To Value Functions or Services? An Analysis of Ecosystem Valuation Approaches[1]

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ABSTRACT

Monetary valuation of ecosystem services is a widely used approach to quantify the benefits supplied by the natural environment to society. An alternative approach is the monetary valuation of ecosystem functions, which is defined as the capacity of the ecosystem to supply services. Using two European case-study areas, this paper explores the relative advantages of the two valuation approaches. This is done using a conceptual analysis, a qualitative application, and an overall comparison of both approaches. It is concluded that both approaches can be defended on theoretical grounds, and – if properly applied – will provide the same value estimates. However, valuation of ecosystem services is preferred from a practical point of view. Because there is no one-to-one match between functions and services, researchers should be consistent in their valuation approach. To avoid overlooking or overlapping of values, valuation should either be solely based on functions, or solely based on services.

KEYWORDS

Environmental valuation, ecosystem functions, ecosystem services

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1. INTRODUCTION

Recent years have shown an increasing pressure on the world's ecosystems, in combination with a growing awareness of the importance of ecosystems for society (Balmford et al., 2002; Millennium Ecosystem Assessment, 2003). In order to support decision making on ecosystems in the context of increasing scarcity of ecological resources, there has been a strong increase in the number of studies that have analysed the economic value of ecosystems (e.g. Turner et al., 2003).

When goods have no price, their value is rarely fully taken into account in decision-making (Hardin, 1968). This may lead to inefficient production and consumption, as well as over-exploitation of ecosystems. Hence, monetary valuation of public goods can facilitate inclusion of the value of public goods in decision making (Turner et al., 2003). For example, a social cost-benefit analysis of an urban development project should include potential negative effects on biodiversity and landscape.

Valuation studies often use the standard assumption that there is a distinction between physical objects and the values that are related to them. They are usually based on the premises of neo-classical welfare economics (see e.g. Brown, 1984; Straton, 2006). Hence, it is assumed that individuals and firms maximise their utility or profit, basing their decisions on their preference ordering and a vector of input and output prices. Provided that values can be assumed to be commensurable, valuation of ecosystems can be instrumental in supporting decision-making (Soma, 2006). Nevertheless, it is clear that the valuation of ecosystems and the (public) goods they provide is not always straightforward, and remains subject to considerable uncertainties (e.g. Damodaran 2007; Lienhoop and MacMillan, 2007).

One of the issues frequently discussed is the specific properties of the ecosystem to be valued. In ecological, landscape and environmental economics literature, two main approaches have developed. The first approach focuses on the benefits supplied by landscapes that were historically strongly influenced by mankind. This approach employs the valuation of the *functions* of ecosystems. It was mainly developed in countries that are characterised by such landscapes, including Germany (e.g. Haase, 1978; Neef, 1983; Bastian and Schreiber, 1994) and the Netherlands (Bouma and Van der Ploeg, 1975; Van der Maarel and Dauvellier, 1978; Hueting, 1980; De Groot, 1992). In this approach, functions have been defined as 'the capacity to provide benefits to society, directly or indirectly' (De Groot, 1992). The second approach focuses on the benefits supplied by natural and semi-natural ecosystems. This approach employs the valuation of the *goods* and *services*[2] of ecosystems. It was mainly developed in the Anglo-Saxon world (e.g. Helliwell, 1969; Odum and Odum, 1972). In this approach, ecosystem services have been defined as 'the benefits provided by ecosystems to society' (Millennium Ecosystem Assessment, 2003). Currently, both approaches persist, although, in recent years, the Anglo-Saxon interpretation has probably become more dominant in international fora (e.g. Costanza et al., 1997; Millennium Ecosystem Assessment, 2003; Turner et al., 2003).

The objective of this paper is to evaluate and compare the valuation of ecosystem services versus the valuation of ecosystem functions. Which measure is more appropriate to give a socially optimal policy? And how do the two approaches compare in terms of applicability? The paper contains a conceptual analysis and comparison of both approaches, based upon a literature study, as well as a qualitative application of both approaches to two ecosystems, a wetland in the Netherlands, and an agri-environmental area in Sweden. The approach outlined in this paper is relevant for a broad range of ecosystems, including man-made agricultural landscapes and natural ecosystems.

The point of departure for our evaluation and comparison of ecosystem valuation approaches is neo-classical welfare economics. We assume that the value of an ecosystem, its functions and its services can be assessed by measuring their contribution to a social welfare function, using a utilitarian approach. Obviously, this implies that we ignore many other valid realms of value such as aesthetic, cultural and social realms, as highlighted by Trainor (2006). We are also aware of the various preconditions for applying valuation of ecosystem functions and services. Soma (2006) provides an overview of these preconditions that include commensurability of values and aggregation of individuals' preferences.

The paper starts with the outline of a causal model that relates the concepts of ecosystem functions, services, and values to each other. It is followed in section 3 by a discussion of value theory and a comparison of the two valuation approaches from theoretical and practical perspectives. In section 4 we then apply the analysis qualitatively to two case-study areas. Section 5 presents conclusions and implications for future valuation studies.

2. ECOSYSTEM FUNCTIONS, SERVICES AND VALUES

Ecosystems are characterised by their components, structure and processes (Mooney et al., 1995). Lakes, pastures and stone walls are examples of physical components of an ecosystem. The components are subject to a certain hierarchical structure, with different ecological units recognisable at different scales. Interactions between these different units come about in the form of a range of ecological and other processes taking place at different spatial and temporal scales.

The concept of ecosystem functions was developed in the early 1970s and can be defined as the capacity of ecosystems to supply goods and services[3] (Ehrlich et al., 1970; Bouma and van der Ploeg, 1975; Hueting, 1980; De Groot, 1992). They depend upon the components, the structure, and the processes taking place in the ecosystem. For instance, the function 'capacity to yield firewood' is related to a range of ecological processes involving the growth of plants and trees that use solar energy to convert water, plant nutrients and CO_2 to biomass. Note the difference between 'ecosystem functions' and 'ecosystem functioning', with the latter indicating the performance of the various ecological processes that underlie the dynamics of the ecosystem (compare with e.g. Turner et al., 2000). That is, functioning is not related to any human use of the ecosystem, but is an indicator for ecosystem health. Ecosystem functioning is primarily part of the ecological domain and not further discussed in this paper.

A function may result in the supply of ecosystem services: the services provided by the ecosystem to society (Costanza et al., 1997; Millennium Ecosystem Assessment, 2003). For example, the amount of firewood extracted from an ecosystem depends on the demand from the local community and the costs at which firewood can be obtained. The supply of ecosystem services will often be variable over time, and both actual and potential future supplies of services should be included in their valuation. The ecosystem functions available to society can be interpreted to represent the natural capital of that society (Drepper and Månsson, 1993; Barbier, 2000; Mäler, 2000).

Values of ecosystem functions and services can be classified in two main categories: use values and non-use values (e.g. Pearce and Turner, 1990; Hanley and Spash, 1993). Use value is the value attached to the current, future, or potential use of the function or service (Weikard, 2005). It comprises direct and indirect use value, option value and quasi-option value. Direct use value arises from the direct use of ecosystems (Pearce and Turner, 1990), and concerns the value of current and expected future use. Examples are the value of recreational hunting, fishing, and medical plants. Indirect use value arises from the indirect use of ecosystems, in particular through the positive externalities that ecosystems provide (Munasinghe and Schwab, 1993). Examples are the value of crop pollination and waste treatment. The option value and quasi-option value relate to information and uncertainty. Because people are unsure about their future demand, circumstances, and information, they value the option of possible consumption in the future and they value the possible arrival of future information (c.f. Weisbrod, 1964; Cicchetti and Freeman, 1971). Non-use value is the value that society assigns to the pure existence of an ecosystem, independent of the use of its functions and services. Non-use value comprises existence value and bequest value. Existence value is based on knowing that the ecosystem exists or on mere existence itself. Bequest value is based on the utility that the ecosystem may give other people and future generations (Kolstad, 2000; Weikard, 2005).

Summarising, on the one hand we have an ecosystem's physical components, structures and processes, and its functions and services. On the other hand we have values that are related to them, see Figure 1. Because values may be related to any of the categories that are defined, it is possible to talk about the value of a pasture, scenic values, recreational values or biodiversity values. There is,

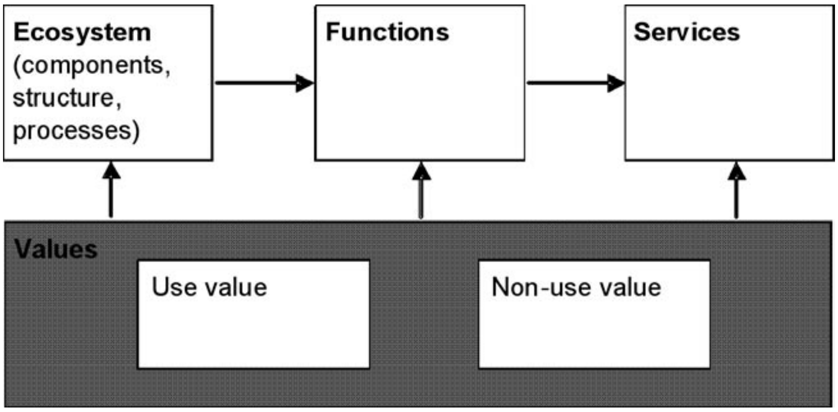

FIGURE 1. Ecosystem functions, services and values

however, a risk of overlapping or overlooking values if different types of values are mixed. The value of scenery (a service) may for instance be related to the value of habitat provision (a function), so both values cannot simply be summed up. It is therefore necessary to carefully distinguish what is being valued. In this paper, we will ignore the valuation of ecosystem components, structure and processes, and focus on the two commonly applied approaches: the valuation of ecosystem functions and of ecosystem services.

3. VALUE THEORY: REASONS FOR VALUATION OF FUNCTIONS OR SERVICES

Two important distinctions can be made in relation to ecosystem values. The first distinction is between subjective values and objective values. Subjective values imply that there is a subject who assigns values. Hence, any value always includes a normative statement. If the biodiversity on a pasture increases and some people appreciate biodiversity (normative valuation), then the pasture has a positive value for them. Objective values are given, independent of anyone noticing, understanding or enjoying the object of valuation. The term 'intrinsic value' is frequently used to refer to objective value. We avoid this term because of its many different connotations, such as non-instrumental value or existence value. Obviously, a decisive factor with this value concept is who has the right to define these values. In the welfare economic approach, all values are considered as subjective, with the value premise that it is the individuals' preferences that defines value.

The second distinction is between end values and instrumental values. End values refer to objects that we value *per se*, '*das Ding an sich*', as Immanuel Kant called it. Society may, for instance, value biodiversity regardless of whether it gives someone utility (cf. Hill, 2006). It is biodiversity itself that is stated as valuable. Instrumental values refer to objects that are not necessarily valued themselves, but provide other objects that have end values. The instrumental value of an ecosystem can be derived from the end values that society assigns to its biodiversity and how much the ecosystem contributes to this biodiversity. An ecosystem can have both instrumental and end values if society also values the ecosystem itself (Holstein, 1998).

Appropriate valuation methods differ for private and public goods. The marginal value of private goods can generally be derived from market prices, whereas marginal values of public goods have to be estimated using non-market valuation techniques, such as the contingent valuation method, hedonic pricing or the travel cost method (e.g. Pearce and Turner, 1990; Hanley and Spash, 1993; Lienhoop and MacMillan, 2007). The importance of marginal values has implications for choosing between valuation of functions or services. Because of their physical presence in the environment, services can be measured and valued at the margin. For functions this is different, because they represent the capacity to provide services, and generally they are difficult to measure or value at the margin.

This makes valuation of ecosystem services more practical and more easily applied within the neo-classical valuation paradigm. Clearly, however, the marginal value of the services an ecosystem provides may only give a very poor indication of the total economic value of that ecosystem, which is also related to the scale at which the ecosystem is analysed (e.g. Hein et al., 2006). In particular life-supporting ecosystem functions and services, such as the provision of drinking water, have strongly increasing marginal values when supply becomes constrained. Valuation of ecosystem functions gives a better estimate of the total economic value of the ecosystem under consideration, but the assumption of marginality is still required in order to establish prices for the functions. In this case, marginality could be interpreted as marginal with regards to the total global stock of natural capital. Both approaches fail if they are applied to value functions or services at the global scale – as the precondition of marginality no longer applies, and meaningful prices for functions or services can not be established at this scale. For more details on the ongoing discussion on the applicability and usefulness of the total economic value concept, we would like to refer to Costanza et al. (1998), Damodaran (2007) and Fromm (2000).

Values assigned to functions are instrumental, because it is not the functions themselves, but their produced services that are ultimately valued by humans. It is convenient to depict this relation between functions and services using the concept of natural capital as a representation of ecosystem functions (cf. Daily et al., 2000; Pearce, 1988). This stock of natural capital is used as a means to produce flows of ecosystem services. This view of stocks and flows (Turner et al., 1998) is consistent with the introduced definition of ecosystem functions as the capacity to supply ecosystem services. Both ecosystem functions and services can be the basis of valuation and the question is which of the two valuation approaches provides a more appropriate value of ecosystems: the value of the natural capital stock or its flows?

Valuation of ecosystem functions assigns a value to the natural capital stock. The value of an ecosystem based on its functions is determined by its capacity to supply services, based on current and expected future services that it will provide. Valuation of ecosystem services assigns a value to the natural capital flows, thereby reflecting the value of the ecosystem based on current and expected future flows of services. Note that for both approaches, it is necessary to form expectations of future provision of services by the function. A function's capacity to provide services may be higher than the current or expected future level of services that it provides. If this is the case, than the value of the function is based on this lower level of current and expected future services, not on capacity that is not being (or expected to be) used. The functions approach cannot be made operational without considering the services that are provided by the function.

The question of whether to value functions or services is partly a theoretical and partly a practical issue. Theoretically, there is a dividing line between those who claim that there is no difference; it is just a matter of valuing the same system at different levels, and those who claim that it is fundamentally different to value functions instead of services. Arguing for this latter claim, Gren et al. (1994) state that the 'primary values' of an ecosystem's self-organising capacity, a vital function including its resilience, can never be fully captured by the non-use values of the ecosystem's services. They state that the services can only partly be measured in monetary terms because of incomplete information and uncertainty over the functions of complex ecosystems. Their claim is supported by Turner et al. (2003) who state that there is a 'glue' or infrastructure value of this self-maintaining capacity of an ecosystem. If, instead, the values of functions and services are considered as compatible, the choice between the two valuation approached becomes a practical issue. The only difference is whether to value the capital stock (the functions) or the flow that it generates (the services). The discounted value of future flows should then be equal to the value of the capital stock.

From this perspective, we question the conclusions by Gren et al. (1994) and Turner et al. (2003) that ecosystems' self-organising capacity cannot be valued through the future services the ecosystem will give. Two arguments are possible for their statement. The first argument is that this capacity is simply not a service that is covered by the total economic value. The second argument is that there is an additional insurance value of this capacity when there is incomplete information and uncertainty about the ecosystem functioning. In our view however, these functions are fully recognised by the instrumental values that can be derived from their provision of future flows of ecosystem services. If, in the end, there is not any use or non-use value that can be derived from this self-organising capacity, what is motivating its value then? Concerning the second argument, the insurance value should be covered by the option and quasi-option values, see section 2. However, we do fully agree with Turner et al. (2003) that these non-use values may be very difficult to measure.

From the above discussion on theoretical and practical issues in valuation, we can extract three possible reasons for the two valuation approaches to result in divergent value estimates (in addition to the marginality argument put forward in the beginning of this section). First, the approaches may differ in their capacity to cover the complete value of an ecosystem without overlapping or overlooking of certain values. Second, the approaches may differ in their efficacy of measuring the functions or services in physical terms and their possibility of valuing the physical measures in monetary terms. Third, the expected future development of the ecosystem and the demand for its services may affect the value estimates for the two approaches differently. Our discussion on valuation approaches, and these three aspects in particular, are tested in two case-studies in the next section.

4. CASE-STUDIES

To illustrate the distinction between valuing functions and services, we apply the discussion so far to two case-study areas. For two specific European ecosystems, we analyse the functions and services provided, as well as the possibilities for valuing the functions and services of these areas. The first case-study is the wetland De Wieden in the Netherlands, the second case-study is the Selaö agri-environmental area in Sweden.

4.1 De Wieden (The Netherlands)

De Wieden is one of the most extensive lowland peatlands in north-western Europe, covering in total around 5200 ha. It comprises a large range of water bodies of different sizes (lakes, canals and marshlands), reedlands, extensive agricultural land and forests, see Figure 2. The main agricultural activity in the De Wieden area is dairy farming, with the largest part of land used as grazing land. Two other locally important economic sectors are reed cutting and fisheries. In addition, the area is well known for its biodiversity and opportunities for recreation. The grazing lands are of particular importance for birds and butterflies. The lakes of De Wieden attract many visitors for short holidays as

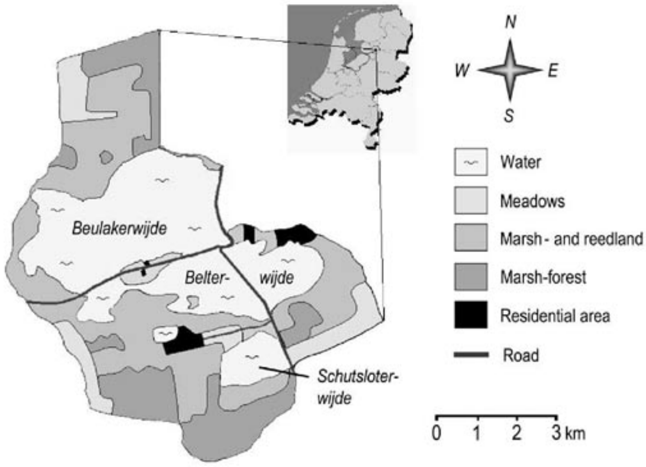

FIGURE 2. Location and map of the De Wieden case-study area

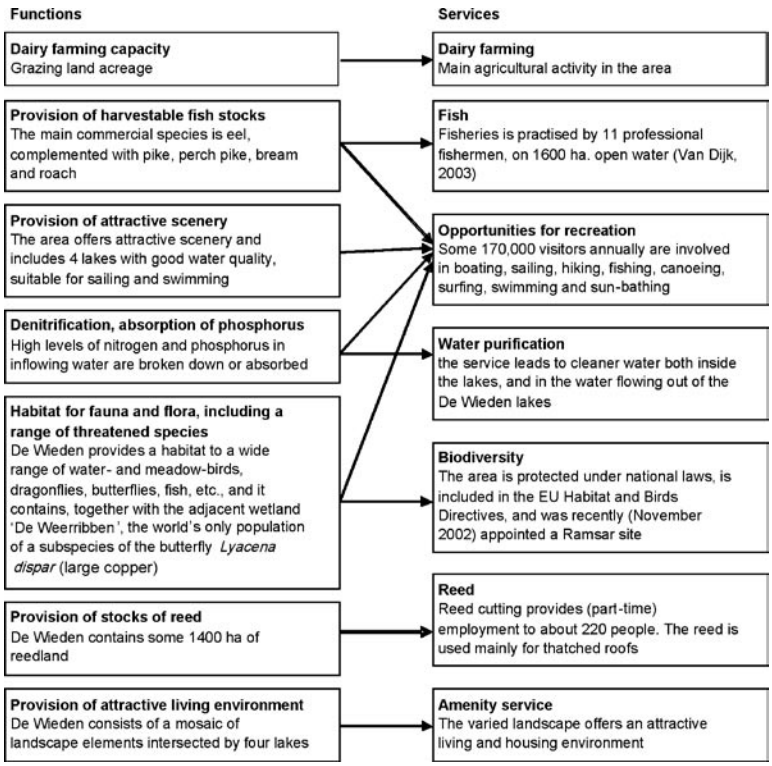

FIGURE 3. Important functions and services of the De Wieden case-study area

well as day-trips (Hein et al., 2006). The functions and services provided by De Wieden are shown in Figure 3.

We will discuss the De Wieden case-study by focusing on the functions 'provision of harvestable fish stocks' and 'provision of attractive scenery' and the services 'fish' and 'opportunities for recreation'.

Most aspects brought up in the discussion do not favour one of the two approaches rather than the other. Both approaches have the capacity to cover the complete value of the ecosystem, when properly applied. Also, both functions and services can be assessed physically. For fish, the current and expected future fish harvest levels can be calculated. This information is necessary both for services and functions. For recreation too, the current and expected future levels of recreation have to be calculated. The uncertainty on future levels is likely larger than for fish harvests, but this uncertainty is equal for functions and services. There are currently no plans that might affect the ecosystem or its capacity to supply services. There is also no reason to expect that the demand for services from De Wieden, e.g. fish and recreation, is going to change in the near future. In the case of fish, however, the amount of fish that can be harvested is likely to diminish in the short term because of decreases in European eel stocks, which affects the value of both function and service.

The single aspect where valuation of services may perform better than valuation of functions is the valuing of physical measures in monetary terms. Appropriate valuation methods are available for the services, but not for the functions. Actual fish harvests and recreation can be valued using market prices and the travel cost method. Their related functions are more difficult to value, because market prices for the function 'provision of harvestable fish stocks' are not available and the travel cost method cannot be used for the function 'opportunities for recreation'.

4.2 Selaö (Sweden)

Selaö is situated at the large lake Mälaren, about 60 km west of Stockholm. It is in many respects typical of the plain districts of Central Sweden. The landscape is a mosaic of arable land (50%), forest (40%), and pastures (5%) next to wetlands, bedrock, housing, and water. Land use in the area has changed drastically over the last century. The most drastic shift is the reduction of grasslands biotopes, where forest grazing has ceased and meadows have been cultivated into arable fields, diminishing pasture area by 90%, see Figure 4. Main agricultural activities in the area include cereals and fodder production for the large horse-industry, as well as limited beef and milk production. The area also provides landscape scenery, biodiversity and land accessibility for recreation, see Figure 5.

In the case of Selaö, both functions and services can be assessed physically. For both functions and services, the current and expected future provision of services has to be calculated. In terms of valuation, there are distinct differences

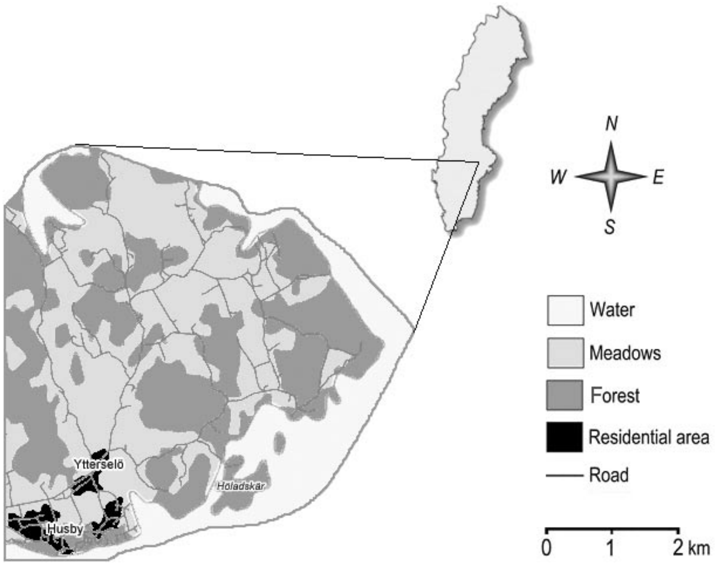

FIGURE 4. Location and map of the Selaö case-study area

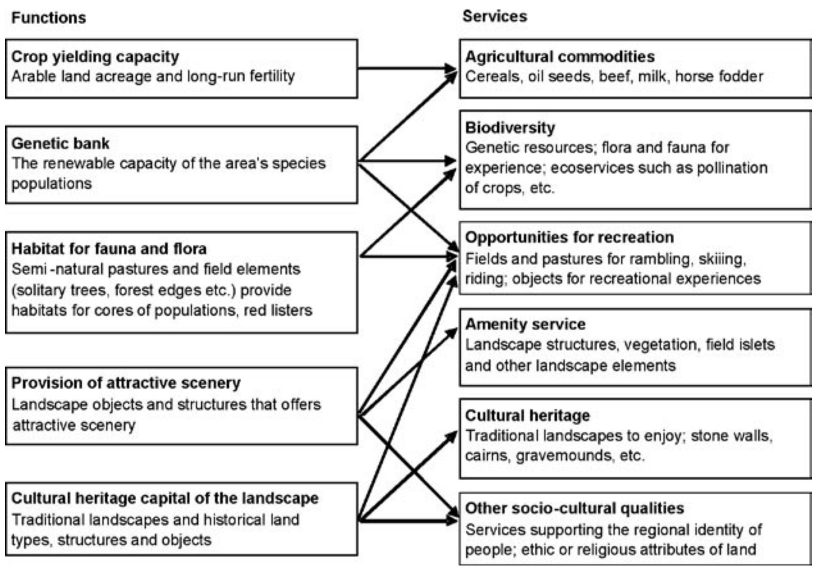

FIGURE 5. Important functions and services of the Selaö case-study area

between valuing functions and services in this area. For instance, for crop production, actual crop harvests can be valued using market prices, and it may be assumed that significant changes in harvest levels, e.g. due to the development of new agricultural techniques, are not likely. The value of the function 'crop yielding capacity' can be derived from prices of arable land. Biodiversity can be valued using contingent valuation, both with regards to the habitat function and the biodiversity service. However, as more services (6) are provided compared to the functions (5), there may be a higher risk of overlap and more methodological demands in the valuation of services. On the other hand, some services are relatively easy to value, such as the recreation service. Hence, this case study does not strongly favour one of the two approaches.

5. DISCUSSION AND CONCLUSION

The De Wieden and Selaö case-studies show that the two valuation approaches are comparable in many aspects. In principle, the researcher has the choice of valuing services or functions. Both approaches express the benefits supplied by the natural environment to society, and both approaches can be defended on theoretical grounds. The main difference between the two approaches is that valuation of functions is based on the environment's capacity to supply benefits, while valuation of services is based on the actual and future flow of benefits. Importantly, there is no one-to-one match between functions and services. The case-studies show, that it is practically more feasible to value services than to value functions. In both areas, functions are more difficult to value than services because functions – being the capacities to provide services – are not physically present in the environment.

If valuation of services is practically preferable, will it also provide correct value estimates? Both the arguments put forward in section 3 and the case studies in section 4 indicate that the two approaches provide the same value, if correctly applied. Hence, the question which of the two approaches is preferable comes down to selecting the approach that is most practical. In general, valuation of services is easier than valuation of functions because services can either be valued at market prices or be valued using valuation methods. However, a catch is that it can often not be assumed *a priori* that flows of ecosystem services are constant, and that current flows also indicate future flows. Future flows may be lower, as in the case of a resource that is being depleted, or higher, in case of increasing demand and an underutilised resource. Changes in flows of ecosystem services need to be accounted for in the valuation of ecosystem services. For functions, market prices are usually not present, and valuation methods are more difficult to apply. Whichever approach is selected, it is important to be consistent. Figures 3 and 5 demonstrate that one function can add to the supply of several services, and one service can depend on several functions. Because there is no one-to-one match between functions and services, researchers should be consistent in their valuation approach. To avoid overlooking or overlapping of values, valuation should either be solely based on functions, or solely based on services.

NOTES

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[2] From here on, we will simply use the term 'services' to refer to 'goods and services'.

[3] Note that some references in the literature do not use this definition of ecosystem functions, but rather define them as processes. Gren et al. (1994), for instance, state: 'wetlands ... produce a flow of functions such as nutrient purification, ground water buffering and biodiversity'.

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