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Abstract

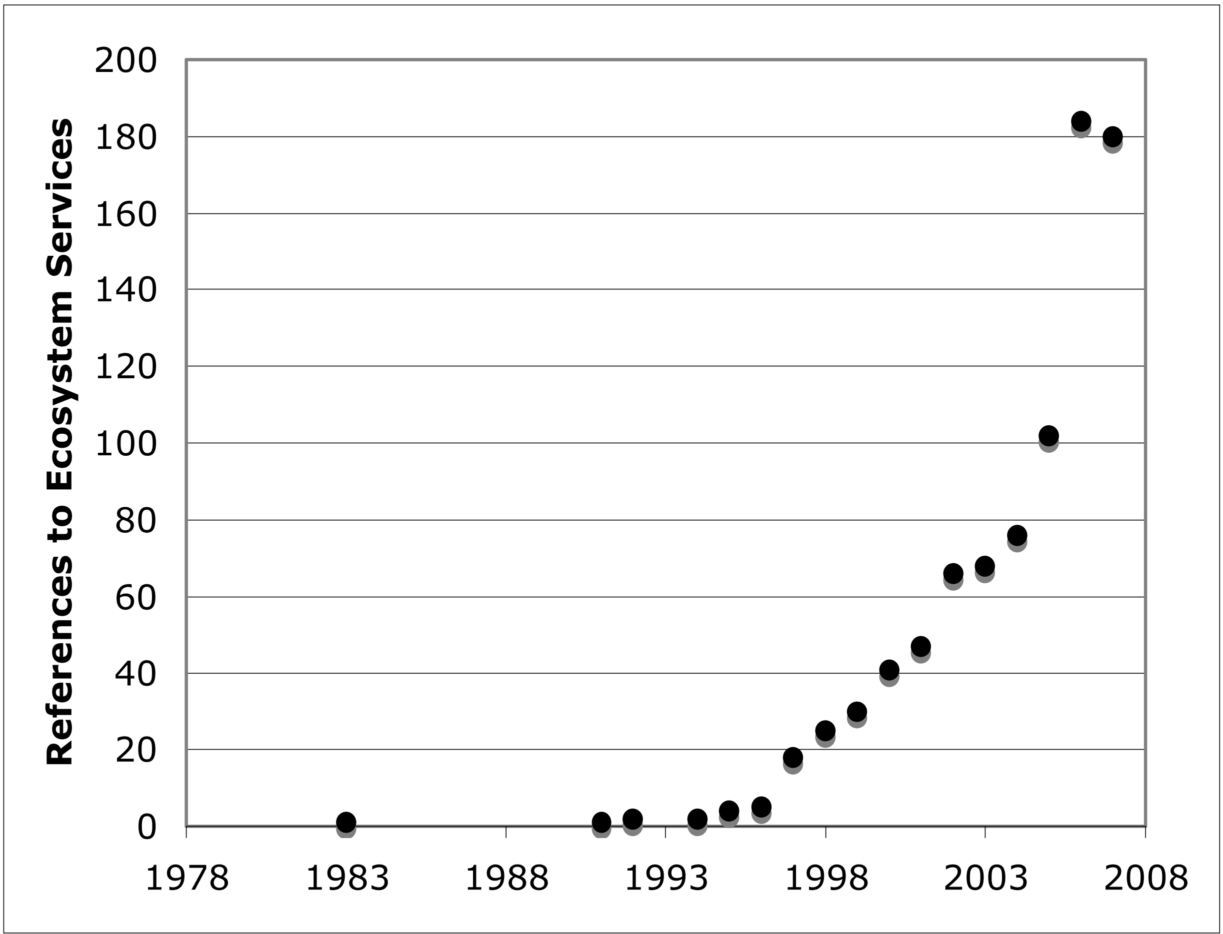
The concept of ecosystems services has become an important model for linking the functioning of ecosystems to human welfare benefits. Understanding this link is critical in decision-making contexts. While there have been several attempts to come up with a classification scheme for ecosystem services, there has not been an agreed upon, meaningful and consistent definition for ecosystem services. In this paper we offer a definition of ecosystem services that is likely to be operational for ecosystem service research and several classification schemes. We argue that any attempt at classifying ecosystem services should be based on both the characteristics of interest and a decision-context. Because of this there is not one classification scheme that will be adequate for the many context in which ecosystem service research may be utilized. We discuss several examples of how classification schemes will be a function of both ecosystem and ecosystem service characteristics and the decision-making context.

Keywords: ecosystem services; ecosystem benefits; human welfare; environmental decision making; Millennium Assessment

1. INTRODUCTION

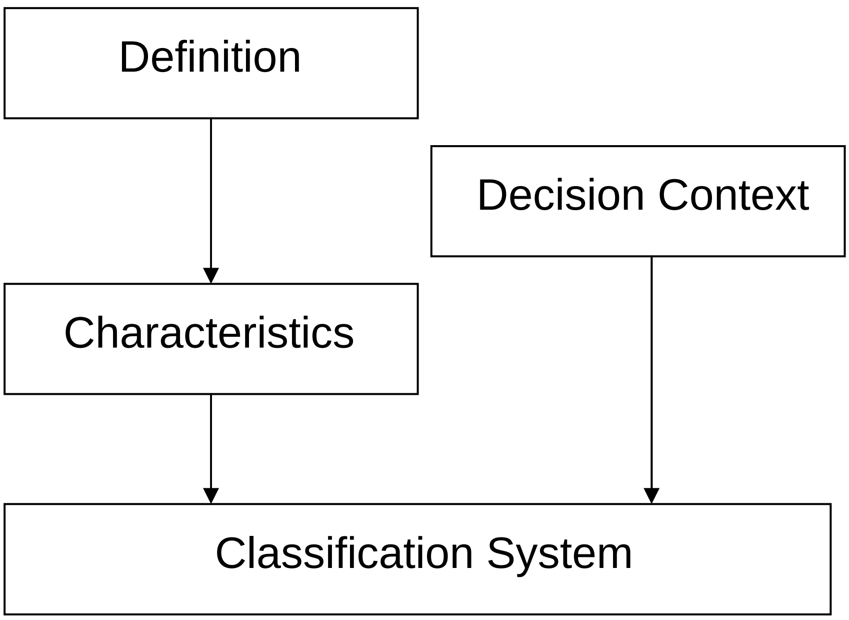
Ecosystem services research has become an important area of investigation over the past decade. The number of papers addressing ecosystems services is rising exponentially (Figure 1). The significance of the concept is witnessed by the publication of the Millennium Ecosystem Assessment (MA), a monumental work involving over 1300 scientists. One of the key results of the MA was the finding that globally 15 of the 24 ecosystem services investigated are in a state of decline (MA 2005), and this is likely to have a large and negative impact on future human welfare. This situation calls for further and more rigorous research on measuring, modelling and mapping ecosystem services and assessing changes in their delivery with respect to human welfare. To do this the scientific community needs to be able to explain clearly what ecosystem services are, and how they can be packaged (classified) for use. This requires a clear and consistent definition and an understanding of what characteristics and applications should drive a classification scheme.

Figure 1: *Number of papers using the term "ecosystem services"*



Despite its recent publication date, one of the most utilized classifications for ecosystem services comes from the MA, dividing ecosystem services into *supporting*, *regulating*, *provisioning* and *cultural* services. However this classification is not fit for all purposes, such as environmental accounting or landscape management for which alternative classifications have been proposed (Boyd and Banzhaf 2007; Wallace 2007). It is in this light that we suggest that there is no single classification system for ecosystem services that is appropriate for use in all cases. In fact a classification system should be informed by: 1) the characteristics of the ecosystem or phenomena under investigation; and 2) the decision-making context for which ecosystem services are being considered. Underlying this, we suggest that there needs to be a clear and consistent definition of what ecosystem services are. This is because a functional definition, widely agreed upon, would allow for meaningful comparisons across different projects, policy contexts, time and space. Such a definition would also provide us with boundaries for the characteristics we are interested in. For example, if we use the MA definition, i.e. benefits to humans, then the characteristics of import include things outside of ecological systems such as imputed cultural meanings. However, if ecosystem services are defined as ecological phenomena, as below or as in Boyd and Banzhaf (2007), than the characteristics we are interested in are characteristics of ecological systems only. Some of the identified characteristics, along with the decision context for mobilizing ecosystem services, will inform an appropriate classification system for use (Figure 2).

Figure 2: *Components for deriving appropriate ecosystem service classification schemes*



In this paper we suggest a broad, yet operational, definition of ecosystem services (Section 2); identify some of the characteristics of ecosystems and the services they provide that might be important for classification schemes (Section 3); and provide examples of decision-making contexts which illustrate how any classification scheme needs to fit the end use for an investigation into ecosystem services (Section 4). We then offer some concluding thoughts on the future of ecosystem service research.

2. DEFINING ECOSYSTEM SERVICES

In 1977 Westman suggested that the social value of the benefits that ecosystems provide could potentially be enumerated so that society can make more informed policy and management decisions. He termed these social benefits 'nature's services." Now we commonly refer to Westman's services as 'ecosystem services' – a term first used by Ehrlich and Ehrlich (1981).

Despite the three decade long history of the concept the current literature still does little to distinguish exactly how ecosystem services should be defined (Barbier 2007). Three commonly cited definitions are:

- *…the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life* (Daily 1997).
- *the benefits human populations derive, directly or indirectly, from ecosystem functions* (Costanza et al 1997).
- *the benefits people obtain from ecosystems* (MA 2005).

These definitions suggest that while there is broad agreement on the general idea of ecosystem services, important differences can be highlighted. In Daily (1997) ecosystem services are the "conditions and processes," as well as the "actual life-support functions." In Costanza et al. (1997) *ecosystem services* represent the goods and services derived from the functions and utilized by humanity. In the MA, services are benefits writ large.

The language surrounding this issue has taken many forms, as illustrated above. Table 1 identifies other related terms in the literature, and is one way to look at the various terms and their meanings. In this typology, the word *organization* represents the physical constitution of ecosystems; the word *operation* represents what authors have been referring to as the processes or functioning of ecosystems; and the word *outcome* for the link to human wellbeing. These are only offered as a way to systematize the various terms used in the literature. The semantics are so nuanced that there is even debate over the difference between ecosystem *function*, which has been argued to imply anthropocentrism (because *function* implies a goal), and ecosystem *functioning*, which does not (Jax 2005).

Table 1: *Various terms used in the literature regarding ecosystems*

Organization	**Operation**	**Outcome**
Stock	Flows	Services
Structure	Function(ing)	Goods
Infrastructure	Services	Benefits
Pattern	Process	
Capital	Income	

Boyd and Banzhaf (2007) offer an alternative definition. In their definition, ecosystem services are not the *benefits* humans obtain from ecosystems, but rather the ecological components directly consumed or enjoyed to produce human well-being. For Boyd and Banzhaf services are directly consumed components (structure included), meaning indirect processes and functions are not ecosystem services. An important distinction that Boyd (2007) elucidates is that services and benefits are not identical. Recreation, often called an ecosystem service, is actually a benefit of multiple inputs; often human, social and built capital inputs are necessary for recreation (Boyd 2007). The ecosystem service that may help produce a recreational benefit could be a number of things including a forest, meadow, vista etc.

Drawing largely on Boyd and Banzhaf (2007) we propose that *ecosystem services are the aspects of ecosystems utilized (actively or passively) to produce human well-being.* The key points include that services must be ecological phenomena and that they do not have to be directly utilized. Defined this way, ecosystem services include ecosystem organization or structure as well as process and/or functions if they are consumed or utilized by humanity either directly or indirectly. *(Boyd and Bazhaf see services as only the directly consumable end point).* The functions or processes become services if there are humans that benefit from them. Without human beneficiaries they are not services.

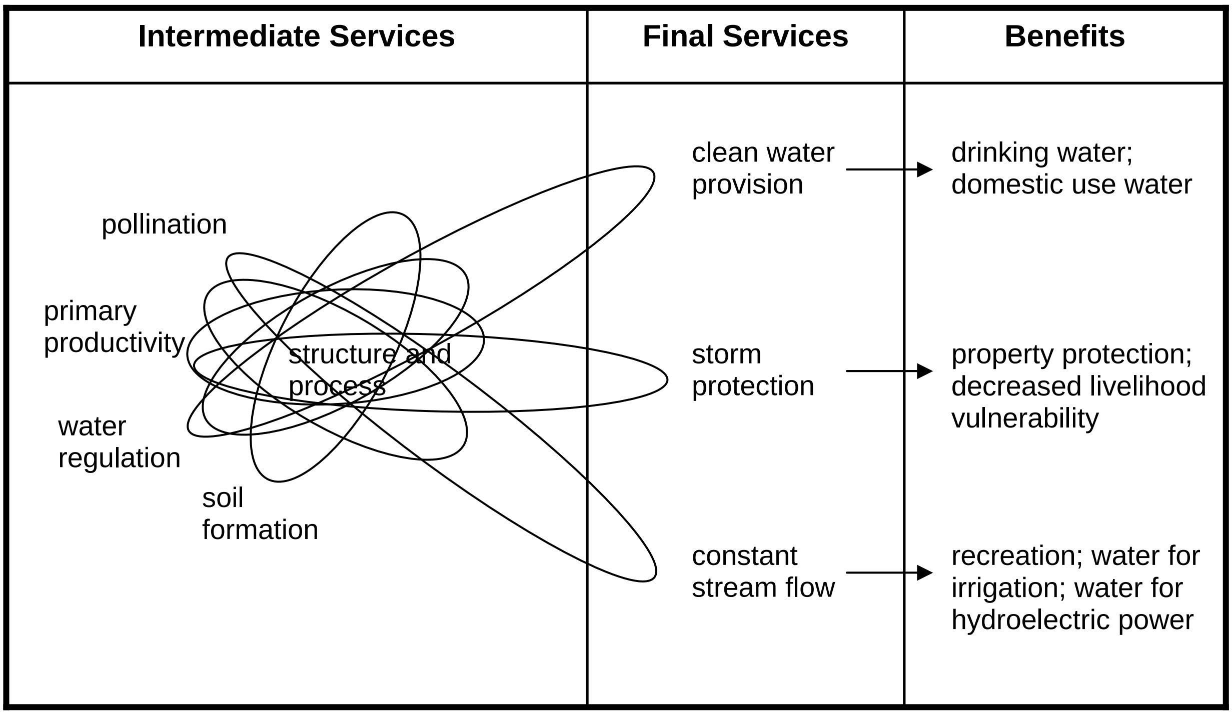
Ecosystem structure (called *component* in Boyd and Banzhaf 2007) is a *service* to the extent that it provides the platform from which ecosystem processes occur. How much structure and process is required to provide a diversity of ecosystem services in a given ecosystem context is still an active research question. Clearly some minimum configuration of structure and process is required for 'healthy' functioning and service provision. This 'infrastructure' has value in the sense that its prior existence and maintenance is necessary for service provision, and is therefore a service in itself (Turner 1999).

This does not mean that structure, function, and services are identical or synonymous. Ecosystem structure and function have been identified and studied for years with no reference to the services to humans, which they also provide. So, while most (if not all) ecosystem structures and processes do provide services they are not the same thing. One can best see this distinction with a simple thought experiment. What if there was an Earth-like planet with no humans? It could have a wide array of ecosystem structures and processes, but no services.

For example, nutrient cycling is a process in which one outcome is clean water. Nutrient cycling is a service that humans utilize, but indirectly. Clean water is also a service that humans utilize, but directly. Clean water, when consumed, is also a benefit of ecosystem services. Here, clean water provision is a service and clean water for consumption is a benefit. Pollination is another ecosystem service that humans utilize, although not directly. Pollination is the service, the benefit may be eating almonds.

Figure 3 is a conceptual model of the connections between ecosystem structure, processes and services. From this figure and our definition, any step in the system can be considered an ecosystem service regardless of where it occurs along the chain of events as long as humans utilize it to produce welfare. Therefore, it can be argued that the seeming lack of consistency in the literature between process, function and service is not inconsistency but rather acknowledgement that there is much overlap between structure, process and service.

Figure 3: *Conceptual relationship between intermediate and final services, also showing how joint products (benefits) can stem from single services*



3. CHARACTERISTICS OF ECOSYSTEMS AND ECOSYSTEM SERVICES

Once we have clearly defined ecosystem services, we can consider their characteristics, and the characteristics of the ecosystems that produce them. By understanding key characteristics we can better manage, maintain, restore or evaluate ecosystem services. For example by knowing that there are seasonal fluctuations in stream flows needed for irrigation we can prepare for this variability though water collection or better irrigation management. Below we discuss a few broad characteristics that can aid in classifying ecosystem services for various decision-making contexts. These are illustrative.

3.1 Public-Private Good Aspect

Two characteristics of goods we traditionally trade in the market are *rivalness* and *excludability*. Rivalness means "my use of the good leaves less for you." Excludability means "I can keep you from using this good." If a good has these two characteristics we typically call it a private good. For example, if I buy a chicken in the market, my use of it precludes your use (rival) and I can keep you from using it by say locking it up (excludability). Ecosystem services provide benefits that are private goods – timber, fish, medicines etc… However they also provide a range of benefits that are neither rival nor excludable. For example, fisheries – a benefit of well-functioning marine ecosystem – are rival, but often not excludable. This type of good is considered an open access. Most ecosystem services provide for benefits that are neither rival nor excludable. Consider the waste assimilation and carbon storage services of wetlands, my use does not preclude your use of these environmental sinks (up to a point) and I cannot keep you from using them. These are public goods. This private-public good dynamic of ecosystem services and the benefits they provide could be a characteristic useful in designing a classification scheme for a particular decision context.

3.2 Spatial and Temporal Dynamics

Ecosystems and the services they provide are not homogenous across the landscape, nor are they static phenomena. They are heterogeneous in space and evolve through time. This spatio-temporal dynamic is a characteristic that can help in understanding and classifying ecosystem services. For example some ecosystems provide services that are utilized *in-situ*. Soil formation is an example of a service that can be used in the same place as it was made - providing a benefit of say an agricultural product. Another example is when a service is provided in one location at one time, but the benefit is realized in another location at another time. For example, water regulation provided by mountain top forest will provide benefits downslope overtime in the form of regulated and extended water provision.

These characteristics are described in more detail below since we can use them to derive a classification scheme.

3.3 Joint Production

Just as discrete ecosystems can deliver several ecosystem services jointly, ecosystem services can provide multiple benefits for human welfare. In both cases, these are considered “joint products”. In Figure 3 we can see that the interactions among several intermediate services produce final services such as clean water provision and storm protection. These final services can provide joint products, or multiple benefits, as in the case that having a regulated stream flow provides humanity with recreation opportunities, water for irrigation and water for hydroelectric power. Joint production is a characteristic of ecosystem services that could be important for deriving accounting and classifications schemes in certain decision-making contexts.

3.4 Complexity

Discerning the complex interactions between structure, process and service is further complicated by the fact that ecosystems are not linear phenomenon, but rather “systems” with feedbacks, time lags, and nested phenomena (Limburg et al 2002). In line with this there are some services we may not be able to measure or monitor directly. For example, it may be possible to measure net primary productivity for an ecosystem from models and remote sensing, but it may be problematic to measure the waste absorption service provided by a landscape with a certain level of productivity. This measurement problem is visible in payments schemes for ecosystem services like the PSA program in Costa Rica. Here landowners are paid for providing services like carbon sequestration, but this service is not measured directly, but rather by proxy - the number of hectares forested. The complexity of the system is a characteristic that can help with classifying ecosystem services. For instance, we might not have knowledge of all the interactions and dependencies between ecosystem components and processes, so delineating between intermediate services, final services and benefits might be enough for a desired outcome, i.e. ecosystem service accounting. This classification may aid in developing financial or market mechanisms for managing ecosystems, i.e. mechanisms with outcomes that can be clearly monitored.

3.5 Benefit dependence

Services are often benefit dependent (Boyd and Banzhaf, 2007), meaning the benefits you are interested in will dictate what you understand as an ecosystem service. For example, water regulation services are an intermediate input to the final service of clean water provision. One benefit is better water quality. But if one was interested in the final service of fish production, then water provision would move from being a final service to an intermediate one, i.e. whether the service is considered final or intermediate will change depending on what is being valued, monitored or measured, as well as who are the beneficiaries. (see Boyd and Banzhaf, 2007 for a full treatment of benefit dependence).

Since different stakeholders perceive different benefits from the same ecosystem processes they can at times be conflicting (Turner, 2003; Hein, 2006). For example, to global stakeholders the carbon sequestration service of tropical rain forests may be valued for climate regulation, but locally the forest may be valued as fuel wood. In economic terms these services are rival. Further complications stem from the fact that many intermediate and final ecosystem services are valuable, providing benefits to humans, even if the stakeholders themselves do not perceive the service. Climate regulation is an example of a vital service for human wellbeing that is probably not perceived by a large portion of the earth's population.

4. CLASSIFICATION AND DECISION CONTEXTS

There have been several efforts to classify ecosystem services (e.g. de Groot et al. 2002, MA 2005, Wallace 2007) however any attempt to come up with a single or fundamental classification system should be approached with caution. The dynamic complexity of ecosystem processes and the innate characteristics of ecosystem services (some noted above) should have us thinking about several different types of classification schemes. The decision context for utilizing ecosystem services research is also crucial for mobilizing the ecosystem services concept. Taken together, the characteristics and the decision context, will then help to decide which classification scheme is most appropriate for use (Figure 2). We provide several examples below.

4.1 Understanding and Education

One decision context for utilizing the concept of ecosystem services might be to promote understanding and to educate a larger public about the services and benefits that well functioning ecosystems provide to humans. This was a major focus of the MA and its classification scheme was fit for purpose. The MA divided ecosystem services into a few very understandable categories – supporting services, regulating services, provisioning services and cultural services. This classification utilized the complexity characteristic of ecosystems and the public-private good dynamic to draw distinct boundaries of different ecosystem services. For example, by acknowledging the many interconnections among ecosystem components and processes the MA classification placed supporting service as an underpinning to the other service categories. This in turn makes their classification readily accessible as a heuristic – one of the key goals of the MA.

4.2 Valuation

If the goal or decision context is to value ecosystem services then the MA classification is not appropriate and some other scheme should be utilized. This is due to the fact that the MA classification could lead to double counting the value of some ecosystem services. For example, in the MA, nutrient cycling is a supporting service, water flow regulation is a regulating service, and recreation is a cultural service. However, if you were a decision maker contemplating the conversion of a wetland and utilized a cost-benefit analysis including these three services, you would commit the error of double counting. This is because nutrient cycling and water regulation (both means) help to provide the same service, providing usable water, and the MA’s recreation service is actually a human benefit of that water provision.

For valuation purposes a classification scheme that divides ecosystem services into intermediate services, final services, and benefits would be more appropriate. With the definition above all ecosystem processes and structure are ecosystem services, but they can be considered as *intermediate* or as *final* services, depending on their degree of connection to human welfare. The same service can also be both intermediate and final depending on the benefit of interest. This classification scheme recognizes that ecosystems are complex, and rather than understanding all of the complexity we just have to be clear about some final services and benefits which we are concerned. In doing so it also appreciates the benefit dependence characteristic. This classification avoids a double counting problem because you would only value the final benefits, and hence is fit for purpose in a valuation context.

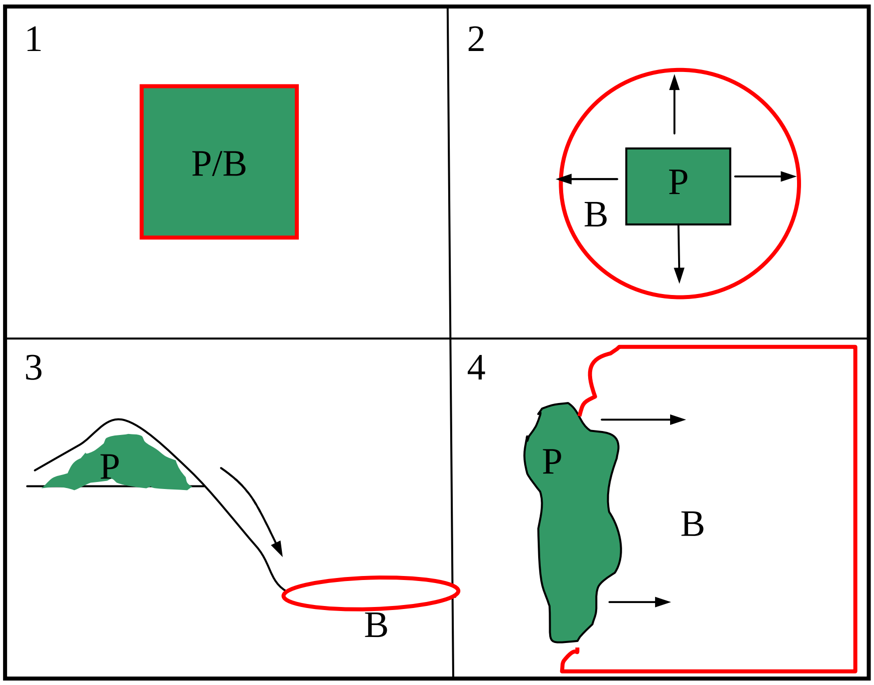
4.3 Landscape Management

Another way to classify ecosystem services would be to use their spatial characteristics. This might be appropriate if the decision context was how to manage a given landscape for the provision of ecosystem services. In this case, it is important for the manager to know what services are provided on the landscape and how these services flow across that landscape. The European Union's Habitats and Water Framework Directives is taking such a tack by incorporating spatio-temporal characteristics of natural systems into policy solutions. Utilizing the spatial characteristics a classification scheme might involve categories that describe relationships between service production and where the benefits are realized (Figure 4). Such a classification might include categories such as:

- *in situ* - where the services are provided and the benefits are realized in the same location
- *omni-directional* – where the services are provided in one location, but benefit the surrounding landscape without directional bias
- *directional* – where the service provision benefits a specific location due to the flow direction

A classification scheme as such could also use scale qualifiers, such as local omni-directional (e.g. pollination), and regional directional (flood protection). Understanding the distribution of services and benefits as well as the landscape (or seascape) where the services are provided informs where management interventions should be concentrated. Classifying ecosystem services in this way recognizes such characteristics as the spatio-temporal dynamics of ecosystems and benefit dependence of services. This distributional classification can also highlight the possibility of cases where beneficiaries might have to compensate providers such as in *payments for environmental services* schemes.

Figure 4: *Possible spatial relationships between service production units (P) and service benefit units (B). In panel 1, both the service provision and benefit occur at the same location (e.g. soil formation, provision of raw materials). In panel 2 the service is provided omni-directionally and benefits the surrounding landscape (e.g. pollination, carbon sequestration). Panels 3 and 4 demonstrate services that have specific directional benefits. In panel 3, down slope units benefit from services provided in uphill areas, for example water regulation services provided by forested slopes. In panel 4, the service provision unit could be coastal wetlands providing storm and flood protection to a coastline*



4.4 Distribution and Equity in Human Welfare

Through the economic concept of an externality – where the action of one agent brings about an inadvertent gain or loss to another without payment or compensation – economists have been long interested in the effects that changes in environmental quality can have on welfare. The work of Alfred Marshall and A.C. Pigou in the late 19th and early 20th centuries on externalities and common property problems, laid early foundations for the future of environmental economics (Laffont 1987). With regards to ecosystem services, one person's harvesting of timber may preclude another person's benefit of bush meat due to declining habitat. The linked effect that the human economy has on the environment and that the environment has on the human economy is difficult to assess since the externalities reverberate throughout complex social and ecological systems (Crocker and Tschirhart 1992). Dynamic modeling of complex systems can help to identify unintended consequences of these linked systems (Boumans et al 2002; Finnoff and Tschirhart 2003).

In light of externalities and distribution issues, one possibly important classification scheme considers the decision context of how ecosystem services relate to equity in the provision of human welfare. This is important as it is now well accepted that failing environmental quality disproportionately affects people more marginalized by the market economy (Dasgupta 2002). The decision context might be a government interested in measuring how the natural environment distributes and provides services and consequent benefits across their constituents. This is made complex by the fact that stakeholders at different spatial scales have different interests in ecosystem services (Hein et al. 2006). For example, the benefits people receive from existence values of biodiversity might conflict with benefits impoverished people receive from converting biologically diverse habitats, where poverty and species diversity have been shown to be highly correlated (Fisher and Christopher 2007). In this decision context several characteristics are important for consideration including – public-private goods aspect, spatio-temporal dynamic and how services are benefit specific. Linking these characteristic to the decision context i.e. fulfilling human needs and wants to a somewhat hierarchical classification as found in Wallace (2007). Here an ecosystem service classification start with basic needs – which Wallace labels *adequate resources.* Other categories include *protection from predators, disease, parasites*; *benign physical and chemical environment*; and *socio-cultural fulfillment*. Dividing services in this way across a landscape can provide decision-makers with information about what level people's needs are being met by ecosystems and their services.

5. CONCLUSIONS

In two fields that are often seen to have conflicting goals, economics and ecology, ecosystem services is an extension of both economic externalities and ecological functioning and provides a nexus between the two fields. The term, ecosystem services, is relatively new, but understanding that nature provides services for human welfare goes back to the myth of Eden. However, it is still early days for concerted scientific research in ecosystem services, and consistent, robust means of measuring, mapping, modelling and valuing ecosystem services have not emerged. In this paper we argue that, as a first step, having a consistent, and ecologically based definition of ecosystem services in important. Since the concept of ecosystem services has become a major topic of study and a critical criterion for conservation assessments (Egoh et al. 2007) it is important that it is clearly defined allowing meaningful comparisons across time and space (Wallace 2007). While a single definition is important, attempts to create a single classification scheme for ecosystem services is unlikely to be helpful. Ecosystem services are a function of complex interactions among species and their abiotic environment; complex use and utilization patterns; and various perceptions by beneficiaries. Since linked ecological-economic systems are complex and evolving, a 'fit-for-purpose' approach should be considered in creating clear classifications. Considering all the parts to ecological system of interest is crucial, but so to is considering the social and political contexts within which ecosystem services are being investigated or utilized. In doing this, researchers can be sure that a classification is based on the diverse characteristics of ecological and social systems and also based in a specific decision context.

References

Barbier, E.B. (2007). “Valuing ecosystem services as productive inputs.” Economic Policy 22 (49): 177–229.

Boumans, R., R. Costanza, J. Farley, M. A. Wilson, R. Portela, J. Rotmans, F. Villa, and M. Grasso. 2002. Modeling the dynamics of the integrated earth system and the value of global ecosystem services using the GUMBO model. Ecological Economics **41**:529-560.

Boyd, J. 2007. Nonmarket benefits of nature: What should be counted in green GDP? Ecological Economics **61**:716-723.

Boyd, J., and S. Banzhaf. 2007. What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics **63**:616-626.

Costanza, R., R. dArge, et al. (1997). "The value of the world's ecosystem services and natural capital." Nature 387(6630): 253-260.

Crocker, T. D., and J. Tschirhart. 1992. Ecosystems, externalities and economics. Environment and Resource Economics **2**:551-567.

Daily, G. C. (1997). Nature's services: societal dependence on natural ecosystems. Washington, DC, Island Press.

Dasgupta, P. 2002. Economic development, environmental degradation, and the persistence of deprivation in poor countries. World Summit on Sustainable Development, Johannesburg.

de Groot, R. S., M. A. Wilson, et al. (2002). "A typology for the classification, description and valuation of ecosystem functions, goods and services." Ecological Economics **41**(3): 393-408.

Ehrlich, P. R. and A. H. Ehrlich (1981). Extinction: the causes and consequences of the disappearance of species. New York, Random House.

Egoh, B., M. Rouget, B. Reyers, A. T. Knight, R. M. Cowling, A. S. vanJaarsveld, and A. Welz. 2007. Integrating ecosystem services into conservation assessments: A review. Ecological Economics **63**:714-721.

Finnoff, D., and J. Tschirhart. 2003. Harvesting in an eight-species ecosystem. Journal of Environmental Economics and Management **45**:589-611.

Fisher, B., and T. Christopher. 2007. Poverty cand biodiversity: Measuring the overlap of human poverty and the biodiversity hotspots. Ecological Economics **62**:93-101.

Hein, L., K. van Koppen, et al. (2006). "Spatial scales, stakeholders and the valuation of ecosystem services." Ecological Economics **57**(2): 209-228.

Jax, K. (2005). "Function and "functioning" in ecology: what does it mean?" OIKOS **111** (3).

Laffont, J. J. 1987. Externalities. *in* J. Eatwell, M. Milgate, and P. Newman, editors. The New Palgrave Dictionary of Economics. The MacMillan Press Limited, London.

Limburg, K. E., R. V. O'Neill, et al. (2002). "Complex systems and valuation." Ecological Economics **41**(3): 409-420.

Millennium Ecosystem Assessment. 2005. Washington, DC, Island Press.

Turner, R.K. (1999). “The Place of Economic values in Environmental Valuation.” In Bateman, I. and K. Willis (eds.), Valuing Environmental Preferences, Oxford University Press, Oxford.

Turner, R. K., J. Paavola, et al. (2003). "Valuing nature: lessons learned and future research directions." Ecological Economics **46**(3): 493-510.

Wallace, K. J. 2007. Classification of ecosystem services: Problems and solutions. Biological Conservation **139**:235-246.

Westman, W. (1977). "How much are nature's services worth." Science 197: 960-964.