Natural Capital Accounts:
Review of available data and accounting options

RESAS 1.4.1c deliverables on Gap analysis of ESS values (1.4.1ci D1) and on the list of potential case studies (1.4.1cii D1)

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Glossary

Broad habitats	Habitat classification developed as part of the UK Biodiversity Action Plan, also used by the UK National Ecosystem Assessment
CICES	Common International Classification of Ecosystem Services (http://cices.eu/)
Consumer surplus	The difference between what a consumer is willing to pay for a good or service and amount they have to pay (i.e. market price).
Economic welfare	The satisfaction or utility experienced from the consumption of a good or service, usually reflecting willingness to pay.
Ecosystem services (ES)	Natural process and the goods and services they provide which provide benefits to people
Exchange value	The value of goods and services used in conventional economic accounts, usually equivalent to market prices.
Natural asset	The stock of assets from nature e.g. tress, soil from which ecosystem services potentially flow
Natural capital	Used interchangeably with natural asset
Producer surplus	The difference between what a producer is willing to accept (or cost of production) and the amount they receive (i.e. market price).
Revealed preference	Non-market valuation methods that infer the value of environmental goods from the value of property (hedonic pricing) or cost of time and travel to recreational sites (travel cost). Also known as surrogate markets.
SEEA	United Nations System of Environmental-Economic Accounting are internationally agreed standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics on the environment and its relationship with the economy.
Stated preference	Non-market valuation methods (e.g. contingent valuation or choice experiments) that ask survey respondents their willingness to pay for changes in provision of environmental goods in hypothetical markets.
TEEB	The Economics of Ecosystem and Biodiversity (http://www.teebweb.org/)

Executive summary

Natural capital is the stock of natural assets that underpins the flow of ecosystem services that benefit human society and the economy. Natural capital accounting (NCA) is a process of quantifying those natural capital stocks and service flows to determine the nature and scale of those benefits to determine how they vary over time and whether our management and use of natural capital is sustainable. By aligning NCA with conventional economic accounts we can also begin to explore the interrelationship between the environment and the economy. This paper presents our review of approaches to NCA and the relevant evidence available for developing NCA for Scotland and our proposed initial case studies.

Principles of natural capital accounts

Defra and ONS (2014) outline the principles of natural capital accounting based on the System of Economic-Environmental Accounting (SEEA) (UN, 2014):

- NCAs aim to gather information on the contribution of ecosystem goods and services generated by ecosystems/land units to the wider economy.
- NCAs should follow the Common International Classification of Ecosystem Services (CICES) system, which distinguishes between provisioning, regulating and cultural services.
- Of particular complexity is the inclusion of biodiversity, the SEEA sees biodiversity as a characteristic of ecosystem assets and an indicator of habitat condition.
- Defra suggests following the NEA Broad Habitats classification.
- Ideally, information regarding all natural assets and ecosystem services should be included, but a prioritization may be needed, e.g. where ecosystem services are: i) sensitive to changes in ecosystems or at risk of irreversible losses; ii) influenced through decision making and/or relevant to people's wellbeing; and/or iii) measurable using acceptable and adequate methods.
- To compile NCAs and make them comparable with the SNA, there is a need to consider natural assets and ecosystem services at national scale, which introduces spatial diversity. The SEEA proposes a units model, based on three spatial units:
    - Basic spatial units (BSUs) – the smallest possible unit identified after partitioning a given area of interest
    - Land cover/ecosystem functional units (LCEU) – reflect a set of BSUs with similar ecological characteristics which commonly correspond to ecosystems.
    - Ecosystem accounting units (EAUs) – an aggregation of BSUs including different land cover types, commonly correspond to countries, regions but also management units (e.g. catchments or national parks).

An alternative approach to using habitat based accounts and that might be more relevant for highlighting economy/environmental interactions would be to develop NCA for particular industry sectors. Whilst forest and woodland accounts match both habitat and industry sector, agriculture crosses multiple habitats both at sector level and potentially when scaled down to single farm level.

Economic valuation for natural capital accounts

A key issue in developing economic values for NCA is the fact that different valuation approaches measure different elements of value. Conventional economic accounts use the concept of exchange

values, which in practice for most sectors mean market prices (for some sectors such as publicly provided health care cost of provision is used). There are a variety of methods for estimate the non-market values of ecosystem goods and services and these determine different types of value:

- Revealed preference (hedonic prices/travel cost): can use market prices or estimated demand curves which include full economic welfare (consumers' surplus).
- Cost based (defensive expenditure/replacement cost): can use market prices or supply costs, so do not measure full economic welfare.
- Stated preference: estimate demand curves (based on willingness to pay) so include full economic welfare. Can also capture non-use values.

Values for ecosystem services may also be influenced by a number of contextual factors:

- Distance: values for some ecosystem services (and disservices) will be related to distance from provision particularly where there is direct use.
- Substitute/complements: values for ecosystem services will reflect the availability and proximity of similar natural capital assets or assets that jointly provide ecosystem services.
- Similarity of environmental context: different habitats may provide similar ecosystem services, but values for those services will vary due to the difference in habitats rather than the similarity in benefits received.
- Similarity of socio-economics context: common socio-economic factors (income, population density, age structure etc.) may be consistent across different populations yet values for ecosystem services still differ due to less tangible factors such as 'sense of place' or 'spatial identity'.

These issues are of particular relevance when considering the use of benefit transfer, as existing values will need to be adjusted to fit different environmental and socio-economic contexts.

Existing valuation evidence

Our review of existing UK relevant values (drawing on the Defra Environmental Look-up tables) revealed that there are significant evidence gaps. Cultural services are well represented, but regulating services are a significant gap. Coverage is also variable in terms of habitat types with some better represented than others. This suggests the need for more primary valuation across ecosystem services and habitat types. Given their flexibility we propose to use stated preference approaches for primary valuation studies.

Initial case studies

Our approach to developing NCA for Scotland will follow a case study approach based on habitats or economic sector where appropriate. As this work is being carried out in parallel with other research to develop the Natural Assets Register and mapping and modelling we propose to begin with case studies with good existing biophysical and economic data. For this reason our proposed initial case studies will be agriculture and forestry as these are well covered in terms data including planned primary valuations covering water quality and biodiversity impacts of agriculture and forest recreation.

1 Introduction

Due to growing human-induced pressures on ecosystems, undermining habitats' capacity to provide goods and services benefiting people, there has been an increasing interest in the development of information systems to track and measure such changes and provide the basis for the design and implementation of appropriate policy responses. One of such instruments is the natural capital accounting (NCA). NCA relies on physical information on natural assets and ecosystem services to provide information on the monetary value of the flow of goods and services generated by those assets (i.e. natural capital) (Hein et al. 2015). Being an extension of the System of National Accounts (SNA), NCA aims to showcase the linkages between the environment and the economy and to supply evidence of the repercussions of environmental degradation on human wellbeing. It is oriented to complement the SNA, focusing only on market-based transactions, by recognizing that the environment benefits people not only when environmental goods are bought in markets (i.e. plants and animals bought in stores), but it affects people also outside existing markets (i.e. life-supporting role of wildlife/biodiversity). To achieve that, and to align with SNA, NCA needs to translate information about the benefits supplied by the flow of ecosystem services generated by ecosystems into monetary terms (i.e. monetization), which relies on economic valuation techniques. Economic valuation has been used in a wide variety of policy contexts and considering potential environmental values is an integrated part of policy impact assessment (HM Treasury, The Green Book, 2011). However, there is still little consideration of economic valuation for the purposes of compiling NCA.

Following an expanding need for such information at international level, triggered by the publication of the System of Environmental-Economic Accounting (UN, 2014), there has been growing discussions around NCAs in various countries, including the UK and Scotland. Playing a leading role in international discussions around the development of NCAs, the UK committed in 2011 to work with the Office for National Statistics (ONS) to incorporate natural capital into the UK Environmental Accounts by 2020. Reflecting this intention, Scotland has also been active on this front. In 2013 it hosted the first ever World Forum on Natural Capital[1] and, following the UK Natural Environment White Paper (Defra, 2011), it has shown clear intentions to work towards the development of NCAs:

"The value of natural capital assets should be incorporated into national accounting and business accounting to ensure this is fully considered in assessing the effectiveness and sustainability of government and business. This is a desirable goal that requires development of data, methodologies and standards. […] There is a commitment at the UK level to putting "natural capital at the heart of Government accounting" (Scottish Government, 2013).[2]

Within the framework of the Rural and Environment Science and Analytical Services Division (RESAS) Strategic Research Programme 2016-2021 and, in particular, within Theme 1 (Natural Assets), Work Package (WP) 1.4 (Integrated and Sustainable Management of Natural Assets) and Research Deliverable (RD) 1.4.1. (Natural Asset Inventory and Accounts), Objective O1.4.1c focuses on natural capital accounting.

This paper discusses the available relevant data sources and options for developing NCA for Scotland. The work in RD 1.4.1c is intended to be an extension of the biophysical data being included

[1] http://news.scotland.gov.uk/Speeches-Briefings/World-Forum-on-Natural-Capital-1f8f.aspx
[2] http://www.gov.scot/Publications/2012/07/5241/4

in the Natural Asset Register (NAR) being developed under RD1.4.1a, and will incorporate outcomes from work to model and assess the flow of ecosystem services that arise from natural capital (RD1.4.1b). The distinction between the NAR and NCA is that the accounts will add information on values (monetary and non-monetary) to the information on biophysical condition of Scotland's natural assets held in the NAR. In this respect there is a flow of information across the three objectives of RD1.4.1. Figure 1 adapts the natural capital accounting framework developed by eftec (2015) to illustrate where different activities within RD1.4.1 contribute to the NCA.

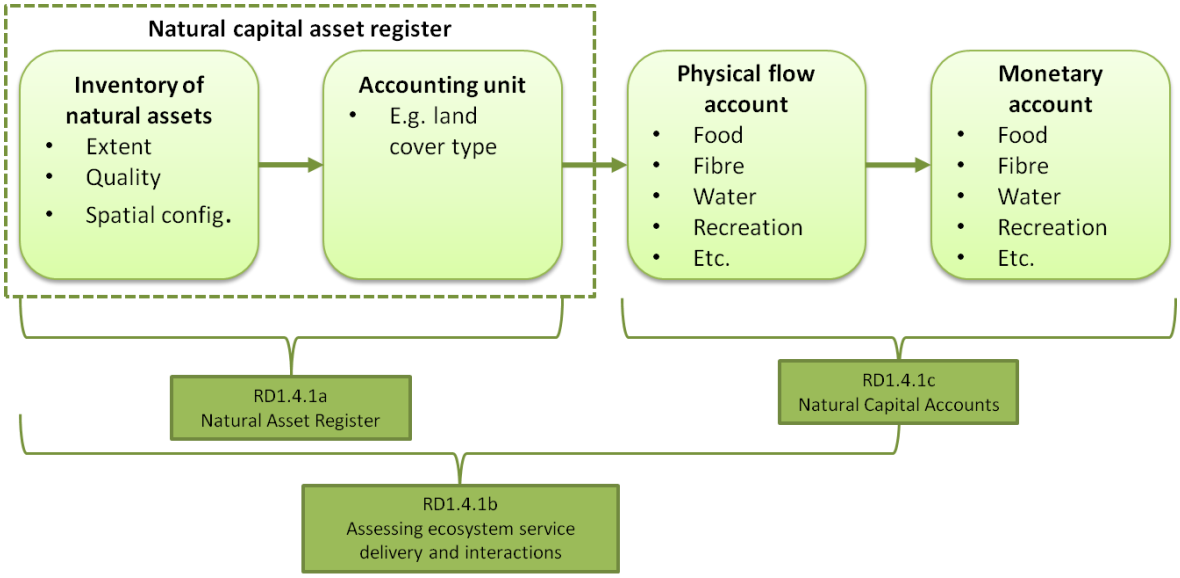

Figure 1 Flow of information across RD1.4.1 (adapted from eftec, 2015 p26)

This paper focuses on our review of existing valuation data that may be relevant for the development of the NCA. For this purpose the paper will first review principles and guidelines in developing NCAs and valuation issues that need to be considered for this task. Then, we will present an overview of existing evidence at UK level. This discussion will finally help us to determine which initial accounting case studies can be developed, what primary valuation data we need to collect, i.e. where there are key data gaps and also what are some of the practical and conceptual issues surrounding the use of non-market or environmental valuation data in accounting.

2 Principles and Guidelines in Developing Natural Capital Accounts

The system of reference for the development of NCAs at international level consists of the set of principles and guidelines detailed within the SEEA, published in 2012. At UK level, it is the ONS which is in charge of developing specific guidelines for the UK. In December 2012, the ONS published a roadmap, *Accounting for the value of nature in the UK*, which set out a strategy to incorporate natural capital into UK Environmental accounts by 2020.[3]

The paper entitled *Principles of ecosystem accounting* (Defra and ONS, 2014) presents and discusses the main issues to consider in the development of a NCA, adapted from the SEEA:

- NCAs aim to gather information on the contribution of ecosystem goods and services generated by ecosystems/land units to the wider economy. This requires the consideration that different ecosystems are capable of supplying different (levels of) ecosystem services. This might also be the case for ecosystems of the same type displaying different health and ecological statuses.
- NCAs should follow the Common International Classification of Ecosystem Services (CICES) system, which distinguishes between provisioning, regulating and cultural services.
- Of particular complexity is the inclusion of biodiversity in the analysis, which is acknowledged to support the provision of all other ecosystem services and is defined by different components. In these terms, the SEEA takes a broader view of biodiversity and sees it as a characteristic of ecosystem assets as well as an indicator of habitat condition (i.e. health).
- Defra suggests following the NEA Broad Habitats classification for the UK, including: mountains, moorland and heat; semi-natural grassland; enclosed farmland; woodlands; open-waters, wetlands and floodplains; urban environment; coastal margins; and marine.
- While, ideally, information regarding all natural assets and ecosystem services should be included in the NCA, the SEEA also supports the consideration of a prioritization approach. This suggests focusing on a selected set of ecosystem services which are: i) particularly sensitive to changes in ecosystems or at risk of irreversible losses and, hence, relevant from an environmental policy perspective; ii) influenced through decision making and/or are particularly relevant in terms of contribution to people's wellbeing; and/or iii) measurable based on acceptable and adequate methods.
- In the SEEA the need to account for spatially explicit information is also emphasized. In fact, to compile NCAs and make them comparable with the SNA, there is a need to consider natural assets and ecosystem services at national scale, which introduces spatial diversity. In this sense, the SEEA proposes a units model, based on spatial areas. The units model consists of three different types of units that might be considered for the development of NCAs:
    - Basic spatial units (BSUs) – the smallest possible unit identified after partitioning a given area of interest (e.g. cadastral units).
    - Land cover/ecosystem functional units (LCEU) – reflect a set of BSUs with similar ecological characteristics which commonly correspond to ecosystems (e.g. UK National Ecosystem Assessment (UK NEA) categories). They can vary in size depending on the setting.

[3] http://www.ons.gov.uk/ons/guide-method/user-guidance/natural-capital/index.html

- Ecosystem accounting units (EAUs) – consist of an aggregation of BSUs often including different land cover types. They should represent a relatively stable area that is relevant for analysis and reporting purposes. Most commonly, EAUs correspond to countries, regions but also management units (e.g. catchments or national parks).

For NCA purposes, LCEU and EAUs are of interest, while BSUs are not appropriate for the development of NCA given that they are too spatially constrained.

- According to the SEEA, different account types may benefit from the collection of monetized information (Hein et al., 2015). These include:
  - the ecosystem services supply account, reflecting the flow of ecosystem services from the ecosystems to the economy (can be expressed both in physical and monetary terms)
  - the ecosystem services use account highlighting the benefits associated to the supply of ecosystem services (mostly based on monetary information)
  - the ecosystem capacity account which records ecosystems' capacity to generate ecosystem services (can be examined both in physical and monetary terms)
  - the biodiversity account (relies on information expressed in physical and ideally in monetary terms).

- The SEEA also points out the need to consider a consistent time frame in the development of NCAs, as well as issues related to uncertainty.
- To build an NCA, information about the flow of ecosystem services generated by natural assets needs to be collected and translated into monetary terms. Generally, ecosystem services and natural assets are not traded in markets in the same way as other goods, services and assets. Therefore, most frequently, changes in environmental goods and services take place externally to markets (i.e. represent externalities) - positive externalities when the change in ecosystem services positively contributes to human welfare (e.g. flood protection) or negative externalities when it negatively contributes (e.g. the degradation of river systems through pollution). Such "missing prices" can be estimated through economic valuation methods. Some guidelines are available on this within the SEEA Experiment Ecosystem Accounting framework (European Commission, 2013).

3 Economic valuation for NCA

3.1 Welfare-based versus exchange value

In NCAs, the SEEA advice is to include information on the monetary value of environmental goods and services based on the **exchange value** principle which is employed in SNAs. This corresponds to the value at which goods, services and assets are exchanged in markets. Exchange values are very close to market prices, which in turn reflect the amount of money that willing purchasers pay to acquire goods, services or assets from willing sellers (Obst et al., 2016). Based on exchange values the value of goods traded in a market is calculated as the product of price and quantity (P x Q in Figure 2). This incorporates the sum of **producer surplus** and production cost. Producer surplus is the difference between what producers would get from selling the product on the market (the price) and what they would be willing to accept to produce the product (the supply curve), for each unit of the good from 0 to Q (i.e. area B in Figure 2). Production cost, is how much it costs the supplier to produce each unit of the product, from 0 to Q (area C in Figure 2). The use of the exchange value can ensure consistency between NCA and SNA.

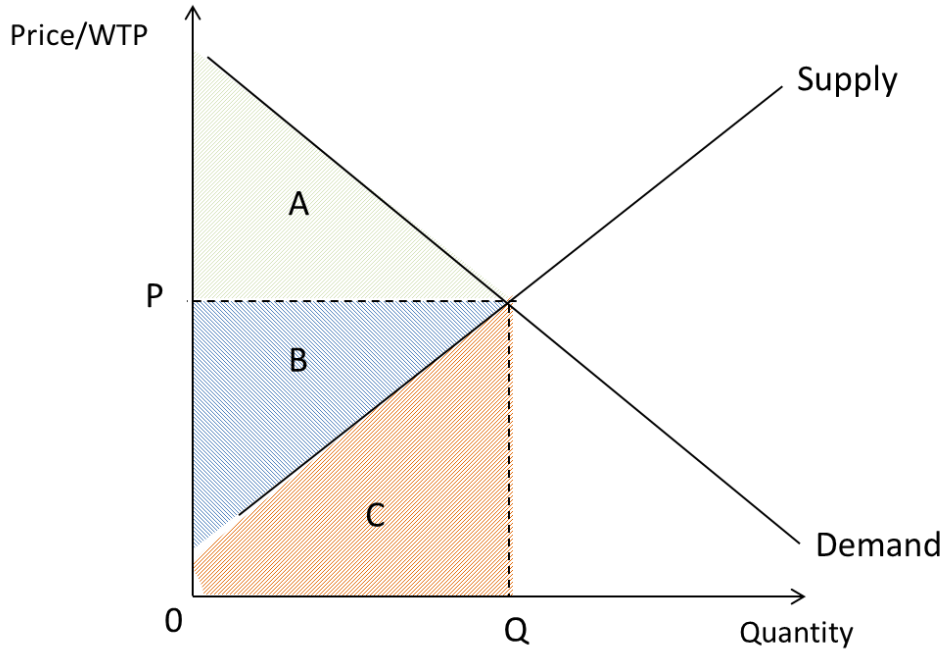

Figure 2: Welfare and exchange values

However, despite some environmental goods being traded in markets and having a market price, in many cases those goods or the related ecosystem services are not traded in markets and no market price exists for them. This raises the fundamental question regarding how to record the 'value' of such goods. A strict application of the SNA principles, based on the consideration of the exchange value, would require taking into account a price of zero, given that most of environmental goods are not traded in markets. Instead, Obst et al. (2016) note that a second best approach would be to use the cost of production as an estimate of exchange value. This is the approach used in SNA for health services. Neither of these options seems particularly satisfactory, and as Day (2013) points out, even

using market prices in national accounts does not provide an accurate measure of the welfare value generated by environmental goods and services.

To explore the impact of environmental changes on individuals' welfare and how this translates into monetary terms, economic valuation represents a useful tool. The concept of 'value' accounted for by economic valuation is welfare-based and it refers to the idea of total economic value. According to this, the value of an environmental good and service is given by the overall benefits that both the producers and the consumers of the environmental goods and services respectively obtain from the 'production' (or provision) and consumption of the good. In this sense, apart from the producer surplus (area B in Figure 2) accounted for also in the exchange value, the welfare-based value also considers another component: the **consumer surplus** (area A in Figure 2), which reflects the difference between what individuals should pay for the product (market price) and what they would be willing to pay to get it, for each unit of the product from 0 to Q. Based on this, it is clear that the value of an environmental good is measured differently depending on whether the exchange value is considered, as in the SNAs, or the welfare-based value is considered based on the total economic value.

In various social science disciplines it is now well-established that the concept of value goes well beyond what market prices signal. The idea of value refers to a whole range of benefits that environmental goods can generate for people, including use values (the benefits associated with the use of environmental goods for production or consumption purposes, including the recreational enjoyment of the environment) and non-use values (the benefits arising from the knowledge that the environment is preserved, regardless of use). Despite the 'benefits' that environmental resources provide can sometimes be difficult to measure, measuring them is important to make the value of environmental goods explicit and comparable with that of other goods or services. To measure the value of the services provided by the environment, one approach is to analyse how changes in environmental quantity or quality affect individuals' welfare and translate this into monetary units. This approach allows us to compare, using the same unit of measurement, market and non-market goods, like the environmental ones.

There is an ongoing debate about whether and how economic values could be adjusted to better reflect exchange values and which approach is superior. However, while exchange values can be a valid measure of value for given environmental services that are particularly close to markets, welfare-based values become relevant especially in those cases where the link between the environmental good and existing markets is weaker, as it is the case for many environmental goods and services. This way, economic valuation techniques based on the notion of welfare-based values should not be discarded in NCA, as reported also in Day (2013). While being aware of all the limitations related to these techniques is important, it is also important to appreciate the fact that they can provide a flexible, pragmatic and robust starting point in the development of NCA.

3.2 Non-Market Valuation methods

There is a variety of techniques available to value the ecosystem services provided by given habitats and natural assets in the NCA. The choice of the specific valuation technique will depend on the 'type' of environmental good. Based on Day (2013), we discuss the main advantages and disadvantages of each method and report a summary in the Appendix.

3.2.1 Hedonic price method

The hedonic price method is appropriate if an environmental good forms an attribute of some other good that can be purchased in a market. This revealed preference method assumes that variations in the price of the market good are driven, to some extent, by variations in the environmental quality. For example, higher costs of housing (property values or rents) can be explained, among other things, by proximity to urban green spaces, such that the increase in the price of properties attributable to vicinity to parks or green areas can be considered to be a proxy of the value of access to green space. However, caution is required with respect to the values obtained as a result of the hedonic price method. Due to the fact that existing markets generally display some degree of specificity (i.e. property markets are segmented both by property types and the characteristics of property buyers/renters), results may be difficult to generalize. Also, the market based transactions that are considered as proxies for the value of the environmental good or service in the hedonic pricing method are already captured to some extent in the national accounts[4]. There is a risk of double-counting, even though this is likely to be very small. There are more practical issues in the use of hedonic prices approaches at anything other than discrete local scales; these include the large amount of property transaction data required in order to account for property market segments and the large number of variables that impacts on values (e.g. property size, local services, transport links etc.) including multiple aspects of environmental quality.

3.2.2 Travel cost method

The travel cost methods is a revealed preference approach that assumes the costs (including time) incurred to travel to a given place to enjoy the environmental quality in the area reveals information on the value individuals place upon maintaining the environmental quality in the location of interest. This method is commonly employed for recreational experiences in natural areas. This method requires caution because it takes into consideration transactions that already take place in the national accounts (e.g. fuel sales, public transport, accommodation etc.). However, it would still be useful to re-assign existing market transactions to understand to what extent the enjoyment of the environment contributes to the wider economy. In this case travel cost studies might inform interpretation of the national accounts as well as contributing to NCA.

3.2.3 Defensive expenditure method

The defensive expenditure method assumes that the expenditure that households face by purchasing given market goods or services to protect themselves against any potential environmental risk represents the value of avoiding a given decline in the environmental conditions. For example, the amount individuals spend to buy bottled water to prevent given health risks in situations of high pollution or leakages represents the value individuals assign to maintaining current health levels or avoiding future health damages. Using the defensive expenditure method adds a new item to the national accounts, as the benefits to health and wellbeing generated by given environmental conditions are not captured anywhere else in the accounts. However, defensive expenditure can only be considered to provide a conservative approximation of the value of the environmental good.

[4] The national accounts include property values through the concept of imputed rent, which is the notional rental value of the national housing stock for owner-occupiers or the actual rental value for rented properties. This is based on a sampling approach which is unlikely to capture the effects of local environmental amenity.

3.2.4 Replacement cost method

The replacement cost method represents another alternative to value an environmental good. It requires identification of the cost that would arise from mitigating potential losses as a result of deterioration in the level of provision of the environmental good. The method assumes that the costs of restoring ecosystems or providing alternative ways to supply the same level of the environmental good can provide a good estimate of the value of the good itself. When environmental losses are irreversible and it would be difficult to replace a given environmental good once lost, this method is not generally recommended (Barbier, 2013). In addition, replacement costs only focus on the costs of replacing the provision of a given level of ecosystem services and do not look at the benefits side. This approach can therefore just provide an approximation of the real value of the good and might substantially underestimate the real benefits associated with preventing the environmental quality deterioration.

3.2.5 Stated preference methods

When the relationship between the environmental good and existing market goods is not evident and the public obtains utility from the direct consumption of an environmental good without having the possibility to influence the level of provision of that good through the choices they make in markets (i.e. public goods), stated preference methods should be considered. Stated preference methods can be considered both in cases when environmental goods cannot be linked to marketed goods, and also in cases when the goods can be related to other goods traded in a market. In this latter case, the advantage of using stated preference methods with compared to for example revealed preference methods is that stated preferences allow us to also consider the benefits that people derive not just from the use of environmental resources but also from the simple knowledge that the environment is cared for (i.e. non-use values). This is the main advantage of considering stated preference over the other methods listed above when valuing changes in the environmental services' provision.

Stated preference methods acquire particular importance when the researcher expects that the benefits that people obtain simply from the knowledge that the environment is in good condition, regardless of access or use opportunities, play an important role. However, this obliges us to consider welfare-based values, which make stated preference methods inconsistent with the valuation principles set in the SEEA based on the exchange value.

However, this is not a sufficient reason to overlook stated preference methods for NCA purposes. Stated preference methods, including the choice experiments and contingent valuation methods, among others, have strong roots in economic theory and they also allow us to disentangle information about trade-offs that acquire particular relevance in the context of NCAs, where different ecosystem services and assets are simultaneously considered. One of the disadvantages of stated preference methods is its reliance on the creation of hypothetical markets in which individuals are required to make choices, express their preferences or indicate their willingness to pay. However, the risk of hypothetical bias, which has been long discussed by practitioners in this field, does not represent a major concern today as a potential factor undermining the reliability of value estimates. Continuous refinements of and improvements to the method have in fact progressively reduced the gap initially identified between what individuals would be willing to pay in real versus hypothetical settings.

3.2.6 Benefit transfer and meta-analysis

Benefit transfer (BT) and meta-analyses are commonly used approaches for non-market valuation. These are not strictly valuation methods; instead they use existing values in the literature to draw conclusions on changes in ecosystems or habitats for which no primary data were collected. Their popularity of the approach arises from the reduced time and resource cost compared to undertaking primary studies. Values are taken from available case study examples ('study' site) and are applied to other case study areas for which no valuation information exists but for which such information would be needed to support decision-taking ('policy' site). It is essentially a statistical question of assessing how well the measured values represent the non-measured values. The transfer of values can involve simple mean values, adjusted values (e.g. to account for income differences) or the use of value function (i.e. utilising the parameters of regression models obtained from some available 'study' site examples to calculate a value estimate calibrated to the characteristics of the 'policy' site). A more complex approach is to construct a comprehensive database of existing studies relevant to a particular ecosystem or habitat type; a meta-analysis is then performed to identify a meta-analytic value function, the aim being to account for as much variation in both values and determining factors as possible. Constructing databases for meta-analysis is however time consuming and recommended when the aim is to estimate values for several policy sites. Both the BT and the meta-analysis represent easier approaches as they rely on data already available and collected by others for different purposes. However, unless the 'study' and 'policy' sites display a sufficient degree of similarity in terms of the environmental problem considered, the profile of the relevant population of reference etc. these methods will inevitably introduce some errors into the valuation process.

3.2.7 Conclusions

The debate concerning which is the most appropriate valuation method in accounting frameworks is still unresolved. In circumstances in which the value that individuals obtain from the provision of given levels of environmental goods and services can be linked to some purchase of market goods, methods such as the hedonic price or the travel cost can be considered. In other occasions, in which the value of the environmental good is not easily associated to any purchase in existing markets, stated preference techniques should be taken into account. Despite the use of stated preference techniques being questioned due to their inconsistency with SNA accounting principles based on exchange values, these techniques are useful for a number of important reasons. They allow the incorporation of non-use values into valuation; these are an important element of the benefits obtained from ecosystems. They allow us to estimate welfare-based values which better reflect the actual benefits received from ecosystem services. Finally, they have practical benefits as they are extremely flexible in the way that hypothetical markets can be constructed; they can identify specific ecosystem services, they can consider different levels of provision, and they can be designed to address of the spatial, geographic and contextual issues that we consider in the follow section.

3.3 Spatial and geographic aspects

Non-market valuation approaches play a central role in identifying values that might be used in constructing an extended set of NCAs at national level. Compiling NCA at national scale to compare and integrate the information collected in NCA with existing data compiled at the level of the SNAs can be both time consuming and costly. For this reason valuation methods have generally been applied to a specific and small scale focusing on projects or localised areas. To build NCAs, an alternative approach consists in the consideration of benefit transfers by using information collected

from 'study' sites and applying it to 'policy' sites to obtain a nation-wide picture of the benefits of a given policy. Scaling valuation methods up to undertake valuation exercises across a whole nation is a considerable challenge. Of particular concern is the fact that the value of environmental goods will undoubtedly exhibit considerable spatial heterogeneity. Spatial heterogeneity needs to be considered when transferring values from the 'study' to the 'policy' site to obtain accurate (i.e. low error) estimates.

In these large-scale and geographically comprehensive valuation exercises, the consideration of spatial issues acquires special importance because there is more and more evidence that spatial aspects affect individuals' preferences (Schaafsma, 2015). In some cases, the value of the flow of ecosystem services is likely to be insensitive to the spatial configuration of natural capital, although in many cases, where multiple services are co-produced, there may be important spatial elements. For example, although the benefits of global climate regulation would not be considered sensitive to spatial configuration, the means by which those benefits are achieved (peatland restoration versus afforestation) and the broader range of ecosystem services they provide (water flow regulation, biodiversity, landscape settings etc.) will have strong spatial dependences.

Therefore, NCA require high-quality spatially explicit datasets at a national scale that record the value of environmental service flows. In this section we present our review of the key spatial issues to consider when applying economic valuation methods to the NCA. The following discussion, based on the review presented in Schaafsma (2015) and other relevant studies on the topic, is framed largely in the context of using stated preference methods, as the preferred candidate for our analysis, but the overarching issues are also often addressed and discussed within other valuation approaches, such as the hedonic price and the travel cost methods.

3.3.1 Distance (distance-decay)

An expanding, but still limited, stated preference literature addresses spatial heterogeneity and the effect of various geographic aspects on willingness to pay (WTP). In this framework, it has been common to explore the effect of distance and some evidence exists in favour of the distance-decay paradigm, according to which WTP diminishes as a continuous function of the distance that separates a population of respondents from a given environmental resource of interest (Johnston et al., 2015). Much less frequently, complex spatial patterns have been considered, such as discrete or non-continuous distance-decay effects leading to the identification of spatial clusters in terms of hotspots and coldspots (Meyerhoff, 2013; Johnston et al., 2015). Although distance effects are relevant in valuation and should be accounted for in benefit transfer studies, this remains a challenge. In fact, the majority of researchers have not explicitly derived WTP by taking into account distance and, in addition, 'policy' and 'study' sites may be subject to different distance decay effects (Artell et al., 2015). In any case, just focusing on distance seems not to be sufficient. Many other factors are expected to drive spatial heterogeneity of individuals' preferences, even though these have been mainly ignored or addressed in a simplified manner by the published stated preference literature, with negative consequences for the potential transferability of study results and the transfer errors that are likely to emerge (Schaafsma 2015).

3.3.2 Substitutes/complements

In addition to distance, another spatially-defined factor that is expected to play a role in determining WTP is the availability of substitutes (goods that provide the same utility to individuals) and

complements (goods that provide utility when consumed jointly). In this sense, disregarding the existence of substitute or complement sites, as it is often the case in the stated preference literature (Brouwer et al., 2010; Bateman et al., 2011; Jørgensen et al., 2013), has implications for the estimation of WTP, such that when substitutes are ignored WTP is likely to be overestimated, while when complements are overlooked the reverse should be true. As a consequence of this, it is possible that transferring WTP from one 'study' site with a given number of substitutes/complements to a 'policy' site with a different number of substitutes/complements will result in high transfer errors. Literature has still to test whether the incorporation of information on substitutes enhances transfer accuracy (Schaafsma, 2015).

3.3.3 Distance and substitutes/complements effects

The effect of distance can be mediated by the availability of substitutes/complements, such that it does not only matter how far individuals are with respect to a given environmental good but also how this distance relates to the location of substitute/complement sites (Schaafsma et al., 2011; 2013). In this sense, distance-decay is not a simple unidirectional phenomenon, but it displays significant multidirectional variation depending on the spatial distribution of substitutes/complements. Taking into account these aspects of spatial heterogeneity should improve WTP estimation, even though accounting for this in BT is challenging, as spatial configuration of land in terms of the location of substitute/complement sites is likely different between 'policy' and 'study' areas.

3.3.4 (Perceived) Similarity of the environmental context/impacts

The concept of substitutability between two goods or services obliges to think about how close/similar individuals perceive given goods to be. This depends, among other things, on some spatially defined characteristics of the biophysical environment. Ecosystem services have been proved to provide different values depending on the specific habitats or ecosystem supplying them (Interis and Petrolia, 2016). Taking this into account, Christie et al. (2011) have estimated the value of generic sets of ecosystem services and have then differentiated such values by habitat type. This was done by consulting experts and identify through expert judgement information on the relative capacity of different habitats to deliver ecosystem services. This is based on the recognition that different habitats have different capacities to provide given ecosystem services.

Similar to the type of habitat, also the level of provision (or the scope of change) of the good or service and the size of the ecosystem where the good is provided are expected to play a role in determining WTP: additional availability of already abundant goods in a given area should be valued less (Sagebiel et al., 2015; Bateman et al., 2011). Linked to this, the existence of ecological connectivity, related to the biological interdependence between different habitat patches, may also enhance WTP if respondents are informed that the maintenance of such connectivity can support species. Related to this, the shape of the ecosystem may influence WTP values, as different land configurations can be capable of delivering different (levels) of ecosystem services. All these aspects characterizing the biophysical context (habitat type, scope of provision/size, shape, etc.) should be adjusted for when transferring benefits from 'study' to 'policy' sites to minimize transfer errors.

3.3.5 Similarity of the socio-economic context

Similarity is also often measured in terms of location-specific characteristics of the population, whose values are examined. Among the socio-demographic characteristics of the population, a more

conservative view would suggest to take into account just differences in income, with higher income respondents displaying higher WTP (Bateman et al., 2011). However, other approaches emphasize also the consideration of additional aspects, such as population density. In this sense, based on Johnston (2007), similarity of land use attributes, including housing density and agricultural and forest land density is more essential to value transfer than simple geographic proximity. Shared experiences, community attitudes and spatial perceptions of location-specific goods might also play a role, particularly if the good is associated with a 'sense of place' or if people assign the good some 'spatial identity' features (Kenter et al. 2015).

Given that mismatches in both the environmental and socio-economic contexts are very likely to appear when looking at different territorial scales, an increasing number of studies have explored the performance of BT when values are transferred across regional, national and international sites. As found in Rolfe and Windle (2008), Brouwer et al. (2015) and partly also in Muthke and Holm-Mueller (2004), focusing on BT across different areas at international level is usually associated with higher transfer errors, while this is not the case when values are transferred within national borders, also for regional analyses.

Table 1 Summary of spatial and contextual issues and potential responses

Transfer issue	Response
Distance (distance-decay)	• Benefitting population may not be discretely defined in the primary valuation sources • Distance-decay will vary across ES and for particular sites (strong interaction of cultural ecosystem services for iconic sites). BT based on meta-analysis across multiple ES may not be appropriate.
Substitutes/complements	• Substitutes/complements can be identified using spatial data. • Care required as availability of an apparent substitute/complement may not mean it acts as such. Are there important cultural/contextual characteristics of the study site (i.e. the reason it was valued)?
Distance and substitutes/complements effects	• Substitutes/compliments can be identified in biophysical terms using spatial data. Meta-analysis can test for substitute/complement site effects together with associated distance-decay.
(Perceived) Similarity of the environmental context/impacts	• Addressing this will be key to determining whether the 'Christie et al. (2011)' approach can be applied, or what adjustments are needed. • Labelled choices across similar bundles of ES attributes might allow exploration of this issue.
Similarity of the socio-economic context	• This issue may require resolution or assumptions to be made about the preceding issues. • Where the benefiting population is not fully specified, but we consider ES values to relate to distance, substitutes etc., we can use secondary data to characterise the relevant population. This could include nationwide samples of the general public. Our adjustments would then be relative to that characterisation.

3.4 UK past and future work on NCA

Simultaneous to the growing interest in NCA generated after the publication of the SEEA, the UK has started to move initial steps towards the realization of NCAs. Initial efforts have already produced preliminary results (ONS, 2015) but further refinements and a broadened scope are required for future years as illustrated in Figure 3.

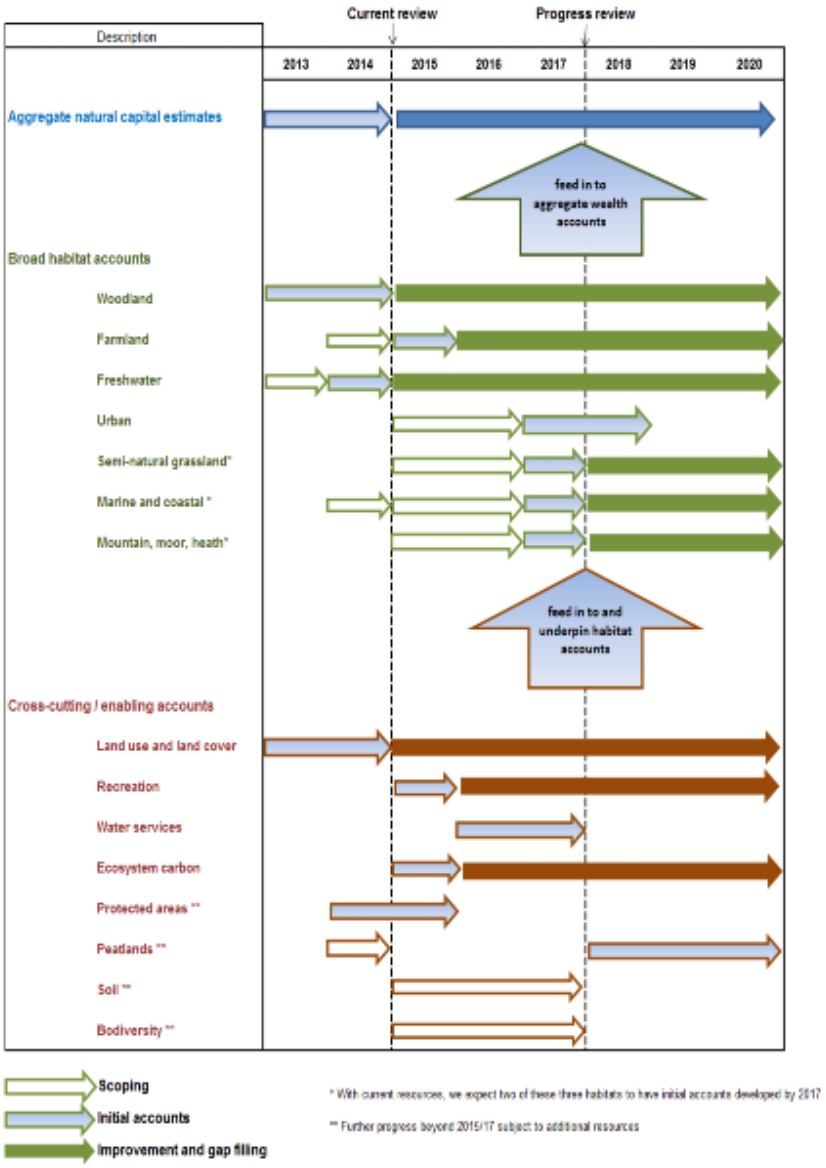

Figure 3 UK ONS Natural Capital Accounting Road Map 2015-20 (Source: **ONS, 2015**)

As outlined in the ONS road map document (ONS, 2012), initial achievements so far and plans for future progress focus on three sets of accounts, as shown in the ONS archive[5]:

- **Cross cutting/enabling accounting** – takes into account that different environmental goods and services are the result of different interactions occurring at landscape level across different

[5] http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/guide-method/user-guidance/natural-capital/index.html

habitats and recognizes that these provide the basic framework for the development of accounts at specific habitat level.

Within cross-cutting accounts, preliminary work has been done on the development of **land use/land cover accounts** in physical but not in monetary terms. Similarly, initial efforts have been towards the generation of an **account for recreation**. For these, initial estimates of the monetary value of outdoor recreation across different habitats were produced based on the implementation of a simplified 'travel cost' analysis. This assumes that the value of visiting a recreation site is given by the travel cost to the place (including visit time of the place) times the actual number of visits to the site[6]. Plans for the coming years are to improve and fill existing gaps around those accounts. Additionally, the intention is to prepare some scoping studies and initial analyses for the preparation of other cross-cutting accounts such as the one for **carbon**, for selected **protected areas** (including National Parks and areas of outstanding natural beauty), for **biodiversity**, **soil** (including **peatlands**, potentially covered separately) and **water services**.

- **Broad habitat accounts** – refer to accounts of all ecosystem goods and services for given habitat types. The habitat-based accounts were designed to be exploratory in the first instance and to focus on getting the physical aspects right to start with, supplemented by monetary entries where available. The ONS has aimed to publish these accounts at an early stage and will continue to work collaboratively with users in the development of such accounts.

  The ONS has produced an experimental account for the monetary value of timber resources in the UK. **Woodland accounts** are needed to inform the balance sheets of the Public Forest Estate and also private forests. To compile initial estimates of the value of UK timber, the available estimates by the Forestry Commission of the average price of coniferous standing sales that buyers pay to the owner of the forest was considered. To take into account that these prices refer to different periods of time, the flow of monetary values was discounted to consider one common temporal unit of reference (as suggested in the net present value approach).

  Enclosed farmland accounts will help to value the flows of ecosystem services provided by farmland. Initial estimates are available concerning the value of agricultural land, which were obtained by considering resource rents. Note that the recent ONS environmental accounts for farmland (ONS, 2016) appear to have been developed without reference to previous environmental accounts for agriculture studies (e.g. Jacobs and SAC, 2008). For the coming years, the intention is to advance and complement work on farmland accounts. Data on the production of crops and other biomass may be easily obtained but there are challenges in presenting a balanced account of the benefits from farmland and the negative impacts of farming activities on other ecosystem services.

  Freshwater accounts also appear to be a priority based on the ONS road map document. Apart from developing physical accounts, initial estimates for monetary accounts were produced for freshwater-dependent ecosystems, including wetlands, open waters and flood plains. Though,

6 http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/dcp171766_361880.pdf

only a limited range of services was considered. These include, fish extraction, water abstraction, peat extraction, estimated based on resource rents, and outdoor recreation/educational visits, estimated by using a 'simplified' travel cost method approximating the value of recreational visits to freshwater ecosystems with the travel cost and time to the site.

Initial accounts for the **marine** environment were produced, though, encountering conceptual and data challenges. Preliminary estimates, based on resource rents, are available on the value of fisheries. However, detailed marine accounts are a low priority.

- **Aggregate natural capital estimates –** By 2020 plans are to improve initial estimates of the aggregate value of ecosystem goods and services provided by natural assets to allow for an immediate overview of the value of the natural assets within the UK.

4 Existing valuation evidence

To complement available information on preliminary NCA estimates in monetary terms, the first step consists of examining the available valuation information and exploring the extent to which this might be employed. Non-market valuation of the environment has been undertaken for over 50 years (for example Davis, 1963; Clawson and Knetsch, 1966), however it is only during the past 30 years that it has become widespread in the UK and European contexts. The early UK applications frequently focused on the benefits of agri-environment schemes and were motivated by the introduction of those schemes following reform of the Common Agricultural Policy (CAP) in the early 1990's. Evidence on the benefits provided by those schemes was sought in order to assess their economic efficiency in the context of a (relatively modest) shift in agricultural support budgets from purely production support to the enhancement of environmental goods' provision. Although this pre-dated the widespread use of ecosystem services frameworks, early agri-environment schemes can be considered as largely concerned with the delivery of cultural ecosystem services (there was a strong landscape element). This contrasted with the purely provisioning service focus of the CAP until that point, which had eroded the cultural and other ecosystem services' provision from agricultural habitats. Beyond the agricultural sector, the adoption of sustainable development as a policy objective had also increased interest in the use of non-market valuation. Since the 1990's the use of non-market valuation has spread beyond that initial agri-environment focus. Early applications also considered cultural and landscape elements of forest management (for example, Willis and Garrod, 1991) again reflecting a shift in the focus of policy away from purely provisioning services towards recreational, biodiversity and landscape benefits.

Despite the abundant evidence base, though, available data on monetary estimates need to be carefully evaluated to explore the extent to which they may be suitable to inform the development of NCA. In response to these issues, Defra recently commissioned research (eftec, 2015) has developed environmental value look-up tables providing indicative estimates. The purpose of these tables was to provide policy analysts with an initial reference source of potentially relevant values to determine the likely magnitude in monetary value terms of policy impacts. Where the look-up tables suggested that values are likely to be significant, this can then act as a guide for determining whether further analysis (e.g. benefit transfer) or primary data collection is justified. The Defra look-up tables also offer advice on the transferability of the values they contain. Other sources, such as the TEEB Valuation Database[7] and an associated manual (McVittie and Hussain, 2013) offers a similar summary of worldwide valuation evidence.

4.1 Assessment of the Defra environmental look-up tables

The Defra Environmental Look-up (EVL) tables were developed by eftec (2015) following a review of UK valuation studies. Users of the EVL tables are able to select from UK NEA broad habitat types and a list of specific ecosystem services. The EVL spreadsheet database then returns (where available) low, central and high estimates of relevant values. An assessment of the quality of the values in terms of strength of evidence and consistency is also returned together with advice on use for benefit transfer and aggregation. Our review of the EVL is primary concerned with determining what the major data gaps are in the UK valuation evidence rather than providing a critique of the EVL tables themselves.

[7] http://es-partnership.org/services/data-knowledge-sharing/ecosystem-service-valuation-database/

4.1.1 Data gaps in the database

The database includes about 40-50 studies, filtered down from an initial 350 impact assessment studies reviewed, which comply with good practice principles for valuation. Monetized information on values was identified after a screening of especially primary valuation research focusing on the UK and on recent (i.e. post 2000) research. Main findings/observations include:

- Monetary information is not provided for supporting services (including soil formation, primary production, nutrient cycle, water cycle, photosynthesis) but just for provisioning, regulating and cultural services. However, directly estimated values for supporting services are problematic as the benefits are reflected in values of final ecosystem services, producing a risk of double-counting. NCA that are consistent with CICES would also not include supporting services as a category.
- Because of the complexities of estimating biodiversity-related benefits and because of the scarcity of UK-based evidence on biodiversity values, biodiversity was not included in the database.
- Cultural services represent the most noted and described services in appraisals, but they are not so much valued in monetary terms.
- Other frequently missed ecosystem goods and services in the database include water purification and waste treatment, freshwater services, food, genetic resources, water regulation, pollination and nutrient cycling.
- Impacts most likely to be monetized include air quality regulation and climate regulation.
- Some habitats are more studied than others. **Freshwater habitats** display the highest ratio of screened-to-identified studies compared to other habitat types. Despite the wide evidence available, though, this reflects a variety of changes in different locations and expressed in different units, so further analysis is required to reconcile current evidence concerning water quality. **Enclosed farmland**, **marine and coastal margins** are not extensively covered in the literature. For marine and coastal margins gaps were especially identified with respect to biodiversity and seascape values. **Woodlands** are well covered in the valuation literature but have the lowest number of screened studies, as studies on woodlands tend to be less recent and they were therefore not included in the EVL value database. **Urban green space** (including parks, gardens, towpaths, urban trees) is a relatively new field of investigation especially at UK level and has the lowest number of identified studies and among the lowest number of screened studies compared to other habitats. Semi-natural grassland and mountains, moors and heaths are well studied, even though very few studies have passed the screening to be included in the EVL tables, either because they are less recent or not UK focused.

Overall, the evidence suggests that key areas that may require further valuation effort to build the evidence base include **urban green space**, **mountains, moors and heaths** (which include **peatlands**), farmland and **semi-natural grassland**. Also, regulating services (pest regulation, waste regulation, pollination) have been generally overlooked across the majority of UK NEA habitat types. A number of studies were identified that focused on cultural services and recreation values but fewer seem to have been focusing on 'landscape values'. Other categories of cultural services such as symbolic and

spiritual are difficult to value (although may be implicit into other cultural categories) and are consequently not represented in the literature[8].

4.1.2 General observations from a preliminary analysis of the database

In the database about 46 studies provide some kind of monetary value. The monetary values provided are either in the form of a point estimate or as an interval range. In terms of methods the prevailing approach is based either on the meta-analysis (with value estimates generally taken from Brander et al., (2008) or, in some cases, on primary valuation, by relying on the travel cost, the hedonic price or the stated preference methods. Due to the great uncertainty in the estimates provided, especially because of the consideration of meta-analysis data, some information is provided on the quality and goodness of the use of the data for informing policy-making processes, based both on strength of evidence (quality and robustness of source study) and level of consistency. Most of the studies reported consider the preferences of the population of users and only to some lesser extent that of non-users. Regarding spatial aspects, these are commonly overlooked in the reviewed evidence. Generally substitute sites are not accounted for, except for a few cases (Hanley et al., 2001; Sen et al., 2014; Christie et al., 2006; Luisetti et al., 2011; Drew Associates, 2004). Especially interesting is the case of Christie et al. (2006) and Luisetti et al. (2011) who introduce a 'distance' attribute in their choice experiments, either to replace the price attribute or in addition to it (distance of the place/site to respondents' home).

4.1.3 Valuing biodiversity

The EVL values give an idea about the value of environmental goods and services, but they also have numerous limitations especially when it comes to biodiversity. Valuing biodiversity is not an easy task. Some aspects of biodiversity (e.g. charismatic mega-fauna) can be demonstrated to have value on their own (see for example Mace et al., 2012). This is specifically recognised in the UK NEA classification of ecosystem services. In the case of accounting, though, it is advisable to consider biodiversity as a 'whole' instead of considering the different biodiversity components. This is not only because focusing on the components of biodiversity may introduce some potential for double-counting. In fact, biodiversity plays a supporting role across a range of ecosystem services and some of the values attributable to biodiversity may have already been accounted for in the calculation of the monetary value of other ecosystem services. Biologically diverse natural assets can also ensure that ecosystems are resilient, which is an increasingly appreciated property of ecosystems that allows them to withstand external shocks. Resilient ecosystems, require some "critical" level of natural capital which need to be preserved and which cannot be traded-off.

4.1.1 Value estimates from the Defra EVL tables may also be appropriate inputs in NCA

If the purpose of the accounting system is to give an overall idea about the magnitude of the monetary values of ecosystem services at an aggregate level, the use of the EVL (or secondary data) values may be regarded as suitable.

However, the EVL values available from the Defra dataset contain insufficient UK-focused evidence and such evidence seems to be biased towards provisioning services and marketed goods (e.g. timber, crop etc.). As the transactions associated with these goods are already recorded in national accounts their inclusion in NCA may be problematic due to the risk of double-counting. Other major

[8] Activity to identify appropriate indicators for cultural ecosystem services is part of RD1.4.1b.

limitations of the EVL values are also linked to the fact that they overlook important aspects, such as spatial heterogeneity, which should also be considered in NCAs.

4.2 Valuation for accounting purposes: recommendations

In this section we present some recommendations for the development of NCA, based on the discussions presented so far in the document. In particular, we will highlight some of the practical issues of applying valuation for natural capital accounting, in terms of what it is that we should value and how this should be approached. The specific approach adopted will depend on the particular nature of the ecosystem services or habitats that we are estimating values for but it will be important to evaluate and adapt the general recommendations to each specific situation on a case-by-case basis during the study design.

4.2.1 Which ecosystem services and habitats are we going to focus on?

Based on the prioritization approach suggested by the SEEA, it is reasonable for the development of the NCA to focus on a selection of habitats and ecosystem services. According to this principle, one criterion can be based on the consideration of priority habitats, identified as those in need of urgent intervention by policy-makers. Taking this, into account, for the case of Scotland, the following habitats/ecosystems should be considered: based on SNH (2016) these include **grassland, woodland, heath, wetland, freshwater, upland**, while based on the UK National Ecosystem Assessment these refer to the broad habitats **mountains, moorland and heathland; semi-natural grassland; enclosed farmland, woodlands, freshwater (including wetlands) and coastal and marine**; these habitat largely overlap with the priority ecosystem categories identified by the ONS in the 2020 road map document.

By excluding the provisioning services, already incorporated in SNAs, the most relevant cultural and regulating ecosystem services in Scotland based on the UK National Ecosystem Assessment are:

- **Hazard regulation** (including **flood regulation** and **soil erosion control**) is an important service provided by all ecosystems (slightly less in grassland, woodland and marine ecosystems), even though in almost all habitats/ecosystems its provision is declining.
- **Soil quality regulation** (including **storage of nutrients**) is generally of high importance in most habitats and its supply has been declining in almost all ecosystems.
- **Climate regulation**, which is importantly supplied by all habitats, is either stable or decreasing for most habitats.
- **Water quality regulation** is of high importance in several habitats/ecosystems except urban areas and its availability is sometimes increasing, sometimes decreasing and sometimes stable.
- **Cultural services** (i.e. local places, landscapes/seascapes, **biodiversity**) are supplied in high (or medium-to-high) levels in all habitats. In general, the trend for cultural services has been either towards stability or increase.

Given the long list of ecosystem services, a sub-set of these might be considered through the identification of priorities in forthcoming stakeholder consultations to gain a better overview of where economic valuation efforts should be concentrated.

4.3 Spatially referenced information

To build NCA, information on the monetary values need to be tightly linked to the biophysical quantification of either the stock of natural assets and/or associated ecosystem services' flows that give rise to the benefits that we are valuing. Ultimately the NCA should reflect the content of the NAR and the information on ecosystem services' flows that derive from it. This would ensure a consistency of data across the RD1.4.1 outputs. However, there is a need to develop case study accounts in parallel to the development of the NAR. This requires that we both use existing data on biophysical flows and ensure the NCA framework and initial valuation data that we collect will be consistent with expectations of the NAR.

Two options for spatially referenced NCA present themselves:

1. We can identify the potential for ecosystem services flows based on habitat type. Here an assessment is made of the types and degree of ecosystem services that are provided by different habitats. A similar approach has been adopted by SNH in their recent revision of the Natural Capital Asset Index. However there are a number of drawbacks to this approach:
    - Available habitat maps such as EUNIS (SNH, 2015) may be of variable accuracy, particularly at finer spatial resolution.
    - Information on flows of ecosystem services by habitat type reflects potential not actual flows, and is derived from expert knowledge at a broad European level (Burkhard et al., 2014).
    - Habitat classifications do not reflect intensity of land use or other biophysical aspects that might influence ecosystem services' flows (e.g. slope and aspect).
    - Ecosystem services' flow potential does not reflect actual supply and use of ecosystem services, therefore more contextual information is required to determine supply.
2. Ecosystem services' maps were developed during the 2011-16 Strategic Research Programme. These covered ecosystem services including: nutrient flows (Nitrogen retention), soil erosion (sediment retention), pollination (habitat suitability for bumblebees), climate regulation (soil organic C concentration), recreation and biodiversity (plant species richness and distinctiveness). Plans for the current Strategic Research Programme are to enrich and expand the development of such maps.

The approach adopted for the NCA will need to be pragmatic, reflecting the ecosystem services that are considered important for different accounting case studies and the availability of complementary valuation data. Consequently, at least the initial NCA case studies may combine different spatial data sources.

4.3.1 How are we going to obtain monetised values?

Where possible, existing valuation evidence based on the EVL tables will be considered. Though, given the limitations highlighted in section 4.1., the reliance on this value evidence should be minimized as much as possible. Especially for those ecosystem services for which poor or no evidence is provided by the available secondary value data supplied by Defra, such as biodiversity, water quality or soil erosion control, primary valuation should be considered.

For the primary valuation, stated preference methods seem to be appropriate. This is because these techniques are capable of estimating non-use values which may play an important role in cultural and some regulating services. In particular, the choice experiment technique seems to be the most appropriate method because it allows to explicitly examine trade-offs between a variety of different ecosystem services and habitats simultaneously.

For the primary valuation, one possible approach would be to collect information on the monetary value of different ecosystem services by habitat type and then to gather evidence across different habitats to ensure a good ecosystem services and habitat coverage.

Another proposal might focus on changes in the levels of given ecosystem services, in a similar way to the Christie et al. (2011) approach. Whilst Christie et al. (2011) asked ecologists to make the link between ecosystem services' values and habitats, another way could be to present respondents with a simplified map showing ecosystem services and habitat distribution. We could then ask people to focus on an area with a given radius around where they live and we could ask people what habitats they focused on and why during the valuation exercise.

An alternative could be to designing two valuation studies: one focusing on different ecosystem services to obtain information on how people make trade-offs over the goods and services provided by the environment and the other would be to focus on the monetary value of different natural assets to understand how people trade-off between different land coverages and uses. Then the information proceeding from the two exercises could be combined to disentangle values by ecosystem service and habitat.

The choice of which approach might work better should be made on a case-by-case basis.

4.3.2 Possible challenges/limitations

In building NCAs, some challenges and limitations should also be considered. One refers to trying to keep a good balance between providing complete information to respondents in the valuation study (specificity) and the degree of generalizability of the results. Regarding primary valuation data collection, the amount of valuation information that can be meaningfully collected given the budget and time restrictions is limited, so careful planning in this sense is advisable to collect as much information as possible. The inclusion of spatial issues has been highlighted as important in building NCAs, however it is likely that only a selection of aspects can be feasibly taken into account. Another important point to define is the scale of the analysis. The scope of the valuation study should be nationwide, even though the consideration of case studies at smaller scale (like regions within countries, parts of regions or specific businesses) are also of interest. Taking into account a variety of different scales would also help to verify to which extent values are matching at different levels and can be transferred across different contexts and geographical scales. There is a considerable risk of double counting in NCA especially when the environmental good is closely connected with other market goods. All attempts should be though made to minimize this risk as much as possible.

5 Proposed initial NCA case studies

The preceding discussion has outlined our review of the approaches to natural capital accounts, recommended valuation approaches and criteria for selection of case study ES or habitats. These issues are not easily resolved, and our final approach will also reflect the need for pragmatism. Even though the plan over the next years of the Research Programme will be to gather as much information as possible on the monetary value of a range of different ecosystem services across the different habitats, based on what discussed in section 4.2.1, for the first year of the Research Programme we propose to undertake the following initial NCA case studies during year 2 of the programme:

5.1 Forests and woodland

We have been approached to participate in a multi-country study on forest recreation values across Europe. This will provide estimates of how different aspects of forest management (e.g. species composition, age structure, management for biodiversity, visitor facilities) contribute to the value placed on forests and woodland by recreational users. The proposed approach for this valuation study will use distance as the main indicator of value such that the values of forest attributes will be related to an estimate of the travel costs of the individual to the site. The approach employed in the valuation exercise will rely on a combined travel cost and choice experiment method. This will allows to overcome various limitations of each method taken on its own. On the one hand, this method requires us to consider links between environmental goods and existing market goods (through the consideration of travel cost expenditures as proxies for the value of ecosystem services). On the other hand, by also relying on the choice experiment method, it allows to obtain estimates of monetary values for hypothetical configurations of forest settings and, in addition, to focus not just on use (e.g. recreation) values but also on non-use values.

This approach will allow the potential for the accounts to be used for the evaluation of prospective future forest and woodland planting. In particular the valuation of age structure may be used to analyse how values might develop over time. This could also be combined with existing knowledge of how carbon sequestration changes over time.

The results of this valuation exercise, which is now being implemented with members of the wider general public at Scottish level, might also be helpful to build a nationwide picture of the demand of recreation. The monetary value information could be combined with information proceeding from the SNH's Scotland's People and Nature Survey (SPANS)[9] data to identify travel times or distances to different types of location for outdoor visits. An alternative to the use of SPANS data might be to undertake recreational opportunity mapping, which combines a variety of relevant data (accessibility, ruggedness, remoteness, etc.) to develop a composite measure (see for example OPENNESS Case Study 9).

5.2 Agriculture

The ONS road map identifies broad habitats related to agriculture: enclosed farmland and semi-natural grassland. This reflects the alignment of ONS efforts with UK NEA habitats rather than economic sectors. We intend to treat agriculture as a sector composed of multiple broad habitat types. This does not preclude the identification of broad habitat level accounts within the agriculture

[9] http://www.snh.gov.uk/land-and-sea/managing-recreation-and-access/increasing-participation/measuring-participation/

sector (e.g. enclosed farmland, semi-natural grassland) and partial accounts for habitats that are impacted upon by agriculture (e.g. freshwater). Our decision to look at agriculture also reflects the relatively good availability of biophysical data and relevant economic valuation data.

Existing environmental accounting frameworks for agriculture (Jacobs and SAC, 2008 and ONS environmental accounts for farmland) will be reviewed and revised. For example the 2008 accounts predated the widespread adoption of ecosystem services as an organising framework. Those accounts largely used secondary valuation data, much of which will be dated. The H2020 PROVIDE project (http://www.provide-project.eu/) is undertaking a primary valuation of the water ecological condition and biodiversity impacts of agriculture in North East Aberdeenshire. The results, which should be available in the early months of 2017, will offer up-to-date values that have been elicited in an agricultural context. We have also identified potential case studies at farm scale where the revised accounting framework can be applied.

5.3 Stakeholder consultation

The Ecosystem and Land Use Stakeholders Engagement Group (ELSEG) workshop in November 2016 was used as an opportunity to explore further priorities for sectors, spatial scales or particular natural capital assets/ecosystem services for the planned and future NCA case studies. Discussions at that event focused on how non-governmental stakeholders could use NCA. In particular, this included applications at different scales, for example including National Parks and individual holdings. There may be interest at some scales in using the benefit (values) information from NCA to inform cost-benefit analysis of land use decisions. A wider range of benefits could be considered and this would go beyond alternative cost-based decision making approaches (i.e. cost-effectiveness analysis).

Brexit was also raised, with the potential for spatially based accounts to be aid targeting of future agricultural support policies, in particular matching supply and demand for benefits such as natural flood management. Linked to this the role of NCA in identifying and demonstrating potential markets for payments for ecosystem services was identified.

6 Conclusions

This paper has presented our review of approaches to natural capital accounting and existing evidence for valuing the benefits that society receives from natural capital. There are a number of ongoing initiatives both internationally and in the UK to develop guidelines and applications of natural capital accounts. Many of these start from basis of identifying physical assets and flows of ecosystem services with limited attention paid to the valuation of benefits. Applying valuation information to natural capital accounts allows users to compare different biophysical outputs and also begin to make comparisons with conventional economic accounts.

The application of economic values to natural capital is faced with a number of hurdles. Many ecosystem services are not traded in markets so do not have readily observable values. Environmental economics does offer a variety of approaches to estimate the value of ecosystem services flows from natural capital. These include inferring values from the cost of replacing ecosystem services or from costs incurred following losses; identifying surrogate markets (revealed preference) such as observing the impact of environmental quality on property values or the cost people will incur to access recreational activities; or hypothetical markets (stated preference) where survey respondents express their willingness to pay for environmental goods and services. However these differing approaches measure different elements of value from cost of provision to the full welfare received from (potential) consumption. In turn these types of value may differ from those used in conventional accounts that rely on observed market prices.

We have also reviewed the contextual issues that are important in valuing ecosystem services. As natural capital and the populations that benefit from its ecosystem service flows are spatially distributed we need to recognise the impacts of that distribution. The distance of beneficiaries from a natural capital asset will impact on the scale and value of benefits received, this will also be affected by the spatial relationship with substitute or complementary assets. These relationships will be more important for some ecosystem services (cultural services such as recreation, water quality, water flow) than others (carbon sequestration, emblematic cultural services). The values that society holds for some ecosystem services may also vary across different natural capital assets even where the service is very similar. For example, there may be difference in preferences for similar flood risk reduction provided by woodland and peatland.

The time and expense required to collect new valuation evidence means that if possible existing values should be used (i.e. benefit or value transfer). Our review of existing UK relevant values (drawing on the Defra Environmental Look-up tables) revealed that there are significant evidence gaps. Cultural services are well represented, but regulating services are a significant gap. Coverage is also variable in terms of habitat types with some better represented than others. This suggests the need for more primary valuation across ecosystem services and habitat types. Given their flexibility we propose to use stated preference approaches for primary valuation studies.

As initial case studies we propose to develop natural capital accounts for forests and woodland, and agriculture. This reflect the availability of good spatial data for these sectors and opportunities that have arisen for relevant primary valuation studies, specifically with respect to forest recreation and water quality and biodiversity impacts from agriculture. Stakeholder engagement with respect to the natural capital accounts has highlighted their potential to inform decision making at a variety of scales, particularly where benefit information across a range of ecosystem services in lacking.

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References

Barbier E (2013) Valuing Ecosystem Services for Coastal Wetland Protection and Restoration: Progress and Challenges, *Resources* 2(3): 213-230. http://www.mdpi.com/2079-9276/2/3/213/htm

Bateman IJ, Brouwer R, Ferrini S, Schaafsma M, Barton DN, Dubgaard A, Hasler B, Hime S, Liekens I, Navrud S, De Nocker L, Ščeponavičiūtė R & Semėnienė D (2011) Making Benefit Transfers Work: Deriving and Testing Principles for Value Transfers for Similar and Dissimilar Sites Using a Case Study of the Non-Market Benefits of Water Quality Improvements Across Europe, *Environmental and Resource Economics* 50(3): 365-387. http://link.springer.com/article/10.1007/s10640-011-9476-8

Brander LM, Ghermandi A, Kuik O J, Markandya A, Nunes PALD, Schaafsma M & Wagtendonk A (2008) Scaling up ecosystem services values: Methodology, applicability and a case study. Fondazione ENI Enrico Mattei, Institute for Environmental Studies, VU University Amsterdam, Venice/Amsterdam. http://www.feem.it/userfiles/attach/2010471736364NDL2010-041.pdf

Brouwer R, Martin-Ortega J & Berbel J (2010) Spatial Preference Heterogeneity: A Choice Experiment, *Land Economics* 86(3): 552–568. http://le.uwpress.org/content/86/3/552.full.pdf+html

Brouwer R, Martin-Ortega J, Dekker T, Sardonini L, Andreu J, Kontogianni A, Skourtos M, Raggi M, Viaggi D, Pulido-Velazquez M, Rolfe J &Windle J (2015) Improving value transfer through socio-economic adjustments in a multicountry choice experiment of water conservation alternatives, *The Australian Journal of Agricultural and Resource Economics* 59(3): 458–478. http://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12099/abstract

Burkhard B, Kandziora M, Hou Y & Müller F (2014) Ecosystem Service Potentials, Flows and Demands – Concepts for Spatial Localisation, Indication and Quantification, *Landscape Online* 34:1-32. http://www.landscapeonline.de/wp-content/uploads/DOI103097-LO201434.pdf

Christie M, Hanley N, Garrod B, Hyde T, Lyons N, Bergmann A & Hynes S (2006) *Valuing Forest Recreation Activities*, Final Phase 2 report to the Forestry Commission. http://www.forestry.gov.uk/pdf/VFRFCFinalReportv5.pdf/$FILE/VFRFCFinalReportv5.pdf

Christie M, Hyde T, Cooper R, Fazey I, Dennis P, Warren J, Colombo S & Hanley N (2011) *Economic Valuation of the Benefits of Ecosystem Services delivered by the UK Biodiversity Action Plan*, Final report to Defra SFFSD 0702. http://users.aber.ac.uk/mec/Publications/Reports/sffsd0702-economic-valuation-uk-bap.pdf

Clawson M & Knetsch KL (1966) *Economics of outdoor recreation*, Published for Resources for the Future by Johns Hopkins Press https://books.google.com/books/about/Economics_of_outdoor_recreation.html?id=FvZW7c_0cUwC

Davis RK (1963) *The value of outdoor recreation: an economic study of the Maine woods*, Thesis Harvard University. http://www.worldcat.org/title/value-of-outdoor-recreation-an-economic-study-of-the-maine-woods/oclc/3113727

Day B (2013) *An overview of valuation techniques for ecosystem accounting*, Issue Paper 1.1 Valuation for Natural Capital Accounting Seminar, 11 November 2013 http://webarchive.nationalarchives.gov.uk/20160105160709/http:/www.ons.gov.uk/ons/about-ons/get-involved/events/events/valuation-for-natural-capital-accounting-seminar/index.html

Defra (2011) *The Natural Choice: securing the value of nature*, HM Government https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228842/8082.pdf

Defra and ONS (2014) *Principles of ecosystems accounting*, Paper by the Department for Environment, Food and Rural Affairs (Defra) and the Office for National Statistics (ONS) http://www.ons.gov.uk/ons/guide-method/user-guidance/natural-capital/related-publications/principles-of-ecosystems-accounting.pdf

Drew Associates (2004) *Research into the Economic Contribution of Sea Angling*, Final report for Defra. http://www.eaa-europe.org/files/economic-impact-sea-angling-england-drew-report-2004_7919.pdf

Eftec (2015) *Developing Corporate Natural Capital Accounts*, Final Report for the Natural Capital Committee http://www.eftec.co.uk/keynotes/envecon-2016/cnca-final-report/download

Eftec (2015) *Development of 'look-up' environmental values for initial appraisal within cost-benefit analysis*, Final report for Defra BE0111 http://sciencesearch.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=19514

European Commission (2013) *System of Environmental-Economic Accounting 2012 Experimental Ecosystem Accounting*, European Commission, Organisation for Economic Co-operation and Development, United Nations, World Bank http://ec.europa.eu/eurostat/documents/3859598/5936709/KS-01-14-120-EN.PDF/334d5c04-b630-4395-8008-94f36712bf6b

Hanley N, Koop G, Álvarez-Farizo B, Wright RE& Nevin C (2001) Go climb a mountain: an application of recreation demand modelling to rock climbing in Scotland, *Journal of Agricultural Economics* 52(1): 36–52. http://onlinelibrary.wiley.com/doi/10.1111/j.1477-9552.2001.tb00908.x/abstract

Hein L, Obst C, Edens B & Remme RP (2015) Progress and challenges in the development of ecosystem accounting as a tool to analyse ecosystem capital, *Current Opinion in Environmental Sustainability*, 14: 86–92. http://www.sciencedirect.com/science/article/pii/S1877343515000408

HM Treasury (2011) *The Green Book: Appraisal and Evaluation in Central Government*, London TSO https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

http://agresearch.teagasc.ie/rerc/EAAE_Pres/papers/A%20simple%20method%20to%20account%20for%20spatially-different%20preferences%20in%20discrete%20choice%20experiments.pdf

Interis MG & Petrolia DR (2016) Location, Location, Habitat: How the Value of Ecosystem Services Varies across Location and by Habitat, *Land Economics* 92(2): 292-307. http://le.uwpress.org/content/92/2/292.abstract

Jacobs and SAC (2008) *Environmental Accounts for Agriculture*, Final Report for Defra, Welsh Assembly Government; Scottish Government; Department of Agriculture & Rural Development (N. Ireland). SFS0601 http://webarchive.nationalarchives.gov.uk/20080306073642/https:/statistics.defra.gov.uk/esg/reports/envacc/default.asp

Johnston RJ, Jarvis D, Wallmo K & Lew DK (2015) Multiscale Spatial Pattern in Nonuse Willingness to Pay: Applications to Threatened and Endangered Marine Species, *Land Economics* 91(4): 739–761. http://le.uwpress.org/content/91/4/739.full.pdf+html

Jørgensen SL,Olsen SB, Ladenburg J, Martinsen L, Svenningsen SR & Hasler B (2013) Spatially induced disparities in users' and non-users' WTP for water quality improvements—Testing the effect of multiple substitutes and distance decay, *Ecological Economics* 92: 58-66. http://www.sciencedirect.com/science/article/pii/S0921800912002790

Kenter JO, O'Brien L, Hockley N, Ravenscroft N, Fazey I, Irvine KN, Reed MS, Christie M, Brady E, Bryce R, Church A, Cooper N, Davies A, Evely A, Everard M, Fish R, Fisher JA, Jobstvogt N, Molloy C, Orchard-Webbe J, Ranger S, Mandy Ryan M, Watson V &Williams S (2015) What are shared and social values of ecosystems? *Ecological Economics* 111: 86-99. http://www.sciencedirect.com/science/article/pii/S0921800915000191

Luisetti T, Turner RK, Bateman IJ, Morse-Jones S, Adams C &Fonseca L (2011) Coastal and marine ecosystem services valuation for policy and management: Managed realignment case studies in England, *Ocean & Coastal Management* 54(3): 212–224. http://www.sciencedirect.com/science/article/pii/S0964569110001961

Mace GM, Norris K & Fitter AH (2012) Biodiversity and ecosystem services: a multilayered relationship, *Trends in Ecology and Evolution* 27(1): 19–26. http://www.sciencedirect.com/science/article/pii/S0169534711002424

McVittie A & Hussain SS (2013) *The Economics of Ecosystems and Biodiversity – Valuation Database Manual*, Report for TEEB/UNEP http://www.teebweb.org/publication/tthe-economics-of-ecosystems-and-biodiversity-valuation-database-manual/

Meyerhoff J (2013) Do turbines in the vicinity of respondents' residences influence choices among programmes for future wind power generation? *Journal of Choice Modelling* 7: 58-71. http://www.sciencedirect.com/science/article/pii/S175553451300016X

Muthke T & Holm-Mueller K (2004) National and International Benefit Transfer Testing with a Rigorous Test Procedure, *Environmental and Resource Economics* 29(3): 323–336. http://link.springer.com/article/10.1007%2Fs10640-004-5268-8

Obst C, Hein L & Edens B (2015) National Accounting and the Valuation of Ecosystem Assets and Their Services, *Environmental and Resource Economics* 64(1): 1–23. http://link.springer.com/article/10.1007/s10640-015-9921-1

ONS (2012) *Accounting for the value of nature in the UK A roadmap for the development of natural capital accounts within the UK Environmental Accounts*, Office for National Statistics http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/guide-method/user-guidance/well-being/publications/roadmap-on-natural-capital-accounting.pdf

ONS (2015) *Natural capital accounting 2020 roadmap Interim review and forward look*, Office for National Statistics
http://webarchive.nationalarchives.gov.uk/20160105160709/http:/www.ons.gov.uk/ons/guide-method/user-guidance/natural-capital/related-publications/nc-accounting-roadmap-2020.pdf

ONS (2016) *UK Natural Capital: Ecosystem accounts for farmland (Experimental Statistics)*, Office for National Statistics

http://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/ecosystemaccountsforfarmlandexperimentalstatistics

OPENNESS case study 9 (2016) *Improved, integrated management of the natural resources within the Cairngorms National Park, Scotland* , in EU FP7 OpenNESS Project, Wijna, van Uden & Delbaere (eds) (2016) Ecosystem services in operation: case studies. European Commission FP7. http://www.openness-project.eu/node/62

Rolfe J & Windle J (2008) Testing for differences in benefit transfer values between state and regional frameworks, *The Australian Journal of Agricultural and Resource Economics* 52: 149–168. http://ageconsearch.umn.edu/bitstream/118536/2/j.1467-8489.2008.00405.x.pdf

Sagebiel J, Glenk K & Meyerhoff J (2015) *A simple method to account for spatially-different preferences in discrete choice experiments*, Paper prepared for presentation at the 150th EAAE Seminar 'The spatial dimension in analysing the linkages between agriculture, rural development and the environment' Edinburgh, UK, October 22-23, 2015

Schaafsma M (2015) *Spatial and Geographical Aspects of Benefit Transfer*, in Johnston RJ, Rolfe J, Rosenberger RS & Brouwer R (eds) Benefit Transfer of Environmental and Resource Values Volume 14 of the series The Economics of Non-Market Goods and Resources pp 421-439. http://link.springer.com/chapter/10.1007%2F978-94-017-9930-0_18

Schaafsma M, Brouwer R & Rose J (2011) Directional heterogeneity in WTP models for environmental valuation, *Ecological Economics* 79: 21-31. http://www.sciencedirect.com/science/article/pii/S0921800912001644

Schaafsma M, Brouwer R, Gilbert A, van den Bergh J & Wagtendonk A (2013) Estimation of Distance-Decay Functions to Account for Substitution and Spatial Heterogeneity in Stated Preference Research, *Land Economics* 89(3): 514-537. http://le.uwpress.org/content/89/3/514.short

Scottish Government (2013) *2020 Challenge for Scotland's Biodiversity - A Strategy for the conservation and enhancement of biodiversity in Scotland*, Scottish Government http://www.gov.scot/Publications/2012/07/5241/4

Sen A , Harwood AM, Bateman IJ, Munday P, Crowe A, Brander L, Raychaudhuri J, Lovett AA, Foden J & Provins A (2014) Economic Assessment of the Recreational Value of Ecosystems: Methodological Development and National and Local Application, *Environmental and Resource Economics* 57(2): 233–249. http://link.springer.com/article/10.1007/s10640-013-9666-7

SNH (2015) Biodiversity - EUNIS land cover of Scotland, http://www.snh.gov.uk/docs/A1622468.pdf

SNH (2016) Biodiversity indicator: Condition of notified habitats
http://www.snh.gov.uk/docs/B424913.pdf

UK National Ecosystem Assessment (2011) The UK National Ecosystem Assessment Technical Report. UNEP-WCMC, Cambridge http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

United Nations (2014) *System of Environmental-Economic Accounting 2012—Central Framework*, United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development, The World Bank http://unstats.un.org/unsd/envaccounting/eea_white_cover.pdf

Willis KG & Garrod GD (1991) An individual travel-cost method of evaluating forest recreation, *Journal of Agricultural Economics* 42(1): 33–42. http://onlinelibrary.wiley.com/doi/10.1111/j.1477-9552.1991.tb00330.x/abstract

Appendix: Summary of valuation methods

Valuation technique	Advantages	Disadvantages
Hedonic price method	• Relates existing market transactions with environmental attributes.	• Difficult to generalize results. • Property markets are complex and segmented, requires large datasets and multiple models. • Risk of double counting market transactions already recorded elsewhere. • Only considers use values, not non-use values
Travel cost method	• Allows disentangling of the extent to which existing market purchases (travel costs) contribute to the recreational enjoyment of the environment.	• Risk of double counting market transactions already recorded elsewhere. • Only considers use values, not non-use values
Defensive expenditure method	• Relatively simple approach, considers expenditure on substitute goods to estimate the value of avoided environmental damages or risks.	• Potentially undervalues the benefits of preventing environmental quality deterioration • Only considers use values, not non-use values
Replacement cost method	• Simple approach • Less time- and resource-intensive as data on value are more easily available	• Assumes that ecosystem goods and services can be replaced and always have substitutes. • Requires evidence that the alternative is demanded by society, otherwise there is no guarantee that the value of the good exceeds the costs and that a cost-based valuation represents at least what society would pay (risk of overestimation)
Stated preference methods	• Main advantage consists of the possibility to consider use and non-use values in the valuation process. • Allow to disentangle trade-offs between the value of different ecosystem goods and services • Strong theoretical foundations • More informative than the other methods	• Not based on exchange value principle and possibly inconsistent with SNA valuation principles.

Benefit transfer	• Can be straightforward to implement. • Lower time and resource requirements then primary valuation studies.	• High risk of uninformative value estimates, unless there is a sufficiently good degree of correspondence and similarity between the 'study' and 'policy' sites.