Ecosystem Services and Ecosystem Services Tools

Literature Review

The Ecosystem Services tools label is used here to identify tools that have been purposefully designed to incorporate ecosystem services. The use of ‘ecosystem services’ has dominated the development of ecosystem tools in science, policy and environmental activism. However, as already indicated it is prone to different understandings and applications (Dempsey and Robertson, 2012). Indeed, the focus on ecosystem services is a simplification from its more complex, original conceptualisation that included ecosystem goods and functions (e.g. de Groot *et al.*, 2002).

The MEA (2005) defines ecosystem services as encompassing the multiple values that ecosystems provide to all sectors of society and, by implication, their equally diverse value systems. Thus, systemic analysis of policy or decision-making processes using the framework of ecosystem services can reveal the range of consequent benefits and dis-benefits, and the distribution of the benefits and costs across societal sectors. Consequently, ecosystem services are being increasingly used to appraise options or innovate new solutions proactively that optimise the cumulative benefit to society, set within longer-term effects and intergenerational equity. However, the inherent complexity of ecosystem services and their interdependencies, with abiotic and biotic factors, means that often highly simplified approaches to ecosystem services assessments are employed. The requirement for more complex systems-based and interdisciplinary understandings and applications of ecosystem services, ecosystem benefits and natural capital, is often overlooked for reasons such as:

- only specific services are considered in isolation from the wider context and potentially complex interactions between different services and between services and their context (Bennett *et al.*, 2009);
- ecosystem services are considered as linear functions, ignoring thresholds and complex non-linear realities where a relatively small additional change may signify dramatic change of a system (Haines-Young and Potschin, 2010);
- data used are often averages (sometimes not even derived from the area but ‘transferred’ from elsewhere) rather than showing the range of actual data and considering associated implications (MEA, 2003);
- nature is commodified where its elements are subjected to a simple exchange value (O’Neill, 2011).

Depending on the disciplinary or policy lens being used, definitions of ecosystem services vary considerably. For example, Boyd and Banzhaf (2006: 8) provide a narrow definition of ecosystem services as “components of nature, directly enjoyed, consumed, or used to yield human well-being”, which accords with neoclassical economic approaches, including cost-benefit analysis (CBA). The Economics of Ecosystems and Biodiversity (TEEB) (2010) presents a wider interpretation, recognising and accounting for externalities, value plurality and governance considerations, showing how economic concepts and tools can help embed the values of nature into decision making at all levels through:

- exploring the relationship between biodiversity and ecosystem services;
- testing applications across important environmental, social and economic domains;
- highlighting the significance of indirect use values of ecosystems that are largely invisible in assessment and accounting endeavours;
- advocating the embedding of value diversity and consideration of trade-offs in policy and decision-making; and
- explicitly acknowledging uncertainty and tipping points/thresholds through advocating precautionary approaches or safe minimum standards.

Ecosystem Services Tools

The Millennium Ecosystem Assessment’s (2005) conceptual framework distinguished between four categories of services – provisioning, regulating, cultural and supporting and still remains the most widely recognised and applied framework (e.g. Defra 2007a; Haines-Young and Potschin 2009; Welsh Assembly Government 2012). Using the same framework enables cross-comparison between different assessments and areas. In practice, however, the actual definition and measurement of specific services have tended to differ substantially between applications (Haines-Young and Potschin 2011). Inconsistencies can also arise from difficulties in distinguishing between different categories of services and delineating between specific 'functions' and 'services' because of the manifold interrelations and interdependencies, in addition to variations in context, including geographical and temporal scales (MEA, 2003; Haines-Young and Potschin, 2011).

Three complementary, yet distinctive, perspectives have been identified for assessing ecosystem services:

- the habitats perspective (identifies the distinct role of habitats to ecosystem services provision and their multifunctional characteristics);
- the services perspective (linking ecosystem services directly to societal benefits/opportunities and problems), and;
- place-based perspective (considering the health and future development of specific geographical areas and how this affects human wellbeing and place-making) (*cf.* Haines-Young and Potschin 2008).

These perspectives are directly relevant to emerging policy instruments associated with the National Policy Planning Framework (e.g. Neighbourhood Plans and Local Enterprise Partnerships) and the Natural Environment White Paper (which created Nature Improvement Areas and Local Nature Partnerships in England and Wales). Smart *et al.* (2012: 4) highlight the potential user needs associated with these new policy instruments, as well as more generally, as providing:

- data about conservation designation, species and habitats at a range of spatial scales;
- information about different drivers of change and their possible future impacts; and
- land-use planning decision-support tools to assist in identifying and balancing competing demands.

The UK NEA (2011a, b) assessed the status and trends of the UK's ecosystems and the services provided at multiple spatial scales, identifying key drivers of change and testing their impacts using plausible future scenarios, enabling the consideration of policy and/or societal response options to secure (maintain or improve) the delivery of ecosystem services into the future. A large part of the assessment focused on identifying and quantifying the value of ecosystem services' contribution to human well-being through both economic and non-economic analyses. The economic analyses for ecosystem services assessment involved two types: (i) sustainability analyses; assessing stocks of natural assets; and (ii) programme evaluation analyses, seeking to determine the value of the flow of services provided by these natural assets. Both types of analyses were found useful, the former to inform macro-level policy, and the latter to support economic calculations for payment for ecosystem services (UK NEA 2011b: 1071).

Ecosystem Services Tools that influence People's Behaviour

Payment for ecosystem services (PES) comprise a suite of market-based tools that together can be used to influence behaviours. They link the 'suppliers' of ecosystem services with their 'users' and beneficiaries. Some services (mainly provisioning services) are already traded, however, most are external to today's market, yet are crucial to society (e.g. pollination and nutrient cycling). Therefore, considerable potential exists for the creation of markets for more effective incorporation into decision-making and protection. For example, the Organisation for Economic Co-operation and Development estimated the existence of over 300 PES initiatives worldwide in 2010 (Defra 2010c). A PES scheme is a *voluntary* contract with payments *conditional* on achieving service enhancement of protection (i.e. agreed action/outcome); be *additional* to basic regulatory requirements and not displace detrimental activities elsewhere. The tool has also attracted significant criticism: its focus on a single ecosystem service; the loss of consideration of multiple values by adopting a single exchange value; and creation of power imbalances that prolong inequalities (Spash, 2008; Kosoy and Corbera, 2010).

Ecosystem Services Tools for Decision-Support

Ecosystem service mapping forms a core focus of many current attempts to identify particular ecosystem services within an area (Lovell, 2010; Medcalf *et al.*, 2012). Such visual support tools, through GIS applications, have proved relatively successful in breaking down barriers between experts and the public, creating relatively easy to use and understood interfaces for assessing (and sometimes also valuing) ecosystem services and benefits. For instance, Maes *et al.* (2011a) promote the mapping of the services and consequent quantification and valuation, with the aim to forming "an economic argument to protect biodiversity" (p. 11). This approach has been implemented by a variety of organisations and authorities throughout the UK (e.g. Countryside Council for Wales (Bridgend County Council[1]); Hölzinger, 2011; Pape and Johnston, 2011).

Ecosystem services assessments at the local or landscape scales are being increasingly adopted by local councils in relation to green infrastructure planning, either in totality or as part of geographical units such as a valley or an Area of Outstanding Natural Beauty or a National Park. The Gaywood Valley project, as part of an EU INTERREG Project, used an ecosystems services assessment to inform their vision for a multiple use green space management plan on King's Lynn urban fringe to create environmental, social and economic benefits (Carroll, 2012). Similarly, Birmingham City Council undertook an ecosystem services assessment of its Green Infrastructure to inform its future development strategy (Hölzinger, 2011).

Modelling tools for decision-support can be split into two broad types: **semi-empirical approaches** which aim to represent the underlying processes to some degree and **expert knowledge-based approaches**. Modelling individual ecosystem functions is not novel and there are countless models of functions in the scientific literature. For example, water regulation and water movement can be described by a myriad of hydrological models such as SWAT, INCA, TOPmodel, SHE (Vigerstol and Aukema, 2011; Corstanje, 2012). There are also a significant number of soil process models that describe nutrients, soil formation and indirectly climate regulation through carbon sequestration, such as CENTURY and ROTHC (Corstanje, 2012). These models can be captured in a Geographic Information System (GIS) environment and their outputs aggregated (i.e. some weighted averaging or addition of the different services for a given area; e.g. carbon sequestration + water storage + biodiversity) to generate an assessment of the current state of ecosystem services delivery. In this same environment, different scenarios can then be introduced to assess the impact of decision-making or climate change. For example InVEST is a GIS-based project that uses land use/cover patterns to estimate levels and economic values of multiple ecosystem services, biodiversity conservation, and the market value of the commodities provided by the landscape (Nelson *et al.*, 2009).

In many cases, collecting, collating and combining data and processes over diverse ecosystems is not cost-effective or practical. The alternative is to survey experts across particular ecosystems and collate their knowledge which can then be represented within a GIS cause-effect modelling framework. A statistical modelling environment is arguably the most effective way to represent 'expert opinion' regarding the controls which determine the supply of ecosystem goods and services (Corstanje, 2012). Such expert knowledge-based modelling approaches include ARIES and MIMES. The advantage of such an approach is that it can be based on sparse data and relatively simple models, and therefore can readily give estimates of ecosystem goods and services delivery in most situations. The disadvantage is that it is ultimately based on opinion, and is therefore less scientifically robust. A second limitation to this method is that every time a new factor needs to be considered, which was not considered in the original expert knowledge elucidation, a follow-up has to be executed. Current, state-of-the-art approaches aim to capture the expert opinion in a 'belief network', which graphically represents the relationships between the drivers and supply of ecosystem goods and services and underlying this is a probabilistic environment which can supply some of the computational and numerical rigor which is usually associated with empirical models.

Expert-based mapping and modelling approaches (such as ARIES and MIMES) have been criticised for restricting accessibility and use (Vigerstol and Aukema, 2011) because specialised software is required and support information is not readily available (Natural England, 2013). In response, some attempts are underway to represent data so that it is more accessible to the public and those without such software, configuring not only the data, but the interface in which it is created (*cf.* CCW, *circa* 2010; Raudsepp-Hearne *et al.*, 2010). Maes *et al.* (2011b) identify a further shortfall, arguing that when mapping is completed and converted into an approachable

[1] See e.g. http://www.youtube.com/watch?v=YpMuLTuo2kg

format, the end result tends to focus on provisioning services and that data on other services, goods or functions (cultural and supporting services) are lacking.

Summary

Tools relating to implementing the ecosystem approach in the form of assessing and valuing ecosystems services have been heavily influenced by ecological economics and environmental accounting and resource mapping as well as models of land use change and impacts. There is a danger of oversimplifying and regarding ecosystem services merely as new goods to trade, or as isolated features or commodities to map. Responses are needed within ecosystem services tools that systematically attempt to assess ecosystem functions, benefits and trade-offs across the full spectrum of services rather than doing so on a fragmented service-by-service basis.