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ANALYSIS

Spatial scales, stakeholders and the valuation of ecosystem services

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Abstract

Since the late 1960s, the valuation of ecosystem services has received ample attention in scientific literature. However, to date, there has been relatively little elaboration of the various spatial and temporal scales at which ecosystem services are supplied. This paper analyzes the *spatial* scales of ecosystem services, and it examines how stakeholders at different spatial scales attach different values to ecosystem services. The paper first establishes an enhanced framework for the valuation of ecosystem services, with specific attention for stakeholders. The framework includes a procedure to assess the value of regulation services that avoids double counting of these services. Subsequently, the paper analyses the spatial scales of ecosystem services: the ecological scales at which ecosystem services are generated, and the institutional scales at which stakeholders benefit from ecosystem services. On the basis of the proposed valuation framework, we value four selected ecosystem services supplied by the De Wieden wetlands in The Netherlands, and we analyze how these services accrue to stakeholders at different institutional scales. These services are the provision of reed for cutting, the provision of fish, recreation, and nature conservation. In the De Wieden wetland, reed cutting and fisheries are only important at the municipal scale, recreation is most relevant at the municipal and provincial scale, and nature conservation is important in particular at the national and international level. Our analysis shows that stakeholders at different spatial scales can have very different interests in ecosystem services, and we argue that it is highly important to consider the scales of ecosystem services when valuation of services is applied to support the formulation or implementation of ecosystem management plans.

Keywords: Ecosystem services; Valuation; Spatial scales; Stakeholders; Wetlands

1. Introduction

Starting in the late 1960s, there has been a growing interest in the analysis and valuation of the multiple benefits provided by ecosystems. This interest was triggered by an increasing awareness that the benefits provided by natural and semi-natural ecosystems were

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often underestimated in decision making (Helliwell, 1969; Odum and Odum, 1972). Since then, economic valuation of ecosystems has received much attention in scientific literature. Methodologies for the valuation of ecosystem services have been developed by, among others, Dixon and Hufschmidt (1986), Pearce and Turner (1990), Freeman (1993), and Hanley and Spash (1993), whereas the value of the services of a particular ecosystem has been assessed by, for example, Ruitenbeek (1994), Kramer et al. (1995) and Van Beukering et al. (2003). In addition, several studies have provided frameworks for the valuation of ecosystem services (Costanza et al., 1997; Turner et al., 2000; De Groot et al., 2002; Millennium Ecosystem Assessment, 2003).

To date, relatively little elaboration of the scales of ecosystem services has taken place (Millennium Ecosystem Assessment, 2003; Turner et al., 2003). Ecosystem services are supplied at various spatial and temporal scales, which has a strong impact on the value different stakeholders attach to the services. Analyzing scales is important in order to reveal the interests of different stakeholders in ecosystem management. It can also be used as a basis for establishing compensation payments to local stakeholders that face opportunity costs of ecosystem conservation (Tacconi, 2000). In addition, it provides insight in the appropriate institutional scales for decision making on ecosystem management. This is highly relevant in the context of The Netherlands, where the national government is currently considering decentralization of the responsibilities for the management of nature reserves (VROM, 2004). Hence, there is a need to examine the various scales at which ecosystem services are generated and used, and, subsequently, how the supply of ecosystem services affects the interests of stakeholders at different scales (Tacconi, 2000; Turner et al., 2000, 2003; Millennium Ecosystem Assessment, 2003).

Therefore, in this paper, we analyze the *spatial* scales at which ecosystem services are supplied, and the implications of these scales for the values attached to ecosystem services by different stakeholders. For a discussion of the *temporal* scales, the reader is referred to, for example, Howarth and Norgaard (1993) and Hanley (1999). On the basis of existing literature, we first present a consistent framework for the valuation of ecosystem services, specifically considering the issue of double counting of services—one of the remaining issues in ecosystem valuation (De Groot et al., 2002; Millennium Ecosystem Assessment, 2003). The framework consists of four steps, and reflects current thinking on ecosystem services valuation. Subsequently, we assess the spatial scales at which ecosystem services are supplied. Based upon this assessment, we propose to extend the framework with a fifth step, dealing with scales and stakeholders, in order to enhance the applicability of ecosystem services valuation for decision making. To illustrate the expanded framework, as well as the relevance of spatial scales, a case study is presented. The case study includes a valuation of the ecosystem services supplied by the De Wieden wetland in The Netherlands, and an assessment of the scales at which these services are delivered. The De Wieden case study is based upon fieldwork, in which quantitative information on visitor numbers has been collected, and interviews with all major stakeholders of the area, conducted in the period January–September 2003.

The paper is organized as follows. In Section 2, a basic framework for the assessment of ecosystem services is established. In Section 3, the spatial scales of ecosystem services are analyzed and an extension of the framework is proposed. In Section 4, the framework is applied to the De Wieden wetland. This is followed by a discussion of the overall implications of spatial scales for ecosystem management in Section 5. Section 6 summarizes the main conclusions of the paper.

2. The ecosystem services valuation framework

Based upon a literature review, this section establishes a framework for the valuation of ecosystem services. The framework includes three types of services and four types of value, and is based upon Pearce and Turner (1990), Costanza et al. (1997), De Groot et al. (2002) and Millennium Ecosystem Assessment (2003). The framework is presented in Fig. 1. It is applicable to all ecosystems, but it will in general be more useful to apply it to natural or semi-natural (modified) ecosystems. This because of the specific attention paid to the goods and services provided by the regulation and cultural services, which

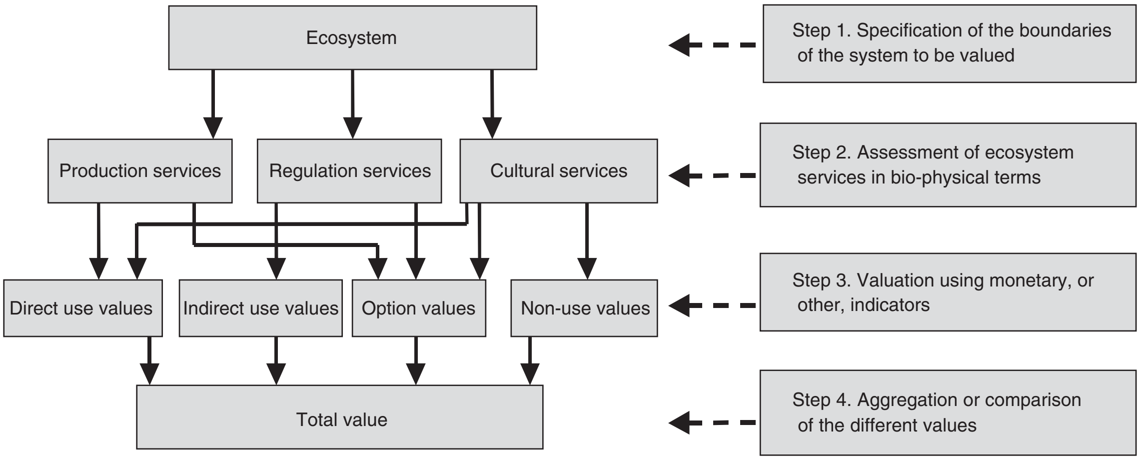

Fig. 1. The ecosystem valuation framework. The solid arrows represent the most important links between the elements of the framework. The dashed arrows indicate the four principal steps in the valuation of ecosystem services.

are often higher in natural and semi-natural systems (Pearce and Turner, 1990; De Groot, 1992; Costanza et al., 1997).

Following this framework, valuation of ecosystem services consists of four steps: (i) specification of the boundaries of the ecosystem to be valued; (ii) assessment of the ecosystem services supplied by the system; (iii) valuation of the ecosystem services; and (iv) aggregation or comparison of the values of the services. These steps are discussed below.

2.1. Specification of the boundaries of the ecosystem to be valued (step 1)

Valuation (as any other analysis) requires that the object of the valuation is clearly defined. The Convention on Biological Diversity provided the following definition of an ecosystem "a dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functional unit" (United Nations, 1992). However, we argue that a *spatial* definition is required to describe the ecosystem to be valued, and we use the following definition of an ecosystem: 'the individuals, species and populations in a spatially defined area, the interactions among them, and those between the organisms and the abiotic environment' (Likens, 1992). The ecosystem to be valued may contain a number of different (sub-)ecosystems.

2.2. Assessment of the services supplied by the ecosystem (step 2)

Ecosystem services are the goods or services provided by the ecosystem to society, and provide the basis for the valuation of the ecosystem. The supply of ecosystem services will often be variable over time, and, where relevant, both actual and potential future supplies of services have to be included in the valuation (Drepper and Månsson, 1993; Barbier, 2000; Mäler, 2000). We propose to distinguish three different categories of ecosystem services: 'production services,' 'regulation services' and 'cultural services,' based upon De Groot et al. (2002) and Millennium Ecosystem Assessment (2003). Table 1 presents the three categories, as well as an overview of the various ecosystem services in each category.

Contrary to the Millennium Ecosystem Assessment (2003), we do not distinguish the category 'supporting services,' which represents the ecological processes that underlie the functioning of the ecosystem. Their inclusion in valuation may lead to double counting—their value is reflected in the other three types of services. In addition, there are a very large number of ecological processes that underlie the functioning of ecosystems, and it is unclear on which basis supporting services should be included in, or excluded from a valuation study.

Table 1
List of ecosystem services (based upon Ehrlich and Ehrlich, 1981; Costanza et al., 1997; De Groot et al., 2002; Millennium Ecosystem Assessment, 2003)

Category	Definition	Examples of goods and services provided
Production services	Production services reflect goods and services *produced* in the ecosystem.	Provision of: –Food –Fodder (including grass from pastures) –Fuel (including wood and dung) –Timber, fibers and other raw materials –Biochemical and medicinal resources –Genetic resources –Ornamentals
Regulation services	Regulation services result from the capacity of ecosystems to regulate climate, hydrological and bio-chemical cycles, earth surface processes, and a variety of biological processes.	–Carbon sequestration –Climate regulation through regulation of albedo, temperature and rainfall patterns –Regulation of the timing and volume of river and ground water flows –Protection against floods by coastal or riparian systems –Regulation of erosion and sedimentation –Regulation of species reproduction (nursery function) –Breakdown of excess nutrients and pollution –Pollination –Regulation of pests and pathogens –Protection against storms –Protection against noise and dust –Biological nitrogen fixation (BNF)
Cultural services	Cultural services relate to the benefits people obtain from ecosystems through recreation, cognitive development, relaxation, and spiritual reflection.	–Nature and biodiversity (provision of a habitat for wild plant and animal species) –Provision of cultural, historical and religious heritage (e.g., a historical landscape or a sacred forests) –Provision of scientific and educational information –Provision of opportunities for recreation and tourism –Provision of attractive landscape features enhancing housing and living conditions (amenity service) –Provision of other information (e.g., cultural or artistic inspiration)

Before the services can be valued, they have to be assessed in bio-physical terms. For *production* services, this involves the quantification of the flows of goods harvested in the ecosystem, in a physical unit. For most *regulation* services, quantification requires spatially explicit analysis of the bio-physical impact of the service on the environment in or surrounding the ecosystem. For example, valuation of the hydrological service of a forest first requires an assessment of the precise impact of the forest on the water flow downstream, including such aspects as the reduction of peak flows, and the increase in dry season water supply (Bosch and Hewitt, 1982). The reduction of peak flows and flood risks is only relevant in a specific zone around the river bed, which needs to be (spatially) defined before the service can be valued. An example of a regulation service that does usually not require spatially explicit assessment prior to valuation is the carbon sequestration service—the value of the carbon storage does not depend upon where it is sequestered. *Cultural* services depend upon a human interpretation of the ecosystem, or of specific characteristics of the ecosystem. They have also been named ‘information services,’ as in De Groot et al. (2002). The benefits people obtain from cultural services depend upon experiences during actual visits to the area, indirect experiences derived from an ecosystem (e.g., through nature movies), and more abstract cultural and moral considerations (see, e.g., Aldred, 1994). Assessment of cultural services requires assessment of the numbers of people benefiting from the service, and the type of interaction they have with the ecosystem involved.

2.3. Valuation of the ecosystem services (step 3)

The values that are attributed to ecosystem services depend upon the stakeholders benefiting from these services. The classic definition of a stakeholder is "any group or individual who can affect or is affected by the achievement of the organization's objective" (Freeman, 1984). For ecosystem valuation, we modify this definition into "any group or individual who can affect or is affected by the ecosystem's services." The value of ecosystem services depends upon the views and needs of stakeholders (Vermeulen and Koziell, 2002), and there is a mutual and dynamic relationship between ecosystem services and stakeholders. The services supplied by an ecosystem determine the relevant stakeholders, and the stakeholders determine relevant ecosystem services. The four value types that stakeholders can attribute to ecosystem services are discussed below.

(i) *Direct use values.* Direct use values arise from human direct utilization of ecosystems (Pearce and Turner, 1990), for example, through the sale or consumption of a piece of fruit. All production services, and some cultural services (such as recreation) have direct use value.

(ii) *Indirect use values.* Indirect use values stem from the indirect utilization of ecosystems, in particular through the positive externalities that ecosystems provide (Munasinghe and Schwab, 1993). This reflects the type of benefits that regulation services provide to society.

(iii) *Option values.* Because people are unsure about their future demand for a service, they are willing to pay to keep open the option of using a resource in the future—insofar as they are, to some extent, risk averse (Weisbrod, 1964; Pearce and Turner, 1990). Option values may be attributed to all services supplied by an ecosystem. Various authors also distinguish quasi-option value (e.g., Hanley and Spash, 1993), which represents the value of avoiding irreversible decisions until new information reveals whether certain ecosystems have values we are not currently aware of. Although theoretically correct, the quasi-option value is in practice very difficult to assess (Turner et al., 2000).

(iv) *None-use values.* Non-use values are derived from attributes inherent to the ecosystem itself (Cummings and Harrison, 1995; Van Koppen, 2000). Hargrove (1989) has pointed out that non-use values can be anthropocentric, as in the case of natural beauty, as well as eco-centric, e.g., related to the notion that animal and plant species may have a certain 'right to exist.' Kolstad (2000) distinguishes three types of non-use value: existence value (based on utility derived from knowing that something exists), altruistic value (based on utility derived from knowing that somebody else benefits) and bequest value (based on utility gained from future improvements in the well-being of one's descendants). The different categories of non-use value are often difficult to separate, both conceptually (Weikard, 2002) and empirically (Kolstad, 2000). Nevertheless, it is important to recognize that there are different motives to attach non-use value to an ecosystem service, and that these motives depend upon the moral, aesthetic and other cultural perspectives of the stakeholders involved.

Applicable valuation methods differ for private and public services. The marginal value of private goods can generally be derived from market prices, whereas marginal values of public goods have to be established using non-market valuation techniques. These include 'stated preference' approaches, such as the Contingent Valuation Method (CVM) and related methods, and 'revealed preference' approaches. Revealed preference techniques use a link with a market good or service to indicate the willingness-to-pay for the service. Valuation of non-use values is particularly cumbersome. Different authors have tried to express them in monetary values (see Nunes and van den Bergh, 2001) or non-monetary indicators (Wathern et al., 1986; Margules and Usher, 1981). For details on valuation techniques, see Dixon and Hufschmidt (1986), Pearce and Turner (1990), Hanley and Spash (1993), Pearce and Moran (1994), Willis and Garrod (1995), and Brouwer et al. (1997).

2.4. Aggregation or comparison of the values (step 4)

In principle, the four value types are exclusive and may be added. The sum of the direct use, indirect use and option values equals the total use value of the system; the sum of the use value and the non-use value is the total value of the ecosystem (Pearce and Turner, 1990). If all values have been expressed as a monetary value, and if the values are expressed through comparable indicators (e.g., consumer and/or producer surplus), the values can be summed. If non-monetary indicators are used for the non-use values, the values can be presented side-by-side—leaving it to the reader to compare the two value types (as in Strijker et al., 2000). Alternatively, they can be compared using Multi Criteria Assessment (MCA). With MCA, stakeholders can be asked to assign relative weights to different sets of indicators (non-monetary as well as monetary), enabling comparison of the indicators (Nijkamp and Spronk, 1979; Costanza and Folke, 1997). Different stakeholder groups can be expected to have different perspectives on the importance of the different types of value (Vermeulen and Koziell, 2002). Through group valuation, or the use of deliberative processes, stakeholders can be encouraged to converge to a representative assessment of the values of different ecosystem services (O'Neill, 2001).

An important issue in the valuation of ecosystem services is the *double counting* of services (Millennium Ecosystem Assessment, 2003; Turner et al., 2003). The various processes involved in the regulation services are paramount to the functioning of ecosystems, and in that sense underlie many other services. However, including both the regulation and these other services in the assessment of the total value of an ecosystem may lead to double counting. For example, pollination is crucial to sustaining the fruit production of an area. Including both the pollination service and the service 'production of fruit' would lead to double counting—the value of the pollination of fruit trees is already included in the value of the fruits. In this paper, it is proposed to deal with double counting by arguing that regulation services should only be included in the valuation if (i) they have an impact outside the ecosystem to be valued; and/or (ii) if they provide a *direct* benefit to people living in the area (i.e., not through sustaining or improving another service). In the first case, it is the spatial configuration, and the interactions with ecosystems or society outside the studied system, that determine the value of the service. For example, if an ecosystem is supporting a population of bees that plays an important role in the pollination of crops in adjacent fields, this should be included in the valuation. Regulation services also need to be included if they provide a direct benefit to society. An example of a service that provides a direct benefit is the service 'protection against noise and dust' provided by a green belt besides a highway. If this affects the living conditions of people living inside the study area, it needs to be included in the valuation. Note that a prerequisite for applying this approach to the valuation of regulation services is that the ecosystem needs to be defined in terms of its spatial boundaries—otherwise the external impacts of the regulation services cannot be precisely defined.

3. Scales of ecosystem services

Scales refer to the physical dimension, in space or time, of phenomena or observations (O'Neill and King, 1998). Ecosystem services are supplied to the economic system at a range of spatial and temporal scales, varying from the short-term, site level (e.g., amenity services) to the long-term, global level (e.g., carbon sequestration) (Turner et al., 2000; Limburg et al., 2002;). Scales and stakeholders are often correlated, as the scale at which the ecosystem service is supplied determines which stakeholders may benefit from it (Vermeulen and Koziell, 2002). This section analyses (i) scales of ecosystems; (ii) scales of socio-economic systems; and (iii) scales and stakeholders in relation to ecosystem services. Subsequently, it proposes a fifth step to be added to the valuation framework described in the previous section, dealing with the analysis of scales and stakeholders.

3.1. Scales of ecosystems

According to its original definition, ecosystems can be defined at a wide range of spatial scales (Tansley, 1935). These range from the level of a small lake up to the boreal forest ecosystem spanning several thousands of kilometers. As it is usually required to define the scale of a particular analysis, it has become common practice to distinguish a range of spatially defined ecological scales (Holling, 1992; Levin, 1992). They vary from the level of the individual plant, via ecosystems and landscapes, to the global system—see Fig. 2. In such a classification of ecological scales, it is common to include the ecosystem itself as a particular scale, for example in terms of a 'forest ecosystem'.

The functioning of ecosystems depends upon earth system processes that take place over a range of spatial (and temporal) scales. This ranges from competition between individual plants at the plot level, via meso-scale processes such as fire and insect outbreaks, to climatic and geomorphologic processes at the largest spatial and temporal scales (Clark et al., 1979; Holling et al., 2002). In general, large-scale, long-period phenomena set physical constraints on smaller scale, shorter period ones (Limburg et al., 2002). However, large-scale processes may be driven by the joint impact of small-scale processes (Levin, 1992). For example, microbes operate on the scale of micrometers and minutes, but their cumulative activity determines a larger scale process such as the nutrient cycle, e.g., through demineralization of organic material and nitrogen fixation.

Ecosystem services are generated at all ecological scales. For instance, fish may be supplied by a small pond, or may be harvested in the Pacific Ocean. Biological nitrogen fixation enhances soil fertility at the ecological scale of the plant, whereas carbon sequestration influences the climate at the global scale.

3.2. Scales of socio-economic systems

In the socio-economic system, a hierarchy of *institutions* can be distinguished (Becker and Ostrom, 1995; O'Riordan et al., 1998). They reflect the different levels at which decisions on the utilization of capital, labor and natural resources are taken (North, 1990). At the lowest institutional level, this includes individuals and households. At higher institutional scales can be distinguished: the communal or municipal, state or provincial, national, and international level (see Fig. 2). Many economic processes, such as income creation, trade, and changes in market conditions can be more readily observed at one or more of these institutional scales (Limburg et al., 2002).

The supply of ecosystem services affects stakeholders at all institutional levels (Berkes and Folke, 1998; Peterson, 2000). Households, as well as local or internationally operating firms, may directly depend upon ecosystem services for their income (e.g., fishermen, ecotourism operators). Government agencies at different levels are involved in managing ecosystems, and in regulating the access to ecosystem services. They may also receive income from specific ecosystem services (park entrance fees, hunting licenses). Ultimately, all individuals depend upon the essential regulation (life-support) services of ecosystems. Ecological and institutional boundaries seldom coincide, and stakeholders in ecosystem services often cut across a range of institutional zones and scales (Cash and Moser, 1998).

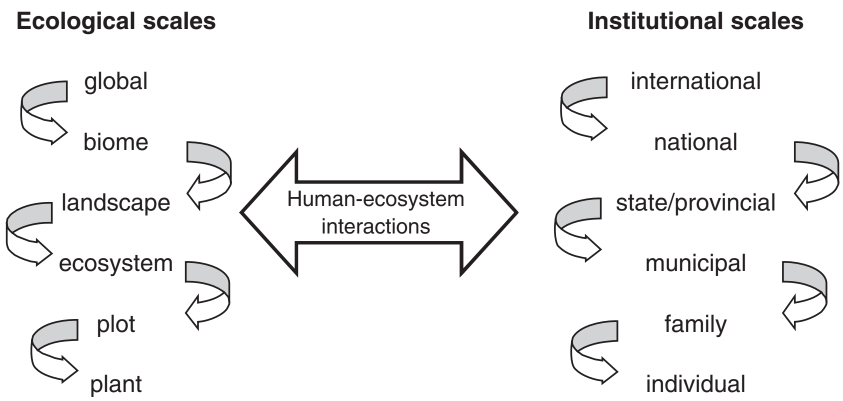

Fig. 2. Selected ecological and institutional scales (adapted from Leemans, 2000).

3.3. Scales and stakeholders of ecosystem services

In the previous paragraphs, we argued that ecosystem services can be generated at a range of ecological scales, and can be supplied to stakeholders at a range of institutional scales (see Fig. 2). We will now briefly discuss this for the three categories of ecosystem services distinguished in our framework.

(i) *Production services*. The possibility to harvest products from natural or semi-natural ecosystems depends upon the availability of the resource, or the stock of the product involved. To analyze the ecological impacts of the resource use, or the harvest levels that can be (sustainably) supported, the appropriate scale of analysis is the level of the ecosystem supplying the service (e.g., the lake, or the Northern Atlantic ocean) (Levin, 1992). The benefits of the resource may accumulate to stakeholders at a range of institutional scales (Turner et al., 2000). Local residents, if present, are often an important actor in the harvest of the resources involved, unless they do not have an interest in, or access to the resource (e.g., due to a lack of technology, or because the ownership or user-right of the resource resides with other stakeholders). In addition, there may be stakeholders' interests at larger scales if the goods involved are harvested, processed or consumed at larger scales. For example, this is the case if a marine ecosystem is fished by an international fleet, or if a particular genetic material or medicinal plants is processed and/or consumed at a larger institutional scale (see, e.g., Blum, 1993).

(ii) *Regulation services.* A regulation service can be interpreted as an ecological process that has (actual or potential) economic value because it has an economic impact outside the studied ecosystem and/or if it provides a *direct* benefit to people living in the area (see the previous section). Because the ecological processes involved take place at certain, ecological scales, it is often possible to define the specific ecological scale at which the regulation service is generated (see Table 2). Note that, whereas regulation services are typically generated at a specific ecological scale, the benefits may accrue to stakeholders at a range of institutional scales. For many regulation services, not only the scale, but also the position in the landscape plays a role—for example, the impact of the water buffering capacity of forests will be noticed only downstream in the same catchment (Bosch and Hewitt, 1982). Stakeholders in a regulation service are all people residing in or otherwise depending upon the area affected by the service.

(iii) *Cultural services*. Cultural services may also be supplied by ecosystems at different ecological scales, such as a monumental tree or a natural park. Stakeholders in cultural services

Table 2
Most relevant ecological scales for the regulation services—note that some services may be relevant at more than one scale

Ecological scale	Dimensions (km^2)	Regulation services
Global	>1,000,000	Carbon sequestration
		Climate regulation through regulation of albedo, temperature and rainfall patterns
Biome–landscape	10,000–1000,000	Regulation of the timing and volume of river and ground water flows
		Protection against floods by coastal or riparian ecosystems
		Regulation of erosion and sedimentation
		Regulation of species reproduction (nursery service)
Ecosystem	1–10,000	Breakdown of excess nutrients and pollution
		Pollination (for most plants)
		Regulation of pests and pathogens
		Protection against storms
Plot–plant	<1	Protection against noise and dust
		Control of run-off
		Biological nitrogen fixation (BNF)

Based upon Hufschmidt et al. (1983), De Groot (1992), Kramer et al. (1995) and Van Beukering et al. (2003).

can vary from the individual to the global scale. For local residents, an important cultural service is commonly the enhancement of the aesthetic, cultural, natural, and recreational quality of their living environment. In addition, in particular for indigenous people, ecosystems may also be a place of rituals and a point of reference in cultural narratives (Posey et al., 1999; Infield, 2001). Nature tourism has become a major cultural service in Western countries, and it is progressively gaining importance in developing countries as well. Because the value attached to the cultural services depends on the cultural background of the stakeholders involved, there may be very different perceptions of the value of cultural services among stakeholders at different scales. Local stakeholders may attach particular value to local heritage cultural or amenity services, whereas national and/or global stakeholders may have a particular interest in the conservation of nature and biodiversity (e.g., Swanson, 1997; Terborgh, 1999).

3.4. Expanding the valuation framework: analysis of scales and stakeholders (step 5)

In this section, we argue that, in order to apply ecosystem services valuation to support decision making on ecosystem management, it is necessary to explicitly consider the scales at which ecosystem services accrue to the different stakeholders. This means that the ecosystem services valuation framework described in Section 2 should be expanded with a fifth step: '(v) Analysis of scales and stakeholders.' As explained above, services generated at a particular ecological level can be provided to stakeholders at a range of institutional scales, and stakeholders at an institutional scale can receive ecosystem services generated at a range of ecological scales. Note that, of course, there will often be different stakeholders at each institutional level. In this case, stakeholder analysis needs to be applied to identify the interests of heterogeneous stakeholder groups (see, e.g., Grimble and Wellard, 1997; De Marchi et al., 2000; Kasemir et al., 2003). Often, ecosystem services are generated, and supplied at particular scales. Analysis of the value of an ecosystem at different spatial scales requires assessing at which scale, and to whom the benefits of the system's services accrue.

As an example, consider the case of a South-Asian mangrove forest that provides the following services: (i) provision of wood and shellfish; (ii) protection from floods; (iii) nursery service for a range of fish species; and (iv) the conservation of biodiversity (Hein, 2002). The provision of wood and shellfish is most relevant at the municipal scale, as the large majority of wood and shellfish is used locally. The two regulation services, 'protection from floods' and the 'nursery service' are generated at the scale of the ecosystem, but they are provided to stakeholders at a range of institutional scales, from the municipality up to the national scale. The conservation of biodiversity is most relevant to stakeholders at the national and international scale. The interests of stakeholders at these scales vary accordingly. Whereas, in general, local residents prefer management that allows the collection of wood and shellfish while maintaining the regulation services, international stakeholders are mostly worried about the global loss of mangrove forest and the associated loss of biodiversity (e.g., Alongi, 2002). As, in a global context, ecosystems as well as institutional settings are highly diverse (e.g., Millennium Ecosystem Assessment, 2003), relevant scales need to be identified on a case by case basis. Fig. 2 above presents the potential relevant scales and interactions, and can be instrumental in such analysis.

Assessment of scales and stakeholders enhances the applicability of ecosystem services valuation to support decision making. Identification of scales and stakeholders allows the analysis of potential conflicts in environmental management, in particular between local stakeholders and stakeholders at larger scales. This applies if services relevant at higher scales restrict the use of local production services. For instance, maintaining the hydrological service of a forest in an upper watershed poses restrictions on the use of the forest by local stakeholders (e.g., Bosch and Hewitt, 1982). Analysis of the (opportunity) costs and benefits of ecosystem management for stakeholders at different scales also provides a basis for determining the size of potential compensation payments to local users.

4. Valuation of the ecosystem services of the De Wieden wetland, and assessment of the scales at which they are supplied

The spatial scales at which ecosystem services are supplied are examined for the De Wieden wetland in The Netherlands. Subsequently, we analyze (i) the values of selected ecosystem services supplied by De Wieden; and (ii) the scales at which these ecosystem services are supplied to stakeholders. As the main aim of this section is to examine the scales of ecosystem services, relatively simple valuation techniques have been used.

4.1. Specification of the study area (step 1)

De Wieden is one of the most extensive lowland peatlands in north-western Europe, and it includes a large range of waterbodies of different sizes (lakes, canals, marshlands), reedlands, extensive agricultural land and forests. For this study, a case study area has been selected that comprises the central part of De Wieden, in total around 5200 ha. It includes the four biggest lakes and the surrounding area (Fig. 3).

4.2. Assessment of ecosystem services (step 2)

Four ecosystem services have been selected for this study: (i) the provision of reed for cutting; (ii) the provision of fish (both production services); (iii) the provision of opportunities for recreation; and (iv) nature conservation (both cultural services). These services have been selected in order to obtain a mix of services important for stakeholders at different levels, and because of the availability of data for these four services. Two other ecosystem services of the wetland that are not further considered in this study are the amenity service and the water purification service. The *amenity* service reflects that De Wieden enhances the local living conditions by the provision of an attractive environment. The service accrues to local stakeholders. It is excluded because the fisheries and recreation services also provide benefits to local stakeholders, and data is more readily available for these two services. The *water purification* service is based upon the breakdown and absorption of pollutants in the wetland. The water purification service is reflected in enhanced opportunities for recreation and nature conservation, but, to avoid double counting, this should not be included in the valuation. The water purification service also leads

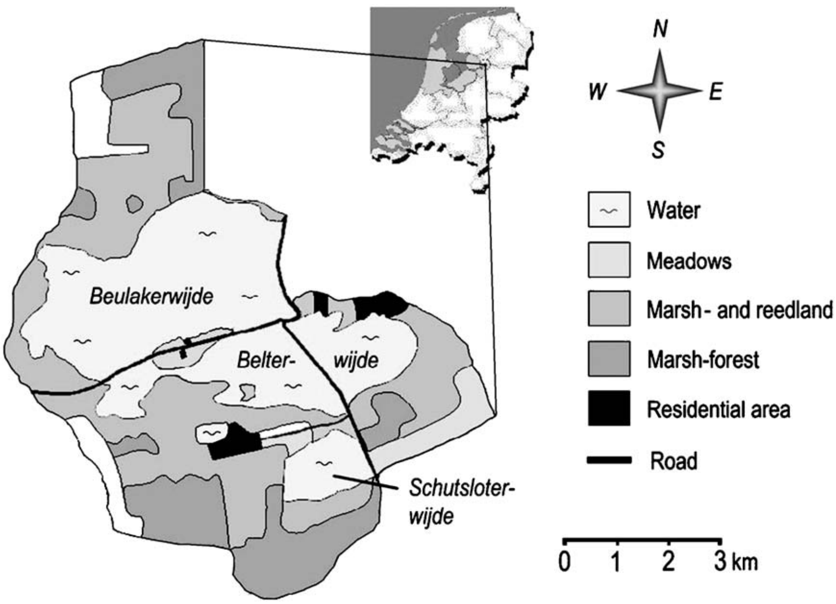

Fig. 3. Map and location of the study area.

to the inflow of cleaner water in lake Ijsselmeer downstream, which represents an economic value generated by De Wieden. However, as only around 0.7% of the water that Lake Ijsselmeer receives flows through De Wieden, the impact on the overall water quality of the lake is likely to be modest and the service is excluded from further analysis.

(i) *Provision of reed (for cutting).* The reed of De Wieden has been cut since several centuries, and is used mainly for thatched roofs. Reed cutting is practiced on some 1400 ha (Natuurmonumenten, 2000), and is locally an important industry, employing around 220 people (De Bruin et al., 2001). Harvests are in the order of 665 kg/ha/year (De Bruin et al., 2001). Most of the reed cutting is done in combination with farming and/or fisheries, a suitable combination because most of the reed cutting takes place in the period October–March, and most farming and fishing activities are conducted in the period April–September.

(ii) *Provision of fish.* Professional fishermen fish each of the four lakes of the case study area, which comprise in total around 1600 ha open water. There are in total 11 professional fishermen working in the area (Van Dijk, 2003). The most important species is eel, which is fished with hoop nets. Fishermen also collect the whitefish that ends up in the nets, including pike, perch pike, bream and roach, although the prices of these fish are relatively low (Klinge, 1999).

(iii) *Recreation*. De Wieden is an important area for recreation, attracting visitors that come for short holidays as well as day-trips. Visitors enjoy a range of activities including boating, sailing, hiking, fishing, canoeing, surfing, swimming and sun-bathing (see Table 3). The authors of this study have estimated the number of people visiting the beaches for swimming and/or sunbathing, and the number of recreational fishermen. The visitors to the 9 (mostly small) beaches in the case study area have been counted during 10 sunny days spread over the spring, summer and autumn of 2003. The average number of visitors for these days (447) has been multiplied with the yearly average number of warm (>25 °C) and sunny days (18), derived from climate statistics (KNMI, 2003). Furthermore, it has been assumed that recreational fisheries takes place on days without rain, during the period 1 April–30 September (interviews with fishermen showed that the large majority did not fish during the cold winter season, or on rainy days). The number of fishermen, as found in surveys on 20 dry days in the selected period (28) has been multiplied with the average number of days without rain in these 6 months (72) (KNMI, 2003).

Benefits of the recreational opportunities of De Wieden also accrue to the local companies offering recreational services. These include boat and canoe rental agencies, hotels, camping sites, marinas, and bars and restaurants. Both companies located in the study area, and companies located in the immediate surroundings of the study area benefit from the visitors to De Wieden.

(iv) *Nature conservation*. De Wieden is highly important for biodiversity conservation. It provides a habitat to a wide range of water- and meadow-

Table 3
Estimate of the number of people involved in various recreational activities in De Wieden per year

Activity	Number of visitor-days per year	Source
People visiting the walking trails and information center (in 2002)	61,404	Natuurmonumenten, 2003a
Swimming/ sunbathing	8040	This study
Fishing	2050	This study
Boating		
–Motorboats	82,165	Number of boats: PoO (2001); number of people per boat: Moonen (1992)
–Sailing boats >5 m	15,123	Number of boats: PoO (2001); number of people per boat: Moonen (1992)
–Speedboats, canoes	3674	Number of boats: PoO (2001); number of people per boat: Moonen (1992)
–Total boating	100,962	
Total	172,456	

birds, dragonflies, butterflies, fish, etc., and it contains, together with the adjacent wetland 'De Weerribben,' the world's only population of a large subspecies of the large copper butterfly (*Lyacena dispar*). The otter, which became extinct in The Netherlands some 12 years ago, was reintroduced to the area in June 2002. The area is protected under national laws, is included in the EU habitat and birds directives, and was recently (November 2002) appointed a Ramsar site.

4.3. Valuation of the ecosystem services of De Wieden (step 3)

On the basis of existing data, and limited surveys, the four selected services have been valued in monetary terms, using revealed preference methods. Due to deficiencies in available data, different approaches have been used to assess the value generated by the four services, see Table 4. For the two production services, and for the benefits of the recreation service accruing to the providers of recreation services (for instance hotels, or boat rental agencies), the net value added generated by the service is used as indicator of its value. To assess the value for visitors to De Wieden, the consumer surplus is used, calculated with the travel cost method. For the nature conservation service, payments to the NGO protecting and managing the site ("Natuurmonumenten") are used as an indication of the lower value of the willingness-to-pay of the Dutch public for this service. A more detailed description of the valuation methodology applied to each service is provided below.

Our calculations present a significant simplification of the complex issue of ecosystem services valuation, involving the use of two conceptually different indicators of value: consumers' surplus and value added. The two indicators compare as follows. On the one hand, the surplus gained through the reed production and fisheries service, and the provision of recreational services, may be larger than indicated through the respective values added because not all utility gained by people working in these sectors will be reflected in their income. For example, fishermen may enjoy their profession and gain utility through the fishing activities themselves. On the other hand, the concept of value added does not account for the shadow costs of labor and capital. This aspect, *c.p.*, causes the value added to be higher than the consumer surplus. The use of two different indicators restricts the possibilities to add the values of the services.

(i) *Provision of reed.* The total turn-over from the reed cutting is around 800,000 euro, and the net value added (taken as a proxy for the value of the service) is around 480,000 euro (De Bruin et al., 2001). It is assumed that an increase or decrease in reed production in De Wieden can be compensated by other producers without changes in the price or quality of the product on the market, and that the consumer surplus resulting from reed production is zero.

(ii) *Provision of fish.* Total annual turnover of the fishery sector is estimated to be only around 215,000 euro (Klinge, 1999; De Bruin et al., 2001; Van Dijk, 2003). Investments are small, and the value added is estimated at around 140,000 euro (De Bruin et al., 2001; Van Dijk, 2003). In comparison with the total eel fisheries in The Netherlands, the contribution from De

Table 4
The approaches used to assess the surplus generated by each service

Stakeholder	Calculation method	Type of value indicator obtained
Reed cutters	Net value added	Income generated
Professional fishermen	Net value added	Income generated
Recreation service		
–Value for visitors to De Wieden	–Travel cost method	–Consumer surplus
–Value for the providers of recreation services (e.g. hotel owners, boat rental agencies)	–Net value added	–Income generated
Nature conservationists	Donations to the NGO protecting the site	The donations are a lower value of the willingness-to-pay for, and the consumers' surplus generated by the service

Wieden is small; less than 1% of the Dutch market is supplied by De Wieden (Klinge, 1999), As with reed cutting, it is assumed that the consumer surplus generated by the fisheries activities in De Wieden is zero.

(iii) *Recreation.* The value of the recreation service is estimated by summing the utility gained by visitors to the area and the net value added of the local recreation sector—insofar as dependent upon visitors to De Wieden. The utility of tourists visiting the site is assessed with the zonal travel cost method (Hanley and Spash, 1993). The demand function for the site is constructed on the basis of the visit rate per zone and the travel costs from each zone. Six zones have been defined at increasing distances from De Wieden. The visit rates per zone have been estimated on the basis of a survey among visitors to the area by Van Konijnenburg (1996). There are a lot of camping sites and holiday houses in the area and, to avoid a bias in the number of visitors per zone, only the travel costs of people visiting from their permanent residence were included ($n=304$). For each zone, the relative visit rates and the average travel cost from the middle of the zone were calculated (see Table 5). The travel costs include the average transportation costs by car (euro 0.28/km), from Rietveld et al. (2000), and the time costs, based upon the average per person hourly wage rate, from CPB (2003).

Following standard procedures in the zonal travel cost method (Hanley and Spash, 1993), we first analyzed the relation between travel costs and visits per capita, using regression analysis. We derived that, for De Wieden, the visit rate depends upon the travel costs according to the equation: visit rate $=0.133\times e^{-0.244*\text{costs}}$ ($F=14$). Subsequently, the demand function for visits to the site has been constructed, under the assumption that expenditure for an entrance fee is viewed in the same way as travel costs by the visitors. The first point on the demand curve is the current amount of visitors to the site (at the moment, there is no entry fee). Subsequent points on the demand curve are calculated for hypothetical entrance fees ranging from 2.5 euro to 30 euro per visit (with steps of 2.5 euro). For the total travel and entrance costs associated with these different fees, the corresponding number of visitors to De Wieden has been estimated using the equation for the visit rate presented above in combination with the total population in each zone (from Table 5). The results are presented in Fig. 4. The area under the demand curve, equaling the consumers' surplus, is around 880,000 euro (which equals around 5 euro per visit).

The value added generated by the recreation sector is calculated as follows. The total *turn-over* of the recreation sector, as generated by visitors to De Wieden, is calculated by multiplying the number of visitors to De Wieden with their average expenditure. Visitors to the municipality (Steenwijkerland) spend, on average, euro 21.10 per day (TRN, 2002), and there are 172,456 visitor-days per year to De Wieden (this study). Hence, the total turn-over generated by De Wieden is euro 3,638,822 per year. It is assumed that all expenditure of these visitors can be attributed to the De Wieden (whereas in reality some of the visitors may combine a visit to De Wieden with a visit to another attraction in the area). The *net value added* is calculated by

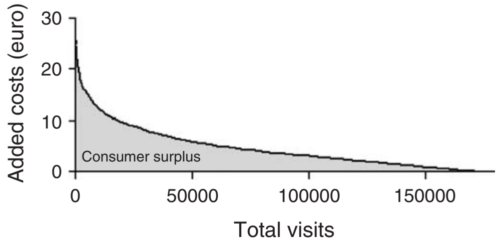

Fig. 4. Demand curve for visits to De Wieden.

Table 5
Travelers and travel costs to De Wieden from different zones

Zone (km)	Total visits/year	Zone population	Visits/ population	Average travel costs
<5	8548	19,010	0.45	1.17
5–10	13,380	45,580	0.29	2.58
10–25	35,681	345,790	0.10	4.45
25–50	27,875	1,024,390	0.03	7.50
50–100	53,521	3,714,010	0.01	12.64
100–250	33,451	6,285,990	0.01	19.19
Total	172,456			

multiplying the turn-over with the average value added generated per unit of turn-over. For the recreational companies in De Wieden, the net value added is around 22% of turn-over (De Bruin et al., 2001)—which compares to a national average of 15% for the hotel sector (BHC, 2003). Hence, the value added generated by De Wieden is around euro 800,000 per year.

The total value of the recreational service of De Wieden is found by summing the utility accruing to the visitors, and the net value added of the recreational sector in the immediate surroundings of De Wieden, insofar as based upon the contribution from visitors to De Wieden. Hence, the total value of the service is 880,000 + 800,000 = 1,680,000 euro.

(iv) *Nature conservation.* The non-use value associated with the nature conservation service is normally analyzed with CVM (Arrow et al., 1993; Hailu et al., 2000). Although CVM has increasingly been applied to analyze the non-material benefits derived from ecosystems, some authors have questioned the validity of CVM (e.g., Carson, 1998). One of the problems associated with CVM is that respondents do not actually have to pay the amount they express to be willing to pay for a service, which may lead to an overestimation of its value (Diamond and Hausman, 1994; Carson, 1998). The implementation of a well-designed CVM study is outside the scope of this paper. Instead, in order to obtain a crude approximation of the monetary value of the nature conservation service, it is assumed that the amount of money contributed to the NGO 'Natuurmonumenten' that manages De Wieden provides an indication of the willingness-to-pay (WTP) of The Netherlands' public for nature conservation in De Wieden. An advantage of this approach is that is measures actual payments instead of a stated willingness to pay. However, the estimate only indicates the minimum amount the Dutch public is willing to pay. The actual amount will be higher because some members of the NGO may be willing to pay a larger sum if this would be necessary to preserve De Wieden, and because some non-members may also be willing to pay for nature conservation in De Wieden.

In the year 2002, the NGO received in total around euro 29 million in donations (Natuurmonumenten, 2003a). However, the NGO manages a number of nature parks in The Netherlands. To estimate the WTP of the members of Natuurmonumenten for *De Wieden*, it is assumed that the WTP for De Wieden is proportional to the aerial surface of De Wieden in comparison to the total area of the sites managed by the NGO. The total area of the sites managed by the NGO is 71,200 ha (June 2002), of which 5400 ha (7.6%) are located in De Wieden (Natuurmonumenten, 2003a). Hence, the minimum value of the nature conservation service of the De Wieden wetlands can be estimated at around euro 2.2 million per year.

4.4. Aggregation and comparison of the values (step 4)

All services have been valued in monetary terms. However, different indicators have been used to indicate the surplus generated by the services (value added, consumer surplus and payments to Natuurmonumenten). This restricts the possibilities to add and compare the values, as discussed earlier in the paper. Nevertheless, the values of the four services have been added to provide a crude indication of their total value, as presented in Table 6. The approximate, combined monetary value of the four selected ecosystem services provided by De Wieden is in the order of euro 4,500,000 per year, or 830 per ha per year.

4.5. Analysis of scales of ecosystem services and stakeholders (step 5)

We now turn to the spatial scales at which the four services of the De Wieden ecosystem are supplied to stakeholders. Four institutional scales are distin-

Table 6
Economic value of the ecosystem services supplied by the study area

Ecosystem service	Economic value (euro/year)
Reed cutting	480,000
Fisheries	140,000
Recreation	1,680,000
Nature conservation	2,200,000
Total value of the selected services	4,500,000

guished: municipal (<5 km from the Wieden), provincial (between 5 and 25 km from De Wieden), national (The Netherlands excluding the area <25 km from De Wieden), and global (excluding The Netherlands).

(i) *Provision of reed*. All reed cutters live in the proximity of the area (Van Dijk, 2003), and the benefits of reed cutting accrue to the stakeholders at the municipal scale. Note that reedlands are a distinctive element of the local landscape and, in this sense, they contribute to the amenity service of the area which accrues to various other local stakeholders. However, for reasons of simplicity, in our analysis, we focus on the value of reed for reed cutters.

(ii) *Provision of fish*. All fishermen live in the proximity of the area (Van Dijk, 2003), and, as with reed cutting, the benefits of fisheries accrue at the municipal scale. As with the service 'Provision of reed,' it is assumed that all benefits of this service accrue to the local fishermen. In reality, it can be expected that there is also a benefit for some other stakeholders. For example, for some visitors, the presence of traditional fisheries adds to the cultural value of the De Wieden wetland.

(iii) *Recreation*. Van Konijnenburg (1996) assessed the amount of visitors arriving from different areas to De Wieden, see Table 7. The numbers do not match with Table 5 as Table 7 indicates the numbers of visitors from different institutional zones, instead of different distances. The international scale comprises all visitors from other countries; foreign visitors come in particular from Germany and Belgium. It is assumed that the WTP is the same for all visitors, and that this information can be used to assess the value of the recreation service at different scales. The recreational value for the tourism industry is entirely attributed to the municipal level as all companies are located in a distance of less than 5 km from De Wieden.

(iv) *Nature conservation*. The membership of Natuurmonumenten at different institutional scales provides a proxy for the value of the nature conservation service at these different levels, see Table 8. Obviously, this approach to split the monetary value of the natural conservation service over different scales is very crude, for example because not all the appreciation of local people for the nature close to their home is reflected in a membership of Natuurmonumenten. However, better data are currently not available to analyze the value of this service at different levels within The Netherlands. The De Wieden wetlands are also of international importance, evident from its qualification as a Ramsar site and its inclusion in the EU habitats and bird directives. This international importance is not reflected in any indicator that can be used to establish a monetary indication of this international value, and it is included *p.m.* in the valuation.

Table 7
Visitors to De Wieden and consumers' surplus at different scales

Scale	Share of visitors (%)[a]	Number of visitors	Consumers' surplus (euro) (rounded)
Municipal	9	15,521	80,000
Provincial	25	43,114	220,000
National	55	94,851	480,000
International	11	18,970	100,000
Total	100	172,456	880,000

[a] Source: Van Konijnenburg (1996).

Table 8
Lower bound value of the nature conservation service at different scales

Scale	Share of members (%)[a]	Number of members	Minimum value (euro) (rounded)
Municipal	0.3	2883	6600
Provincial	6.6	63,426	145,200
National	93	894,691	2,048,200
International	–	–	*p.m.*
Total	100	961,000	2,200,000

[a] Source: Natuurmonumenten, 2003b.

Fig. 5 shows how the values of the four services are distributed over the four scales. The production services are attributed to the municipal scale, whereas the nature conservation and recreation service are spread according to the approach explained above. Obviously, the analysis is very crude and provides only an order of magnitude indication of the values at different scales. Only the main stakeholders in each

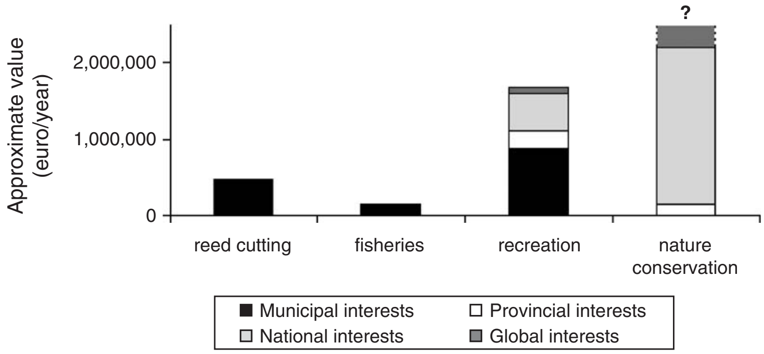

Fig. 5. The relation between institutional scale and the value of ecosystem services (at the global level, the value of the nature conservation service is not known).

service have been considered, whereas in reality there are a range of other stakeholders (e.g., local residents) that also have an interest in the analyzed services. Nevertheless, the figure demonstrates how scale determines the value of the services for the stakeholders at the different levels. At the municipal scale, the most important stakeholder interests relate to recreation, reed cutting and fisheries. At the provincial scale, the main stakeholder interests are in recreation, whereas nature conservation is also important. At the national level, nature conservation is by far the most important service. The value of the nature conservation service at the global scale is not known.

5. Implications for ecosystem management

The functioning of ecosystems depends upon earth system processes that take place over a range of spatial and temporal scales. Ecosystem services, that depend upon the functioning of the ecosystem, are generated at different, sometimes overlapping, *ecological* scales. In spite of the myriad of processes underlying most ecosystem services, often a typical ecological scale can be identified at which the service is generated. For example, carbon sequestration involves a range of processes taking place mostly at the scale of the plot (e.g., plant production) and the ecosystem (e.g., fire). Nevertheless, the service is generated at the global scale—it is the global amount of sequestered carbon that is one of the drivers of the global climate. Ecosystem services are supplied to the socio-economic system according to a range of *institutional* scales, varying from the individual to the global level (see Fig. 2). Each institutional scale commonly comprises different stakeholders, with sometimes conflicting interests (Grimble and Wellard, 1997; Tacconi, 2000).

Consideration of scales and stakeholders enhances the applicability of ecosystem services valuation to support decision making. Stakeholders at different scales often attach a different value to ecosystem services, depending upon their cultural background, and upon the impact of the service on their income and/or living conditions. These different interests often result in different visions on the management of the area (see also Brown, 1996; Tacconi, 2000). This is illustrated by stakeholders' preferences in the De Wieden wetland. Local stakeholders benefit from the reed and fish resources of the area that are of little importance at the national scale, and national stakeholders' main interest is in the biodiversity of De Wieden. This leads to conflicting views on the management of the area. For instance, reed cutters prefer to cut reed when it is 1 year old in order to get the best price for the reed, whereas nature conservationists would like to restrict reed cutting as birds need 2- to 4-year-old reed for nesting.

The formulation of management plans that are acceptable to all stakeholders requires the balancing of these different interests. If an optimal management strategy is sought on the basis of the interests of one particular scale alone, this may lead to unacceptable solutions for stakeholders at other scales. For instance, a management plan for De Wieden based upon local interests only would not do justice to national and international value of the biodiversity conservation service of De Wieden. On the other side, a management plan for a natural park based upon national interests would leave little opportunity for local activities—and risk confrontation with local residents. In De Wieden, compromise solutions are found to balance the use of ecosystem services. For example, fishermen cooperate with nature conservationist by installing (subsidized) otter-protection devices on their hoop nets, and the nature conservation NGO managing the area poses relatively few restrictions on reed cutting in most of De Wieden.

Furthermore, consideration of scales and stakeholders allows identification of the appropriate institutional level for decision making. In general, decision making on ecosystems should take place at a high enough level to ensure that all main benefits of the ecosystem are accounted for (Millennium Ecosystem Assessment, 2003). Services provided at high institutional scales, in particular the nature conservation and carbon sequestration services, require institutional arrangements at the national and international scale in order to ensure their continued supply. This paper also demonstrates the potential risk of the decentralization of responsibilities for nature reserve management to lower (provincial and municipal) authorities, as currently proposed in The Netherlands (VROM, 2004). Most of the benefits of the nature conservation service accrue at the national scale. Local authorities, that have the specific mandate to look after provincial or municipal interests, cannot be expected to be the appropriate institutional level to ensure the maintenance of this service. In addition, in The Netherlands, they are faced with a strong demand for space from local residents, e.g., for the construction of houses. Therefore, the proposed decentralization risks to lead to a decline in nature reserves in a way that is sub-optimal from the national perspective.

6. Conclusions

Ecosystem services are generated at a range of ecological scales, and are supplied to stakeholders at a range of institutional scales. Across the institutional scales, stakeholders can have very different perspectives on the values of ecosystem services, based, among others, on their dependency upon specific services to provide income or sustain their living environment. Therefore, it is crucial to consider the scales of ecosystem services when valuation of services is applied to support the formulation or implementation of ecosystem management plans. Formulation or implementation of management plans on the basis of stakeholders' interest at one institutional scale is bound to lead to sub-optimal ecosystem management from the perspective of stakeholders at other scales.

Analysis of the values of ecosystem services at different scales appears, in principle, feasible for the four services tested in this paper: two production services, recreation and nature conservation. However, the difficulties encountered in other studies in the monetary valuation of the nature conservation services (Spash and Hanley, 1995; Nunes and van den Bergh, 2001) were confirmed in our study. Furthermore, it appears that monetary valuation of the nature conservation service at the *global* scale is particularly difficult as it is difficult to find a benchmark with which the nature conservation service can be compared.

The paper only presents one further step towards the integration of scales in ecological–economic analysis. Whereas the paper pinpoints the role of scales and stakeholders in relation to ecosystem services valuation, it also highlights a number of issues that are in need of further research. First, there is a need to assess the role of scales of ecosystem services in relation to CVM, in order to reveal how stakeholders' willingness to pay for ecosystem services varies with scale and how this can be accounted for in CVM. A distance function approach, as recently applied to environmental amenities by, e.g., Färe and Grosskopf (1998) and Ferraro (2004), may provide a suitable entry point here. Second, there is a need to further analyze the spatial heterogeneity of ecosystem services and the consequences of this heterogeneity for the value of these services. This is particularly relevant for regulation services supplied at the landscape and ecosystem level, such as the flood protection service. Third, further study is required in order to allow quantification of the global value of nature and biodiversity, and enhance its consideration in local and national ecosystem management.

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