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# Application of an ecosystem services inventory approach to the Goulburn Broken Catchment

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**SUMMARY:** Rivers, streams and wetlands provide people with a wide range of benefits often referred to as "Ecosystem Services" (Cork et al. this volume). These services include maintenance of atmosphere and climates suitable for human life; filtration, purification and delivery of water; maintenance of soil fertility and structure; pollination of crops and other vegetation; control of the vast majority of potential pests, diseases and weeds; provision of genetic resources; production of goods like food and fibre; and provision of cultural, spiritual and intellectual values. The difficulty faced by natural resource managers is how do we prioritise and manage for the full range of benefits provided by ecosystems. This paper presents one method for identifying the full range of goods/products provided by ecosystems in a case study catchment (the Goulburn Broken in Northern Victoria), 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.

**THE MAIN POINTS OF THIS PAPER**

- Rivers, streams and wetlands provide people with a wide range of benefits often referred to as "Ecosystem Services".
- Using the methodology presented, ecosystem services can be classified and prioritised in relation to the role played in contributing to production of a good, or maintaining the stock of natural assets.

## 1. INTRODUCTION

Rivers, streams and wetlands provide people with a wide range of benefits often referred to as "Ecosystem Services" (Cork et al. this volume). These services include maintenance of atmosphere and climates suitable for human life; filtration, purification and delivery of water; maintenance of soil fertility and structure; pollination of crops and other vegetation; control of the vast majority of potential pests, diseases and weeds; provision of genetic resources; production of goods like food and fibre; and provision of cultural, spiritual and intellectual values (Daily, 1997; Cork and Shelton, 2000; Cork et al. this volume).

The concept of ecosystem services is being applied in Australia as a way to facilitate dialogue between scientists and communities and to promote consideration of a fuller range of values in decision-making about management of natural resources (Cork and Shelton, 2000; Cork et al. this volume). Ecosystem services have been conceptualised as transformations of natural assets (soil, water, atmosphere and living organisms) into goods and other products (including experiences) that are valuable to people (**Figure 1**).

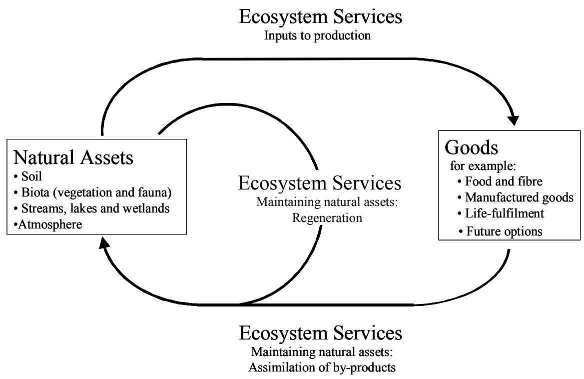


**Figure 1:** *Conceptual framework defining ecosystem services in terms of three types of transformations: (1) Transformations of natural assets into products valued economically and in other ways by people in a catchment; (2) transformations of the by-products of Type 1 ecosystem services back into natural assets; (3) internal transformations among natural assets to maintain those assets.*

This conceptual framework is being applied in an Australia-wide project (Cork and Shelton, 2000; Cork et al. this volume) that aims to:

- engage policy developers, decision makers, and implementers throughout;
- assess what ecosystem services are provided by a range of Australian ecosystems;
- assess who benefits from the services, where;
- explore and analyse change under different scenarios (including interactions between ecological, economic and social processes);
- investigate new institutional, market, and policy structures to encourage accounting of, and investment in, natural assets; and

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- develop and test guidelines for performing such assessments in Australia and elsewhere.

The first step in achieving these aims is an inventory of ecosystem services at a catchment-wide scale in partnership with community members and local experts (**Figure 2**).

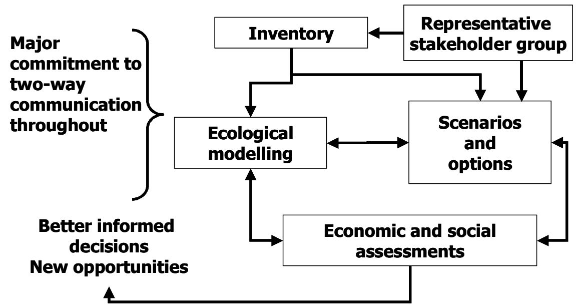


**Figure 2:** *Key elements of the approach to assessing and valuing ecosystem services as applied by The Ecosystem Services Project (Cork et al. this volume).*

In this paper we report on the inventory process developed and tested in a case study of the Goulburn Broken Catchment in north central Victoria. The process included a preliminary ranking of the importance of individual ecosystem services to land uses and industries in the catchment, based on consideration of the impacts of a marginal change in delivery of the services. We focus in particular here on services associated with waterways in the Goulburn Broken including a major waterway and its floodplain.

## 2. CHARACTERISTICS OF THE GOULBURN BROKEN CATCHMENT

Often referred to as the "food bowl" of Australia (Binning et al. 2001), the Goulburn Broken Catchment is located in Northern Victoria, Australia (**Figure 3**). The Catchment is diverse in terms of landuse, 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 with 190,000 people calling the Catchment home, of which 17,000 are employed in agriculture and associated industries.

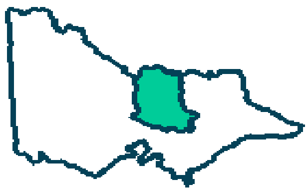

**Figure 3**: *Location of the Goulburn Broken Catchment in Victoria.*

The population of the Catchment is predicted to grow to approximately 210,000 by 2021 (an annual rate of 0.6%). The Shepparton Irrigation Region contains 63% of the population of the Catchment, but significant population growth is predicted for the southern shires close to the Hume Highway. These areas are within two hours drive of Melbourne, which is leading to increased interest in the land for rural lifestyle living, cheaper housing and new industries. The result of this is land values in the area are increasing, making it less cost effective to purchase land for traditional agricultural enterprises. Some of the increased land value is attributable to retained native vegetation, giving value to this component of biodiversity not recognised in the past.

## 3. DEVELOPMENT AND TRIAL OF METHODS FOR INVENTORY OF ECOSYSTEM SERVICES

The first step in The Ecosystem Services Project (**Figure 2**) is an inventory of ecosystem goods and services (Cork et al. this volume). This process is fraught with difficulty as there have been relatively few comparable assessments of ecosystem services at a catchment or similar geographic scale anywhere in the world to use as models. One such attempt is the World Resources Institute Report "People and Ecosystems" (World Resources Institute 2000) which attempts to assess the current state of the world's major ecosystems and the trend in their capacity to deliver a range of ecosystem services. The methods developed for the Australian Ecosystem Services Project are described below and thus far have been applied in the Goulburn Broken Catchment of Victoria (Binning et al. 2001).

The objectives of the inventory phase of The Ecosystem Services Project were to:

- describe the full range of goods (products) produced from the environment in the study area;
- identify the dependence of these products on ecosystem services;
- identify the ecosystem services of highest priority for further study and management.

There are substantial limitations on the information available to address these objectives. We took the approach of combining local knowledge of the Goulburn Broken Catchment with the knowledge of leading experts in the disciplines covered by the range of ecosystem services.

The first step was to work with local stakeholders to assemble a comprehensive list of products from ecosystems that people value in economic or other terms. These products included tangible, marketable commodities such as beef, wool and wheat, less tangible, marketable products like recreational opportunities, and intangible, often unmarketable products like aesthetic beauty, sites of cultural importance and intellectual or spiritual stimulation. These products were identified through a series of workshops involving scientists, economists, and representatives from industries, agencies and the general community within the Catchment. The discussions were enhanced with prompting from lists of ecosystem products from other studies. To make later analyses manageable, the products were aggregated into groups on the basis of industries and land-uses expected to have similar impacts and management pressures.

Using this list of products/goods, the ecosystem services involved in the transformation of natural assets into those products/goods was derived in workshops with community members and scientists, and by local experts working as consultants. These people considered what ecological processes were important in producing the ecosystem products identified, and then aggregated these into higher-level services such as those in **Table 1**. Lists of ecosystem services developed in other studies also guided this process, but groupings of processes and names of the services were modified in relation to the perceptions of the workshop participants and their perceptions about important processes in the Goulburn Broken Catchment.

Once the goods produced, and the role of ecosystem services were identified, the services were ranked in an iterative process involving local stakeholders and scientific experts. This process was fraught with difficulty because of the interconnected nature of the services and the different perceptions of the services people receive from ecosystems. Therefore, considerable effort was made to consult a wide range of stakeholders and experts, and to document the reasoning used in the process so that it could be assessed and reproduced by others.

The importance of each ecosystem service was considered in relation to each of the major groups of ecosystem products. The possible roles of each ecosystem service as an input to production of ecosystem products and/or in the maintenance of natural assets (**Figure 1**) were considered separately. Three assessment criteria were used to assess relative importance:

- *Overall importance/impact* - the overall importance of the service was considered in terms of the importance of the products 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, or the maintenance of natural assets.
- *Manageability* - the capacity to manage the land-use/industry to ensure the ongoing delivery of the service.

Given the purpose of the ranking (i.e. prioritising key services and issues) and lack of information, only three levels of ranking, low, medium and high, were derived. For each land-use or industry, highly ranked ecosystem services were considered further by the expert consultants. For the highly ranked services, drivers of decline in service delivery were identified along with the observed impact and a set of possible ameliorative actions.

## 4. KEY FINDINGS OF THE GOULBURN BROKEN CASE STUDY

Application of the inventory process described above to the Goulburn Broken Catchment revealed that all ecosystem services were of high importance (usually implying that further decline in the service would have a significant impact on production) for at least one major land-use or industry (**Table 1**).

**Table 1:** *Ecosystem services (rows) judged to be of high importance to various land uses (columns) in the Goulburn Broken Catchment. 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 | ■ | ■ | | | | ■ | | ■ | | | | |
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Further consideration of the ecological and management drivers of this situation, and possible management actions, revealed nine key issues that the Ecosystem Services Project will be investigating further. Many of the following nine issues are particularly relevant to stream management:

- Integration, evaluation and management of the multiple benefits provided by the interactions between ecosystem services. S*ection 5 discusses an example of this in more detail.*

- The trend towards intensified landuse in some areas, particularly for irrigated agriculture, will need to be carefully managed to avoid offsite impacts.
- Change in land ownership, particularly in areas close to Melbourne, which are being purchased by wealthy "lifestyle" farmers, provides a significant opportunity to improve environmental outcomes.
- Strategic re-establishment of trees and other vegetation is already a key issue in current NRM. An urgent task in restoring the full suite of ecosystem services is to quantify the multiple benefits of re/vegetation to further improve cost-sharing arrangements.
- Catchment planning will need to take more explicit account of the life-fulfilling values of nature including indigenous culture and the intrinsic values of biodiversity, and landscape amenity.
- Management of soil (acidification, sodicity, soil carbon, breakdown of structure) and evaluating the services provided by soil biodiversity emerged as the single most significant on-farm ecosystem service issue for the catchment.
- Accounting, and explicitly planning for, the dependence of non-agricultural land & water values (tourism, recreation) on the catchments resources.
- The ecosystem services inventory has reaffirmed water management as a key issue for the Catchment with a focus on salinity, environmental flows, nutrient management and the potential conflicts with non-agricultural requirements (see above).
- The final, and potentially the most significant future management issue, is how to adaptively manage for emerging and longer term issues? Climate change, shade & shelter, waste management, pest control and pollination all present potentially significant management issues that may need to be addressed.

## 5. EXAMPLE: FLOOD PLAIN MANAGEMENT ON THE GOULBURN RIVER

A primary area identified for further study is the Goulburn Broken Catchment Management Authority's proposed Goulburn River floodplain rehabilitation scheme. This scheme aims to aid in flood management by restoring the function of a floodplain near Shepparton. Floodwaters will be allowed to spill out into a large natural drainage channel, reducing strain on levees that are currently protecting high value horticulture. This scheme will also deliver a range of other ecosystem services in addition to its design purpose of flood mitigation.

The Goulburn River is Victoria's longest, rising in the Victorian high country north of the Great Dividing Range and draining to the Murray River near Echuca. The 156 km stretch of river between Shepparton and the confluence with The Murray is closely flanked by a system of levees that were built at the turn of the century. Within these levees the capacity of the lower Goulburn River is 185,000 ML/d at a point 12km downstream (north-west) of Shepparton. A further 25km downstream the capacity falls to a mere 37,000 ML/d.

Despite controlled releases at various structures, a flood equal to or greater than a 10-year average recurrence interval will spill over, or break through, levees (requiring repair 10 times in the last century) and onto the surrounding plains to the north and south. Failure of the ageing levee banks is random and causes heavy losses to agricultural production, particularly the economically important horticultural areas adjacent to the river.

With the levees in place, flows are channelled with greater volume and velocity than would be the case under natural conditions. This increases stream power, which in turn increases channel scour, and erosion (Young, 2001). In the past damaged levees were repaired using Natural Disaster Funds, however these funds are unlikely to remain available unless further flood damage minimisation strategies are put in place.

At this stage, the Catchment Management Authority has investigated three options. Option one is the minimal approach, that is, levees would continue to be repaired as damage occurs. The problem with this option is that Natural Disaster Funds may not be available for repairs, as this approach doesn't represent adequate flood protection. Option two is the fully engineered solution. Spillways would be constructed to prevent levee damage, and existing facilities would be upgraded. The third option is the floodplain rehabilitation scheme. By removing levees at strategic locations, floodwaters would be allowed to flow over a natural floodplain. This would reduce stress on existing levees in locations currently protecting the horticultural area.

A benefit cost analysis of options two and three (GBCMA, n.d.), using conservative, not probable estimates, yields a benefit cost ratio of 0.95 for option 2 (engineered) and 1.32 for option three (floodplain rehabilitation). This increases to 0.74 and 1.96 for engineered and floodplain rehabilitation respectively using the most probable assumptions. However, these calculations only consider the economic benefits of the increased flood protection. Consideration of the benefits to the environment and ecosystem services provided by the floodplain scheme were not quantified but may further enhance the equation.

Without considering the social issues of the proposed scheme, rehabilitating the floodplain has the potential to deliver a range of ecosystem services in addition to the flood protection availed by allowing floodwaters to spill over a larger area. The area of land under consideration is 10,500 ha of predominantly flat floodplain. Current landuse is primarily grazing with some cropping and minimal water rights. There is limited recreational use, no substantial crown land and little housing. The natural vegetation within the area is primarily Red Gum and Grey Box woodland. Several ecological communities of local, state and national significance (e.g. Plains Grassy Woodland), along with a number of rare and vulnerable species (e.g. Grey Crowned Babbler, Bush Stone Curlew) are also represented in the area.

Consideration of the magnitude of additional ecosystem services provided by this scheme may include carbon sequestration, timber products, water filtration, erosion control, help to maintain the hydrological balance, and more intangibly, the preservation and maintenance of the aesthetic appeal of the area. Applying the ecosystem services framework allows us to identify and quantify the full range of benefits that are important to people.

### 5.1 Carbon sequestration

Early estimates of potential carbon sequestration, from regeneration of Red Gums and Grey Box on the floodplain, indicate the floodplain scheme has the potential to make a significant contribution to carbon sequestration.

### 5.2 Maintenance and provision of habitat

The floodplain scheme will also help to restore natural environmental flows to the area, thus aiding a range of natural processes that have been impaired by the highly regulated flows and levee bounded rivers. With rehabilitation, the understorey might be expected to regenerate quickly, thus providing habitat for a wider range of species. The area may also act as enhanced habitat for various pest controlling species as well as important crop pollinators, both of significant importance to the nearby horticultural areas. The question is, what are the benefits or dis-benefits of providing “better” habitat?

Another well-discussed issue (Young, 2001) is that of fish breeding. Many Australian native fish undergo a portion of their life cycle (e.g. breeding and immature stages) in billabongs, but migrate to the main channel in times of flood for the majority of their life, before returning to billabongs. Significant decreases in fish abundance and distribution have been recorded in many regulated rivers (Young, 2001), some of this reduction has been attributed to reduced breeding success resulting from reduced occurrence of periods when billabongs are connected to the main channel.

The floodplain rehabilitation scheme would result in a significant increase in occasions when billabongs adjacent to the river are connected to the main channel. Local experts believe this will result in a significant increase in abundance and diversity of fish species, as well as increase habitat for a number of rare native fish species.

### 5.3 Waste absorption

Soil/plant systems have the ability to break down wastes (e.g. carbon, nitrogen, phosphorus, biocides) via of variety of mechanisms including: incorporation into soil organic matter, conversion into carbon dioxide and water, and storage for uptake by vegetation. All of these mechanisms are mediated by the “healthy functioning” of soil micro-organisms which are in-turn dependant on soil structure, water content, aeration, and minimal exposure to toxic materials (e.g. salts, biocides, heavy metals) (Binning et al. 2001).

By restoring the floodplain, and with the ensuing change in landuse, intensity and vegetation cover, we may witness an increase in the volume of various wastes that can sustainably be applied and assimilated by the floodplain. This is significant to both upstream (e.g. possible offset trading for nutrients) and downstream users (e.g. reduction in waste inputs to the river).

### 5.4 Filtration and erosion control

Closely linked to waste absorption (many wastes are attached to small sediment particles), filtration and erosion control are possibly the most significant ecosystem services to be delivered by the floodplain. Filtration refers to the process of capturing mobile sediment (and other material) and returning it to the landscape, while erosion control refers to the protection from erosive forces, wind and water, afforded by vegetation, and to a lesser extent litter, mosses and lichens.

With the expected regeneration of vegetation offered by the floodplain rehabilitation, we would expect to see an increase in the filtration potential of the floodplain. At times of low flow, the floodplain would be acting to capture particles moving in smaller overland and underground flow from the adjacent farming land. Various bacterial and protozoan pathogens may also be captured. Studies have shown that riparian zones are capable of trapping up to 90% of incoming sediment (Barling and Moore, 1994). Near-natural complex understories (grasses and shrubs) combined with litter layers, trap similar levels of sediment and associated nutrients as single-purpose dense grass buffer strip (Hairsine et al., 1996). Any reduction in sediment reaching streams has a range of benefits; e.g. smothering of instream habitat is reduced, stock productivity of stock dependant on the water increases (Carson, 2000) and in-stream nutrient levels are reduced. Other benefits for consideration may include decreased mechanical filtration necessary to treat water to drinking standards.

In times of high flow, when waters spill over the floodplain, water velocity decreases, thus sediment mobilised upstream would be trapped by, and deposited on, the floodplain reducing the nutrient and sediment load returned to the river and received in The Murray River. Furthermore, the resulting reduction in stream power decreases channel scouring and damage to levees further reducing the relative amount of sediment becoming mobilised.

### 5.5 Maintenance of hydrological balance

Finally, an increase in the extent of deep rooted perennial vegetation could be expected to play a role in reducing groundwater levels in the vicinity of the floodplain and therefore prevent further expansion of salinity. This would be brought about by an increase in evapotranspiration. Newly established woody vegetation on the floodplain would be expected to transpire 75-150 mm more per year than the grazing lands in place today (Vertessy, 2001). This would create a drier soil profile, reducing recharge to groundwater, by up to 90 mm per year (Petheram et al., 2000). A drier floodplain would also confer some benefits in terms of reduced flood levels for small to medium size flood events (Fahey and Jackson, 1997). The benefits of deep rooted perennials for flood mitigation/reduction is expected to take place in the short term, whereas the impact on groundwater level reduction is a longer term impact due to the slow drainage capacity of major alluvial groundwater systems (National Land and Water Resources Audit, 2001).

## 6. CONCLUSION

The framework presented above is the first step in an analysis of ecosystem services and is essential for identifying and prioritising the relative importance of the services and goods produced by ecosystems. The next step in the process uses a scenario analysis approach to look at the highly ranked issues and services in more detail. Under future scenarios, the changes in delivery of the "highly ranked" ecosystem services are assessed using both economic and other indicators of value.

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