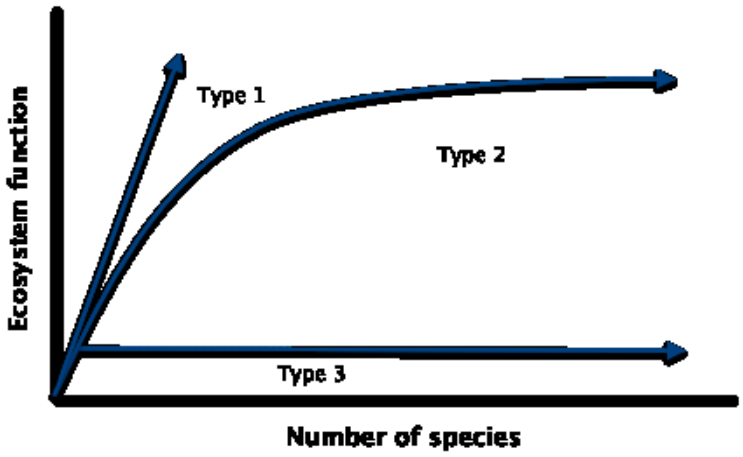

Figure 9: Possible relationships between biological diversity and ecosystem functions for the plant subsystem.[237]

7.2 Relationship between diversity and ecosystem function

The research cited above generally has supported the existence of the Type 2 relationship of Figure 9.[121] Research on agricultural ecosystems has suggested that genetic, species and functional diversity are all important for providing the ecosystem service of natural pest control but that the right combinations of functions are also important.[121] In some cases, natural pest control increases with increasing diversity of plant and insect species[167] but, in other cases where the combinations of functions are not conducive, higher biodiversity appears to encourage greater pest populations through such mechanisms as providing key hosts of high palatability or that allow pests to complete a complex life cycle.[43, 185]

7.3 The significance of "replicate" functions

There are at least three ways in which diversity of species and functions might be important in agricultural landscapes:[234]

- Biodiversity might enhance ecosystem function because different species or genotypes perform slightly different functions (have different niches)
- Biodiversity might be neutral or negative in that there are many more species than there are functions and thus redundancy is built into the system
- Biodiversity might enhance ecosystem function because those components that appear redundant at one point in time become important when some environmental change occurs.

More and more evidence is emerging that the third possibility is most often the reality. Maintaining a diversity of functional types is thought to confer resilience on ecosystems. Resilience is a complicated issue but put simply is the ability of a system to cope with change.[191] Resilience often comes from the presence of rare species that can take on critical functions when conditions previously favouring dominant species change. In other words, maintaining a mix of species that respond differently to different environmental perturbations maintains management options.[121] For the below-ground community, for instance, there is evidence that the same enzymatic function is carried out by different species of bacteria or fungi from the same soil under different, and even fluctuating, conditions of moisture stress or pH.[112]

In the case of plants, different species may play a similar functional role in different seasons, under varying conditions of environmental stress and in different stages of patch-level succession.[212] In savanna rangeland communities in Australia minor species that were functionally similar in trait space (redundant) to the dominant herbaceous species responsible for the majority of ecosystem functions (carbon storage, nitrogen cycling, etc.) were also more resistant to grazing, becoming superior competitors under conditions of high grazing.[239]

These and other arguments and research findings argue that protecting as much biodiversity as possible is a wise strategy for managing risks associated with medium and long term climate and other environmental change and for keeping future management options open. Because lost diversity is difficult or impossible to reconstruct, it would be unwise to sacrifice it simply because of uncertainty about the extent and mechanisms by which it affects ecosystem properties and services.[121]

7.4 How do ecosystems assemble and disassemble?

The number and types of species in an ecosystem are the result of dynamic interactions among many factors, including competition for resources among species, synergies among species, the history of which species arrived first and when other species arrived, local extinctions or adaptation of roles (e.g. competitors, predators, pests or diseases) by new or existing species to changed species composition and/or abiotic environmental conditions and influence of random events.[122, 212] Attempts to assemble combinations of the same number of species under slightly different conditions and in particular without the history of interaction often fail.[96, 97, 212]

In agricultural ecosystems, farmers become part of this dynamic interplay by the selection of which organisms are present, by modifying the abiotic environment and by interventions aimed at regulating the populations of specific organisms. In addition to the biodiversity that farmers manipulate in a planned way, there is *associated biodiversity*.[212] Some species leave and some move into the agricultural system as a result of the planned changes. Some support the agricultural endeavours (e.g. soil organisms that take over essential nutrient cycling functions) while some do not (e.g. pests, weeds and diseases). Conversion to agriculture almost always results in fewer species and fewer functional groups,[212] making it important to consider managing diversity at larger scales than the farm to ensure that sources of functional groups exist to colonies the farms and to continue providing broader ecosystem services as conditions change in the future.

Decline in biodiversity with intensification of land management could follow various paths (Figure 10).

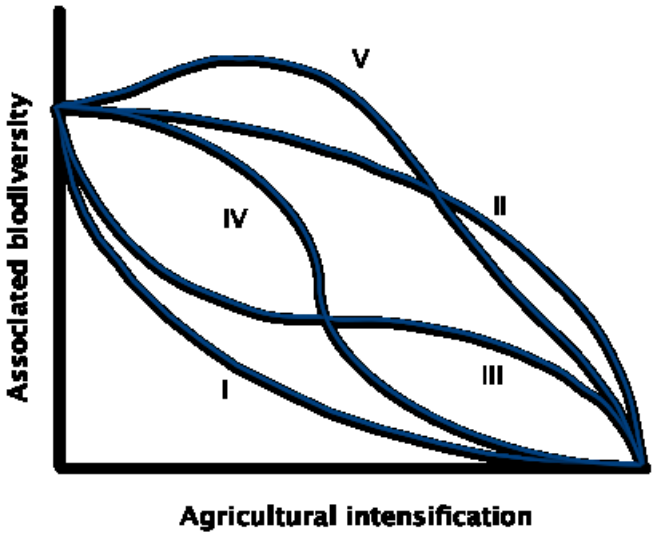

Figure 10: Potential effects of intensification of agriculture on biodiversity.[121]

Letters a–f on the *x*-axis refer to increasing states of management intensity, with ''a'' being an unmanaged ecosystem and ''f'' being intensive, industrialized agriculture. Intensification tends to reduce diversity of associated taxa, although a range of trajectories is possible, including the potential for initial increases in biodiversity as intermediate levels of disturbance create more niches.

Until recently, speculation about the implications of these paths for ecosystem services was limited. A few recent publications have summarized the evidence about decline (disassembly) of ecosystems and concluded that this is rarely, if ever, a random process – in other words some species groups and functions are more likely than others to decline first.[84, 212] Using this knowledge, it is possible to speculate about different rates of loss of different ecosystem services (Figure 11).

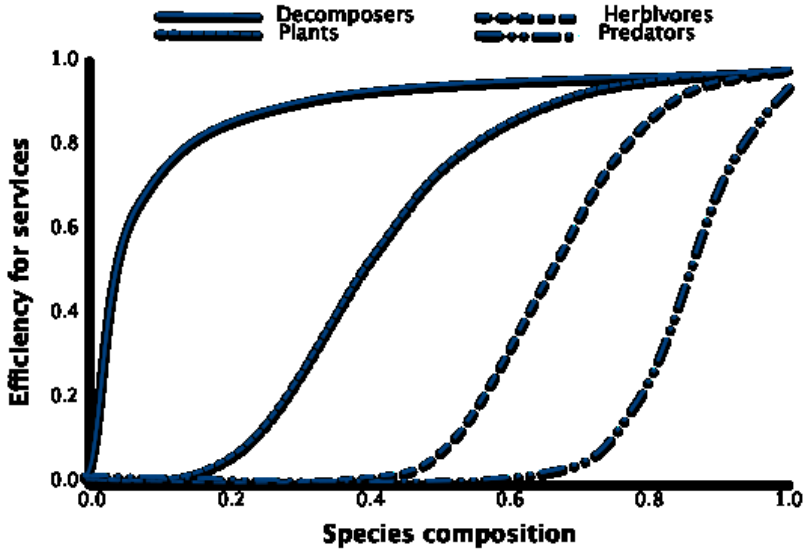

Figure 11: Functional forms for the relationship between loss of biodiversity and loss of function.[84]

Each of the curves represents the decline in both number of species at each trophic level and the ecosystem services undertaken by species on different trophic levels as the total number of species in the community declines. The lowest line (alternating dots and dashes) is for predators and services on the top trophic level, the second lowest line is for herbivores, the dotted line is for plants, and the solid line is for decomposers. The threshold values occur when each trophic level passes through the value of species composition that corresponds to 50% of maximum efficiency for services undertaken at that trophic level.

The scientific community has come to a broad consensus on many aspects of the relationship between biodiversity and ecosystem functioning, including many points relevant to management of ecosystems.[121] Detailed management prescriptions and monitoring are not possible for all ecosystem services, and there are complications because ecosystem processes and services overlap and interact with one another. Understanding is, however, adequate for broad management objectives to be set within a framework relating ecosystem function to human needs and for progress against those objectives to be assessed.

7.5 How much biodiversity is enough?

For over fifty years ecologists have pondered the question 'why are there so many species?'[123] Allied to this question is the one occupying the minds of policy makers and land managers worldwide, i.e. 'how much biodiversity is enough?' An implication from current understanding of the relationship between biodiversity and ecosystem function is that it is not possible to define a level of biodiversity that is ideal for all ecosystems or all purposes. Optimal levels will

depend on the ecosystem functions required for specific purposes and needs, what functions are present at a site and in a landscape, the degree of overlap in functions between species, the degree of change possible, the resilience of the ecosystems and the preferences of people who derive value from the ecosystem.[212]

Some generalizations have, however, been offered in the literature. There is substantial experimental evidence that many key functions can be maintained by only small numbers of species within a particular functional in an artificial and space-restricted ecosystem group. For example, single-species plantings of perennial plants can be as effective as a diverse plant community in controlling erosion. In a laboratory, decomposition of organic matter can be achieved by a single species of fungus yet across a landscape there might be thousands of species of fungi, bacteria or invertebrates with different species playing a role in nutrient distribution and decomposition functions at differences places and in different environments.[107, 211, 212]

The role of replicate species in providing resilience over time has been discussed previously. The same argument leads to the hypothesis that the diversity of functional groups and species within functional groups needs to be higher in nature than in laboratories and higher at landscape scales than plot and farm scales because of greater variation in abiotic environments and biotic and abiotic perturbations[212] (Figure 12). Resilience also depends on the degree of connectivity between and among the elements of ecosystems and landscapes.[4, 119, 191] It follows that diversity of land uses within a landscape is likely to be an important strategy for maintaining resilience of both ecosystem services and human welfare in the medium and long terms.[212]

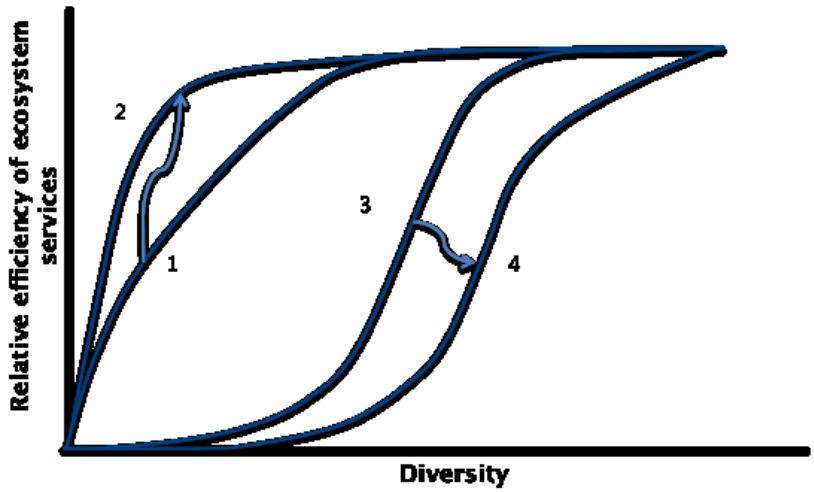

Figure 12: Hypothesised relationships between diversity (as measured by species richness) and the efficiency of ecosystem services at plot to landscape scales.[212]

Curve 1 represents the type of relationship suggested by most current knowledge. Curve 2 depicts how substitution of diversity by inputs derived from human labor and petro-chemical energy in an intensively managed agricultural plot may lead to higher efficiencies. Curve 3 is the equivalent relationship to curve 1 but at a landscape scale. At this scale it is postulated that the threshold of 'essential' diversity is greater because the variation in stresses and disturbances and the likelihood of change due to human or other

impacts is far greater. Curve 4 represents circumstances of high disturbance of the landscape by human intervention. These impacts increase the levels of diversity required to maintain a resilient system.

7.6 Identifying ecosystem service providers and their efficiencies

As a way to advance thinking about the relationships between biodiversity, and ecosystem services, some researchers have attempted to characterize ecosystem services by the component populations, species, functional groups (guilds), food webs or habitat types that collectively produce them. These have been termed 'Ecosystem Service Providers'[134] or 'Service Providing Units'.[142] Ecosystem service providers are defined at different levels within ecological hierarchies depending on the type of service being provided, and the geographic scale over which it operates (Table 9). For example, maintenance of resistance to pests, weeds and diseases in crops is a service provided at the scale of genes and operates at local scales.[142] On the other hand, biological control of crop pests operates at the population and/or food-web level at landscape scales[243] and regulation of water flow by vegetation occurs over landscape and larger (e.g. regional) scales.[113]

A few studies have applied this reasoning to perform Functional Inventories of ecosystems. These studies have identified the component Ecosystem Service Providers and measured or estimated the contribution of each in terms of its abundance and the efficiency with which it performs the service.[26] Examples of the units in which functional efficiencies are measured include pollen grains deposited per bee and dung burial rates by dung beetle.[138] According to Kremen (2005),[135] functional inventories provide a range of insights into ecosystem function that can form the basis for prioritization of research, policy and management. For example:

- Particularly influential Ecosystem Service Providers (ESPs) can be identified by ranking ESPs in terms of their contribution in relation to abundance
- The functional structure of an ecosystem can be explored by ranking species by their functional importance and investigating how equal or unequal the contributions of different ESPs are
- Species traits, such as body size, dispersal distance, and response to disturbance can be correlated with functional efficiency, to characterize the suite of response and effect traits that a community exhibits and predict its resilience to disturbance
- Using functional importance values, predictions can be made about how delivery of ecosystem services might change as the composition of ESPs changes over space or time, along disturbance gradients, or with different management regimes.

Table 9: Ecosystem services and their ecosystem service providers.[134]

'Functional units' refer to the unit of study for assessing functional contributions of ecosystem service providers; spatial scale indicates the scale(s) of operation of the service. The author's (Kremen 2005)[134] **assessment of the potential to apply this conceptual framework to the service is purposefully conservative and is based on the degree to which the contributions of individual species or communities can currently be quantified.**

Service	*Ecosystem service providers/ trophic level*	*Functional units*	*Spatial scale*
Aesthetic, cultural	All biodiversity	Populations, species, communities, ecosystems	Local–global
Ecosystem goods	Diverse species	Populations, species, communities, ecosystems	Local–global
UV protection	Biogeochemical cycles, micro-organisms, plants	Biogeochemical cycles, functional groups	Global
Purification of air	Micro-organisms, plants	Biogeochemical cycles, populations, species, functional groups	Regional–global
Flood mitigation	Vegetation	Communities, habitats	Local–regional
Drought mitigation	Vegetation	Communities, habitats	Local–regional
Climate stability	Vegetation	Communities, habitats	Local–global
Pollination	Insects, birds, mammals	Populations, species, functional groups	Local
Pest control	Invertebrate parasitoids and predators and vertebrate predators	Populations, species, functional groups	Local
Purification of water	Vegetation, soil micro-organisms, aquatic micro-organisms, aquatic invertebrates	Populations, species, functional groups, communities, habitats	Local–regional
Detoxification and decomposition of wastes	Leaf litter and soil invertebrates; soil micro-organisms; aquatic micro-organisms	Populations, species, functional groups, communities, habitats	Local–regional
Soil generation and soil fertility	Leaf litter and soil invertebrates; soil micro-organisms; nitrogen-fixing plants; plant and animal production of waste products	Populations, species, functional groups	Local
Seed dispersal	Ants, birds, mammals	Populations, species, functional groups	Local

8 Dealing with multiple ecological processes and multiple benefits

Key conclusions for this chapter:

- Several large scale international projects have developed and tested frameworks for integrated assessments of multiple ecosystem processes and services
- The key components of these approaches are:
  - Identification of information gaps and initiation of research to fill them
  - Establishing relationships between indicators of ecosystem state and capacity to deliver ecosystem services
  - Mapping ecosystem condition and functions as an aid to spatial planning
  - Modelling of multiple interacting ecosystem processes to improve ability to anticipate outcomes of policy and/or management interventions
  - Development of scenarios of future human development to anticipate requirements for ecosystem services

8.1 Policy challenges

A key dilemma for policy makers is how to adjust policy settings in relation to ecosystem services when different services are likely to change at different rates as policies and land management change.[63] This dilemma is illustrated in Figure 13. As landscapes move along the continuum between pristine and highly modified (X- axis), not only will the sum of ecosystem services change but also the relative amounts of different types of services. Because of the different needs of different stakeholders in different places and at different times, there will potentially be winners and losers at any point along the land conversion continuum.

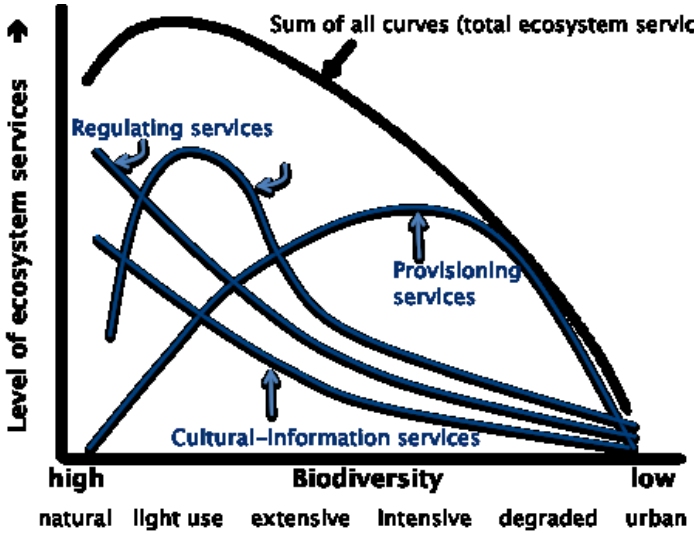

Figure 13: Generalized functional relationships between the levels of ecosystem services provision (Y-axis) and the degree of loss of biodiversity related to different land use intensities (X-axis).[77]

The fact that many ecosystem services are not recognised in markets has led Australian governments, like many other governments around the world, to use incentives, regulations, guidelines and resource-use caps to create and guide markets to include a wider range of ecosystem services.[11, 33, 54, 157] Increasingly, there are calls for policy to encourage integrated management of multiple services to avoid unintended consequences of only intervening in parts of complex systems. This will require methods for engaging stakeholders in dialogue about the opportunities and tradeoffs that might be involved if governments want support for complex policies and system-level interventions.

8.2 Frameworks for integrated assessment of multiple ecosystem processes and benefits

Figure 14 and Figure 15 show two conceptual frameworks for dealing with multiple ecological processes and values at ecosystem scales up to national scales. They build on the types of conceptual frameworks of relationships between ecosystem services and human wellbeing presented in previous Chapters.

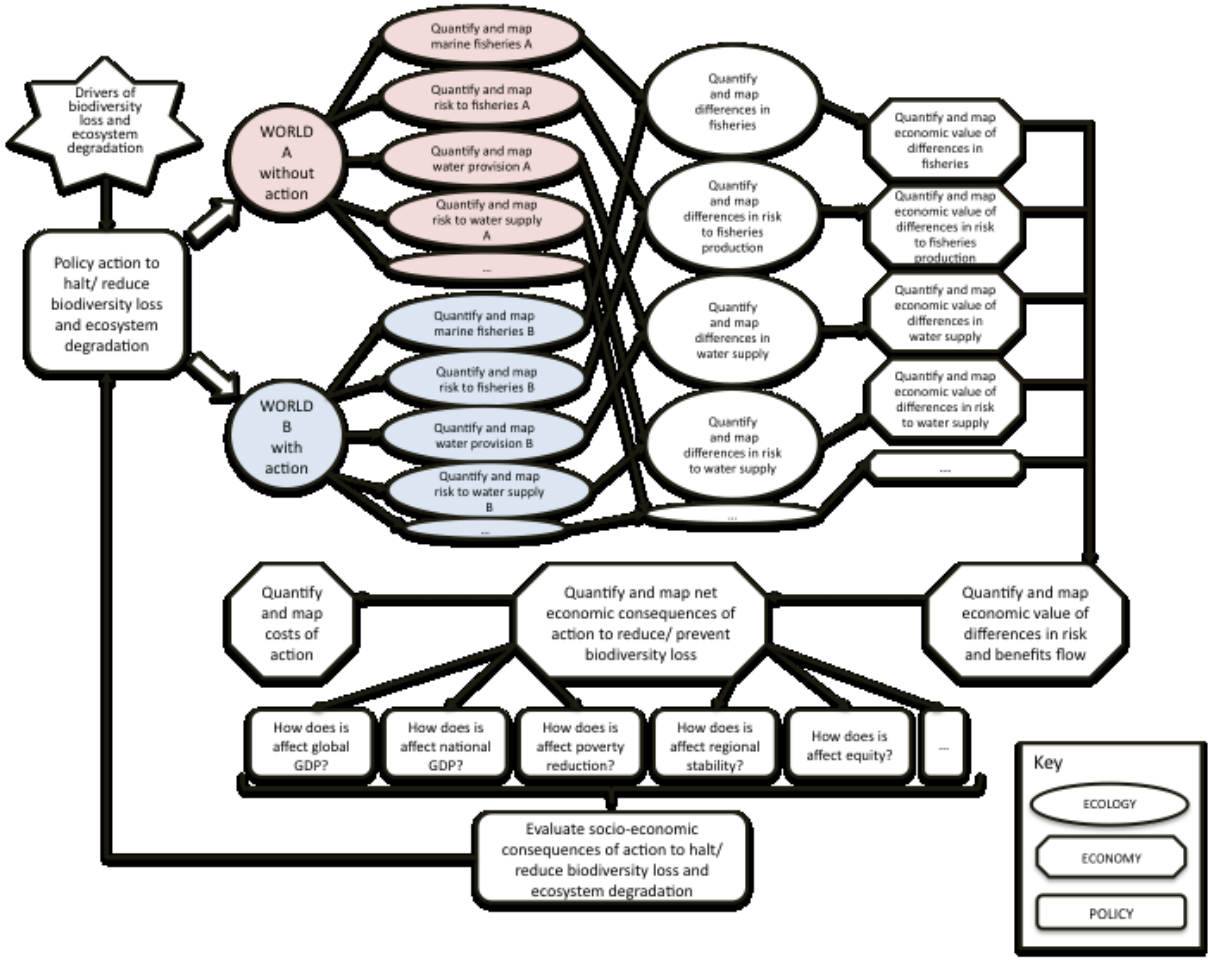

Figure 14: Conceptual framework for evaluating the implications of alternative future scenarios (e.g., policy choices) in relation to multiple ecosystem processes, services and benefits in the TEEB project.[215]

Both approaches stress the need to consider multiple scenarios (with and without actions to manage ecosystem services in the case of TEEB and scenarios for the future of the UK in the case of the UN National Ecosystem Assessment) rather than simply considering current value. This approach requires a good understanding of the service flows and the determinants of demand, and also attention to the spatial heterogeneity of service flows and economic values. This valuation framework is largely consistent with a number of other frameworks developed at around about the same time [51] and represents leading thinking in this area. A modification of this framework forms the basis for the current CSIRO project assessing the ecosystem services implications of alternative flow regimes in the Murray Darling Basin (Neville Crossman, CSIRO, personal communication 2011).

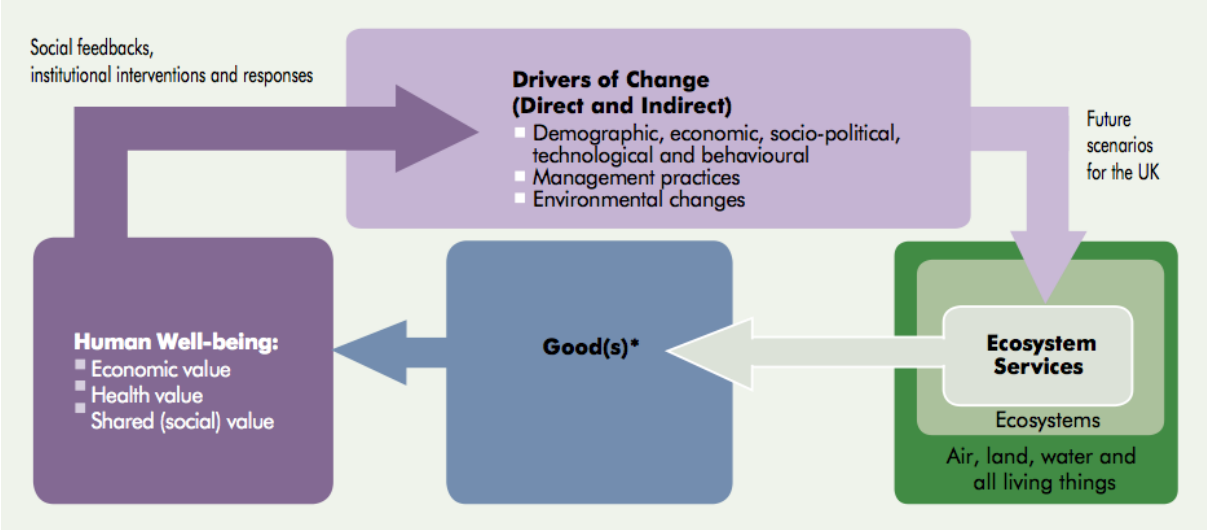

Figure 15: Conceptual Framework for the UK National Ecosystem Assessment showing the links between ecosystems, ecosystem services, good(s), valuation, human well-being, change processes and scenarios for the future of the UK.[228]

***Note that the term good(s) includes all use and non-use, material and non-material benefits from ecosystems that have value for people.**

8.3 Assessing and addressing information needs

Several recent syntheses have identified the state of information and the research still needed to support integrated assessments of ecosystem service outcomes.[47, 75, 124, 143, 144, 215] is a summary of key research questions building on these studies.

Box 5: Key research questions to be resolved to support integrated assessments of multiple ecosystem services in landscape planning, management and decision-making.[77]

a. Understanding and quantifying how ecosystems provide services

(1) What is the state-of-the art regarding the typology of ecosystem services?

(2) How can the relationship between landscape and ecosystem characteristics and their associated functions

and ser- vices be quantified?
(3) What are the main indicators and benchmark-values for measuring the capacity of an ecosystem to provide services (and what are maximum sustainable use levels)?
(4) How can ecosystem/landscape functions and services be spatially defined (mapped) and visualized?
(5) How can relationships between ecosystem and landscape character and services, and their relevant dynamic interactions, be modelled?
(6) What is the effect of (changes in) dynamic conditions (temporal and spatial) of landscape functions on services, in terms of sustainability and resilience? Are there possible critical thresholds?

b. Valuing ecosystem services
(7) What are the most appropriate economic and social valuation methods for ecosystem and landscape services, including the role and perceptions of stakeholders?
(8) How to make economic and social valuation of landscape and ecosystem services consistent and comparable?
(9) What is the influence of scaling-issues on the economic value of ecosystem and landscape services to society?
(10) How can standardized indicators (benchmark-values) help to determine the value of ecosystem services and how can aggregation steps be dealt with?
(11) How can values (ecological, social and economic) be mapped to facilitate the use of ecosystem services in (spatial) landscape planning and design?

c. Use of ecosystem services in trade-off analysis and decision-making
(12) How can all the costs and benefits (ecological, socio- cultural and economic) of changes in ecosystem services and values of all stakeholders (in time and space), be taken into account properly in discounting and cost-effectiveness issues?
(13) How can analytical and participatory methods be combined to enable effective participatory policy and decision-making dialogues?
(14) How can spatial and dynamic ecosystem services model- ling be linked to participatory trade-off assessment methods to optimize multi-functional use of the ‘‘green and blue space’’?
(15) How can landscape design-alternatives be visualized and made accessible for decision-making, e.g. through expert systems and other decision and policy support tools?

d. Use of ecosystem services in Planning and Management
(16) How to incorporate resilience of landscape functions, and thresholds of service-use, into methods for landscape planning, design and management of ‘green and blue space’?
(17) What are the main bottlenecks in data availability and reliability with regard to ecosystem services management and how can they be overcome? (18) What is the relationship between ecosystem management state and the provision of ecosystem services (both on individual services and the total mix of ecosystem ser- vices)?
e. Financing sustainable use of ecosystem services
(19) What is the adequacy of current financing methods for investing in ecosystem and landscape services? How can they be improved (and linked to valuation-outcomes)?
(20) How to communicate ecosystem and landscape services, and their social and economic importance, to all stake- holders.

In an assessment of the ‘state of ecosystem services’ globally, Searle & Cox[204] concluded that, in order to build a comprehensive knowledge base, researchers must:

- Increase replication and standardization of projects
- Increase coordination across disciplines
- Shift to more prospective, decision-guiding research
- Be more willing to publish and accept preliminary results
- Focus on local conditions

They also concluded that:

- The Ecosystem Services field lacks a comprehensive knowledge base (and needs more viable databases for capturing knowledge)
- Greater depth of knowledge exists for wetlands and forests than other ecosystems
- Greater depth of knowledge exists for water and carbon services
- Projects are globally spread, but there is a lack of replication and standardization of projects
- The field lacks standards, and sufficient measurement and monitoring tools
- The field lacks standard decision-support applications
- No application covers all geographies for even the most prevalent ecosystems and services

8.4 Inferring capacity to deliver ecosystem services from indicators of ecosystem state

One approach to assessing the capacity of ecosystems to provide services is to establish a typology of state for different types of ecosystems.[41, 77, 103, 174] For example, a temperate forest might be classified as wild or unmanaged, sustainably managed (selective logging), degraded (clearcut + burnt), intensively managed (plantations, agroforestry, agriculture) or developed (permanent human infrastructure) and a set of ecosystem services might be expected to be associated with each of these states. Figure 16 illustrates this sort of approach. The VAST approach to classifying landscapes and ecosystems, which is widely used in Australia, is based on a similar principle.[217]

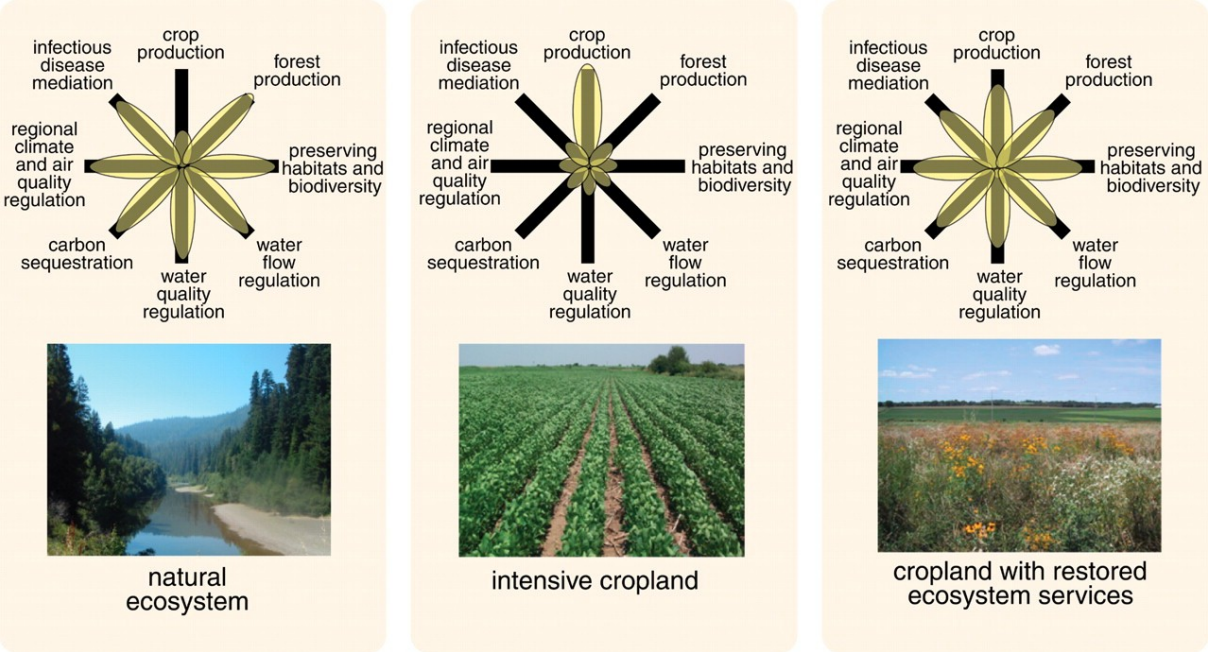

Figure 16: An example of how the broad state of ecosystems can be assessed visually and related to likely combinations of ecosystem services produced.[103]

A further level of sophistication is to collect data on indicators of ecosystem services.[76, 77, 117, 143] Increasingly, indicators of ecosystem function have been used to diagnose the state of ecosystem services provision spatially, which is the subject of the next sub-section.

8.5 Mapping the potential spatial arrangement of ecosystem services

Mapping of physical and/or social aspects of landscapes can provide insights into the potential for ecosystem services production and can be related to the places where people and live and require services. There has been a large number of projects producing maps of 'ecosystem services' (actually maps of indicators of ecosystem state, condition and/or function) at scales from local to regional.[188; 48; 90, 163] These studies have consistently found that different ecosystem services are most strongly produced in different areas of landscapes and regions, meaning that spatial mapping and modelling (see next sub-section) are vital tools for considering how to align land management strategies with human needs.[77]

A mapping approach has been adopted successfully in southeastern Queensland, in which relationships between ecosystem attributes and functions were developed by expert panels and the functions were mapped.[150] Maps of this type allow planners and stakeholders to have productive dialogue about the consequences of increases or decreases in human populations in different places, changes in demands on ecosystem services related to the activities and lifestyles of communities in different places, or land management interventions in different places. The feedback from this project (Simone Maynard, personal communication, August 2011) is that the ability to consider ecosystem processes spatially has increased awareness among stakeholders about human-ecosystem interrelationships and alerted them to opportunities for better planning and management of both rural and urban areas. While

contemplation of possible economic values of ecosystem services has been useful, the stakeholders have said that the dialogue generated by the maps and associated biophysical and social assessments have been the most important influences on their thinking to date.

8.6 Modelling multiple ecosystem services

The past decade has seen the development of a range of computerized models that assess the impacts of economic and environmental factors on natural resources, including the provisioning of goods and services. These include IMAGE-GLOBIO[41], GUMBO[40] and MIMES (www.uvm.edu/giee/ mimes). Most of these models, however, usually focus only on a few ecosystem goods and services and have limited ability to consider potential effects of management strategies suites of services.[77]

Some regional (dynamic) models have been developed to simulate the impacts of land use change and management on ecosystem goods and services.[113, 182] The InVEST model is widely used around the world. It provides spatially explicit modelling of multiple services and trade-offs.[168] A number of studies have used GIS techniques to consider the intersection of layers of information on biodiversity, ecosystem function and landuse change.[48, 90, 106, 131, 151, 236]

Indices of some ecosystem functions have been developed, which can be mapped as part of the consideration of potential for delivery of ecosystem services. These include Mean Species Abundance [3, 41], Biodiversity Integrity Index[147], the Biodiversity Intactness Index[202], and the Living Planet Index.[140]

In Australia sophisticated landscape models have been developed and applied to considering ecosystem services [31] and integrating economic assessments with landuse considerations.[173]

8.7 Approaches to assessing the value of multiple ecosystem services

Numerous useful papers, reports and books have been written about approaches to valuing ecosystem services [32, 38, 77, 78, 80, 175, 215, 223] and we will not attempt a comprehensive review here. Table 10 provides a summary.

Table 10: Summary of approaches to assessing values of ecosystem services in the TEEB project.[215]

	Valuation/ accounting subject			*Methods/ tools/ models*	
Preference-based approaches	Output value	Use value	Direct use value	Market analysis	**Disciplinary framework: Neoclassical economics/ market theory**
				Cost methods	
				Production function	
			Indirect use value	Market analysis	
				Cost methods	
				Hedonic pricing	
				Contingent valuation	
			(Quasi) option value	Replacement cost method	

				Mitigation cost method Avoided cost method	
		Non-use value	Legacy/ existence/ altruism	Contingent valuation Contingent election	
		Social justice/ deontological values/ lexicographic preferences, non human values		Group valuation Deliberative valuation Joint analysis	**Political science**
Biophysical approaches	Insurance value	Resilience value	Probability of flips	Regime shift analysis Adaptive cycles Panarchies Risk analysis	**Resilience theory**
	Physical consumption	Physical cost	Energy/ exergy/ emergy	Emodied energy Exergy analysis Emergy analysis	**Industrial ecology/ Thermodynamics**
			Materials/ surface/ landcover	Material flow analysis Input-output analysis Ecological footprint Land-cover flow	

A major challenge for economists is aggregating the values of individual ecosystem services affected by such scenarios. The study by Costanza and colleagues [69], which focussed worldwide attention on ecosystem services, generated a long and heated debate among ecologists and economists about the legitimacy of calculating total values for the world's ecosystem services. Many critics argued that it was not legitimate to estimate the total value of ecosystem good and services by multiplying willingness to pay for marginal changes in an ecosystem service (e.g. for services provided by an individual wetland) by the total supply of the service (e.g., the total area of wetlands in a region, country or the world).[68] Others argued that the total value of the world's ecosystem services is a meaningless concept as humanity would not accept any amount to lose its life support systems and, anyway, there is no buyer for these systems in their totality. [93]

At a finer scale, the problem of potential multiple counting of services and benefits has been a long-standing matter for discussion. The differentiation of intermediate and final ecosystem services, discussed earlier in the section, has gone a long way towards providing a rigorous basis for considering multiple services and benefits (Appendix III). Thus, for example, where previously economists might have been concerned that the value of pollination of plants by animals might get counted twice as the avoided cost of labour to fertilise crops and the value of the food produced by those plants, more recent approaches would see pollination of crops as an intermediate service whose value is (in theory) included in the cost of the products. There still remains the problem that the real value of pollination and other environmental processes are not in reality captured in the cost of agricultural products, and the sort of dialogue that an ecosystem services approach encourages is aimed at gaining recognition of this type of market failure.

The TEEB study has also considered three other aspects of aggregation: aggregation across different groups of people with potentially different needs and values; aggregation of values over different spatial scales; and aggregation of values over time.[78]

Identifying and dealing with tradeoffs among services requires an understanding of the nature of the ecological, social and economic systems, which requires some sort of modelling (addressed below). Key tools used by economists include cost- benefit analysis and cost-effectiveness analysis.[7, 23, 24, 78, 89, 163, 215] In the past, studies of ecosystem services often focused only on benefits but increasingly studies are considering both benefits and costs together.[78, 163] Another tool used increasingly, although not favoured by all economists, is multi-criteria analysis[186, 187]

A critical issue for policy makers arises from the constraint on economists to focus on marginal change (Figure 17). Economics approaches estimate prices for services and commodities by considering how willingness to pay is likely to change in response to a change in supply of, or demand for, that service or commodity, assuming that other components of the economic, social or ecological system stay constant. In practice, this means that the size of the change must usually be small and over a discrete period of time. Another complication is that people's willingness to pay does not change linearly as supply changes. If a person is thirsty they will pay more for their first drink than subsequent drinks, for example. Value, as against price, is calculated as the sum of all marginal changes in a consumer's willingness to pay (consumer surplus) and a producer's willingness to accept payment (producer surplus). These surpluses are, mathematically, the areas under different parts of a supply-demand curve, which, especially when dealing with environmental outcomes, is likely to be non-linear and even discontinuous (i.e., it might involve step-changes, thresholds and irreversibilities).

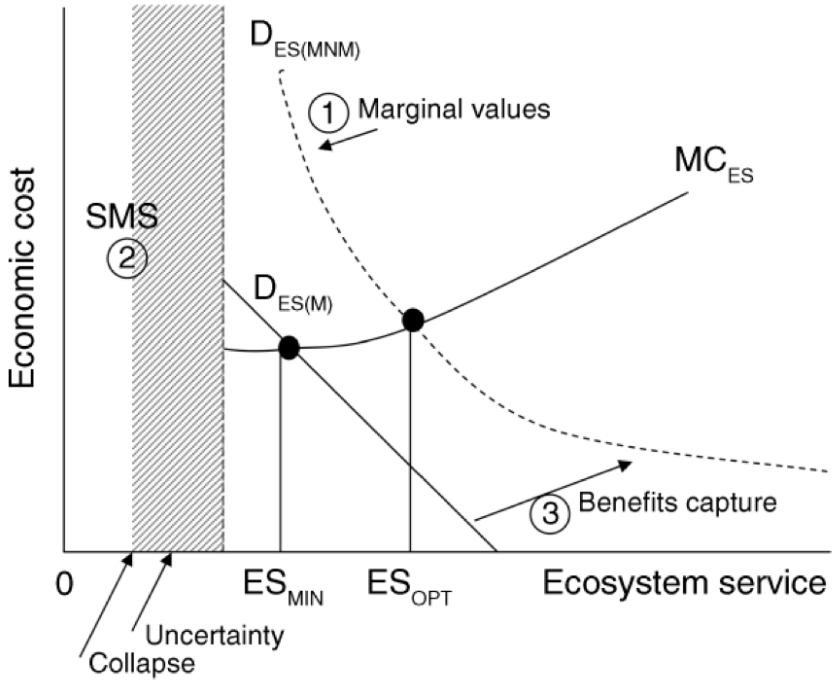

Figure 17: A depiction insights for policy from an economic framework for ecosystem service provision.[101]

Circled numbers refer to the following insights. (1) Ecosystem services should be studied as marginal changes in landscapes or seascapes. Researchers should ask questions such as 'Does the conversion of one more

hectare of forest to agriculture represent a beneficial trade-off?' This should lead to further questions of 'Who benefits/loses?' and 'Where is the benefit realized?' (2) At some level of degradation most systems will collapse. Knowing where this point is (safe minimum standard [SMS], i.e., some minimum level of structure or process) is crucial for point 1 (appropriate evaluation) and point 3 (policy integration). (3) Because most ecosystem services are public goods, the market will not provide an optimal level but only DES(M), the demand curve (for marketed ecosystem service benefits). For optimal ecosystem service provision we need mechanisms to provide for nonmarket services, moving to DES(MNM), the demand curve for all ecosystem service benefits, both marketed and non-marketed. The supply curve, MCES, represents the marginal cost of acquiring and managing additional units of ecosystems; ESMIN is the point where only marketed services of a landscape are provided (demanded); ESOPT is the optimal level of forest diversity and cover to supply other services.

The reason that these issues are a problem for policy makers is that many stakeholders will be asking questions about major environmental and social changes. For example, in relation to the proposed changes to water diversions in the Murray Darling Basin, many stakeholders are asking questions like: 'What are the likely ecological, social and economic changes over the next 50-100 years as a result of different diversion options?' The answer to this question depends not just on the likely ecological changes as a result of changed water flows, but also on how people respond in terms of land management, and social and business processes. Economic valuations can contribute to dialogue around this question, but it requires a much broader range of inputs and consideration of multiple possible futures.

Fisher and colleagues[101] reviewed 34 studies that focused on ecosystem services with either an explicit or potential policy interaction. Few of these studies investigated how ecosystem services and/or their value changed with time or in relation to alternative policy or management scenarios (most focused on current value, for example). Fisher and colleagues suggested that there needs to be much greater focus on alternative future scenarios of policy and decision-making options in research on the economics of ecosystem services (notably, this recommendation was taken up in the recent UK National Ecosystem Assessment[228]). Another limitation of most studies was that it has not been possible to consider the minimum requirements for ongoing service delivery, especially the minimum numbers and types of species required and the possibility of non-linear change, such as sudden changes in ecosystem function once a critical threshold in species composition and/or resource levels is reached. These needs have been recognized in other major international studies, including the Millennium Ecosystem Assessment [47] and The Economics of Ecosystems and Biodiversity [210] (also see Figure 6).

Many of the studies reviewed highlighted the importance of establishing mechanisms, such as taxes, levies, payments for ecosystem services and cap and trade mechanisms as ways to allow markets to find ways to share ecosystem benefits among potential beneficiaries efficiently.[101] A major study of the potential for payments for ecosystem services in China concluded that:

> While the valuation of ecosystem services is an important ongoing part of developing ecosystem service markets, PES, and eco-compensation programs, policy makers focus less on calculating these values, and more on designing the mechanisms necessary to allow stakeholder negotiations to effectively arrive at eco-compensation subsidy rates.[248]

Payments for ecosystem services (PES) is a concept that emerged in the mid-2000s. It can be defined as: 'a voluntary transaction whereby a well-defined ecosystem service, or a land-use likely to secure that service, is being "bought" by at least one buyer from at least one provider – if, and only if, the provider secures the provision of the service'.[230, 247] An International Payments for Ecosystem Services Programme (IPES) was established in 2006 jointly by The World Conservation Union (IUCN) and the United Nations Environment Programme (UNEP), in close collaboration with the Secretariat of the Convention on Biological Diversity (CBD).[230] Australia had involvement in that programme via CSIRO. This initiative appears to have stimulated a number of smaller projects around the world, especially in developing countries.

A related debate is that about 'bundling' or 'stacking' ecosystem service payments.[33, 87] This debate has been active in Australia since the early 2000s, when there was growing interest in promoting farm forestry as a way to reverse salinity and it became clear that profits from growing and harvesting trees would not yield a sufficient return in many parts of Australia to be competitive with other land uses.[33] Stewardship programs in Australia, which pay land owners to manage for protection and improvement of biodiversity, allow those land owners to also receive payments for other ecosystem services, such as carbon sequestration.[14, 15] There is currently an active debate in the USA about the merits of 'stacked' payments for multiple ecosystem services from the same piece of land.[87] On the one hand, it is argued that multiple payments provide greater incentives for landowners to manage for balanced ecosystem services outcomes and they might allow different types of projects to be undertaken than those possible when only single payments are allowed. On the other hand there is concern that multiple payments that only target a small proportion of services have just as much potential to distort land management as payments for single services and that the processes for defining and measuring services separately from one another might be too complicated for most potential participants in the markets to cope with.

9 Activities currently underway in Australia and overseas that seek to incorporate ecosystem services approaches into the management of natural resources

Key conclusions from this Chapter:

- There has been a core set of major international studies that have developed the ecosystem services concept globally, which has included the Millennium Ecosystem Assessment, The Economics of Ecosystems and Biodiversity (TEEB) programme and the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) programme
- The core tool for the WAVES program is the System of Environmental-Economic Accounting (SEEA), which Australia has played a role in developing
- The SEEA framework has been adopted by the Australian Bureau of Statistics' for the development of national environmental-economic accounts,[6; 235] and relates to a National Plan for Environmental Information.[15]
- The focus of research activity in Europe and the USA over the past decade has moved from studies on the economic worth of individual ecosystem services to large scale studies of multiple services
- There has also been a lot of activity to refine typologies and frameworks for ecosystem services to align them better with economic and ecological theory
- In Australia there has been series of world-leading projects demonstrating the importance of ecosystem services to various agricultural industries and to human settlements, and ecosystem services analysis is currently being applied to assessing implications of sustainable diversion limits in the Murray Darling Basin
- Ecosystem services have become core business for some agencies in Europe and the USA
- Ecosystem services are significant components of conservation and land management policies and strategies at the national scale in Australia and in most states and territories.

Globally, and in Australia, there has been an exponential growth in publication about ecosystem services overt he past decade (Figure 18). Appendices IV and V summarise some of the major international and Australian activity on ecosystem services over the past decade. Most of the key lessons from this activity — especially with respect to conceptual frameworks, typologies and approaches to assessing multiple ecosystem services and benefits — have been captured in other sections of this report. Our summary here is very brief, therefore.

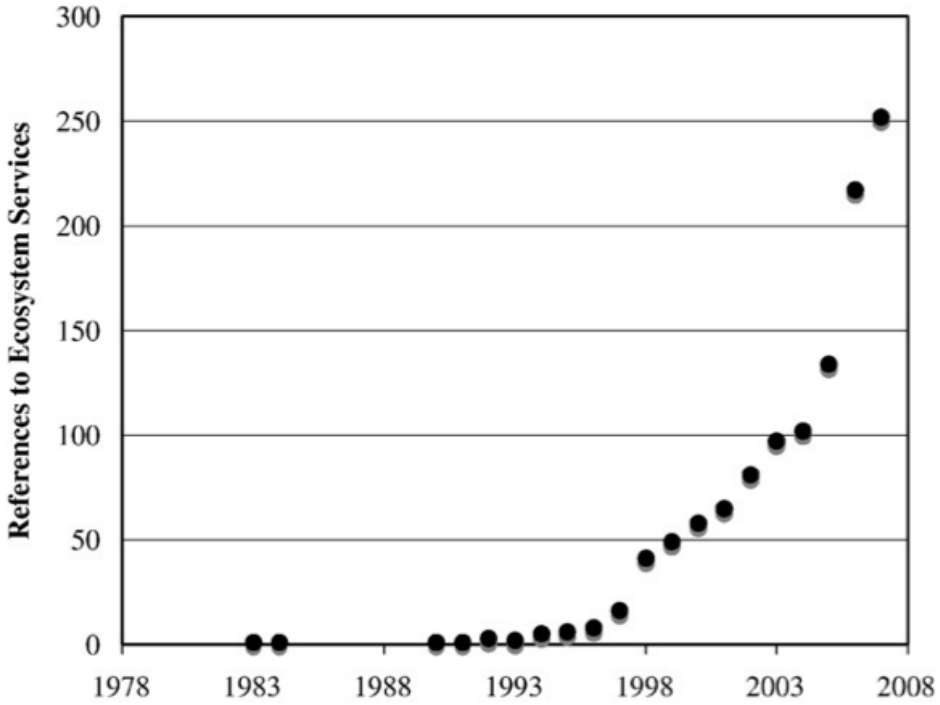

Figure 18: Number of papers using the term 'ecosystem services' or 'ecological services' in an ISI Web of Science search through 2007.[102]

'Environmental services' as a search term, was left out as it returned publications related to hospital environments. Therefore, the graph is indicative but clearly an underestimate.

There has been a core set of major international studies that have developed the ecosystem services concept globally, which has included the Millennium Ecosystem Assessment (MA), The Economics of Ecosystems and Biodiversity (TEEB) programme and the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) programme. These have been supported by the United Nations, the World Bank and a range of private and public partners, including the Australian Government. They have interacted and overlapped with a range of other programmes running at regional, national and global scales. The Millennium Ecosystem Assessment built on the foundational work by Robert Costanza, Gretchen Daily and their research groups in the late 1990s and developed a framework that more explicitly related ecosystem services with elements of human well being and options for intervention by decision makers. TEEB refined frameworks and approaches for economic valuation of ecosystem services. WAVES aims to develop and implement internationally accepted and standardized approaches to natural capital accounting, focusing on ecosystem services, at the national or sub-national levels. Development will occur initially in six to ten developing and developed countries to demonstrate its feasibility, and then the approaches will be promoted more widely. The core tool for this program is the System of Environmental-Economic Accounting (SEEA), which Australia has played a role in developing. The SEEA framework has been adopted by the Australian Bureau of Statistics' for the development of national environmental-economic accounts,[6] and relates to a National Plan for Environmental Information being developed as a whole of government initiative implemented jointly by the Department of Sustainability, Environment, Water, Population and Communities and the Bureau of Meteorology.[15]

Interlinked with this core pathway of development, has been a very large amount of research activity in relation to ecosystem services in the past decade, especially in Europe and the USA. There has been a movement from many studies on the economic worth of individual ecosystem services to a few large-scale studies of multiple services. Three reasons suggested for the primary focus on studies of single or a few services are: (1) the science is often clearer and analysis more straightforward when dealing with a small number of services; (2) in the case of policy development, government departments usually have a focus that includes authority to address only some ecosystem services and so they are more interested in supporting projects that are narrow rather than broad; and (3) businesses also are more likely to support and use research focussed on those services that either provide benefits to them or are affected by their operations.[204]

There has been a lot of activity to refine typologies and frameworks for ecosystem services to align them better with economic and ecological theory. Thinking about how to assess economic and other aspects of the value of ecosystem services has advanced considerably, to the point where most obstacles to collaboration between ecologists and economists have been overcome.

Although Australia took an early lead in attempting large-scale studies of ecosystem services, support for such projects has waned in the past decade. CSIRO and university researchers have conducted a number of high quality small-scale studies that have demonstrated the importance of certain ecosystems services and/or groups of organisms to particular agricultural industries and/or Australian society generally.[1, 28, 29, 34-37, 46, 55, 56, 65, 71, 129, 133, 139, 189, 190, 192, 193, 207, 238, 244] This year a project has been commissioned to apply the sorts of approaches used in large scale studies in Europe and the USA to assess the potential ecosystem benefits of a sustainable diversion limit scenario for the Murray Darling Basin and compare the benefits with those expected from a business as usual scenario. CSIRO and Charles Sturt University are the lead researchers (Tony Webster, MDBA, personal communication 2011). This project is, however, being run on a very limited timeframe and so can hope to make only modest progress.

Ecosystem services have become core business for some agencies in Europe and the USA (Appendix IV) and they are significant components of conservation and land management policies and strategies at the national scale in Australia and in most states and territories (Appendix V).

10 An example framework for the ecosystem services associated with Australian rural lands

Key conclusions from this chapter:

- A framework for ecosystem services associated with rural lands should have the following characteristics:
  - A clear definition that is relevant to, and can be understood by, all stakeholders and is sufficiently broad to allow adaptation by different stakeholders to different situations but provides sufficient principles to avoid misinterpretation or miscommunication
  - A typology that, as far as is possible, aligns ecosystem services and the ecological processes that underpin them with theory and practice in ecology and economics
  - Acknowledges policy imperatives of government land management agencies as well as imperatives of businesses and communities living and working in and rural and regional Australia
- Existing typologies for ecosystem services need no modification for application to Australia's rural lands (i.e., lands outside major urban centres), as rural lands represent over 99% of the area of Australia and therefore potentially deliver the full range of ecosystem services identified in existing typologies
- Rural land other than those in protected tenures represent over 60% of Australia's land area and are managed for purposes such as agriculture, forestry, fisheries and mining
- Managers of rural lands play a role in the delivery of benefits from ecosystem services in two ways: (1) they provide input of human and other capital to turn some ecosystem services into benefits (e.g., ecosystems provide the conditions for growing food and inputs from farmers allow food to be produced); and (2) they influence ecosystem processes (e.g., the role of native vegetation in soil retention or the role of soil organisms in maintaining soil fertility), which produce ecosystem services
- Strategies for achieving sustainable farm practices under Caring for Our Country already focus implicitly on improving delivery of ecosystem services
- Data being collected on land management practices under Caring for Our Country can be used to draw inferences about impacts of improved land management on ecosystem processes, ecosystem services and benefits to Australians, and steps are already being taken to establish these links.

Drawing on previous chapters of this report, a framework for ecosystem services associated with rural lands should have the following characteristics:

- A clear definition that is relevant to, and can be understood by, all stakeholders and is sufficiently broad to allow adaptation by different stakeholders to different situations but provides sufficient principles to avoid misinterpretation or miscommunication
- A typology that, as far as is possible, aligns ecosystem services and the ecological processes that underpin them with theory and practice in ecology and economics

- Acknowledges policy imperatives of government land management agencies as well as imperatives of businesses and communities living and working in and rural and regional Australia

Below, we consider how existing typologies of ecosystem services can be adapted and aligned with current and future policy and management initiatives for improving the delivery of benefits to Australians from rural lands.

10.1 What are rural lands?

Rural lands are all lands outside major urban settlements. By the Organisation for Economic Co-operation and Development (OECD) definition (Figure 19), around 85% of Australia's area is predominantly rural and most of the rest is rural with large urban centres embedded in it.

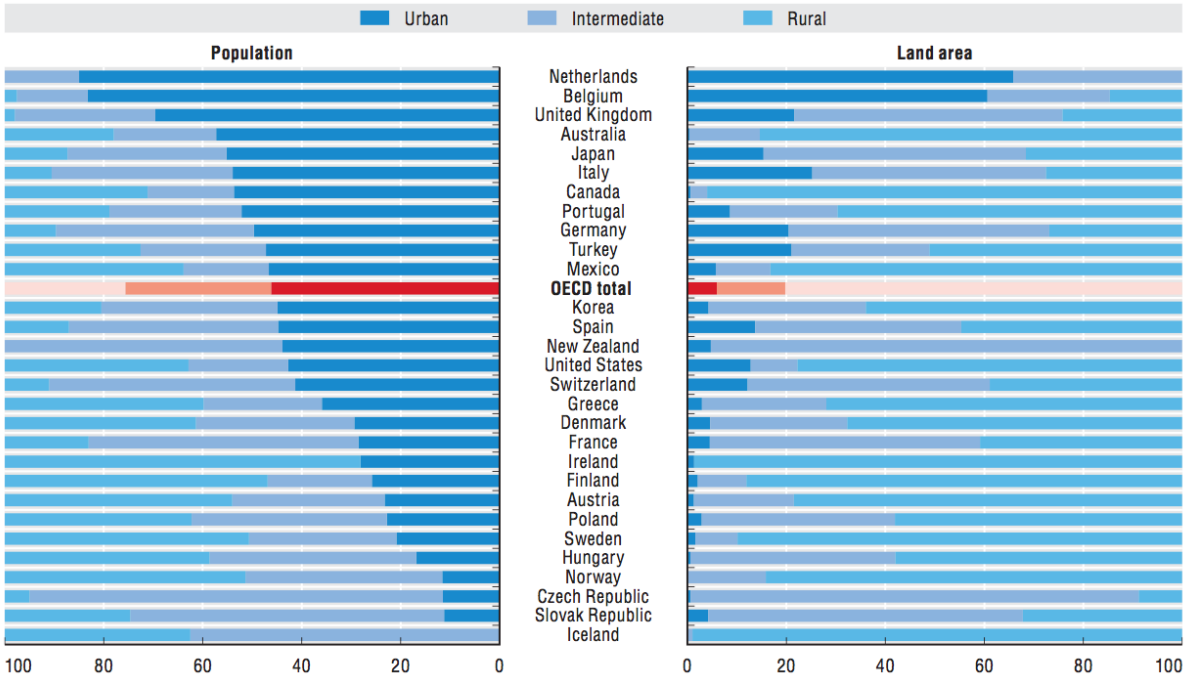

Figure 19: Distribution of population and area across predominantly urban, intermediate and predominantly rural regions in the OECD in 2005.[171]

Regions are classified as 'Rural' if more than 50% of its population lives in rural local units (less than 150 inhabitants per square kilometre), except where there is an urban centre larger than 200,000 inhabitants that contains more than 25% of the regional population (in which case the region is classified as 'Intermediate').

Less than 0.2% of Australia's land area is taken up by built environments and around 37% is protected or used only minimally.[45] This means that a large proportion of the ecosystem services that provide benefits to Australia's human population come from over 60% of Australia's land area that is managed for purposes such as grazing of natural vegetation, grazing of modified pastures, production forestry, plantation forestry, dryland cropping, dryland horticulture, irrigated pastures and cropping, irrigated horticulture, and mining. [45]

10.2 Applying ecosystem services typologies to rural lands

The typologies for ecosystem services reviewed in Section 5.2 require little modification to be applied to rural lands in total (i.e., including protected tenures) as these typologies have been developed for most of the types of ecosystems occurring in rural lands, both in Australia and globally. Lands outside protected tenures, including land managed for agriculture, forestry and fisheries, also provide ecosystem services (Table 11). Considerable attention is being given to identifying and paying for ecosystem services from various land tenures, but particularly forests, in China.[246]

Table 11: An example of a typology of ecosystem services provided by agricultural lands.[136]

Benefit	*Ecosystem services*
Harvests	
Managed commercial	Pollinator populations, soil quality, shade and shelter, water availability
Subsistence	Target fish, animal, and plant populations
Pharmaceutical	Biodiversity
Amenities and fulfillment	
Aesthetic	Natural land cover in viewsheds; rural landscapes
Bequest, stewardship, spiritual, emotional	Wilderness, biodiversity, varied natural land cover and rural agri-landscapes
Existence	Relevant species populations; relevant rural agri-landscapes
Damage avoidance	
Health	Air quality, drinking water quality, land uses or species populations hostile to disease transmission
Property	Wetlands, forests, natural land cover
Waste assimilation	
Avoided disposal cost	Surface and groundwater, open land
Drinking water provision	
Avoided treatment cost	Aquifer, surface water quality
Avoided pumping/ transport cost	Aquifer availability
Recreation	
Birding/wildlife watching	Relevant species populations
Hiking, biking, pleasure driving	Natural land cover, rural agri- landscapes, vistas, surface waters
Angling	Surface waters, target species populations, natural land cover
Hunting	Natural land cover, target species populations
Swimming	Surface waters, river banks, lake shores

10.3 Relating ecosystem services to land management practices

The literature contains many analyses of changes in ecosystem services over the past century and attributes many of these changes to the expansion of agriculture and associated land management practices.[144] Agriculture generally increases provisioning ecosystem services at the

expense of regulating and cultural ecosystem services that are often higher in less human-dominated ecosystems.[110] Increasingly, there are analyses of how these declines can be addressed through management of soils, water, vegetation and other landscape components at landscape scales using an understanding of the relationships between ecosystem processes `and how they relate to the maintenance of functional ecosystems and benefits to humans.[30, 108, 110] Examples are given later in this sub-section.

To allow the impacts of rural land management on ecosystem services to be considered in developing policies and programmes, suites of indicators are required that are pertinent at different spatial resolutions.[184] [76] Figure 20 illustrates the different types of indicators required to assess ecosystem service implications of international and national policies and programs, such as Caring for Our Country or programs for addressing Australia's obligations under international conventions such as RAMSAR, compared with individual programmes, such as component programmes of Caring for Our Country or the Murray Darling Basin Plan, and interventions at farm-scale or finer.

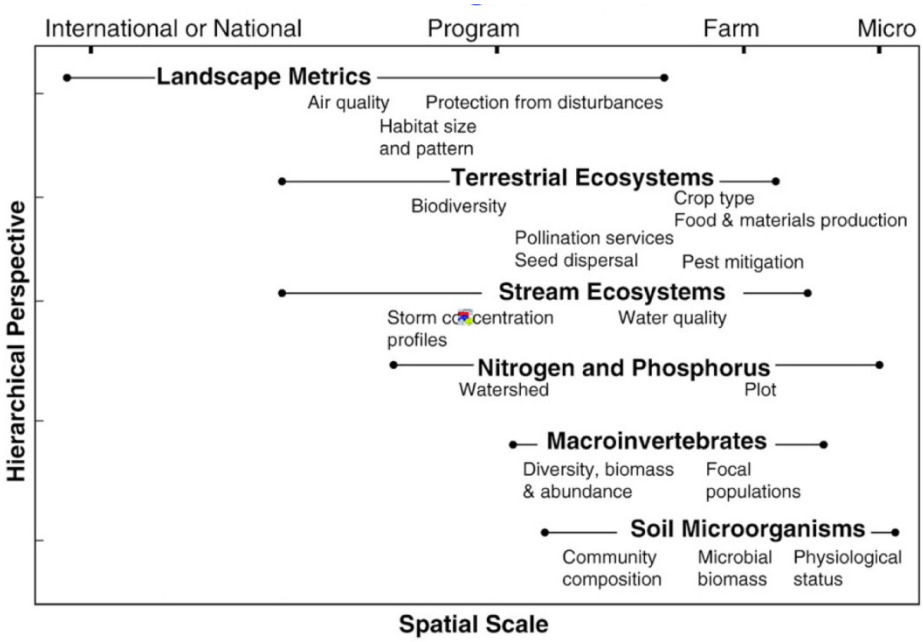

Figure 20: Spatial scales of metrics that relate to ecosystem services from rural land management.[76]

The term 'program' in the top axis refers to the scale of individual land management programmes, such as soil conservation programmes or market-based incentives for habitat protection.

By focusing on the effects of land management practices on ecological processes, land management regimes can be understood in terms of how they affect ecosystem services and, therefore, how they affect private and public benefits to a range of beneficiaries (Figure 21).

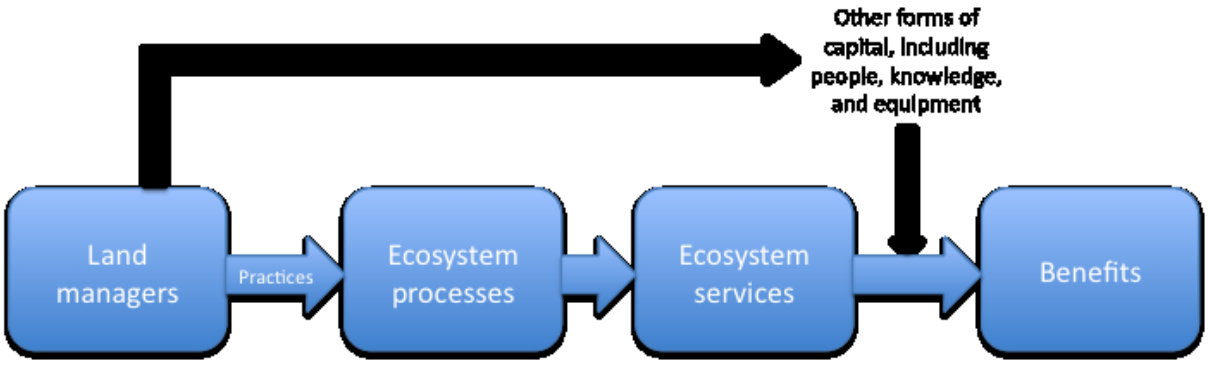

Figure 21: Conceptual relationship between land management practices, ecosystem services and benefits from ecosystems to people.

Land managers influence benefits from ecosystems to people in two ways: (1) they provide input of human and other capital to turn some ecosystem services into benefits (e.g., ecosystems provide the conditions for growing food and inputs from farmers allow food to be produced); and (2) they influence ecosystem processes (e.g., the role of native vegetation in soil retention or the role of soil organisms in maintaining soil fertility), which produce ecosystem services. Note that some commentators would argue that services provided *because* of intervention by land managers (e.g., services created by planting exotic vegetation) are not truly *ecosystem* services but this does not change the fact that benefits are provided nevertheless.

Table 12 and Table 13 show an example of this approach being applied to considering the ecosystem services and benefits related to soil and soil management in Australia.[30] This example illustrates how an ecosystem services approach separates the processes that provide intermediate or supporting services from those that directly provide a benefit to people. Such an analysis then provides a basis for dialogue about when, how and why steps should be taken to improve soil management and who might benefit. This particular example was developed because of concern that debate about the values of soil and the benefits of better management were being under-recognised in decision-making because of a focus on soil health. The authors argued that soil health was not clearly related to ecosystem function or the benefits to people and so there was little incentive for action to address declines in soil health.

Table 12: Soil-based ecosystem services appropriate to Australia illustrating the distinction between intermediate (supporting) services and final services (which lead directly to benefits) (from Bennett *et al.* 2010).[30]

Codes in the first column link final services to public benefits in the following table. Intermediate service abbreviations: 'SSM' soil structure maintenance; 'OC' organic matter cycling; 'NC' nutrient cycling; 'IE' ion retention and exchange; 'WC' water cycling; 'GC' gas cycling; 'BC' soil biological life cycles.

Code	*Final services (lead to benefits)*	*Description*	*Intermediate services (support final services)*
S1	Provision of marketable goods	Provision of, e.g. food, fibre, timber	SSM, OC, NC, IE, WC, GC, BC
S2	Soil structure stabilization	Retention of soil (prevention of loss by wind and water)	SSM, OC, BC
S3	Gas regulation	Consumption/emission of atmospheric gases	SSM, OC, NC, IE, GC,

Code	Final services (lead to benefits)	Description	Intermediate services (support final services)
			BC
S4	Carbon sequestration	Net carbon stored in soil	SSM, OC, NC, GC, BC
S5	Water quality regulation	Water filtration/purification	SSM, OC, NC, IE, WC, BC
S6	Water yield	Water storage and availability	SSM, OC, WC
S7	Water flow regulation	Mitigation of, e.g. runoff, flooding	SSM, WC
S8	Weather regulation	Ameliorate daily extremes in air temperature and moisture	OC, WC
S9	Remediation of wastes and pollutants	Breakdown, immobilization, or detoxification of excess or harmful organic and inorganic materials	OC, NC, IE, BC
S10	Disease and pest regulation	Control of potential pests and pathogens	BC
S11	Habitat provision/genetic resource maintenance	Habitat for and maintenance of soil biodiversity (genes, species, phyla, functional groups)	SSM, OC, NC, WC, GC

Table 13: Public benefits potentially impacted by changes in soil management (from Bennett *et al.* 2010).[30] Codes for services relate to Table 12.

Public benefit	Description	Service
Rural economic activity	Decreased vulnerability of rural societies	S1
Future choices	Sustained soil capital to accommodate future land uses or expectations	S2, S9, S10, S11
Clean air	Healthy air quality (e.g. low dust load, low pollutants)	S2, S3, S9
Favorable climate	Climate change mitigation, and local climate amelioration	S3, S4, S8
Water quality	Water quality meets or exceeds standards for required uses	S2, S5, S9, S10
Water volume	Sufficient quantity of water available for required uses	S6, S7
Protection of physical assets	Protection of buildings, machinery, etc. against, e.g. excess windborne soil, landslide, flood damage	S2, S5, S7
Novel products	Discovery/development of new public good products for, e.g. pharmaceuticals, material development	S11
Pollution control	Containment of wastes, pollutants, toxins	S9
Disease and pest control	Containment of soil-based diseases and pests	S10
Reduced pesticide use	Reduced exposure to potentially harmful chemicals	S10, S11
Soil inoculation potential	Increased potential for inoculation by useful biota (e.g. root symbionts in revegetation)	S11
Ecosystem resilience	'Insurance' (and associated avoided cost) for disturbance recovery in the form of, e.g. stored water, functional diversity of biota	S2, S4, S6, S11
Aesthetics	Expectations of soil-based aesthetics, sense of place, cultural heritage	S2

The authors of the research reported in Table 12 and Table 13 also identified 'ecosystem disservices', such as salinisation, acidification, wind erosion and organic matter decline. Others

in the literature have also referred to disservices, but we suggest it is better to consider these as the results of declines in services. For example, salinisation is the result of reductions in deep-rooted plants in a landscape and therefore a reduction in the service of watertable regulation. We suggest that it is inconsistent with the concept of ecosystem services to argue that ecosystems are causing salinisation or the other disservices listed above. Water and wind erosion are, indeed, caused by non-living elements of the environment but they have their effect because of reductions in the living components (plants).

This research illustrates another important aspect of ecosystem services approaches that has been mentioned several times elsewhere in this report — assessing the likely relative consequences of alternative decisions in terms of human wellbeing often can be done from expert judgement based on existing ecological knowledge sometimes does not require economic valuation or even a monetary analysis at all. Table 14 shows the qualitative assessment done by Bennett *et al.*[30] based on their judgement about the impacts of management on the services and benefits identified in Table 12 and Table 13. This is an example of how strategic exploration of decisions with an environmental component could be carried out at a range of scales. In some cases more research and/or analysis might be needed to support strategic decisions but often the qualitative assessment will reveal the best option or at least the major risks and uncertainties.

Table 14: Estimated change in public and private net benefits produced by a change in soil management of light-textured Calcarosols in the Murray Mallee Bioregion from conventional tillage to either conservation tillage or restored native vegetation (from Bennett *et al.* 2010).[30]

Assessments were qualitative (expert judgement). Anticipated change of '+3' indicates considerable increase in net benefit, '0' indicates no change, and '–3' indicates considerable decrease in net benefit relative to conventional tillage. 'ND' indicates not determined due to insufficient information.

Net benefit type	*Anticipated change (-3 to +3)*	
	Conservation tillage	*Restored*
Public		
Rural economic activity	0	-2
Future choices	+1	+2
Clean air	+2	+3
Favorable climate	0	ND
Water quality	-1	+1
Water volume	+1	-1
Protection of physical assets	0	+2
Novel products	ND	ND
Pollution control	ND	ND
Disease and pest control	ND	ND
Reduced pesticide use	ND	ND
Soil inoculation potential	ND	ND
Ecosystem resilience	+1	+1
Aesthetics	+1	+1
Balance	+5	+6
Private		
Short-term profit	0	-2

Net benefit type	*Anticipated change (-3 to +3)*	
	Conservation tillage	*Restored*
Financial certainty	0	-1
Ease of implementation	0	-1
Future choices	+1	+1
Clean air	+2	+3
Protection of physical assets	+2	+3
Reduced pesticide use	ND	ND
Aesthetics	+1	+1
Balance	+6	+4

More refined estimates of overall net benefit can be obtained by weighting individual net benefits in terms of such factors as their likelihood, degree, consequence, scale, direction, and time lag.[30]

Other approaches to classifying soil ecosystem services have been proposed (Appendix VI). These differ in detail from that of Bennett *et al.*[30] (e.g., there are differences in how ecosystem function, processes, services and benefits are distinguished and distinctions between intermediate and final services differ slightly) but the broad philosophy is similar across approaches. Rather than endorse one or the other, we recommend that anyone wanting to apply a typology consider their objectives and then match those to the reasons for which different typologies have been developed.

A beginning towards applying this sort of approach in national environmental policy is being made through the Sustainable Farm Practice strategies and targets in Caring for Our Country (Table 15).

Table 15: Five-year outcomes and strategies for Sustainable Farm Practices under Caring for Our Country.[12]

Five-year Outcomes: By 2013, Caring for our Country will:	*Strategies To Achieve The Five-Year Outcomes:*
Assist at least 30 per cent of farmers to increase their uptake of sustainable farm and land management practices that deliver improved ecosystem services	Improve the environmental outcomes from farm management while maintaining or improving productivity: • Support on-farm actions and investments that improve natural assets (including soil, water and biodiversity) and reduce the impact of invasive species • Support the use of flexible, innovative and cost-effective approaches, including market-based incentives, to deliver sustainable on-farm natural resources management and improve our natural assets

Increase the number of farmers who adopt stewardship, covenanting, property management plans or other arrangements to improve the environment both on-farm and off-farm	Provide information to allow farmers to make better decisions in a changing climate:
	• Support the uptake of sustainable farming techniques and technology by providing information and advice on:
	  • new technologies, sustainable farm practices, and ecosystems services
	  • the management of emerging threats to sustainable food and fibre production, including weeds, salinisation and pest animals.

Improve the knowledge, skills and engagement of at least 30 per cent of land managers and farmers in managing our natural resources and the environment	Work with community and industry organisations, including landcare, to accelerate the adoption of more sustainable farm management • Support the work of voluntary groups, including landcare groups, to build the skills and capacity of land managers and farmers to deal with emerging threats and opportunities relating to sustainable production and land management. • Encourage effective partnerships between key stakeholders, including industry, regional, community and landcare groups, research and teaching organisations and governments which will drive on-ground practice change.

To assess progress towards these outcomes, Caring for Our Country commissioned the Australian Bureau of Statistics (ABS) to establish the Agricultural Resource Management Survey to report every two years on land management practices being used by Australian farmers.[16] This survey reports on the extent of different categories of rural land and the types of land (including soil) and biodiversity management being applied to those lands.[16]

From these types of data, it should be possible to adopt the approach illustrated in Figure 21. Table 16 is an example of how this can be done (it refers to soils but the approach could be applied to all aspects of land management in rural lands).

Table 16: Example of mapping land management practices to ecological processes.

This table draws on the results of the 2008-08 ARMS relating to practices expected to improve soil condition (Michele Barson, personal communication, August 2011). From this information inferences can be made

about how management practices might affect delivery of ecosystem services and benefits to humans as described in Figure 21.

Practice	*Type of agriculture*	*Increases Carbon content*	*Reduces risk of wind erosion*	*Reduces risk of water erosion*	*Reduces risk of soil acid-ification (low pH)*
No cultivation/ tillage apart from sowing	Broadacre cropping	Indirectly	Y	Y	
Crop residue left intact	Broadacre cropping	Y	Y	Y	
Reduce fallow	Broadacre cropping	Y	Y	Y	
Soil pH testing	Broadacre cropping Horticulture Dairying Grazing (beef cattle/ sheep meat)^	Indirectly	Indirectly	Indirectly	Y
Soil nutrient testing	Broadacre cropping Horticulture Dairying Grazing (beef cattle/ sheep meat)^				Y
Lime or dolomite applied to reduce soil acidity	Broadacre cropping Horticulture Dairying Grazing (beef cattle/ sheep meat)^	Indirectly	Indirectly	Indirectly	Y
Monitoring of ground cover	Grazing (beef cattle/ sheep meat)	Y	Y	Y	
Use of ground cover management targets*	Grazing (beef cattle/ sheep meat)	Y	Y	Y	
Pasture phase in crop rotations	Broadacre cropping	Y	Indirectly	Indirectly	
Increasing perennial pastures	Grazing (beef cattle/ sheep meat) Dairying	Y	Y	Y	

* Ground cover management target is the desired percentage of the soil surface covered by living or dead vegetation.

^For grazing (beef cattle/ sheep meat) businesses in natural resource management regions outside the rangelands.

10.4 Helping rural land managers to find innovative ways to manage ecosystem services

Peter Ampt (Australia21 and Sydney University) has provided some commentary on the Communities in Landscapes Project,[5, 6, 58] a partnership that is funded by Caring for Our Country

under the Landcare component. This project aims to work with communities to improve the extent and quality of Box Gum Grassy Woodlands across their range through strategies that integrate conservation and production. The project focuses on the Murrumbidgee, Lachlan and Central West Catchments and demonstrates how a collaborative approach among stakeholders is helping rural land managers find novel solutions to managing ecosystem services ( ).

Box 6: The Communities in Landscape Project.[57]

There is an emerging community of practice around grazing management that attempts to regenerate perennial native grasslands while maintaining profitability. Participants enunciate values that are strongly consistent with an ecosystem services approach. Broadly they are aiming to 'get nature to do more of the work' by managing to increase perennial native grass and litter cover which they claim leads to improved 'soil health' with little or no applied fertilizers or herbicides.

They focus on maintaining 100% groundcover and increased litter and report improved soil structure, reduced runoff and erosion, more soil moisture, increased soil organic matter and higher fertility. They are using rotational, time control or cell grazing strategies which involve consolidating their livestock into large mobs, grazing small areas for short periods of time (2-7 days) then allowing for long periods for rest and recovery (120-180 days). They regularly adjust their rotation and stocking rate, based primarily on the amount of plant material and litter. Some have opted for ultimate flexibility by trading in livestock, while others maintain studs and have periods of the year when the grazing rotation schedule is modified to accommodate animal husbandry needs, such as lambing.

Any crops (for fodder and or for grain) are direct drilled into the emerging grassland with or without the use of herbicides to suppress pasture growth for establishment. Practitioners report that this is an ideal strategy for transition between previous cropping paddocks and the system based on maintaining permanent perennial soil cover.

A key feature of this community of practice is that it is adaptive. People are generally not following a strict protocol, but have a range of strategies for monitoring the impact of their management. For example, most are looking ahead to assess the amount of plant growth and litter in the paddocks ahead of the stock, as well as observing the recovery of the recently grazed paddocks. Many keep track of the species present and can track the return of desirable native grasses back into their paddocks. They use the information generated to adjust their stocking rate, intensity, duration and time of grazing and length of rest and recovery.

The 'Communities in Landscapes' project has focused on these practices and conducted a benchmark study to describe them and to determine the extent to which 10 innovators are succeeding in integrating conservation with production.[6] The results show that these practices have resulted in an increase in the basal cover of perennial native grasses and litter, which has significantly improved soil stability, water infiltration and nutrient cycling as measured by Landscape Function Analysis (LFA). Soil fertility is higher (increased P, N, C and pH and decreased soil bulk density), and soil microbiological communities are more abundant, active and diverse. From this we were able to conclude that these strategies are resulting in a transition towards a more highly functioning native grassland that provides a larger range and quantity of ecosystem services than the system that it replaces. Services enhanced include nutrient cycling, soil formation, plant production leading to food and fibre production, climate regulation through increase soil C, flood mitigation and water purification through increased water infiltration, and greater levels of motivation and optimism through the recognition that management is leading to regeneration and greater degree of personal control and reduction of risk.

In terms of supportive policy, some CMAs have provided incentives for training and for 'water and wire' to support implementation of improved grazing management. However state government agencies are yet to advocate these practices due to lack of published peer-reviewed papers that support it. The adaptive nature of

this management is a challenge to traditional agronomic research practices. Instead it lends itself to ecological research methods. Practitioners also have multiple objectives in mind and are actively involved in negotiating the trade-offs between services. Rather than focus solely on optimizing production, they are taking a more holistic approach that aims for clear expression of their values and aims and regular monitoring of the happiness of family members. Rather than feeling 'caught on a treadmill', they are taking a longer term view that minimizes their exposure to climatic and economic risk. This often means reducing expenditure on expensive purchased inputs in favour of strategies that cost less. This may mean less production but often means higher profit with greater peace-of-mind and a greater sense of control over their destiny. Interwoven with this is confidence that their practices are leading to a regenerating landscape. As more evidence is collected on these practices it would be ideal if policies would support this innovation, especially in enhancing the monitoring already being done and scaling it up from farm to district or region. This should ideally be in the form of ongoing documentation of the enhanced ecosystem services resulting from the regenerating grasslands.

Another initiative of the Communities in Landscapes project was to support the development of cross property collaboration in environmental management. This involved support in the form of farm visits, mapping, meetings, courses and field days with $75k grant to groups of landholders who develop individual property biodiversity plans that contribute to a cross property plan. At the time of writing 6 groups of about 10 members each were in various stages of plan development through to funding and initial implementation. Several groups are keen to document the collective impact of their plans. There are opportunities to gain economies of scale in terms of valuing the benefits of a group's collective approach. For example one group covers more than 80% of a small sub-catchment and their approach to land management appears to be having a beneficial impact on the riparian zone with resulting improvement in the delivery of clean water to a major regional water storage.

The particular relevance of ecosystem services to this cross property approach is that the groups have grasped the importance of scaling up from an individual property to support a broader ecosystem. It supports the use of ES approach to generate understanding and to provide a framework that facilitates collaboration to achieve environmental objectives in production landscapes. There is potential for the development of opportunities for philanthropic and even commercial support of groups that generate public goods such as has been achieved through this project. Critical to the apparent success of the approach was the grant and the active on-ground facilitation. The project funded Community Woodlands Officers and the deployment of a NSW Department of Primary Industries officer to develop property plans that contributed to a cross property plan. This practical support was enhanced by the 'carrot' of the $75k grant, which resourced the initial stages of implementing the landscape scale plan.

A possible policy initiative emerging from this discussion is for DAFF to drive and support the development of an integrated resource condition monitoring process not unlike what is being achieved through Waterwatch using Landscape Function Analysis (LFA). Training of community members in could facilitate widespread community monitoring of soil stability, water infiltration and nutrient cycling – all supporting services. Community data complemented by expert LFA data could build a picture of a transition to greater ES provision, and provide individual landholders with a standard with which they could assess their individual contribution. They key to this is that strategies that improve landscape function will also improve their production potential so should also impact positively on profitability.

11 Issues associated with implementation of an ecosystem services approach in Australia

Key conclusions from this chapter:

- Among people involved in natural resource management policy, the concept of ecosystem services is familiar and generally thought to be useful as a communication device; opinions differ about how easily it can be applied
- Among the broader community it appears that familiarity with the term 'ecosystem services' is patchy but that people are generally familiar with the idea that nature provides benefits (although understanding of the range of these benefits is very limited)
- An ecosystem services approach potentially makes significant contributions to most components of policy and decision cycles, especially in terms of better identification of the nature of social-ecological issues and the range of stakeholders potentially affected, and in strategic consideration of policy options and their implications across different government portfolios
- There was wide agreement among those interviewed that a strategic approach to considering human dependence on ecosystems is needed that:
  - Considers the full range of benefits and costs of environmental management
  - Engages decision makers across government departments, levels of government and governance, and sectors of society
  - Considers factors affecting possible future needs for, and impacts on, benefits from the environment, including population size and distribution, lifestyles and the nature of economic activity.
- Factors considered to be important for application of an ecosystem services include:
  - Clarification, communication and education about the benefits from the environment
  - Refinement of the concept so that barriers between scientific disciplines are removed and the ability to measure relevant aspects of ecosystem service delivery is improved
  - Research & development to improve understanding of how ecosystem services are delivered and anticipation of the effects of interventions on service delivery
  - Collection and sharing of data that supports strategic thinking and planning around ecosystem services and allows monitoring and improvement of ecosystem service management
  - Governance regimes that support recognition of ecosystem services at appropriate scales in space and time and allow innovative and flexible approaches to adjusting flow of benefits between beneficiaries for enhanced human well being
  - Leadership to encourage new thinking and approaches
  - Processes for strategic, holistic environmental-social thinking and planning across interest groups, sectors, government departments, and levels of government and society.
- It appears that most agencies, organisations and groups of people engaged in natural resources policy and management in Australia contribute to these enabling factors, but that

achievement of strategic, holistic environmental-social thinking and planning across interest groups, sectors, government departments, and levels of government and society has so far been elusive.

- We recommend actions to improve the application of an ecosystem services approach in Australia

This Chapter draws heavily on our interviews with a range of people who have been involved in development and implementation of environmental and landuse policy at Australian, state, natural resource management region, or local government levels, research and development on ecosystem services or related topics, public or private investment in the environment, agricultural and other landuse industries, advocacy for landuse industries and/or environmental conservation, and regional community-level governance of environmental, social and economic issues. These interviews are supplemented by our literature review.

This chapter, therefore, contains many opinions. Although readers might question the factual basis and underlying assumptions for these opinions, they represent the interpretations of interviewees who have had involvement in interpreting and applying the concept of ecosystem services. As such, they provide important information about the perceived strengths and weaknesses of an ecosystem services approach and the factors enabling or blocking the application of this concept.

11.1 Attitudes towards the concept of ecosystem services

11.1.1 Data from our interviews

Table 17 summarises the main attitudes towards the concept of ecosystem services emerging from the direct interviews conducted for the project and the additional information drawn from other interview processes.

Table 17: Summary of interview responses.

Question	*Summary of responses*
Understanding about the concept of ecosystem services	Those interviewed were mostly people considered to understand the challenges associated with human dependence on the environment, although we also drew on broader surveys of people not directly involved in natural resource management. It was not surprising, therefore, that most of those directly interviewed had heard of the term 'ecosystem services'. All interviewees understood that ecosystem services are the benefits to people from nature and that these include the full range of use and non-use, market and non-market, tangible and intangible benefits.
Opinions about usefulness of the concept	All interviewees considered that the concept is useful as a high-level strategic thinking tool. Opinions differed in terms of the practicality of the concept. Most interviewees considered that there are significant challenges in measuring ecosystem services and, therefore, in assessing the ecosystem services implications of different decision choices. Several interviewees with extensive experience working with environmental benefits pointed out that it is vitally important to be clear what question is being asked in any situation, rather than assuming that application of an ecosystem services approach is

Question	Summary of responses
	necessarily about economic valuation of the services. One interviewee, which had been involved in a survey of regional bodies and communities told us that many of those people were previously familiar with the idea that ecosystem provide benefits to people but started using the term 'ecosystem services' mostly because that was the term used by state and Australian Governments and they thought using it would improve their connection with government processes.
The degree to which the concept meets particular needs of decision makers at some or all levels of government and/or non-government decision-making in Australia	All interviewees considered that there is a strong need for approaches to considering the full range of social and economic benefits and costs associated with environmental policies and management, and particularly ways to facilitate dialogue and decisions in relation to tradeoffs between competing values and objectives among stakeholders. There was a considerable range of opinions about how well an ecosystem services approach might meet these needs. Some interviewees thought an ecosystem services approach provides a useful framework for strategic conversations at various levels of government, because if makes clear what the benefits of environmental management might be and potentially provides tools for exploring tradeoffs. Others said that such conversations rarely, if ever, happen so there is little opportunity to use an ecosystem services approach across government. Some interviewees thought that it is unrealistic to expect government departments to contemplate the range of issues encompassed by ecosystem services. Some scientists (economists, ecologists and social scientists) felt that ecosystem services provides a useful framework for interdisciplinary conversations, but others thought that many frameworks for ecosystem services inhibit, rather than facilitate, interdisciplinary conversations and research.
Whether there are alternative and/or better ways to address those needs	Most interviewees considered that the concept of ecosystem services brings a different perspective to dialogue about human interactions with nature to the ones promoted by ecology and economics and embodied in concepts like sustainability, ecological footprint, resilience and the like. Not all interviewees were clear about how these concepts interrelate. Some still understood that ecosystem services was being promoted as an alternative to these other concepts but most understood that it is intended to be complementary.
How those needs are currently being met and could be met better	Discussed in the following sub-sections.

One interviewee provided an illustration of how he sees ecosystem services providing the basis for considering resilience and sustainability (Figure 22).

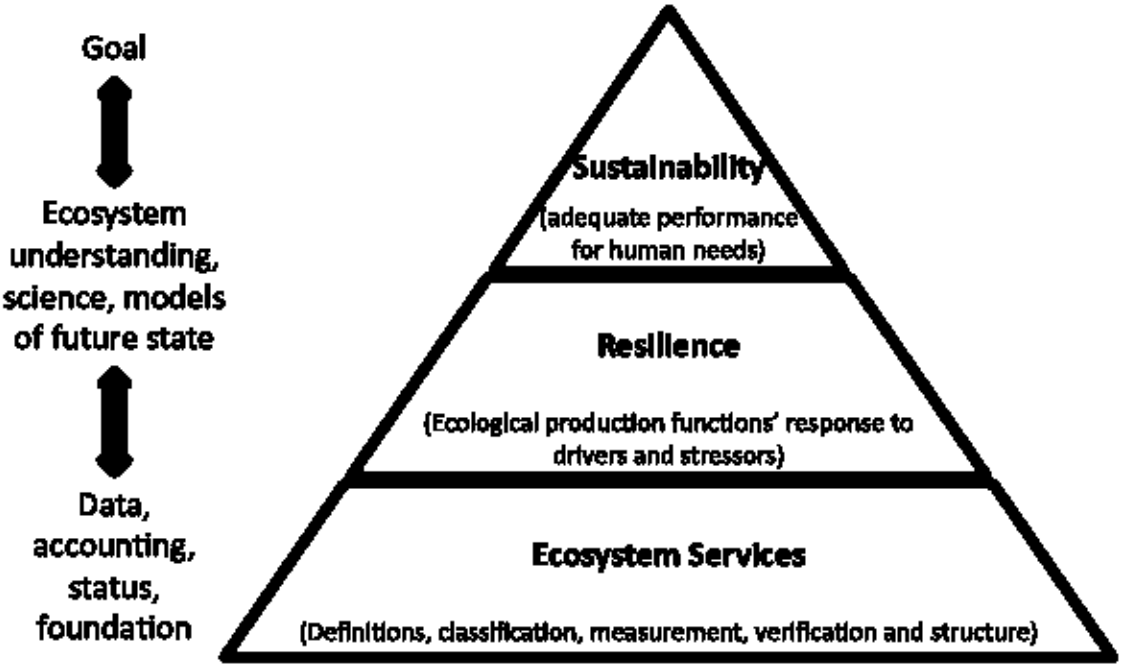

Figure 22: Ecosystem services as a foundation for resilience and sustainability (Dixon Landers, US EPA, personal communication 2011).

The high level of common understanding about ecosystem services among those interviewed for this project contrasts with our own experience working with community members, and the results of several surveys of communities that indicate that many people struggle to be able to fit the concept of ecosystem services within their current ways of thinking about their relationship with the environment.[179] The selection of interviewees in this project was biased towards people who understand the issues surrounding relationships between people and the environment, but even among these people there have been diverse understandings and misunderstanding about ecosystem services over the past decade.[63] It appears that there is now a much higher degree of understanding of the general intend and scope of ecosystem services approaches than there was even 5 years ago.

This is not to say there is no longer misrepresentation of the concept, or at least the suspicion by some interest groups that the concept will be misused by others (we are aware of such suspicion being expressed frequently, publically and privately, in a range of forums).

Most interviewees argued that the concept of ecosystem services is useful for prompting decision makers to consider the full range of benefits from the environment. They thought it is useful and important to identify what those benefits are. In particular there was very strong agreement among stakeholders that current challenges facing Australia and the world require rigorous methods for addressing both the nature of benefits from the environment and who benefits (i.e., the types of questions identified in Section 6.1 as being integral to an ecosystem services approach).

Seven interviewees who have all had first-hand experience with using the concept of ecosystem services to engage in dialogue and planning with community, industry and government stakeholders all said that most stakeholders were at first unfamiliar with the concept but that

they quickly understood is and found it easy to apply it to their particular situation. These interviewees all considered that the concept improved understanding of complex social, economic and environmental issues, and generated productive and focussed dialogue that enable the exploration of decision trade-offs and the seeking of agreed ways forward among participants.

The main areas of difference among interviewees related to: whether there are alternative ways to address the issues that ecosystem services approaches have been developed to address (this was discussed in Chapter 6); the ways in which ecosystem services are defined and characterised (discussed in Chapters 4 and 5); and the challenges that arise in implementing ecosystem services classifications in practical environmental policy and management decisions (discussed in Section 8.1). These differences of viewpoint can be reduced to the key issues highlighted in . As mentioned in and Table 17, and discussed further at the end of this subsection, most of these points of difference can be dealt with if there is careful thought about the aims of employing an ecosystem services approach and the questions being asked.

Box 7: Key points of difference in opinions about ecosystem services.

Several stakeholders interviewed were unclear about whether the concept of ecosystem services is intended to replace concepts like 'sustainability' or 'resilience' or disciplines like economics (and this raises concerns about whether advances that have been made in these other areas over many years might be lost or abandoned). The interrelationships among ecosystem services, sustainability, resilience and similar concepts were dealt with in Section 4.3. In short, an ecosystem services approach complements and adds richness to the other concepts by identifying what the elements of a sustainable environment might need to be and what aspects of life support for humans might need to be resilient.

Some, especially in the discipline of environmental economics, argue that many ecosystem services classifications do not differentiate between processes, functions, and services in consistent ways, and that this not only prevents robust economic valuations, but also can lead to biased conclusions in non-quantitative deliberative approaches (note that recent advances in ecosystems services typologies address this issue – see Chapter 5).

Some stakeholders interviewed thought that lack of detailed knowledge about ecological processes and likely responses to policy and management interventions means that an ecosystem services approach cannot be implemented across Australia, while others considered that there is sufficient understanding the generate the type of strategic conversations that are required to get better planning for multiple ecosystem benefits. These differences of opinion were probably influenced by different levels of understanding about what knowledge is available and different experiences with access to, and use of, scientific information and so the balance of opinion in our surveys is unlikely to reflect either the true situation or the balance of opinion among stakeholders generally. The level of understanding required will vary with the issues being addressed and the services involved. Often, available understanding will be more than adequate because the benefits versus costs will be obviously greater for one scenario than another.

Some stakeholders interviewed thought that it is important to clarify land managers' duty of care responsibilities and property rights so that a wider range of market-based approaches to managing ecosystem services can be developed, while others thought that it is not necessary, or desirable, to get into this very difficult area as there are likely to be other ways than payment schemes to manage non-market ecosystem services (and that some of these ways have yet to be discovered by encouraging stakeholders to explore their own innovative solutions).

The challenges posed by lack of clarity in duty of care and property rights are real, but probably less significant than often thought. They only become a problem if government seeks to intervene directly in markets using regulations and/or incentives, including payments for ecosystem services. This creates moral hazards, including paying land managers for services that they should provide as part of their duty to society to maintain the productive capacity of the land. The Australian Government and various state governments have avoided this problem so far by encouraging markets around values that are well above duty of care. For example, stewardship programs[14] have paid landowners for protection and/or management of habitat for native species of high conservation significance that is above and beyond management that provides private benefit. Several interviewees, including some involved in representing agricultural industries and some involved in nature-conservation policy, told us that attempts to define duty of care and property rights in more detail could be unproductive as it would discourage many land managers from providing public benefits above duty of care.

Another way for governments to avoid moral hazards is to facilitate mechanisms that allow providers and beneficiaries of ecosystem services to develop their own formal and informal agreements. One interviewee recounted how he had been involved in an international program to use economic valuation to aid planning of natural resource use in the Philippines. The program struggled to cope with the complexities of the real-world situation, but it also revealed that land managers had established many effective informal arrangements that acknowledged and exchanged ecosystem services benefits. For example, in one sub-catchment, people from the upper catchment were given preferential hunting rights in the lower catchment in exchange for restraint in land development in the upper catchment. Recent reforms to encourage trading in water and to allow the use of offsets to compensate for impacts on biodiversity in land development are examples of mechanisms that allow stakeholders to find their own solutions to managing ecosystem benefits, and the devolution of responsibilities for natural resources policies and management to catchment management bodies under NHT also allowed a degree of self-organisation among stakeholders. Numerous contributors to research on societal resilience argue that greater sharing of responsibility, authority and resourcing across society, especially in regional Australia, is required to encourage exploration of innovative solutions by stakeholders.[59]

As mentioned above, most of these points of difference can be addressed by careful thought about the aim of using an ecosystem services approach and the questions being asked in any situation. For example, if the aim is to encourage dialogue then tradeoffs might need to be made between being rigid about multiple counting of benefits and allowing stakeholders to develop their own thinking. The process adopted in southeast Queensland,[150] which engaged 140 individuals from government, universities and non-government organizations, is a good example of how this sort of dialogue was allowed, but was channelled into a framework that minimises the chances of multiple counting (see Sections 4.3 and 4.4). Although most published research on ecosystem services includes some form of economic valuation, this is not an essential part of applying and ecosystem services approach. Several interviewees who are experienced economists pointed out that it is critical at the beginning of any project to ask: 'Do we need to make detailed assessments of ecosystem services and their economic values to establish which decision-alternatives are likely to be best?' Examples of questions that might be asked that do not necessarily require detailed economic valuation include:

- Have we considered the full range of potential interactions among ecological, social and economic systems that might have implications for our decision-making?
- What are the likely magnitudes of economic and other benefits and costs of alternative decision-possibilities?
- Is it likely that the economic and/or social benefits of making detailed analyses will be greater than the transaction costs involved? (For example, detailed analyses might be required to support complex regulatory approaches, but this might not be warranted if the social benefits are less than the cost of the regulatory mechanisms. Alternatively, broad measurements and estimates might be sufficient to encourage decisions by private sector investors or land managers that might have both private and public benefits).
- What sorts of ecosystem services might be required, and where, under alternative scenarios for Australia's population, and where and how people live in the future and what decision rules should be applied to minimise the risk of failing to meet demand for ecosystem services?

Although addressing these sorts of questions might not require detailed economic valuations, it is important that the logic and theory of economics be included. This is a point often overlooked in discussion of the interactions among economists, ecologists and policy makers. The thinking around how humans value the future versus the present (discounting) and how real or perceived rarity affects perceptions of worth is often not considered in dialogue about ecosystem services. An example is the often-repeated mistake of thinking that what people are willing to pay for an outcome on a small piece of land can be expected to apply over much larger scales. The amount that people might be prepared to pay for protection of threatened species in a particular wetland will be influenced by their perceptions about how unique that wetland is, and how rare the opportunity is to protect the species. Once one such wetland is protected, people's willingness to pay for additional ones is likely to decrease. This is why the practice of multiplying marginal values from small-scale studies of environmental assets over the total areas of such assets to estimate, for example, the total value of a nation's or the world's environmental assets has been criticised.[68] This same thinking mistake can be made in general dialogue about environmental management.

11.1.2 A view from industry

Those who have applied ecosystem services approaches consistently report that understanding of the relationships between humans and the environment is patchy, ranging from very sophisticated among some people and very rudimentary among others. Despite this, all practitioners that have worked with interested stakeholders in rural or urban communities have reported that the ideas conveyed by an ecosystem services approach are readily understood in workshops and generate lively and productive debate. This evidence is largely anecdotal and does not establish that an ecosystem services approach is better than general communication about ecological issues, although the suggestion is that an ecosystem services focus transcends multiple interests and backgrounds among stakeholders.[100, 111, 150]

Dewar[83] surveyed Australian businesses to assess the level of knowledge about ecosystem services. She found that understanding the underlying concepts among senior executives was relatively high and that many had heard of the term 'ecosystem services'. However, most were reluctant to use the term because of the connotations that it had among staff and stakeholders. The greatest reported barrier to addressing ecosystem services issues was lack of

understanding of the issues among staff and stakeholders. Dewar concluded that many of the perceptions that these business people had about the meaning of the term were incorrect and that if the term was fully understood by businesses and their stakeholders it would meet their needs. This parallels the findings from our interviews and raises two key issues: (1) The importance of clarifying the concept; and (2) the question of how much any ecological concept will always be vulnerable to misunderstanding and misinterpretation.

Dewar's research also confirmed previous surveys that suggest the approach of most businesses towards environmental issues relates to compliance and minimisation of detrimental impacts rather than taking a system-level view that includes how the environment supports the business. Like governments, businesses were reluctant to address ecosystem services unless they could be measured and there was a clear imperative related to core business.

11.1.3 Insights from the UK National Ecosystem Assessment

A component of the recent UK National ecosystem assessment[228] was a survey to establish the level of understanding about ecosystems and the benefits they provide among the public. The results revealed that the terms 'ecosystem' and 'ecosystem services' were very poorly known among the general public although they are increasingly used by academics and in government. The public identified more with more general concepts like 'nature', 'place' and 'landscape'. Despite this, the majority of people had a high appreciation of nature and understood that it provides benefits, including provisioning, regulating and cultural benefits.

These findings are consistent with what our limited set of interviews revealed for a group of Australians, most of whom are likely better informed than the average about natural resource management issues.

11.2 A system-level view of enablers and blockers of ecosystem services approaches

Ecosystem services approaches are about encouraging holistic (interdisciplinary), strategic thinking and planning about the relationships between humans and the natural environment (see Chapter 6). In this sub-section, we consider the factors that might be helping (enabling) or hindering (blocking) this sort of high-level strategic environmental-social thinking in policy making and land management. These factors are depicted in Figure 23, which is a simplified system map. This map is based on the opinions of people who we interviewed and other opinions from the literature (as explained in Chapter 3). It is intended as a way to stimulate productive dialogue about if, and how, better outcomes might be achieved.

At the right of Figure 23, depicted as green-shaded boxes, are what we assume to be the ultimate goals of holistic, strategic think and planning of the sort encouraged by ecosystem services approaches (i.e., societies and economies that are better adapted to their resource base so that they achieve higher levels of human wellbeing and they are better able to meet their accepted ethical and moral responsibilities to humans and other species).

The major risks of not achieving this holistic, strategic thinking and planning are shown as red-shaded boxes (i.e., overlooking of important processes that support economies and/or social wellbeing, leading to perverse outcomes that work against human wellbeing).

At the left of Figure 23 and into the centre are some of the organisations and groups of people that we think play key roles and enablers, blockers, or both, of holistic, strategic thinking about relationships between humans and the environment (grey-outlined boxes). Details of ways in which the policies and programmes of Australian Government Departments might benefit from and/or influence ecosystem services approaches are given in Table 18. Australia21's discussion paper on a national ecosystem services strategy contains detailed consideration of the roles of other parts of Australian society.[9]

Enabling factors are shown in Figure 23 with green outlines and seven key enabling factors are shown with bold green outlines. These are discussed in more detail in Table 19. Key blocking factors are shown as red-bordered boxes. In general, blocking factors are those that work against the enabling factors.

Three factors (two are actually groups of factors) are highlighted with a yellow border. Theses were seen to be particularly influential components of the system. Two are enablers and one is a blocker. The two key enablers are 'clarification communication and education' and a group of factors related to 'open, cooperative cross-sector dialogue about human needs and environmental processes' (the green and yellow-highlighted boxes). The factors most widely thought by interviewees to inhibit achievement of such dialogue were those related to the adversarial nature of environmental debates in Australia, together with processes and cultures that encourage competition for resources and attention, and compartmentalisation of functions within government and across society (the red and yellow-highlighted box).

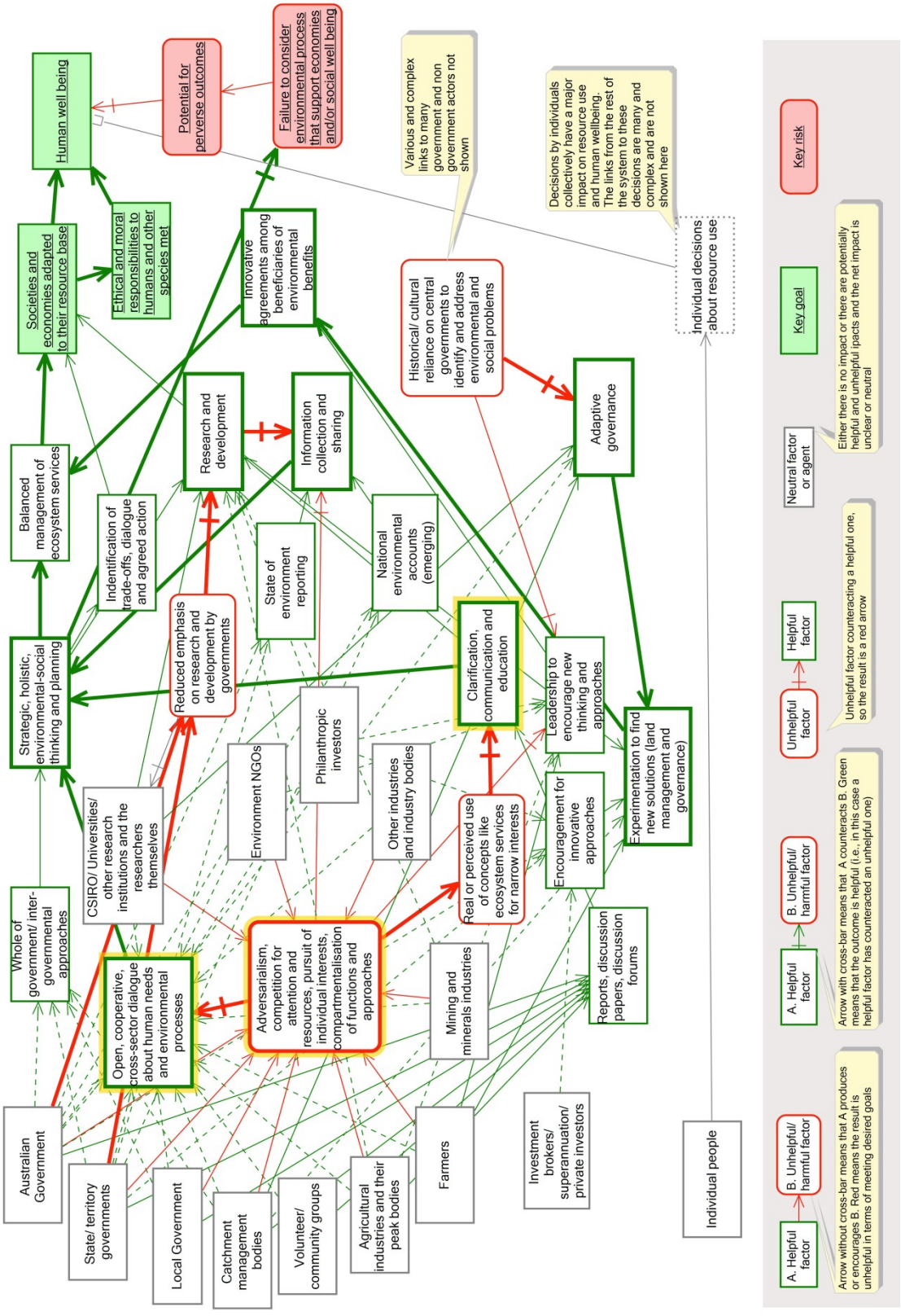

Figure 23: System map (depiction of key relationships, processes and issues that interviewees considered to affect Australia's ability to consider the full range of benefits from the environment strategically and to translate this into human wellbeing).

Broken lines indicate relationships considered to have weak influence over outcomes of the system and bold lines indicate especially strong influence.

The red and green, broken and solid, arrows in Figure 23 indicate how different factors encourage one another (ordinary arrows) or counteract one another (arrows with a line through them). Green arrows indicate that the result is helpful for application of an ecosystem services approach, while red arrows indicate an unhelpful outcome. These arrows show that most groups of people considered in the system map contribute to both the processes helpful to strategic, cross-sector dialogue and to processes that are unhelpful (Table 19).

Some especially strong helpful linkages are emphasised as bold green arrows in the system map and especially strong unhelpful linkages are shown as bold red arrows (note that some of these unhelpful relationships result from encouragement of something undesirable — red ordinary arrows — and some result from the discouragement of something that would otherwise have been helpful — red arrows with lines through them).

Taking the dynamics of this system into account, we suggest there are several key influence cycles encouraging the sort of holistic, strategic environmental-social thinking and planning that an ecosystem services approach encourages, and each of these has a blocking factor that, if addressed, could see the rate of progress accelerate ( ).

Box 8: Key pathways helpful to the adoption of the sort of holistic, strategic environmental-social thinking and planning that an ecosystem services approach encourages, together with key factors working again those helpful cycles (these cycles are shown by the bold arrows in Figure 23 – see text for further explanation).

Helpful Pathway 1: Open, cooperative cross-sector dialogue about human needs and environmental processes —*(helps)*—> Strategic, holistic environmental-social thinking and planning —*(helps)*—> Balanced management of ecosystem services —*(helps)*—> Societies and economies adapted to their resource base —*(helps)*—> Human wellbeing. **Key factors unhelpful to this pathway:** Adversarialism, competition for attention and resources, pursuit of individual interests, compartmentalisation of functions and approaches —*(hinders)*—> Open, cooperative cross-sector dialogue etc.

Helpful Pathway 2: Research and development —*(helps)*—> Information collection and sharing —*(helps)*—> Strategic, holistic, environmental-social thinking and planning —*(leads to)*—>—> Human wellbeing (as in Pathway 1, above). **Key factors unhelpful to this cycle:** Reduced emphasis on research and development by governments —*(hinders)*—> Research and development etc.

Helpful Pathway 3: Adaptive governance —*(helps)*—> Experimentation to find new solutions (to land management and governance) —*(helps)*—> Innovative agreements among beneficiaries of environmental benefits —*(helps)*—> Balanced management of ecosystem services —*(leads to)*—>—> Human wellbeing (as in Pathway 1, above). **Key factors unhelpful to this pathway:** Over-reliance on governments to solve environmental and social problems —*(hinders)*—> Experimentation to find new solutions etc.

Helpful Pathway 4: Clarification, communication and education —*(helps)*—> Strategic, holistic environmental-social thinking and planning —*(leads to)*—>—> Human wellbeing (as in Pathway 1, above). **Key factors unhelpful to this pathway:** Adversarialism, competition for attention and resources etc. —*(helps)*—> Real or perceived use of ecosystem services for narrow interests —*(hinders)*—> Clarification, communication and educations etc.

The need for open, cross-sectoral dialogue is obvious as this is the pathway by which an ecosystem services approach seeks to achieve holistic, strategic environmental-social thinking and planning. Most of those interviewed gave examples of factors that create obstacles to cross-sectoral dialogue by creating boundaries to issues that different disciplines, agencies and groups of people can become involved in and by creating a sense of competition and adversarialism. As Professor Stephen Dovers (Australian National University) put it: interdisciplinarity is not rewarded in academia or consulting and is discouraged in agencies. Soloism and adversarialism are major problems for many approaches to transdisciplinarity, not just ecosystem services, but, ironically, different approaches to transdisciplinarity can be adversaries with one another as well.

All of those interviewed emphasised the importance of achieving clarity and understanding about ecosystem services (noting that these are not yet widely available) and of having good and accessible information on the state of environmental assets and processes. These requirements are emphasised in the literature as well. The current processes to develop a national plan for environmental information[19] and for that to feed into a set of national accounts, was seen as promising by many interviewees.

It was suggested by several interviewees that there has been on over-reliance on governments to address imbalances in environmental management, and production and consumption of natural resources, and that a critical requirement for making progress is incentives for individuals and groups outside government to become involved in finding innovative approaches to managing and sharing ecosystem services.

Although it has become fashionable to dismiss calls from scientists for more research funding, there was a very strong agreement among those interviewed that reduced emphasis on research and development by governments in recent years has gone too far and that vital research to understand ecological responses to policy and management options is being inhibited critically.

In the following sub-sections, we discuss how perceptions in the literature align with those from our interviewees and then we consider what value an ecosystem services approach might add to policy and decision-making processes, before making some recommendations for better application of an ecosystem services approach in Australia.

Table 18: Australian Government departments whose policies and programs affects the delivery of ecosystem services to Australians and/or might benefits from a strategic consideration of ecosystem services.

Department	*Nature of policies and programs*	*Ecosystem services categories*
Broadband, Communications and the Digital Economy	Communication policies affect many aspects of life and lifestyles, including the ability of people to live and work remotely from major urban centres. This has implications for water supply and other aspects of natural resource management in and around urban centres.	All services to some degree

Department	*Nature of policies and programs*	*Ecosystem services categories*
Climate Change and Energy Efficiency	Carbon emission policies affect investment in environmental interventions and thus affect a range of ecosystem services. Consideration should be given to the possible unintended consequences of stimulating markets for environmental carbon sequestration at the development stage. The recent coupling of a biodiversity fund with the carbon tax policy is a promising development.	All services to some extent, especially those associated with native vegetation
Defence	The Department of Defence manages large areas of natural ecosystems for conservation and other purposes. As Defence lands are often in places that provide ecosystem services to nearby settlements, these should be considered in management plans. In a sense, Defence receives some important ecosystem services as much of the land it holds is used to help military personnel learn about operating in natural environments.	Regulatory and Cultural services in particular
Education, Employment and Workplace Relations	Ecosystems contribute importantly to environmental education at a range of levels (primary and secondary schools, tertiary education and research). This department can also contribute to increasing understanding and research about ecosystem services and, therefore, to better decisions in the future. Location of businesses in areas with scenic beauty and places that offer recreational opportunities has been shown to affect productivity. These factors should be considered at some level in whole of government thinking about environmental management.	All services but especially cultural services
Families, Housing, Community Services and Indigenous Affairs	Ecosystems play a key role in indigenous culture. Ecosystems also provide protection from extreme weather, which can be a factor in survival of homeless people in cities. The value of houses in affected by ecosystem services and people on low income often are deprived of some cultural and psychological aspects of ecosystem services and they often are exposed to areas in which effects of extreme weather are greater than in more expensive areas. These might seem like minor points but their importance is often high and they should be at least considered at some scale in strategic thinking within this department. Similarly, other departments should consider the possible impacts if their policies on the policies of this department	Cultural and regulatory services
Finance and Deregulation	Finance should be aware of the true costs and benefits of interactions between people and the environment, so that budgets relating to managing ecosystems services can be assessed in an informed way.	All services
Foreign Affairs and Trade	Securing access to foreign markets is often contingent on how Australian businesses manage their interactions with the environment. There is likely to be an advantage in being able to show that Australian Government departments take a whole of government strategic view of policy interactions with ecosystems. In addition,	All services

Department	*Nature of policies and programs*	*Ecosystem services categories*
	many of the potential beneficiaries of Australian ecosystem services reside outside Australia (e.g., foreign tourists, foreign investors, those who influence trade and foreign policy in other countries who are influenced by their impressions of environmental management in Australia)	
Health and Ageing	Evidence is emerging that many aspects of ecosystems affect the physical and mental health of people. This is often considered in some way in health and aging policy how well can the Australian government currently anticipate or manage the way that policies implemented by other departments affect health outcomes and/or impacts on the aging?	Mostly cultural services
Human Services	The relationships between people and the environment affect many aspects of the works of Human Services. There would be benefit in these effects being considered at a strategic level across all government departments	Mostly cultural services
Immigration and Citizenship	Where immigrants settle and in what numbers has major implications for the mental and physical well being of those immigrants, the social processes in their new home areas, and the demands that communities place on ecosystem services associated with productive use of land, regulation of ecological processes and cultural values. The nature of the natural environment can have major importance for immigrants, especially when they have previously had close relationships with ecosystems. Similarly, immigrants can bring innovative new approaches to land management and it is important to consider whether the areas in which they are encouraged to settle can provide the ecosystem services suitable for these approaches. Policy decisions by other departments that relate to infrastructure, population, water use and conservation, for example, should consider their impacts on immigration policies and vice versa.	All services, especially cultural ones
Infrastructure and Transport	Development of infrastructure can have positive or negative impacts on delivery of provisioning, regulatory and cultural ecosystem services. General environmental impacts are considered in impact assessments but rarely is the full range of ecosystem services considered. There are many indirect effects of infrastructure developments that can be overlooked (e.g., changes in use of land as a result of new roads). Many major challenges facing Australia involve interactions between infrastructure, environment and other departments that are often difficult to deal with due to lack of mechanisms for cross-department strategic thinking. For example, coastal development pressures arise from a mixture of employment, social pressures, demands on infrastructure, environmental impacts and needs for ecosystem services, and economic development	All services but especially regulatory and cultural

Department	*Nature of policies and programs*	*Ecosystem services categories*
	pressures.	
Innovation, Industry, Science and Research	Nowhere is encouragement of innovative research needed more than in relation to understanding the processes generating ecosystem services and assessing future needs for these services. There is a tendency for governments to see investment in industries that produce tangible produces as more desirable than investments in intangibles like ecosystem services, but such investments may be the most effective ways to support economic and social wellbeing of Australians.	All services
Prime Minister and Cabinet	The Department of Prime Minister and Cabinet is the driver of whole of government approaches. It has been championing such approaches for some years but a lot more is needed to facilitate whole of government strategic thinking about ecosystem services. Most government departments still operate within clearly demarcated boundaries and leave thinking about the environment to the environment department, which we argue leads to inefficient and ineffective environmental policies and outcomes for society and the economy that are less favourable than could be achieved with a more holistic strategic approach.	All services
Regional Australia, Regional Development and Local Government	Most leading thinking about ecosystem services and ecosystem stewardship approaches conclude that it is important for Australia to develop new approaches to governance that empower and engage regional communities in anticipating, preparing for, detecting and acting on environmental and social change. This is the core of thinking about maintaining resilience ecosystems and communities. This department should be engaged at the heart of whole of government strategic thinking about managing production of ecosystem services and their use by Australians.	All services
Resources, Energy and Tourism	Ecosystem services are at the heart of tourism and many resource extraction industries. Both of these sorts of industries also affect the capacity of ecosystems to deliver a range of services to other beneficiaries. There are ever increasing calls for a strategic approach to balancing the various dependencies and impacts on ecosystems services by extractive and productive industries and the public.	
Sustainability, Environment, Water, Population and Communities	This is the 'natural' home of ecosystems services. Protection of biodiversity, including ecosystem diversity, is core business. However, some aspects of ecosystem services are considered to be outside the remit of this department and there are concerns that an ecosystem services approach can work against traditional approaches to conservation. This department has pioneered the application of market-based instruments, including stewardship schemes, to achieving conservation objectives. However, it has been difficult for it	

Department	*Nature of policies and programs*	*Ecosystem services categories*
	to address issues of property rights and land managers' duty of care, so payments for ecosystem services has been limited to matters of national environmental significance, which are seen to be above and beyond any duty of care considerations. While it is important to have a home for thinking about ecosystem services, we argue that there is a need to other departments to think strategically and routinely about their own interactions with ecosystem services and for there to be a process for considering strategically about the whole of government's interactions. This would not necessarily be an expensive or large-scale process but we argue that it is important to at least consider at a broad qualitative level what the needs of Australians are for ecosystem services, how individual departments' actions affect those demands and the ability of ecosystems to meet them, and how policies of different departments might help or hinder those of others.	
The Treasury	Decisions by Treasury affect the operations of most other departments. Often the focus on market-based assessments of return on investments means that non-market benefits of ecosystem services to society are overlooked. There should be a process by which the potential importance of ecosystem services to all departments is considered and, especially, the potential for unintended negative impacts of some departments on others via ecosystems services. The Australian Bureau of Statistics, which is responsible for the Set of National Accounts and is currently developing an approach to environmental-economic accounts,[10] is part of the Treasury.	
Veterans' Affairs	Policies of this department probably have limited impacts on ecosystem services but many ecosystem services are important to veterans — as they are to the public in general. Investing in building awareness of what ecosystem services are and how they might be important to this department's clients could be useful in representing the interests of those clients in inter-departmental strategic discussions.	

Table 19: Summary of the enablers and blockers of ecosystem services approaches identified in Figure 23.

Factor	**Enablers** ***Blockers (in italics)***
Clarification, communicatio	Reports and workshops by government and non-government organisations

Factor	Enablers *Blockers (in italics)*
n and education	Communication around stewardship programmes by both state and federal governments *Despite the consistency of understanding among those interviewed in this study, there remain misunderstandings and suspicions among interest groups about one another's interpretations and motives. Such tensions would likely subside if widely agreed principles and frameworks for dialogue about ecosystem services were developed.* *The confusion of different frameworks in the literature and the sense that this is a concept that is still evolving discourages government agencies from committing to a framework or approach.* *While levels of understanding and agreement are low, there remains a low willingness of consumers to pay a premium for products coming from environmentally sustainable and ethical land management.*
Research & development	Research and development funding through a range of government programmes (e.g. CERF, NERP, R&D Corporations, ARC, investment by DIISR at the national scale and various R&D programmes within states) Support for R&D by philanthropic institutions Adaptive management and innovation by land managers Investment in R&D by industries outside the R&D Corporations (e.g., mining, energy) *Inadequate action to address declining agricultural productivity* *Limited ability to scale up (e.g., paddock to landscape or region) or down (to paddock) because of an historical lack of attention to scale issues in many biophysical disciplines (e.g., soil science) (this deficiency is being addressed but there is some way to go)* *Poor understanding of links between management actions, ecosystem function and delivery of services* *Reduced focus and support for R&D to address system-level environmental issues (e.g., closure of Land & Water Australia)*
Information collection and sharing	Research and development funding through a range of government programmes (e.g. CERF, NERP, R&D Corporations, ARC, investment by DIISR at the national scale and various R&D programmes within states) Support for R&D by philanthropic institutions Adaptive management and innovation by land managers Investment in R&D by industries outside the R&D Corporations (e.g., mining, energy) *Limited resources have been allocated in the past by all levels of government for data collection and analysis and integration of ecosystem services in planning* *Having information on the state of environmental assets is a key first step towards an ecosystem services approach.* *In the view of some interviewees, current thinking about national environmental accounts (both in Australia and elsewhere and spreading across academia and government) appears to be focused strongly on measuring assets and only weakly on ecological functionality and*

Factor	Enablers *Blockers (in italics)*
	service delivery, which might limit its ability to support an ecosystem services approach
Adaptive governance	Improved approaches to assessing return on investments in environmental programs (e.g., Caring for Our Country)
	Research on governance options, fitting governance models to the nature of environmental and social challenges, and defining and assessing adaptive capacity, resilience and social wellbeing
	Related to the above, development of 'pathways to implementation' (links through and across decision-making chains – also called 'vertical and horizontal integration')
	Support for application of ecosystem services approaches by regional bodies and communities as concern grows about the sustainability of regional economies and settlements
	Establishment and testing of 'regional models' under recent government programmes (e.g., NHT, Caring for Our Country)
	Reform of planning process in regional Australia to include thinking about ecosystem services, resilience, adaptive capacity and social wellbeing (e.g., Victorian Government Biodiversity White Paper, resilience-based planning in NSW encouraged by NRC)
	Governments in the past have placed strong reliance on market-based economic valuation to assess return on investment and allocation of government funding. Investment in non-market environmental issues has been disadvantaged by this approach, which is one reason why the concept of ecosystem services has emerged
	When governments focus on reducing budgets, cutting all but core functions, optimising productivity they risk reducing resilience and the capacity to innovate and adapt with respect to environmental, social and economic issues (i.e., by reducing diversity, spare capacity, overlapping institutions, networking, social capital etc.)
	It is argued, by a number of recent reviews of natural resource management in Australia, that governments have been reluctant to allow movement towards polycentric governance (governance in which responsibility, authority and resourcing is spread across society so that the people in the best place to detect and deal with issues are in a position to do so. It is argued that many of the social-environmental issues faced in Australia at present require greater engagement of people at regional scales than is currently encouraged. Many stakeholders in regional areas complain that they cannot engage productively in dialogue of the sort encouraged by ecosystem services approaches due to over-centralized governance structures.
	Among farmers, there has been a high level of innovation, which some interviewees think is under-recognised and under-supported. On the other hand, some farmers have expressed the view that incremental adaptation (i.e., coping by making a few adjustments to management) is not necessarily sustainable in the long term.
Leadership to encourage new thinking and approaches	Role of governments in developing and testing new approaches to governance and coupled environmental-social-economic management
	Advocacy of new approaches by NGOs (environment and industry)
	Degree to which members of civil society are prepared and able to show leadership

Factor	Enablers *Blockers (in italics)*
	(versus reliance on governments to identify and solve environmental and social problems) *There is a cultural expectation that governments will deal with environmental and social issues* *There is a poorly developed culture of philanthropy and private investment in environmental and social issues in Australia*
Mechanisms for allowing and encouraging innovative agreements among beneficiaries of environmental benefits	Incentives for developing markets for ecosystem services (e.g., land stewardship and other approaches to creating markets for biodiversity, linking carbon-emissions trading and markets with broader environmental objectives) Strategic use of regulation and legislation to drive a focus on ecosystem services (e.g., the Murray Darling Basin Plan, planning reforms in Victoria, Queensland and NSW, review of the EPBC Act) Community-driven assessments of benefits and beneficiaries and exploration of new mechanisms for harmonization (e.g., several regional bodies and other community coalitions in all state and territories) Industry-driven initiatives (especially around carbon markets, biodiversity offsets and maintenance of cultural values) *Some interviewees suggested that there is insufficient attention given to ecosystem services in legislation. It was pointed out that issues like human resources and discrimination became mainstream in public and private organizations only after legislation was introduced to require attention to them.*
Processes for strategic, holistic environmental -social thinking and planning across interest groups, sectors, government departments, and levels of government and society	Encouragement of whole-of-government approaches from within government (e.g., blueprint for reform of the Australian public service) Support for inter-jurisdictional decision-making forums (e.g., MDBA, COAG) Review of the Environment Protection and Biodiversity Conservation Act 1999, probably leading to more strategic application with a focus on ecosystems Anticipating future demands on ecosystem services in relation to population, food production, water use, infrastructure and conservation objectives (e.g., 2020 Summit, Australian Government's 2010 Sustainable Population discussion paper, discussion papers by the Australian Academy of Sciences Australia21, Australia Institute, Climate Institute, Grattan Institute and the Strategic Policy Institute, and various scenario planning exercise by regional bodies throughout Australia) *Despite official encouragement of whole-of-government approaches from within government, issues are compartmentalized between departments at all levels of government and environmental issues are the primary, and often sole, provenance of one department. This means that the implications of environmental benefits and impacts are not routinely considered in most other departments.* *There are limits to cooperation and agreement among jurisdictions in inter-jurisdictional decision-making forums due to competition for resources and concerns about the transactions costs of changing to more compatible approaches.*

Factor	Enablers *Blockers (in italics)*
	There are limited incentives for environment and industry NGOs to cooperate in addressing environmental-social issues (several interviewees referred to the 1990s collaboration between the NFF and ACF to address land degradation in rural Australia as a model for what is needed again now) *Related to the above, the level of adversarialism in environmental debates in Australia was considered to be higher than in the past and a powerful blocker of ecosystem services approaches.* *One consequence of adversarialism appears to be a suspicion of ecosystem services approaches among some conservation agencies and interest groups (for example some have expressed concern that a focus on utilitarian aspects of biodiversity will result in the ethical and moral dimensions of conservation being marginalised)* *Several interviewees expressed the opinion that agriculture has decreased in importance on policy agendas of both state and federal governments, and that this makes effective dialogue about natural resource management in regional Australia difficult. Declines in the absolute contributions of agriculture to the Australian economy are considered as partly to blame but also the rising contributions from mining to both regional and national economies has made agriculture seem relatively less important.*

11.3 Perceptions from the literature

Appendix VII summarises some conclusions and insights from work that has critically analysed the development of ecosystems services approaches and considered what is required to develop and apply an ecosystem services approach at a range of spatial scales.

Several common themes arise, most of which are consistent with what we found in our interviews:

- There are clear roles for government in creating the conditions under which private individuals and businesses can find innovative ways to recognise the benefits from good ecosystem management and incorporate them into the transactions that are part of everyday life for businesses and communities (in the language of government this is 'addressing market failure')
- There is a need to recognise that governments cannot, and in the views of many should not attempt to, address all of the challenges associated with recognising benefits to humans from the environment (in general, government should intervene to manage benefits that accrue to the general population, and which are unlikely to be protected by current market and non-market mechanisms, and where the benefits of the intervention outweigh the transaction and other costs)
- The state of functionality of ecosystems should be considered in a country's national accounts (although there is ongoing debate worldwide about how this should be done)
- While arguments for an ecosystem services/ management/ stewardship approach are now well documented (see Chapter 6), implementation is often based on a range of

untested assumptions that should be a priority for research and development (details of research priorities were given in Section 8.3)

- Progress is particularly needed on three fronts: 'the science of ecosystem production functions and service mapping; the design of appropriate finance, policy, and governance systems; and the art of implementing these in diverse biophysical and social contexts'[73]
- Applying an ecosystem services approach in many cases requires new approaches to environmental and social aspects of policy and governance, especially to establish 'pathways to implementation' that stretch throughout society, and this will require testing and learning from new approaches which can be best done by embedding research and its evaluation as an interactive part of policy and management processes
- Much of the thinking about how to develop and apply lessons from research on ecosystem services approaches has been done by individual groups or small networks that have had limited interactions with one another. Although there are examples of regular 'gatherings' of ecosystem services researchers at meetings, there is a need for a more formal mechanisms to encourage the sharing of insights and the development of commonly agreed definitions and principles to give policy makers and land managers confidence to put the lessons into practice. Such a network would allow an ongoing dialogue that could, over time, arrive at a robust set of conclusions that have broad agreement. Such agreements are rarely, if ever, achieved at irregular meetings or symposia.
- There remains a key role for ecosystem services frameworks as communication tools for bringing new understanding to the value of natural capital, especially at local and regional levels

Progress towards addressing these issues has, in the past, been impeded by resistance from disciplines, functional units within bureaucracies, and/or sectors of society that require convincing about the merits of taking new, and potentially ill-defined, approaches. Many of the reasons for this resistance have been removed by improved typologies that align ecosystem services approaches with theory in economics and ecology but some of the most fundamental barriers have little to do with the ecosystem services approach itself (for example, reluctance of government departments to expose themselves to risks by engaging in strategic analyses that cut across departmental boundaries, or the lack of professional or other incentives for researchers to engage in inter-disciplinary or transdisciplinary approaches that go beyond the bounds of their skills and experience). Addressing the latter, requires creation of new incentives and reward structures, within both government and a range of scientific and other disciplines.

11.4 What value might be added to policy by an ecosystem services approach?

Several recent reviews have considered how an ecosystem services approach can add value to decision-making by governments and other sectors of society. Turner & Daily (Figure 24) and Cowling *et al.* (Figure 25) have proposed frameworks for aligning ecosystem services approaches with policy and decision-support cycles. Cork *et al.*[63] and Maher & Thackway[146] considered how ecosystem services approaches can contribute to these cycles.

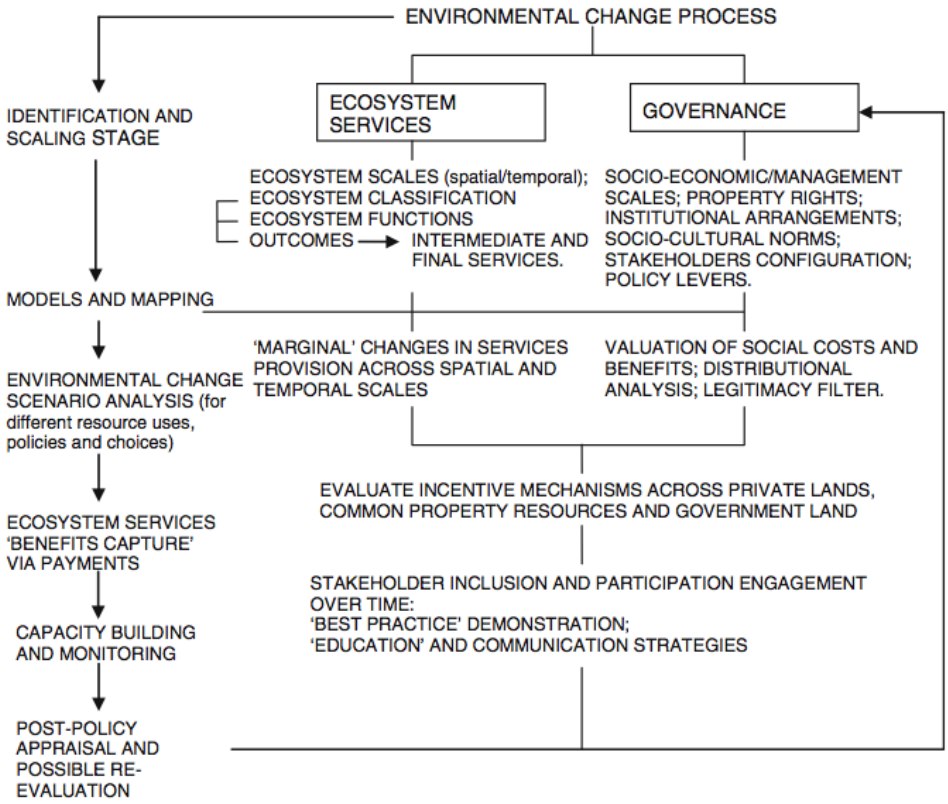

Figure 24: Framework proposed by Turner and Daily (2008)[222] for integrating ecosystem services analysis with policy and other decision-making cycles.

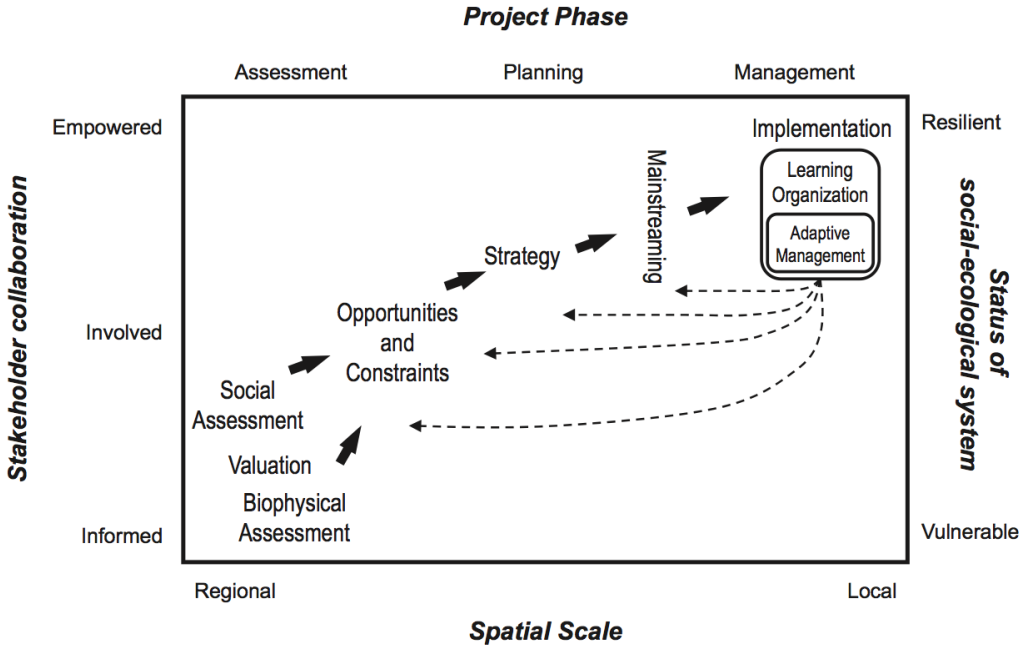

Figure 25: An operational model proposed by Cowling *et al.* (2008)[70] for making assessment and management of ecosystem services part of mainstream decision-making.

In Australia in 2007, it appeared that ecosystem services assessments (and similar approaches under different names) made substantial contributions to only two steps in a typical decision-support cycle: Step 1, 'Characterising the Resource or Asset' (mostly through frameworks and tools for describing and assessing ecosystem services), and Step 3, 'Designing and Implementing a Programme' (mostly through incentive-based approaches such as market-based instruments).[146] Contributions to other phases of decision cycles — Step 2, 'Influencing Priority Settings', Step 4, 'Tracking On-Ground Progress Toward Desired Goals/ Objectives, and Step 5, 'Complete Resource Assessments Following Action — were considered to be relatively insignificant at the time. This situation has improved slightly in Australia since 2007. The term 'ecosystem services' is now found throughout most key environmental policy documents at all levels of government and in programs developed by non-government organisations, and markets for some ecosystem services, including biodiversity and carbon sequestration are emerging. However, ecosystem services are far from being central in environmental decision-making, are only moderately considered in food and other agricultural policy and are almost unconsidered in other policy, such as population policy (see Chapter 11).

In contrast, the recent review by deGroot *et al.*[77] concluded that ecosystem services approaches now contribute strongly to all phases of policy and decision-support cycles in Europe and the USA. As a result of the UK's National Ecosystem Assessment, natural capital is being placed 'at the centre of economic thinking and at the heart of the way the way we measure economic progress nationally'.[227] The elements of state of the art approaches to ecosystem services analysis are discussed more fully in Chapter 7. In summary, the literature suggests that an ecosystem services approach should include the following elements:

- Social analysis (including consideration of beliefs, norms, needs, values, owners and beneficiaries of ecosystem services, and institutional and governance arrangements)
- Biophysical analysis (including analysis of the state of ecosystem assets, flows and impacts over a range of spatio-temporal scales as well as mapping, modelling and other visualisation techniques to engage stakeholders)
- Valuation (in both monetary and other terms)
- Scenario analysis and other approaches to considering alternative policy and management options over a range of spatio-temporal scales
- Effective engagement with stakeholders

The ways in which and ecosystem services approach can add value to policy and decision-support cycles is considered in Table 20. Most of the above elements play roles at one or more phases of these cycles.

Table 20: Ways in which ecosystem services approaches can add value to policy and decision-support cycles.

Policy phase[a]	*Nature of value added*
Identify issues	More comprehensive and systems-based assessment of the issues, including interactions between social, economic and environmental processes. Greater insights into where to look further to understand the issues and devise effective interventions. A focus on multiple benefits and beneficiaries provides a way to approach complex, multi-stakeholder issues that have an environmental component, such as population and food security policies.

Policy phase[a]	*Nature of value added*
	Collection and sharing of information to support ecosystem services analyses, by government and non-government organisations, plays a key role in identifying emerging issues and allowing them to be addressed early.
Policy analysis	The conceptual framework relating ecological processes to human wellbeing is likely to give a more complete understanding of the context of the issues that other approaches that do not explicitly aim to identify all benefits and beneficiaries.
Policy instruments	Supports a rich dialogue about possible future implications of alternative instruments and opens up possibilities for greater use of tools such as information, promotion, grants and other suasive approaches targeted at improving service delivery and human well being, market based instruments, regulation, and certification or labelling programs.[21]
Consultation	Ideally stakeholder engagement would be involved in al steps of this process The great value that an ecosystem services approach offers is that it enables diverse stakeholders to rapidly understand the issues and take part in dialogue about options and their implications. This makes for stakeholder engagement that is more informed than in many other processes in which stakeholders might struggle to understand the technical information and the issues.
Coordination	An ecosystem services framework can provide common understanding and language to enhance coordination among government agencies and between government and nongovernment organisations so long as the effort is made to explain the concept and seek agreement on terms.
Decision	Decision-making is enhanced if there is a clear analysis of who is affected, how and when. An ecosystem services analysis aims to do this through a focus on all costs, benefits and beneficiaries from ecosystems and of policies that influence ecosystem function.
Implementation	The comprehensive analysis of benefits, beneficiaries and current and future expected demands for ecosystem services provides a framework for monitoring and adaptive management to both assess whether plans are working and incorporation lessons learned into revision of policies and plans. The focus on the links between ecosystems and human wellbeing is a strong basis for developing visions and objectives in the planning process. The conceptual and quantitative models of ecological and social process developed in an ecosystem services analysis support scenario planning to consider the possible paths forward and their implications in clear and concrete terms. Ecosystem services processes have been shown to engage and encourage stakeholders to take responsibility for developing and implementing plans and so have the potential to increase the effectiveness of government investments.
Evaluation	Defining the issues and policy and planning objectives at least partly in terms of ecosystem services and human wellbeing facilitates evaluation of whether objectives have been met (although setting inflexible targets is unwise as it is likely to work against resilience and adaptability of both ecosystems and societies).

11.4.1 Identifying issues

An ecosystem services approach starts with a framework that prompts those assessing the issues to consider the full range of potential benefits and beneficiaries of ecosystem processes, the needs of people in the system, and the capacity of the ecological systems to meet those needs. This approach defines the issues more fully than approaches that do not start with such a comprehensive framework. Experience of many studies has shown that the process of considering exactly what benefits people get from ecosystems, what processes provide them and what the alternatives are is highly enlightening and can fundamentally change stakeholder's understanding of the issues and ideas about solutions.[1, 64, 150, 178] The UK Department for Environment Food and Rural Affairs has adopted an ecosystem services framework as a high proportion of environmental impact assessments failed to consider impacts comprehensively.[225] Combining ecosystem services analysis with an analysis of social and ecological resilience, adaptability and transformability allows analysts to identify whether the real issues are environmental, social or both and to identify where to look further to understand the issues and devise effective interventions. Collection and sharing of information to support ecosystem services analyses, by government and non-government organisations, plays a key role in identifying emerging issues and allowing them to be addressed early. While economic valuation might often be required to clarify the nature of the issues and those affected, is has been argued that the biophysical information is the key as this is the basis for people's value judgements.[116]

11.4.2 Policy analysis

An ecosystem services approach draws on the tools of ecology, economics, social sciences, engineering and mathematics to consider the nature of the coupled social-ecological system in question, including understanding factors determining people's needs, where those needs are found spatially, and what ecological processes are operating to provide ecosystem services.[70, 77, 222] The conceptual framework relating ecological processes to human wellbeing is likely to give a more complete understanding of the context of the issues that other approaches that do not explicitly aim to identify all benefits and beneficiaries. Ideally, an ecosystem services approach would include a robust analysis of institutions, governance and other social factors contributing to the issues.

11.4.3 Policy instruments

An ecosystem services approach does not create new policy instruments but it supports a rich dialogue about possible future implications of alternative instruments and opens up possibilities for greater use of tools such as information, promotion, grants and other suasive approaches targeted at improving service delivery and human well being, market based instruments, regulation, and certification or labelling programs.[21]

Recent summaries of studies around the world have concluded that application of an ecosystem services approach has allowed market forces to bring about major landuse and industrial change in several Latin American Countries and in the USA and has allowed China to launch the most far-reaching payments for ecosystem services program yet seen globally.[44, 205, 222] In Australia, the power of markets for water have become apparent in the Murray Darling Basin[62] and programs nationally and in Victoria and South Australia that involvement payments for management of habitat for biodiversity have begun to have impact.[21, 64]

11.4.4 Consultation

Ideally stakeholder engagement would be involved in al steps of this process. The great value that an ecosystem services approach offers is that it enables diverse stakeholders to rapidly understand the issues and take part in dialogue about options and their implications. This makes for stakeholder engagement that is more informed than in many other processes in which stakeholders might struggle to understand the technical information and the issues. In an ideal ecosystem services approach, stakeholders will contribute to all phases of identifying and assessing ecosystem services, giving them ownership of the process and understanding of the different viewpoints among their fellow stakeholders. Stakeholder engagement under these circumstances is likely to be more productive, less adversarial and, therefore, more efficient and effective that in processes where governments attempt to convey complex information and decisions to audiences that feel unengaged with the decision process.[1, 100, 178, 227]

11.4.5 Coordination

With respect to coordination among government departments, and ecosystem services framework can provide common understanding of the issues and reasons for policy interventions. Coordination will also be enhanced by an analysis that shows how different departments are affected by ecosystem services and therefore how the policy decisions under consideration could influence other policies in other departments.

11.4.6 Decision

Decision-making is enhanced if there is a clear analysis of who is affected, how and when. An ecosystem services analysis aims to do this through a focus on all costs, benefits and beneficiaries from ecosystems and of policies that influence ecosystem function. An ecosystem services analysis would normally be accompanied by an analysis of non-ecosystem costs and benefits.

11.4.7 Implementation

An ecosystem services approach potentially adds value to implementation of policies in a number of ways. The comprehensive analysis of benefits, beneficiaries and current and future expected demands for ecosystem services provides a framework for monitoring and adaptive management to both assess whether plans are working and incorporation lessons learned into revision of policies and plans. The focus on the links between ecosystems and human wellbeing is a string basis for developing visions and objectives in the planning process. The conceptual and, where possible, quantitative models of ecological and social process developed in an ecosystem services analysis support scenario planning to consider the possible paths forward and their implications.[145] Many plans in the past sought a ‘sustainable future’ without a clear of idea of what that meant. An ecosystem services approach, however imperfect, provides a basis for considering what the nature of sustainability might be. Ecosystem services processes have been shown to engage and encourage stakeholders to take responsibility for developing and implementing plans and so have the potential to increase the effectiveness of government investments.[1, 64, 150]

11.4.8 Evaluation

Defining the issues and policy and planning objectives at least partly in terms of ecosystem services and human wellbeing facilitates evaluation of whether objectives have been met. The combined literature of ecosystems services and resilience, however, warns against setting inflexible objectives as there must be room for adaptation and learning, especially about the nature of human well being and the processes by which ecosystems function. In any case, current understanding and technologies will not support the setting or measurement of precise targets with respect to ecosystem services.

11.4.9 Contributions to other dimensions of policy analysis

It is easy for the misconception that ecosystem services is synonymous with economic valuation to arise as so many ecosystem services projects involve economic valuation and the approach was developed in part to get benefits from ecosystems considered along with issues that have clear monetary value. Proponents of an ecosystem services approach emphasise that it addresses a much wider range of aspects of environment-social policy (Table 21) and that it goes beyond the scope of most other approaches to measuring demand and impacts of humans, such as ecosystem health.[30]

Table 21: Potential contributions of an ecosystem services approach to social, technological, economic, environmental and political/ legal dimensions of decision-making.

Aspect	*Potential contributions*
Social	At the heart of an ecosystem services framework is explicit links between ecosystems and human wellbeing. A focus on benefits and beneficiaries is a basis for considering ethical and justice dimensions of environmental decision-making.
Technological	A fundamental part of an ecosystem services approach is considering the nature and cost-effectiveness of technological (e.g., engineering) alternatives to ecosystem services. The focus on relationships between ecosystem processes and how they lead to services and benefits is a basis for considering what functions would need to be provided in engineering solutions. An ecosystem services approach does not assume that an ecosystem is necessarily superior to a technological solution but it does aim to provide stakeholders with relevant information on which to base value judgements and decisions.
Economic	As discussed in several places in the report and throughout the literature, one major aspect of the development of ecosystem services approaches over the past decade has been closer alignment with ecology and economics. Recent frameworks allow diverse stakeholders to take part in dialogue about 'worth' of ecosystems and to understand the basis for benefit-cost analyses and other economic analyses. The improvements that have been made in economic approaches to non-market valuation over this same time period have meant that an ecosystem services valuations are being used frequently in decision-making in the USA and Europe and even in courts of law in the USA.
Environmental	An ecosystem services approach provides a framework that can be used to organise the complex information about states and trends in ecological systems. It provides language and concepts that relate to everyday transactions (the giving and receiving services between producers and consumers) and allow non-ecologists to engage in productive dialogue about what trends in biodiversity and ecosystem function might mean, and it

Aspect	Potential contributions
	therefore provides bridges between scientists, communities, businesses and policy makers.
Political/ legal	The language and concepts of ecosystem services allow politicians to couch explanations of environmental decisions in terms that relate to human wellbeing. As explained throughout this report, the concept does not only deal with tangible uses of biodiversity and its services but also the intangible values, including existence and bequest values, that make sense to most people when included within a framework that considers the full range of values. Although the concept is still not quite at the stage where all services can be defined and measured precisely, the evidence is that once such definitions and measurements become possible, as they have for habitat, water quality and carbon sequestration, regulations, markets and, eventually, codification of rights and responsibilities in law become possible. Legal practitioners have said for some time that one factor holding back the mainstreaming of 'sustainability' has been the difficulty of defining it in ways that hold up in courts. There is promise that the concept of ecosystem services will evolve to the point where it becomes part of legislation.[198, 199]

11.4.10 Potential costs

Appendix VIII reports an assessment of strengths, weaknesses, opportunities and threats associated with applying an ecosystem services approach in Australia. The most obvious costs of applying an ecosystem services approach are transaction costs and costs of research and data collection. These costs are not likely, however, to be greater than applying alternative approaches and are likely to be lower in many cases. The Australian Government is committed to whole of government approaches for addressing major public issues and to stakeholder engagement in policy development. Developing a framework for classifying and discussing benefits from ecosystems is likely to improve communication between government departments and with stakeholders. Just as importantly, it is likely to increase the quality and relevance of stakeholder input and allow government departments to develop strategic approaches to dealing with environmental issues that have relevance to multiple departments.

The costs of research to improve ability to measure ecosystem processes and anticipate demand and supply of ecosystem services spatially and temporarily might be high, but these costs would need to be incurred anyway as it becomes more clear that Australia's ability to report on environmental change and its implications is inadequate. Applying an ecosystem services approach as one component of a national approach to environmental information collection is likely to enhance the use of the data in strategic thinking and planning. It is highly likely that the type and level of information that is required for an ecosystem services approach will be the same as that called for by most academics and non-government organisations that have expressed informed opinions about what data are needed to assess the state of Australia's environments. The types of information needed include data on ecosystem processes in soil, plant and animal systems, including natural and human managed systems, at a range of spatial and temporal scales. This information is vital even if an ecosystem services approach is not applied — the difference is that an ecosystem services approach will give an additional way to interpret the information and relate it to big policy issues related to human wellbeing.

11.5 Key issues and recommended actions

Taking the results of our interviews (Section 11.2) and conclusions from the literature (Section 11.3), we have identified a consolidated set of issues that we think, if addressed, would greatly improve the Australian Government's ability to consider, strategically, the alignment between environmental policy and management and human wellbeing and increase the effectiveness of investments in environmental management by engaging a wider range of society in dialogue and action. In the following subsections we briefly outline our key recommendations, and the issues that underpin them, and suggest actions for implementing the recommendations

Recommendation 1: Develop a process for strategic dialogue and planning within the Australian Government that considers the full range of potential benefits from ecosystems along with other information relevant to strategic decisions.

This recommendation is based on the feedback from our interviews, and from our literature analyses, which suggests that not only are the potential environmental impacts of policies developed in many government departments (at all levels of government) being poorly considered but that there are also potential benefits from ecosystems that are not being taken into account and opportunities for synergism between environmental and other policies that are being overlooked. Later in the chapter we highlight population and food policies as two such areas but there are potentially many others (as indicated in Table 18). Furthermore, the experience of several governments around the world, including the UK, USA and China, and also Australia to a degree, has shown that an ecosystem services framework can lead to both productive strategic dialogue and major new opportunities for aligning economic development with improved environmental management and human wellbeing.

Fundamental to achieving this recommendation is a need to develop a common understanding, language and framework to support strategic dialogue about environmental issues across government departments and with stakeholders outside of government. This understanding needs to be at a systems level, going beyond minimisation of undesirable environmental impacts and including understanding of how suites of species interacting with one another and the non-living world support activities that are important to all governments departments and all sectors of society. The language and framework should not be overly specific and should be sufficiently flexible to incorporate different perspectives and different disciplines as well as new knowledge as it emerges.

These processes for strategic dialogue should be capable of engaging with and drawing on expert and public opinion and should include steps to build the capacity of all stakeholders to understand the concepts and language used in this dialogue; examples of cross-departmental issues that should be considered by such processes include populations policy, food security policy, coastal policy and conservation policy.

Recommended actions:

1.1 Build on lessons learned in the review of Caring for Our Country about how to present and communicate ideas about benefits from ecosystems and human wellbeing within government and with other stakeholders and especially how the high-level rhetoric has influenced delivery of programmes

1.2 Convene a multi-departmental working group (preferably linked to a National Ecosystem Services Network – see Action 2.1) to work towards a conceptual framework that would facilitate productive dialogue about ecosystem services across Australian Government departments and with the Australian Government's stakeholders. Available evidence suggests that this would need to be a high-level, guiding framework. It should avoid trying to be specific about categorising ecosystems and ecosystem services as this is likely to get bogged down in debate between ecologists, economists and communities with little benefit. This is better achieved on a case study basis.

1.3 Establish a high-level strategic forum but make sure it is supported by an advisory panel of lower-level technical experts and policy developers who are wrestling with the implementation issues and are able to make recommendations for consideration (this is based on the experience in the USA where a high-level forum exists but is not supported by those dealing with the day to day issues)

1.3 As a mechanism for achieving Action 1.3, consider establishment of an "Office of Ecosystem Services", which is responsible for achieving strategic thinking and action across departments (this has been done in the USA and an equivalent mechanisms now exists in the UK arising from the National Ecosystem Assessment)

1.4 As a mechanism to support Action 1.3, seek agreement that all government programs include a strategic assessment against an ecosystem services framework

Recommendation 2: Explore improvements to governance arrangements to encourage appropriate sharing of responsibility for strategic alignment of human wellbeing and ecosystem management across society

Recommendation 1 is a contribution to these improvements in governance, but there is a need to recognise that government cannot solve all ecosystem services issues. There is need for understanding, capacity and authority to be spread through the decision-making chain so that there are 'pathways to implementation' for government policies, 'pathways for feedback' from stakeholders to policy makers, and all sectors of society understand and can play their part on strategic management of ecosystem and human wellbeing.

Recommended actions:

2.1 Encourage and, at least initially finance, development of a national ecosystem services network of researchers, policy makers and policy implementers from all sectors and levels of society to encourage dialogue about what the key issues are and how to addressed them (this might also be seen as a 'community of practice'). This network should be hosted by a non-government entity NGO (such as a University) but supported by government. Australia 21 has previously produced a report suggesting how this could be done,[9] which could serve as a starting point. Feedback from similar networks, such as the Ecosystem Services Partnership in the USA,[88] suggests that active government involvement is critical but that organisation and leadership should be independent of government.

2.2 Convene a multi-stakeholder working party to consider the different roles and responsibilities of different parts of society for identifying and managing ecosystem services and how governance arrangements can be modified to facilitate those roles and responsibilities (this should involve an Office of Ecosystem Services, if established, but also representatives from all organisations and institutions that contribute to environmental governance).

Recommendation 3: To support all of the above, continue and enhance initiatives to establish an appropriate and accessible set of information capable of supporting strategic dialogue about ecosystem management and human wellbeing

To support constructive strategic dialogue that adds, rather than detracts from, efforts to align environmental policy and management with human wellbeing, there is a need for information that tracks changes in the state and capacity of ecosystems to produce benefits to people as well as assessments of likely demands for these benefits spatially and temporarily. We recognise that development of a national set of environmental-economic accounts is underway in Australia and that a National Plan for Environmental Information is under development and that ecosystems services approaches are being considered as one input to those processes. We suggest that demands for ecosystem services analyses will grow rapidly in the next decade and that people performing these analyses will be major clients for national data sets. State of the environment reports over the past decade have highlighted the dearth of information for tracking change in ecosystem function. Another major gap in Australia's ability to align environmental management and human wellbeing is the scarcity of information on current, and possible future, human demands on ecosystems.

Recommended actions:

3.1 In the design of national environmental data collection and analysis, consider information required for assessing the capacity of ecosystems generate benefits in relation to when and where humans need them (e.g., collect data on not only the state of ecosystem assets but also functionality and also collect information that will allow assessments of current, and possible future, human needs).

3.2 Use the above to identify key research gaps and develop a program to address them

3.3 Consider a national ecosystem assessment, grounded in action by regional bodies and building on the UK's National Ecosystem Assessment and the lessons learned from that process, which includes not only assessment of the state of the assets but also scenarios for future human demands on ecosystems – this assessment should be seen as a whole of government and whole of nation project designed to support multiple sectors and policies across society.

3.4 Encourage integration of ecosystem services assessments into key cross-departmental policies and programs, such as population, immigration and food security policies and programs (e.g., include strategic thinking about future demands on ecosystems services, where those demands might occur and how policy settings might affect the size and nature of the demands)

3.5 Consider how centralised data collection and distribution can facilitate multi-stakeholder dialogue about ecosystem service tradeoffs

Recommendation 4: Build on and enhance Australia's investments in innovative ways to link ecological and economic research with business to drive desirable environmental change

Australia is already investing productively in this area and producing examples that have been emulated elsewhere in the world. This process should built on and encouraged to develop further. Harnessing the force of markets has become a major component of environmental policy but there is a need to be more innovative so that the outcomes achieved are consistent with well-informed strategic dialogue about the implications of multiple ecosystem benefits to current and future Australians.

4.1 Convene a working group (linked with a National Ecosystem Services Network and Australian Government working groups established in response to the recommendations above) to consider whether a set of environmental assets can be identified that satisfy the needs of economic (especially benefit-cost) analysis (the indications are that this is close to being possible as a result of recent advances in ecosystem services classifications and typologies) and to consider how an ecosystem services framework for Australia can better support development of market-based approaches to achieving balanced wellbeing outcomes from ecosystems for Australians.

4.2 Linked with Recommendation 2.2, invest in building capacity and opportunities for beneficiaries of ecosystem services to explore mutually beneficial solutions to sharing benefits. This might require new consideration of the roles of government in encouraging or discouraging innovation in institutional design and governance.

11.6 Achieving strategic, holistic environmental-social thinking and planning across interest groups, sectors, government departments, and levels of government and society

Perhaps one of the greatest challenges in this list is that of improving strategic dialogue across government departments and between governments and the rest of society.

There was broad agreement among interviewees that there have been serious efforts at both state and federal levels to encourage whole-of-government approaches to major challenges in recent years but that departments still tend to function somewhat independently of one another and often in competition for recognition and resources. In the past, responsibility for environmental issues was often not considered or taken by most departments as it was expected that the environment department would do that. This meant that there was little routine consideration of how decisions within departments, other than the environment department, either affected ecosystems services or could benefit from consideration of them. This worked strongly against a strategic or integrated approach to considering ecological, social and economic benefits, risks and tradeoffs at any level of government. In recent years, DSEWPaC has

been directed to take the lead in considering environmental issues in relation to challenges like the development and implementation of the Murray Darling Basin Plan and, more recently, integrating environmental management with carbon-emissions policies and programs. While this makes sense from an efficiency point of view, there is a risk that inadequate thinking about links with ecosystem services will occur in other departments. Several interviewees associated with agricultural industries expressed concern that DAFF has had a limited profile in environmental discussions in the past few years and expressed concern that this has reduced the ability of agriculture, forestry and fisheries industries to engage in strategic dialogue about ecosystem services.

On the other hand, it was emphasised to us that Caring for Our Country is a genuine and productive partnership between DAFF and DSEWPaC, and that DAFF had important inputs into the review of the *Environment Protection and Biodiversity Conservation Act 1999*.

The observation has been made several times recently that the environment has not been mentioned often in debates about population policy in Australia. [53, 60, 104, 208] In the opinion of at least some interviewees, this is partly a reflection of the separation of immigration, industry, infrastructure and environmental thinking with governments (at all levels) and the limited mechanisms for strategic conversations about ecosystem services across these functionalities.

Several emerging developments offer possibilities for greater strategic dialogue about ecosystem services among Ministers and government departments at state and federal levels and between government and other sectors:

1 The finalisation and implementation of the Murray Darling Basin Plan has attracted both positive and negative feedback from stakeholders but it, and the ongoing activities of the Murray Darling Basin Authority (MDBA), have considerable potential to facilitate the sort of dialogue required to identify and deal with tradeoffs between environmental, social and economic values (and a major study of potential ecosystem services benefits from the Plan is underway, as mentioned in Chapter 9);
2 The recent review of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which included recommendations to apply the act more strategically with an ecosystem-scale focus, was seen as an important opportunity for a more strategic approach to considering society's current and future needs for ecosystem services and the impacts of decisions by a wide range of government departments on those need and on the ability of ecosystems to meet them. Although decisions under the EPBC Act are ultimately taken by the DSEWPC Minister, there is a requirement for that Minister to consult other Ministers and this could be a mechanisms for inter-departmental strategic dialogue about ecosystem services.
3 The development of a national approach to collecting and sharing environmental information[19] has the potential to support informed dialogue about the relationships between people and the natural environment at a level previously not possible in Australia, and Australia's involvement in the development of the System of Environmental-Economic Accounts[231] and the associated Wealth Accounting and Valuation of Ecosystem Services programme[137] will provide mechanisms for accessing leading international thinking in this area.
4 Ongoing implementation of Caring for Our Country, which has a strong focus on ecosystem services from both protected and production lands, should provide a vehicle

for developing an ecosystem services approach further, as might any future developments following from this programme.

5 Finally, the Australian Government's involvement in the development of the Intergovernmental Platform on Biodiversity and Ecosystem Services[20] could provide a mechanism to refine thinking about the strategic application of an ecosystem services approach, including improving alignment between research and policy, and to play an international leadership role as Australia's approach develops.

11.7 Application of an ecosystem services approach in food, environment, agriculture and population policy

Around 60% of Australia's land area is used for agricultural activities such as grazing, cropping and horticulture.[180] The largest use by area is extensive grazing of mainly natural vegetation, but most farm profit is derived from intensive industries (especially irrigated cropping and horticulture).

We know of no national-scale strategic thinking integrating future trajectories for these extensive and intensive land uses with areas of national policy that are likely to influence the needs of Australians for ecosystem services and the ability of ecosystems to meet those needs. Such policies include those relating to population, immigration, infrastructure development, food security, water, and biodiversity.

The recent PMSEIC report[180] acknowledged the central importance of food and food production to human wellbeing and environmental health. The report discussed a range of ways in which the food production chain might interact with aspects of environmental management and the development of Australia society, including through competition for arable land from alternative land uses like urban development. It noted that landuse conflicts are likely to become more acute in the future. Competition for arable land will be strongly influenced by population, immigration and settlement policies as where and how people live influences spatial patterns of land value. And yet, PMSEIC observed: '…food is not currently dealt with in an integrated way which brings together the policy and regulatory agencies involved with food'.

PMSEIC further observed that:

> The development of a consistent and whole-of-government approach to food will encourage understanding, communication and innovation in the food sector. Such an approach will be vital to respond to global and domestic food security challenges. A holistic approach to the food value chain could also result in the creation of new international markets for food and food technologies developed in Australia, as well as opportunities to export technologies and innovations to help address global food security issues.

A recent review by the Australian Bureau of Agricultural and Resource Economics (ABARE)[206] concluded that there is no immediate threat to Australia's domestic food supply but that Australia will increasingly be called on to play a role in ensuring global food security. The report observed that: 'Australia has an opportunity to share its technologies, institutional knowledge, agricultural policy and rural development capability with poorer nations through extension initiatives and aid programs. Collaborative agricultural research, particularly in the areas of

tropical and dryland agriculture, would benefit multiple stakeholders from a range of countries'. Development, testing and communicating an ecosystem services approach could be one important aspect of this global contribution.

It has been noted by some stakeholders in our interviews that DAFF has very little substantive engagement with core government policy beyond quarantine and customs, biosecurity and food security policies. This view overlooks DAFF's considerable role in Caring for Our Country.[13] Even within its core policy areas, there remain some significant mechanisms through which DAFF could influence application of an ecosystem services approach nationally. The recent discussion paper on a National Food Plan[72] points out that decisions on land-use planning and zoning, especially in relation to factor affecting access to arable land (e.g., the granting of mining licences and or urban development decisions) are primarily a state, territory and local government responsibility, but that the Australian Government has a role, through the *Environment Protection and Biodiversity Conservation Act 1999*, when proposed developments are likely to have an impact on matters of national environmental significance. Application of the *Environment Protection and Biodiversity Conservation Act 1999* requires the responsible minister to consult with other relevant ministers, including DAFF's minister. The recent review of the *Environment Protection and Biodiversity Conservation Act 1999* recommended a more strategic application using an ecosystem approach (see Chapter 6). This is an opportunity for DAFF to link its areas of policy interest into a broader ecosystem management agenda. A third opportunity comes from the current exploration of a national approach to collecting environmental information and inclusion of such information into a set of national accounts.[19, 235] The potential contributions of an ecosystem services approach to that process are being investigated and key people involved in that process have been interviewed as part of this project.

Perhaps the most substantial opportunity for DAFF to influence application of an ecosystem services approach in Australia is via food security policy. It was suggested by some interviewees that the current discussion paper for a National Food Plan[72] contains little reference to environmental issues. We note, however, that the discussion paper invites input from respondents on several aspects of environmental management: environmental sustainability and safety of food production; the capacity of natural resources, including fresh water, clean air and biodiversity, the influence of food production on the capacity of the environment to provide food and other ecosystem services; the influence of ecosystem services on development of the food industry over the short and long-term; implications of climatic factors for ongoing agricultural productivity growth; contributions by farmers, fishers, industries and the community to maintenance and improvement of natural resources; cost-effectiveness and prevention of environmental degradation; and helping farming and fishing enterprises improve their knowledge and skills and management practices to promote sustainable resource management. If these areas are developed in the ensuing National Food Plan it will provide a strong basis for integrating agriculture into national strategic thinking and planning about ecosystem-service based relationships between people and the environment.

Appendix I Some definitions of ecosystem services

Those who played key roles in the initial development and promotion of the concept of ecosystem services deliberately kept the definition broad so that the details could be developed by different stakeholder groups to suit their particular purposes. [74] This has led to a debate about whether or not standardised and more specific definitions are needed (see Section 4.1). Table 22 gives examples of some of the definitions that appear in key papers in the literature.

Table 22: Examples of how ecosystem services have been defined.

Source	*Definition*
Daily (1997)[74]	… conditions and processes through which natural ecosystems, and the species that are part of them, help sustain and fulfil human life
ESA (2000)[95]	… the processes by which the environment produces resources that we often take for granted such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants
Binning et al. (2001)[34]	… the transformation of a set of natural assets (soil, plants and animals, air and water) into things that we value. For example, when fungi, worms and bacteria transform the raw "ingredients" of sunlight, carbon and nitrogen into fertile soil this transformation is an ecosystem service
De Groot et al. (2002)[81]	… ecosystem functions [are defined] as 'the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly' [and] observed ecosystem functions are reconceptualized as 'ecosystem goods or services' when human values are implied. (This paper was one of the first attempts to separate intermediate processes from the final good and services received by humans so that typologies of ecosystem services can be aligned with economic and resource accounting approaches)
SEEA (2003)[229]	The System of Environmental-Economic Accounts (SEEA) is the statistical framework that provides internationally agreed concepts, definitions, classifications, accounting rules and standard tables for producing internationally comparable statistics on the environment and its relationship with the economy. The SEEA approach is being revised under the guidance of the United Nations Statistics Division.[231] In the current (2003) SEEA handbook, ecosystem services are not formally defined but the following distinction is made between ecosystem services and 'ecosystem inputs', which for an important part of environmental-economic accounts: 'There is an important distinction to be made between ecosystem inputs and ecosystem services. Ecosystem services are much wider and include the assimilative capacity of the environment and the provision of biodiversity. Ecosystem inputs are restricted to the substances absorbed from the ecosystem for purposes of production and consumption such as the gases needed for combustion and production processes as well as oxygen, carbon dioxide, water and nutrients. Unlike natural resources, ecosystem inputs are not easily identifiable in any of the products to which they contribute. Care must be taken not to count as ecosystem inputs any chemical substances, water, feeding stuff etc. which are a result of production'.

Source	*Definition*
Boyd and Banzhaf (2007)[42]	Final ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being (another example of a definition that distinguishes intermediate products from end-products)
IPCC (2007)[126]	… ecological processes or functions having monetary or non-monetary value to individuals or society at large
Fisher et al. (2008 and 2009)[101, 102]	… the aspects of ecosystems utilized (actively or passively) to produce human well-being … the end products of benefit to human welfare … [including] ecosystem organization (structure), operation (process), and outflows, if they are consumed or utilized by humanity either directly or indirectly
TEEB (2010)[210]	… the direct and indirect contributions of ecosystems to human well-being
Haines-Young and Potschin (2010)[114]	… the contributions that ecosystems make to human wellbeing, and arise from the interaction of biotic and abiotic processes
Maynard et al. (2010)[150]	Ecosystem functions are … the biological, geochemical and physical processes and components that take place or occur within an ecosystem Ecosystem services are … the benefits people obtain from ecosystems … [and] therefore the flows or outputs of [ecosystem] processes that are valued for their direct benefit to humans
Johnstone & Russell (2011)[128]	[Final ecosystem services are] biophysical outcomes which directly enhance the welfare of at least one human beneficiary Intermediate services … are those conditions or processes that only benefit humans through effects on other, final services
UK National Ecosystem Assessment (2011)[228]	… the benefits that we derive from the natural world and its constituent ecosystems
Lange (2011)[137]	The Wealth Accounting and Valuation of Ecosystem Services (WAVES) programme (World Bank, United Nations Environment Programme and various partners) is the mechanism by which ways to include environmental information into SEEA are being investigated

Appendix II Examples of ecosystem services typologies

Figure 26: Typology of ecosystem services and functions and potential indicators proposed by de Groot et al (2010).[77]

Services comments and examples	*Ecological process and/or component providing the service (or influencing its availability) = functions*	*State indicator (how much of the service is present)*	*Performance indicator (how much can be used/provided in sustainable way)*
Provisioning			
1 Food	Presence of edible plants and animals	Total or average stock in kg/ha	Net Productivity (in kcal/ha/year or other unit)
2 Water	Presence of water reservoirs	Total amount of water (m3/ha)	Max sust. water-extraction (m3/ha/year)
3 Fibre & Fuel & other raw materials	Presence of species or abiotic components with potential use for timber, fuel or raw material	Total biomass (kg/ha)	Net productivity (kg/ha/year)
4 Genetic Materials: genes for resistance to plant pathogens	Presence of species with (potentially) useful genetic material	Total ''gene bank'' value (e.g. number of species & sub-species)	Maximum sustainable harvest
5 Biochemical products and medicinal resources	Presence of species or abiotic components with potentially useful chemicals and/or medicinal use	Total amount of useful substances that can be extracted (kg/ha)	Maximum sustainable harvest (in unit mass/area/time)
6 Ornamental species and/or resources	Presence of species or abiotic resources with ornamental use	Total biomass (kg/ha)	Maximum sustainable harvest
Regulating			
7 Air quality regulation: (e.g. capturing dust particles)	Capacity of ecosystems to extract aerosols & chemicals from the atmosphere	Leaf area index NOx-fixation, etc.	Amount of aerosols or chemicals ''extracted''— effect on air quality
8 Climate Regulation	Influence of ecosystems on local and global climate through land-cover and biologically-mediated processes	Greenhouse gas-balance(esp. C-sequestration); Land cover characteristics, etc.	Quantity of Greenhouse gases, etc. fixed and/or emitted: effect on climate parameters

9 Natural Hazard mitigation	Role of forests in dampening extreme events (e.g. protection against flood damage)	Water-storage (buffer) capacity in m3	Reduction of flood-danger and prevented damage to infrastructure
10 Water regulation	Role of forests in water infiltration and gradual release of water	Water retention capacity in soils, etc. or at the surface	Quantity of water retention and influence of hydro-logical regime (e.g. irrigation)
11 Waste treatment	Role of biota and abiotic processes in removal or breakdown of organic matter, xenic nutrients and compounds	Denitrification (kg N/ha/y); Immobilization in plants and soil	Max amount of chemicals that can be recycled or immobilized on a sustainable basis.
12 Erosion protection	Role of vegetation and biota in soil retention	Vegetation cover Root-matrix	Amount of soil retained or sediment captured
13 Soil formation and regeneration	Role of natural processes in soil formation and regeneration	E.g. bio-turbation	Amount of topsoil (re)generated per ha/year
14 Pollination	Abundance and effectiveness of pollinators	Number & impact of pollinating species	Dependence of crops on natural pollination
15 Biological Regulation	Control of pest populations through trophic relations	Number & impact of pest-control species	Reduction of human diseases, live-stock pests, etc.
Habitat or supporting			
16 Nursery habitat	Importance of ecosystems to provide breeding, feeding or resting habitat for transient species	Number of transient species& individuals (esp. with commercial value)	Dependence of other ecosystems (or ''economies'')on nursery service
17 Genepool protection	Maintenance of a given ecological balance and evolutionary processes	Natural biodiversity (esp. endemic species); Habitat integrity (irt min. critical size)	''Ecological Value'' (i.e. difference between actual and potential biodiversity value)
Cultural & amenity			
18 Aesthetic: appreciation of natural scenery (other than through deliberate recreational activities)	Aesthetic quality of the landscape, based on e.g. structural diversity, ''greenness'', tranquility	Number/area of landscape features with stated appreciation	Expressed aesthetic value, e.g.: Number of houses bordering natural areas# users of ''scenic routes''
19 Recreational: opportunities for tourism and recreational activities	Landscape-features Attractive wildlife	Number/area of landscape & wildlife features with stated recreational value	Maximum sustainable number of people &facilities. Actual use
20 Inspiration for culture, art and design	Landscape features or species with inspirational value to human arts, etc.	Number/area of Landscape features or species with inspirational value	#books, paintings, etc. using ecosystems as inspiration

21 Cultural heritage and identity: sense of place and belonging	Culturally important landscape features or species	Number/area of culturally important landscape features or species	Number of people ''using'' forests for cultural heritage and identity
22 Spiritual & religious inspiration	Landscape features or species with spiritual & religious value	Presence of Landscape features or species with spiritual value	Number of people who attach spiritual or religious significance to ecosystems
23 Education & science: opportunities for formal and informal education & training	Features with special educational and scientific value/interest	Presence of features with special educational and scientific value/interest	Number of classes visiting Number of scientific studies, etc.

Box 9: Typology of ecosystem services from The Economics of Ecosystems and Biodiversity (TEEB) project.[210]

Provisioning Services are ecosystem services that describe the material outputs from ecosystems. They include food, water and other resources.

Food: Ecosystems provide the conditions for growing food – in wild habitats and in managed agro-ecosystems.

Raw materials: Ecosystems provide a great diversity of materials for construction and fuel.

Fresh water: Ecosystems provide surface and groundwater.

Medicinal resources: Many plants are used as traditional medicines and as input for the pharmaceutical industry.

Regulating Services are the services that ecosystems provide by acting as regulators eg regulating the quality of air and soil or by providing flood and disease control.

Local climate and air quality regulation: Trees provide shade and remove pollutants from the atmosphere. Forests influence rainfall.

Carbon sequestration and storage: As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues.

Moderation of extreme events: Ecosystems and living organisms create buffers against natural hazards such as floods, storms, and landslides.

Waste-water treatment: Micro-organisms in soil and in wetlands decompose human and animal waste, as well as many pollutants.

Erosion prevention and maintenance of soil fertility: Soil erosion is a key factor in the process of land degradation and desertification.

Pollination: Some 87 out of the 115 leading global food crops depend upon animal pollination including important cash crops such as cocoa and coffee.

Biological control: Ecosystems are important for regulating pests and vector borne diseases.

Habitat or Supporting Services underpin almost all other services. Ecosystems provide living spaces for plants or animals; they also maintain a diversity of different breeds of plants and animals.

Habitats for species: Habitats provide everything that an individual plant or animal needs to survive. Migratory species need habitats along their migrating routes.

Maintenance of genetic diversity: Genetic diversity distinguishes different breeds or races, providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock.

Cultural Services include the non-material benefits people obtain from contact with ecosystems. They include aesthetic, spiritual and psychological benefits.

Recreation and mental and physical health: The role of natural landscapes and urban green space for maintaining mental and physical health is increasingly being recognized.

Tourism: Nature tourism provides considerable economic benefits and is a vital source of income for many countries.

Aesthetic appreciation and inspiration for culture, art and design: Language, knowledge and appreciation of the natural environment have been intimately related throughout human history.

Spiritual experience and sense of place: Nature is a common element of all major religions; natural landscapes also form local identity and sense of belonging.

Table 23: Conceptual framework and typology adopted in a study of ecosystem services in southeast Queensland.[150]

Ecosystem reporting categories	*Ecosystem functions*	*Ecosystem services*	*Constituents of well-being*

Deep Ocean (Marine)	Gas Regulation (R)	Food (P)	Breathing (E)
Open Water—Pelagic (Coastal)	Climate Regulation (R)	Water for Consumption (P)	Drinking (E)
Open Water—Benthic (Coastal)	Disturbance Regulation (R)	Building and Fibre (P)	Nutrition (E)
Coral Reefs (Coastal)	Water Regulation (R)	Fuel (P)	Shelter (E)
Seagrass (Coastal)	Soil Retention (R)	Genetic Resources (P)	Physical Health (H)
Rocky Shores (Coastal)	Nutrient Regulation (R)	Biochemicals, medicines and pharmaceuticals (P)	Mental Health (H)
Beaches (Coastal)	Waste Treatment and Assimilation (R) Pollination (R)	Ornamental Resources (P)	Secure and Continuous Supply of Services (S)
Dunes (Coastal)	Biological Control (R)	Transport Infrastructure (P)	Security of Person (S)
Coastal Zone Wetlands (Coastal)	Barrier Effect of Vegetation (R)	Air Quality (R)	Security of Health (S)
Palustrine Wetlands (I. Water)	Soil Formation (R)	Habitable Climate (R)	Secure Access to Services (S)
Lacustrine Wetlands (I. Water)	Supporting Habitats (S)	Water Quality (R)	Security of Property (S)
Riverine Wetlands (I. Water)	Food (P)	Arable Land (R)	Family Cohesion (GSR)
Rainforests (Forest)	Raw Materials (P)	Buffering Against Extremes (R)	Community and Social Cohesion (GSR)
Schlerophyll Forests (Forest)	Water Supply (P)	Pollination (R)	Social and Economic Freedom (FCA)
Native Plantations (Forest)	Genetic Resources (P)	Reduce Pests and Diseases (R)	Self-Actualisation (FCA)
Exotic Plantations (Forest)	Provision of Shade and Shelter (P)	Productive Soils (R)	
Regrowth (Forest)	Pharmacological Resources (P)	Noise Abatement (R)	
Grasslands (Dryland)	Landscape Opportunity (C)	Iconic Species (C)	
Shrublands/Woodlands (Dryland)		Cultural Diversity (C)	
Moreton Island		Spiritual and Religious Values (C)	
Bribie Island		Knowledge Systems (C)	
North Stradbroke Island		Inspiration (C)	
South Stradbroke and other Bay Islands		Aesthetic Values (C)	
Montane (Mountain)		Affect on Social Interactions (C)	
Sugar Cane (Cultivated)		Sense of Place (C)	
Horticulture—small crops (Cultivated)		Iconic Landscapes (C)	
Horticulture—tree crops (Cultivated)		Recreational Opportunities (C)	
Other Irrigated Crops (Cultivated)		Therapeutic Landscapes (C)	
Dams (Urban)			
Hard Surfaces (Urban)			
Parks and Gardens (Urban)			
Residential Gardens (Urban)			

Key to categories: (P) provisioning; (R) regulating; (C) cultural; (E) existence; (H) health; (S) security; (GSR) good social relations; (FCA) freedom of choice and action (FCA).

Table 24: Ecosystem services classified according to their spatial characteristics (a type of classification that might assist landscape scale assessments and planning).[67]

Spatial characteristic	*Ecosystem services*
Global non-proximal (does not depend on proximity)	Climate regulation Carbon sequestration (NEP) Carbon storage Cultural/existence value
Local proximal (depends on proximity)	Disturbance regulation/ storm protection Waste treatment Pollination Biological control Habitat/refugia
Directional flow related: flow from point of production to point of use	Water regulation/flood protection Water supply Sediment regulation/erosion control Nutrient regulation
In situ (point of use)	Soil formation Food production/non-timber forest products Raw materials
User movement related: flow of people to unique natural features	Genetic resources Recreation potential Cultural/aesthetic

Table 25: Ecosystem services classified according to their excludability and rivalness (a type of classification that might suit some economic assessments).[67]

	Excludable	*Non-excludable*
Rival	Market goods and services (most provisioning services)	Open access resources (some provisioning services)
Non-rival	Club goods (some recreation services)	Public goods and services (most regulatory and cultural services)

Appendix III Rules for identifying 'final' ecosystem services

Box 10: Operational guidelines for developing ecosystem services typologies.[128]

Rule One: Willingness to Pay
For biophysical outcome h to serve as an ecosystem service for beneficiary j, changes in h must influence the welfare of beneficiary j, so that a fully informed, rational beneficiary j would be willing to pay for increases in h rather than go without.
(If Rule One is satisfied for outcome h and beneficiary j, Rule Two is invoked to further distinguish between outputs of biophysical production and outputs of human production).

Rule Two: Natural Outputs
For biophysical outcome h to serve as an ecosystem service for beneficiary j, h must represent the output of an ecological system prior to any combination with human labour, capital or technology.
In combination with Rule One, Rule Two is invoked to distinguish whether the valued output in question satisfies the standard definition of an ecosystem service.
(Assuming these conditions hold, Rule Three is then invoked to determine status as a final versus intermediate service to a specific beneficiary).

Rule Three: Direct Benefits
For endpoint h to serve as a final ecosystem service for rational beneficiary j, the beneficiary must be willing to pay for increases in h, assuming that all other ecosystem outputs and conditions i not equal to h are held constant.
(Rules One, Two and Three – when appropriately applied – account for the fact that the capacity of specific ecosystem outcomes to provide final services can depend on the presence or absence of other ecosystem outcomes).

Rule Four: Services to All Beneficiaries
An ecosystem outcome h can also simultaneously represent both a final service to beneficiary j and an intermediate service to another beneficiary $n \neq j$. To avoid double counting, only benefits of final services should be counted and aggregated, where final services are identified by Rules One, Two and Three.
(Rule Four requires that one treat each beneficiary identically using Rules One through Three, thereby measuring and aggregating only the benefits of (e.g., willingness to pay for) final ecosystem services. It ensures consistent aggregation and avoidance of double counting whether one considers one or multiple beneficiaries, thereby providing a theoretically-consistent welfare measure).

Appendix IV Major international ecosystem services projects and activities

Table 26: Ecosystem services related activities globally in 2011 (this is a selected summary as there are many activities underway).

(Note: Unlike other parts of this report, citations are given within this table, to make it easy for readers to go to web sites)

Title	*Agency*	*Scope/Timeframe*	*Description*	*Reference/Web Links*
Millennium Ecosystem Assessment (MA)	1400 leading scientists	Global	Important milestone report that highlighted the dependence of human wellbeing on ecosystems; identified global decline in the world's ecosystem services and promoted Payment for Ecosystem Services (PES) as a promising tool (positive incentives) to motivate ecosystem-hosting communities to restore damaged ecosystems and sustain the supply of critical service.	MA website www.MAweb.org
Intergovernmental Platform on Biodiversity and Ecosystem Services	IPBES	Global – 1st Plenary October 2011 in Nairobi, Kenya	Aim is to provide an authoritative independent channel that meets the needs of policymakers for the best available science on biodiversity and ecosystem services, drawing on multidisciplinary expertise. A blueprint for governance with strong capacity building program.	www.ipbes.net also Perrings *et al.* 2011 in Science http://www.sciencemag.org/content/331/6021/1139.summary
ICSU Program on Ecosystem Change and Society (PECS)	International Council for Science/ UNESCO	Global – established 2008	New 10 year research program with a mission to foster coordinated research into the dynamic relationship between humans and ecosystems. Research projects use the Millennium Ecosystem Assessment framework. Key question: 'How do policies and practices affect resilience of the portfolio of ecosystem services that support human well-being and allow for adaptation to a changing environment?'	http://www.icsu.org/what-we-do/interdisciplinary-bodies/pecs/ NB PECS will provide scientific knowledge to IPBES. International programme office for PECS to be established in Stockholm in 2011.
Strategic Plan for Biodiversity	Convention on Biological	Global – adopted in	Development of national targets, updating and revising national	Information on the Strategic Plan

Title	*Agency*	*Scope/Timefr ame*	*Description*	*Reference/Web Links*
2011-2020 – including the 20 Aichi Biodiversity Targets	Diversity (CBD)	Nagoya, Japan in October 2010	biodiversity strategies and action plans, via capacity building workshop 2011-12. Aichi Biodiversity Targets explicitly include ecosystem services as a strategic goal	www.cbd.int/sp2020 Workshop Information www.cbd.int/nbsap . Aichi Targets at www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf.
Earth Summit Rio +20	Rio Conventions CBD, UNFCCC and UNCCD.	Global 2012	Taking stock of progress. The implementation of ecosystem-based approaches for adaptation and mitigation and the integration of biodiversity and sustainable land management considerations into relevant climate change adaptation and mitigation plans and strategies will require enhanced cooperation and increased synergies.	Find Rio+20 website & description Ecosystem and Climate Change Pavilion http://www.ecosystemspavilion.org/themes/57-economics-of-ecosystem-services-and-biodiversity-climate-change-and-sustainable-land-management
The Economics of Ecosystems and Biodiversity (TEEB)	Hosted by UNEP, supported by EC, Germany, UK, Netherlands, Norway, Japan and Sweden	Global 2007 - ongoing	TEEB is a major Payments for Ecosystem Services project at the National Level, working to provide a comprehensive global assessment and a compelling economics case for the conservation of ecosystems and biodiversity. Project Leader Pavan Sukhdev visualizes a new form of economy, which quantifies natural capital and thus makes the ecosystem the supplier of capital, and a new entity in public and private markets. TEEB proves taking 'natural capital' into account could help countries on a global level, enhancing quality of life and boosting the economy at a local level.	Websites: http://teebweb.org/ ; http://bankofnaturalcapital.com/2010/10/05/payments-for-ecosystem-services-at-the-national-level/ ; http://www.earthscan.co.uk/tabid/102729/Default.aspx. 'The logical next step for countries interested in utilising the potential of their natural capital and 'ecosystem services' is to conduct studies of their own natural resources and implement new policies that focus on their benefits and

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
				use.'
IUCN's Commission on Ecosystem Management CEM	International Union for Conservation of Nature (IUCN)	2009 - 2012 intercessional plan	Ecosystem Services is one of 20 priority themes. Objectives: to improve the knowledge base on ecosystem services and values and stimulate integration of this in planning and decision-making for sustainable Ecosystem Management through case studies and guidelines. Theme leader is Rudolf de Groot, Wageningen University.	Commission on Ecosystem Management www.iucn.org/about/union/commissions/cem/
The Ecosystem Services Partnership (ESP)	IUCN CEM	Global 2008 – ongoing	A platform created to stimulate collaboration between scientists and practitioners, rapidly becaming an important tool for exchange of recent initiatives and achievements on ecosystem services. Coordinated since 2009 by CEM ES-Theme Lead Dolf de Groot.	See ESP www.es-partnership.org
FAO Report on Payments for Ecosystem Services and Food Security	UN Food and Agriculture Organisation (FAO)	Global July 2011	Fighting hunger and achieving food security for all is at the heart of FAO's efforts. Biological diversity and the related ecosystem services are seen to be of pivotal importance. In 300 pages, this recent report examines: the role of Payments for Ecosystem Services (PES) in agriculture; relevance of the OECD agri-environmental measures; implementation opportunities and gaps; cost-effective targeting; social and cultural drivers behind the success of PES; landscape labelling approaches to PES through bundling services, products and stewards; enabling conditions and complementary legislative tools; and PES within the context of a green economy.	For full report, see www.fao.org/docrep/014/i2100e/i2100e00.htm or http://www.fao.org/docrep/014/i2100e/i2100e00.htm
OECD Green Growth Strategy	Organisation for Economic Cooperation and Development (OECD)	Global From 2012 - ongoing	From 2012 the OECD will mainstream green factors, integrating green growth considerations in Economic Surveys, Environmental Performance Reviews and Innovation Reviews. Designed to help countries foster economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which	Green Growth Strategy announced at July 2011 OECD Ministerial Council Meeting (http://www.oecd.org/dataoecd/62/59/48302542.pdf), 15 Apr 2010, the OECD's Development

Title	Agency	Scope/Timefr ame	Description	Reference/Web Links
			human well-being relies. Putting environmental factors into top level judgments of national economies is potentially a big step towards sustainability.	Assistance Committee endorsed a Policy Statement on Integrating Biodiversity and associated Ecosystems Services into development co-operation www.oecd.org/dataoecd/37/52/46024461.pdf
A major World Bank report – Biodiversity, ecosystem services, and climate change : the economic problem.	The World Bank	2010 - 2011	The Millennium Ecosystem Assessment categories of ecosystem services used to measure impact on human wellbeing by the change in ecosystem services caused by climate-related change in biodiversity. Similarly, the role of species richness/abundance in climate change mitigation or adaptation is measured by the change in the climate-related services of biodiversity. Insights from the economic treatment of the relation between biodiversity and ecosystem services then re-evaluate the connection between biodiversity and climate change, and draw conclusions for climate policy.	Short account at: http://go.worldbank.org/845IAO8WV0 Entire Report at http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/05/10/000333038_20110510232037/Rendered/PDF/581650revised000000Economic0Problem.pdf
Scoping workshop on biodiversity and ecosystem services, organised by APN, held at Tokyo United Nations University.	Asia-Pacific Network for Global Change Research (APN) ICSU Regional Office for Asia and the Pacific	Asia Pacific February 2011 - ongoing	The workshop analysed gaps in biodiversity and ecosystem services research to identify priority areas of research for future APN funding (new activity). The analysis identified research and policy needs and areas of activity where APN can be expected to 'make a difference considering that the Asia-Pacific region is a densely populated region where human coexistence with nature are heavily affected by changes in the environment.'	http://www.icsu.org/icsu-asia/news-centre/news/icsu-roap-and-the-apn-workshop-on-biodiversity-and-ecosystem-services-in-asia-and-the-pacific
FFPRI Symposium	Forestry and Forest Products Research Inst. & Japan's Environmental Research Inst (Waseda	Global Forests 2010 - ongoing	Symposium on the role of forest biodiversity in the sustainable use of ecosystem goods and services in agro-forestry, fisheries and forestry. Aims were to show 1) how forest biodiversity affects ecosystem services which may benefit	FFPRI http://astp.jst.go.jp/modules/event_meeting/index.php?content_id=193

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
	University)		agriculture, fisheries and forestry, 2) what causes forest biodiversity loss from ecological, social or economical aspect and 3) how multidisciplinary scientists can together monitor forest biodiversity in order to share their findings with non-scientists, including policy makers.	
Common International Classification of Ecosystem Services for Integrated Environmental and Economic Accounting (CICES)	*London Group and SEEA revision process*	National and international accounts 2009 - ongoing	As a contribution to the review of the Systems of Environmental-Economic Accounts (SEEA), a classification and framework for assessing ecosystems in SEEA has been developed by the London Group. This has drawn on several international meetings, to which Australia contributed through the ABS and BoM. It appears likely that this will become a formal or informal international standard.	London Group on Environmental Accounting. (2012)[141] http://unstats.un.org/unsd/envaccounting/londongroup/

Appendix V Major recent research and other activities relating to ecosystem services in Australia

Table 27: Major recent research and other activities relating to ecosystem services in Australia.

(Note: Unlike other parts of this report, citations are given within this table, to make it easy for readers to go to web sites).

Title	*Agency*	*Scope/Timeframe*	*Description*	*Reference/Web Links*
National Projects on Ecosystem Services				
National Ecosystem Services Strategy (NESS) and National Ecosystem Services Network (NESN)	Australia 21	National 2005 - ongoing	A major report entitled A National Strategy on Ecosystem Services (NESS) was released in 2008, following a series of expert roundtables in Queensland, South Australia, Canberra and Western Australia. The Australia21 team then called for development of an Australia-wide Ecosystems Services Network to bring together key stakeholders from across the nation to ensure that ecosystems services are properly valued and supported by the Australian economy.	See www.australia21.org.au Documents describing the Strategy and the Network concepts can be found here http://www.australia21.org.au/aust_land_ecosystem_services.htm
Ecosystem Services Working Group Report to the NRM Ministerial Council	NRPCC working group under direction from the NRM Ministerial Council	National 2008	This report was produced to provide a national overview of the development and uptake of Ecosystem Services approaches to decision-making within Australian government NRM agencies. The questions underpinning the report are varied and many including definitions, measurement, policy application and the relationship between ecosystem services thinking and other ways of thinking about the interactions between humans and the natural environment. Incorporating Ecosystem Services thinking in environmental/NRM decision-making processes is potentially a significant enhancement in terms of completeness, robustness and sustainability of outcomes.	http://trove.nla.gov.au/work/34215211 (archived at National Library of Australia) Available at: http://www.environment.gov.au/biodiversity/publications/ecosystem-services-nrm-futures/index.html. http://www.environment.gov.au/biodiversity/publications/ecosystem-services-nrm-futures/pubs/ecosystem-services.pdf The ecosystem services concept has been used successfully in Australia and internationally as a way to focus on natural resource

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
				management (NRM) priorities at catchment, regional, national and global scales and to link and report on the relationship between the environment and human well-being.
Various articles, fact sheets, opinion pieces on Ecosystem Services	Australia Museum	2003	In Australia, the Australian Museum (2003, p. 1) argued that: Ecosystem services maintain the atmosphere, provide clean water, control soil erosion, pollution and pests, pollinate plants, and much more. Their total annual value in Australia has been estimated by CSIRO to be $1327 billion...	Cited by Phillips and Lowe (2005): Australian Museum. 2003. Fact Sheets: Ecosystem Services. Australian Museum, Sydney. Online at: http://www.amonline.net.au/factsheets/ecosystem_services.htm
Seed funding for a national project on ecosystem services	The Myer Foundation, CSIRO, Land & Water Australia	June 1999 to June 2003	The Myer Foundation. CSIRO and Land & Water Australia provided funds for a project that aimed to provide a detailed assessment of the goods and services coming from a range of Australian ecosystems, an assessment of the consumers and consumption of these services, and an evaluation of the economic costs and benefits of the services under future management scenarios. The project sought to provide information that is relevant and useful to policy writers and decision makers. It produced a range of products, spawned a number of collaborative projects and performed one major case study in the Goulburn Broken catchment (later in this table)	http://www.ecosystemservicesproject.org/ http://lwa.gov.au/products/ef051059 Cork S. J., Proctor W., Shelton D., Abel N. & Binning C. (2002) The ecosystem services project: Exploring the importance of ecosystems to people. Ecological Management & Restoration 3, 143-8 Involved CSIRO and a wide range of land managers, community groups, land management agencies, scientists and economists.
National Invertebrate Pest Initiative - Managing ecosystem services and pests in broadacre landscapes	CSIRO Australian Grain	2009	To help grain growers manage their crop pests, the National Invertebrate Pest Initiative has been set up with the support of the Grains Research and Development Corporation. NIPI pulls together scientists from state government departments, universities, farmer groups and CSIRO and its coordinator is Dr Gary Fitt from CSIRO Entomology. Australian Grain will be presenting articles reviewing the current knowledge of invertebrate	http://www.ausgrain.com.au/Back%20Issues/191mjgrn09/15_Managing.pdf

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
			pests – and their management in Australian grain systems.	
Managing ecosystem services in broadacre landscapes: what are the appropriate spatial scales?	CSIRO	2009	Article on ecosystem services is a summary of a paper by Nancy Schellhorn, Sarina Macfadyen, Felix Bianchi, David Williams and Myron Zalucki on Managing ecosystem services in broadacre landscapes: what are the appropriate spatial scales? in the Australian Journal of Experimental Agriculture 48 (12): 1549–1559 one of a suite of papers published in special edition	http://www.csiro.au/files/files/prpe.pdf Farming Ahead July 2009 No. 210 www.farmingahead.com.au
Staying ahead of the pests: responses to future tropical and sub-tropical biosecurity threats	The Crawford Fund	Queensland 2009	Biosecurity research will enable us to face some of the food security challenges that will arise in Queensland and throughout the world. Pests and diseases threaten food security directly through reduction of crop and livestock yields, loss of export markets due to quarantine measures (e.g. Foot and Mouth Disease), costs of switching to alternative production systems and losses of ecosystem services required for sustainable food production.	http://www.crawfordfund.org/resources/articles/buckley.html
National Market Based Instrument Forum	Federal Govt	August 2011	Forum included talk of agriculture sector's capacity to participate in ecosystem services markets by ABARES' Philip Townsend. Research gaps identified include valuing and trading the full complement of ecosystem services (bundling and stacking) as well as net environmental gain instead of single services. Research into engaging the private sector in NRM through markets was a priority for many, particularly how the Carbon Farming Initiative might produce biodiversity co-benefits from investments in carbon bio-sequestration. The necessity of quantifying ecosystem services and consistent environmental accounting standards was also a common theme.	http://www.marketbasedinstruments.gov.au/News/tabid/181/ArticleType/ArticleView/ArticleID/52/Default.aspx
Caring for Country	Federal Govt		*T*his major Australian Government initiative seeks to achieve an environment that is healthy, better protected, well-managed and resilient, and "provides essential ecosystem services in a changing climate". In practice, few true ES projects appear to be funded at present.	http://www.nrm.gov.au
'National roundtable for ecosystems	Australian Bureau of	23 May 2011	The 'task group' should adopt the definition previously used by NRPPC – "Social capital, in this context, refers to	http://www.marketbasedinstruments.gov.au/Events/tabid/110/

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
services'	Statistics?		the networks, relationships, values and informal sanctions that shape the quantity and cooperative quality of a society's social interactions" Australian Public Service Commission, 2007). The Australian Bureau of Statistics (ABS) has developed Social Capital Framework for measuring aspects of social capital. Networks are considered integral to social capital and appear as the central feature of the ABS Social Capital Framework, along with 4 key societal conditions that shape social capital: Culture and Political, Legal and Institutional.	Mid/1329/ItemID/44 /ctl/Details/Default.aspx?selecteddate=23 /05/2011
Vegetation and Ecosystem Services				Richard Thackway - National vegetation attributes for linking vegetation type and condition to the delivery of ecosystem services Rhiannon Smith - Ecosystem service provision by native vegetation and trade-offs with grazing http://www.esa2010.org.au/Detailed%20program.pdf
Pollination as an ecosystem service	University of Queensland	Coastal Queensland 2008 2009	Liz Law, a graduate student in my lab, is starting a project to study the impacts of different cultivation practices and landscape structures on the pollination of Macadamia by native and wild insects. The goal is to improve our understanding of the factors involved in maintaining this key ecosystem service in coastal Queensland.	http://www.uq.edu.au/uqresearchers/researcher/mayfieldm.html?uv_category=int
Plant Community Ecology of fragmented tropical landscapes		Dr Margaret Mayfield	Research on understanding how forest fragmentation impacts the plant communities found in tropical landscapes. In particular, how functional diversity, ecosystem services and ecosystem function are influence by forest fragmentation across landscapes. Collaborative reforestation experiment in North Queensland. The goal of this	

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
			project is to identify reforestation methods that maximize the return of native biodiversity while allowing for profits through global carbon markets.	
Rainforest reforestation for biodiversity and Carbon sequestration		North Queensland 2009		
Socio-Economics and the Environment in Discussion (SEED) working paper	CSIRO	28 Apr 2008	The Socio-Economics and the Environment in Discussion CSIRO Working Paper Series aims to bring together environmental socio-economic research from across CSIRO. Working paper number 2008-03, deals with Ecosystem Services	http://www.csiro.au/resources/SEEDPaper13.html
State and Regional Projects on Ecosystem Services				
Ecosystem Services Framework for South East Queensland	SEQ Catchments Ltd	South East Queensland 2008 - ongoing	The SEQ Ecosystem Services Framework (Australia) aims to provide the tools to enable government, industry, business, researchers, non-government organizations and land managers to apply the concept of ecosystem services in their planning and management practices. Matrices and maps identify and illustrate the linkages between ecosystems, ecosystem functions, ecosystem services and community wellbeing. These maps can identify areas in the region where the most ecosystem services are generated. This allows areas to be considered as valuable natural assets, deserving appropriate protection measures or significant offsets if they are diminished or degraded in any way.	Maynard, James and Davidson (2010) The Development of an Ecosystem Services Framework for South East Queensland. Environmental Management
Natural assets: an inventory of ecosystems goods and services in the Goulburn-Broken catchment.	CSIRO Sustainable Ecosystems, Canberra	Goulburn-Broken Catchment, N. Vic. Regional 2001	The difficulty faced by natural resource managers is how to prioritise and manage for the full range of benefits provided by ecosystems. One method for identifying the full range of goods/products provided by ecosystems in the Goulburn Broken catchment, and a means of identifying, classifying and prioritising the role of ecosystem services in both transforming natural assets into those goods/products, or breaking down the by-products of those transformations	Binning C, Cork S, Parry R, Shelton D (2001) http://www.ecosystemservicesproject.org/html/publications/docs/application_of_ecosystem_approach.pdf. Also GBCMA & CSIRO, 2000
Wetland Tender Project	Glenelg Hopkins CMA	Glenelg Hopkins Catchment, Victoria	This region has over 5400 wetlands (44% of Victoria's total), mainly on private land, providing multiple ecosystem services: water purification,	http://www.ghcma.vic.gov.au/news/article/wetlands-tenders-due

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
River Tender Project ***and*** ***Sustainable Farming Practices***			flood mitigation, carbon sequestration and native wildlife conservation (incl. threatened spp like brolgas & blue-billed ducks). Under Wetland Tender, successful landholders (offering the best-quality outcomes for the investment) receive periodic payments for management activities under signed five-year agreements. Landholders manage threats to wetlands on their property eg. drainage, grazing, removal of vegetation, weeds and pests, excess nutrients, rubbish, salinity and competition for limited water resources.	http://www.ghcma.vic.gov.au/media/uploads/WetlandTenderFactSheetWeb.pdf http://www.marketbasedinstruments.gov.au/MBIsinaction/Currentcasestudies/WetlandTenderProgram/tabid/373/Default.aspx
			This CMA has two Caring for Country Sustainable farm practises projects, soil acidification and woodlands protection, to improve delivery of ecosystem services, such as capacity to produce food and fibre, clean air, water, healthy soils and biodiversity conservation'.	http://www.ghcma.vic.gov.au/media/uploads/Probity_Report_1745x.pdf
			Glenelg Hopkins CMA recently (Aug 2011) committed $360,000 towards landholder incentive payments over the next five years under the RiverTender voluntary incentive program, funded via Victorian Government's Victorian Water Trust Healthy Rivers Initiative (no mention of ecosystem services).	http://www.ghcma.vic.gov.au/land/sustainable-farm-practices/ http://www.ghcma.vic.gov.au/news/article/rivertender-a-popular-choice
Queensland Terrain	Far north Queensland		"A policy model for community-grounded biodiversity offset management within an NRM framework". The aim of the project is to enhance the capacity of regional communities to utilise MBIs through a case study which will develop a policy model for regional biodiversity offset management that can be used to catalyse capacity improvement in other NRM regions. Objectives include a specific draft policy on biodiversity offset management for the Wet Tropics region and an enhanced capacity across the region for applying biodiversity offsets to maintain	Contact: Allan Dale, Rowena Grace

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
			and protect ecosystem services. Terrain intends to position itself as a broker for offsets occurring in the Wet Tropics, and this project will help the group improve its capacity as an adviser and broker, particularly in the management of biodiversity offsets.	
Ecosystem Services in SA Riverland Citrus Orchards	CSIRO, Australian Landscape Trust and citrus growers,	South Australian Riverland 1998 – 2003/present?	Project outcomes included indicators of ecological sustainability, and data leading to better understanding of key ecosystem services. A baseline survey of soil biodiversity was done in a range of citrus orchards - two properties in each category: organic, pesticide- free, conventional and high-tech. Quarterly quantitative monitoring of soil invertebrates was conducted from August 1998 to August 1999 on the 8 properties within the area between Waikerie, Loxton and Paringa. The key ecosystem services investigated - pest control and nutrient cycling - are of economic value to citrus growers and delivered by components of soil biodiversity. NB Subsequent work, the first study to quantify the rate of recovery of an invertebrate-driven soil hydrological ecosystem function following revegetation, investigated the ecosystem function of water infiltration to tree root zones and channels, delivered by invertebrates that form soil macropores.	Coloff *et al.* 2003 http://www.ecosystemservicesproject.org/html/publications/docs/soil_final_report.pdf Coloff et al 2010 http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2010.00667.x/full
Ecosystem Services through Land Stewardship Practices: Issues and Options.	Victorian Catchment Management Council/Dept of Sustainability and Environment	Victoria 2003	This early paper refined the concept of Land Stewardship and its relation to the basic responsibilities. Issues and options relating to the 'payment' idea are explored, current land use is reviewed in relation to social and environmental trends and changing community expectations and broad-scale support for sustainability are discussed. Available ways to support change are reviewed, including a focus on market based instruments which led to the concept of payment for ecosystem services. .	VCMC/DSE (2003) DSE, Melbourne See http://www.vcmc.vic.gov.au/Web/Docs/LandStewardI&O.pdf
Gwydir Ecosystem	Australian Cotton CRC,	Gwydir, Namoi and Border	Aims of Gwydir Ecosystem Services	Nick Reid

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
Services in Cotton	Gwydir Valley Irrigators Association and Natural Heritage Trust	Rivers catchments, NSW 2001	Project were: to gauge the most important ecosystem services to the Gwydir community; to assess the vulnerability and ease of management of the various ecosystem services; to develop analytical approaches and tools to assess ecosystem services; and to assess the ecological, economic and social impact of changes in delivery of priority ecosystem services A subproject investigated the ecosystem services underpinning and affected by cotton production in the Gwydir catchment, developing ecological and economic models to quantify and value changes in management that affect the provision of ecosystem services important to the cotton industry. Role of native vegetation in harbouring beneficial insects in cotton growing areas in the Gwydir, Namoi and Border Rivers catchments was investigated. A DWLC subproject led by Dr Brian Wilson into the maintenance of soil health, nutrient conservation and impacts on deep drainage of different land uses and vegetation types (e.g. remnant woodland, regrowth, native pasture, sown pasture and cropping) in the middle Gwydir catchment..	Francis Karanja http://une-au.academia.edu/Karanja/Papers/246151/Evaluating_the_impact_of_integrated_catchment_management_interventions_on_provision_of_ecosystem_services_using_GIStions_on Francis Karanja has developed a model which uses changes in land and water management to identify which practices will have the greatest ecological and economic impact on a catchment. NB Check for any links to DLWC's Environmental Services scheme that piloted the use of environmental stewardship payments to landowners who change management in order to deliver specified environmental outcomes in the public interest
Biodiversity and Ecosystem Services Associated with Native Vegetation in an Agricultural Landscape'	University of New England	Lower Namoi Cotton 2010	Rhiannon Smith's PhD quantified eight ecosystem services provided by native vegetation, including carbon storage, erosion mitigation and biodiversity conservation on cotton farms on the lower Namoi floodplain. River red gum sites were by far the highest carbon storage in the landscape, storing 216	Rhiannon Smith PhD http://www.cottoncrc.org.au/content/Industry/People/Featured_Achiever/Rhiannon_Smith.aspx Postgraduate: The

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
			tonnes of carbon per hectare. Rhiannon's results will assist cotton grower's value and manage native vegetation for ecosystem services. Non-crop ecosystems comprise a substantial proportion of many cotton farms and the likelihood that natural and revegetated areas will contribute significant income streams in the medium term through emerging markets in carbon and biodiversity is high. "Ecosystem services generated by native vegetation on cotton farms therefore have the potential to contribute directly to the farm's income."	Ecosystem Service Value of Native Vegetation on Cotton Farms of the Namoi Floodplain http://www.cottoncrc.org.au/content/Catchments/Noticeboard/Media/Value_of_es.aspx NB This research is some of the first in the world to evaluate several ecosystem services across a large study area with a variety of vegetation types and climatic conditions
South Australian BushBids Program	South Australian Murray Darling Basin Natural Resource Management Board	South Australia 2006-2011	In its fifth year in South Australia, BushBids has enhanced the protection and improvement of biodiversity and ecosystem values in the remaining 10 percent of remnant vegetation within the Eastern Hills of the South Australian Murray Darling Basin region, without increased financial burden to landholders. Landholders receive a Payment for Environmental Services (PES) and society as a whole receives the ecosystem services (nature's life support services) through conservation. Currently there are two BushBids projects running successfully - Eastern Mount Lofty Ranges BushBids and Woodland BushBids.	http://www.marketbasedinstruments.gov.au/MBIsinaction/Currentcasestudies/BushBidsProgram/tabid/354/Default.aspx Contact SAMDB NRM Board Biodiversity principal project officer Sarah Lance.
Ecosystem Servi in the Wimmerc	CSIRO	Victorian Mallee Feb 2006	A large research project conducted in partnership with The Arthur Rylah Institute for Environmental Research, Victorian DSE (ARI), CSIRO Sustainable Ecosystems (CSE) and the Birchip Cropping Group (BCG), with NHT and the National Action Plan for Salinity and Water Quality funding through the North Central and Mallee CMAs. This report presents a conceptual framework to describe the interactions amongst highly valued ecosystem services and native vegetation assets (natural capital), including how changes in vegetation condition affect the delivery of ecosystem services.	http://www.bcg.org.au/resources/Rpt2_wimmera_ecosyetem_services_descriptions_submitted2.pdf David Freudenberger CSIRO Sustainable Eco

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
Queensland's Protected Areas, Forests and Wildlife	Qld Dept Env and Resource Management (DERM)	Queensland	Ecosystem services for human populations, such as fresh air, clean water and productive soils and oceans, are among the benefits of protected areas, forests and wildlife are	http://www.derm.qld.gov.au/parks_and_forests/managing_parks_and_forests/management_plans_and_strategies/pdf/master-plan/overview.pdf
Scenario Planning for sustainable land use in the Namoi	Namoi CMA and the Ecosystem Services Research Group	2010	Paper included the strategy of continui natural resource management and con development paradigms closer togethe take a lead in thinking about how envir management might be integrated with and social objectives (e.g. ecosystem s markets), have a strong input to policy and be ready to get in early to reap fin environmental and social benefits once policies emerge	Ecosystem Services Research Group (2010) Social – Ecological Resilience of. Cultural Landscapes. International Workshop 15-15 June 2010 Also Cork and Delaney 2007 and 2009 http://www.namoi.cma.nsw.gov.au/scenario_planning_report_dec09.pdf
Other Ecosystem Services Related Issues				
Managing water in agriculture to deal with trade-offs and find synergies among food production and other ecosystem services.		National 2009	. Agricultural Water Management 97, 512–519.	Gordon, L., Finlayson, C.M. and Falkenmark, M. 2009
Water management	National Water Commission	Floodplains 2009	Floodplain ecosystems: resilience, value of ecosystem services and principles for diverting water from floodplains	http://www.nwc.gov.au/www/html/2528-floodplain-ecosystems-resilience-value-of-services-and-principles-for-diverting-water
A Framework for Determining Commonwealth Environmental Watering Actions.	Department of Environment, Water, Heritage and the Arts	National legislation 2007 - ongoing	The Water Act 2007 defines environmental assets as water-dependent ecosystems, ecosystem services, and sites of ecological significance. Water-dependent ecosystems include wetlands, streams, floodplains, lakes and other bodies of water, salt marshes, estuaries, karst,	DEWHA 2009

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
			and groundwater systems.	
Track	Charles Darwin University	Tropical Australia	This project provides assessments of the potential impacts of future development scenarios on the ecosystem services of Australia's tropical rivers.	www.track.gov.au/publications/registry/774
Approaches for measuring and accounting for ecosystem services	Bureau of Resource Sciences	National 2007	Report summarises the approaches developed for measuring and accounting for the ecosystem services provided by vegetation in Australia. Also contains excellent list of key current ecosystem services projects and activities	Maher and Thackway (2007) NB See Appendix A in http://adl.brs.gov.au/brsShop/data/ecoservices_acc.pdf
Natural pest control provided by predatory insects	CSIRO	Cotton landscapes 2008	Dr Felix Bianchi and Dr Nancy Schellhorn (CSIRO) work on the ecosystem service of natural pest control provided by predatory insects. Preliminary results suggest that native vegetation in the cotton landscapes is important and provides habitats for predatory insects. Research shows beneficial insects are using native vegetation habitats, moving into crops and attacking pests early in the cotton season. Having a diversity of habitats is important for agricultural ecosystem services as this allows flexibility throughout the year and in changing environments. This work is on going with more trials planned in the next cotton-growing season.	1.http://www.cottoncrc.org.au/content/Catchments/Noticeboard/Media/Knowledge_of_Nature.aspx 2.http://www.greenmountpress.com.au/cottongrower/Back%20issues/295ybcot08/S6/82_Nature.pdf 3.http://www.cottoncrc.org.au/files/f7dab364-5c80-4194-951f-9ef500cc70dd/ACPM2011_14_ReducePesticide_.pdf
Impact of rainforest insects on North Queensland Crops	CSIRO (Entomology that was)	Atherton Tableland North Queensland	Research will assess the relative value of services and dis-services flowing from rainforest insects to north Queensland crops (including pollination, natural enemies of herbivore pests and the dis-service of damage to crops by herbivores. A key variable will be distance from rainforest. Very little is currently known of the identity, origin and role of native insect pollinators, predators and parasites in tropical crops. This project aims to estimate the economic value of these services by comparing natural processes with the cost of artificial substitution, pest control costs and production losses. The project will also provide recommendations on land-use options that may enhance the value of such services.	http://www.ecosystemservicesproject.org/html/case_studies/Atherton4.html http://www.ecosystemservicesproject.org/html/publications/docs/facts/Atherton_Insects_poster.pdf Rosalind BLANCHEa, Saul CUNNINGHAMband Rob FLOYDb; aCSIRO Entomology, Atherton Qld 4883; bCSIRO Entomology

Title	Agency	Scope/Timeframe	Description	Reference/Web Links
Market for Ecosystem Services in Australia: practical design and case studies		Australia	The use of market-based approaches to provide and protect ecosystem services in has gained significant attention in Australia.	Whitten, S. and Shelton, D. (2005) www.cifor.org/pes/publications/pdf_files/Whitten-Australia.pdf
Examining links between soil management, soil health, and public benefits in agricultural landscapes: An Australian perspective	University of Melbourne, Victorian Department of Primary Industries, Victorian Department of Sustainability and Environment	Concept study: Australian perspective	Conceptual and case study links were examined between soil properties and processes, soil-based services, and private and public net benefits. In this framework, benefits were produced from services, and were considered a more tangible point for public understanding and valuation than services. The qualitative case study highlighted many knowledge gaps relating to non-agricultural services and benefits from soils, particularly in the scaling- up of sub-paddock measurements, and in the form and constancy of relationships among services and benefits. Criteria for identifying priority public benefits from soil management were examined.	Bennett L. T., Mele P. M., Annett S. & Kasel S. (2010) Examining links between soil management, soil health, and public benefits in agricultural landscapes: An Australian perspective. Agriculture, Ecosystems & Environment 139, 1-12, <http://linkinghub.elsevier.com/retrieve/pii/S0167880910001714>.

Appendix VI Alternative typologies for soil ecosystem services

There has been increasing interest in identifying and classifying the ecosystem services from soils. The following figure and table illustrate two of these attempts.

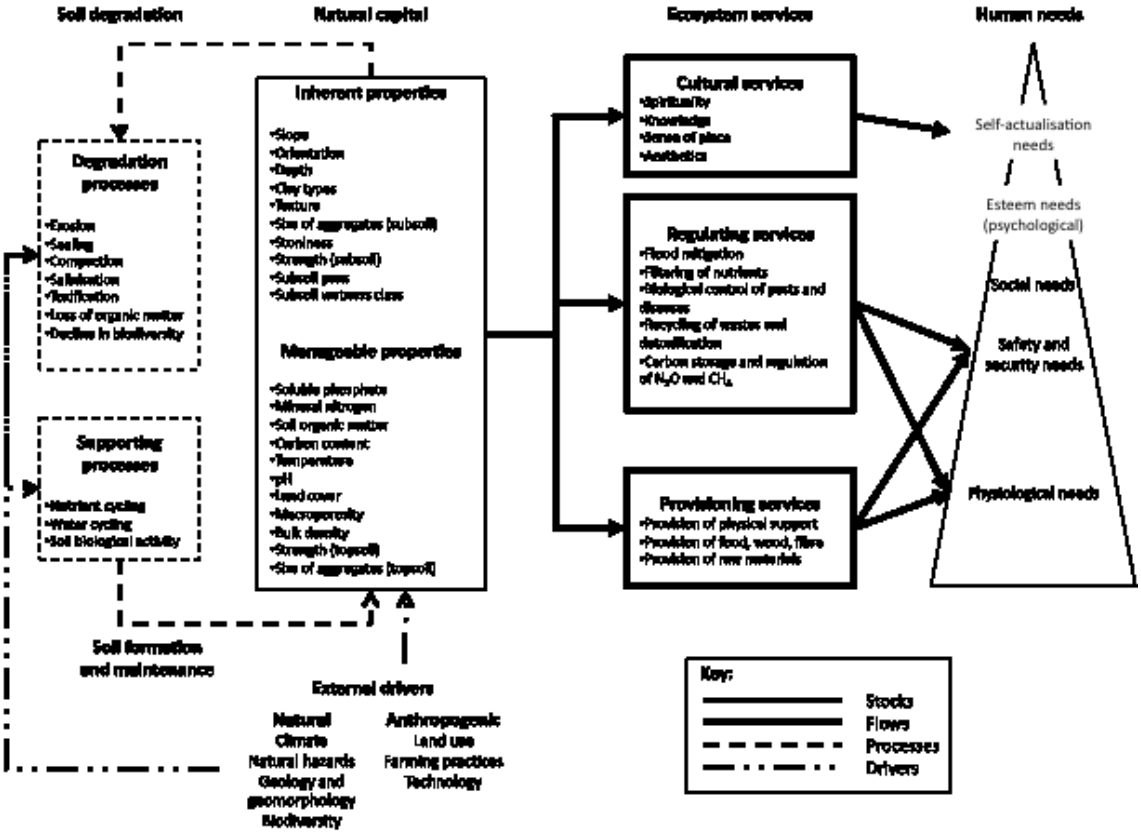

Figure 27: Framework for the provision of ecosystem services from soil natural capital (from Dominati et al. 2010[85]

Table 28: The Robinson et al. (2010 and 2012)[196] alternative way of categorizing soil natural capital

Natural capital	Measurable or quantifiable soil stock
Mass	
Solid	***inorganic material: mineral stock and nutrient stock***
	organic material: organic matter and C stocks and organisms
Liquid	***soil water content***
Gas	***soil air***
Thermal energy	***soil temperature***
Biomass energy	***soil biomass***
Organization–entropy	
Physicochemical structure	***soil physicochemical organization, soil structure***
Biotic structure	***biological population organization, food webs, and biodiversity***
Spatiotemporal structure	***connectivity, patches, and gradients***

Appendix VII Insights about actions needed to facilitate an ecosystem services approach

Table 29: Recommendations and insights, from various authoritative sources, about applying an ecosystem services approach.

Note that this is a synthesis of published ideas, and the approaches are not necessarily recommended by the authors of this report.

Source	*Recommended actions*
Archer (2008)[8] Proposal for a National Ecosystem Services Scheme and a National Stewardship initiative for Australia	Establish a National Ecosystem Services Scheme (ESS), including a National Stewardship initiative. The ESS would be voluntary, implemented on marginally productive land and paid as a performance-based, annual cashflow stream utilising a range of Market-Based Instruments (MBI's). Farmers would be encouraged to identify their least productive land (e.g., riparian zones, acidic or saline soils, remnant vegetation, water logged areas, wind swept ridge lines, highly eroded or degraded sites). They would manage these marginal areas to deliver ecological goods and services (e.g., carbon, water, biodiversity or soil related). These ecological goods and services would generate environmental 'credits' that would entitle the farmer to an annual cashflow stream, with ongoing payment predicated on the continued delivery of environmental benefits to a standard of peer reviewed industry best management practice which were over and above the farmer's 'environmental duty-of-care'. Australia should establish a National Stewardship Initiative, using seed capital from Government, with a clearly defined process and timetable for moving to a self-funded model. It aims should be to: a. engage all stakeholders; b. develop targeted R&D tax concession programmes to assist the private sector to best allocate R&D funding; c. design robust MBI's incorporating national Best Management Practice (BMP) standards; consider in detail all funding options; create a communications strategy for end users and land managers to promote the ESS and its benefits. The benefit to Government, land managers, taxpayers and the environment is a more cost- effective delivery of landscape scale ecosystem services and preservation. It would also provide national oversight of the collective work that is being undertaken, ensure corporate knowledge is retained and remove many of the underlying factors that contribute to the current piece meal approach. The Initiative's charter should include the establishment of: a National Stewardship Centre that contributes to ecosystem solutions and knowledge through innovative, interdisciplinary approaches to applied research, development, extension, practice and market engagement; a National Stewardship Framework to ensure rigour, integrity and consistency in the development of all ecosystem initiatives; and appropriate sites to undertake R&D and demonstrate the principles of the Initiative by show casing working rural landscapes delivering triple bottom line results.
Australia21 (2008)[9] Proposal for a National	Key activities within a national ecosystem service strategy should be: 1. Developing and using information about ecosystem services; 2. Strengthening the rights of local people to use and manage ecosystem services; 3. Managing ecosystem services across multiple levels and timeframes; 4. Improving the evaluation, accreditation and monitoring of

Source	Recommended actions
Ecosystem Services Strategy	ecosystem services using the work that has been extensively developed in Australia on Environmental Management Systems within the agricultural industry; 5. Aligning economic and financial incentives with ecosystem stewardship and sustainable management.
Boyd & Banzhaf (2007)[42] Standardized approach to environmental accounting that includes ecosystem services	Environmental accounting frameworks require at least three things: 1. Definition and measurement of quantities (e.g., ecosystem services and benefit units); 2. Aggregation of the quantities (a process that requires information on the relative importance of different ecosystem services); 3. Gathering of information on the relative importance of different units (services) to support the aggregation process (e.g., estimation of willingness to pay for ecosystem services in place-based scenarios comparing decision options); 4. Depreciation of ecosystem assets, including intermediate assets and processes that are not ecosystem end-products but affect those end-products. The authors argue that developing biophysical models to predict changes in the stream of future ecosystem services is important but that the most progress can be made by first improving measurement of current services.
Carpenter et al (2009)[47] The research agenda	Recent research has been addressing the basic science needed to assess, project, and manage flows of ecosystem services and effects on human well-being. Yet, our ability to draw general conclusions remains limited by focus on discipline-bound sectors of the full social–ecological system. At the same time, some polices and practices intended to improve ecosystem services and human well-being are based on untested assumptions and sparse information. The people who are affected and those who provide resources are increasingly asking for evidence that interventions improve ecosystem services and human well-being. New research is needed that considers the full ensemble of processes and feedbacks, for a range of biophysical and social systems, to better understand and manage the dynamics of the relationship between humans and the ecosystems on which they rely. Such research will expand the capacity to address fundamental questions about complex social–ecological systems while evaluating assumptions of policies and practices intended to advance human well-being through improved ecosystem services.
Cosier & McDonald (2010)[66] Approach to national environment accounts	A system of environmental (ecosystem) accounts should be built around a common unit of measure which is capable of assigning a value for all environmental assets and indicators of ecosystem health. The adoption of a system of environmental (ecosystem) accounts based on reference condition benchmarks creates this common currency for ecosystem health. This means that an environmental asset, such as a forest, can have both a monetary value and an ecological value. The result is a transparent system of accounting where the impact of economic activity (both positive and negative) on environmental health can actually be measured.
Daily & Matson (2008)[75] Priorities for advancing the concept of ecosystem services	Advances are required on three key fronts: the science of ecosystem production functions and service mapping; the design of appropriate finance, policy, and governance systems; and the art of implementing these in diverse biophysical and social contexts. Scientific understanding of ecosystem production functions is improving rapidly but remains a limiting factor in incorporating natural capital into decisions, via systems of national accounting and other mechanisms. Novel institutional structures are being established for a broad array of services and places, creating a need and opportunity for systematic assessment of their scope and limitations. Finally, it is clear that formal sharing of

Source	Recommended actions
	experience, and defining of priorities for future work, could greatly accelerate the rate of innovation and uptake of new approaches.
Mooney (2010)[153] The ecosystem-service chain and the biological diversity crisis	The losses that are being incurred of the Earth's biological diversity, at all levels, are now staggering. The political processes for matching this crisis are now inadequate and the science needs to address this issue are huge and slow to fulfil. A more integrated approach to evaluating biodiversity in terms that are meaningful to the larger community is needed that can provide understandable metrics of the consequences to society of the losses that are occurring. Greater attention is also needed in forecasting likely diversity-loss scenarios in the near term and strategies for alleviating detrimental consequences. At the international level, the Convention on Biological Diversity must be revisited to make it more powerful to meet the needs that originally motivated its creation. Similarly, at local and regional levels, an ecosystem-service approach to conservation can bring new understanding to the value, and hence the need for protection, of the existing natural capital.
Perrings et al (2011)[177] Commentary on the establishment of the IPBES? And the relationship between governance and research	A critical lesson from the Global Biodiversity Assessment, the Millenium Ecosystem Assessment, and the IPCC is that assessments should evaluate consequences of real policy options. This requires closer integration of the different elements of the science-policy process—research, monitoring, assessment, and policy development. Research uncovers mechanisms that explain how biodiversity change impacts ecosystem services and human well-being. Monitoring records trends in indicators of change. Assessment reports scientific evidence of change and evaluates mitigation, adaptation, or stabilization options identified by policy-makers. Policy selects the “best” response. The blueprint for the recently establishment Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) includes all of these elements but concerns are being raised about whether the body can remain sufficiently independent of governments to test policy options generated by researchers and not necessarily put on the table by those governments. This concern is equally relevant for any government-established approaches to ecosystem services research and development and/or assessment of policy options.
Seppelt et al. (2011)[205] Quantitative review of ecosystem services studies	Employing the ecosystem service concept is intended to support the development of policies and instruments that integrate social, economic and ecological perspectives. In recent years, this concept has become the paradigm of ecosystem management. A diversity of approaches has been taken and there has been a lack of consistent methodology. The holistic ideal of ecosystem services research includes: (i) biophysical realism of ecosystem data and models; (ii) consideration of local trade-offs; (iii) recognition of off-site effects; and (iv) comprehensive but critical involvement of stakeholders within assessment studies. These four facets should be taken as a methodological blueprint for further development and discussion to critically reveal and elucidate what may often appear to be ad-hoc approaches to ecosystem service assessments.
Searle & Cox (2009)[204] The State of Ecosystem Services	Experience suggests that four factors determine whether an ecosystem services conservation program successfully changes behavior and achieves impact: clear science, defined benefit, confined system, and good governance.

Source	Recommended actions
Steffen et al. (2009)[209] Research agenda and learning from the past	An important way to gain better understanding of the effects of management decisions on ecosystem services, and especially the potential trade-offs between ecosystem services, is to embed research and its evaluation as an interactive part of the policy and management process from its initiation. Ideal candidates for using such an approach are policies currently developed that afcets tradeoffs among food production, carbon storage, biodiversity, recreation, and water resources.
Ecosystem Services Partnership (global)[88]	The Ecosystem Services Partnership (ES-Partnership) was launched in 2008 by the Gund Institute for Ecological Economics (University of Vermont, USA) and is now being coordinated by the Environmental Systems Analysis Group (Wageningen University, the Netherlands), supported by the Netherlands Environmental Assessment Agency (Bilthoven, the Netherlands) and the Foundation for Sustainable Development (Wageningen, the Netherlands). The ES-Partnership aims to enhance communication, coordination and cooperation, and to build a strong network of individuals and organizations. ES-Partnership will enhance and encourage a diversity of approaches, while reducing unnecessary duplication of effort in the conceptualization and application of ecosystem services. By raising the profile of ecosystem services and promoting better practice, the ES-Partnership will also increase opportunities for financial support and help focus the funding of individual organizations for more efficient utilization of existing funds. The ESP is an institutional membership organization. Governance will be by a steering committee elected by the members. It will set the priorities for ES-Partnership activities and ensure that the ES-Partnership runs smoothly. Feedback from some members suggests that this governance approach is a major strength as it minimises the chance of the partnership being dominated by political imperatives.

Appendix VIII SWOT analysis

Table 30 presents a strengths, weaknesses, opportunities and threats (SWOT) analysis for applying an ecosystem services approach within the Australian government. We have focussed on the Australian Government because we expect that this will be the immediate concern of DAFF as a result of this report and because broadening the analysis to include all sectors of Australian society would make for a very complex and confusing table. Most of the principles would apply to other sectors but the details would differ.

Table 30: Strengths, weaknesses, opportunities and threats associated with applying an ecosystem services approach within the Australian Government.

Strengths (benefits)	*Weaknesses (costs)*
More efficient and effective policy through better strategic thinking and planning based on all types of capital underpinning human wellbeing Improved communication between government departments once a common framework and agreed definitions are in place Efficient and effective engagement with stakeholders once agreed principles and a framework are in place Avoidance of criticism that food and population policy are not linked with environmental and social policy sufficiently well Potential to provide a robust basis for policies that cut across multiple departments (e.g., population, water and food policy) Constructive engagement with stakeholders, including recognition of the value of stakeholders' contributions and less time dealing with disaffected interest groups)	Initially high transaction costs to get agreement on principles and framework across departments if the approach proposed is overly detailed and specific High transactions costs to involve a wide range of stakeholders in understanding and agreeing to a set of principles and a framework Increased transaction costs associated with whole of government strategic interactions around an ecosystem services approach Will require increased investment in key research to establish the benefits quantitatively and enable measurement to get to the point where regulations, incentives and markets can develop around multiple ecosystems services apart from carbon sequestration, water and aspects of biodiversity conservation
Opportunities (potential benefits)	***Threats (risks)***
True long term sustainability for Australia Increased support and respect for government's role in leading Australia forward through the next few difficult decades New market opportunities for land managers Increased recognition of the role of agriculture and regional communities in Australia's long term sustainability strategies A more nutritious food supply, the costs of which are fully factored in to a long term sustainability strategy	Resistance and potential loss of goodwill from other departments and some stakeholders if the intent and assumptions behind the approach are not well explained Alienation of some stakeholders if the intent and assumptions behind the approach are not well explained or are not in line with stakeholder views and interests Ecosystem services might lose its popularity among other countries' governments (this risk can be minimised by building the principles of an ecosystem services approach into policy so that language can be changed if necessary without changing intent and underlying processes)

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