Ecological Economics xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Determining the value of multiple ecosystem services in terms of community wellbeing: Who should be the valuing agent?

S. Maynard [a,b,*], D. James [c], A. Davidson [a]

[a] SEQ Catchments, Level 2, 183 North Quay, Brisbane, Queensland 4003, Australia
[b] Australian National University, Australian Capital Territory 0200, Canberra, Australia
[c] University of the Sunshine Coast, Queensland 4556, Australia

ARTICLE INFO

Article history:
Received 17 October 2012
Received in revised form 7 January 2014
Accepted 4 February 2014
Available online xxxx

Keywords:
Regional planning
Multiple ecosystem services
Ecosystem services framework
Valuation
Community wellbeing

ABSTRACT

When multiple ecosystem services are derived from multiple ecosystems across different policy, planning or management jurisdictions, questions arise regarding the valuation of ecosystem services such as: who are the beneficiaries; how do they value ecosystem services; and who should be the valuing agent? In attempting to achieve an integrated approach to natural resource management in South East Queensland (SEQ), stakeholders have combined their knowledge to develop a framework to identify, measure and value ecosystem services provided by the region. This paper focuses on a methodology trialled to value the ecosystem services derived from the SEQ region in terms of the wellbeing of the SEQ community. The methodology allows flexibility of choice regarding whose values count and who should be the valuing agent. The methodology was trialled with community participants and scientific experts. The building blocks of the Framework can be used to construct different model variants, each of which reveals key characteristics of ecosystem services in SEQ. The approach adopted to value ecosystems and ecosystem services offers scope for decision makers to think more broadly about possible impacts of decisions on the wellbeing of the community and has facilitated the inclusion of ecosystem services in statutory planning policy in SEQ.

1. Introduction

Identifying the ecosystem services provided by a region and assessing their contribution to human wellbeing is a daunting task. It requires application of complex systems theory, as it typically involves an analysis of the many diverse, autonomous, interrelated and interdependent components of socio-ecological systems (Limburg et al., 2002; Stratton, 2005). The relationships between a given ecosystem, the multiple services it provides and human wellbeing are complicated (de Groot et al., 2002; Fisher et al., 2009; Maynard et al., 2010). Research to date has therefore focused mostly on the services provided by a single ecosystem (Campbell and McKenzie, 2004; Ricketts et al., 2004) or only a few ecosystem services simultaneously (Chan et al., 2006; Egoh et al., 2008; Naidoo et al., 2008; Willemen et al., 2008). A greater challenge is faced when attempting to develop and apply tools that can consistently and comprehensively account for the full range of ecosystems and ecosystem services derived from a region; and support the diverse decision-making and functions of multiple agencies, such as statutory planning, community planning, water management, nature conservation and community education.

The Millennium Ecosystem Assessment (MA, 2005) suggests that, to make ethical and informed policy, planning and management decisions, the full range of ecosystems and ecosystem services should be assessed. For example, the MA identifies twenty-four ecosystem services derived from ten Reporting Categories (biome groups), providing an assessment of the full range of ecosystems and services for the whole planet. Costanza et al. (2011, p. 2) advocate this approach, stating 'the full range of ecosystem services must be considered to prevent creating dysfunctional incentives and to maximize net benefits to society'. To mainstream ecosystem services in decision-making processes, effective approaches are required to demonstrate the value of maintaining and/or enhancing different ecosystems in terms of their importance to the wellbeing of generations, in the context of competing stakeholder interests (Cowling et al., 2008; MA, 2005; Smith et al., 2013).

When multiple ecosystem services are derived from many types of ecosystems across different policy, planning or management jurisdictions, fundamental questions underpinning the valuation of ecosystem services arise such as: who are the beneficiaries; how do they value ecosystem services; and who should be the valuing agent? Additional questions are: what kind of analytical frameworks should be developed in demonstrating the inter-connections between ecosystem services and beneficiaries; how might such a framework best be developed; and how might the relevant supporting data be obtained?

* Corresponding author at: SEQ Catchments, PO Box 13204, George St, Queensland 4003, Australia. Tel.: +61 403 940 055.
E-mail address: maynardsimone@gmail.com (S. Maynard).

http://dx.doi.org/10.1016/j.ecolecon.2014.02.002
0921-8009/© 2014 Published by Elsevier B.V.

The South East Queensland (SEQ) region is approximately 23,000 km^2. It is one of the fastest growing regions in Australia with the current population of around 3.4 million predicted to grow to 4 million by the early 2030s (Department of Environment and Resource Management, 2009; Office of Economic and Statistical Research, 2012, p. 17). The region has a rich variety of ecosystems and is a recognized Australian Government 'biodiversity hotspot' (Department of Environment and Resource Management, 2009; Department of Environment, 2013). Collating the information required for a comprehensive assessment of the multiple ecosystem services provided by the SEQ region is accordingly a major challenge.

Since 2005, work has progressed under the SEQ Ecosystem Services Project on developing, refining and applying an ecosystem services framework (the Framework) to meet the multiple objectives of planning, environment protection and natural resource management in the region. The Project is coordinated by SEQ Catchments, an independent body recognised by the Australian Government, responsible for facilitating projects and programmes for natural resource management in SEQ (Australian Government, 2011). The Project was designed specifically to engage stakeholders and potential users in developing the Framework. Those involved have included representatives of government and non-government agencies, business, industry, academia and the general community.

This paper describes the way in which the Framework was developed, its main components and general structure, some results from its application, and an evaluation of the methodology adopted to value ecosystem services derived from the SEQ region in terms of the wellbeing of the SEQ community.

2. The SEQ Methodology

An innovative approach to developing the Framework was adopted, similar to that used in collaborative planning (Healey, 2003, 2005), Bayesian networks (Neapolitan, 1988; Pearl, 2009), participatory systems analysis (Smith et al., 2007) and decision support systems (Janssen, 1992). Such models create opportunities for stakeholders and experts to be actively involved in the processes of model construction and application, as well as handling inter-relationships in the simplest possible way, including making use of quantitative and qualitative data. Participation by stakeholders in assessing ecosystem services has been recommended by many, such as the MA (2005), van den Hove (2000), Reid (2006), Cowling et al. (2008), Liu et al. (2013) among others. The SEQ Project was deliberately designed to encourage participants to acquire a sense of ownership of the Framework and, through its development, gain a better understanding of the requirements for better managing ecosystem services in the region (Maynard et al., 2012).

2.1. Participatory Processes

Stakeholders in the Project participated in various ways. General directions for developing the Framework were established by a Steering Group, comprised mainly of potential key users of the Framework and/or funders of the Project. Facilitated workshops were staged to report on progress and seek input from a broader group of stakeholders. To cover scientific aspects of the Framework, Scientific Expert Panels were formed, comprising individuals with expertise in the physical and biological sciences. A Socio-Economics Expert Panel contained individuals with expertise in social sciences and economics. Multidisciplinary Expert Panels brought these experts together. Data to populate the Framework was provided by Working Groups within the Expert Panels. Each Working Group concentrated on a particular aspect of the Framework, as described further in Section 2.2. Experts were selected on the basis of their experience and published works and were well-recognised by peers in their specialist fields Mostly they resided in SEQ, with detailed knowledge of the region and its natural or socio-economic features. In all, more than 190 individuals participated in the project. Further details of the participatory processes adopted are described by Maynard et al. (2010, 2012).

2.2. General Structure of the Framework

Participants overwhelmingly recommended using the Millennium Ecosystem Assessment (MA) as the basis for the SEQ Framework. However, some modifications of the MA framework were introduced. Experts involved in the process considered that many of the services in the MA were ecological processes or ecosystem functions rather than ecosystem services. In the SEQ Framework, ecosystem functions are recognised as being necessary for maintaining ecosystems and biodiversity for its own sake (Maynard et al., 2010; Petter et al., 2012). Whether ecosystem functions contribute to service provision depends on many factors, such as the extent of the function, location of people and the importance that people place on different services (Maynard et al., 2010). The schema advocated by de Groot et al. (2002) was instrumental in developing the final list of ecosystem functions adopted for the Framework, but it was appropriately amended to suit the SEQ region. To avoid the problem of double counting in ecosystem valuation – a key issue highlighted by Haines-Young and Potschin (2010), The Economics of Ecosystems and Biodiversity (2010) and the UK National Ecosystem Assessment (2011) among others – only the MA service categories of Provisioning, Regulating and Cultural were adopted for the Framework.

The Framework identifies four main components of an ecosystem service assessment: ecosystems, ecosystem functions, ecosystem services and constituents of wellbeing (Maynard et al., 2010):

Ecosystem Reporting Categories (ERCs) — 32 groups of ecosystems, each ecosystem within a group having similarities in climatic conditions, geophysical condition, dominant use by humans, surface cover, species composition and resource management systems and institutions;
Ecosystem Functions — 19 biological, geochemical and physical processes and components that take place or occur within an ecosystem;
Ecosystem Services — 28 goods and services provided by natural (and semi-natural) ecosystems that benefit, sustain and support the wellbeing of people;
Constituents of Wellbeing (COWB) — 15 aspects of human wellbeing that are improved through the use of ecosystem services or the knowledge that these services exist.

Fig. 1 displays the four main components, and a full listing of all categories appears in Table 1. Inter-connections between the components are represented by a set of linked matrices and vectors, with elements in the form of scores indicating the relative magnitudes of the inter-connections, as well as scores representing relative value weights for ecosystem services or COWB. The various matrices and vectors act as building blocks to construct different assessment models, as well as revealing important properties of the system.

The Framework includes a detailed GIS database able to produce a wide range of maps indicating the spatial distribution of ecosystems and functions important for the provision of different ecosystem services and human wellbeing. Information on the spatial characteristics of the region is critical for land-use planning, the design of offset programmes, and investments aimed at protecting or enhancing natural assets. Details of mapping capabilities, procedures and applications of the GIS as an integral aspect of the Framework are described by Petter et al. (2012) and are on the Framework's website (SEQ Catchments, 2013).

2.3. Expert Scores for Ecosystems, Functions and Services

The algebraic notation, dimensions and sources of data to populate the matrices and vectors in Fig. 1 are presented in Table 2. The matrix **E** was constructed by biological and physical science experts, divided into small Working Groups, each concentrating on a subset of ecosystem

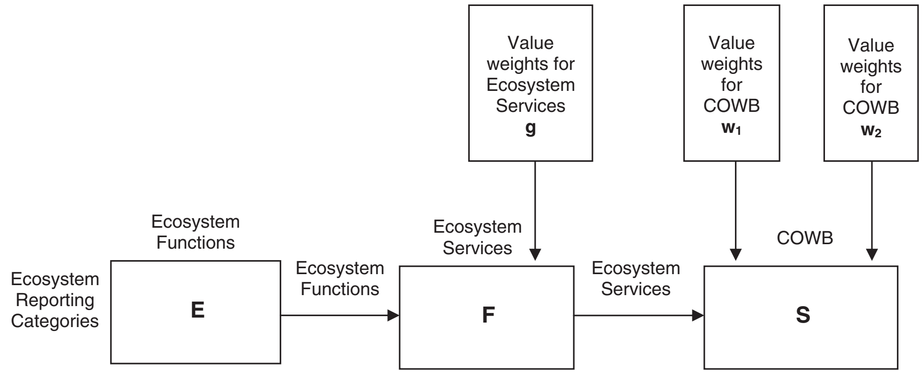

Fig. 1. The conceptual framework underpinning the scoring system in the SEQ ecosystem services framework.

functions and allocating scores on a scale of 0 to 5 indicating the relative magnitudes they are performed by each ERC. To construct matrix **F**, in Working Groups experts in environmental, social and economic sciences provided scores on a scale of 0 to 5 indicating the relative magnitude ecosystem functions provided ecosystem services. A consensus approach was used to obtain each Working Group's scores.

The matrix product **EF** takes the form of a 32 × 28 matrix, the elements of which comprise index scores indicating the ‘quantities’ of ecosystem services produced per unit area of each ERC (e.g. a hectare of croplands) relative to unit areas of other ERCs (e.g. a hectare of rainforest). The ‘quantities’ refer to potential supplies of ecosystem services rather than the actual quantities presently produced within the region, as ecosystem condition was not taken into account during scoring nor were socio-economic factors that may influence service provision. Total areas for different ERCs within the region are indicated through the maps constructed using the GIS database. Total potential ‘quantities’ for each ERC can be determined by multiplying expert scores by ERC area.

2.4. Approach to Valuation

When multiple ecosystem services are derived from a range of ecosystems and delivered to different beneficiaries over time and space (such as across a region), key issues regarding their valuation must be addressed. Debate about the best way to derive such values is ongoing, with economists focusing on the application of valuation techniques drawn from an extensive literature in environmental, ecological and resource economics (Costanza et al., 1997; de Groot et al., 2002, 2006; Freeman, 2003; Hanley and Barbier, 2009). According to the Department for the Environment, Food and Rural Affairs (2011) ‘monetary valuation alone cannot provide a meaningful or complete picture of the costs or benefits of a given policy change and the use

Table 1
The four key components of the SEQ Ecosystem Services Framework (adapted from Maynard et al., 2010).

Ecosystem reporting categories	Ecosystem functions	Ecosystem services	Constituents of wellbeing
Deep ocean	Gas regulation	Food products	Breathing
Open water — pelagic	Climate regulation	Water for consumption	Drinking
Open water — benthic	Disturbance regulation	Building & fibre products	Nutrition
Coral reefs	Water regulation	Fuel	Shelter
Seagrass	Soil retention	Genetic resources	Physical health
Rocky shores	Nutrient regulation	Biochemicals, medicines & pharmaceuticals	Mental health
Beaches	Waste treatment & assimilation	Ornamental resources	Secure & continuous supply of services
Dunes	Pollination	Transport infrastructure	Security of health
Coastal zone wetlands	Biological control	Air quality	Security of person
Palustrine wetlands	Barrier effect of vegetation	Habitable climate	Community & social cohesion
Lacustrine wetlands	Supporting habitats	Water quality	Secure access to services
Riverine wetlands	Soil formation	Arable land	Family cohesion
Rainforests	Food	Buffering against extremes	Security of property
Sclerophyll forests	Raw materials	Pollination	Social & economic freedom
Native plantations	Water supply	Reduce pests & diseases	Self-actualisation
Exotic plantations	Genetic resources	Productive soils	
Regrowth	Provision of shade & shelter	Noise abatement	
Native & improved grasslands	Pharmacological resources	Iconic species	
Shrublands & Woodlands	Landscape opportunity	Cultural diversity	
Moreton Island		Spiritual & religious values	
Bribie Island		Knowledge systems	
N. Stradbroke Island		Inspiration	
S. Stradbroke & Bay Islands		Aesthetic values	
Montane		Effect on social interactions	
Sugar cane		Sense of place	
Horticulture — small crops		Iconic landscapes	
Horticulture — tree crops		Recreational opportunities	
Other irrigated crops		Therapeutic landscapes	
Dams			
Hard surfaces			
Parks & gardens			
Residential gardens			

Please cite this article as: Maynard, S., et al., Determining the value of multiple ecosystem services in terms of community wellbeing: Who should be the valuing agent? Ecol. Econ. (2014), http://dx.doi.org/10.1016/j.ecolecon.2014.02.002

Table 2
Matrices and input data for the SEQ Ccosystem Services Framework.

Matrix	Dimension	Rows	Columns	Scores	Provided by
E	32 × 19	Ecosystem Reporting Categories	Ecosystem Functions	0–5	Expert panel
F	19 × 28	Ecosystem Functions	Ecosystem Services	0–5	Expert panel
S	28 × 15	Ecosystem Services	COWB	0–5	Expert panel
g	28 × 1	Value weights for Ecosystem Services	NA	1–10	Community participants
$\mathbf{w_1}$	15 × 1	Importance weights for COWB	NA	1–10	Community participants
$\mathbf{w_2}$	15 × 1	Importance weights for COWB	NA	1–10	Expert panel

of non-monetary evidence may be more appropriate'. Costanza et al. (2011) suggest that because 'many ecosystem services are public goods, … analyzing individual choices is not the most appropriate way to assess an ecosystem's value and use, … [so] we need to develop other methods to assess their value'.

Stakeholders involved in the development of the Framework considered the main beneficiaries of ecosystem services derived from SEQ to be the 'SEQ community' itself, defined as people living within the region. It was agreed a common unit would be required for valuing the full range of services contained in the Framework. However, an important requirement was the flexibility to incorporate different value sets depending on the decision context and whose values should be counted. Participants agreed that, for the purpose of developing and applying the Framework, the values of ecosystem services would be most appropriately assessed along similar lines to the MA. Monetary valuation methods for determining values were considered inappropriate under the circumstances, given the extent and diversity of valuations required; limited budget to conduct the work; concern about what a monetary value really meant; how decision-makers would make tradeoffs using the information; and a tight timeline for completing the framework in order to incorporate it in statutory plans within the current policy cycle (Maynard et al., 2010).

Two alternative approaches were adopted as a means of deriving community values for ecosystem services. The first involved direct elicitation of relative value weights for ecosystem services from members of the community. To trial this approach, a facilitated workshop was held for a local government area within SEQ, attended by 36 members of the local community. Participants were asked to provide a score on a scale of 1 to 10 indicating the relative values they place on all 28 ecosystem services in the Framework. The data so obtained populated the vector **g** in the Framework (Fig. 1).

The second procedure adopted focuses on the inter-connections between ecosystem services and COWB. A list of 15 COWB tailored for the SEQ region was developed by the Project Manager and a panel of recognised experts in the social sciences. It involved an iterative process of drafting, review and amendment. The list was based closely on the work of the MA (2005), Costanza et al. (2007), Max-Neef (1991) and Maslow (1943).

The MA (2005, p. vi) uses a diagram, in which the intensity of linkages between ecosystem services and human wellbeing is indicated conceptually by the widths of inter-connecting arrows. The procedure adopted in constructing the SEQ Framework carries this conceptual approach one step further by using expert scores to represent the relevant inter-connections. To implement this approach two different kinds of data were obtained. The first comprises a matrix of scores (matrix **S**) indicating on a scale of 0 to 5 the relative magnitudes of the contribution that each ecosystem service makes to each COWB. The scores in **S** take the form of semi-quantitative scientific data based on objective expert judgment. Experts in the social and economic sciences provided this information in an iterative process similar to a Delphi process, producing a finally agreed set of scores. The second kind of data is a set of subjective value weights indicating the relative importance or value of the various COWB, in terms of human wellbeing. Scores on a scale of 1 to 10 were elicited from participants in the local government workshop, producing the 15 × 1 vector of weights $\mathbf{w_1}$.

For comparative purposes, scores were also obtained from experts, represented by vector $\mathbf{w_2}$. Similar instructions for scoring were given to the community participants and the social science experts. However, the community participants were asked to score the COWB in terms of their own individual wellbeing, whereas the experts were asked to respond in terms of their judgments regarding the wellbeing of the whole SEQ community. Having obtained the information just described, it was possible to calculate a 28 × 1 vector of relative value weights for ecosystem services, either as the matrix product $\mathbf{Sw_1}$ making use of the community scores for COWB, or as $\mathbf{Sw_2}$ when using the scores provided by experts. The statistical properties of the scores provided by the community participants and experts were explored in terms of means, correlation coefficients, standard deviations and coefficients of variation. Correlations were assessed, where relevant, using product moment coefficients and/or Spearman's rank correlation coefficients.

2.5. Construction of Assessment Models

This section explains how some assessment models were constructed using the data described in Table 2. Model 1 (see Eq. (1)) makes use of the matrix product **EF** and the relative value weights for ecosystem services represented by the vector **g**. The resulting vector $\mathbf{v_1}$ indicates the relative values of ERCs as providers of ecosystem services per unit area in the region. A ranking of ERCs can be obtained in terms of these relative values.

$$\text{Model 1} \quad v_1 = EFg. \tag{1}$$

Model 2, shown in Eqs. (2a) and (2b), enables a ranking of ERCs to be obtained making use of the matrix product **EF**, the matrix **S** and the vector of relative importance weights for COWB provided by either the community ($\mathbf{w_1}$) or by experts ($\mathbf{w_2}$). The ERCs can be ranked in terms of their contribution to wellbeing according to the corresponding vectors $\mathbf{v_2}$ or $\mathbf{v_3}$.

$$\text{Model 2} \quad v_2 = EFSw_1 \tag{2a}$$

$$v_3 = EFSw_2. \tag{2b}$$

Instead of relying on raw data to calculate total scores for each ERC, normalising the data models can also be constructed along the lines of a multi-criteria analysis (MCA) model, a technique recommended by de Groot et al. (2006) in valuing wetlands. Other applications of the Framework are also possible. For example, models can be constructed that produce rankings of ecosystem functions rather than ERCs. Exogenous impacts such as those resulting from climate change or policy interventions can be simulated by altering key elements within the system, such as modifying the magnitudes of the functions performed by ERCs or the 'quantities' of ecosystem services provided by each function in the Framework. The scores for relative importance weights can also be changed for different ecosystem services if the valuing agent determines that certain ecosystem services become more or less valuable over time. The outputs of such exercises can act as inputs to the GIS, enabling maps to be produced identifying the locations within the region where the modelled changes would take place. For each such exercise undertaken, further expert judgment and/or scientific assessments regarding the relevant causal mechanisms and effects would be required.

3. Results

3.1. Community Scores for Ecosystem Services and COWB

According to the scores allocated for ecosystem services by community participants, the ecosystem services of highest importance belong mainly to the Regulating category, namely, ecosystem structure and functions that contribute to the regulation of natural conditions important for maintaining human wellbeing: Air Quality, Water Quality, Productive Soils and Habitable Climate. The provision of Water for Consumption also scored highly. The services with low importance scores are mainly those from the Provisioning category, such as Building and Fibre, Transport Infrastructure, Fuel and Ornamental Resources. Apart from these extremes, there was no obvious pattern in the ranking. In particular, some of the Cultural services appeared high in the ranking such as Therapeutic Landscapes, Knowledge Systems, Aesthetic Values and Iconic Species; some mid-way such as Sense of Place, Recreational Opportunities and Iconic Landscapes; and others at the lower end including Effect on Social Interactions, Cultural Diversity, Inspiration, and Spiritual and Religious Values. Most of the services from the Regulatory category occupied positions mid-way in the ranking. The services with the smallest coefficients of variation are those appearing high in the ranking, and those with the largest coefficients low in the rank order, suggesting that participants were more confident and in agreement about the most important services but more diverse in their views for the services of lower importance.

The ranking of COWB by the community participants closely parallels that of the Maslow hierarchy (Maslow, 1943). The results clearly indicate that participants considered that the most important COWB are those underpinning physical survival, in particular Breathing, Drinking, Nutrition, Physical Health and Shelter. The least important are the more intangible COWB such as Social and Economic Freedom. Other aspects of health appear in the mid-range, followed by Family Cohesion and Community and Social Cohesion. It is significant that the coefficients of variation for the different COWB are smallest (showing a high degree of agreement) for the 'Existence' COWB category and the largest (much less agreement) for the 'Freedom of Choice and Action' COWB category.

3.2. Expert Scores for COWB

Members of the Expert Panel were not asked to provide value scores for ecosystem services directly. However, they did provide scores for COWB. The highest scores were allocated to COWB in the 'Existence' category, again revealing close parallels with Maslow's hierarchy of needs (Maslow, 1943). For the matrix **S**, the scores allocated by experts indicated that ecosystem services making the largest contributions to wellbeing belong mostly to the Regulating category. Some Provisioning services appear high in the ranking (e.g. Food and Water) but others occupy lower positions (e.g. Fuel, Ornamental Resources, Building and Fibre and Genetic Resources). Cultural services occur mainly at the lower end of the ranking, although some (e.g. Knowledge systems) had a very high score. A comparison of the COWB scores provided by the community participants and the Expert Panel revealed fairly close agreement. The product moment correlation coefficient for the two data sets was 0.75.

3.3. Comparison of Relative Importance Scores for Ecosystem Services

Product moment correlation coefficients were calculated by comparing the scores provided by community participants for ecosystem services directly (vector **g**) with the scores for the indirect value weights $\mathbf{Sw_1}$ or $\mathbf{Sw_2}$. The results indicated that **g** is not highly correlated with either $\mathbf{Sw_1}$ or $\mathbf{Sw_2}$ as the relevant correlation coefficients were both approximately 0.5. However, there was very close agreement between the scores for $\mathbf{Sw_1}$ and $\mathbf{Sw_2}$ for which the correlation coefficient was 0.995. This should not be surprising, as the matrix **S** is common to both sets of calculations, and the COWB scores provided by experts and the community participants were very similar. The level of agreement among the three sets of scores for ecosystem services was assessed also by means of Spearman rank correlation coefficients. The results were similar to those obtained using product moment correlation coefficients.

3.4. Ranking of ERCs

Space limitations preclude presenting all results obtained by constructing various models and carrying out model simulations. An illustrative set of results is, however, presented in Table 3 comprising a ranking of ERCs derived using Model 2a making use of the matrix product **EF**, matrix **S** and the vector of relative importance weights for COWB provided by the community ($\mathbf{w_1}$). ERCs are ranked in the table from most important to least important based on the potential relative contribution they make per unit area to community wellbeing. ERCs that appear highest in the ranking mostly comprise terrestrial natural ecosystems, while ERCs in the lower positions require significant human input or other capital contributions to provide services, contain little or no vegetation, have hard or impermeable surfaces as a dominant component of ecosystem structure, or comprise marine or coastal ecosystems (in which data and engaging expertise on these ERCs were recognised limitations). Model simulations using Models 1 and 2b, whether in raw form or based on normalised data, produced similar rankings of ERCs. Sensitivity analysis was also carried out, such as restricting the scores in **E** and **F** to values of 4 or 5. A general finding is, regardless of model structure, the ERCs occurring higher in the rankings tended to maintain their positions, as did ERCs in the lower positions. Variations in the rankings appeared mostly in the mid-range, depending on the particular model applied and the empirical data used.

4. Discussion

The methodology adopted as a means of assessing the value of ecosystems and ecosystem services in terms of community wellbeing in SEQ can be evaluated in various ways. A judgment can be made regarding its success in attracting participants to engage in the process of developing the Framework. As already noted, more than 190 professionals (not including community representatives) participated, all on a voluntary basis. As most of these professionals reside in the SEQ region, this may be a reflection of the high level of interest shown by SEQ residents regarding the importance of ecosystem services in supporting liveability in the region. It also can be viewed as the outcome of a carefully managed process of conceptualisation, information gathering and analysis by the many stakeholders involved.

Endorsement of the Project and acceptance of the Framework as a useful tool for landscape planning on a regional scale are evidenced by its incorporation in policy and statutory planning for the SEQ region. In 2008 the Project received an Award for Excellence in environmental, conservation and rural planning from the Queensland Division of the Planning Institute of Australia, and in 2009 'ecosystem services' became one of two Guiding Principles underpinning the SEQ Natural Resource Management Plan. In 2009 the statutory plan for managing growth in SEQ, the SEQ Regional Plan 2009–2031 (Department of Infrastructure and Planning, 2009), identified the Framework as the tool to apply to meet objectives under the following two important Policies: *3.1 – Regional Landscape Values:* Protect, manage and enhance the multiple values of the regional landscape and optimise the contribution these values make to the region's liveability, health, lifestyle and economy; and *4.3 – Ecosystem Services:* Protect, maintain and enhance the capacity of the region's ecosystems to supply ecosystem services.

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Table 3
Ranking of ERCs based on their potential contribution to community wellbeing as derived from the provision of ecosystem services.

ERC	Category	Position	ERC	Category	Position
Rainforests	Forests	1	Beaches	Coastal	17
Riverine wetlands	Inland water	2	Exotic plantations	Forests	18
Sclerophyll forests	Forests	3	Horticulture — tree crops	Cultivated	19
Palustrine wetlands	Inland water	4	Dams	Urban	20
Coastal zone wetlands	Coastal	5	Seagrass	Coastal	21
Lacustrine wetlands	Inland water	6	Coral reefs	Coastal	22
Moreton Island	Island	7	Parks & gardens	Urban	23
N. Stradbroke Island	Island	8	Pelagic	Coastal	24
Shrubland/woodland	Dryland	9	Benthic	Coastal	25
S. Stradbroke & Bay Islands	Island	10	Residential gardens	Urban	26
Montane	Mountain	11	Horticulture — small crops	Cultivated	27
Native plantations	Forests	12	Sugar cane	Cultivated	28
Native & improved grasslands	Dryland	13	Other irrigated crops	Cultivated	29
Bribie Island	Island	14	Deep ocean	Marine	30
Regrowth	Forests	15	Rocky shores	Coastal	31
Dunes	Coastal	16	Hard surfaces	Urban	32

The methodology clearly permits flexibility in incorporating different value sets, either for ecosystem services directly or in terms of COWB, whether elicited from community participants, scientific experts or any other interest group. There was close agreement between social science experts and community participants regarding COWB. However, divergences in the computed results based on matrix **S** compared with vector **g** suggest that further research is warranted on the relationships between ecosystem services and COWB.

A demographic analysis of participants in the local government workshop (e.g. age, profession, time living in local area) indicated they were not highly representative of the local population as a whole. For example, 48% were engaged with an environmental group and 9% were engaged with some other kind of community group showing an already high level of awareness and engagement in local issues. Invitations to participate were distributed through a general network database held within the local government and participants were self-selected rather than being drawn as a random sample. To draw a more representative sample a much larger number of respondents would be required, possibly using different mechanisms for data collection.

It could be asked, if different experts were engaged would the scores derived be different? Do large standard deviations in scores allocated by individuals represent a lack of knowledge and therefore call for a wider range of expertise to be engaged? How might the subjective values of experts influence their judgments? There is also the question of whether expert judgement reflects the broader preferences of the public. If they differ, decision-makers may misinterpret values held by the public and in turn run the risk of policies being rejected (Rogers and Cleland, 2012). Other considerations regarding wellbeing relate to intergenerational equity and the management of ecosystem services over time. Furthermore, it is recognised that factors other than ecosystem services (e.g. genetics, culture, other forms of capital) underpin human wellbeing, although they were not taken into account in developing the Framework (Costanza et al., 2007).

It is possible to assess the credibility of the rankings obtained for ERCs in the light of general scientific knowledge about ecosystems and the wellbeing they support. As shown in Table 3, ERCs ranked highest are the most 'natural' in the region, such as forests and wetlands, featuring rich biodiversity, vegetation as a dominant component of ecosystem structure and minimal reliance on human input. The ecosystem services produced by such ecosystems tend to comprise 'public goods'. ERCs appearing lower in the rankings, particularly crops, horticulture, parks and gardens, are those requiring significant human input to function and the services provided are more likely to take the form of 'private goods'.

The simple mathematical structure of the Framework was an important factor enabling the process to be managed effectively. Tasks for data collection could be sub-divided, and the use of scoring methods obviated the need for complex model construction. Participants readily understood what they were required to do. However, whether the mathematical structure of the Framework adequately represents the complex inter-connections between ecosystems and wellbeing in reality can be questioned. For example, all relationships within the Framework are linear and additive. Models derived from the Framework do not feature feedback loops, thresholds or threats to different ecosystems, nor do they provide information on resilience, minimal habitat requirements, ecosystem condition or contiguity.

Another problem is that of multiple causality. Ecosystem services do not occur in isolation. The production of one ecosystem service may inhibit the provision of another; hence the wellbeing derived from one ecosystem service could be in competition with the wellbeing derived from another. Conversely, it may take several ecosystems, acting synergistically or antagonistically, to provide an ecosystem service (e.g. Therapeutic Landscapes). There are also issues of spatial and temporal scales; the need to consider ecosystem services imported into the region; as well as ecosystem services that originate in SEQ and benefit a wider community (e.g. globally).

Finally, the methodology adopted to develop the Framework does not incorporate monetary values, thus the results of ecosystem service valuations obtained by means of the Framework may not easily be combined with other assessments such as those based on cost-benefit analysis. Although in principle it would be possible to use relative importance weights based on monetary values instead of participant-derived scores in the various models, that approach has not been trialled or suggested by stakeholders in SEQ.

5. Conclusion

The MA states that wellbeing derived from ecosystem services is culture, location, time and context dependent (MA, 2005). The SEQ experience suggests that, at regional and local scales, this information can be aptly captured through expert input, focus group discussions and facilitated community workshops. A major challenge in the SEQ Project has been to engage relevant stakeholders in the development of a common set of definitions, assessment methodology and model structure, thereby cultivating a sense of ownership of the resulting Framework and its potential applications (Maynard et al., 2012).

Although the research described in this paper does not directly answer the question of who should be the valuing agent, the experience and results of the Project suggest that methodologies can be devised that allow flexibility of choice regarding who can participate in the information gathering process as well as ways in which the required data can be obtained. The full potential of the Framework and activity

Please cite this article as: Maynard, S., et al., Determining the value of multiple ecosystem services in terms of community wellbeing: Who should be the valuing agent? Ecol. Econ. (2014), http://dx.doi.org/10.1016/j.ecolecon.2014.02.002

surrounding it has not yet been realised. While ecosystem services has yet to find a place in mainstream economic development planning at state and regional scales, the Framework now has a dedicated role in statutory planning policy for SEQ.

Acknowledgements

The Authors would like to thank the Editors of the ACES Special Issue for the opportunity to contribute to this initiative. They would also like to thank the three anonymous Reviewers of this article for their helpful feedback and comments. Acknowledgement also goes to the SEQ stakeholders who participated in the development of the Framework and who continue to be pioneers in ecosystem services research through its application. This involvement by the stakeholders is a credit to the individuals and organisations involved.

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Please cite this article as: Maynard, S., et al., Determining the value of multiple ecosystem services in terms of community wellbeing: Who should be the valuing agent? Ecol. Econ. (2014), http://dx.doi.org/10.1016/j.ecolecon.2014.02.002