Ecosystem services and institutional rules

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ABSTRACT

Environmental problems often arise from deficient, uncertain or confusing information about what ecosystem goods and services are available, how they are important to humans, who benefits and over what scales, combined with incomplete, inconsistent or unenforceable rules, rights and responsibilities. Establishing rules, rights and responsibilities at the range of spatial and temporal scales at which ecosystems function is a major challenge. Furthermore, the costs of implementing regimes of property rights and responsibilities can be beyond many land owners and managers. The concept of ecosystem services is being adapted and tested in Australia as a way to address some of the limitations of information and institutional rules. It attempts to express the benefits of ecosystems in language and concepts that the majority of land managers and users can understand and identify with, and it lays the foundations for developing formal and informal markets in which a fuller range of the beneficiaries of ecosystems contribute to the costs of their maintenance.

INTRODUCTION

The literature on natural resource management contains many hypotheses trying to explain why we see ongoing declines in natural systems around the world. These explanations concern three major failures (Pearce & Moran 1994; Bingham et al. 1995; Daily 1997):

- Understanding failure (society's failure to collect and disseminate the right information in ways that allow individuals and communities to understand and learn about their relationship with the natural world)
- Market failure (failure of economic markets to function ideally and act as regulators of resource use so that supply and demand are in balance)
- Institutional failure more broadly (failure of the formal and informal rules by which society works, which includes markets, to adequately recognise and protect the values that come from nature-based systems).

Associated with these failures are the often quoted drivers of ecosystem decline, including population growth and increasing consumption of resources. The failures of understanding, markets and other institutions are largely failures to deal with these drivers.

There is now an extensive literature on how we might address the failure of institutions. Many authors propose ways in which human institutions can be adapted to match the scales at which nature works in space and time (e.g. Hanna et al. 1996a; Berkes & Folke 1997; Binning & Young 1997).

One of the central themes running through the debate about institutional reform is the need to make the rules of access to, and ownership of, land and the environmental goods and services it provides clearer and more equitable (Bromley 1991; Hanna et al. 1996a and b). At present, many components of nature-based systems are perceived to be owned in common by all of society, yet the rights and responsibilities for maintaining those systems are unclear and incentives for sustainable management are limited (Heal 2000).

In the much discussed and quoted parable of the "tragedy of the commons" (Hardin 1968), commonly-owned natural resources are overexploited because individuals are not limited in their access and take only their own costs and benefits into account without considering the cumulative impacts that come when these individual actions are added up. There are many ways in which this situation can be rectified, including: tying clearly defined use rights to private land ownership; placing regulations on who can use publicly-owned resources and how they can use them, and; using economic and other incentives to guide land use practices (Hanna et al. 1996b; Binning & Young 1997). Central to achieving these sorts of improvements in the rules of land use is understanding how impacts on multiple goods and services from land interact with one another and add up to some overall impact.

Hanna et al. (1996b) list a set of key questions that must be addressed if property ownership and access rights are to be clarified:

- Who has rights to nature?
- Is it possible to define rights that exclude some from use of nature?
- How are the rights specified, what are the rules under which rights are exercised, and what are the duties and responsibilities that accompany those rights?
- How are rights allocated among competing interests?
- To what extent are they connected spatially and temporally, and how do they evolve?
- Are they in tune with the dynamics of resource stocks, and processes and functions of ecosystems?
- What are the characteristics of successful property rights systems, and how can they be designed for flexibility and adaptability, and redirected so that instead of causing overexploitation and environmental degradation, they contribute to a sustainable management of the natural environment?

To answer most of these questions, we need to be aware what goods and services society or individuals might want to have access to or ownership of. The evidence suggests that most people are very poorly informed about the services they receive from nature or the role of ecosystem processes in providing many of the goods that sustain and fulfill human life (Daily 1997). Furthermore, the human mind seems incapable of objectively assessing the outcomes of complex systems like the ecological-social-economic ones in which we live (Sterman 2000). In this paper, I introduce the concept of ecosystem services, which is being adapted in Australia as a focus for bridging the gap between scientific understanding of environmental, economic and social processes and public perceptions about the tradeoffs they make concerning the environment every day. Specifically, this concept is being used to address the questions:

- What services do humans receive from nature?
- Who benefits and who is involved in maintaining and delivering the services (the basis for an equitable approach to sharing costs and benefits)?
- How are current systems of access and ownership rights impacting on ecosystem services?

- What opportunities are there for more effective and/or efficient use of ecosystem services in the future?
- How do we measure sustainability and value of ecosystem services?
- How can the complexity of these issues be made tractable to decision makers at a range of levels in society?

THE CONCEPT OF ECOSYSTEM SERVICES

The concept of ecosystem services has been developing 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"*. Ecosystem services 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 (Figure 1). Services exist at all levels within ecosystems, and there has been some debate about how to classify ecosystem services. As with all such debates, it seems that the level of aggregation depends on the purpose of the analysis. Classifications like that depicted in Figure 1, or in some Australian studies discussed below, are aimed at expressing ecosystem services at a level that a wide range of people within society can understand and appreciate.

[Insert Figure 1 near here]

In late 1999, CSIRO and The Myer Foundation commenced an initiative (now called The Ecosystem Services Project) to address the questions listed above, via partnerships between scientists and other parts of Australian society. Land and Water Australia joined as another major funder in 2000 and the initiative has now grown to include a large number of partners. Over 10 case studies on ecosystem services are under way around Australia and are sharing skills, experience, lessons and information in an effort to increase their effectiveness (www.ecosystemservicesproject.org) .

Bringing these two words "ecosystem" and "services" together forces us to recognise many aspects of the relationship between humans and their environments that usually are not addressed in traditional ecological research (Figure 2). The study of *ecosystems* includes a wide range of theory and issues, including debate about whether ecological systems can ever be considered to be in equilibrium, how they maintain a range of functions and their resilience, and even whether the concept of "ecosystems" is a useful or valid one.

When we think seriously about *services* coming from the environment we need to consider not only economic theories of value (which is where most treatments of ecosystem services stop) but also such diverse areas of social science as fundamental human needs (to help us consider what need might be satisfied by ecosystem services), learning and marketing theory (to understand how the benefits of ecosystems should be communicated with the public so they can make informed value judgements), and theory relating to how institutions can be designed to better take account of human dependence on nature. Property access and ownership rights need to be considered in the context of these multiple and interacting issues.

[Insert Figure 2 near here]

Development of the concept of ecosystem services in Australia recognises the need to put scientific and economic research into the language and concepts of everyday life for people without specialist training in these disciplines. Learning theory suggests that people learn best when they receive concepts within the language and frameworks that they are familiar with and when they are given the opportunity to explore the consequences of new ideas and revise their own "mental models" gradually and in the light of tangible situations (Sterman 2000). 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 (Figure 3).

[Insert Figure 3 near here]

Both perceptions are valid and important. The scientist's perceptions are based on beliefs, values and experience within the scientific community, whereas the perceptions of other parts of society are equally influenced by beliefs, values and experiences. Often the perceptions of the public relate to some of the fundamental needs and desires of humans (Max-Neef 1991), which may or may not align with classifications of ecosystem processes developed by ecologists or economists. We might expect that the perceptions of the public will most closely relate to what services they will be prepared to pay for. Therefore, a key challenge for using the concept of ecosystem services to address issues of land access and ownership is to establish a conceptual bridge between the public perceptions of services and values and the way ecologists and economists think about nature.

The literature on the way industrial, social, or natural systems work abounds with examples of how intervention in part of the system more often than not leads to creating problems elsewhere (Sterman 2000). This is the problem with many policies involving subsidies designed to correct one problem but which create others. A major problem that has emerged with natural resource management around the world is that intervention has considered only small parts of ecosystems, landscapes and catchments. For example, efforts to control salinity by planting trees have found the problem sometimes gets worse because although the trees contribute to lowering water tables they also intercept and use water that normally would flow into rivers and this can reduce river flows and exacerbate in-stream salinity. Similarly, planting of trees with consideration only to their carbon sequestration roles risks missing opportunities for pollination, pest control, flood mitigation, erosion control, weather protection and biodiversity services.

The concept of ecosystem services encourages us to think about the full suite of services that sustain and fulfil human life and how that suite can be managed for the best outcome. In their thinking about using markets to help achieve ecological sustainability, several authors have recommended some sort of regional brokerage or bank that is informed by a strategic plan designed to allocate investment to projects that maintain the full range of ecosystem services (Figure 4). This becomes particularly important if only a few high-profile markets (e.g. water, carbon, biodiversity, salt) arise in the near future – the rules guiding these markets need to ensure that others services are bundled with the marketable ones.

[Insert Figure 4 near here]

EXAMPLES OF ECOSYSTEM SERVICES ASSESSMENTS IN AUSTRALIA

Two major studies of ecosystem services in partnership with communities are at advanced stages in Australia at present. One is in the Goulburn Broken Catchment of north-central Victoria (Binning et al. 2001; Cork et al. 2001; Shelton et al. 2001), and the other is in the Gwydir Catchment of central-eastern New South Wales (Reid et al. 2001).

Both studies have included an initial assessment of what services exist at a catchment or sub catchment scale and involve stakeholders in a qualitative assessment of how the services are changing, what impacts various land practices have and what values are obtained for Australians at a range of spatial scales. Figure 5 summarises the results of the inventory from 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. 2001; 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.ecosystemservices.org).

[Insert Figure 5 near here]

Twelve major ecosystem services were identified and assessed against 12 groupings of land-uses and industries (Figure 5). Some ecosystem services, e.g. pollination, while being important to a wide range of land uses, 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. This rapid assessment provides insights into the ecosystem services that require urgent attention with respect to rules of access and ownership.

The Gwydir study has conducted a more limited inventory, but their stakeholders also identified similar ecosystem services (i.e. maintenance of soil health, maintenance and regeneration of habitat, maintenance of healthy waterways, life fulfilment, and maintenance of river flows and groundwater levels) as having the largest impacts on current land uses and to be the highest priorities for further investigation (Reid et al. 2001). There was a strong feeling among stakeholders that threats to ecosystem services were largely the result of lack of adoption of improved management practices (including

a lack of extension) and the social pressures on rural communities. They called for a focus on extension of existing information and to social research on ways of mitigating the deteriorating quality of life of rural communities.

Both studies recognize that any assessment of value, be it expressed in dollars or other terms, is relative. People's perception of nature's value is revealed by the tradeoffs they are prepared to make between ecosystem services and other uses of the land, and this is in turn a reflection of their current understanding of what services exist, and how they personally or as part of a community will benefit.

There are two consequences of these approaches. Firstly, both studies have gone to some lengths to identify the visions and options for the futures of their study areas, so that the importance of ecosystem services can be considered in context. Secondly, both studies are more interested in giving stakeholders understandable information so they can make more-informed tradeoffs than in measuring the economic value of ecosystem services based only on current perceptions. Both studies are currently grappling with the major challenges of quantitatively analysing social, economic and ecological options for the future with respect to ecosystem services.

Some common themes with implications for property access and ownership rights emerge from these and other studies around the world. Ecosystem services emerge from processes operating at various scales often larger than individual properties or even larger than the scales of local governments. These scales do not match well with the scales of existing systems of land ownership and management responsibility. The beneficiaries of ecosystem services also vary greatly from individual land owners for some services to neighbours, fellow residents of a shire or catchment, and people elsewhere in Australia and the world (Table 1).

These trends have led to calls for redesigning institutions that have flexibility and adaptability to deal with these scales of ecosystem services (Berkes & Folke 1997; Binning & Young 1997). The changes proposed often are based on cultures that have maintained a closer link with the natural environment than most western societies, or on nature itself, which gives insights into the requirements for adaptability and resilience in complex systems. I will leave it to others in this meeting to discuss innovative options for Australia.

HOW DOES A FOCUS ON ECOSYSTEM SERVICES HELP US ADDRESS PROPERTY ACCESS AND OWNERSHIP RIGHTS?

Environmental problems, broadly speaking, arise from deficient, uncertain or confusing information about what ecosystem goods and services are available, how they are important to humans, who benefits and over what scales, combined with incomplete, inconsistent or unenforceable rules, rights and responsibilities (Hanna et al. 1996a; Ostrom & Sclager 1996). Rules do not have to be developed by governments, and often this is undesirable (Ostrom & Schlager 1996). The rules can be as diverse as strong and enforceable legislations and regulations, economic and other incentives for wise land use, establishment of standards, targets and caps that encourage trading in ecosystem services, and social conventions and agreements about what is acceptable practice, and different regimes are appropriate in different circumstances (Hanna et al. 1996b; Binning & Young 1997).

Establishing rules, rights and responsibilities at the range of spatial and temporal scales at which ecosystems function is a major challenge. Dealing with this complex issue should be helped (although not solved) by expressing the benefits of ecosystems in language and concepts that the majority of land managers and users understand and identify with.

A further issue is the cost of implementing complex property rights and responsibilities, which often is beyond individual land owners and managers (Hanna et al. 1996a; Pannell 2000). One way to address this problem is to encourage formal and informal markets in which a fuller range of the beneficiaries of ecosystem services contribute to their maintenance. Using market forces is potentially one of the most powerful ways to achieve rapid change, but it also is one of the most dangerous if not guided carefully (Hanna et al. 1996a; Binning et al. 2002). Analyzing the benefits of ecosystems in terms of services and those who receive the services is a first step towards creating markets. Schemes such as that depicted in Figure 4 attempt to guide market development and investment using regionally focused plans that aim to maintain the full range of ecosystem services. Implementing such schemes requires developing ways to measure delivery of ecosystem services, so that returns on investments can be assessed, and gaining a sufficient understanding of the interactions among services to inform bundling of services to achieve balanced environmental outcomes and to predict unexpected or unintended outcomes of managing for only one or a few services.

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Production of Goods

Food: Terrestrial animal and plant products, forage, seafood, spice

Pharmaceuticals: Medicines, precursors to synthetic drugs

Durable materials: Natural fibre, timber

Energy: Biomass fuels, low-sediment water for hydropower

Industrial products: Waxes, oils, fragrances, dyes, latex, rubber, precursors to many synthetic products

Genetic resources: The basis for the production of other goods

Regeneration Processes

Cycling and filtration processes: Detoxification and decomposition of wastes, renewal of soil fertility, purification of air and water

Translocation processes: Dispersal of seeds necessary for revegetation, pollination of crops and native vegetation

Stabilizing Processes

Coastal and river channel stability, compensation and substitution of one species for another when environments vary, control of the majority of potential pest species, moderation of weather extremes (such as temperature and wind), partial stabilisation of climate, regulation of the hydrological cycle (mitigation of floods, droughts, salinity)

Life-Fulfilling Functions

Aesthetic beauty, cultural, intellectual, and spiritual inspiration, existence value, scientific discovery, serenity

Preservation of Options

Maintenance of ecological components and systems needed for the future, supply of goods and services awaiting discovery

Figure 1 – A classification and examples of ecosystem services (adapted from Daily 1999)

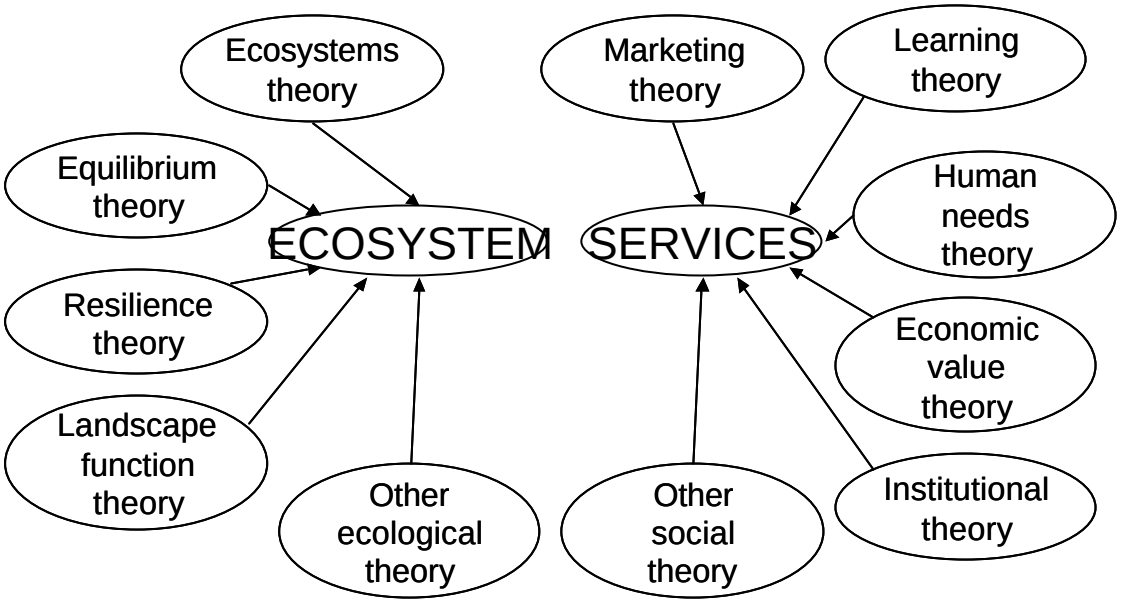

Figure 2: Some of the bodies of theory brought together by the concept of ecosystem services

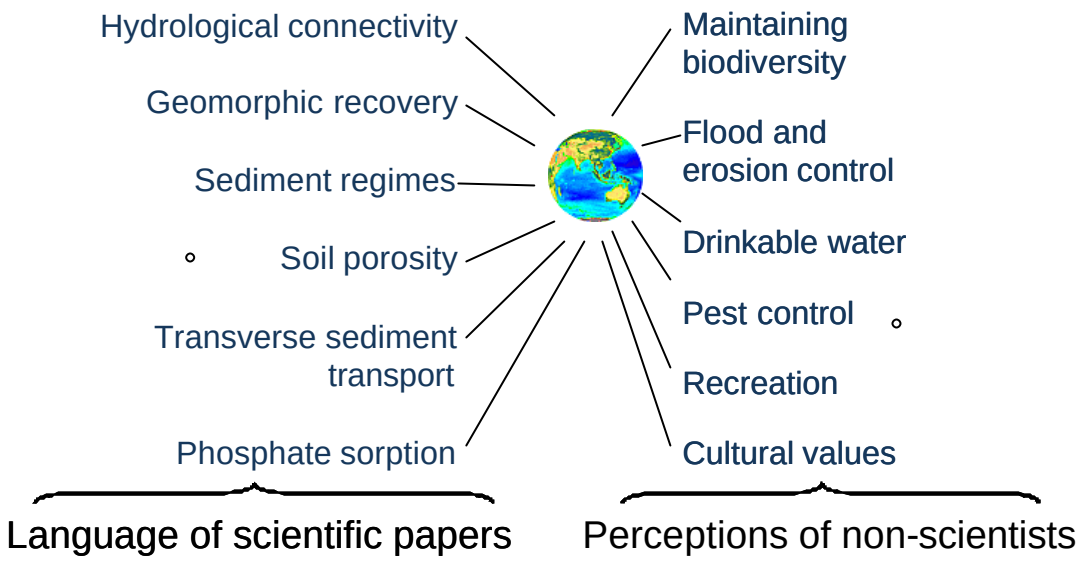

Figure 3: Some differences in perceptions and language relating to stream ecosystems at a recent stream management conference

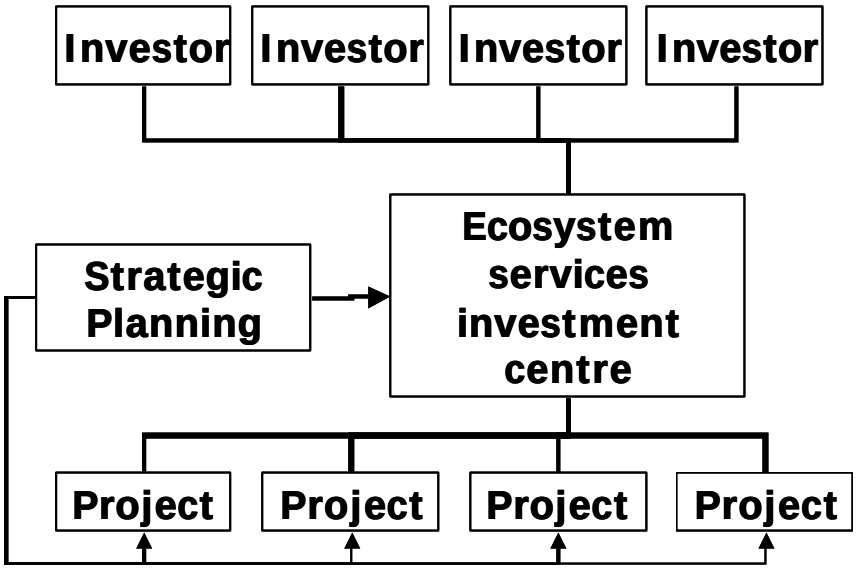

Figure 4: Generic design for an investment framework to encourage balanced environmental outcomes at regional scales (from Binning et al. 2002)

Figure 1: High-priority interactions between ecosystem services (rows) and land uses (columns) in the Goulburn Broken Catchment 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.

Services	**Land uses**											
	1	2	3	4	5	6	7	8	9	10	11	12
a		■										
b	■			■					■			■
c	■	■				■		■				
d		■	■	■	■							
e				■								
f		■	■	■			■		■		■	■
g	■	■		■	■				■			
h	■	■	■	■	■							
I	■	■		■			■	■		■	■	
j			■	■	■					■		
k	■	■			■					■	■	
l	■	■	■	■	■	■		■	■	■	■	