8th National Conference and Workshop on the
Productive Use and Rehabilitation of Saline Land (PUR$L), Fremantle, 16-20 September 2002

IDENTIFYING THE OPPORTUNITIES: HOW THE CONCEPT OF ECOSYSTEM SERVICES CAN HELP

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INTRODUCTION

Increasingly, plants and animals tolerant of saline water are being shown to have potential for both rehabilitation of salt affected (discharge) areas and for economic returns from agricultural products. Engineering solutions also are emerging as cost-effective alternatives in certain circumstances. Adoption is limited primarily by whether the groundwater system is of a type (e.g. local versus regional recharge) that will respond to the available solutions, and how big the gap is between the economic return from agricultural products and the costs of managing the farm, including those of applying the management strategies (Pannell 2001).

In recharge areas, there remain uncertainties about the benefits of available ecological strategies for salinity prevention, costs for achieving major change are large, political will to take large scale action is lacking, and the areas and long time frames needed to test and demonstrate options are prohibitive (Pannell 2000).

In both cases, private benefit can be insufficient to encourage land managers to apply strategies to live with, ameliorate or prevent salinity. Recognition of the public benefits from agricultural landscapes can then be critically important to land-use decisions. If convincing information is available, governments can make payments, impose taxes, or implement a range of laws, regulations and policies that protect public values and/or create private benefit (e.g. markets) for investing in sustainable management of ecosystems. Support is growing for such incentives with respect to Australian environments generally, but it seems that there remains skepticism about the public benefits of the strategies being proposed for management of saline and potentially saline lands (Pannell, this conference).

Murtough et al. (2002) identified several requirements for development of markets for ecosystem services in Australia. The middle two apply equally to other forms of economic incentives:

- clearly defined and enforceable property rights;
- information and certainty about the attributes of the goods and services being traded;
- acceptable transaction costs;
- sufficient buyers and sellers and equal information for both.

The concept of Ecosystem Services provides a practical framework for addressing these and other key issues. It has become increasingly popular over recent decades as a way to recognize the dependence of humans on nature. In this paper, I explore some ways in which the concept of ecosystem services can help identify new opportunities for productive use and rehabilitation of saline lands.

THE CONCEPT OF ECOSYSTEM SERVICES

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).

The concept of ecosystem services has been developing gradually for over a century in parallel with research on the functional role of biological diversity (Mooney and Ehrlich 1997). At its heart is the idea that natural systems provide goods and services that humans benefit from in economic and other ways, but which are largely unrecognized by most people and so get undervalued in decisions about land-use. The emphasis on *services* tries to bring people's relationship with nature into the same frame of reference as their relationships with businesses, government agencies and voluntary organisations that supply a range of goods and services as part of everyday life, and for which information sets and institutional arrangements are much more developed.

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*". Cork and Shelton (2000) cite some examples from Australian systems.

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)

Most of the issues that an ecosystem services approach addresses have been addressed by others in various ways. For example, the need for better communication has been emphasized by education and extension specialists for many years. The concept of “Ecological Footprints” has been an important communication device, focussing on the demands that cities place on the natural environment far beyond their formal boundaries. Economists have long recognized the fact that many components of natural systems are commonly owned and therefore do not pass through markets and do not have economic value ascribed to them readily. Impacts of land management that fall outside markets have been termed “externalities”. Ecosystem services are not just externalities, however, as they are also the basis, directly and indirectly, for most marketed goods (Figure 1). Various techniques have been developed to estimate the economic value of non-market environmental good and services (e.g. Bennett 1999). Institutional analysts have pointed out that deficiencies exist in our rules and rights with respect to public, common and private property and have debated the requirements for development of new markets (Ostrom and Sclager 1996; Murtough et al. 2002).

Each of these approaches has important messages for different audiences and all in some way argue for better and more broadly informed decision making that takes account not only of private benefits from the environment but also community-wide benefits. An ecosystem services approach, however, treats the service-based relationship between humans and the natural environment as the starting point for planning of all land-based economic activity, and focuses on collecting the information necessary for the full range of ecosystem services to be considered. There need be no presumption that “natural” ecosystems are superior to human-modified systems, or that ecological solutions are superior to technological substitutes, but decision makers should be in a position to consider these possibilities.

To make this concept useful and practical for all the purposes listed above, there is a need firstly to find ways to define, describe and measure the fullest possible range of ecosystem services in ways that are understandable to a wide range of people across society. Then it is important to be able to consider the implications of changes in ecosystem services under real-world scenarios of policy and management. Finally, there needs to be practical consideration of how society’s rules, rights and responsibilities can be changed to allow maximum benefit from ecosystem services. In the following section, I give some examples of attempts to apply an ecosystem services approach around the world.

SOME APPLICATIONS OF THE CONCEPT

The words “ecosystem services” or “environmental services” now appear in major policy documents in most states of Australia and at the federal level. Bill Clinton, while President of the USA, introduced the term into regular usage. He commissioned a report by a group of eminent scientists, industry representatives and bankers, which identified a set of important questions that need to be addressed to allow an efficient, effective and equitable balance between economic development and ongoing delivery of ecosystem services. These questions are summarised in Figure 2.

What ecosystems provide which life support services? Who benefits and over what scales of time and space? What are the impacts of humans upon the supply of services? How is the supply of services related to the condition of ecosystems? How much damage has been done already? What is needed to repair damaged ecosystems? Where are the problems geographically? How interdependent are ecosystem services? How reliant are ecosystem services on biological diversity? How much can technology substitute for ecosystem services? Given likely future technology, what area of natural ecosystems will be needed to support human life into the future?

Figure 2: Important questions about ecosystem services (adapted from PCAST 1998)

Subsets of these questions have formed the basis for various attempts in the last decade to assess the nature of services coming from natural ecosystems around the world and to estimate their importance to humans (e.g., Costanza et al. 1997; Daily 1997; Pimental et al. 1997; Balmford et al. 2002). Many of these studies seek to draw attention to the potential value of ecosystem services by extrapolating from valuations done in a small number of cases to larger areas of the world's ecosystems and often considering the costs of totally losing the services. However, what is needed for practical application of an ecosystem services approach at farm, catchment and regional scales is reliable information on how the delivery of ecosystem services might change under a series of realistic alternative scenarios (Salzman 1997). For example, the value of salt tolerant plants in rehabilitating saline lands and providing a marketable product needs to be judged against alternative strategies such as doing nothing and employing engineering solutions.

Relatively few such studies have been made, but some good examples exist. For example, Higgins et al. (1997) developed a dynamic ecological economic model of ecosystem services provided by the mountain fynbos ecosystems of South Africa to assess whether the benefits of controlling alien plants would outweigh the costs associated with clearing of the plants, management of fire, wildflower harvesting, and controlling hikers and ecotourists. It was concluded that, even taking account of uncertainties in some economic estimates, the value of water production and maintenance of unique genetic resources far outweighed the costs. Other examples on a range of ecosystem types can be found in Daily (1997).

More recently, Balmford et al (2002) searched over 300 case studies to find examples that explicitly measured both market and non-market values in adequately matched comparisons of different management regimes, using comparable economic valuation techniques, and found only 5 that met their criteria. These five dealt with tropical rainforests in Malaysia and Cameroon, wetlands in Canada, mangroves in Thailand, and ocean reefs in the Philipines. The market goods were timber, seafood, and agricultural produce, while the non-market goods and services included non-timber forest products, water supply and regulation, sedimentation control, storm and flood prevention, hunting, angling and other recreation, the maintenance of carbon stocks, coastal protection, tourism and endangered species. For 10 of 16 biomes for which information was sought no studies were found that met the criteria. Of those studies analysed, only a handful of well-established ecosystem services were considered, and some particularly valuable services, such as nutrient cycling, waste treatment, and the provision of cultural values, were not examined at all. This scarcity of information is one of the greatest and the most immediate challenge for the application of ecosystem services approaches in Australia and the world.

Most applications of the concept of ecosystem services in Australia have been recent, although studies relating to the relationships between Australian agriculture and the environment have been going on for many years. Since 1999, a national network of researchers has been establishing case studies using the ecosystem services concept and sharing experiences and lessons about how the concept can be useful for addressing real-world challenges facing communities in regional Australia (Cork et al. 2001; Cork 2002; www.ecosystemservicesproject.org). This network was started with seed funding from The Myer Foundation, a philanthropic organisation based in Melbourne.

The two most extensive projects within this network focus on the Goulburn Broken catchment in Victoria and the Gwydir catchment in NSW. Below I discuss some results from the Goulburn Broken study. This study seeks to address information, institutional and intervention failure by:

- establishing learning partnerships between scientists and community leaders;
- assessing what ecosystem services come from the catchment, what state they are in, and what industries, land uses and people they benefit;

- exploring the ecological, economic and social impacts possible under a set of scenarios for change identified by the catchment communities;
- exploration of improvements to institutional arrangements to encourage more effective private and public investment in returns from ecosystem services (Cork et al. 2001).

Like many catchments in Australia, the Goulburn Broken faces big challenges related to salinity. The ecosystem services inventory, however, highlighted the wider range of ecosystem services that appear to be under threat and which in turn threaten businesses and people's life-fulfillment. The inventory drew heavily on expert knowledge within the catchment but still produced a few surprises for the catchment managers. Its greater value, however, lay in the picture it presented of the whole catchment systems and the message that could be conveyed to catchment residents, politicians and others about the need to support action focused on whole ecosystems rather than applying piecemeal solutions to parts of the catchment systems. Two other major benefits were: (1) the inventory identified where targeted research is needed to address the most pressing issues facing the catchment decision-makers; (2) it provides strong support for the development of market-based approaches that involve bundling ecosystem services to enable investors to obtain competitive returns from investing in natural systems.

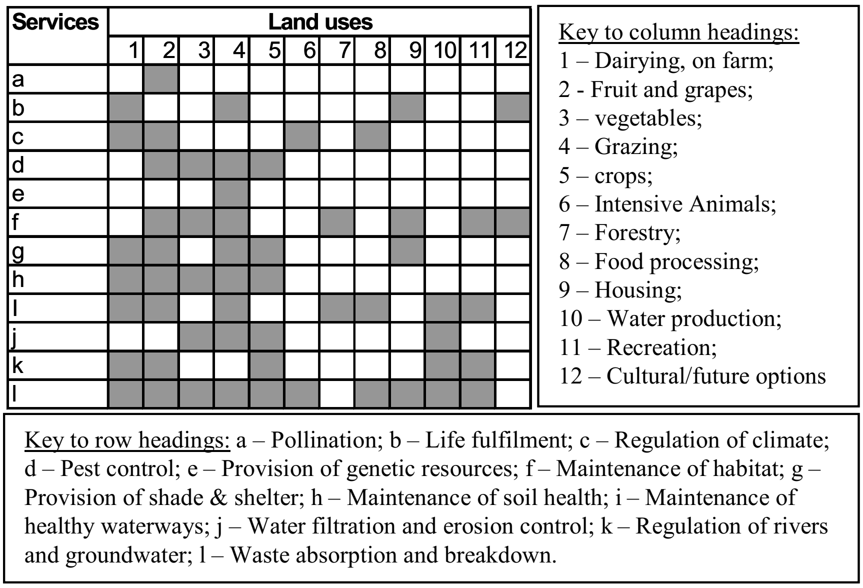

Figure 3: Summary of the inventory phase of the ecosystem services study in the Goulburn Broken catchment. An explanation for the shaded cells is given in the text.

Figure 3 summarises the results from the first (inventory) phase of the Goulburn Broken study. In this phase, we asked a range of experts from the catchment and elsewhere to identify what ecosystem services they thought come from the catchment and to assess their importance with respect to each major land use in the catchment. The purpose of this phase were to identify key services for further research and to capture the perceptions and understandings of scientists and land managers to act as initial hypotheses for testing in later research. Services were ranked as low, medium or high priority with respect to each land use on the basis of the following criteria taken together (Binning et al. 2000; Shelton et al. 2001):

- *Overall importance/impact* - the overall importance of the service was considered in terms of the importance of the products of the land use to the catchment (gross value of production), the perceived importance of the ecosystem service to the products, and the impact of the land-use/industry on the ecosystem service's capacity to maintain natural assets;

- *Importance at the margin* - the impact of a small change in a service on the production of products, or the maintenance of natural assets like soil, water and native vegetation;
- *Manageability* - the capacity to manage the land-use/industry to ensure the ongoing delivery of the service.

For both the scientists and the community representatives involved, a major lesson was the need to take the time to identify what the real research questions are. As a scientist, there is always the tendency to want to apply the methods and models that one is familiar and comfortable with, but sometimes these do not address the question that needs to be answered. Similarly, decision-makers, like all of us, see only part of the ecological-social system that they live in, and interactions with outsiders can lead them to modify the questions that they thought were of highest priority (Cork et al. 2002).

USEFULNESS OF THE CONCEPT OF ECOSYSTEM SERVICES TO PUR$L

As noted in the Introduction, recognition of the public (non-agricultural) benefits from agricultural landscapes can be critically important to whether strategies for living with, ameliorating or preventing salinity are applied. An ecosystem services approach such as that being trialled in the Goulburn Broken and Gwydir catchments is one way to address the requirements for encouraging greater public and private investment in non-agricultural ecosystem services (i.e. defining property rights, increasing information and certainty about attributes of ecosystem goods and services, minimizing transaction costs and making equal information available to buyers and sellers – see Introduction). It also helps to minimize the cost of research, which is another factor limiting progress on approaches to dealing with salinity.

Defining property rights with respect to ecosystem services requires a clear understanding of what services exist and how they interrelate. The latter is especially important if different services are to be paid for separately or bundled. It would be undesirable, for example, to have an unbalanced portfolio of investments that overemphasized some services while unexpectedly decreasing others. Although insufficient information exists to determine the interrelationships among ecosystem services with high precision, sufficient understanding probably exists to describe the likely shapes of the interrelationships, which might be enough for many investment decisions.

Table 1: Hypothetical ecosystem services, suppliers and users in an Agricultural district

Service	**Supplier**	**User**
Food production	Farmland	Market (local, national, international)
Pest control	Remnant vegetation	Farm
Pollination	Remnant vegetation, hives	Farm
Timber	Forest	Market, locals
Climate stability (including carbon sequestration)	Forest and farmland	Market, residents of Australia and the world
Flood control	Forest, remnant vegetation	Cities, towns, farms
Water purification	Forest, remnant vegetation	Cities, towns, farms
Recreation	Forest, waterways	Cities and towns, locals
Options for the future	Whole landscape	All

Information and certainty about the attributes of ecosystem goods and services can be improved through detailed descriptions and assessments of what ecosystem services are provided by the landscapes, what changes could be expected under alternative management regimes, what economic and other benefits, public and private, could come from those regimes, and who the beneficiaries are (Table 1 gives a hypothetical example). Our experience in the Goulburn

Broken and Gwydir studies is that the combined knowledge and experience of scientists and representatives from government, industries and the broader community goes a long way towards not only increasing confidence in the magnitude of public benefits from ecosystem services but also is a powerful way to identify the key information gaps needed to build confidence further.

In salt-affected lands and lands with potential to become saline, the key uncertainties relate not to what ecosystem services potentially come from those lands (there is enough research worldwide to establish what these are) but what levels the services currently are at in relation to human needs, what changes might be possible under a set of management regimes in the future, and how the marginal change in supply of ecosystem services is likely to relate to demands for the services to meet human needs in the future. The relationship between supply and demand is central to estimating the economic value of ecosystem services. Demand itself is influenced by the awareness of potential buyers of the services (including the tax-paying public), while the relationship between supply and demand can be influenced by caps, targets and standards of the type applied to water in recent years. Another major determinant of the economic value of ecosystem services is the availability and cost of technological alternatives.

Transaction costs with respect to identifying key research and communicating results are minimized if the research is designed and implemented in a learning partnership with the key policy makers and land managers at a local and regional scale, as we have tried to do in the Goulburn Broken and Gwydir studies. This approach also helps to make *information available to potential buyers and sellers* of ecosystem services. Transaction costs with respect to economic instruments such as markets can be minimized by giving attention to policies, rules, rights and responsibilities (institutional arrangements), including those discussed above. It can be argued that these arrangements are most effectively addressed by a mixture of bottom up investigation of local arrangements and opportunities with top down theoretical approaches.

The research needed to underpin these processes need not take billions of dollars and decades to collect in the first instance. In NSW, for example, a pilot scheme of "salinity control credits" has been pioneered by State Forests NSW and Macquarie River Food and Fibre. In the absence of reliable data to predict impacts of tree planting on salinity, this scheme bases its credits on rates of transpiration by the trees on the assumption that water pumping will in some way be related to impact on water table. In another move to acknowledge the value of ecosystem services without waiting for the rigorous data, Allegheny Energy Inc in the USA earlier this year sold roughly 12,000 acres of land to the U.S. Fish and Wildlife Service. The company calculated the property's value for tax purposes by including the worth of the land's ecosystem services, which more than doubled traditional estimates. The land was sold for the traditional value ($16 million) and this so-called "bargain sale" allowed Allegheny to claim a charitable contribution of another $16 million. If allowed, this will save the company several million dollars in taxes (Ellison 2002). Similarly, certification of sustainable management of forests around the world is proceeding without the full certainty of scientific knowledge but still is being taken seriously enough by buyers of forest products to influence market access by supply companies.

Investment in options to deal with salinity could piggy-back on investments in other ecosystem services. Since markets for individual ecosystem services are unlikely to provide returns competitive with investment in other markets like the stock market, for example, it probably will be necessary to bundle ecosystem services together (Binning et al. 2002). Thus, for example, returns on investment in vegetation planting projects could be determined as the combined returns from salinity mitigation, carbon storage, biodiversity protection, flood mitigation, pest control, and erosion control to name a few. For example, works to manage salt affected land potentially improve habitat for native animals, reduce flood risk and stabilise soils. Evidence sufficient to clarify these possibilities should not require huge investments of time or money and would directly address the concerns of some policy makers that these works have minimal public benefit (Pannell, this conference).

COUPLED SCIAL AND ECOLOGICAL ANALYSES

My experiences with the Ecosystem Services Project in the Gouburn Broken catchment suggest an extension to the approach that could be useful for application in salinised and potentially salinised landscapes. Most studies on human-environment interactions have attempted to integrate biophysical and/or engineering science with economics. This approach has produced important insights, but also has limitations that have been discussed widely in the literature. Economic analyses tend to focus on individual preferences, whereas decisions about sustainable management and intergenerational equity tend to be community decisions (Costanza and Folke 1997).

Similarly, ecological-economic approaches do not focus on many of the social processes that can bring about seemingly illogical, or at least unexpected, changes in the way we treat the environment in legislation, policy and decision-making. Recent research has acknowledged that not only are human social-ecological systems complex, but the rules change as new knowledge and understanding find their way into the system (Walker et al. 2002). This means that outcomes of these systems are hard to predict, but it also means that the system could change for the better even if it seems hopeless based on what we currently see. The tax concession claim for a capital-loss sale of land in the USA (discussed above) is a good example of an unexpected but hopeful development in relation to ecosystem services.

The extension to traditional approaches that I advocate includes:

- analyses of people's needs and wants (because defining a "service" is as much about identifying hat is needed as what can be provided);
- applying more of what psychologists know about perceptions and learning so that scientists and land managers can understand and learn from one another better (this applies as much to identifying the research questions as it does to communicating results to land managers);
- applying the emerging understanding of how ecological-social systems develop and maintain resilience so that unhelpful social processes can be addressed and helpful ones encouraged more effectively;
- applying all of these approaches to building a greater awareness among city-dwellers of the benefits they receive from regional land and land managers, and of the costs and benefits of greater public and private investment in maintaining or increasing those benefits.

CONCLUSIONS

The concept of ecosystem services attempts to place the relationship between people and nature into the same service-based framework that we face in our everyday relationships with businesses, government and voluntary organisations. Uptake of options for living with, ameliorating or preventing salinity in agricultural landscapes is often limited by the gap between the costs of applying the options and the economic returns to the farmer from agriculture. The approach to analyzing ecosystem services being trialled in two catchments in eastern Australia offer a way to address some of the key issues limiting investment in non-agricultural ecosystem services, which is a way to bridge this gap. This approach involves broad analyses of what ecosystem services come from farming landscapes, what natural assets supply these services, and who the users and beneficiaries are. Furthermore, there is a need for coupled social analyses to understand what human needs require ecosystem services, how scientists and land managers can learn more effectively from one another, and how ecological and social processes can interact to either slow or encourage progress.

Better information of this sort will allow more confident decisions to be made about public and private investment in ecosystem services. Although much further research is required to provide precise predictions of the responses of ecosystem services to management options, I suggest that there are smart ways to identify which key pieces of research are needed first to allow policy and management to move forward.

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