Forest Research

Spatial Analysis and Prioritisation of Cultural Ecosystem Services: A Review of Methods

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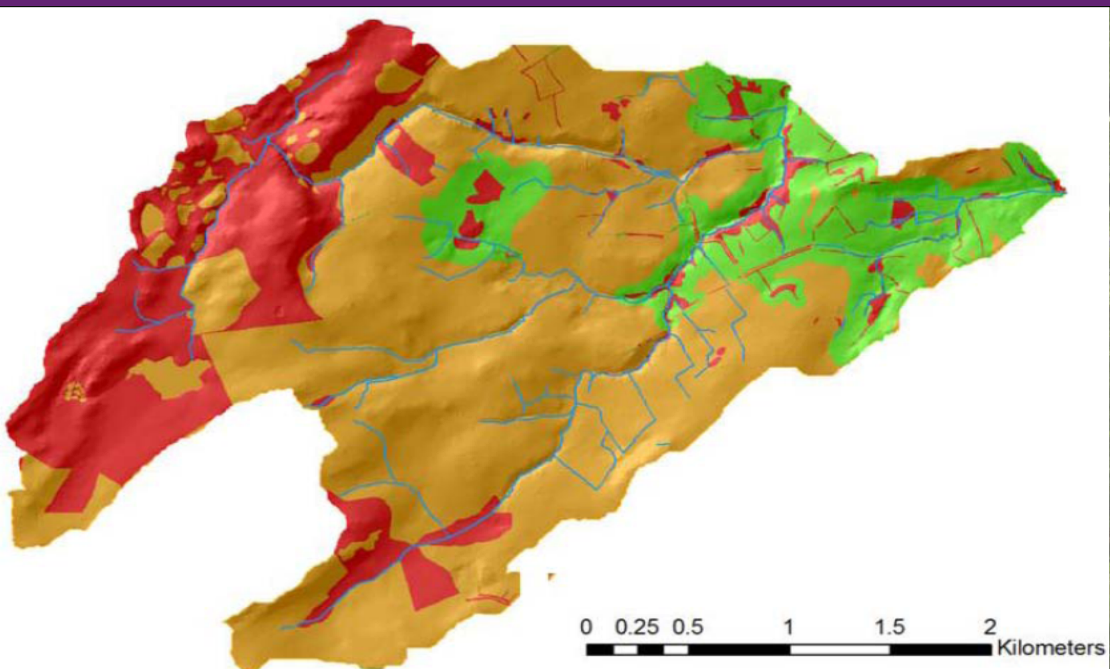

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Contents

Executive Summary

1. The emerging ecosystem services framework aims to provide a system for better assessing the link between ecosystems and human well being. The approach offers improved methods of taking into account the full range of goods and services provided by ecosystems such as woodlands, and thereby contribute to better decision making in natural resource management and policy development.

2. In Wales the ecosystem services approach is being taken forward through the “Living Wales” programme. This is a developing governance process which aims to place the ecosystem approach at the heart of environmental policy, land and resource management.

3. Delivering the ecosystems approach practically, on the ground, requires an understanding of the extent to which ecosystems generate the goods and services demanded by society. It is also important to assess how changes to ecosystem management might alter the flow of those benefits either positively or negatively, and who this will affect.

4. Cultural ecosystem services refer to the aesthetic, spiritual, psychological, and other non-material benefits that humans obtain from contact with ecosystems. These benefits continue to be overlooked in many assessments because of the many difficulties associated with measuring and mapping them. In addition to this the degree of importance they are afforded by different stakeholders in the decision making process varies dramatically. However, cultural services and other types of social value are often fundamentally important to understanding how people use and value nature, and how they accrue other material and non-material benefits from the environment.

5. In the UK, forests and woodlands play an important cultural role, and a number of spatially explicit methodologies have been developed which attempt to explore the value of cultural ecosystem services provided by them. However, the current indicators of wellbeing linked to cultural and social values that are used in mapping approaches, if present at all, tend to be the more generic and easily quantifiable values. These are ecosystem goods such as recreation, tourism and some aesthetic values. There is very limited representation of non-market goods such as spiritual connections with woodlands, or emotional attachment to local places. This presents a significant barrier to understanding the wider societal benefits associated with woodlands and similar greenspaces. The result is that woodlands cultural and social values are underestimated.

6. Because the mapping of ecosystem services is a relatively new area, problems associated with the spatial analysis of cultural values stems from unresolved issues, the most important of which are:
   - the continuing and critical lack of appropriate data for mapping cultural ecosystem services
   - lack of data at a level of detail which recognises who within society is benefitting from the flow of cultural services, and where these people are located
   - the use of valuation methods which aggregate societal values in economic terms rather than other forms of valuation acceptable to stakeholders
   - the application of valuation methods which are unable to explicitly link changes to ecosystems with changes to the positive or negative flow of benefits.
7. Developing existing methodologies to meet these needs requires a broader approach incorporating:
   - acceptable valuation methods (including non-economic metrics)
   - recognition of the wider 'catchment area' over which woodlands and similar green spaces provide their benefits, rather than continuing with the current methodological focus that concentrates on goods and services being provided solely within woodland.
8. This study found that current spatial analysis and mapping approaches dealing with cultural ecosystem services tend to operate at large scales, e.g. regions, national parks. There are very few examples looking at values accrued at the local level. However, cultural values and cultural ecosystem goods and services flow at two different scale levels: The local level within close proximity to ecosystems, as well as a regional level in cases where a woodland attracts visitors from further afield. The problem is finding methods which can incorporate the way in which different local stakeholders benefit (or not) from their local woodlands, as well as accounting for the values attached to iconic and well visited sites with a large social catchment of influence and impact not necessarily connected with the local population.
9. Both scales of analysis are important. Strategic decision making which takes into account management of numerous woodland and forest sites across a region or country can usefully employ more generic spatial analysis approaches, but there will be limits to how far these analyses can provide comparative value assessments. Management of sites at an operational level will continue to demand methods which provide a far more detailed analysis of local and broader

social and cultural benefits. The problem with spatial analysis is that we have still not worked out how best to mesh or scale-up local detail into strategic assessments of cultural value.

10. The review has shown that finding the most appropriate approach relies on very careful identification of **the purpose** of mapping and spatial analysis, and the question or problem that is to be answered. This involves agreement around how far the analysis:

- **plots and describes** goods and services (i.e. indicates spatially what exists where and within which boundaries),
- **measures** goods and services (i.e. plot how much of something is there),
- **values** ecosystem goods and services (i.e. indicates what that something is worth in quantitative terms)
- is applied to **actual or potential** ecosystem services.

11. The review has provided examples of the different valuation techniques employed, as well as the variety of scoring and weighting approaches tried in different contexts. The scoring and weighting techniques used were:

- **Counts**

  i.e. records of the presence or absence of cultural goods and services, or the numbers of different goods and services or ecosystem functions mentioned by respondents, this could include negative as well as positive values.

- **Measures of magnitude from scores**

  Applying scores rather than counts to generate values proportionate to the degree of importance or the level of benefit experienced by respondents for each cultural ecosystem good or service mentioned

- **Integrated or 'stacked' measures of aggregate value**

  Using comparative quantitative values which are aggregated and combined to give "heat indices" or combined total values for a range of different ecosystem goods and services.

All of these were applied either to clearly defined spatial units (e.g. areas defined by woodland boundaries, park boundaries or demographic boundaries such as wards), or left a little more fuzzy and applied to general areas of the landscape/woodland where physical qualities were assumed to generate the values of interest.

12. Many of the current spatial analysis approaches link the "total value", or weighted value of ecosystem benefits, to population size. Weightings are applied using a crude methodology multiplying the scale of cultural and social ecosystem service provision, by the total numbers of people in the local area. Not only does this miss the benefits accrued by populations who live some distance from the woodland resource, it also assumes that all people in a local area benefit to the same degree as each other. This approach also disadvantages smaller communities will may draw just as significant cultural value from their woodland environment.

13. The review has revealed significant potential for the greater use of participatory tools to support the mapping and spatial analysis of cultural and social goods and services from woodlands. This can be achieved at large scale levels as well as site focused local levels. The benefits of participatory approaches include:

    - more accurate valuation techniques
    - clear attribution of benefits to different sections of local communities or stakeholders
    - greater understanding of the wider social catchments woodlands influence, and
    - deliberative processes which enable stakeholders to agree the importance and legitimacy of the valuation techniques and spatial analysis methods employed.

14. Stakeholders will, however, continue to find it difficult to agree on the valuation criteria and weighting systems applied, since very significant gaps remain in methods for integrating systems of description, measurement and valuation of cultural ecosystem services not only in the mapping and analysis of the cultural ecosystem services themselves, but also in their weighting and integration with other kinds of ecosystem services to provide a clear and comprehensive picture of the value of woodlands using ecosystem service approaches. The biggest problems exist around properly weighting existing ecosystem service provision, and in the indicators chosen to express value at local scales.

15. There is no clear prescription regarding the most appropriate spatial analysis methodology to apply when considering cultural and social ecosystem services. Universally accepted tools or methods are unlikely. It is important to find a method of plotting, describing, valuing, and weighting criteria and indicators which not only address specific management problems and questions, but are also accepted and legitimised by all the stakeholders involved.

1. Introduction

1.1. Ecosystem services

> "*Ecosystem services are the aspects of ecosystems utilized (actively or passively) to produce human well-being*"
>
> (Fisher and Turner, 2008).

Healthy ecosystems provide a broad range of benefits to human populations. Increasingly it is the ecosystem service framework that is used to broaden our understanding of how the supply of goods and services associated with these systems is related to resource management and the other human actions which modify landscapes and ecosystems. Since its genesis in the 1970s the concept of ecosystem services has evolved rapidly both as a scientific discipline and as a framework influencing environmental policy (Fisher et al., 2008; Norgaard, 2010).

A major milestone for the wider adoption of the approach was the publication of the Millennium Ecosystem Assessment (MA, 2005) which built on a number of influential studies at the end of the 1990s (Daily et al., 2009; Daily, 1997; Costanza et al., 1997). The MA provided the first comprehensive summary of the state of ecosystem health for the 14 major terrestrial biomes across the globe. It also made explicit the linkages between the health of these systems and human welfare. The MA concluded that whilst modifications to many ecosystems had contributed to net gains in human wellbeing and economic development, this had come at considerable cost. There had been substantial degradation of 15 of the 24 ecosystem services assessed. Arguably the MA's most significant impact was presenting the framework in a format that easily understood and used by policy makers and has since become widely adopted.

Whilst the ecosystems approach has not been without controversy, particularly in relation to the role of economic valuation (for example, Norgaard et al., 2009 which suggested an over reliance on an economic stock-flow framework (used in many ecosystem service valuations) was far too simplistic;(Spangenberg and Settele, 2010) its underlying utility has been widely recognised in relation to developing more holistic approaches to land management. In the UK Defra produced an action plan for adoption of an ecosystem approach (Defra, 2007), and the first National Ecosystem Assessment (NEA) was published in (2011). This assessment covered all of the UK and included specific chapters on Wales, Scotland, England and Northern Ireland. It is important to note the NEA has had a significant impact on policy including in Wales the development of "Living Wales" the emerging environment strategy which is based on ecosystem services approach to governance.

1.2. Defining the Ecosystems Approach

The ecosystems approach is a term which is used when describing the application of ecosystem service framework. The **ecosystems approach** came to prominence through the Convention on Biological Diversity (CBD) where it has a specific definition in relation to sustainable development[1]. The term is used here as a generic description for applying the underlying and evolving principles associated with the ecosystem service paradigm. The major components of the ecosystem approach are:

a) that the nature of the interactions between natural systems and human well being are explicitly understood and

b) that consequences of ecosystem change are considered holistically and explicitly and incorporated in decision making across sectors.

1.3. Mapping Ecosystem services

Ecosystem services are the mechanisms through which the lives of people are enhanced or maintained. It is both the ***location* and *extent*** of natural features (such as woodlands) within a ***defined system area*** that has a significant influence on the ***type* and *degree*** of the services supplied (Morse-Jones et al., 2011). Consequently, developing understanding ecosystem service delivery relies on spatial analysis and the mapping of ecosystem services and system boundaries. This is particularly important moving from theoretical discussion of the conceptual framework to operational planning and real-world implementation of an ecosystem approach (see Boumans and Costanza, 2007; Fisher et al., 2009), such as that being planned for the environment in Wales[2]. Mapping and spatial analysis could support environmental decision making by providing tools which:

- improve inter-institutional understanding and informing both strategic and operational decision making (de Groot et al., 2010);Pettit et al., 2011).
- intuitively and simply communicate information amongst resource managers and members of the public, about complex interactions between ecosystem services across spatial and temporal scales (Cowling et al., 2008).

Although intuitively simple, in practice mapping ecosystem services is a complicated task. There are a number of methodological and conceptual issues that require particular attention. These include:

Explicit considerations of the **scales** at which various services manifest are required for valuation (Hein et al., 2006; Kozak et al., 2011).

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[1] http://www.cbd.int/ecosystem/default.shtml
[2] http://wales.gov.uk/topics/environmentcountryside/consmanagement/nef/?lang=en

Whether the purpose of mapping and spatial analysis is to

- **plot and describe** (i.e. indicate what exists where),
- **measure** (i.e. plot how much of something is there) or
- **value** ecosystem services (i.e. indicate what that something is worth in quantitative terms)
- decide whether this is applied to **actual or potential** ecosystem services.

Each of these objectives is quite distinct and has different methodological challenges, significant amongst these are:

1. How to define the **time** period the mapping reflects and how far spatial analysis needs to tracking change through time whether through modelling or monitoring
2. Linking **social distribution** of wellbeing impacts from ecosystem services to diverse communities and populations, and how far this distribution is likely to be impacted by climate change e.g. increased storms, droughts, flooding and predicted sea level rise

It may be these challenges which have seen the fairly slow emergence of spatially explicit approaches and methodologies to map ecosystem services (Morse-Jones et al., 2011). In particular there is a significant disconnect between the state of knowledge about the management of ecosystem services, and knowledge about the societal wellbeing affects of these services.

The role of woodlands in providing a potentially very broad range of ecosystem services is well recognised. Woodlands not only provide timber and other important economic goods, they also play an important role in sequestering carbon, regulating hydrological systems and "slowing the flow" in flood prone areas, as well as providing a for cultural and recreational activities. Much work has been undertaken calculating the economic values of these services, under the umbrella of the United Nations Environmental Programme and its initiative on The Economics of Ecosystems and Biodiversity. One valuation put the value of the UK's woodland for recreation purposes alone at nearly £450m a year. There is further value, which cannot easily be captured in economic terms, arising from woodland's ability to inspire volunteering and to create social capital."[3] Additional work has been done assessing the importance of woodlands to society. For example, three quarters of the population in England consider local green space to be a very important part of the local environment, and 50% visit it at least once a week (UKNEA, 2011), up to 13% of all visits to English greenspace during 2011-12

[3]http://www.woodlandtrust.org.uk/en/campaigning/our-views-and-policy/woods-for people/Documents/respublica-report.pdf

were to woodlands (Natural England, 2012), with 18% of all outdoor visits in Wales being to woodlands (CCW, 2012). There still remains a gap in the studies and tools available for mapping or spatially analysing these values in a way that is meaningful to the full range of stakeholders.

1.4. Cultural ecosystem services links to wellbeing

The MA divided ecosystem services into four main categories summarised briefly below:

- **Supporting services** represent long term ecosystem functions that support the delivery of other services (including primary production and long term nutrient cycling),
- **Provisioning services** represent the goods derived from ecosystems and include food, water, fibre and fuel,
- **Regulating services** represent the benefits derived from ecosystem functions such as the regulation of flows of water, soil, climate and organisms.
- **Cultural services** which are the social benefits derived from natural systems, including recreation and enjoyment of aesthetically pleasing features.

In this formulation cultural ecosystem services refer then to the aesthetic, spiritual, psychological, and other non-material benefits that humans obtain from contact with ecosystems (Butler and Oluoch-Kosura, 2006). The MA identified nine sub-categories of cultural service (i. Aesthetic values, ii. Recreation and ecotourism, iii. Cultural diversity, iv. Cultural heritage values, v. Spiritual and religious values, vi. Knowledge systems, vii. Educational values, viii. social relations and ix. Inspiration/sense of place). The MA also explored the consequences of ecosystem change over recent decades for human wellbeing through the work of over 1,300 experts in 95 countries from 2001 to 2005 (MA, 2005). The MA talks about the constituents of human wellbeing in terms of security, basic materials, health, good social relations and freedom and choice. The links between cultural services and other provisioning and supporting services that are important to human wellbeing are complex and do not map neatly onto each other. But thinking about these links is beneficial because it exposes how there may be both **tangible** and **intangible** aspects of cultural services, and how these might be described and measured. For example,

the **intangible** aspects of cultural services include:

- Aesthetics and 'spiritual' values
- Existence and moral values
- Sense of identity and connection to place.

The **tangible** connections between cultural and provisioning services include:

- Use values connected to norms and traditions of interaction with the natural environment e.g. gathering fruits and nuts
- Livelihoods and lifestyles linked to local economies, business and individual incomes, and health
- Social networks of land managers and others directly affecting the range and quality of services provided.

Whilst much progress has been made articulating the units of measurement and values, including monetised values, that adequately represent supporting, provisioning, and regulating services because they are tangible, there is still much confusion and debate surrounding robust methods of capturing cultural service values and measures because they are generally less tangible (DEFRA 2007; Harper and Price 2011; Maxwell et al 2011). Furthermore, when looking to establish measures of wellbeing those measures already developed may not be the most appropriate, and they may not make a clear distinction between social/community level values compared with those of individuals. A notable problem with the MA was that it did not explicitly acknowledge that human well-being had determinants that were derived outside of ecosystems, for example, both 'manufactured capital' and 'social capital' have significant impacts upon human wellbeing). In some instances these may overshadow the ecosystem effects (ICSU et al., 2008).

2. Review objectives and methods

2.1. Objectives

A fundamental issue facing policy makers is how best to prioritise investments in environmental management and protection or the development of green infrastructure. It is finding the most advantageous mix of land uses in terms of the range of ecosystem goods and services provided for the support of human wellbeing, that presents the greatest challenge. Currently, wellbeing remains either incidental or a non-explicit issue to land use planning and some types of environmental decision making. Tools are needed which can support these strategic governance processes.

The emerging use of GIS-based spatial analysis tools offers a powerful means to bring together data concerning social values and choices, and the links with ecosystem service provision, in the process of land use and land management decision making, and understanding the impact of delivery strategies on customers and local populations. This is particularly true where tools:

- explicitly link ecosystem services to wellbeing
- integrate cultural ecosystem services in a way understood and accepted by natural scientists, policy makers and other stakeholders
- can be used as a means to build collaborative decision making, social learning and deliberation amongst a wide stakeholder group
- include criteria and weighting systems which can be agreed by stakeholders and stand in contrast to monetised valuations

The broad aim of this work was to provide a critical review of current approaches to mapping cultural ecosystem services and wellbeing ‘indicators’ or ‘variables’ in spatial analysis tools. The review identifies the scales at which cultural ecosystem services are mapped and approaches to mapping wellbeing. Of particular interest was the extent to which existing mapping approaches could be used to inform local decision making, across a range of scales, about the provision of cultural services from green spaces particularly from forests, woodland, and wooded or forested landscapes.

The research objectives were as follows:

1. Conduct a review of current spatial analysis methods focused on forests, woodland and greenspace:

    i. identifying the various spatial analysis tools and weighting systems applied

    ii. assessing how indicators are set and evaluated.

2. To clearly identify the strategic objectives met and/or applied research questions answered by the different approaches and tools and identify data and process gaps.

3. To comment on the scale of decision making offered by different tools.

4. To comment on the value of these techniques to policy makers, land managers and other stakeholders.

2.2. Methods

This review initially drew on two sets of source material, namely,

i. peer reviewed scientific literature and

ii. ‘grey’ literature and tools.

The peer reviewed scientific literature included research which explicitly attempted to map cultural ecosystem services. The studies were drawn from an ISI web of Knowledge search using the key terms ('spatial' or 'mapping' or 'spatial modelling'; 'cultural ecosystem services' and 'wellbeing'). The review was confined to publications produced after the publication of the Millennium Ecosystem Assessment (which introduced the most prominent typology of ecosystem services), to the present i.e. between 2005 and March 2012. From this list studies were selected that had produced mapped output of cultural ecosystem services at either local, landscape or at broader strategic scales. Where appropriate other mapped output referenced by these studies was also included. Where multiple studies were linked to one site, they were grouped together (e.g. (Anderson et al., 2009; Eigenbrod et al., 2010). This resulted in 34 peer reviewed studies being included in the review.

Given that much of the ongoing work on mapping cultural ecosystem services remains unpublished, a second set of material was collected which was derived from 'grey' literature as shown in Table 1. This material was confined to UK examples and focussed primarily on examples where a mapping component was present and were linked with natural landscapes, green infrastructure and woodlands or forests. In most cases the studies were not explicitly focused on ecosystem services, however the benefits being described were analogous to ecosystem services. The material consisted primarily of reports derived from web searches and informal discussions with knowledgeable stakeholders. Given the limited time available for the study this second set of literature can not claim to be exhaustive but instead is indicative of the current tools available to resource planners in a UK context.

For each set of data and evidence the aim was to:

- Identify which cultural services were mapped (in particular those emanating from woodlands or green spaces).
- Identify the links between service provision and well being – particularly in relation to which indicators of wellbeing were used (if any) and the rationale for their use
- Identify data requirements
- Identify the scale at which the approaches were applied
- Understand the weighting systems applied and
- Identify data and process gaps.

Table 1. Gray literature reviewed - operational delivery of well being benefits from green infrastructure

	Reports	Year	Website
Approaches that produced mapped output			
1	Green Infrastructure for the West Midlands Region: Technical Mapping Paper: A guide to the spatial mapping and assessment of GI for public and wildlife benefit	2007	**http://www.growingourfuture.org/** http://www.growingourfuture.org/wmwff/taskgroups/gip/tech_map_paper.pdf
2	Analysis of Accessible Natural Greenspace Provision (examples for Hertfordshire, Norfolk, Suffolk and essex)	2007	**http://www.naturalengland.org.uk/regions/east_of_england/ourwork/gi/accessiblenaturalgreenspacestandardangst.aspx** http://www.naturalengland.org.uk/Images/HertsReport_tcm6-21928.pdf
3	Green infrastructure solutions to pinch point issues in north west England (examples Mersey Forest)	2012	**http://www.greeninfrastructurenw.co.uk/** http://www.greeninfrastructurenw.co.uk/resources/Critical_GI_23rd_March_lores.pdf http://www.merseyforest.org.uk/files/The_Value_of_Mapping_Green_Infrastructure_pdf.pdf
4	GVC green network. (examples include Renfrewshire Green Network Opportunities Mapping)	2011	**http://www.gcvgreennetwork.gov.uk/**
5	Heads of the Valleys Woodland plan	2010	http://www.forestry.gov.uk/pdf/HeadsoftheValleysWoodlandPlanExecutiveSummary2010a.pdf
6	Sustaining Ecosystem Services for Human Well–Being: Mapping Ecosystem Services	2010	**http://www.ccgc.gov.uk**/landscape--wildlife/managing-land-and-sea/sustaining-ecosystem-services.aspx
Toolkits (Not spatially explicit)			
7	Building natural value for sustainable economic development: the green infrastructure valuation toolkit user guide	2010	**http://www.greeninfrastructurenw.co.uk**/resources/Green_Infrastructure_Valuation_Toolkit_UserGuide.pdf
8	The Public Benefit Recording System (PBRS)	?	**www.pbrs.org.uk** http://www.naturaleconomynorthwest.co.uk/resources+reports.php
9	Woodland Trust - How to value forests and woodlands	2010	**http://respublica.org.uk/documents/uas_Natural%20Policy%20Choices.pdf**

3. Results

3.1. Methodologies for classifying cultural ecosystem services

Given the global profile of the MA (2005) it's framework of classification is the ubiquitous typology for ecosystem services. However, as far as cultural ecosystem services are concerned, considerable overlap exists between different lists of cultural services produced by different researchers or policy makers. Different systems make it difficult to develop consistent theoretical and methodological frameworks for measurement and evaluation. There is an ongoing discussion amongst researchers about how to produce an updated more universally accepted typology which enables explicit quantification of the **material and non-material value** of cultural services (Fisher *et al*., 2009; Morse-Jones *et al*., 2011). Some work is also being carried out by Forest Research see for example LUES and SERG (2012).

This section begins with a consideration of two important recent iterations of cultural ecosystem service typologies that try and deal with these issues. These are the typology used by the UK National Ecosystem Assessment (UK NEA) and the Common International Classification of Ecosystem Goods and Services (CICES).

The UK NEA has met the challenges of characterising cultural ecosystem services by recognising there are cultural ecosystem **services** and cultural ecosystem **goods**. The UK NEA begins by suggesting that cultural services are best understood using the Human-Scale Development Matrix (H-SDM) developed by Manfred Max Neef (1989). This framework suggested that four key existence needs (i.e. being, having, doing and interacting) and a set of associated value needs (*'subsistence', 'protection', 'affection', ,'participation', 'creativity', 'leisure', 'understanding' 'identity'* and *'freedom')* which can be met through interaction with ecosystems.

The UKNEA proposed that these 'interactions' are essential for human well-being and constitute ecosystem services, and that 'environmental (natural/naturalistic) settings' represent the final cultural ecosystem service. The UK NEA separated out some of the cultural services described in the MA (such as recreation and tourism) as being better described as the ecosystem goods required for wellbeing. The UKNEA considered five main groups of ecosystem goods:

- Leisure, recreation and tourism
- Health goods
- Heritage Goods

- Education and ecological knowledge goods and
- Religious and spiritual goods.

The UK NEA recognised that a value of using the concept of 'environmental settings' was that their boundaries could be spatially explicit. The UK NEA acknowledged that spatially disaggregated data based upon environmental settings were better suited for the assessment of status and trends. This facilitates their use for decision-making and trade-offs involved with managing and conserving ecosystems. However the UK NEA did not produce any maps to represent environmental settings or demonstrate how these might work in practice. The rationale for follow up work for the NEA identified significant gaps in the work on cultural services.

> *"The category of "cultural ecosystem services" (CES), whilst recognised to be an important attribute of agendas for ecosystem services, remains one of the least developed areas of ecosystem assessment and it is treated unevenly in research and decision making taking an ecosystems approach…. Yet, to strengthen the link between CES and wellbeing, there is evidence that decision makers (and indeed researchers) require greater clarity about how to define, analyse and operationalise CES in practice.*"[4]

The Common International Classification of Ecosystem Goods and Services (CICES) was a framework developed to meet a need for a standard classification of ecosystem services that "would both be consistent with accepted categorisations and conceptualisations and allow the easy translation of statistical information between different applications" (Haines-Young and Potschin, 2010).

Cultural (and social) services within CICES includes all **non-material** ecosystem outputs that have symbolic, cultural or intellectual significance. Within the Cultural or Social Service Theme, two major classes of services were recognised: 'Symbolic' and 'Intellectual and experiential'. There are distinctions made between physical or intellectual activity. Table 2Table 2 illustrates the characterisation. The classifications were intended to provide a bridge between the biophysical components of ecosystems and the various products, activities and benefits that were wholly or partly dependent on them. In effect to clearly distinguish tangible ecosystem benefits which could then be valued (Haines-Young and Potschin, 2011).

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4 http://uknea.unepwcmc.org/NEWFollowonPhase/Whatdoesthefollowonphaseinclude/tabid/129/Default.aspx

Table 2. Cultural services in the proposed Common International Classification of Ecosystem Goods and Services (CICES)

Theme	Service Class	Potential Service group	Service type
Cultural	Symbolic	Aesthetic, heritage	Landscape character
			Cultural landscapes
		Spiritual	Wilderness
			Sacred places
	Intellectual and experiential	Recreation and community activities	Charismatic or iconic wildlife or habitats
			Prey for hunting or collecting
		Information and knowledge	Scientific
			Educational

3.2. Mapping of cultural services

The tools and studies reviewed dealt with the following issues:

- Mapping the type of greenspace or habitats and where they were located
- Assessing and mapping the kind of services provided by the greenspace or habitat (i.e. analysis of functionality)
- Scenario testing – evaluating what functions are needed and where these are needed
- Experimenting with different measurement and valuation techniques.

Most of the mapping and spatial analysis tools and research schemes apply the MA typology or a variation, but In general the mapping of cultural services reported in the literature was limited in terms of the breadth of services covered. Of the 34 studies reviewed there was a strong focus on mapping services for which tangible material values could be generated. Overall 47% of the peer reviewed studies mapped only one cultural service – primarily recreation/ tourism or aesthetics. Figure 1 illustrates the range of cultural ecosystem services covered by the research studies reviewed.

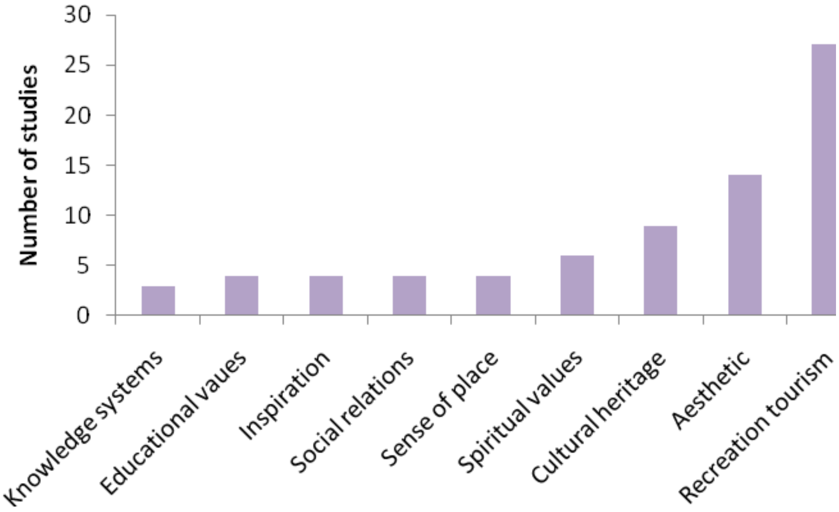

Figure 1. Spatial representation of different ecosystem services within the peer reviewed studies

Similarly, the benefits mapped in the grey literature covering the nine mapping projects reviewed, whilst not generally framed using the ecosystems service terminology, were still analogous with the three most readily mapped ecosystem services, i.e. recreation, aesthetic and cultural heritage values**.** These categories are often chosen because of established methods of valuation that come mostly from economics. Overall there was very limited spatially explicit representation or analysis of the non-material cultural benefits that woodland provides.

In Wales the work has tended to follow the same pattern. The broad scale mapping work commissioned by the Countryside Council for Wales (CCW, 2011) focused on three cultural services: physical health, recreation, cultural heritage and diversity. Similarly, the research commissioned by Forestry Commission Wales on opportunities for woodland creation in the Heads of the Valley research identified recreation and health, landscape quality and cultural heritage (see reference in Table 1).

3.2.1. Criteria and weighting systems

What data is used and what criteria included?

In the studies reviewed the datasets used for mapping cultural services fell into two broad categories. The first set described the extent of the asset (ecosystem unit) and included:

- Bio-physical data (information on the biophysical components of the system such as typography, soils ,land use)

- Designated areas (e.g. maps of urban parks, Areas of Outstanding Natural Beauty)
- Access infrastructure (e.g. pathways)

The second set focused on data that identified stakeholder needs covering, for example, indices of deprivation explain which areas may benefit most from new woodland plantings. These fell into a further two sub-categories, i.e. data that could be i. derived from existing spatial datasets, and, ii. primary data derived from interaction with stakeholders. Included here was:

- Population data, Indices of Multiple Deprivation, extent of disconnection from/proximity to green space
- Process modelling (where rules/guidelines are generated to explore interactions)
- Qualitative data derived from participatory research.

How is the extent of the asset supplying ecosystem services defined?

Combining land use data with maps of designated areas (such as park boundaries, *etc*) enables the size of the asset to be determined, i.e. how much of a given landuse is actually available for the production of ecosystem goods and services. These maps also determine the physical boundaries of ecosystems. Of those studies reviewed there was a significant difference in the degree of accuracy of the boundary mapping. This was associated with the resolution of the land use data used within the study (see, for example, Raymond *et al.,* (2009) who were mapping areas important for ecosystem service provision). These datasets also provide some measure of the implicit or potential cultural value of the site.

More studies examined the distribution and congruence of ecosystem services, often with the goal of identifying areas that will provide multiple ecosystem service 'hotspots'. Land use datasets often play a central role in defining these areas. There are obvious limitations is using land use data alone for such purposes but the lack of supplementary spatially referenced data means that currently land use data alone serves as a proxy for ecosystem service delivery. A serious limitation of these datasets is that they tend to lack data on the condition or quality of the habitat. This is actually critical in determining what range or degree of goods and services could potentially be delivered by the habitat or ecosystem unit. Eigenbrod et al (2010) identified some of the key issues of using land cover as a proxy to map ecosystem service distribution. Proxies may be suitable for identifying broad-scale trends in ecosystem services, but even relatively good proxies are likely to be unsuitable for identifying hotspots or priority areas for multiple services.

How are social preferences, benefits and cultural values accounted for?

The first category of spatially referenced datasets (i.e. land use data and land use boundaries) formed the vast majority of those used in the UK green infrastructure studies. There were very few spatial datasets that provide information directly relevant to the way in which humans interact (culturally) with the landscape. The individual asset focused datasets used were common across most of the UK studies, despite their inadequacy for providing detailed information on the level of ecosystem service provision.

The approach taken by the recent Mersey Forest research looking to identify 'pinch points' provides a good example (see Table 1 for reference). The study defined pinch points as:

> "*localised areas where investment for growth and/or redevelopment is planned but where specific issues ('pinches'), that may have green infrastructure solutions, manifest themselves most seriously*".

The approach used spatially explicit methods to produces maps to help prioritise interventions. The mapping output consisted of composite maps. From a total of 49 datasets incorporated within the tool, only four social datasets[5] were used in the development of the mapping outputs. Of those four datasets cultural interaction was only explicit in one, the Natural Environment Index. This tracked aesthetic quality, and was included as an implied measure. These datasets provide very patchy and crude information about the cultural value of a woodland or green space to society or local populations[6]. This is particularly true where the community or associated stakeholders are very diverse in terms of their socio-economic characteristics and their degree of interest and interaction with the greenspace or woodland being considered.

These limitations to data availability and dataset use within the mapping approaches currently adopted create a number of important problems:

1. There is an overly-simple linear relationship between the size of population and the value of natural habitats (or green space). This reflects an increasing value to planners – rather than the public - when these natural settings are located in areas of high population.

2. Proximity to green space is the key metric used in the UK Green infrastructure studies to determine priorities. Proximity and implied access in effect become the main metric for judging social and cultural value to the population[7]. Implicit

[5] These were the Natural Environment Index (TEP), population density produced by the Office for National Statistics, Indices of Multiple Deprivation, and the Woods for People dataset setting access boundaries

[6] These limitations were noted by the authors.

[7] For examples see http://www.greeninfrastructurenw.co.uk/resources/Critical_GI_23rd_March_lores.pdf and http://www.naturalengland.org.uk/Images/HertsReport_tcm6-21928.pdf

in this measure is the assumption that green space provides equal benefits to all parts of society. There is certainly a strong relationship between the value derived from a system and its proximity to potential beneficiaries (Kozak, 2011). However, it is not the only factor of importance nor does it distinguish the preferences of different communities, or of different sections of a community, or of those communities within equal distance of more than one green space.

3. Related to proximity is the question of scarcity. How many distinct woodlands were local to communities and stakeholders and how was this accounted for in spatial analyses? In areas where there are numerous accessible woodlands are the cultural values associated with any one of them equal, and would the addition of a new woodland have significant additional value? Conversely the value of woodland in an area without tree cover may be considerably higher because of the rarity. This is a key principle behind programmes such as Forestry Commission Scotland's Woods In and Around Towns programme. One piece of research conducted by the Glasgow and Clyde Valley Green Network Partnership (GCVGNP) evaluated the value of existing and newly planted local woodlands to local communities in areas of greenspace scarcity and showed that access to existing woods and new planting were very highly valued natural capital.

4. Lack of data on the condition or quality of green space and woodland makes it difficult to determine the relative value of the potential cultural benefits or to differentiate one patch from another in terms of its cultural qualities. Evidence about social preferences and attachment to woodlands and forests demonstrates that variations in woodland quality may affect the flow of cultural good and services (see for example Ambrose-Oji 2009; Morris *et al* 2011; Edwards 2011; Edwards et al 2012). However, this issue of quality has to be taken alongside the issue of rarity since there is also evidence from urban woodland project evaluations (see for example TNS, 2010; Ward Thompson et al 2008, 2010) that in some areas, even poor quality woodland can provide a significant stream of cultural benefits and services

5. The data largely assumes uniform preferences for green spaces amongst the population. However, evidence suggests that not all stakeholders within a catchment area for an ecosystem service benefit equally, or have similar preferences. Are all those served by a specific woodland benefiting equally from an improvement in the quality or quantity of that resource? Society is made up of a diverse set of stakeholders who often have different needs and priorities for their green space. Many of the operational approaches have used indices of multiple deprivation to define areas considered most in need of greenspace provision. This is a very crude metric for defining where greatest value or preference may lie. It does not acknowledge that there may be equally important needs for greenspace in areas which are less deprived areas, and

which might be home to more vulnerable segments of society for example, children, the elderly and the less able,. There is further requirement for segmentation studies[8] and then to link these to what is already known about the cultural connections different parts of society have with woodland or the barriers they face accessing woodlands (see for example Natural England 2012; Morris *et al* 2011, Ambrose-Oji 2009)

As well as recognising that most cultural components of ecosystem services and goods being difficult to map, the UK studies demonstrated that reference had to be made to the flow of goods and services from woodland and greenspace. This consideration of the flow of goods and services must be done in context, i.e. within the wider landscape that woodlands and greenspaces are situated. The GCVGNP for example, pointed out that:

> "i*t is vital that the planning process looks beyond the boundaries of individual development sites, however large, to consider the broader spatial context; helping to create a more coordinated and joined up network. It needs to consider two dimensions of the Green Network. Firstly, how does a given site relate to the wider Green Network? Secondly, what kinds of Green Network benefits are most appropriate in that location?"*

It is the second element of that presents the greatest challenge using existing spatially referenced datasets, because they do not currently allow factors such as scarcity and quality to be taken into account. Neither does the data needed to properly explore social need or preferences exist. Issues here relate to community, stakeholder and societal need in terms of what communities require from their greenspace (location, quality, access, design) in order to realise the social and cultural aspects of wellbeing. This requires a more detailed understanding of how humans understand and use that landscape.

Maps generated in the peer reviewed research used three main sources of data:

- Assumptions derived from other academic literature
- Process modelling or
- Values based on participant observation or knowledge.

A study by Birch *et al* (2010) explored the cost-effectiveness of dryland forest restoration in four study sites in Latin America. The approach was economic. The purpose of the mapping was to locate ecosystem service benefits, and value them using

[8] Defra has developed a number of farmer segmentation studies that begin this process in rural environments – see for example the report by Wilson, Harpur and Darling: http://www.fbspartnership.co.uk/documents/Analysis_of_Farmer_Segmentation_Research_within_the_Farm_Business_Survey.pdf Similarly English Nature has undertaken a segmentation analysis of the MENE data and identified various segments of society in relation to how they use the environment for recreation and wellbeing activities see the report by the Futures Company http://www.naturalengland.org.uk/ourwork/research/mene.aspx

implied economic measures, as part of a scenario testing and choice experiment. This study used Net Present Values (NPVs) of five ecosystem services (carbon sequestration, non-timber forest products (NTFP), timber, tourism, and livestock production) to produce maps of ecosystem service provision. Maps were generated for three different scenarios with NPV values generated for existing forest cover and for two potential modelled restored landscape. From these values, a figure estimating the Net Social Benefit (NSB) was generated.

The NSB was defined as the net change in value of the ecosystem services associated with land cover change minus the financial costs associated with reforestation. The value of woodlands for tourism was based on annual tourism income data and annual visitor numbers (derived from scientific literature and interviews with local tourism experts). The mean annual spend per visitor per unit area of dry forest was used as an indication of willingness to pay. The authors acknowledged limitations with these economic indicators in terms of the degree of provision (how much produced) and values applied. Example mapping outputs from this research are shown in Figure 2.

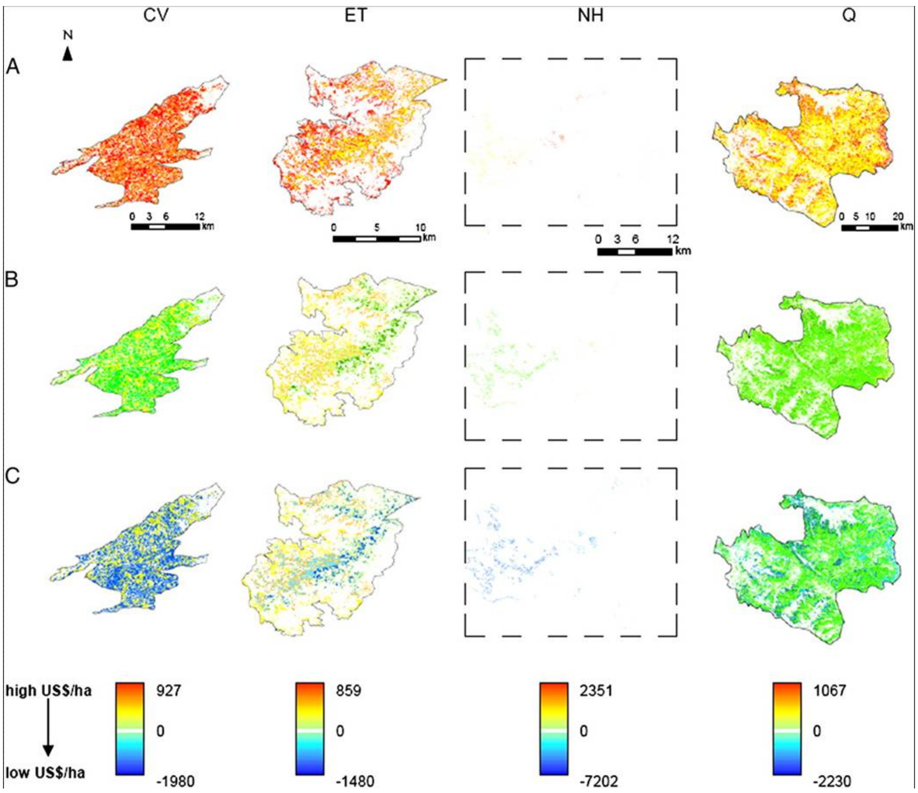

Figure 2. Output from the Birch et al (2010) study showing maps of NSB (US$/ha) for the combined ecosystem services (20 y, 5% discount rate) for the four study areas under three restoration scenarios: (A) passive restoration; (B) passive restoration with protection; and (C) active restoration

This output focuses on the material benefits derived from changing tree cover and shows the potential variation in delivery of NSBs generally. It does not refer to who the final beneficiaries might be or what associated non-material benefits are delivered. This is an approach which allows spatial representation of assumed (modelled) changes, using economic values that may or may not be accepted by key stakeholders. The approach, links cultural ecosystem services only to the potential income derived from tourism.

A number of the peer reviewed studies used modelling to generate values for cultural services. The modelling approach allows different types of data to be generated based on values derived from other studies i.e. without the need for stakeholder interaction to generate values. For example, Grêt-Regamey (2008) used a 3-D GIS model of the landscape to calculate what they called visual magnitudes representing areas of high scenic value. The visual magnitudes were defined as the portion of the field of view occupied by an object. In this case the value for scenic beauty was negatively affected where urban expansion or features such as new ski slopes were visible. Lavorel et al., (2011) used spatially explicit ecosystem service models based on plant traits and abiotic characteristics to determine the cultural value of alpine landscapes. For example, alpine pastures with flowering plants were associated with greater cultural value demonstrated by increased tourism. Similarly, Chen et al (2009) derived values for tourism using modelled accessibility based on distance to scenic areas and visibility from scenic spots. In their work they showed that the strength of the tourism value decreased with distance from scenic spots, and increased with visibility from scenic spots. The measures they used were based on the entrance fees paid to beauty spots in China[9]. Gimona and van de Horst (2007) used an aggregate visual amenity score (AVAS) calculated on the basis of four key variables. The variables they used were the spatial distribution of the viewing population (i.e. numbers and location of people combined with travel data to present both local inhabitants and visitors), the general preference of the public for the amount of woodland they like to see in the landscape, the amount of woodland already visible in the local landscape and the actual visibility of grid cells in the landscape from (public) points of observation. A prototype method to map the potential visual amenity benefits of new farm woodlands has also been developed by Van der Horst (2006) but was not available for review. Again the methods use a narrow set of values, based on economic calculations which are open to dispute and debate amongst stakeholders, with tourism and aesthetic included as the only cultural ecosystem goods or services of value.

Common to all the above methodologies was reliance on professional expert knowledge and a focus on economic measures and implied values drawn from tangible costs and benefits. These approaches all demonstrated significant gaps in mapping the non-material benefits that stakeholders derive from ecosystems.

[9] The authors acknowledged this was problematic as there is very little ‘willingness to pay’ data available in China especially as site fees are set.

There is an increasing amount of empirical evidence that communities themselves are able to identify and map different non-material cultural values, which present problems to researchers. Several case studies from the U.S. and Australia have mapped community cultural preferences for forest planning (see for example Raymond et al., 2009; Bryan et al., 2010; Bryan et al., 2011 and Sherrouse et al (2011)).

In the study conducted by Raymond et al., (2009) a community values mapping method was developed that used landscape values to link local perception of place to a broader measure of environmental value. These measures were derived from interviews and a mapping task conducted with natural resource management decision-makers and community representatives. GIS-based techniques were used to map the spatial distribution of natural capital and ecosystem service values and threats, using a mixture of stakeholder consultation and mapping data for the Murray-Darling Basin which covered an area of just over 56,000km^2. Participants used scoring methodologies to allocate one or more dots to locations within a study area. The dots represented area of high value for specific ecosystem services.

The spatial extent of each value/threat was described by the participant and sketched on a topographic map. Participants were asked about factors that could impact upon these values and if they could suggest ways that these values could be managed and protected or the threats mitigated. The study used the MA typology of services but introduced a "People" component that included the Built Environment, Zoning and Planning, Family, Community, Economic Viability, Employment, General Politics, Representation and Leadership and Indigenous Perspectives. In this exercise it turned out that the most highly valued ecosystem services were recreation and tourism, followed by bequest, intrinsic and existence values, fresh water provision, water regulation and food provision. Participants assigned the highest threat to the regulating services associated with water and land assets. The mapped output visualises where values aggregate within the study area as shown in Figure 3. A limitation with this approach is that the actual location of where the benefits are realised and who has access to them is not indicated.

In the mapping task participants used plastic dots to locate and describe places of value and threat in the study area. Participants were given a limited number of green dots (to represent positive value) and red dots (to represent negative values). Restricting participants to 40 green dots and 10 red dots enabled a limited representation of scarcity and value associated with features. The interviewees used the red dots to represent threats to natural capital assets and ecosystem services, as well as threats to their quality of life or more general management concerns. Participants were encouraged to place green and red dots to represent their place-specific values. One or more dots could be placed at each locality representing a value/threat intensity. They were then asked to describe why their place values were important to them. After the interviews, 881 individual value and threat areas were digitised as polygons in a GIS (see Figure 3).

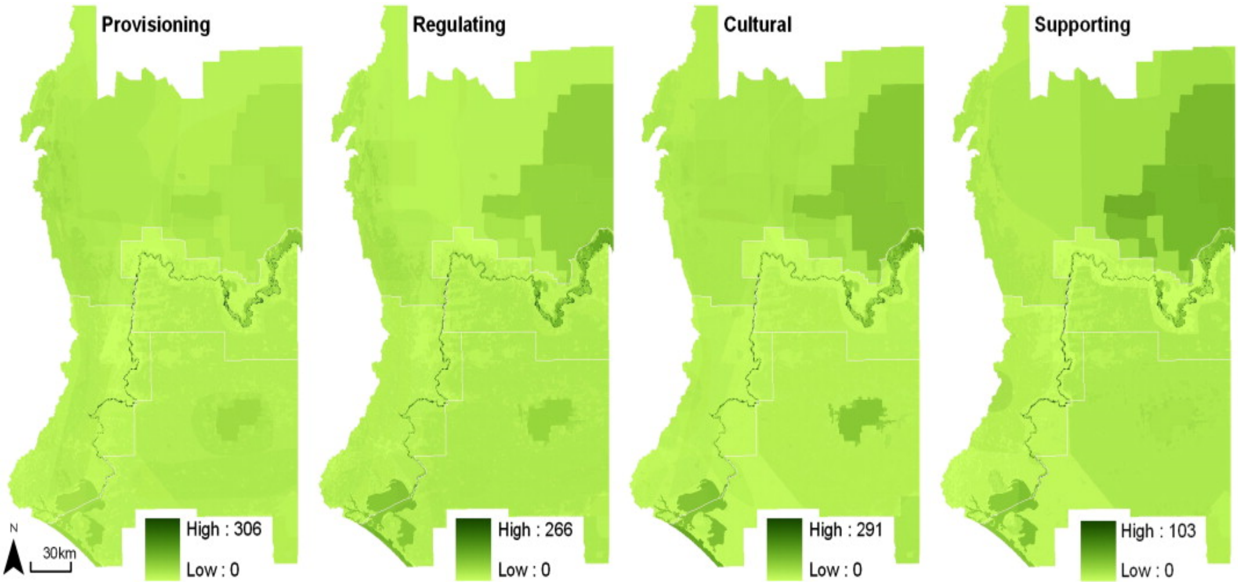

Figure 3: Mapped output showing the spatial distribution of value for ecosystem service types: provisioning, regulating, cultural and supporting over the Murray –Darling basin

These maps rely were developed with relatively few informants for a very large area and there are likely to be uncertainties about how representative these values are across the community (do upstream and downstream stakeholders share the same values?).

A limited number of studies attempted to map a range of material and non-material benefits using participatory mapping approaches (see Raymond et al., 2009; Brown and Weber, 2011; Fagerholm et al., 2012).

Fagerholm et al., (2012) used participatory mapping to map the location and value of ecosystem services and goods and explore the links between natural spaces and well being in communities in Zanzibar. Data collection was organised through a participatory mapping campaign in the local communities. Data collection consisted of a combination of semi-structured interview questions, and participatory mapping conducted with approximately 8% of the adult population of the area. Informants were selected by the village leaders in each sub-village to balance both the gender and age structure. As part of the process informants marked their home on a map and then used beads to score different landscape services.

Informants were allowed to map as many places for each indicator as they wanted, but for aesthetic values the three most important were indicated. Each mapped indicator was complemented with descriptive questions to append related attribute information, such as what crops were cultivated or how medicinal plants were used, and why certain places were considered beautiful. In addition, informants were also asked to evaluate on scale of 1–5, for example, self perceived familiarity and knowledge of the landscape (1 = very low, 5 = very good).

The findings demonstrated that the communities valued the non-material services of the landscape in terms of intrinsic value to just as high a degree as other material goods. The mapped output is illustrated in Figure 4.

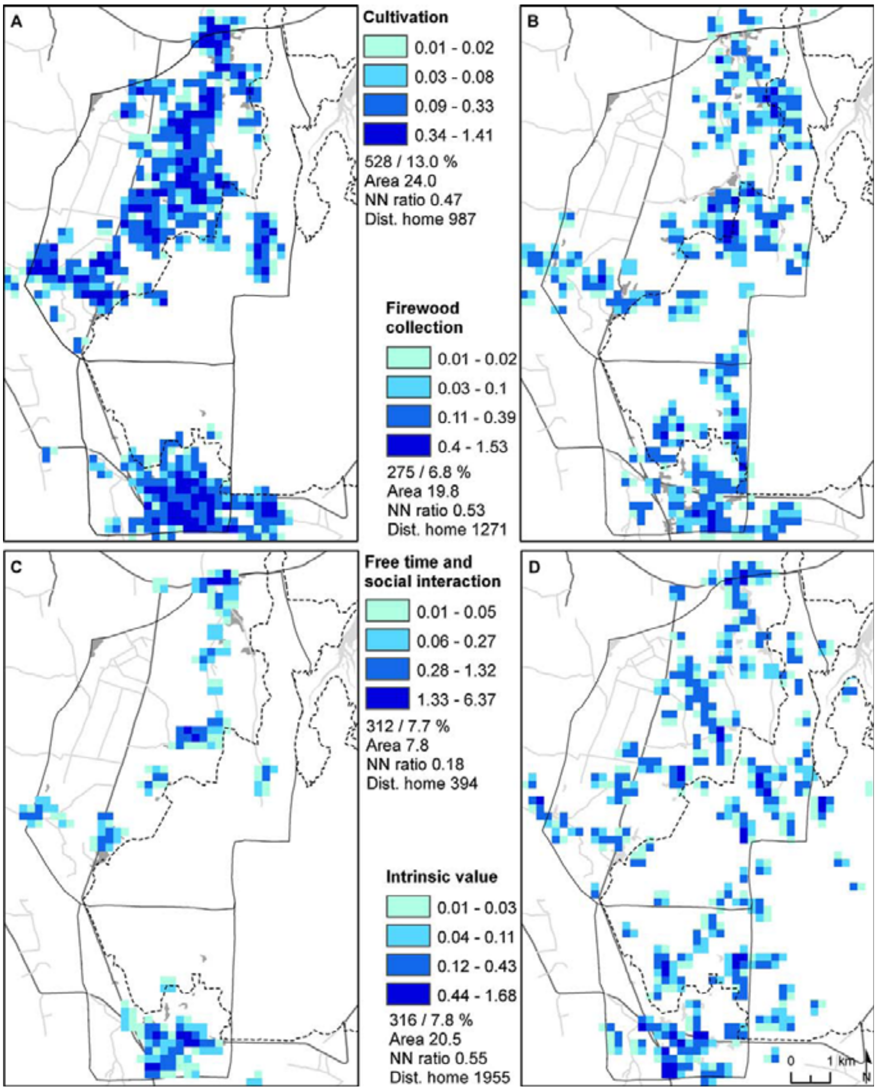

Figure 4: Spatial intensity (points/ha) for four landscape service indicators of: cultivation (A); firewood collection (B); free time and social interaction (C); and valuation of nature as such (D) calculated as Kernel density surface with 200m cell size and search radius. Descriptive data indicate the number of mapped points and relative proportion of all mapped points per indicator, nearest neighbour ratio, and average distance (m) from informant home to mapped point locations (Fagerholm et al., 2012).

Whilst the study found that cultural services were highest in green spaces close to habitation areas, there was there was significant spatial variation between service types and variation in the spatial clustering of key areas for the provision of services (see Figure 4). It is interesting to note that this spatial heterogeneity in the ways the benefits are distributed in relation to ecosystems is not captured in the UK green infrastructure studies. This study also demonstrated the value of more in depth community involvement and the way in which participatory mapping might enhance in understanding the delivery of services at broader scales.

3.2.2. Scale of Application

When thinking about the mapping of ecosystem services there are two critical scales to consider. Much of the policy interest in ecosystem services has focussed on understanding the societal values of ecosystems. This requires broad, strategic scale mapping (Kienast et al., 2009; Maes et al, 2011). However, as we move from a policy framework to considering an operational approach then the scale at which ecosystem services needs to be mapped changes (as does the resolution of data required). This is because the recipients are now at the community level and the mapping needs to be at a scale that reflects their interaction.

The Murray-Darling river basin example above, as well as other studies, show that it is possible to involve people in participatory mapping exercises using informant's local knowledge at these broader scales (Raymond et al., 2009; Bryan et al., 2010; Bryan et al., 2011 Brown and Weber , 2011). However there are limitations regarding the methods applied and the robustness of the outputs obtained.

In many cases the methods involved informants being given a checklist of ecosystem services with a brief description, and then invited to associate these with areas of the landscape. An important issue to emerge from these research studies was the potential effect of "super-mappers". This resulted from a combination of method and participant knowledge and attitude. Where no limits are placed on the number of ecosystem service markers that can be placed on maps by individual respondents, some individuals tend to place many more markers than others. For example, in the Brown and Weber study (2011), seven individuals from a total study size of 57 were responsible for the placement of over 50% of all markers on the maps. This obviously has significant implications in terms of the representativeness of the maps produced using these techniques.

Kozak et al. (2011), suggested that many 'routine' cultural ecosystem services (e.g., gardening, biking, jogging, fishing, picnicking, boating, hunting, casual scenery and wildlife viewing), were likely to have steep rates of spatial discounting. In other words most of the value accruing within a small spatial range, so that for many cultural services the benefits are primarily realised where people live. Despite this obvious limitation, the majority of peer reviewed academic studies, with the exception of Fagerholm et al (2012), were mapping cultural services at broad scales. It is the grey literature and the work of the project oriented approaches which have tried to tackle local level mapping.

3.2.3. Dealing with multiple cultural services and flows of benefits

The mapping of a range of different ecosystem service flow pathways is currently beyond the capabilities of available mapping techniques. This calls into question our ability to associate wellbeing impacts with the full compliment of goods and services provided from nature.

Stacking

The current approach in overcoming these limitations is to ‘stack’ potential benefits (or functions) at what is called the ‘point of generation’, i.e. the place where the goods and services are produced rather than the area over which they flow. Just as with the other approaches discussed, this can be achieved either through the use of spatially referenced datasets (and the use of land use data as a proxy for ecosystem service delivery), or through participatory approaches. There are numerous examples of this from the green infrastructure work conducted in the UK including the Mersey Forest project[10].

Typology mapping determines where the green infrastructure resources are in the study area, and what defines the type of green infrastructure the resource is (e.g. park, woodland). It is carried out by first dividing the study area into polygons of land (a parcel system), which are then each assigned a green infrastructure type from a master list following a set of consistent rules. The parcels chosen as the mapping units are relatively small, which gives a potentially high level of detail. Once the initial register has been created containing each physical feature and its type, the next stage is to assign a function or functions. Each area of green infrastructure can have more than one function, drawn from the typology list. Functions include goods and services such as recreation, shading from the sun, heritage, or food production. Mapping the range of ‘green infrastructure functions’ (analogous to ecosystem services) that a parcel of habitat could potentially deliver (up to a maximum of 20 different functions in the Mersey Forest study) enables a ‘multifunctionality heat index’ to be drawn. The mapped output is shown in Figure 5.

There was low confidence in some of the datasets used to inform these maps for example aesthetic values were mapped using the Natural Environment Index (TEP) which had issues with resolution and did not match very well with common subjective assessments of aesthetic quality. The quality of these underlying spatial datasets vary,

10 http://www.merseyforest.org.uk/files/The_Value_of_Mapping_Green_Infrastructure_pdf.pdf

with those relating to cultural services having the lowest quality datasets. As such there may be issues with how well communities at risk from low cultural benefits are represented – instead a location where ‘green infrastructure’ is likely to have maximum impact is biased towards regulating services (i.e. flood risk). There was no ability to directly map actual local community needs, other than through indices of deprivation

The approach focuses on benefits consisting mainly of cultural and regulating services which, in reality all have different areas of effect, i.e. the point of generation varies from the point of reception (impacting different sections of society in different ways). For benefits associated to landscape scale processes there was little acknowledgement of the need for a coherent mosaic of green infrastructure to provide real benefits as flooding, for example, tends to manifest at landscape scales.

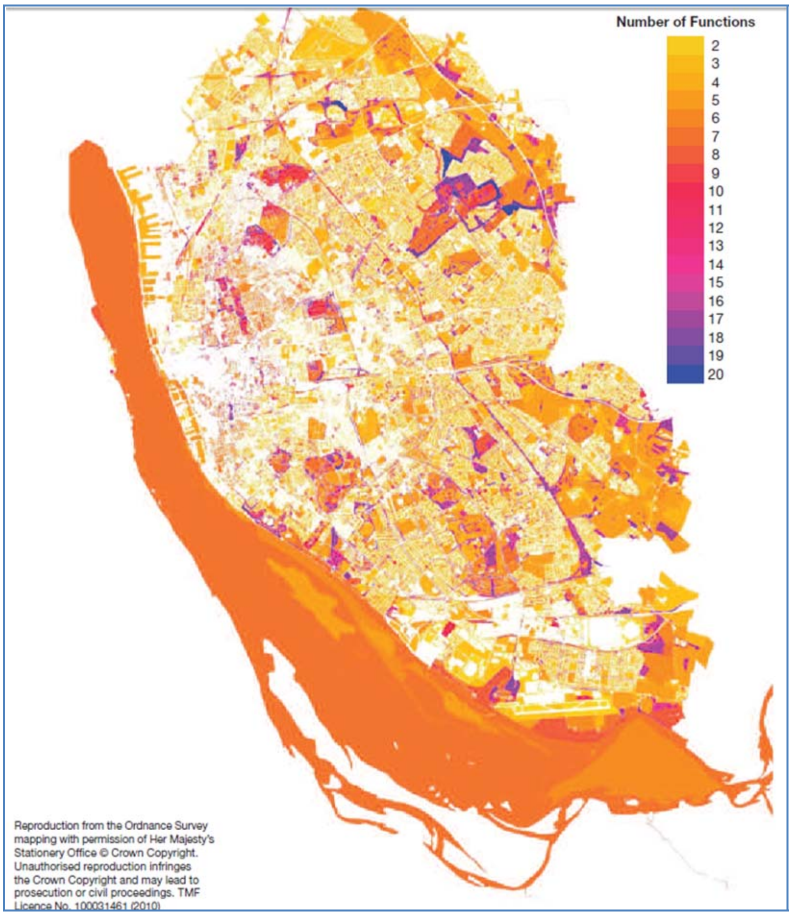

Figure 5: Multifunctionality mapping using the Mersey Forest approach ‘stacking’ multiple services

An example of participatory work in this area is a study of social values of urban woodlands in Helsinki (Tyrvainen et al., 2007). They tested a systematic approach using a postal survey that collected social values that residents in urban green areas experienced. The study area included approximately 20,000 inhabitants. The questions residents were asked were: the kinds of green area benefits important to them; what quality do the current green are as provided; and how can the green area qualities experienced be identified and linked to particular areas for planning purposes?

Most expressions used in the survey such as 'beautiful landscape' or 'valuable natures' were formulated in colloquial language. The main part of the questionnaire dealt with mapping the social values of green areas. Local residents were asked to identify areas on that had particular positive qualities, such as beautiful scenery, peace and quiet and the feeling of being in a forest. The methodology used a mixture of both qualitative (personal experiences, memories) and quantitative aspects (numerical social value maps) permitting examination of residential information spatially (see Figure 3). These maps differ from the UK green infrastructure maps as the values are derived from the communities and then compiled into spatial datasets. However there is still this issue of stacking benefits at the point of provision and little or no attempt to explore how variation in benefits between green spaces impacts on community well being – just broad preferences.

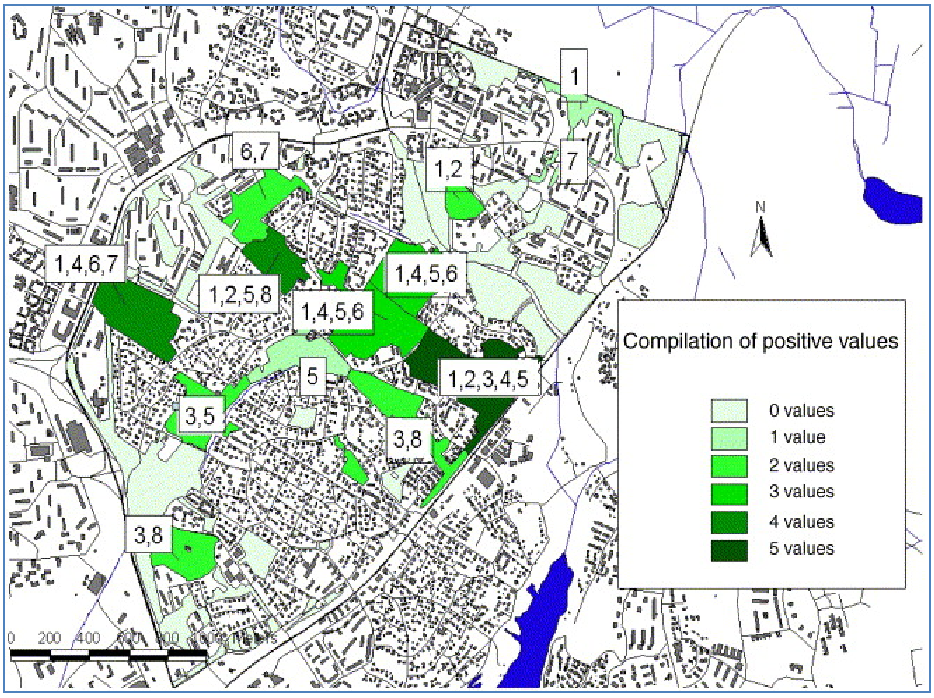

Figure 6: A synthesis map of the areas with the highest scores on various social value classes. Explanation of numbers: (1) beautiful landscape, (2) valuable nature site, (3) the feeling of forest, (4) space and freedom, (5) peace and quiet, (6) attractive parkland, (7) opportunity for activities and (8) history and culture (Tyrvainen et al., 2007)

In a similar vein Public Participation Geographic Information Systems (PPGIS) methods used computer-based applications to map areas that provide ecosystem services using the MA typology of services with the stated aim of "including and empowering marginalized populations" (Brown and Weber, 2009). The approach draws on the Community Values Mapping methodologies from Raymond et al., (2009). Brown et al (2009) used internet surveying techniques to enable participants to identify locations using digital tagging or drawing. Study participants dragged and dropped different ecosystem service markers on to a prepared Google map of Grand County, Colorado. Participants were asked where they thought ecosystem services were located. Following participant identification and mapping of various ecosystem services, the participant was directed to a web page that asked a series of survey questions to measure participant characteristics. The spatial and non-spatial data provided by study participants (500 participants invited – 57 responses) were analysed as shown in Table 3.

Ecosystem Service/USGS LULC[1]	Aesthetic	Air Quality	Biological control	Cultural	Erosion Control	Food	Genetic Materials	Habitat	Medicines	Natural Hazard	Natural Materials	Nutrient Cycling	Ornaments	Pollination	Recreation	Science	Social Interaction	Soil Formation	Spiritual	Waste Treatment	Water	Water Regulation	Total
Open Water	16	0	0	5	1	3	0	4	0	0	1	0	0	0	42	4	3	0	1	1	54	12	147
Perennial Ice/Snow	6	0	0	0	0	0	0	1	0	0	0	0	0	1	5	0	0	0	0	1	2	0	16
Developed, Open Space	5	1	0	2	0	3	0	0	0	0	2	1	0	0	6	4	6	0	1	1	3	1	36
Developed, Low Intensity	3	1	0	7	0	1	0	0	2	0	0	1	0	0	5	1	4	1	1	0	2	0	29
Developed, Medium Intensity	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	3	0	0	0	0	1	6
Barren Land (Rock/Sand/Clay)	12	2	0	1	2	2	0	4	0	0	0	1	0	0	4	2	0	0	4	0	5	6	45
Deciduous Forest	7	1	1	0	0	0	4	5	0	2	2	0	0	0	4	2	1	1	0	0	1	1	32
Evergreen Forest	146	18	6	17	17	27	13	90	10	17	46	7	3	7	163	26	31	6	32	12	98	34	826
Mixed Forest	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Shrub/Scrub	36	3	1	5	1	20	1	12	2	4	16	3	6	2	55	13	12	3	14	8	45	8	270
Grassland/Herbaceous	30	3	0	2	4	10	2	6	2	3	5	1	3	1	15	3	4	1	3	3	6	10	117
Pasture/Hay	8	0	0	1	1	5	1	14	0	2	2	2	1	2	2	2	2	1	1	0	4	13	64
Woody Wetlands	18	1	0	4	3	0	1	25	1	1	3	1	0	1	27	6	11	2	3	2	14	11	135
Emergent Herbaceous Wetlands	8	0	0	1	0	3	1	2	1	0	1	1	0	2	1	1	0	0	0	0	4	1	27
Total # Points	295	30	8	45	29	74	23	167	18	29	78	18	13	16	330	64	77	15	60	28	238	98	1753

[1] There were no points located in the cover types of "developed, high intensity" or in "cultivated crops"
2 Green shaded cells indicate statistically significant relationship (over-representation with standardized residuals > 1.96)
3 Pink shaded cells indicate statistically significant relationship (under-representation with standardized residuals > 1.96)

Table 3: The distribution of individual ecosystem services from PPGIS conducted in Grand County, Colorado.

In this approach two cultural ecosystem services were explored (alongside a broader range of provisioning and regulating services). These were:

- Recreation and aesthetic values – using the number of visitors or facilities; and a questionnaire concerning personal preferences

- Intrinsic value of biodiversity – the number of endangered, protected or rare species or habitats.

In Wales the Polyscape methodology (Pagella, 2011) uses a participatory approach to negotiate the placement of tree features in rural landscapes to provide multiple ecosystem service benefits. In Polyscape decisions about which ecosystem services to represent are agreed with stakeholders but includes a layer representing the livelihood objectives of the land owners. All ecosystem services are valued equally in the initial representations. Stakeholders need to see opportunities both at the scale where changes were made (i.e. local scales) but also to see them within the wider landscape context of that decision making. In common with the other studies data about ecosystem service provision is limited. The tool was designed to provide output using commonly available (generally national scale) spatial datasets, supplemented where appropriate by incorporating local knowledge and data.

The incorporation of local knowledge ensures local engagement and ownership. Collective development of the specification for output also facilitates participation and knowledge exchange between agencies. Hence the process of developing output for Polyscape is an iterative and participatory process that explicitly acknowledges land managers' wellbeing.

Ecosystem service Hotspots

In all these examples there are attempts to stack benefits from ecosystems at the point of provision (in effect identifying ecosystem service hotspots). As Figure 6 (above) suggests there is likely to be significant variation in the ecosystem service flow associated with each ecosystem function. For cultural services this ecosystem service flow will be directly related to the needs or perceptions and attachments of local stakeholders – which will vary within communities. There has been very little work to develop spatially referenced datasets that explore this variation and therefore map needs. As a result we tend to see maps of function hotspots rather than maps of benefits – which would be required to determine impacts upon well being.

3.3. Indicators of wellbeing

The value of taking spatially explicit approaches should be to determine both the potential for ecosystems to provide a range of services that may impact human wellbeing and to determine where communities with specific needs are in relation to the point of provision.

3.3.1. Economic valuation as a potential proxy for well being

As we have already seen in some of the research work presented in this review, much of the recent research emphasis around putting ecosystem services frameworks into operation has been on economic valuation tools (Boyd and Banzhaf, 2007; Cornell, 2011). The broad aim of these tools has been to provide economic values (where possible) for policy makers to deliberate and use as decisions support tools. Whilst these approaches have real value for engaging policy makers and other stakeholders in discussion, there are limitations in relation to using economic indicators to describe the real impacts on well being.

There is some research that attempts to provide spatially explicit economic values for ecosystem services (Liu et al., 2010; Troy and Wilson, 2006; O'Higgins et al., 2010). This is almost exclusively focussed on the point of provision, i.e. looking at the value of the asset rather than the value of the service to individual recipients. The current inability of many mapping approaches to map system boundaries or flow pathways for ecosystem services means that tools and methods linking service production to stakeholders, and then analysing wellbeing impact, continues to be limited. Without this ability to link flow with stakeholder it is difficult to link these economic values to human well being.

A study by Dobbs et al., (2011) looked at a number of indicators of ecosystem service provision from urban woodlands. Dobbs identified indicators that link ES provision to well-being using a typology of ecosystem services developed by de Groot (2002). These linked the services to well being indicators and include, for example, impacts of trees on health (due to filtering of dust particles and noise reduction). The study included two cultural services which he described as “information functions” These were aesthetics (the preference of people to live in pleasant environments) and recreation. The study used primary data about the location and condition of tree material within urban locations but used relatively unsophisticated proxies in relation to cultural services. The key indicator of high aesthetic value used were real estate prices. The study found recreational values to be highest in forested and institutional land uses. Values decreased in industrial and commercial areas. Aesthetic indicators had lower values on average when compared to recreation. Aesthetic indicator values were greater in residential areas with higher property values. The two cultural services had medium indicator values for all plots and the highest values were on residential land uses and the lowest in forested land uses.. The study did not produce any mapped output.

3.3.2. Non economic indicators of well being in spatial analysis

Most of the studies excluded information about the impacts on well being. This is largely because the types of data being utilised does not enable these values to be derived. Whilst there were a number of studies that used participatory approaches to identify areas that were important for ecosystem service provision (e.g. Raymond et al., 2009; Brown and Weber, 2011) there were only a limited number that sought to clarify the values that local stakeholders placed on ecosystems which could then be used to inform their wellbeing impacts. Perhaps the best example is Fagerholm et al., (2012) study in

Zanzibar which was detailed above as it documented ecosystem services supporting livelihoods as well as social interaction and intrinsic preferences. Three other studies also looked at wellbeing impacts. The work by Tyrvainen et al., (2007) was one of these. The main aim of this study was to develop a simple method to describe the *experienced qualities of green areas*. These "experienced qualities" effectively act as surrogates for certain aspects of well being.

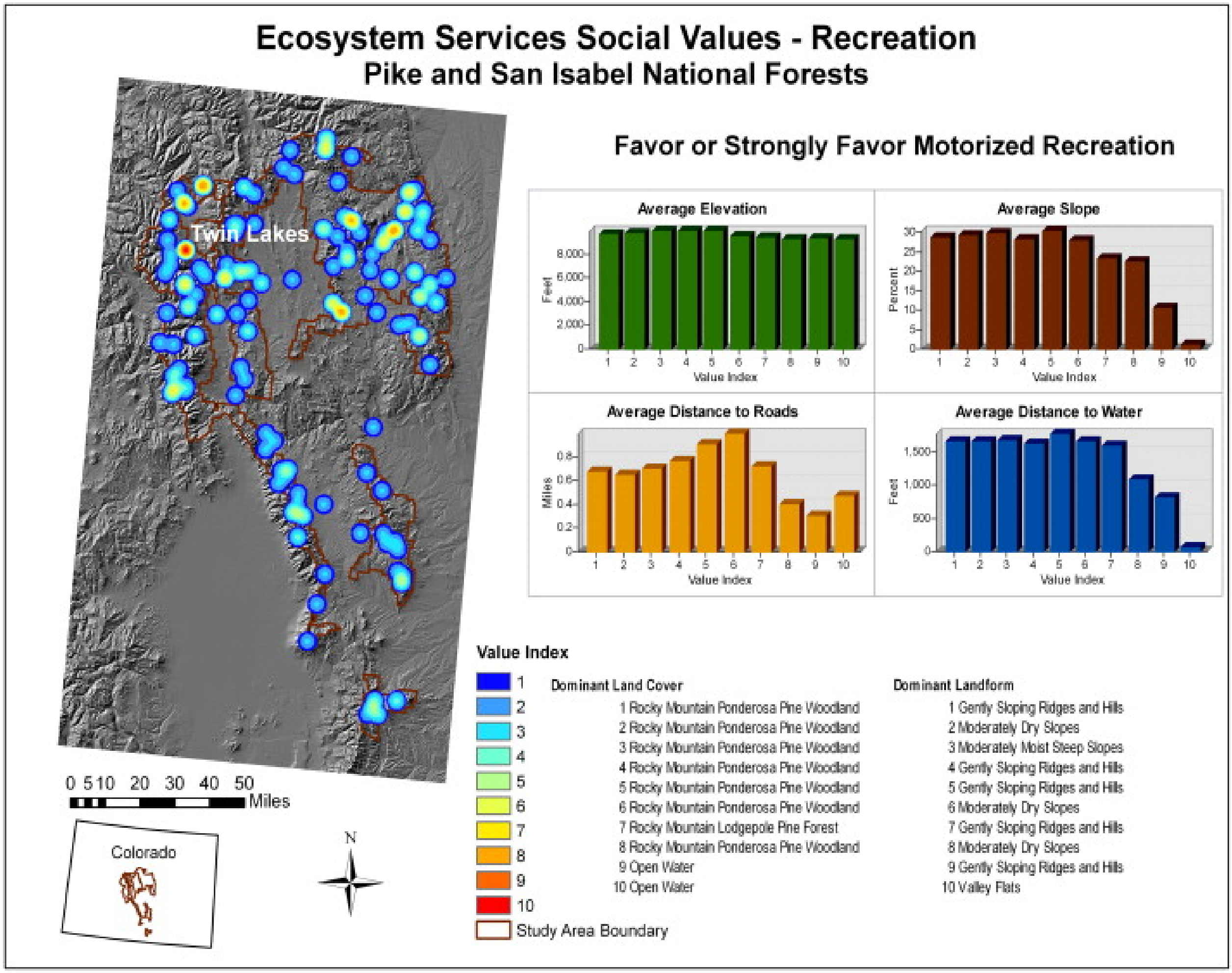

Figure 7: Example SolVES output showing the recreation social value type map and landscape metrics for the survey subgroup in favour of motorized recreation (Sherrouse et al., 2011)

The approach used by the Social Values for Ecosystem Services (SolVES) model uses quantified, spatially explicit social value metrics to assess relative tradeoffs among ecosystem services (Sherrouse et al., 2011). This tool kit uses data derived from public attitude and preference surveys conducted with users of woodlands to determine non-monetary values. SolVES is then used to map different stakeholders groups' preferences for woodland, allowing comparisons between stakeholder groups, and between land use types as shown in Figure 7

The maps were developed by collecting data using a mail survey of a random sample of 2,000 households. The survey was divided into five sections. Four sections of the survey identified the respondent's familiarity with the site, whether they favoured or opposed each of 18 public uses of the woodland and their views on activities impacting the woodland (such as road building) and demographic/ socio-economic information. The mapping section requested respondents to allocate '$100' among 12 different social value types associated with the wood. Following the allocation exercise, respondents were instructed to mark points on a series of maps corresponding to the social value types to which they had allocated dollars.

4. Discussion and recommendations

4.1. Summary discussion

Managing landscapes for ecosystem services requires spatially explicit identification of the "points of provision" of ecosystem services, flow pathways and the locations of the actual (and potential) recipients of these services. In effect mapping the supply and demand chain as it affects different stakeholder groups within society. In particular, linking ecosystem functions and benefits to human wellbeing requires explicit acknowledgement of the points of reception for ecosystem services, that is where they impact on people. Once such receptor areas have been identified then stakeholders who benefit from the supply of these services (i.e. 'winners') and stakeholders who either do not receive services or who see a decrease in service supply ('losers') can be identified. This idea is illustrated in Figure 8 below.

In panel 1 of the diagram 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 in one direction and benefits the surrounding landscape. This delivery can happen at local scales such as for pollination or pest control (dashed line) up to the global scale such as in a service such as carbon sequestration (solid line). Panel 3 demonstrates services that have specific directional benefits. For example, uphill forested areas provide water-regulation services to both local (dashed line) and regional (solid line) areas (Fisher et al., 2011).

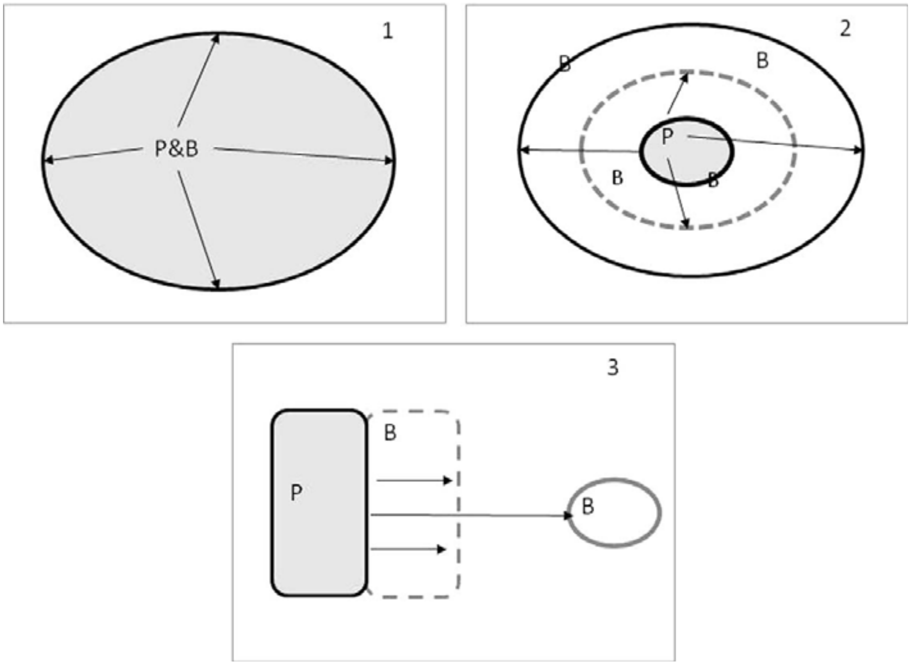

Figure 8: Possible spatial relationships between service production units (P) and service benefit units (B) (from Fisher et al., 2011).

This theoretical approach to spatial analysis of ecosystem services is partially realised in some of the examples reviewed. However, applying the approach described in Figure 8 in relation to cultural services continues to be problematic. The reason for this is that for cultural services, the inherent value of an ecosystem will often draw stakeholders to an area – so the ecosystem service benefits do not flow directly to them (Fagerholm et al, 2012). This is a familiar issue in woodland management where the social catchment for some woodlands, for example Newborough or Coed Y Brenin, sees visitors coming from as far as Manchester, Birmingham and Cardiff. In these cases the flow of services could be better represented if the direction of the arrows were reversed as stakeholders bring some of their associated their values with them to the point of provision, the woodland. The continuing focus on local community and stakeholder values, however crudely applied in the examples reviewed, stems for this issue and the fact that cultural and recreational opportunities are greatest in the immediate vicinity of where local populations live, as well as being an important part of a community's sense of place. However, the destination and iconic woodlands with smaller local communities and larger numbers of visitors from the wider social catchment (e.g. Coed Y Brenin, Newborough, Gwydr, and Nant Yr Arian) provide significant cultural and wellbeing services that need to be captured.

In the case of aesthetic or spiritual services, the ecosystems themselves may not need to be interacted with directly. Cultural values and contributions ot wellbeing may be accrued by locals and a wider social catchment by viewing the landscape, or simply knowing the ecosystem exists. For example, *Machapuchare* in the Annapurna Himal of north central Nepal is revered as a holy mountain, it has deep cultural significance, but visiting and climbing this mountain ecosystem is forbidden. Sherwood Forest, would be a similar example in England, there are many people who gain intangible wellbeing benefits from this woodland ecosystem without ever visiting it, instead attaching cultural values through stories and legends associated with forest.

These flows of ecosystem goods services and benefits have a temporal dimension too. There are potentially significant temporal variations in how stakeholders interact with nature too. Woods can be spaces to enjoy by day but become threatening spaces by night (O'Brien and Tabbush, 2005). In many rural populations in the UK the beneficiaries of cultural services may include significant numbers of ex situ stakeholders (tourists) attracted to more high profile or 'iconic' locations. This may require trade-offs from local stakeholders at times of the year when these areas are highly populated.

Ecosystem service footprint

Linked to the point about flows, the second important issue which is pulled out through the discussion and by the review is the scale at which the different ecosystem services benefits have an impact. Services may not actually flow into the social catchment, but depending on the stakeholder group, or segment of society, the social and cultural impacts of woodland can be felt over a very broad area. All the mapping approaches reviewed have ignored what has been called the 'area of affect' for different services derived from woodlands.

This is what we suggest should be called the "**ecosystem service footprint**". To make this idea clearer Figure 10 describes the concept in visual terms.

The ecosystem service footprint idea is that the benefits derived from woodlands have a range of influence; they are either present and flow, or have impact, over a dynamic locus rather than a small static point. Determining this range is fundamental for providing information about the potential impacts on human well being (Pagella and Sinclair, 2011).

Mapping the system boundaries for these types of services is, as we have seen through the review, a complex issue. Whilst the physical features of a woodland and wooded landscape are likely to remain fairly static, the area of effects is likely to be considerably broader, much more fluid and with fuzzy boundaries. The reason for this is that there is both a physical and an intellectual component to how we engage with natural ecosystems (Haines-Young *et al*, 2010). People visit, live with and experience woodlands and well as view, hear about and appreciate them through more distant media and mechanisms. Both generate ecosystem service benefits.

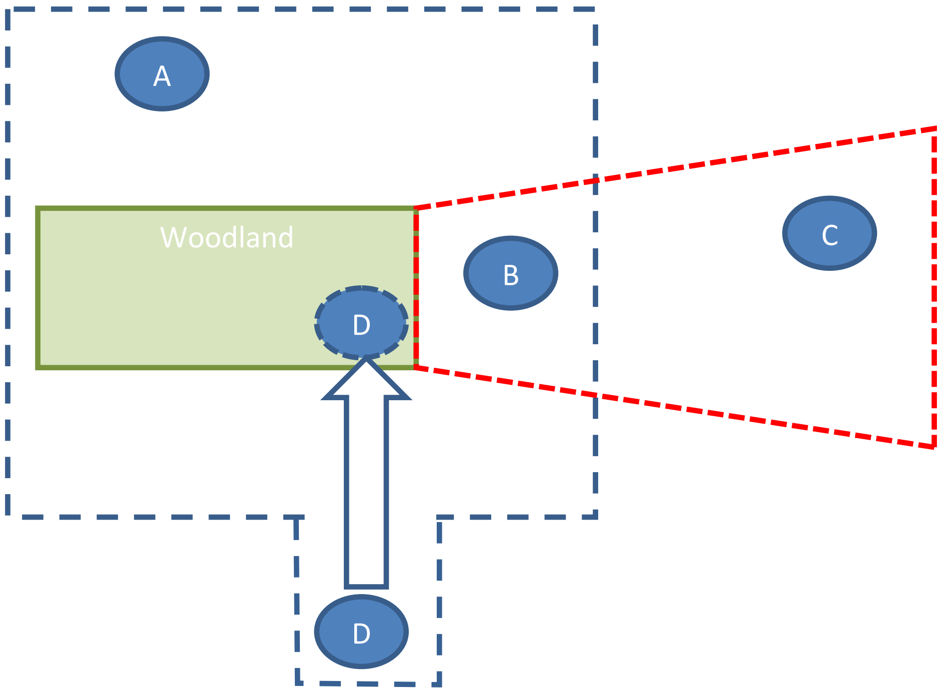

Figure 9: A conceptual representation of an ecosystem service footprint. The green area represents the ecosystem (i.e. the point of provision), the hashed lines represent the area of effect for different ecosystem services emanating from (or used within) the ecosystem. The blue spheres represent the points of reception (i.e. the community who will benefit from the flow of that service)

If we take a simplified example of a woodland, represented in Figure 9, we can think of the woodland providing a number of different services. The area within the blue hashed lines represents the aesthetic value of the woodland. In this simplified case the line of sight essentially defines the boundary, and communities A, B and D directly benefit from this service. The red hashed line may represent the reductions to flood risk (a regulating service), in this case the ecosystem footprint is unidirectional and only communities B and C benefit. Only community B receives both positive impacts. If we look at recreational use we may find that the wood has a special iconic status for community D located some distance away and out of the line of sight, but who are prepared to travel into the ecosystem to enjoy its benefit – in effect a unidirectional flow into the woodland (in contrast to Figure 8). The footprint would extend asymmetrically to incorporate Community D, out of the line of sight, but still representing the value of the woodland held and enjoyed by that particular community. It is this recognition of the spread of values beyond the physical location of woodland sites which has not been adequately incorporated into current conceptions of social and cultural ecosystem mapping. The cultural and social ecosystem service benefits included in the footprint are therefore stacked, and the flows and area of impact are not defined by land use units but by the social effects and interaction, following social and community boundaries.

The majority of the green infrastructure work reviewed assumed that the benefits of green spaces have been demonstrated within the academic literature. Access to these benefits is assumed to dependent on people being located close to these green spaces. There is no consideration of applying footprint approaches which can maps out the wider spread of benefits and impacts all visitors and users of these spaces appreciate, nor were methods applied to differentiate in the levels or types of cultural and social values appreciated by different kinds of people within a community or within a user segment. The spatial analysis focussed on the creation of buffer zones to determine how close people were to green networks. The datasets used (and often frequently recycled between the studies reviewed) lend themselves to this form of analysis, which, whilst not without value, does not capture the nuanced ways that different sections of society may want to interact with ecosystems.

What we can conclude is that the integration of participatory mapping methods in landscape service assessments is therefore a crucial way forward in building a truely collaborative, bottom-up understanding of the cultural and social value of woodlands. Stakeholder involvement has the potential to deepen the assessment and appreciation of the non-material benefits that the landscape and ecosystems provide to humans. It is these kinds of methods which can also begin to bring about comparison and judgement between potential tradeoffs amongst ecosystem service benefits under different management options.

4.2. Conclusions: Summary against review objectives

1. How do current methodologies link ecosystem services to wellbeing and how are indicators identified, measured and weighted?

1.1. Developing maps that link green infrastructure and woodland to human well being requires data both on the woodland asset under consideration, and information about the actual and potential benefits that the asset offers society.

1.1. The link between ecosystem service and human wellbeing is explicitly made in frameworks characterising the ecosystems service approach. However, in the spatial analysis and mapping of ecosystem services the clear link to wellbeing is lost.

1.2. Furthermore linkages between the provision of services from ecosystems and the flow of these to areas where they are felt, is also problematic and not always included. The review also shows that current spatial analysis tools are focused on potential societal impacts on wellbeing rather, than teasing out actual community or individual wellbeing impacts.

1.3. This situation is perpetuated by existing spatially referenced datasets tending to focus on function rather than benefits, which are in any case, assumed and based on literature rather than measured.

1.4. Indicators are therefore linked more to what is available than what is needed.

1.5. What is needed is obviously dependent upon the objective and purpose of the spatial analysis and mapping exercise. This means that the purpose of the exercise must be clarified in a way that defines who should be included, e.g. which community local or distant, which social segment, which stakeholders, just as much as what should be measured and how.

1.6. The methods and approaches available are limited and diverse and those reviewed do not provide a clear indication of which indicators, measures and weights are best applied in any particular situation. This remains an emerging and experimental area.

1.7. Existing datasets and their use in mapping approaches currently overemphasise the importance of proximity, and tend to involve much less information on the quality of the asset (in relation to stakeholder perception and needs), and the increased value of low quality assets in environments where the resources are scarce.

1.8. There are potential problems in current approaches linking the value of assets to population size, i.e. going for the 'biggest bang for the buck' and multiplying scale of cultural and social ecosystem service provision by total numbers of people in the local area. Smaller communities will also draw significant cultural value from their woodland environment, and some remote woods and forests will have significant value to large numbers of people distant from the resource.

1.9. Stacking systems applying community and stakeholder defined indicators elicited through collaborative discussion may offer the best way forward.

1.10. Tying indicators to specific landuse or area mapping units remains limiting, as the full extend of ecosystem service impact is not realised. There has been no research to date explicitly mapping ecosystem service 'footprints'. These are critical for understanding impacts upon wellbeing, and, for creating better assessments of value. This significant methodological gap requires research attention.

2. What is the scale of decision making offered by different tools? And what objectives are met or applied research questions answered?

2.1. This study found that with the exception of access mapping, current spatial analysis and mapping approaches tend to operate at relatively broad scales, whereas cultural values and ecosystem goods and services generally flow within close proximity to ecosystems. This approach lends itself to aggregate societal values for green spaces and woodlands which may mask the actual way in which different local stakeholders benefit (or not) from their local environment. This presents a problem as far as woodlands are concerned as many iconic and special sites have a wide social catchment of influence and impact not necessarily connected with the local population.

2.2. The main focus of current mapping approaches has been at societal level values derived from ecosystem goods and services (i.e. broad scale approaches). Current spatially referenced datasets are inadequate for providing much of the vital information required to determine impacts on wellbeing at local scales

2.3. As a consequence planning for wellbeing remains with an assessment of provisioning and regulating ecosystem services. Assessment of social and cultural ecosystem service provision is an incidental feature of wellbeing delivery rather than an explicitly planned delivery. This will continue to be the case until methods are employed which improve the social and cultural datasets available for spatial analysis.

2.4. The scale of decision making serviced by different tools depends upon whether approaches are working at strategic conceptual or tactical operational scales.

2.5. Conceptual strategic decision making is best served by generic feature mapping. Tools such as the economic valuation methods and the multifunctionality mapping would serve this purpose.

2.6. Tactical operational scales will deal with specific place mapping. At operational scales participatory methods are likely to be the most appropriate for determining how needs and perceptions and values vary within communities and for planning interventions to account for values or meet these needs or demands. Assumptions and limitations related to mapping at these scale levels as outlined in this review should be properly explained.

3. Are cultural ecosystem service spatial analysis and mapping approaches understood, accepted and valued by scientists, policy makers, land managers and other stakeholders?

3.1. Since very significant gaps remain integrating systems of description, measurement and valuation of ecosystem services not all methods are accepted by different stakeholders. The biggest problems exist around the proper weighting of existing ecosystem service provision, and in the indicators chosen to express value at local scales.

3.2. Seeking stakeholder agreement in approaches means that, currently, cultural services are aggregated and combined with other measures, with the main focus being on those that provide material benefits because these are more easily quantified.

3.3. The main mapping and integrated analysis methods employed are techniques which employ:

- **Counts**

  i.e. records of the presence or absence of cultural goods and services, or the numbers of different goods and services or ecosystem functions mentioned by respondents, this could include negative as well as positive values.

- **Measures of magnitude from scores**

  Applying scores rather than counts to generate values proportionate to the degree of importance or the level of benefit experienced by respondents for each ecosystem good or service mentioned

- **Integrated or 'stacked' measures of aggregate value**

  Using comparative quantitative values which are aggregated and combined to give "heat indices" or combined total values for a range of different ecosystem goods and services.

All of these were applied either to clearly defined spatial units (e.g. areas defined by woodland boundaries, park boundaries or demographic boundaries such as wards), or left a little more fuzzy and applied to general areas of the landscape/woodland where physical qualities were assumed to generate the values of interest

3.4. There were few examples, and little evidence, demonstrating how spatial mapping of the cultural and social ecosystem services were combined with participatory decision making processes at local scales. Involvement of local level stakeholders was really confined to the research studies rather than the operational level tools.

3.5. The focus instead has been on mapping potential “hotspots” in terms of the number (and range) of ecosystem services provided using stacking methods. These are most often generated using expert assumptions rather than empirical studies or other methods involving the people impacted by cultural and social benefits.

3.6. There is little evidence of robust stakeholder analyses being used to ensure that objectives are defined in a collaborative process. Instead there is a tendency for ‘megamapping’. Polyscape was the only tool which combined a range of stakeholders in a deliberative analysis and mapping of a range of ecosystem services, although there was no explicit mapping of cultural and social values. These were implicit in the discussion about other ecosystem benefits, and the choices made in terms of visioning future landscape management.

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Appendix 1. Definitions of Well-being

Well-being depends substantially, but not exclusively, on ecosystem services. The table below describes the five main categories of well-being used in the MA (2005) with those delivered by ecosystem services described in the second column.

Primary requirements for Wellbeing	Contribution from Ecosystem services
Security	a safe environment; resilience to ecological shocks or stresses such as droughts, floods, and pests; secure rights and access to ecosystem services
Basic material for a good life	access to resources for a viable livelihood (including food and building materials) or the income to purchase them
Health	adequate food and nutrition; avoidance of disease; clean and safe drinking water; clean air; energy for comfortable temperature control
Good social relations	realization of aesthetic and recreational values; ability to express cultural and spiritual values; opportunity to observe and learn from nature; development of social capital; avoidance of tension and conflict over a declining resource base
Freedom and choice	the ability to influence decisions regarding ecosystem services and wellbeing

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