COTTON AND THE ENVIRONMENT – ECOSYSTEM SERVICES

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Abstract

Ecosystem services are the natural processes responsible for clean air, clean water, healthy uncontaminated food and a host of other environmental goods that we take for granted. Natural control of pests on farms, the maintenance of biologically active and productive soils, water filtration, the break down of wastes and pollutants, provision of shade and shelter, and pollination are some of the services that we all depend on to a lesser or greater extent, but probably give little thought to. Ecosystem services can be damaged through ignorance and mismanagement or simply because there are no markets in which to trade particular services or their products. The concept of ecosystem services is broad and a new field of research endeavour in natural resource management. Research in ecosystem services potentially offers quantitative ecological, economic and social information (the 'triple-bottom line') to aid decision makers and is a useful framework for establishing equitable and transparent resource management policy at state, regional and local scales. There may be tradeoffs between ecological and economic goals, and we are attempting to quantify those tradeoffs using bio-economic models.

What are Ecosystem Services?

Ecosystem services are the natural processes that are responsible for clean air, clean water, healthy uncontaminated food and a host of other environmental goods that we tend to take for granted. Natural control of pests on farms, the maintenance of productive, biologically active soils, water filtration, the break down of wastes and pollutants, provision of shade and shelter, and biotic pollination are some of the services that we all depend on to a lesser or greater extent, but probably give little thought to. Ecosystem services can be damaged through ignorance, mismanagement or simply because there are no markets in which to trade particular services or their products.

A good recent example of ecosystem services at work is the research done by Hoque *et al.* (2000) where the economic contribution of beneficial insects (who provide an ecosystem service of natural pest control) was estimated by comparing the gross margins of cotton fields on which "hard" or "soft" insect control chemicals were used (ranked according to their impact on beneficial insects). In fields where the chemicals had little impact on beneficial insect populations, the gross margin was greater than in fields where the chemicals had a detrimental impact on beneficial insect populations (Hoque *et al.* 2000). This suggests that if the growers are able to utilize the natural pest control actions of the beneficial insects on their farms, they will be financially better-off at the end of the season, this is despite the often-higher cost of some of the "soft" chemicals.

Figure 1 shows the three categories of ecosystem services: (1) services that turn natural assets into goods and other products (category 1); (2) services that assimilate by-products back into the natural asset base (category 2); and (3) services that maintain the natural asset base (category 3).

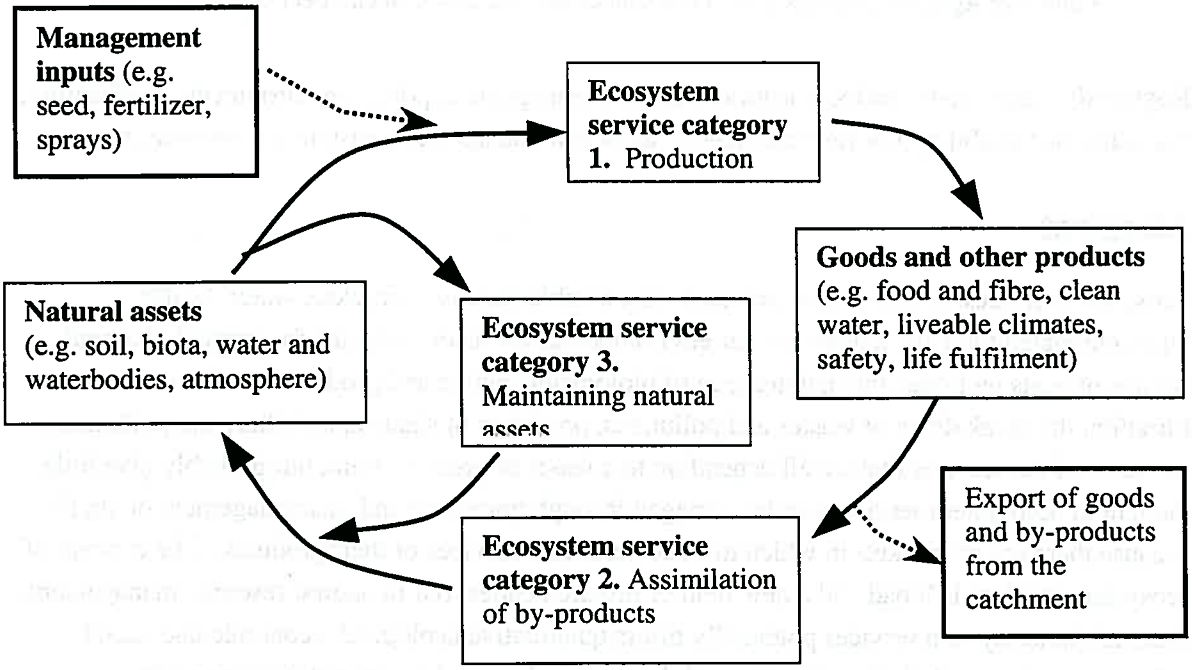


Fig. 1. The three major cycles that link ecosystem services, goods and natural assets: (1) the production cycle whereby 'goods' and other products are produced from natural assets by ecosystem services; (2) the breakdown cycle where waste products arising from the production of goods are returned to the natural resource base; and (3) the regenerative cycle of ecosystem services that maintain natural assets (GBCMA & CSIRO 2000).

If people are aware of ecosystem services and we learn how to value them in dollar (or other) terms, land and water managers will be better equipped to manage for enhanced provision of profitable ecosystem services, which will benefit both producers and the environment. Additionally, policy and decision makers are more likely to recognise and reward the providers of important services that are in the 'public interest'. At the very least, if decision makers are aware of the biophysical-economic tradeoffs, they are making decisions with this information in mind.

The rural community is disheartened with recent developments in natural resource management policy. Ecosystem services provides potentially win-win outcomes for land managers who manage their natural resources to maintain healthy ecosystems. There is also an issue in that current natural resources policy is creating confusion and anxiety for rural land and water users. The ecosystem services concept provides an implementation framework for achieving the outcomes sought within current NSW catchment management policy and catchment targets.

What is the potential for an ecosystem services approach? How is it new and how does it add value?

A relevant question likely to be asked by stakeholders is "how is an ecosystem services approach different to what has been done in the past or is currently being done in the field of natural resource management research"? Alternatively, this question might be posed as "how does an ecosystem services approach add value to the current body of research"?

Several responses to these questions are appropriate:

- The study of ecosystem services is an explicit attempt to recognise that the ecosystem provides a number of free services, some quite subtle, that are often taken for granted in productive activities. However, productive activities may alter the provision or quality of those services;

- The concept acknowledges that geographic dispersion can be important in ecosystem service delivery and encourages attempts to measure impacts on ecosystem services at points distant from where productive activities may occur;

- Apart from recognising the human use of and in some cases damage to ecosystem services, the concept also acknowledges that some management practices can enhance the value of ecosystem services for other users and that many landholders are custodians of these services and provide public benefits free of charge to the wider community. In the past, natural resource management research has focused on ameliorating damaging activities, but these more positive aspects of natural resource management and environmental stewardship have received less attention but are no less important;

- The concept also encourages exploration of the trade-offs between private economic and public environmental benefits. Agriculture can be undertaken in a great many different ways, each with varying impacts on the provision of ecosystem services. Agricultural management practices that enhance ecosystem services may come at the expense of reduced farm profit. This is ignored in much of the current debate over farmers' management of natural resources such as native vegetation on farms;

- The ecosystem services approach proposed in this study is an explicit attempt to measure both the biophysical and the economic implications of alternative management systems and to quantify trade-offs. Too often, resource management research is couched either as an economic or ecological choice, with little regard for the fact that decision makers may imperil ecosystem services or that businesses must make a profit. Integrating ecology and economics is a challenging but critical area of value-adding in this project.

Who Pays; Who Benefits?

Commentary about who bears the costs and who receives the benefits from the provision of ecosystem services is starting to enter the policy debate surrounding resource management in rural areas. Unfortunately, the analytical tools required to accurately estimate these costs and benefits are only now being developed and applied. This is at a time when various resource management committees are trying to make critical decisions about resource management, including several committees in the Gwydir Valley.

There has often been a perception that since some farming practices damage ecosystem health (and hence the ecosystem services provided), farmers should bear the costs of rehabilitating those services or ecosystems. While it is true that some farming (and non-farming) practices have been detrimental, it is simplistic and impractical to expect these businesses to bear the entire cost burden for rehabilitation, or for implementing new management systems to minimise further damage.

There are a number of reasons for this:

- In many cases, the costs of such action would be beyond the financial capacity of the business;
- Some of the detrimental practices were actually required or condoned by governments (e.g. land clearing and the over-allocation of water licenses), so it is inequitable for current farming businesses to bear all the costs;
- There is a lack of information on the financial and ecological implications of many 'ecosystem-friendly' management systems. This is an area where this project can make a significant contribution. Until managers are given some clear and practical information on the financial and biological impacts of alternative management systems, it is difficult for them to factor these options into their decision making;
- Often the beneficiaries of ecosystem services are outside the farming system, so it is inequitable to expect farmers to bear the entire cost burden.

Modelling Ecosystem Services in the Cotton Industry

Good policy regarding environmental management in agriculture requires some detailed modelling at the microeconomic (ie farm) level. This should include an assessment of how individual business are likely to respond to management options or policy induced regulations. In particular, much recent work surrounding the response of farmers to policy decisions such as water sharing plans has been restricted to assuming that the impacts are based upon current farming operations. In most cases, this simply means a reduction in farm production as water entitlements are reduced. However it ignores the fact that, over the longer term, innovative producers are likely to modify their farming operations to respond to the new conditions. Eventually, the majority of producers will respond in a similar manner if it is deemed successful and those generating low production values per megalitre of water may trade out of the industry.

Similarly, innovative producers will analyse the array of alternative management options and new technologies on offer and make a decision whether or not to adopt, reject or adopt in a modified manner. This process will apply to ecosystem friendly alternatives and a large component of the decision will revolve around the likely financial impact on the farm business. Hence the need for some detailed microeconomic modelling.

What has been missing in many cases is an assessment of the ecological outcomes that occur alongside the financial impacts. This is clearly evident in most of the current resource management planning processes underway in NSW. Some limited mircoeconomic modelling has been undertaken, though this usually suffers from the deficiency that it is based on a straight-line reduction in current production levels, not allowing for possible adjustments farm managers might take and rarely accounting for the stochastic (ie uncertain) nature of the operating environment. The biophysical modelling needed to assess economic-environmental trade-offs is virtually non-existent and those impacted by the changes are being asked to take a 'leap of faith' that the new policy or management option on the table will improve ecological (and hence ecosystem services) outcomes and result in a net benefit in social welfare.

Where adequate resources *are* invested in some detailed biophysical data collection and modelling, results may be obtained that fly in the face of conventional wisdom and make a mockery of widely accepted opinion. For example, recent work by Montgomery and Faulkner (2001) in the Gwydir Valley demonstrated that cotton irrigation activity actually *reduced* the sediment load in the Gwydir River because irrigation water is recycled on farms and not discharged back into the stream. The common perception is that irrigation run-off causes increased stream sedimentation.

The information generated from the micro (farm) level modelling can then be aggregated or scaled up for use in regional impact analysis. This analysis will capture any significant flow-on effects to the rest of the regional economy that result from changes at the farm business level.

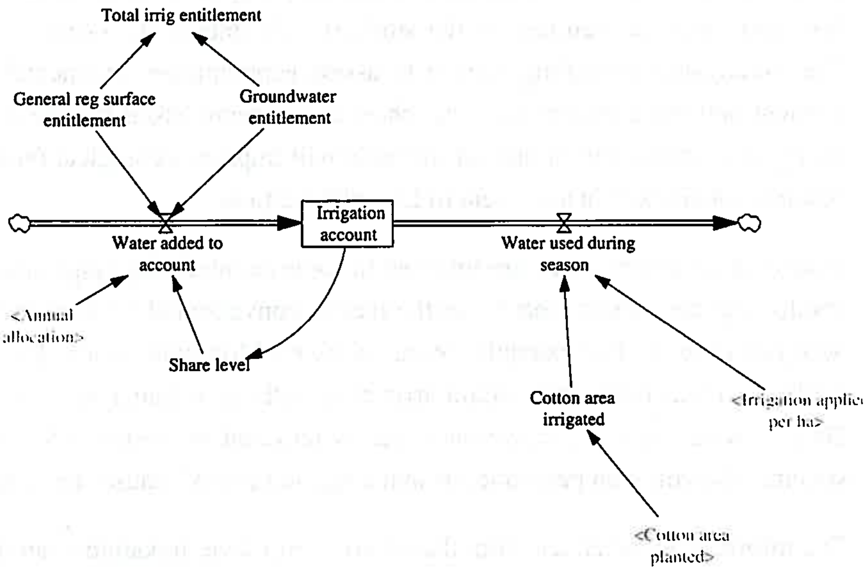
In this project, we attempt to make use of a bioeconomic modelling framework to explicitly examine the financial and biophysical impacts of alternative management options and policy decisions. As is always the case with bioeconomic modelling, this task tends to be constrained by a lack of biophysical data (not economic data). Quite simply, the nature of some biophysical relationships in not known or, if data is available for one site, there are doubts about its applicability to other sites.

The bioeconomic modelling approach used in this project has a number of features which add value to our understanding of ecosystem services and how they interact with farm production including:

The capacity to integrate biophysical and economic information – this is the essence of bioeconomic modelling. In this project we attempt to describe both sides of the cotton production story so that environmental-financial tradeoffs (and win-win situations) can be identified and measured. We are using the Vensim simulation software to achieve this task and have the explicit goal of trying to quantify these tradeoffs (or win-wins) rather than simply quantifying the economic values and assuming that the ecological gains are a given. Where there is insufficient data to measure the ecological gains, we can at least say something about the value of ecological gains that need to be achieved to offset any losses in productive values, or identify situations where both ecological and profit gains can be made.

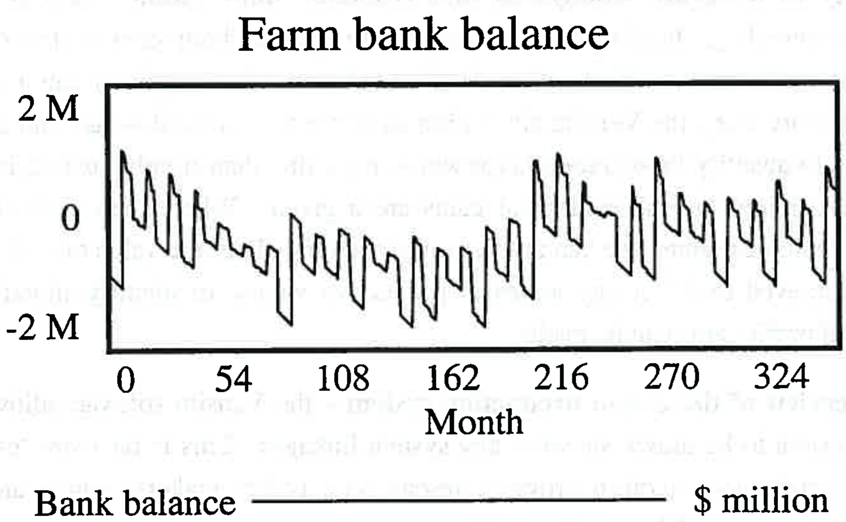
A visual overview of the cotton production system – the Vensim software allows a 'sketch' of production system to be drawn showing key system linkages. This is far more 'user-friendly' for most of our 'customers' (cotton growers, researchers, policy makers) which aids in obtaining feedback to refine the models (see Figure 1);

Figure 1. An example from a whole-farm cotton production model for the Gwydir



The ability to deal with uncertainty – most of the economic modelling to date surrounding policy decisions has worked with averages. We attempt to model the uncertain nature of variables like rainfall and capture the spread of possible financial and biophysical outcomes. This can be critical because often it is runs of poor years which threaten farm business survival and this cannot be captured in an analysis which produces a simple average reduction in farm profits. Figure 2 provides an example of Vensim output (in this case, the farm bank balance) over a number of seasons with uncertain rainfall and irrigation allocations.

Figure 2. Example of Vensim output for a model cotton farm



The use of decision rules – farm management decisions are flexible and will respond to operating circumstances. Our modelling includes some simple decision rules which reflect farmer responses to variables such as available water or insect pest pressure. This is integrated with uncertain variables in the model to produce a more realistic system;

The ability to represent dynamic feedback in the system – farming systems involve feedback information which modify system behaviour. For example, reinvestment in new capital items is dictated to some extent by the current financial position. This type of function has been included in the Vensim models used in the project;

The ability to represent a whole-farm system through time – much analysis that considers the interaction between biophysical and financial performance on cotton farms has stopped at the level of annual gross margin analysis. In our work, we have developed whole-farm models which can be run over numerous years to show the cumulative impact of decisions on key farm financial measures like debt and equity levels and cash flows (the model tracks the farm bank balance). The models account for financial parameters such as loans, overdrafts, assets, new investments, capital depreciation and overhead costs as well as the standard inputs to gross margins (yields, prices, variable costs).

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