

THE NATURE AND VALUE OF ECOSYSTEM SERVICES IN AUSTRALIA

Steven J. Cork

CSIRO Sustainable Ecosystems, GPO Box 284, Canberra, ACT 2602, AUSTRALIA. (Current address: Land and Water Australia, GPO Box 2182, Canberra ACT 2601, Australia, steve.cork@lwa.gov.au)

ABSTRACT

In 1999, a team from Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) initiated a project, with major funding from a philanthropic agency (The Myer Foundation), to assess the nature and value of ecosystem services in a set of ecosystems across the country. This initiative has grown to become an alliance of 10 loosely coordinated projects and a large number of institutions that are sharing skills and experiences in an effort to address the substantial challenges of research on this topic. In the most advanced study, in the Goulburn Broken Catchment of south-eastern Australia, the approach taken has involved an initial inventory of what services are provided to people by the catchment's ecosystems, a semi-quantitative assessment of which services are in danger of critical decline in relation to the catchment's commercial and other land-uses, development of a set of scenarios for the catchment's future that take account of the full range of ecosystem services, and an integrated ecological-economic-social analysis that focuses on those scenarios. All steps are performed in full partnership with community leaders from the catchment so that they and the research team learn together and develop shared understanding of the issues and the scientific inputs to solutions. Value judgements (economic or otherwise) about ecosystem services are limited by insufficient and/or poorly communicated scientific knowledge, poor community understanding of natural systems and their benefits, and inappropriate laws, regulations, incentives and other institutional arrangements. Therefore, our ecological-economic-social analyses have been embedded in community participation and learning processes, including citizens' juries. An emerging new component of the project focuses on development of markets for ecosystem services.

INTRODUCTION

Concern has been growing over the last half century as evidence of decline in the world's ecosystems grows and ecologists, economists and other social scientists debate the underlying socio-economic causes. More than ever before in human history, people living in cities have lost their awareness of their reliance on natural ecosystems for food, regulation of the atmosphere and climate, purification of water, provision of building and raw materials for industry, protection from pests, diseases and extreme weather, and for cultural, spiritual and intellectual stimulation and fulfillment (i.e. ecosystem services: Figure 1). Thus, it is not surprising (but still disturbing) that many children in the USA, when asked in a recent survey where milk comes from, replied without hesitation: "from the grocery store" (Salzman 1997).

Added to this lack of understanding (often termed "information failure") are two other major "failures". Humans generally are unable to comprehend complex systems like the ecological-social ones we live in, and our attempts to correct problems often make them worse (intervention failure) (Sterman, 2000). Furthermore, society's rules, rights and responsibilities (institutions) with respect to management of the natural environment are sometimes lacking and often unclear and inconsistent, which inhibits investment in maintenance of natural resources and encourages abrogation of responsibilities (market and institutional failure) (Pearce and Moran 1994; Ostrom and Sclager 1996; Daily 1997; Costanza and Folke 1997; Heal, 2000).

In 1999, Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and The Myer Foundation started a project to bring together researchers and stakeholders from various institutions and communities around Australia to explore the use of the concept of ecosystem services to address some of the issues discussed above. The "Ecosystem Services Project" is now a multi-partner initiative that draws on theory from ecology, the physical sciences, economics, political, policy and other social sciences.

THE CONCEPT OF ECOSYSTEM SERVICES

The concept of ecosystem services has been developing gradually for over a century as a way to recognise the dependence of human societies on nature-based systems (Daily 1997). Daily (1997) defined ecosystem services as "... the conditions and processes by which natural ecosystems, and the species that make them up, sustain and fulfil human life". In the Ecosystem Services Project we see a focus on "services" as a way to put scientific and economic research into the language and concepts of everyday life for people without specialist training in these disciplines. Just as services provided by businesses need to be described and marketed in language that consumers understand and identify with, so ecosystem services need to be expressed in relation to the perceptions of the general public if that public is to value the services. This means that the ecosystem services identified by stakeholders often do not match precisely the way ecologists would describe ecosystem processes. The challenge for the scientists in this project, then, is to establish the bridge between the public perceptions of services and values and the theory underpinning the disciplinary approaches to ecosystem analysis.

Various authors in Daily (1997) give examples of ecosystem services. These include not only life support services like maintaining air and water quality, flood protection, pollination and control of pests, but also life-fulfilling services like provision of cultural, spiritual and intellectual stimulation and maintenance of other species for their existence value. Cork and Shelton (2000) cite some studies on Australian systems.

THE ECOSYSTEM SERVICES PROJECT

The aims of the Project include:

- increasing awareness and understanding of ecosystem services among members of society;
- exploring the value of ecosystem services (in economic and other terms) to people in relation to real decisions and challenges;
- investigating new mechanisms and institutional arrangements for recognising and making better use of these values;
- providing information in a form that will support decision making, especially at a catchment scale.

Currently more than eight case studies around Australia are cooperating in the initiative (Figure 1; Cork et al. 2001; www.ecosystemservicesproject.org). These include ecosystems in temperate and tropical Australia, a range of rainfall regimes from wet to arid, and land uses including agriculture, forestry, water production, recreation, and conservation.

We have developed a framework for analysis of ecosystem services at a range of scales in partnership with stakeholders. The approach has the following elements:

- a semi-quantitative inventory of what ecosystem services are present, how they are being used, and what is happening to them under current land use regimes;
- identification of major decision scenarios for the future;
- quantitative and qualitative economic, social and ecological assessments of decisions and exploration of new options;
- engaging in a wide-ranging communication effort to both raise awareness and increase understanding of ecosystems services among decision makers and engage them in dialogue about how the project should proceed and what outputs would be used in decision making.

An emerging component of the project, not discussed further in this paper, involves analysis of institutional arrangements and exploration of new mechanisms for gaining greater value from ecosystem services.

Most importantly, key knowledge holders from the catchment communities have been involved as partners from the start to facilitate shared learning using local, as well as specialist scientific, knowledge.

In the following sections, I report progress on these components with respect to the most advanced case study, in the Goulburn Broken catchment of Victoria. Other case studies are proceeding at varying rates. More details of the approach and progress in case studies can be found in Binning et al. (2001), Cork et al (2001), Shelton et al. (2001) and at www.ecosystemservicesproject.org.

THE GOULBURN BROKEN CATCHMENT

Often referred to as the “food bowl” of Australia, the Goulburn Broken Catchment is located in the north of the State of Victoria, in southeastern Australia (Figure 1; www.gbcma.vic.gov.au/). The Catchment is diverse in terms of land-use, consisting of an irrigated region in the north (270,655 ha in size) primarily made up of horticulture (fruit) and irrigated dairy pasture, a central dryland grazing and cropping region (1,397,130 ha in size), and a southern high country area valued for its timber, tourism and recreational uses (690,603ha in size). Approximately two-thirds of the catchment has been cleared for agriculture. The catchment population is 190,000 people, of which 17,000 are employed in agriculture and associated industries. Population is growing in the southern shires, which are within two hours drive of Melbourne. This is leading to increased interest in the land for rural lifestyle living, cheaper housing and new industries. Victoria has implemented a system of Catchment Management Authorities, appointed by government to represent the catchment communities and integrate policy and decision making at a catchment scale. In this project, we saw the Goulburn Broken Catchment Management Authority and the community representatives associated with it as our major stakeholders and partners.

INVENTORY OF ECOSYSTEM SERVICES IN THE GOULBURN BROKEN CATCHMENT

An economic, social and biophysical profile for the catchment was derived from data from the Australian Bureau of Statistics and an input-output analysis of the catchment. Qualitative assessments of interactions between ecosystem services and land-uses were derived as expert judgements using staff from CSIRO, other research institutions, government land management agencies, industries, and other stakeholders (Binning et al. 2000; Shelton et al. 2001). Participants were asked to identify what goods and services of value come from the catchment’s ecosystems and to judge the impacts of marginal changes in the ecosystem services or land uses. Interactions between services and land uses were judged to be high priority for future investigation if either: (1) a marginal change in the service is likely to have a substantial impact on delivery of valued products from the land use, or; (2) a marginal change in the land use is likely to negatively impact on the ecosystem service. This was essentially a process to engage a wide range of stakeholders in thinking about the catchment’s values and challenges and to identify where we should focus more detailed quantitative analyses. We documented the reasoning of the participants to provide hypotheses that could be assessed by readers and tested experimentally if necessary. We also commissioned a set of issues papers from experts in various fields of ecology to link existing knowledge and theory with the set of ecosystem services identified by stakeholders and with the reasoning behind the assessments (Binning et al. 2001; www.ecosystems-services.org).

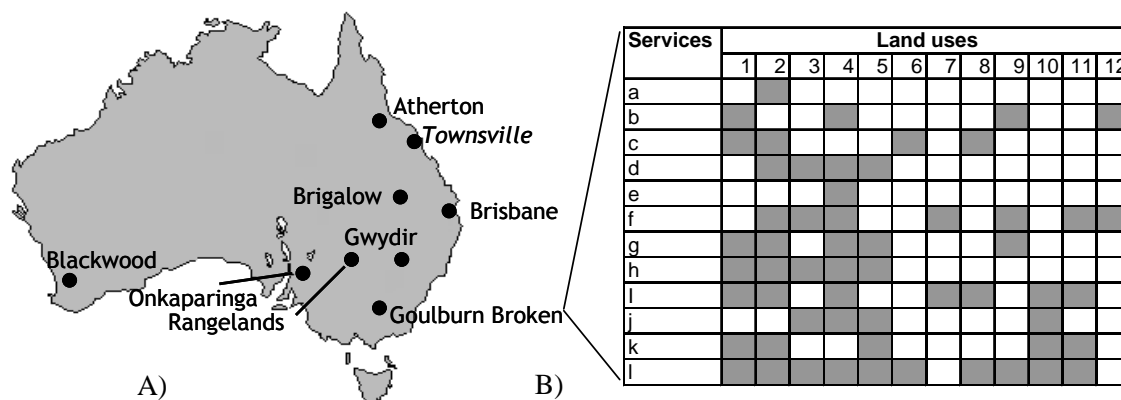


Figure 1: A) Location of case studies cooperating in the Ecosystem Services Project. B) Summary of ecosystem services inventory for the Goulburn Broken catchment. Shaded cells are high-priority interactions between ecosystem services (rows) and land uses (columns) as judged by expert opinion. Key to column headings: 1 – Dairying, on farm; 2 - Fruit and grapes; 3 – vegetables; 4 – Grazing; 5 – crops; 6 – Intensive Animals; 7 – Forestry; 8 – Food processing; 9 – Housing; 10 – Water production; 11 – Recreation; 12 – Areas of cultural/future options. Key to row headings: a – Pollination; b – Life fulfilment; c – Regulation of climate; d – Pest control; e – Provision of genetic resources; f – Maintenance of habitat; g – Provision of shade & shelter; h – Maintenance of soil health; i – Maintenance of healthy waterways; j – Water filtration and erosion control; k – Regulation of rivers and groundwater; l – Waste absorption and breakdown.

Twelve major ecosystem services were identified and assessed against 12 groupings of land-uses and industries (Figure 1). Some ecosystem services, i.e. pollination, are very important to a wide range of land uses but only appear to be of high priority as defined above for one or a few. Other services, like waste absorption and maintenance of soil health, appear to be at high priority points for most land uses.

DECISIONS, SCENARIOS AND ECONOMIC-ECOLOGICAL-SOCIAL ANALYSES

The inventory process also identified decisions and issues facing the catchment in the next 10-50 years and beyond. These included:

- re-establishing part of the floodplain of the lower Goulburn River by redirecting flow away from the main channel;
- alternative strategies for managing vegetation across the catchment;
- options for enhancing cultural values and growing the tourism and recreation industries in the upper catchment;
- intensification of some industries with possible offsets on other land uses;
- management of combinations of land uses to enhance value to communities at a catchment scale

The research challenges that the above issues pose include: exploring the costs and benefits of ecosystem services (such as water filtration, flood control, maintenance of soil fertility, and natural pest control) compared with technological alternatives (such as water filtration facilities, levee banks and application of fertilisers and pesticides); assessing non-market values (e.g. aesthetic, cultural and biodiversity values); assessing economic returns from public investment in land use change under current institutional arrangements (compared with possible improvements like development of markets for some ecosystem services); and, exploring ways to consider whole ecological-social systems and interactions among ecosystem services and land-use options.

Our approach has been to combine ecological modelling with a range of economic valuation methods focussing on a set of sub-projects within the Goulburn Broken Catchment study corresponding with several of the major challenges listed above. The economic valuation techniques being used include input-output analysis, traditional benefit-cost analysis, and various approaches to assessing non-market values. A multi-criteria decision framework is being used to organise the economic and other assessments (Proctor 2001; Proctor & Drechsler, 2003) and to clarify the decision options.

Fundamental to our approach is the recognition that awareness and understanding of ecosystem services is limited among people at all levels of decision making and that application of economic valuation methods without processes to increase this understanding merely measures the values arising from current understanding which, we argue, are leading often to undervaluation of ecosystem services. Therefore, we are exploring other processes, like citizens' juries and deliberative polls, that allow stakeholders and decision makers to come together with technical experts to consider existing knowledge and uncertainties before making value judgements (Proctor 2001; Proctor & Drechsler, 2003; www.ecosystemservicesproject.org). To focus our use of quantitative ecosystem modelling, we are putting considerable effort into defining the issues that need to be resolved by stakeholders, to define the research questions, and avoid the need to build all-purpose models that rarely answer specific questions adequately.

Priorities for managing ecosystem services in the upper catchment

The presence of numerous water bodies and waterways, together with native and planted forests and proximity to the large city of Melbourne, mean that tourism and recreation are increasingly popular in the upper catchment and compete with forestry, grazing and other industries for land and ecosystem services. This sub-project aimed to both inform decision makers and identify their priorities for management of ecosystem services in relation to different options for tourism and recreation in the upper catchment. A deliberative process based on citizens' juries was used, aided by multi-criteria evaluation (Proctor & Drechsler, 2003). The jury consisted of a set of key decision makers involved in a range of aspects of natural resources management in the catchment. These jurors were provided with input from scientific experts on a suite of economic, social and ecological criteria (Table 1), which included consideration of a wide range of ecosystem services. The jurors were able to question these experts over a one day period. They were then asked to assess the decision options in relation to the criteria and to reach consensus on the ranking of the options.

The jurors placed overwhelming importance on only four of the nine ecosystem services considered (maintenance of water health, water quality, biodiversity, and aesthetic values). The process demonstrated that decisions on natural resource

management can be very different when information on a full range of ecosystem services is available. It also demonstrated to the researchers and the decision-makers the importance of identifying the right questions to be asking and having the right information available in an appropriate form as part of the decision process.

Table 1: Impact matrix for five options for management of the upper Goulburn Broken catchment. Decision criteria are listed in the lefthand column followed by the indicator used to assess the criteria. The quantitative and qualitative values assigned to the criteria from available data and expert judgment form the body of the table. The options are: 1. Continue current land uses; 2. Maximise ecosystem services; 3. Maximise social benefits; 4. Maximise economic benefits; 5. Sustainable tourism, environment, society mix. (From Proctor and Drechsler, 2003).

Decision criteria	Indicator	Options				
		1. Current	2. Max ES	3. Max Soc	4. Max Ec	5. Mix
Ecosystem Services:						
Water Quality	mg/l P	0.02	0.005	0.05	0.1	0.0
Water Quantity	Discharge	150	250	100	125	150
	10 ⁹ l					
Biodiversity	QI ¹	6	10	3	5	10
Sediment	QI	3	8	6	8	8
Filtration						
Erosion Control	QI	7	10	7	4	7
Nutrient	QI	3	8	7	3	8
Management						
Shading	QI	5	10	6	2	8
Stream Health	ISC ²	35–41	42–50	35–41	26–34	35–41
Aesthetics	QI	5	8	6	2	7
Social and Cultural:						
Public Access	QI	5	1	7	10	5
Jobs	'000	15	18	20	25	18
Cultural/Heritage	BI ³	0	1	1	0	1
Sites ⁴						
Education ⁴	BI	0	0	1	0	1
Economic:						
Costs	\$mill	2.5–3.5	0	2.5–3.5	0	18.3
Benefits	\$mill	5.5–6.5	0	6.4–49	4.3–40.1	9–57.3

¹Qualitative Index: High = 10, Low = 1

²ISC = Index of Stream Condition: Very Poor = 0–19, Poor = 20–25, Moderate = 26–34, Good = 35–41, Very Good = 42–50

³Binary Index: 1 = present, 0 = not present

⁴These were added during the stakeholder jury.

Vegetation scenarios in the mid catchment

The mid catchment, which includes the transition from the hilly upper catchment to the flat dryland farming areas, faces significant problems related to salinity, erosion and river health, and loss of biodiversity related to past clearing of vegetation. However, it also provides pleasant views and recreation/ lifestyle opportunities related to remaining vegetation. Vegetation management, including re-vegetation, is a priority for the catchment managers.

This sub-project aims to quantify the relationships between vegetation systems and ecosystem services and to evaluate changes in the delivery of ecosystem services under various proposed or contemplated scenarios for vegetation management. Key ecosystem services were identified from the inventory phase and with consideration of their ability to be influenced by changes in vegetation cover and the availability of data to support the analysis. Scenarios of varying amount and types of vegetation (native and introduced) within the study area were developed using design rules relevant for salinity control, biodiversity enhancement, fodder production, cropping and farm forestry. Quantitative process models were developed based on relationships between the delivery of each ecosystem service and each of the vegetation types. Ecosystem services were not modelled directly. Instead, indicators of the key services were modelled (Table 2). Economic

analyses are proceeding to estimate the benefits and costs of each vegetation scenario with respect to the ways in which ecosystem services impact on cropping, grazing and farm forestry.

Table 2: Indicators used to model ecosystem services outcomes in vegetation management scenarios

Key ecosystem services	Indicator of service (the focus for modelling)
Climate regulation	Carbon sequestered
Maintenance and regeneration of habitat	Habitat score
Provision of shade and shelter	Shaded area versus water competition tradeoff
Maintaining health water ways	Water yield, salt and nutrient loads
Water filtration and erosion control	Erosion risk, length of stream susceptible to bank erosion
Regulation of river flows and ground water	Water yielded to aquifer
Maintenance of soil health	Soil acidity risk, buffering capacity, remediation costs

Floodplain scenarios

In the late 1990s, the Goulburn Broken Catchment Management Authority prepared a benefit:cost analysis that showed the benefits from agriculture in the northern part of the floodplain of the Goulburn River near Shepparton were considerably outweighed by the costs of maintaining flood-protection levee banks and paying compensation when the banks failed in large floods. The aim of the floodplain sub-project is to explore the ecosystem services implications of different scenarios for managing this floodplain, including removal of the levee banks and various ways in which the land could be managed for agricultural and conservation objectives.

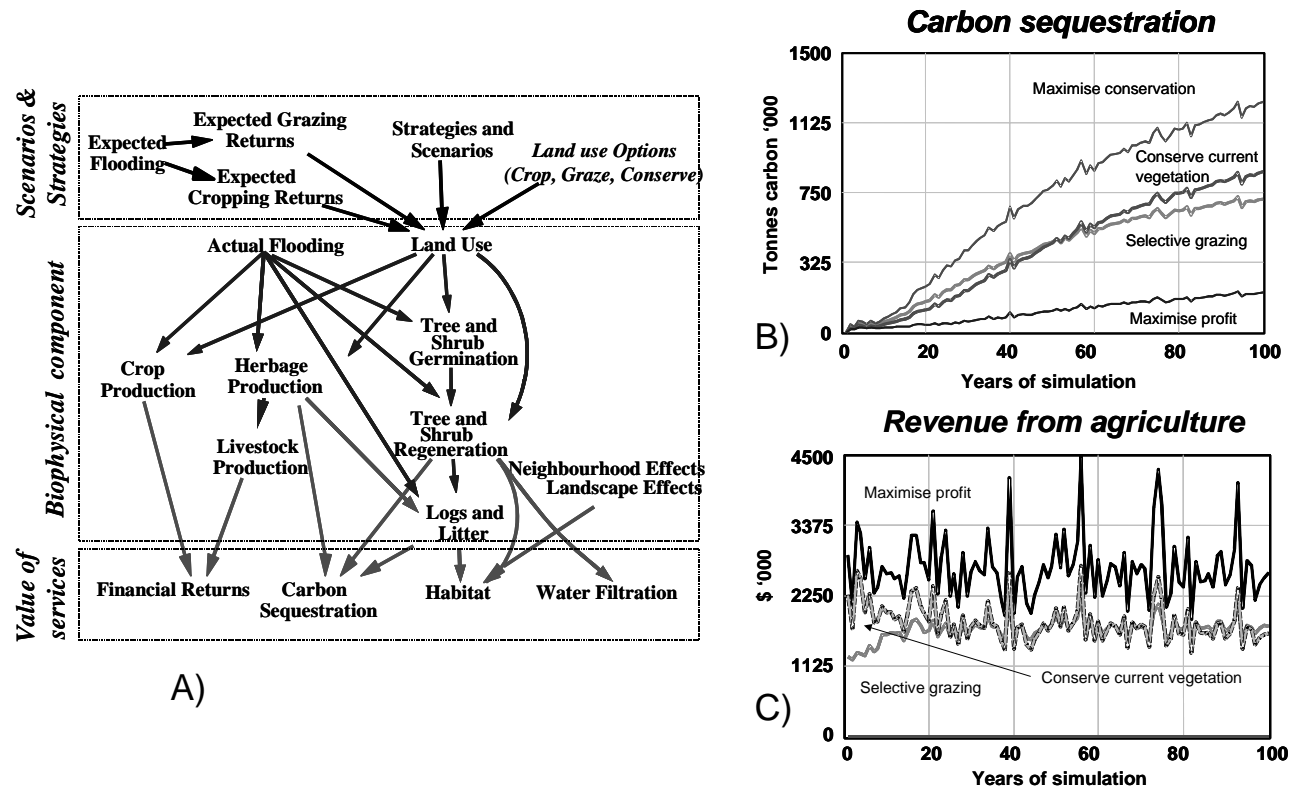


Figure 2: A) Framework for floodplain ecological-economic model. B, C) Examples of outputs.

Integrated ecological-economic models (Figure 2) that focus on vegetation changes under the various management scenarios are under development. Particular attention is being paid to how vegetation changes affect possible tradeoffs among agricultural productivity, water filtration, flood mitigation, and the value of habitat for key components of

biodiversity. A major challenge for this project is that, while the economic value of the first three of these is relatively straightforward to estimate, the value of biodiversity is not easily assessed in ways that are accepted by decision makers. Therefore, the emphasis is on providing robust models of the biophysical changes that could occur, to provide a firm base for debate about what those changes mean in terms of the catchment's environmental, social and economic goals.

Whole of catchment integrated economic and ecosystems accounting

The strongest message coming from interactions with the key decision makers from the catchment communities was that they need a way to deal with the complex interactions among ecosystem services that occur across land uses at a catchment scale. There was a clear recognition among these people that they needed to base decision making on an understanding of whole systems, but that they needed help in developing understanding and tools to support these decisions.

This component of the study aimed to link the structure of the regional economy in the catchment to the use of ecosystem services in order to provide the catchment decision makers with a method to explore the effects of different land and water use scenarios on regional employment, income, and gross product. Input-Output Analysis (IOA), an analytical framework to analyse the interdependence of industries and sectors in an economy, is the approach being employed. Analyses are being made for all major industries of the goods produced, resources consumed and inter-industry transactions. This traditional framework is being extended to encompass ecosystem sectors. A set of scenarios for future development of the catchment are being considered, including a comparison of business-as-usual versus a double-the-production-on-half-the-land scenario.

LESSONS AND IMPLICATIONS ARISING SO FAR FROM THE PROJECT

The ecosystem services approach is one way that issues behind decline in ecosystems and associated human welfare may be addressed. The key feature of the approach is its use to engage a broad segment of society in understanding and debating the benefits and costs of decisions that affect natural ecosystems. We are suggesting this approach as a complement rather than an alternative to more traditional approaches to decision making based on economics and policy or political sciences. We are mindful of the need to link the use of ecosystem services with these approaches so that the engagement with stakeholders produces outputs relevant and useful to policy makers and other decision makers. It is for this reason that we have engaged key decision makers throughout the project and we are regularly reviewing our approach as we learn together with them.

Our experience over the past two years has been that farmers, other land managers and the general public who are concerned about environmental issues find this framework useful for working towards practical solutions that recognise a wide range of values. It is being used already as a component of the Goulburn Broken Catchment Management Authority's approach to equitable sharing of the costs and benefits of environmental management. It is an important challenge for us to develop methods that integrate theory in ecology, economics and political, policy and other social sciences.

A tension has emerged in this study between the inclination of scientists to want to get on with experimentation and modelling of ecological and economic processes versus the reality that identifying the questions that need to be addressed takes time in building trust and shared understanding among the partners. While scientists are usually more aware of the scientific questions most in need of research, catchment communities have a better understanding of social and economic issues impacting on those questions. There is a need for both scientists and catchment managers to reassess their perceptions of key questions through dialogue and mutual understanding of viewpoints. So far, the mostly qualitative approach taken in the inventory phase has been welcomed and applied in catchment planning. It provided many of the elements of an integrated system approach to ecosystem services that the catchment planners were looking for. Clearly there is a need for better quantitative understanding of the systems-level processes so that the type of prioritisation of actions identified in the inventory can be given more authority. But the effort and expense to reach a point where the modelling processes and the data they are based on can hope to provide a better outcome than the faster qualitative approach is considerable. It can be argued that the first major requirement for better management of catchment ecosystems is providing an understanding of the full range of ecosystem services and a conceptual framework within which to consider tradeoffs and priorities, both of which can be achieved through qualitative analyses. One of the most important outcomes of this study will be the joint assessment by the project partners of the optimal combination of qualitative and quantitative analyses to meet the needs of catchment-scale decision makers.

ACKNOWLEDGEMENTS

We thank The Myer Foundation, CSIRO, Land and Water Australia, the Goulburn Broken Catchment Management Authority, and the Rainforest and Cotton Cooperative Research Centres for their support; and our other partners for their contribution to defining the framework and research agenda. Information on partners, other details of the project, and copies of most of the references below can be found at www.ecosystems-services-project.org.

REFERENCES

- Berkes, F., and Folke, C. (1997). Linking social and ecological systems: Management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge, UK.
- Bingham, G., Bishop, R., Brody, M., Bromley, D., Clark, E., Cooper, W., Costanza, R., Hale, T., Hayden, G., Kellert, S., Norgaard, R., Norton, B., Payne, J., Russell, C., and Suter, G. (1995). Issues in ecosystem valuation: Improving information for decision making. *Ecological Economics* 14: 73-90.
- Binning, C., Cork, S., Parry, R. and Shelton, D. (2001). *Natural assets: An inventory of ecosystem goods and services in the Goulburn Broken catchment*. CSIRO, Canberra.
- Cork, S.J., and Shelton, D. (2000). The nature and value of Australia's ecosystem services: A framework for sustainable environmental solutions. In: *Sustainable environmental solutions for industry and government*. Pp151-159. Environmental Engineering Society, Queensland Chapter, The Institution of Engineers, Australia, Queensland Division, and Queensland Chamber of Commerce and Industry.
- Cork, S., Shelton, D., Binning, C. and Parry, R. (2001). A framework for applying the concept of ecosystem services to natural resource management in Australia. In: *Third Australian Stream Management Conference August 27-29, 2001*. (eds. I. Rutherford, F. Sheldon, G. Brierley and C. Kenyon). Pp 157-162. Cooperative Research Centre for Catchment Hydrology, Brisbane.
- Costanza, R., and Folke, C.. (1997). Valuing ecosystem services with efficiency, fairness, and sustainability goals. In: G.E. Daily (ed.), *Nature's Services - Societal Dependence on Natural Ecosystems*, Pp. 49-65, Washington D.C., Island Press.
- Daily, G. E. (1997). *Nature's Services - Societal Dependence on Natural Ecosystems*. Island Press, Washington.
- Heal, G. (2000). *Nature and the Marketplace*. Washington, D.C., Island Press,
- Ostrom, E., and Schlager, E. (1996). The formation of property rights. In: S. Hanna, C. Folke, and K-G Mäler (eds.), *Rights to Nature: Ecological, Cultural, and Political Principles of Institutions for the Environment*, pp 127-156, Washington D.C. Island Press.
- Pannell, D.J. (2000). Salinity policy: A tale of fallacies, misconceptions and hidden assumptions. SEA Working Paper 00/08. <http://www.general.uwa.edu.au/u/dpannell/dpap0008.htm>
- Pearce, D., and Moran, D. (1994). *The Economic Value of Biodiversity*. London, Earthscan Publications Ltd.
- Proctor, W. (2001). Valuing Australia's Ecosystem Services Using a Deliberative Multi-Criteria Approach. In: *European Society for Ecological Economics, Frontiers I Conference: Fundamental Issues of Ecological Economics*. Cambridge UK.
- Proctor, W. and Drechsler, M. (2003). Deliberative multi-criteria evaluation: A case study of recreation and tourism options in Victoria. Paper presented to the European Society for Ecological Economics Frontiers II Conference, Tenerife, Canary Islands, Feb 2003 (also available at www.ecosystems-services-project.org).
- Salzman, J. (1997). Valuing ecosystem services. *Ecology Law Quarterly* 24: 887-903.
- Shelton, D., Cork, S., Binning, C., Parry, R., Hairsine, P., Vertessy, R. and Stauffacher, M. (2001). Application of an ecosystem services inventory approach to the Goulburn Broken Catchment . In: *Third Australian Stream Management Conference August 27-29, 2001*. (eds. I. Rutherford, F. Sheldon, G. Brierley and C. Kenyon). pp 571-576. Cooperative Research Centre for Catchment Hydrology: Brisbane.
- Sterman, J.D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Boston, Irwin McGraw-Hill.