Reviewing cultural services valuation methodology for inclusion in aggregate UK natural capital estimates

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Executive summary

Background

The Office for National Statistics (ONS) commissioned Ricardo Energy & Environment to undertake this study to develop an approach for valuing cultural ecosystem services[1] (CES), with a focus on those services that provide recreation benefits, for inclusion in the UK's ecosystem accounts.

The study began with a review of potential approaches to value CES within national ecosystem accounts. The findings from the review were then discussed with ONS, and an approach was selected for further development and implementation within the study.

Review of potential approaches

There are currently no clear guidelines for valuing CES as part of national ecosystem accounts. Nevertheless, several studies have attempted to value CES, or related services, at national level. A review of these studies was used to identify potential methodologies with the potential for replication, and further development, as part of the study. A total of 10 separate studies were reviewed.

The review captured a range of different methodologies, and highlighted divergences around key methodological choices. The aim of the review was not to solve these complexities, but instead to identify what might constitute a transparent and practical method that provides useful outputs for policy makers.

Following this review, the simple travel-cost method used in the Initial and Partial Ecosystem Accounts and Freshwater Ecosystem Accounts (ONS, 2014; ONS, 2015) was selected as the most suitable method to further develop for the valuation of CES. This method is transparent, can be implemented based on accessible data and its implementation was achievable within the timeframe of the study.

Development of the approach

The simple travel-cost method developed by ONS as part of the previous studies uses travel expenditure as an indicator of a price associated with CES for recreation if a market existed. We sought to improve on this existing method by making full use of available data, increasing the flexibility associated with the method and making the calculations more transparent.

The method draws upon the Monitor of Engagement with Natural Environment (MENE) dataset which provides the most comprehensive dataset on recreation in England. The data is readily available and provides six years' worth of surveys. No directly equivalent dataset was available for Scotland, Wales and Northern Ireland, so results from England had to be scaled to these regions.

The analysis utilised key outputs from MENE related to: length of visit, type of place visited, distance travelled, mode of transport, the number of adults on a trip, expenditure, and working status of people. These outputs were combined with additional data sources to calculate: expenditure, time spent travelling and on site, values for time, and asset values. The method calculated the total expenditure associated with travelling to recreational sites in the UK and from this asset values were calculated. These calculations were performed in an Excel model.

The simple travel-cost method provides a pragmatic approach, drawing upon existing data, to valuing CES as part of national ecosystem accounts. However, it has some limitations. In particular, the valuation methodology only provides values for those visitors that spent something in travelling to the recreational site. A large proportion of recreational visits are 'free' and are not valued i.e. walking the dog in the local park. Three additional methods were explored as approaches which could provide a value to these 'free' trips:

- The WebTAG approach valued time spent travelling to a recreational site using those values for time used in DfT appraisals.
- The Median Wage approach valued time according to the median wage as captured by ASHE and a factor to reflect assumed opportunity cost.

[1] Defined as the environmental settings that give rise to the cultural goods and benefits that people obtain from ecosystems (UK NEA, 2011).

- Imputed admission fee, taking average admission fees per minute and applying this value to those visitors that didn't pay any admission fees.

Although these approaches do provide a value for those 'free trips' their inclusion in ecosystem accounts is not accepted in the literature and therefore not included in our final valuation.

All calculations were also performed for each location category as recorded in the MENE survey. The categories provided by MENE were mapped to UK NEA habitat classes.

Key results

The key outputs of our calculations are presented in the table below:

Table 1 – Summary of results

Time category	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
UK visits	3,409	2,972	3,249	3,393	3,486	3,713
Total trip time (million hours)	6,844	6,017	6,680	7,164	7,171	7,463
UK expenditure on accessing recreation (£million)	£7,889	£8,432	£7,860	£8,080	£6,562	£6,520
Asset value (£million)	£213,500	£260,154	£225,947	£223,728	£177,665	£166,324

Discussion and recommendations

Our results highlight the issue of using just financial expenditures for CES for recreation. Visit numbers and aggregate trip time increase over the study period but expenditure and asset values fall. Therefore, serious consideration must be given to the value of time or imputing admission fees. Given the existing conventions for ecosystem accounts the values based on expenditure only should be recorded in the ecosystem accounts. But these values should be presented alongside visitor data to demonstrate the gaps in the valuation.

Future work on ecosystem accounting should continue to explore alternative data sources and methodologies but with a firm focus on outputs that are of most use to all stakeholders.

Acknowledgements

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1 Introduction

The Office for National Statistics (ONS) commissioned Ricardo Energy & Environment to undertake this study to:

- Review potential approaches that could be taken to value cultural ecosystem services (CES), for inclusion in the UK's ecosystem accounts;
- Agree the most suitable approach that could be taken forward in the current study;
- Implement the proposed approach.

The output from the study is an estimate of a value for CES for inclusion in the UK's ecosystem accounts.

1.1 Scope of the review

The review of potential approaches included the existing method used by ONS to provide a value for outdoor recreation included in the UK Natural Capital Initial and Partial Monetary Estimates (Initial and Partial Ecosystem Accounts; ONS, 2014) and the UK Natural Capital Freshwater Ecosystem Assets and Service Accounts (Freshwater Ecosystem Accounts) (ONS, 2015).

The literature review was also supported by feedback received from expert stakeholders at a project workshop held in London on 16 July 2016. We subsequently adapted methodologies for valuing CES adopted by ONS in the Initial and Partial Monetary Estimates (ONS, 2014) and Freshwater Ecosystem Accounts (ONS, 2015).

1.2 Agreement of the methodology

In the development of the methodology, a number of success criteria were agreed with ONS at the start of the project, which then informed the project methodology. These were:

- The methodology should be simple and transparent in order to aid understanding and enable emulation by companies and charities that wish to implement their own natural environment accounts.
- The methodology should bear in mind the System of Environmental and Economic Accounting (SEEA) framework (United Nations, et al., 2014) and Defra and ONS' Principles for Ecosystem Accounting (Defra & ONS, 2014).
- The estimated value of CES should focus on recreation but could, ideally, embrace additional facets of amenity value or even of CES more generally.
- The estimated value of CES should be spatially disaggregated, if practical, i.e. if the methodology and available data allow.
- The estimated value of CES should reflect their importance to the UK.

These success criteria reflect the experimental nature of ecosystem accounts, and the ONS' desire that *"something roughly right is more important than undue precision".* Hence, our analysis does not enter into the theoretical debates surrounding ecosystem accounting, and instead is focussed on the development of a practical methodology that could be implemented with the data and time available for the study.

2 Background

2.1 Cultural ecosystem services

The UK National Ecosystem Assessment (UK NEA) defines CES as *"...the environmental settings that give rise to the cultural goods and benefits that people obtain from ecosystems"* (UK NEA, 2011). A classification of the services that fall within the definition of CES is provided in the Common International Classification of Ecosystem Services (CICES), as presented in Table 2[2].

Table 2 – Classification of CES, as defined by CICES

Section	Division	Group	Class	Examples
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	In-situ whale and bird watching, snorkelling, diving etc.
			Physical use of land-/seascapes in different environmental settings	Walking, hiking, climbing, boating, leisure fishing (angling) and leisure hunting
		Intellectual and representative interactions	Scientific	Subject matter for research both on location and via other media
			Educational	Subject matter of education both on location and via other media
			Heritage, cultural	Historic records, cultural heritage e.g. preserved in water bodies and soils
			Entertainment	Ex-situ viewing/experience of natural world through different media
			Aesthetic	Sense of place, artistic representations of nature
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	Emblematic plants and animals e.g. national symbols such as American eagle, British rose, Welsh daffodil
			Sacred and/or religious	Spiritual, ritual identity e.g. 'dream paths' of native Australians, holy places; sacred plants and animals and their parts
		Other cultural outputs	Existence	Enjoyment provided by wild species, wilderness, ecosystems, land-/seascapes
			Bequest	Willingness to preserve plants, animals, ecosystems, land-/seascapes for the experience and use of future generations; moral/ethical perspective or belief

[2] CICES V4.3 http://cices.eu/

This classification is useful for understanding the different kind of services that are captured when referring to CES. However, as reported by ONS, this approach is *"…rather cumbersome to apply in practice and some of the definitions could be described in more accessible terms"* (Defra & ONS, 2014). Moreover, many of these CES are very challenging or impossible to value, particularly spiritual or symbolic services.

It is therefore necessary to develop a valuation framework that where possible identifies the different aspects of CES, but also recognises the difficulties in accurately identifying and valuing these aspects.

2.2 The valuation framework

2.2.1 Defining the scope

As described in Chapter 1, it was agreed that the estimated value of CES should focus on recreation but could, ideally, embrace additional facets of amenity value or even of CES more generally.

Recreation within the context of this study was defined as any leisure activity that takes place at natural environment sites (hereafter referred to as 'sites'). Services for recreation were the easiest CES to capture and value because of the 'physical and experiential interactions' of visitors with the ecosystem, their interaction with economic markets in undertaking the recreational activity, and the availability of related data.

2.2.2 Valuing ecosystem services

Many studies have created 'logic chains' that conceptualise the provision of ecosystem services for the purposes of ecosystem accounting, which are essentially based on the cascade model (Figure 1; Haines-Young and Potschin, 2010; de Groot, 2010).

In relation to recreation, these logic chains establish that CES are dependent on both ecosystems and human inputs, (Cryle, et al., 2015; United Nations, et al., 2014), see Figure 2. Identifying the contributions of ecosystems and human inputs to the CES that provide recreation benefits presented key challenges for valuation.

Figure 1 - The pathway from ecosystem structure and processes to human well-being

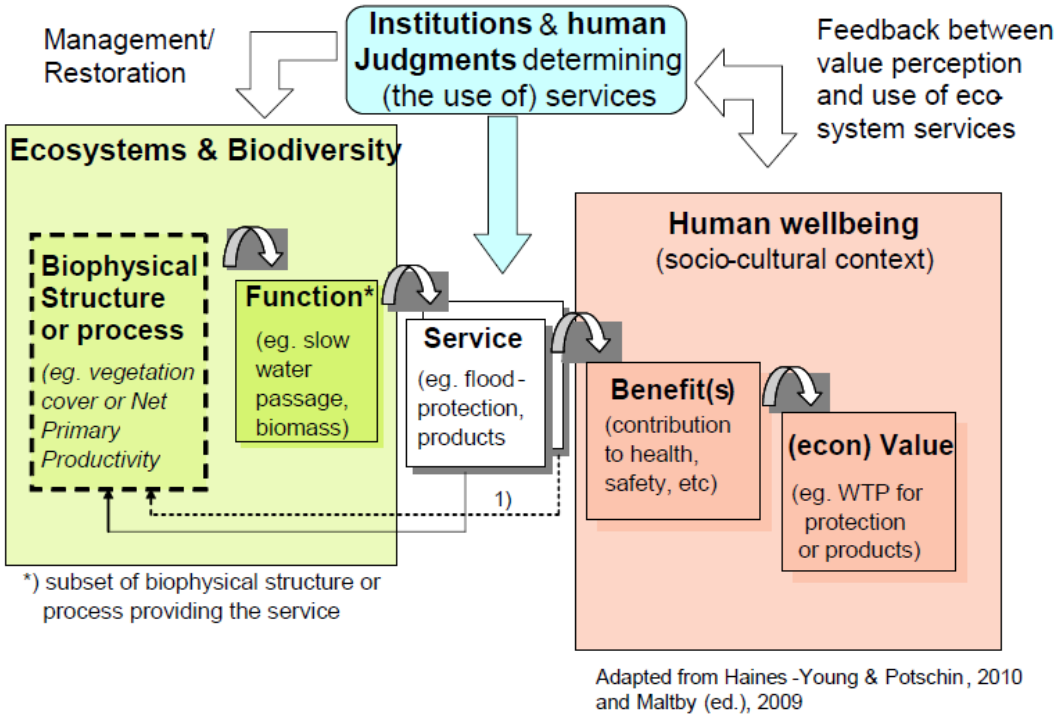
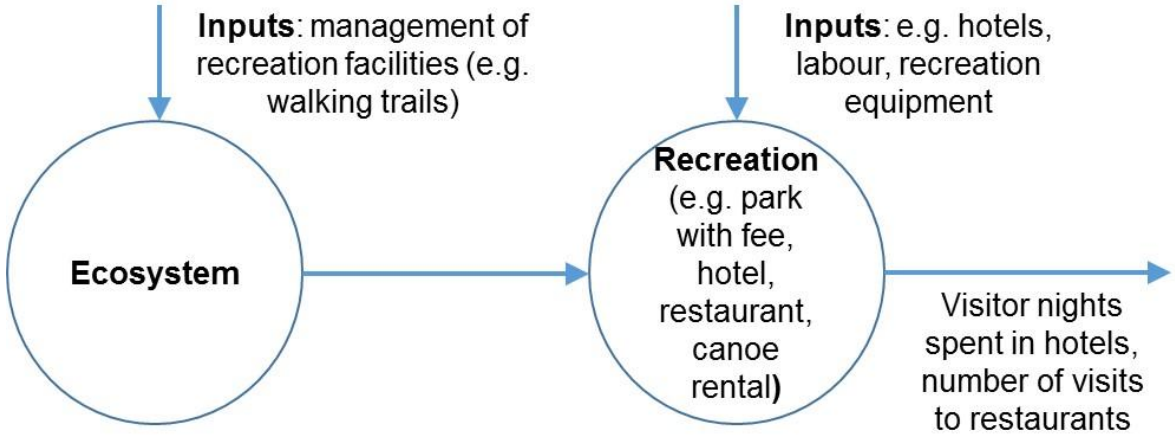


Figure 2 - Logic chain for recreation and tourism services (United Nations, et al., 2014)



Figures 1 and 2 present straightforward links between the ecosystem and human benefits and the concept is easy to follow. Unfortunately, valuing ecosystem services is not so easy in practice, especially within the conventions of ecosystem accounts.

2.2.3 National accounting

Many people visiting ecosystems undertake recreational activities that are within the System of National Accounts (SNA) production boundary[3] due to the interactions with existing markets (admission fees, bike hire etc.). As such, some elements of the value of CES for recreation are already recorded in national accounts, although the specifics are difficult to determine. For example, an admission fee to a site may reflect elements of the value of the CES for recreation arising from both the existence and quality of the ecosystem, and the quantity and quality of human inputs. Some value of CES for recreation is, therefore, reflected by existing markets and contained within the SNA but identifying what exactly is attributed to the CES is one challenge for valuation. What is recorded in the SNA does not reflect CES that provide the full range of recreation benefits where there is no interaction with markets (e.g. for walking the dog, going for a jog etc.).

As stated in SEEA (United Nations, et al., 2014) ecosystem accounts should encompass "… *[1]* ***measurement of the contribution of ecosystems to standard measures of economic activity****, such as GDP and national income, and [2]* ***measurement of the role that ecosystems play in providing a range of other benefits to human well-being that are commonly unpriced and not considered in national level economic reporting and analysis****".* Therefore, the ecosystem accounts should seek to capture those CES that lie outside the SNA production boundary as well as the contribution of CES to standard measures of economic activity, if possible. Finding a valuation method that satisfies either/or both of these valuation challenges (1 and 2) while adhering to the principles of ecosystem accounting was the focus of our literature review.

2.2.4 Ecosystem accounting principles

There is no universally accepted or prescribed method of valuing CES for the purposes of ecosystem accounting. As part of this study, we undertook a literature review in relation to established principles for ecosystem accounting and considered their suitability for our study.

[3] *"Activities are within the economic production boundary defined by the SNA if they comprise: (a) Production of goods or services supplied, or intended to be supplied to units other than their producers, including the production of goods and services used up in the process of producing such goods or services (intermediate consumption); (b) Production of all goods retained by their producers for their own final use (own-account production of goods); (c) Production of housing services by owner-occupiers; (d) Production of domestic and personal services produced by paid domestic staff."* http://unstats.un.org/unsd/demographic/sconcerns/econchar/econcharmethods.htm

Our review of key reports related to ecosystem accounting in the UK and was supplemented by discussions with members of the project steering group from ONS and Defra. A full list of principles extracted from these reports are presented in Appendix 1. There is consensus about many of the principles related to ecosystem accounting set out in the existing literature, such as:

- Valuation should be recorded for both the values of goods and services provided in an accounting period (recorded in the flow accounts) and the present value of current and future goods and services (recorded in the asset accounts) (Defra & ONS, 2014).
- Asset values are regarded as equal to the discounted sum of annual values of ecosystem services (Provins, 2013; United Nations, et al., 2014).
- Valuation should be based on actual use of services (Defra & ONS, 2014).
- The Green Book's discount rate should be used to calculate asset values (Defra & ONS, 2014).
- Assets values should be calculated over a 50-year time frame (ONS, 2015).

However, the literature is less clear on a number of other key issues:

- Exchange values are those values for ecosystem services if a market for the service existed (United Nations, et al., 2014). Some publications favour use of exchange values[4] only:
    - Using exchange values for the purposes of valuation is the favoured approach (United Nations, et al., 2014; Defra & ONS, 2014).
    - Ecosystem valuation for the purposes of ecosystem accounting should align with national accounting approaches (Pittini, 2011).
    - Using welfare values in the ecosystem accounts would require re-estimation of SNA (Provins, et al., 2015).
- Welfare values measure the total costs and benefits that are associated with ecosystem services (United Nations, et al., 2014). Other publications favour using welfare values (not just exchange values):
    - The focus on exchange values is a restrictive approach (Pittini, 2011).
    - There is nothing logically inconsistent with using surplus measures (welfare measures) (Day, 2014).
- With regard to future patterns of use there are differing views:
    - Expected service flows should be based on the current pattern of use (Defra & ONS, 2014).
    - The burden of proof is on the constant flow assumption (Provins, et al., 2015).
- Uncertainty exists in the literature about whether a travel-cost methodology contributes a new line (additional output) to the national accounts or whether it simply reattributes expenditure to ecosystems that is already recorded in the SNA.
    - One view is that this method would not add anything new to the accounts (Day, 2014; Defra & ONS, 2014).
    - While Binner et al. (n.d.) state that *"Travel cost valuation does not 'add up' expenditure on transport and tourism and reattribute it to an environmental sector, but rather uses this data in order to impute a welfare value for the final environmental goods and services in question (recreation)…. complementary market data can be used to estimate recreation values without double counting..".*
- The inclusion of time in ecosystem accounts is particularly controversial:
    - Time should not be valued because it is inconsistent with SNA approaches (Defra & ONS, 2014; Day, 2014). This is a "*logical consequence of existing conventions"* (Atkinson & Obst, 2016).

[4] Considerable debate exists in the literature regarding the use of exchange versus welfare values for the purposes of ecosystem accounting. Day (2014) provides a good introduction to the confusing topic. It is our experience that the definitive guide to the exchange/welfare value debate has yet to be written.

- However, discussions with ONS and Defra have revealed an interest in valuing time to ensure a full range of services are valued when using expenditure-based valuation methods.

The literature, including SEEA, provides no prescriptive or practical recommendations on how to value CES for recreation. Currently, the literature seems to be focused on trying to solve theoretical complications set by valuing CES within an SNA context, and makes few practical recommendations.

2.2.5 Review of existing valuation studies

Existing methods to value CES cover two broad methodologies where preferences and values can be determined through:

1. "Revealed preference" from existing markets, with a valuation determined from hedonic pricing, travel-cost methods and random-utility modelling.
2. "Stated preference" from asking individuals using carefully constructed questionnaires with values calculated by contingent valuation and choice modelling (Defra, 2007).

Values for CES can be measured using both approaches, but revealed preference is often chosen in relation to recreation due to the interaction of people undertaking recreation with existing markets.

There are many studies that have estimated values for CES in relation to recreation. However, the majority of these studies concern local or site level values, and relatively few studies have focused on the valuation of ecosystem services for recreation at a national scale. Fewer still have been undertaken for the purposes of ecosystem accounting.

We focussed our literature review on those studies that had valued CES for the purposes of ecosystem accounting or valued CES on a national scale. In total 10 studies were considered, as described further below. Each of the studies were assessed in relation to the suitability of the methodology for use in the current analysis. Suitability was assessed against the following criteria:

- The method and resultant value is **intuitive** and makes sense to the casual reader. A primary objective of ecosystem accounting is improving "individual and social decisions" (United Nations, et al., 2014) related to the environment. In order to influence decision making, valuation must provide coherent and relatable values for all stakeholders. As a result valuations should not be based on arbitrary values.
- The method was **replicable** by the study team within the timeframe of the study, i.e. the requisite data was accessible and the method was transparent and could be followed easily.
- The method would be **consistent** over time. ONS sought a valuation method, which could be updated (and possibly improved upon) over time.

The key studies reviewed are summarised below.

ONS - Initial and Partial Ecosystem Accounts and Freshwater Ecosystem Accounts (ONS, 2014; ONS, 2015)

A simple travel-cost method[5] was adopted by the ONS for the purposes of their 2014 ecosystem accounts (ONS, 2014) and repeated for the Freshwater Ecosystem Accounts (ONS, 2015). It based the valuation of outdoor recreation on travel expenditure as recorded in the Monitor of Engagement with Natural Environment (MENE). The expenditure associated with reaching a natural environment site was taken as indicative of a price associated with recreation if a market existed. Time was handled differently in the two sets of accounts: in the Initial and Partial Ecosystem Accounts the opportunity cost of time was valued, in the Freshwater Ecosystem Accounts it was not included. Further details on the methodology used in these studies is provided in Box 1 below.

The approach used by ONS in these previous studies is relatively straightforward to grasp and easy to undertake, although, in practice, the value was calculated with limited transparency and the method and its presentation provides an opportunity for substantial improvement.

Box 1: Methodology used in the Initial and Partial Ecosystem Accounts and the Freshwater

[5] The travel-cost method is commonly associated with statistical analysis to estimate demand curves. The simple travel-cost method as described by ONS does not undertake such statistical analysis using aggregate outputs from MENE.

Accounts

The ONS studies both use a simple travel-cost method drawing upon the high-level outputs from MENE, and other data sources. The specific datasets that were used in the studies are summarised in the table below. The datasets are similar but have some slight differences. For example, Freshwater Ecosystem Accounts use additional visit data from Scotland and Wales supported with GIS analysis.

Table 3 – Data sources used in the two existing ONS studies

Variable	Initial and Partial Ecosystem Accounts	Freshwater Ecosystem Accounts
Visit data	MENE data for 2009-2011	MENE 2012 data Scottish Recreation Survey Welsh Outdoor Recreation Survey Supported by GIS analysis
Expenditure data	MENE data – fuel spending and admission fees	MENE data – fuel spending, , parking, admission fees
Wage rates	ONS Annual Survey of Hours and Earnings (ASHE) for years 2007-2011	No data used
Population	Not sure of source but used	Not sure of source but used
Capital costs	No data used	No data used
Inflation Index	GDP Deflator	GDP Deflator

The methodology adopted by the Initial and Partial Ecosystem Accounts and by the Freshwater Ecosystem Accounts are very similar, but with some deviations. A summary of the methodology used in each of the studies is provided below. This is based on information reported in the published reports for both sets of ecosystem accounts. In addition an Excel workbook was also provided for the Initial and Partial Accounts.

The Initial and Partial Ecosystem Accounts

ONS undertook a 'simple travel-cost method' to value outdoor recreation services in their Initial and Partial Ecosystem Accounts (ONS, 2014). A value was given to outdoor recreation through the estimation of individual's willingness to pay by using the cost of visiting a recreational site. The adoption of the simple travel-cost method assumed that a market could exist whereby individuals are charged for their willingness to pay for the CES. The estimated willingness to pay and the number of visits were multiplied together to provide an aggregate value for outdoor recreation in the UK.

Two aspects of travel costs were captured from MENE: expenditure and visit time. Expenditures used in the valuation were admission fees and fuel expenditure. These values were taken from high-level outputs from MENE; the raw data was not used. Parking, public transport and travel time were not included in the analysis. Although visit time recorded in MENE does encompass travel time, this was not acknowledged in the report.

In order to value time, the average duration of a visit was multiplied by 75% of the average hourly wage (based on the Annual Survey of Hours and Earnings, ASHE) and the number of visits. Data was not available for 2007 and 2008 from MENE and was, therefore, estimated using average values of visits, visit time and expenditure from 2009 to 2011 that were present in the MENE data. The resultant figures (fuel and time) are for England, which is the boundary of the MENE survey. These figures were scaled to the UK based on the relative population sizes of England and the UK.

The resultant values represent the yearly flow of benefits from outdoor recreation provided by natural capital. Asset values were calculated using a 25-year asset life using HM Treasury discount rates. All expenditures were provided in 2011 prices using the GDP deflator. The calculated asset

values in 2007 and 2011 were £1.356 billion and £1,353 billion. Annual benefits were equal to £83.9 billion in 2007 and £77.4 billion in 2011.

Freshwater Ecosystem Accounts

A similar approach was undertaken by ONS in valuing outdoor recreation in the Freshwater Ecosystem Accounts (ONS, 2015), although visit time was excluded from the calculations. It was stated that the inclusion of time was an area for future research and therefore excluded from the calculations.

The Freshwater Ecosystem Accounts require a specific habitat breakdown. However, MENE does not provide a breakdown of site visits to wetlands and open waters. Therefore, additional GIS data from Natural England, and data from the Scottish Recreation Survey and the Welsh Recreation Survey, were used to provide a breakdown of site visits to wetlands and open waters. The specific approach that was used in the Freshwater Accounts to estimate visitor numbers is not however clear from the published report.

Expenditure was not only based on fuel spending and admission fees but also parking expenditures, as provided in MENE. Per capita expenditure was calculated for England and then applied to site visits in Scotland and Wales.

Asset values were calculated based on actual and projected benefits over 50 years. The asset values for recreational services were estimated to be between £13.5 billion in 2008 and £13.4 billion in 2012 at 2012 prices.

Economic assessment of the recreational value of ecosystems: methodological development and national and local application (Sen, et al., 2014)

This study describes an approach that was developed to provide an aggregate value for recreational benefits from ecosystems in Great Britain. A trip-generating function was created to predict visitors to particular ecosystems. A meta-analysis function based on 98 different studies provided a unit value for recreation associated with particular habitats. The unit values from the Sen et al study have subsequently been used by eftec (Cryle, et al., 2015), which also adopted the trip generating function, and AECOM (White, et al., 2015) in their ecosystem-accounting studies.

The approach adopted by Sen et al is complicated, as it draws upon data from a range of studies. Therefore, this approach would be difficult to replicate within the timeframe of our study.

An alternative to replication would be the use of the Sen et al (2014) value for the purposes of value transfer. However, this approach was also deemed inappropriate because the meta-analysis was not sufficiently transparent and, therefore, could not be updated over time.

The amenity value of English Nature: a hedonic-price approach (Gibbons, et al., 2014)

This study employed hedonic-pricing and based valuation of CES on a statistical analysis of house prices. It provides a value which is easy for the public and policy makers to understand and appears to be consistent with SNA. Unfortunately, the method requires an extremely large dataset. Decomposing appropriate values for the purposes of ecosystem accounting also presents a difficult hurdle.

This approach was considered inappropriate for the purposes of this study but is discussed further in Appendix 3 as a potential area for future research.

Simulated Exchange Value Method: Applying Green National Accounting to Forest Public Recreation (Oviedo, et al., 2010) and Simulated Exchange Values and Ecosystem Accounting (Caparros, et al., 2015)

The Simulated Exchange Method is a novel method that seeks to answer the challenges of extracting the exchange values of CES for inclusion in ecosystem accounts. Unfortunately, the approach is neither intuitive nor particularly transparent and could not be implemented in the course of this study. Concerns also exist in the literature that the approach is logically inconsistent (Provins, et al., 2015; Day, 2014).

Monetary accounting of ecosystem services: A test case for Limburg province, the Netherlands (Remme, et al., 2015) and Towards Experimental Ecosystem Accounts for the Great Barrier Reef (Australian Bureau of Statistics, 2014)

This method seeks to value CES by subtracting all capital and labour costs from tourism expenditure. It is an attractive model that is intuitive but, unfortunately, accessing the relevant data related to capital costs proved difficult, and the approach also risked resulting in very low values. As discussed in SEEA in open access environments marginal unit resource rents tends to zero (United Nations, et al., 2014).

2.3 Conclusions

The evaluation of the literature confirms that there is no clearly prescribed method for valuing CES for recreation. However, taking into account the specific requirements and limitations of the current study, we selected the simple travel-cost method, as undertaken by ONS, to be most appropriate approach to be develop and applied for the valuation of CES. This selection, along with the results from the literature review more generally, were discussed and agreed at a project workshop held in London on 16th July 2016.

A key strength of the simple travel-cost method using MENE data is that it is straightforward to replicate without the need for additional primary data collection or extensive data processing; it therefore makes good use of existing datasets. Also, by providing a value for CES from the gross expenditure associated with recreational trips to the natural environment it provides an intuitive approach that can be readily understood by the non-expert. This value can be understood as a rough price which would be paid if a market for CES for recreation existed.

However, it is also recognised that the method has some important limitations. In particular, those trips where no expenditure has been made are not represented (when time is not valued) and as such the method does not provide a value for a large number of trips. It also provides only a very broad estimate for CES for recreation that does not take into account trips with multiple purposes. It can also be argued that using only expenditure relates to the market values for the complementary goods, not CES for recreation (Cryle, et al., 2015).

SEEA states that travel cost methods estimate values that include some element of consumer surplus. Unless a method explicitly seeks to extract exchange values it likely that travel-cost methods are not consistent with the conventions as set out in SEEA (United Nations, et al., 2014). But in the absence of any practical method for extracting exchange values this inconsistency is acceptable.

Accepting these methodological limitations, with the time and resource available for this study the simple travel-cost is still preferable to the other methods. It also follows the precedent set by the existing ONS ecosystem accounts.

3 Data sources used or considered by our study

As described above, following the literature review, the simple travel-cost method was selected as the most appropriate methodology for application in the current analysis.

We first describe the data sources that have been used in the analysis, and then the data sources that were considered for use in the analysis, but were subsequently rejected.

3.1 Data sources used

3.1.1 MENE

The main data source available for analysis of recreation in the natural environment is MENE, which collects information about the ways that people engage with the natural environment, such as visiting the countryside, enjoying green spaces in towns and cities, watching wildlife and volunteering to help protect the natural environment. It is focused on respondents in England.

The survey involves weekly waves of interviewing and explores in detail a visit to a site by respondents during the last 7 days (Natural England, 2015). MENE is funded by Natural England and the survey is undertaken by the consultancy TNS.

MENE is the most comprehensive dataset on people's use of the natural environment and is considered an appropriate source for national-level ecosystem accounts (Provins, et al., 2015; Natural England, 2015). We have therefore drawn upon this dataset within our approach. More specifically, we used six years of raw survey data from 2009-2015, which is available online[6].

Our analysis was based on the following questions and their responses in the MENE survey:

- Q3. How long did this visit last altogether – that is from the time you left to when you returned?
- Q5. Which of the following list of types of place best describe where you spent your time during this visit?
- Q8. Approximately how far, in miles did you travel to reach this place [place visited]?
- Q11. What form of transport did you use on this journey?
- Q13a. On this visit how many adults aged 16 or over including yourself, were on this visit?
- Q16. How much did you spend on….[food and drink, petrol\diesel\LPG, car parking etc.]
- Q5. of the standard classification questions. Working status.

3.1.2 Additional data sources

To complement the MENE dataset, the simple travel-cost method requires additional data for the valuation calculations. Building upon the sources used in the previous ONS studies, a range of data sources were identified for the other variables required for the valuation. The main data sources are summarised in the table below. Full details of these sources and how they were used are provided in Appendix 2.

[6] Year 1 -6 year data available here http://publications.naturalengland.org.uk/publication/2248731?category=47018

Table 4 – Data sources used in this study

Variable	Based on the following sources
Car running costs (cost/mile)	DriveinData – car prices in the UK The AA - Running costs in of diesel and petrol cars Government statistics on vehicles mileage and occupancy
Taxis (cost/mile)	Transport for London (TfL) Taxi Fare and Tariff Review
Average speed	Government statistics on road traffic
Inflation	CPI Index provided by ONS
WebTAG values	Department for Transport (DfT) report on Valuing Impacts of Transport Investment
Median Wage	Annual Survey of Hours and Earnings (ASHE) provided by ONS
Population statistics	ONS population projections and estimates

3.2 Additional data sources considered

As part of the development of the methodology some additional data sources were also considered for use in the simple travel-cost method. However, following further investigation, these data sources were found to be either not available or considered inappropriate for the purposes of our analysis. The data sources that were reviewed are described below.

3.2.1 Scottish and Welsh recreation surveys

The Freshwater Ecosystem Accounts used recreation surveys undertaken in Scotland and Wales to help estimate the site visits to wetlands and open waters. The Scottish Recreation Survey, as used in the Freshwater Ecosystem Accounts, is no longer being undertaken. This information is now collected in the Scottish Household Survey. This could have been used in our calculation to provide visit numbers for Scotland. The Welsh Outdoor Recreation Survey is undertaken once every three years and, therefore, does not correspond directly with the annual data presented in MENE. No such survey focusing on recreation in the natural environment exists for Northern Ireland.

Due to the differences in the availability of data and different approaches, we opted for simplicity in adopting the method used by the Initial and Partial Ecosystem Accounts and scaled values for England to the UK based on population.

3.2.2 Tourism data

An alternative data source for calculating the value of CES could be tourism data. There are two different data sources that are used to calculate the UK Tourism Satellite Accounts[7].

First, the Great Britain Day Visit Survey[8] collects data on day visits taken by residents of Great Britain undertaking an activity that:

1. Has lasted at least three hours, including travel.
2. Involved participation in one of the 15 leisure activities.
3. Is not undertaken 'very regularly'.
4. Takes place in a destination which is not the respondent's place of residence.

However, data is collected for all visits as long as they meet criteria 2-4 as presented above.

[7] http://www.ons.gov.uk/economy/nationalaccounts/satelliteaccounts/bulletins/theeconomicimportanceoftourismuktourismsatelliteaccounts/previousReleases

[8] https://www.visitbritain.org/about-gbts-and-gbdvs

The Great Britain Day Visit Survey is a useful dataset, however, the data miss many recreational trips that are made regularly (e.g. dog walking etc.), which limits its usefulness for valuing CES for recreation for the UK's ecosystem accounts.

The second dataset is the Great Britain Tourist Survey[8], which collects data on residents of Great Britain that have returned from an overnight trip within the past four weeks. Data are presented on an annual basis but the raw data are not publicly available. The Great Britain Tourist Survey is able to capture the trips related to the natural environment through Question 13 (Which of the following best describes the type of place you visited on the trip/outing?[9]) and/or through Question 19 (More specifically, which of the following activities, if any, did you take part in during this visit?[10]). In addition, expenditure is captured through 17 product categories, which include transportation and entrance fees. The number of visits, region visited and the duration of trip are also captured. While the data capture a many trips relating to the natural environment, it is also likely to miss recreational trips made from the place of residence.

The Great Britain Day Visit Survey and the Great Britain Tourist Survey were considered inappropriate for use in our study because of their gaps in representation of regular recreational activities. Further work could identify how these data sources could be used alongside MENE.

3.2.3 Capital costs

ONS did not adjust its valuations of CES for recreation in relation to any relevant capital or labour inputs but acknowledged that it was an area for further research (ONS, 2014; ONS, 2015). Unfortunately, no suitable data has become available in the course of this study, so capital costs were not, therefore, considered.

3.2.4 Membership fees

Admission fees are a key component of the expenditure that should be captured as part of the simple travel-cost method. However, many people do not pay admission fees because they pay an annual membership fee to organisations that own natural environment sites. The need to capture this expenditure was discussed during the course of this project.

Nearly one in ten people in the UK are members of environmental organisations but not all join to solely gain access to natural environment sites (Cracknell, et al., 2013). If membership fees are to be recorded in the UK's ecosystem accounts, what they represent and the motivations for paying those fees should be clear.

Membership fees for organisations that own sites in the UK (e.g. National Trust, £157m in 2015[11], RSPB £45.6m in 2015[12]) could be recorded as admission fees to the sites that the organisation manages (i.e. added to admission fees recorded in MENE). However, this would rely on the assumption that the membership fees are tied directly to site admission. Membership of the RSPB, for example, includes a magazine subscription and supports RSPB's conservation work. Extracting the admission charges as a component of membership fees in order to provide an indication of CES for recreation is likely to be difficult. To avoid this complication, membership fees could be used as an indication of the general mix of benefits provided by CES. This would mean that membership fees for those organisations that do not own sites could also be included (e.g. WWF UK £37m in 2015[13], Friends of the Earth UK £1.4m in 2015). However, this does raise the question of the value that should be included that is relevant to the UK. Many environmental organisations undertake international conservation work, so membership fees can contribute towards saving nature across the UK and internationally. The international component should be stripped out for the UK's ecosystem accounts. It may be possible to do so using the split of an individual charity's expenditure on UK and international projects, but it is anticipated that the availability and presentation of such data would not allow for straightforward analysis.

[9] Options include city/large town, small town, village, rural countryside, seaside resort or town, seaside coastline – a beach, other seaside coastline or other.

[10] Include activities such as long walk, hike or ramble, mountain biking, water sports, sailing, short walk etc.

[11] https://www.nationaltrust.org.uk/documents/annual-report-2014-15.pdf

[12] https://www.rspb.org.uk/Images/trusteesreportsandaccounts2015_tcm9-382815.pdf

[13] http://assets.wwf.org.uk/downloads/wwf_uk_annual_report_and_financial_statements_2014_15.pdf?_ga=1.65834350.1124271290.1473426250

Due to the uncertainties described above membership fees of environmental organisations were not included in the analysis. The inclusion of membership fees would provide an additional data source and increase the coverage of the accounts but it is believed the scale would not change the aggregate values by a large amount.

3.2.5 Time-use surveys

One approach which provides an alternative source of data to MENE's recording of visitors and time is the use of time-use surveys. Time-use surveys, also called time-budget surveys, aim to provide information on people's activities over a given time period (generally a day or a week). The intention of many of the surveys is to highlight the time spent on unpaid activities, which is generally either under-recorded in surveys or not recorded at all (Budlender, 2007). The resultant time-use accounts provide the basis for the systematic integration of various measures of well-being (Gershuny, 2011), which can inform public policy. Aside from public policy uses, time-use data can improve our understanding of individual and household behaviour, especially with respect to time allocation decisions and in improving our knowledge of the well-being of the nation (Ver Ploeg et al., 2000).

Time-use surveys provide considerable improvements in accuracy when compared with alternative approaches, including MENE due to its short recall period. In the UK, NatCen Social Research has been commissioned by the Centre for Time Use Research at the University of Oxford to conduct the UK Time Diary Study. This survey of around 5,500 households, funded by the Economic and Social Research Council (ESRC), requires participants across the UK to record what they are doing every ten minutes over the course of two days, giving a unique insight into how the British public spend their time. It reveals everything from work, sleep and eating habits, to how much time people spend socialising and doing leisure activities.

Time-surveys inform understanding of how much time people are spending in the natural environment and how much they are enjoying themselves (by using a metric, such as average subjective enjoyment).

As part of this project, data from the most recent time-use survey was shared with the study team. This data provided details on the time spent undertaking different activities in 'Location 18' as recorded in the time-use survey. Location 18 is defined as parks, countryside, and seaside beach or coast. The data break the time in Location 18 down by main activity and include only people between 8 and 99 years old. The data is scaled by UK population estimates for mid-year 2014 for ages 8 and over.

Nearly 2.7 billion hours (for people aged 8 and over) were spent in Location 18 from April 2014 to April 2015. However, around 43.6 million hours were spent as part of a main job, which we excluded from our analysis. Figure 3 breaks down the top 10 activities, which account for over 75% of the time spent in Location 18. The "other" category comprises 84 activities, which add up to 25% of the time.

Figure 3 - Split of activities undertaken in Location 18 (parks, countryside and seaside of coast), as recorded in the UK time diary study

The advantages of the time-use survey are the increased accuracy of recorded time at a natural environment site. It would also allow time spent in the natural environment (as defined by Location 18) to be put into the context of other activities and locations recorded in the time-use survey. Subjective enjoyment of activities that are undertaken in the natural environment could be compared with activities in other locations. This could be potentially used as an indicator of ecosystem flow. The key disadvantage with this data source is that the survey is only undertaken once every 10 years, and the classification of Location 18 is too broad for any analysis of habitats. It was not considered for this analysis but is a useful potential source of information.

4 How we improved upon the method used in the existing ONS accounts

As concluded in Section 2.2.5, it was agreed with ONS to build upon the simple travel-cost method previously used by ONS in the Initial and Partial Ecosystem Accounts (ONS, 2014) and Freshwater Ecosystem Accounts (ONS, 2015). The simple travel-cost method takes market goods that are consumed as part of a recreational visit (i.e. admission fees, fuel, parking), as providing a marginal price for accessing the site (Day, 2014; Atkinson & Obst, 2016). In this chapter we describe how we have built upon and further developed the method used in these previous ONS studies.

4.1 Making full use of the data

The previous ONS analysis only used high-level outputs from MENE in its analysis for the Initial and Partial Ecosystem Accounts and Freshwater Ecosystem Accounts. In our approach the full dataset (not high-level outputs) has been used to provide a more granular analysis. This allows detailed exploration of the data and resultant value as well as an understanding of the scale of what is not being captured by the simple travel-cost method. Complete raw data files from MENE are provided online in multiple file formats[14].

4.2 Transparency and flexibility

As part of this study ONS shared some of the calculations that were undertaken as part of the Initial and Partial Ecosystem Accounts (ONS, 2014), which were presented in an Excel workbook which did not provide calculations with a clear logical flow.

The calculations that were undertaken in this study are presented in a workbook that is completely transparent, flexible and replicable. This means that if detailed data become available in the future, related to capital costs for example, it will be easy to include them in our calculations and for ONS to update the valuation.

4.3 Expenditures

The expenditures recorded in MENE that are used in our analysis are admission fees, transport fares and parking associated with recreational visits. Fuel costs were not taken directly from MENE, as was done in both ONS studies, instead we developed an approach to calculating travel costs associated with cars, motorbikes and taxis.

The amount spent on petrol/diesel/LPG is recorded as part of Q16 of the MENE survey. The study team was sceptical whether this figure was robust. We felt it was unlikely that respondents would have been able to identify the amount spent on fuel for a specific trip. Instead, we expected respondents would have reported money spent filling the tank while on a trip, which would have subsequently been used on multiple car trips, or would not have reported any fuel cost if they did not visit a petrol station while on a trip. We, therefore, developed a method for calculating expenditure on fuel and running costs in travelling to recreational sites based on MENE outputs on distance travelled by transport mode and using data on the running costs of a car.

4.4 Value of time

The literature states that time should not be included in ecosystem accounting (see Section 2.2.4). However the project steering group recognised that time spent by visitors in pursuit of ecosystem services for the purposes of recreation (i.e. travelling to sites and while on site) may be viewed as reflecting the greatest proportion of the non-market value of those services. A tension exists in presenting values that are consistent with the existing conventions for ecosystem accounting and ensuring that valuations are as representative as possible. **We present a number of options for valuing time but do not believe if the conventions are to be adhered to, that values for time**

[14] Year 1 -6 year data available here http://publications.naturalengland.org.uk/publication/2248731?category=47018

should be included in the final asset valuation. The methodologies presented here are not included in the final valuation but presented for further consideration.

Only the Initial and Partial Ecosystem Accounts valued time. Trip time was valued in its entirety. However, a number of different methods of valuing time exist and some are based on travel time only. In addition, a breakdown of time spent on site and travelling to a site is valuable information. We, therefore, developed a methodology to calculate travel and site time using the MENE data and assumed speeds by mode of transport. These were then valued according to the following three approaches.

4.4.1 WebTAG

WebTAG values are those values used for the appraisal of transport projects and associated reductions in travel time (Department for Transport, 2015). WebTAG values are based on willingness to pay for journey time reductions. We used these WebTAG values to value the travel time to a recreational site.

The advantage of this approach is that it provides consistency across government in the way that time is valued. A disadvantage is that the numbers remain static over time and therefore do not reflect changes in individuals' willingness to pay over time.

4.4.2 Median wage approach

Given limited resources, everyone constantly needs to make decisions about what to do with their time, which implies giving up other potential ways of using it. This is known as the opportunity cost of time.

In the context of this study, a decision to enjoy CES implies giving up other opportunities, such as doing productive work.[15] However, the literature does not provide an agreed economic method to define and calculate the opportunity cost of time. In Table 5 we present two approaches that have been adopted recently in the literature (the first one is related to valuing natural capital).

[15] Technology has made the distinction between leisure and work less clear as people might do work while hiking in forests. However, when discussing the opportunity costs of time, the choices are assumed to be mutually exclusive.

Table 5 - Opportunity cost of time research

Publication/Approach	Valuation of opportunity cost of time	Notes
ONS (2014)	75% of the average hourly wage rate	Based on Fezzi et al (2014) Authors use drivers' actual choices between open access and toll roads to estimate a value of travel time (VTT) that was then used specifically in relation to valuing trips to sites for the purposes of recreation. Results suggest that 75% of the wage rate provides a reasonable approximation of the average VTT for trips to sites for the purposes of recreation. VTT of respondents older than 60 years is, on average, about 30% lower than that of younger age groups.
Oxera (2013)	Assumes that the wage rate is an appropriate approximation of the value of time.	To value the economic impact of GEO[16] services the total number of hours saved was estimated using data on average duration of journeys, and the average reduction in journey time resulting from the use of GEO services. In order to convert the hours saved to a value of time, annual wages were divided by average yearly working hours[17].

As noted, the Initial and Partial Ecosystem Accounts use an adjusted wage rate as representative for all visitors. This results from taking high-level outputs from the MENE survey. However, visitors to ecosystems in pursuit of recreational benefits are heterogeneous and a constant opportunity cost of time spent on site may not be appropriate. For example, as children, unemployed, students and retired people do not participate in the labour market, there is no mechanism by which their opportunity costs can be calculated in relation to the wage rate. For these reasons and for the sake of prudence, we only used 75% (the opportunity cost factor) of the median wage rate (as provided by ONS) for those employed full time and part time[18].

An advantage of this approach is that in being tied to median wage rates that the data is easily updateable. The disadvantage of this approach is that the theory and literature surrounding this approach is not well established.

4.4.3 Imputed admission fees

Owner occupied housing is given an imputed rental value in the national accounts. This imputed value is approximately based on the number of rooms in rent free dwellings multiplied by the average private rent per room[19]. Based on this approach we, therefore, explored the possibility of imputing admission fees for those that did not pay them in accessing recreation sites. This approach is yet to be peer reviewed but is presented here for consideration. It can be seen to be valuing time but based on a rate recreational visitors are already paying. An advantage of this approach is that it adopts a method that has already been accepted as part of the SNA and could, therefore, be potentially acceptable in relation to the conventions of ecosystem accounting.

[16] Geographic mapping and location based services

[17] Theoretical underpinning: The marginal values of leisure and work time should be equal, otherwise individuals would substitute between them.

[18] MENE records occupation and this has been used as the basis of our calculation

[19] http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/about-ons/business-transparency/freedom-of-information/previous-foi-requests/economy/imputed-rent-figures-methodology/index.html

Key questions that remain on this method include whether admission fees as recorded in MENE provide a good indication of the price that recreational visitors, that don't pay admission fees, may pay. In addition this approach is based on the assumption that admission fees are directly related to time spent on site. This is not necessarily true.

4.5 Asset calculations

Both the Initial and Partial Ecosystem Accounts and the Freshwater Accounts do not provide much detail on how asset values were calculated. Asset valuation is based on projected ecosystem flows using a five-year average of actual data. Our method departed from this approach in providing projected ecosystem flows that were adjusted for increases in population and actual visits.

The central issue surrounding calculating asset values was projecting values over the timeframe (50 years) of the analysis. It is our opinion that robust forecasts of variables relevant to recreation should be included in the analysis. ONS projections of population growth (see Appendix 2) were, therefore, used in our analysis and we assumed that visits increased directly in line with population.

Visits are known between the years of 2009/2010 and 2014/2015. These were included in our asset calculations.

4.6 Habitat breakdown

The Initial and Partial Ecosystem Accounts provide no breakdown by habitat, while the Freshwater Accounts provide valuations based only on one habitat. Our method made full use of MENE to provide all outputs by key UK NEA habitat.

4.7 Inflation index

The Initial and Partial Ecosystem Accounts and Freshwater Ecosystem Accounts used a GDP deflator to correct the valuation for inflation. Two price indices were considered in our study, Consumer Price Index (CPI) and GDP deflators. The GDP index measures the change in price in all goods in the economy, while CPI measures the change in price on a defined 'basket' of goods. CPI is considered to be more representative of costs faced by consumers and, therefore, considered more appropriate for our purposes.

5 Our method

Our method built on the simple travel-cost method adopted by ONS described in Section 3 and included our improvements discussed in Section 5. A value is given to CES for recreation through the estimation of individual's willingness to pay by using the cost of visiting a recreational site. The adoption of the simple travel-cost method assumed that a market could exist whereby individuals are charged for their willingness to pay for the CES.

This section explains concepts that underpin the methodology, the data sources used and the calculations undertaken. An outline of the content of each of the sub-sections is described below:

5.1 Use of data**Error! Reference source not found.**– details how the data was handled in the odel

5.2 Expenditure calculations – provides details on how expenditure was captured and calculated for the purposes of this study.

5.3 Time and imputed values – describes the method with which we calculated values of time and imputed admission fees.

5.4 Asset values – details the calculations performed in undertaking the asset valuation.

5.5 Scaling – details how England values were extrapolated to provide UK values.

5.6 Habitats – describes how values were disaggregated by habitat.

5.1 Use of data

MENE described in Section 3.1 was the focus of our analysis and was utilised in the following ways:

- We extracted relevant data (e.g. expenditure, time and/or any other variable) by year and by habitat.
- We used the data extracted from MENE in association with data extracted from other sources to calculate values of interest that are not recorded or not considered robust (travel time, site time, petrol expenditure) in MENE.

The 226MB raw data Excel file for six years of MENE data was downloaded from the Natural England website.

5.1.1 MENE weighting

MENE data required weighting in order to make it representative of the total visits taken by the population of England. These weighting factors were based on the frequency with which a particular question is asked, different questions are asked at different frequencies throughout the year. For example:

- Q8 (distance travelled to place visited) is asked weekly and, therefore, WeekVWeight (as recorded in the Excel visit dataset) would be the appropriate weighting factor to use if analysing just annual miles travelled in England for recreation in the natural environment.
- Q16 (amount of expenditure) is asked monthly and, therefore, MonthVWeight (as recorded in the Excel visit dataset) would be the appropriate weighting factor to use if analysing just annual expenditure in England associated with recreation in the natural environment.

However, instead of using different weighting factors for different questions the study team followed the advice provided by Natural England in that "*When cross-tabulating two or more questions, the weight that relates to the least frequently asked question should be applied."* (Natural England, 2015). This meant that monthly weights (MonthVWeight) were used for response data for all questions.

MENE weighting provided numbers in thousands. Our calculations included an additional step of multiplying the MENE weighting output by 1,000 to ensure that unadjusted figures were used in our calculations.

All calculations explored in the sections that follow are multiplied according to the MENE weighting and to allow for the fact that MENE weighting provides figures in thousands. This is the weighting factor referred to in Figure . A further weighting factor was applied when calculating values based on habitats, this was discussed in Section 5.6.

5.1.2 The model

An Excel model was used in undertaking our method. Excel was chosen as the most appropriate programme for the analysis, given its near ubiquity and that no statistical testing was being undertaken.

The MENE dataset has over 350,000 lines of data and as a consequence the model was particularly large (322 MB). The dataset was imported unedited into the model to maintain transparency resulting in a large file size.

5.1.3 Correcting for inflation and MENE periods

As instructed by the ONS, all monetary measures have been presented in 2013 values. This adjustment was made using the CPI.

MENE data spans March to February, so although in theory the data spans two years, we took the earlier year in the range as the year it represents for calculation purposes (e.g. inflation calculations).

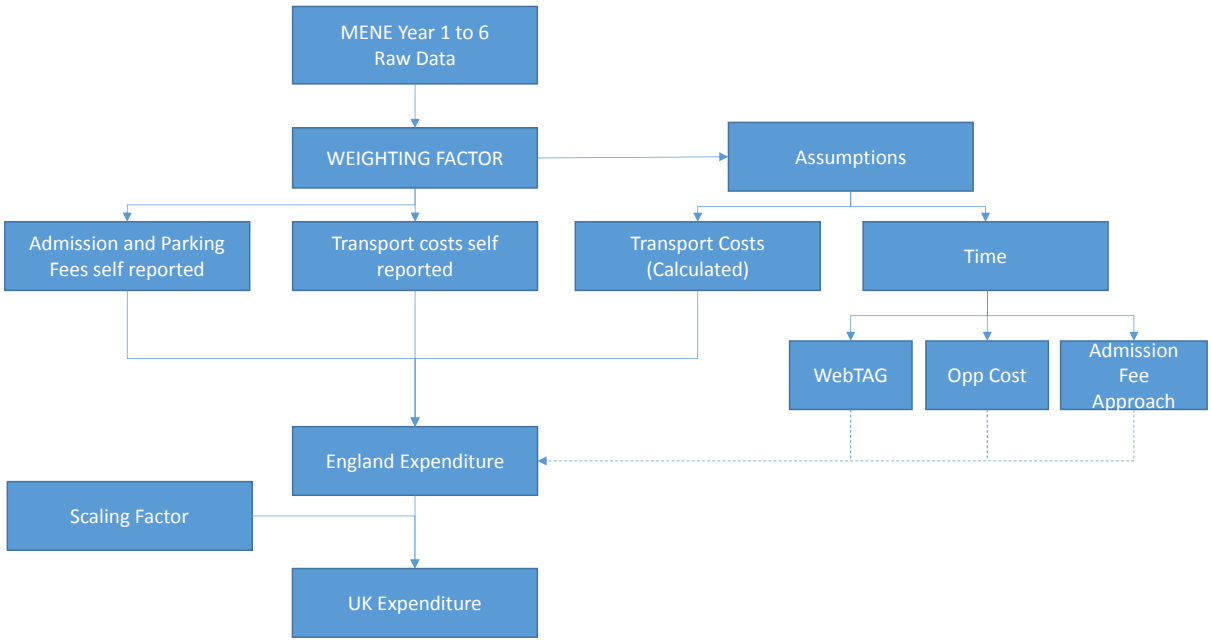
5.2 Expenditure calculations

Our method was based on identifying those expenditures that were incurred by people making visits to the natural environment (as recorded in MENE) for the purposes of recreation. We calculated the following values based on the MENE database for each year that the survey has been reported:

- The aggregate expenditure on travelling to sites for the purposes of recreation.
- The aggregate expenditure on parking at sites.
- The aggregate expenditure on admission fees to sites.
- The aggregate time spent travelling to and from sites, and 'enjoying' sites for the purposes of recreation.

Our approach to the data extraction and calculations is presented in Figure 4 – Calculation overview.

Figure 4 – Calculation overview



This section details how we used MENE data to calculate expenditure incurred by visitors to the natural environment (i.e. associated with transport, public transport, admission fees and parking), which reflects the value of CES for recreation.

5.2.1 Transport costs – calculated

Expenditure was calculated for those journeys to sites involving expenditure on fuel (i.e. cars and motorbikes). This calculation was based on the distance to and from recreational sites (i.e. Q8, multiplied by two to reflect a return trip) divided by the number of people in the car[20] and multiplied by cost per mile[21] associated with cars (motorbikes were assumed to have the same running costs) to calculate the transport cost per trip (see Appendix 2 for the data used in this calculation). This was aggregated for each year that MENE was undertaken.

It is not clear whether taxi expenditure is included as part of the transport fare category of MENE (Q16). Aggregate expenditure on taxis was, therefore, estimated using the same methodology as for cars and motorbikes but using an assumed cost per mile for taxis (see Appendix 2). This was aggregated for each year that MENE was undertaken.

5.2.2 Self-reported expenditure - public transport, admission fees and parking

Self-reported expenditure on bus and train fares was extracted from the MENE database (Q16) for each year. It was felt such expenditure was likely to be easily recalled and strongly associated with an individual trip and, therefore, appropriate to use. Expenditure on admission fees and parking expenditure was also aggregated for each year based on the MENE database (Q16).

5.3 Time and imputed values

The duration of trips by visitors to the natural environment is recorded in MENE (Q3). The following general approach was taken to calculating travel and site time from the MENE dataset. Travel time was determined by taking total miles travelled (as reported in question Q2 * 2) by mode of transport and dividing this by an assumed speed for the mode of transport (Appendix 2). The trip duration (recorded in Q3) minus travel time was then assumed to equal site time.

In the sub-sections below we present two alternative measures for valuing time directly and one method for imputing values for time spent on a site where an admission fee had not been paid. **These values are not included in the asset calculations.**

5.3.1 Time – WebTAG

WebTAG valuation was based purely on travel time, as calculated using the general approach described above. WebTAG values were kept constant across the period of analysis and multiplied by travel time.

5.3.2 Time – Median wage approach

It was necessary to follow the general approach to calculating travel and site time for each occupation (as recorded in the TNS Omnibus) as recorded in MENE to provide heterogeneous opportunity costs in relation to the following categories:

- Full time 30+ hours.
- Part time 8-29 hours.
- Not seeking.
- Retired.
- Unemployed.
- Full-time higher education.

[20] If 4 people are in a car, 1 person will spend money on petrol and maintenance. This will in theory be recorded in MENE by 3 people spending nothing on petrol and 1 person spending £x. But uses mile travelled as the basis of our calculation for running costs. 4 people travelling in the car would report the same distance travelled, if we applied the cost per mile to each traveller petrol costs would be grossly overestimated. Total miles are therefore divided by number of people on the trip to reflect that split the cost across all travellers.

[21] MENE records petrol price. We take running costs of a car which includes petrol, tyres, service labour costs and replacement parts based in the AA analysis (details in Appendix 2) but we exclude parking costs which are calculated elsewhere.

- Part time under 8 hours.
- At school.

Aggregate travel and site time was provided for each occupation type. This time was multiplied by 75%, which represents the opportunity cost factor and by the real median wage, as presented in ASHE for each year. This figure provided the opportunity costs associated with travel and site time. Only full-time and part-time employees were valued using this method.

5.3.3 Imputed admission fee approach

The method in calculating imputed admission fees first recorded the number of visits for people paying admission fees from MENE (Q16). The amount of time that these paying visits spent on site (using the general approach identified above) and the total amount they paid in admission fees were both calculated. Dividing total admission fees by number of paying visits provided admission fees per visit. Dividing the resulting figure by average site time provided the average admission fee per visit per minute on site.

The number of visits of those not paying admission fees is recorded. The site time for these non-paying visits was calculated (using the general approach identified above) and multiplied by the average admissions fee per visit per minute on site. This provided an imputed admission fee for those visitors that did not pay entry to a recreation site.

5.4 Asset values

The following steps were taken in calculating future flows of the CES for recreation. 2009/2010 is used here as an example:

1. To avoid confusion the starting year was referred to (2009/2010 = 2009).
2. Expenditure as calculated for 2009 was recorded.
3. For years 2010 – 2014 actual visits were used. Expenditure was calculated using the 2009 expenditure per visit multiplied by actual visits in these years.
4. For the year 2015 (one year after we have actual visits) an average of the annual visits between 2010 and 2015 was taken (5 year average), this average was increased by the population growth rate between 2014 and 2015. Expenditure was calculated by multiplying these visits by the 2009 expenditure per visit.
5. For the years following 2015, the preceding year's visits were increased at the rate of population growth. Expenditure was calculated by multiplying these visits by 2009 expenditure per visit.

These annual flows were then discounted according to the Green Book's 3% and 3.5% discount rate schedule, as recommended by ONS (Defra & ONS, 2014; HM Treasury, 2011). Asset values are given for each year based on the sum of the discounted values.

5.5 Scaling

Any sophisticated extrapolation of our results from England to Scotland, Wales and Northern Ireland, or spatial disaggregation within England, would require MENE data to be attributed to National Grid Reference (NGR) data and a method of determining recreational visits undertaken (such as the trip generating function used by Sen et al. 2014). This was beyond the scope of our study and, therefore, the calculations based on MENE data for England were simply extrapolated to the other countries of the UK pro rata according to population and were not spatially disaggregated within England.

Table 6 – Scaling factors used

Publication/approach	2009	2010	2011	2012	2013	2014
England population (millions)	52.2	52.6	53.1	53.5	53.9	54.3

UK population (millions)	62.3	62.8	63.3	63.7	64.1	64.6
Scaling factor	**1.19**	**1.19**	**1.19**	**1.19**	**1.190**	**1.19**

5.6 Habitat

The MENE survey asks, "*Which of the following best describe where you spent your time during this visit? Select more than one, if necessary*". The choice of categories are mapped onto the classes of habitat from the UK NEA (Table 7). Five MENE categories do not map neatly to UKNEA habitats and are matched somewhat arbitrarily, as italicised in Table 7.

Table 7. Mapping of MENE survey data to UKNEA habitats used in the UK ecosystem accounts.

UK National Ecosystem Assessment	MENE
Woodland	Woodland, forest
Enclosed farmland	Farmland; *Other open space in countryside*
Semi-natural grassland	*Country park;*
Open water, wetland floodplain	River, lake, canal
Mountain, moorland, heath	Mountain, *hill,* moorland
Coastal margins	Beach Other coastline
Marine	-
Urban	Village; Path, cycleway, bridleway; Park in town or city; Allotment or community garden; Playing field or other recreation area; Other open space in a town or city; *Other open space; playground; and don't know*

The model was constructed to allow all calculations to be run for individual habitats. A macro was included in the model to step through the calculations for each habitat automatically and to record the results.

MENE allows respondents to record multiple locations for their recreational visit, for example, a visitor may spend time in a woodland and a beach. For this reason a habitat weighting factor was constructed to split any expenditure or time equally against the habitats recorded. For instance, if four types of habitat were visited and recorded by a respondent in MENE then each habitat was assigned a weight of 0.25 (1/4) and assigned 25% of the time and expenditure.

6 Results

6.1 Unvalued components

To provide appropriate context to the valuation results in Section 6.2, it is necessary to present visit numbers and trip times. It is important to understand the underlying activity in recreation to allow proper analysis of the values calculated.

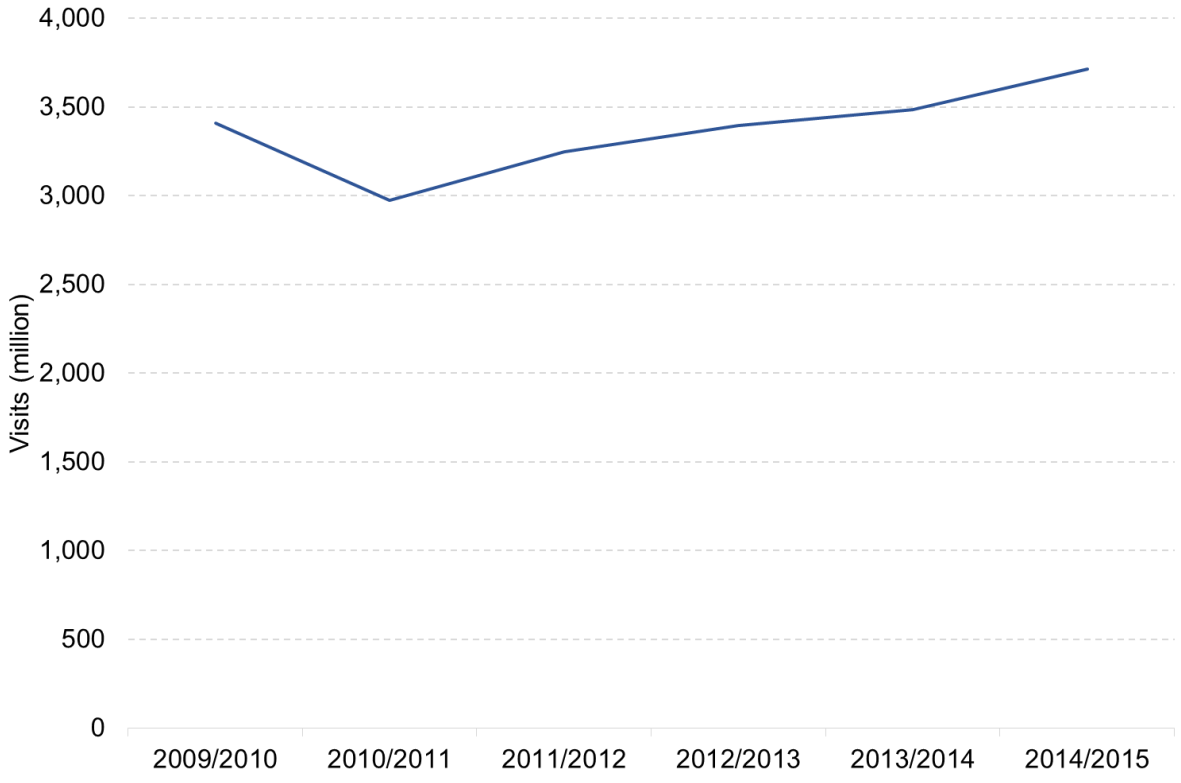
6.1.1 Visits

After a high number of visitors were recorded in 2009/2010, visits rose steadily between 20010/2011 and 2014/2015. The approximate rate of growth each year is 5.7% (using a compound average growth rate[22] (CAGR).

Table 8 - Visits to the natural environment for the purposes of recreation in the UK

	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
UK visits (scaled on the basis of population) (million)	3,409	2,972	3,249	3,393	3,486	3,713

Figure 5 – Estimated visits in the natural environment in the UK



[22] $CAGR = \left(\frac{End\ value}{Start\ value}\right)^{\left(\frac{1}{number\ pf\ periods}\right)} - 1$

Compound average growth rates (CAGR) are utilised to determine general trends in figures. CAGR is the mean annual growth rate between two periods. It provides an easy reference point of analysis of trend in numbers of the study period. CAGR has been calculated between 2010/2011 and 2014/2015, 2009/2010 was deemed an outlier year and therefore not included in the calculation.

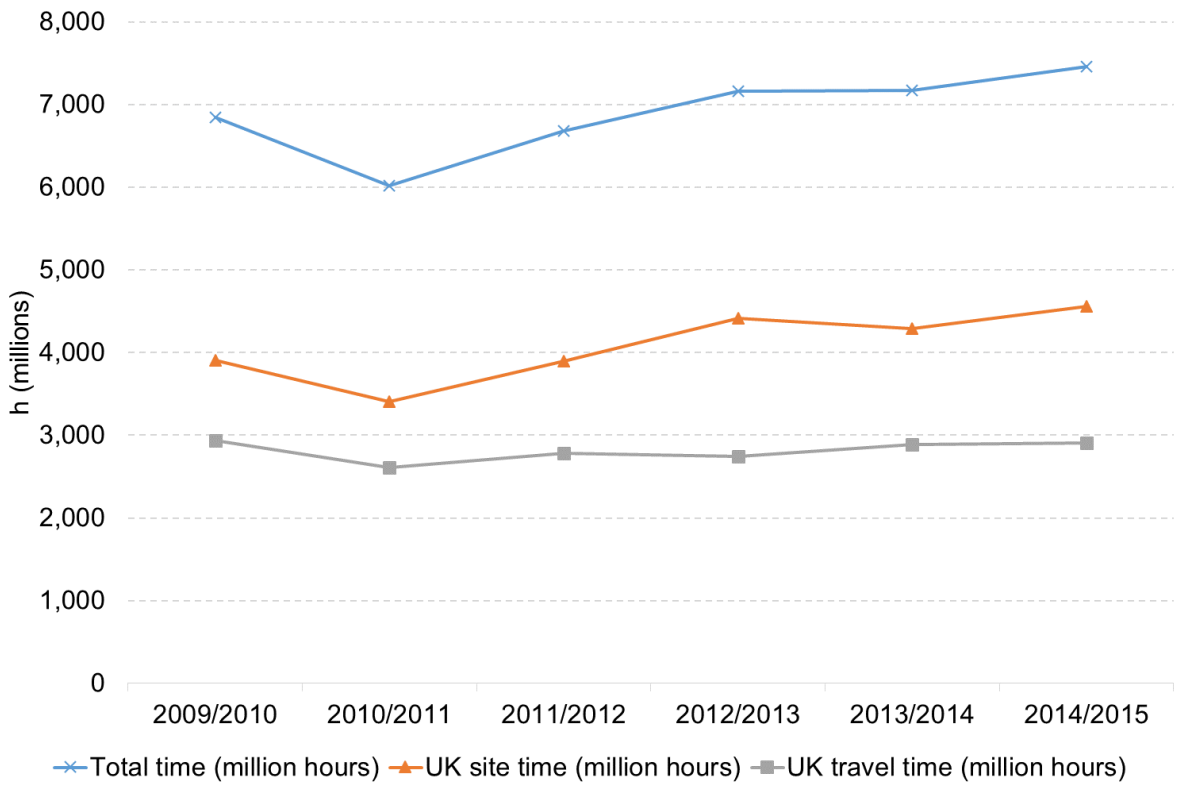
6.1.2 Time spent in travelling to sites for recreation

Visit time in MENE approximately follows the same pattern as that for visits, which is to be expected. 2009/2010 shows a high aggregate visit time followed by a steady growth between 2010/2011 and 2014/2015 (5.5 % CAGR in this period), this period of growth is driven by site time (7.5% CAGR) not by travel time (2.8% CAGR).

Table 9 - Time spent travelling to sites and 'on site' for recreation in the UK

Time category	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
Travel time (million hours)	2,938	2,607	2,781	2,745	2,885	2,909
Site time (million hours)	3,906	3,409	3,899	4,418	4,286	4,554
Total (million hours)	**6,844**	**6,017**	**6,680**	**7,164**	**7,171**	**7,463**
Average Travel time	52mins	53 mins	51 mins	49 mins	50 mins	47 mins
Average Site	1hr 9 mins	1 hr 9 mins	1hr 12 mins	1hr 18mins	1hr 14mins	1hr 14mins
Average Total	2hrs	2hrs 1min	2hrs 3mins	2hrs 7mins	2hrs 3mins	2hrs 1min

Figure 6 – Time spent travelling to sites and 'on site' for recreation in the UK



6.2 CES valuation results

Presented below are our valuations based on the simple travel-cost method of CES for recreation across the UK. These are split between the annual values (ecosystem flow) and asset values.

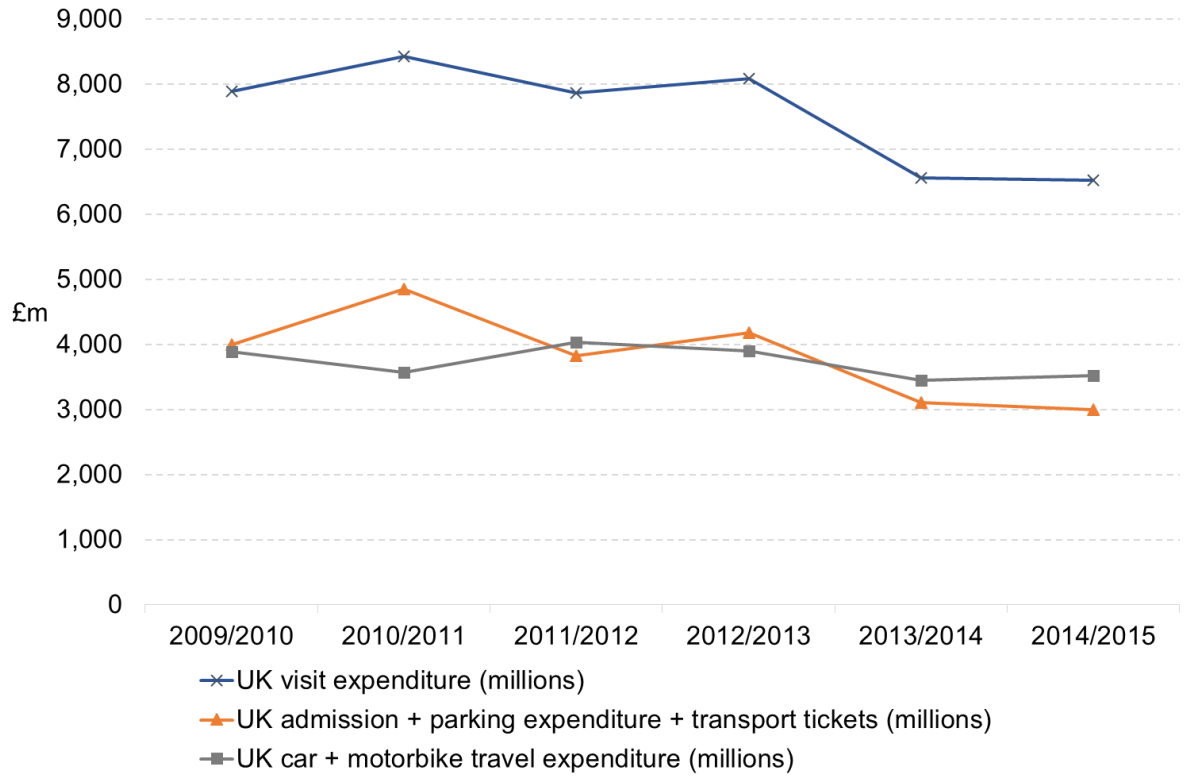
6.2.1 Ecosystem flow valuation

Expenditures associated with recreation generally follow the opposite trend to that demonstrated by visitor numbers. After a low value in 2009/2010, total expenditures fell from a high in 2010/2011 to a low in 2014/2015 (-6.23 % CAGR). This was largely driven by the fall in admission fees, parking expenditures and transport fares, which fell significantly over the same period (-11.4% CAGR %). Expenditures on fuel (including taxis) roughly remained flat over the same period (- 0.3% CAGR).

Table 10 – Expenditure associated with accessing the natural environment in the UK

Type of value	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
UK admiss, parking expenditure, transport tickets (£million)	£3,999	£4,858	£3,830	£4,182	£3,110	£2,994
UK car, motorbike and taxi expenditure (£million)	£3,890	£3,574	£4,030	£3,898	£3,452	£3,526
UK total (£million)	**£7,889**	**£8,432**	**£7,860**	**£8,080**	**£6,562**	**£6,520**

Figure 7 – Expenditure associated with accessing the natural environment in the UK



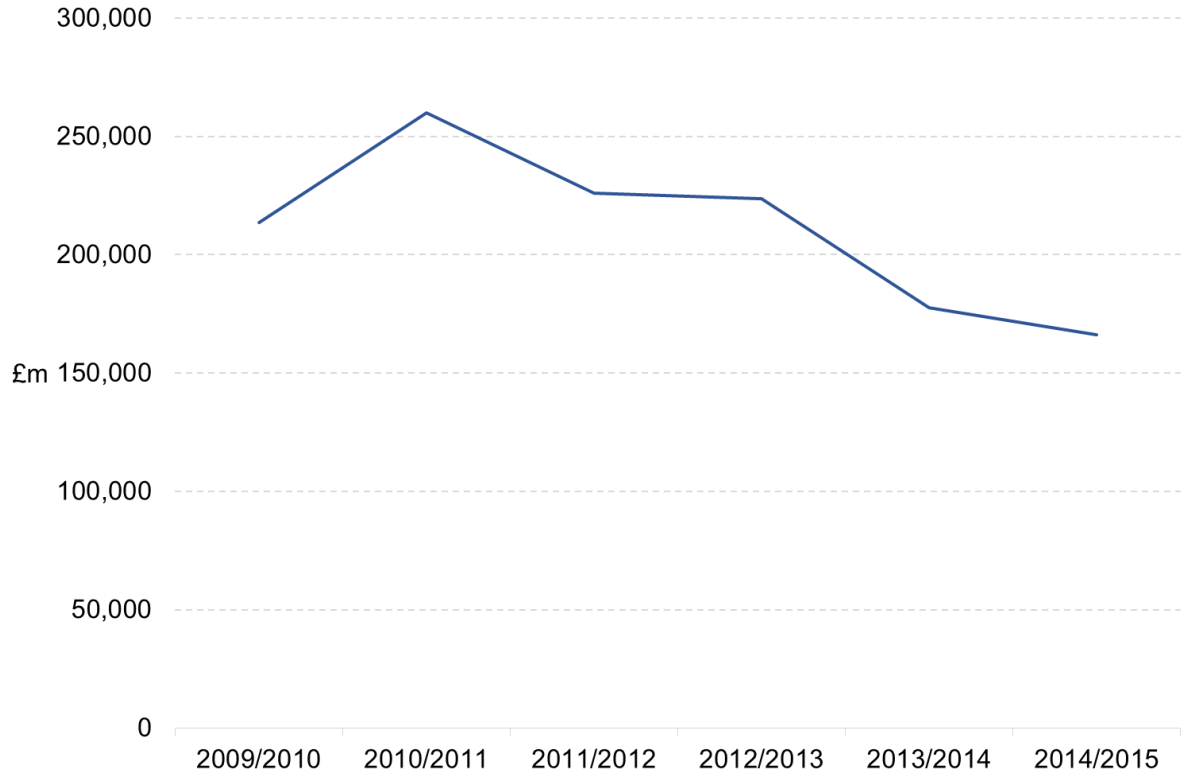
6.2.2 Asset values

Asset values increased the difference in expenditure in years calculated above because the declining per visit expenditures were carried forwards over 50 years.

Table 11 – Asset values based on expenditure associated with accessing the natural environment in the UK

	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
Asset value (£million)	£213,500	£260,154	£225,947	£223,728	£177,665	£166,324

Figure 8 – Asset values based on expenditure on travel to accessing the natural environment in the UK.



6.3 Additional valuation methods

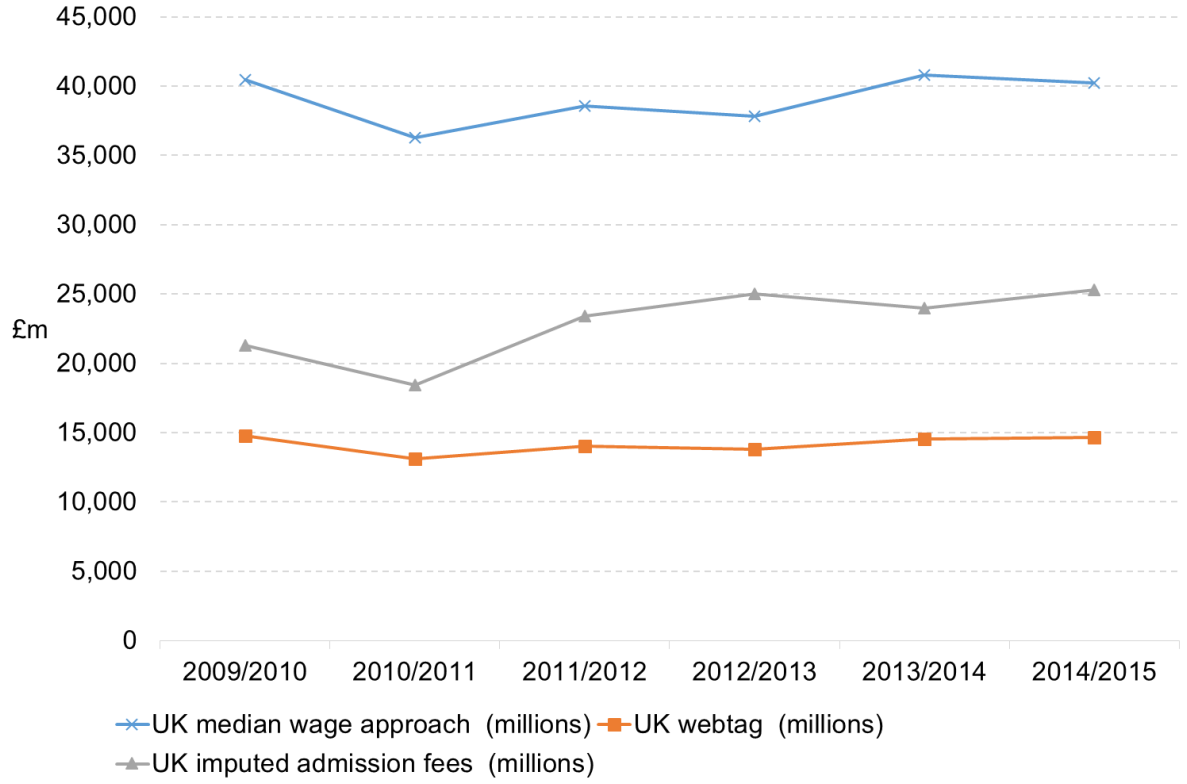
We present below the results of our additional valuations, which explored the valuation of time.

The WebTAG valuation applied a constant value for travel time and, therefore, followed the trends in travel time exactly. The median wage valuation grew at a slower pace than overall trip time despite being directly based on trip times (perhaps as a result of decline in real wages). UK imputed admission fees grew strongly between 2010/2011 and 2014/2015 at 8.8% CAGR.

Table 12 - Additional valuation methods

Method	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
WebTAG (£m)	£14,793	£13,128	£14,002	£13,824	£14,527	£14,646
Median Wage (£m)	£40,055	£36,135	£38,320	£37,422	£40,542	£39,741
Imputed Admission Fees (£m)	£21,303	£18,444	£23,425	£25,001	£23,955	£25,282
Asset Values						
Exp + Webtag (£m)	613,847	668,538	628,458	606,517	570,979	539,940
Exp + Median Wage (£m)	1,309,028	1,388,175	1,335,470	1,270,818	1,282,078	1,192,973
Exp + Imputed Admission Fees (£m)	790,023	840,966	899,361	916,016	826,231	811,280

Figure 9 – Alternative valuation methods (flow values) (£million)



6.4 Habitat analysis

The habitat results are based on the MENE – UK NEA mapping as presented in section 5.6. The strongest growth in visits over the period was demonstrated in urban habitats, which experienced a CAGR of 7.4% between 2010/2011 and 2014/2015. Urban habitats also are the most frequently

visited and habitat with the greatest values. Asset values followed the general trend in all habitats with enclosed farmland showing a particularly steep decline over the period. Totals have not been provided due to the non-linear effects as discussed in the caveats section.

Table 13 - Visits to habitat types

NEA Habitat	MENE Habitat	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015
Woodland (million)	Woodland, forest	294	308	287	246	329	358
Enclosed farmland (million)	Farmland; Other open space in countryside	512	445	471	467	416	478
Semi-natural grassland (million)	Country park;	173	176	183	207	212	219
Open water, wetland floodplain (million)	River, lake, canal	234	165	205	205	198	213
Mountain, moorland, heath (million)	Mountain, hill, moorland	44	38	63	51	71	44
Coastal margins (million)	Beach, Other coastline	296	273	232	249	243	312
Marine (million)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Urban (million)	Village; Path, cycleway, bridleway; Park in town or city; Allotment or community garden; Playing field or other recreation area; Other open space in a town or city; Other open space; playground; and don't know	1,855	1,566	1,809	1,970	2,018	2,090

Figure 10 – Visits to habitat types

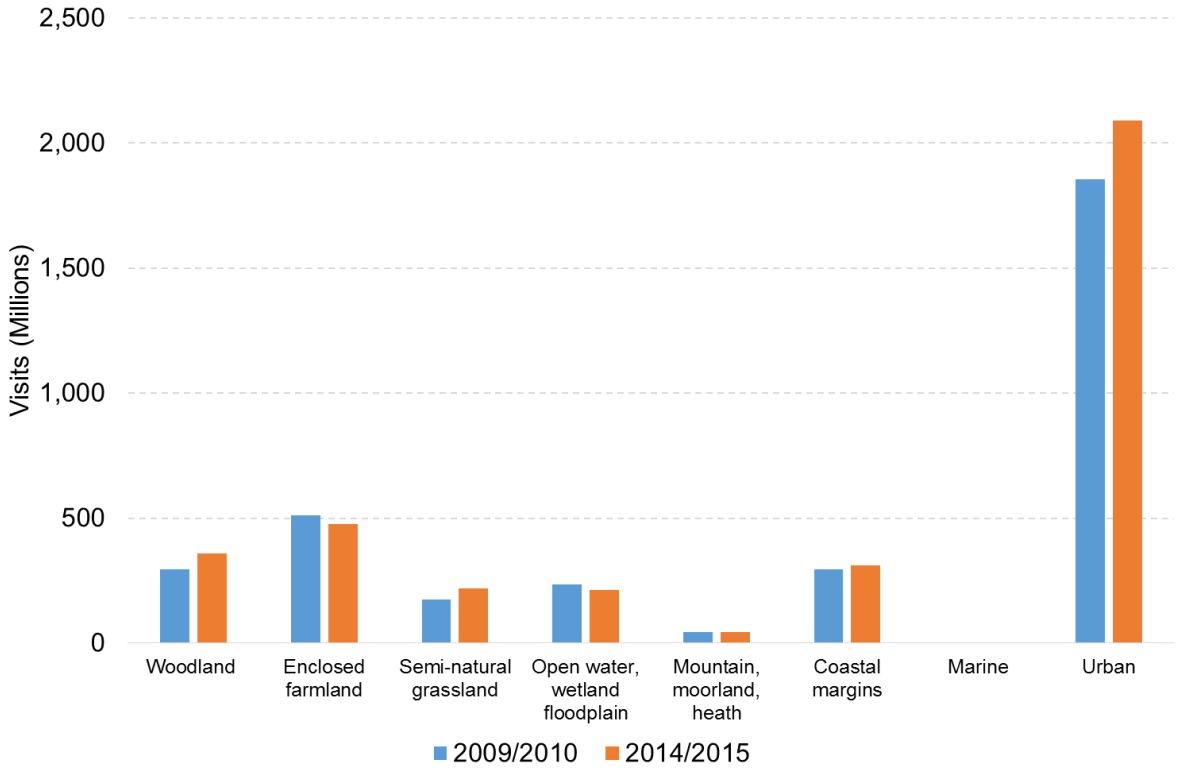
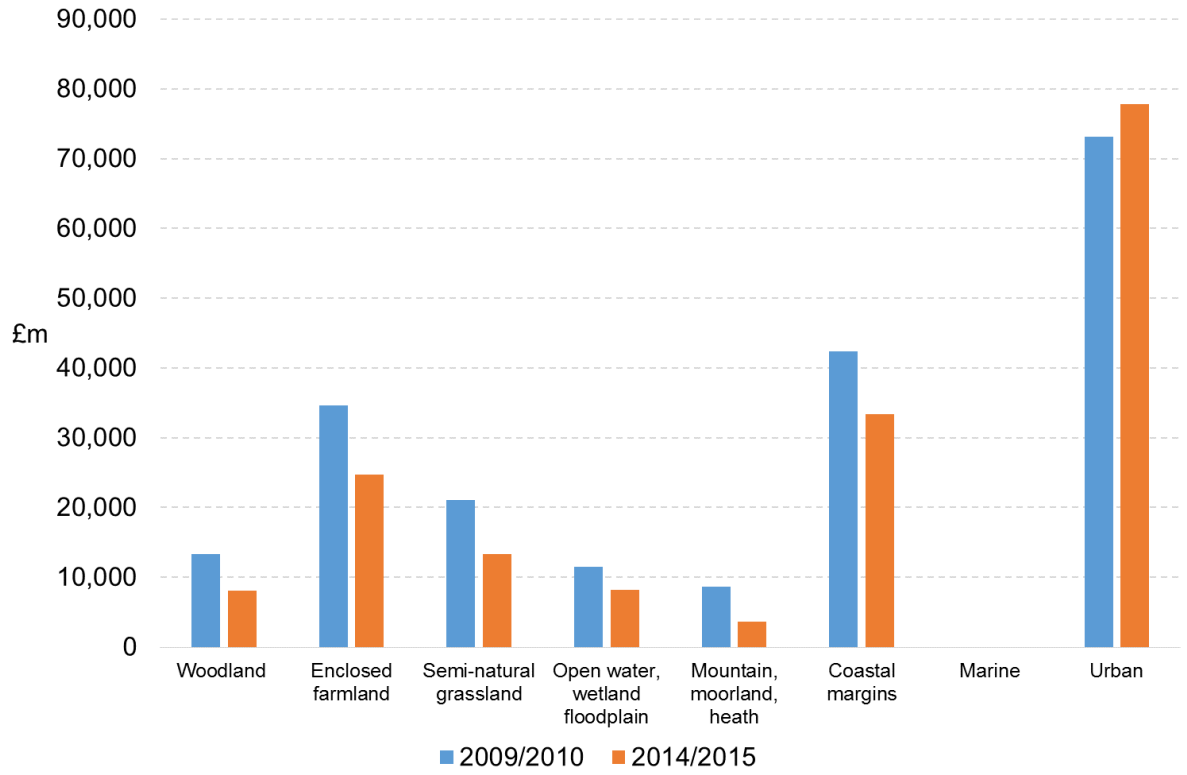


Table 14 - Asset values of habitat types

NEA Habitat	MENE Habitat	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015
Woodland (£m)	Woodland, forest	£13,388	£9,918	£11,492	£16,615	£13,130	£8,053
Enclosed farmland (£m)	Farmland; Other open space in countryside	£34,591	£50,714	£35,105	£21,736	£14,249	£24,740
Semi-natural grassland (£m)	Country park;	£21,109	£19,103	£23,976	£23,164	£19,377	£13,320
Open water, wetland floodplain (£m)	River, lake, canal	£11,483	£13,833	£14,186	£12,083	£12,426	£8,201
Mountain, moorland, heath (£m)	Mountain, hill, moorland	£8,641	£9,383	£7,289	£5,633	£6,978	£3,597
Coastal margins (£m)	Beach, Other coastline	£42,441	£49,428	£47,925	£40,340	£35,024	£33,370
Marine (£m)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Urban (£m)	Village; Path, cycleway, bridleway; Park in town or city; Allotment or community garden; Playing field or other recreation area; Other open space in a town or city; Other open space; playground; and don't know	£73,194	£96,323	£89,175	£106,534	£80,434	£77,850

Figure 11 – Asset values of habitat types



6.5 Caveats

Our approach was based on the best available data. This data was an excellent resource but was not designed for the specific purposes of ecosystem accounting. In order to ensure that our approach is transparent, robust and repeatable, set out below are some caveats that resulted from our method:

- In the model the values for individual habitats for the imputed admission fee approach and asset valuations did not add up to the value when no habitat breakdown was provided (the all habitat value). This issue arose from the use of averages in the model when different habitats with varying sample sizes are applied. The small sample size for certain MENE habitat categories resulted in non-linear effects. The average value (visitors, expenditure or time) for a habitat with a few observations was likely to be swayed by outliers, while a habitat with a large number of observations was likely to centre on a more representative average. Effectively this meant an average of a value taken across all habitats was not equal to the sum of the averages of individual habitats. The end result in the model was an error in summation ranging between -4% and +2%.
- The MENE technical report (Natural England, 2015) applies confidence intervals to visit numbers and expenditures. We did not apply such confidence intervals to our estimates. Our model was a large file and running it took considerable time due to the large computational requirements. Adding confidence intervals would have required running the model with two additional sets of data, which was deemed infeasible. The MENE technical report provides details on confidence intervals in data. In order to provide some indication of the errors associated with our use of the data:
    - The confidence intervals ranged between 2% and 2.6% of estimated visits across all visits in Year 1-4 of the survey (2009-2014).
    - The confidence intervals for all habitats were wider with smaller response numbers. For example allotment visits had confidence intervals that ranged around 31% of their visit numbers for 2009/2010, although this is by far the habitat where there was the least confidence in visit numbers. The average confidence interval (excluding

allotments) was around 9% of total visits across Years 1-4, as presented in the MENE technical report.

- The errors in expenditure per person, as recorded in MENE, were between 15% and 17% in Years 1-4.

The imputed admission fee approach relied on a particularly small sample size (just 2.1% paid admission fees in 2014/2015) and, therefore, the results should be treated with extreme caution.

- Our valuations are based on a number of assumptions on cost per mile of transport and average speeds. We used the best evidence available within the scope of this study in providing these assumptions. It is not possible to provide an indication of the exact errors associated with these sources or calculations but users of the valuation should be aware of the potential inaccuracy resulting from these assumptions.
- As reported in the 2013-14 MENE Technical Report23, the MENE captures expenditure that people make on trips that include a visit to the natural environment. This means that some irrelevant expenditure may be captured by MENE (expenditure on any part of the trip, not just in the natural environment). However, as in the Initial and Partial Ecosystem Accounts, we assumed all travel and expenditure was for the sole purpose of recreation.
- The MENE survey is undertaken between March and February in a given year which means that the data does not fall neatly into either financial years or calendar years. In order to reflect that the majority of survey responses fall within the start year, this year was considered for calculations using additional data sources. This may meant that any responses recorded in January and February were used with the preceding year.
- The habitat results are based on the MENE – UK NEA mapping. The classification of recreation sites as presented in MENE contains considerable uncertainty (specifically what does the other categories represent) and this uncertainty is carried forwards in our mapping to NEA habitats.
- A central assumption of this approach is that travel expenditure is a good indication of willingness to pay for an ecosystem service. Whether this is the case is uncertain and should be acknowledged in any use of the numbers.

[23] http://publications.naturalengland.org.uk/publication/4750201384337408

7 Discussion

7.1 Implications of our results

The results above show that despite visit numbers and visit times increasing over the study period (after the high numbers demonstrated in 2009/2010) expenditure and asset value fell. This fall in expenditure was mainly driven by a large fall in admission fees recorded across the period. Further exploration of the model revealed that this was driven by a particularly large fall in admission fees paid by the 'Other Countryside' location (as recorded by MENE). However, visitors overwhelmingly spent time on sites where no admission fees was required (97.9% of visits pay no admission fees in 2014/2015). In addition, modes of transport with no associated costs represent 67.7% of all visits (67.3% trips paid no admission fees or had any associated transport cost).

These results demonstrate the scale of CES for recreation that are unvalued using a simple travel-cost method that focuses on purely financial expenditures. Such results provide a strong argument for valuing trips where there has been no interaction with an existing market. This is the reason behind the appetite to value time in the ecosystem accounts and the different methodologies considered in our study. Imputed admission fees present a novel approach but a question remains whether admission fees paid by just 2.1% of visits in 2014/2015 can provide an imputed admission fee that is representative of all trips.

The results also demonstrate the importance of understanding the different dynamics behind the trends in asset and flow values. Increasing/decreasing asset values could be driven by a wide variety of factors which does not necessarily translate to enhanced/degrading ecosystem services.

7.2 Use of the values

How the valuations should be recorded is a source of uncertainty in handling the results. As discussed in Section 2.2.4, uncertainty exists in the literature about whether a simple travel-cost methodology contributes a new line (additional output) to the national accounts or whether it simply reattributes expenditure to ecosystems that is already recorded in the SNA. The uncertainty hinges on whether the simple travel-cost method provides a welfare value of CES for recreation and, therefore, represents a previously unvalued component of ecosystem value, or if the simple travel-cost method just reattributes values that already exist in the SNA to the CES. We have come to no firm conclusions on this matter and recommend that ONS follow the bulk of literature (Day, 2014; Defra & ONS, 2014; Atkinson & Obst, 2016) on this issue and take the value of the CES based on expenditure calculated using the simple travel-cost method as already included in the SNA and reattribute it to the CES, although this is an area for further clarification.

If values for time are considered in the ecosystem accounts, they would be much larger than expenditure values and much larger than ecosystem service values calculated for other ecosystem accounts. It is our understanding that this is source of concern for those compiling accounts. However, the large size of resultant values should be unsurprising, given the following considerations:

- There are a large number of visits that go unvalued in the existing accounts. These values would be added to trips where expenditure has been made.
- Time is unlikely to be a valued component of any other ecosystem service and, therefore, any comparison made across ecosystem services would not be comparing like for like.
- The scale of a value is not a reason to be uncertain about a non-market valuation. These valuations look to capture what previously has not been recorded in an accounting context and, therefore, focus should be on the assumptions that go into a valuation instead of the final valuation.

7.3 The future of the MENE survey

Our study has been based on MENE due to the availability of the data and because a precedent exists (ONS, 2014; ONS, 2015) in using the data to calculate CES for recreation. Although the MENE is an excellent source of data for the purposes of ecosystem accounting in its current form, the survey is likely to change over time, with frequency and the detail of the survey likely to be subject to

revision. The future of the survey is currently open to consultation[24]. However, the issue presented by MENE is common to all government datasets, as no guarantee can be given that any will be maintained unchanged or that data collection will be continued in perpetuity. Notably, MENE fulfils a range of purposes and our proposed use of it in relation to the UK ecosystem accounts should further strengthen the case for maintenance of the MENE and its current methods.

[24] https://consult.defra.gov.uk/statistics/specific-proposed-changes-to-official-statistics/supporting_documents/Annex%20A%20Natural%20England%20statistics.pdf

8 Recommendations

We present below key recommendations arising from our study.

8.1 Results to include in ecosystem accounts

- We recommend including our annual flow and assets values based on expenditure only in the ecosystem accounts but this should be heavily prefaced by the context of recreational visits in the UK.
- We recommend these are considered values that are already recorded in the national accounts and should, therefore, be reattributed to CES for recreation, although further guidance is required on whether the theory of travel cost supports this assumption.

8.2 Priorities for future data collection

MENE is a useful resource, but not a perfect one for ecosystem accounting. We recommend the following considerations to improve MENE for this purpose:

- We made assumptions in calculating time spent travelling and on site. It would be extremely helpful if MENE were to reduce the need for these gross assumptions (average speeds/mode of transport) by asking about the time on site and time spent travelling.
- The weighting of MENE appears to be led by age, region of residence, social grade presence of children, sex and working status, presence of children and/or a dog in the household and urban/rural residence. It is not clear whether a weighted visit is representative of the expenditure made, distance travelled or visit time. Further work should seek to understand whether this weighting can be tailored for the purposes of ecosystem accounting.

8.3 Future method developments

Further research should:

- Consider how tourism data could be included with the MENE data.
- Clarify whether membership fees of environmental organisations can be used in ecosystem accounts as indicative of CES.
- Seek to access data on capital costs associated with recreation and consider how they should be used in valuation of CES.
- Understand whether developments in time-use surveys can be used in ecosystem accounts including the study of wellbeing.
- Seek to identify admission fees for different recreational sites and experiences (and perhaps suggested admission fees from membership fees) to tailor the imputed admission fees calculation.
- In general, there is a need to consider the marginal costs associated with increased complexity (in terms of loss of understanding of the method, time spent on calculations) and whether such complexity provides ecosystem accounting with a clear path forwards (as opposed to solving theoretical problems).

8.4 Priorities for future work in this area

The priorities in this area are:

- Adopting a top-down approach to the objectives of valuing ecosystem services in ecosystem accounts. The ultimate use of ecosystem accounts needs to be better understood and as result what aspects of value would be most effective in reaching that goal. Trying to find a methodology that satisfies each of the conventions of ecosystem accounts has produced many think-pieces but little practical guidance. This focus on theory debate risks diverting attention away from the primary goal of valuing ecosystem services to support individual and social decision-making.

9 References

Atkinson, G. & Obst, C., 2016. *Defining exchange values for non-market transactions in ecosystem accounting using environmental economics,* s.l.: s.n.

Australian Bureau of Statistics, 2014. *Towards Experimental Ecosystem Accounts for the.* Information Paper for the 20th London Group Meeting New Delhi, 15-17 October 2014, s.n.

Binner, A. et al., n.d. *Scoping study on valuing the social and environmental benefits of trees and woodlands in England, Scotland and Wales,* s.l.: Forestry Commission.

Budlender, D., 2007. *A Critical Review of Selected Time Use Surveys,* Switzerland: UNRISD.

Caparros, A., Oviedo, J. & Alvarez, A., 2015. *Simulated Exchange Values and Ecosystem Accounting,* s.l.: CSIC Working Paper.

Cracknell, J., Miller, F. & Williams, H., 2013. *Passionate Collaboration,* s.l.: Green Funders.

Cryle, P. et al., 2015. *Developing UK Natural Capital Accounts: Woodland Ecosystem Accounts.* s.l.:s.n.

Day, B., 2014. *An overview of valuation techniques for ecosystem accounting.* s.l.:s.n.

Defra & ONS, 2014. *Principles of ecosystems accounting.* s.l.:s.n.

Defra, 2007 . *An introductory guide to valuing ecosystem services,* London: Defra.

Department for Transport, 2015. *Understanding and Valuing Impacts of Transport Investment - Values of travel time savings,* London: s.n.

Fezzi, C., Bateman, I. & Ferrini, S., 2014. Using revealed preferences to estimate the value of travel time to recreation sites. *Journal of Environmental Economics and Management,* Volume 67.

Gershuny, J., 2011. *Time Use Surveys and the Measurement of National Well-Being,* Oxford: Centre for Time-use Research Department of Sociology University of Oxford.

Gibbons, S., Mourato, S. & Resende, G. M., 2014. The amenity value of English nature: a hedonic price approach. *Environmental and Resource Economics,* pp. 175-196.

HM Treasury, 2011. *The Green Book,* London: HM Treasury.

Natural England, 2015. *Monitor of Engagement with the Natural Environment - Technical Report from year 6 of the survey,* s.l.: Natural England.

Natural England, 2015. Weighting and analysing MENE data – a guide for SPSS and Excel users.

Obst, C., 2015. *SEEA Experimental Ecosystem Accounting: Technical Guidance - Draft,* s.l.: s.n.

Obst, C., Hein, L. & Edens, B., 2016. National Accounting and the Valuation of Ecosystem Assets and Their Services. *Environmental and Resource Economics,* pp. 1-23.

ONS, 2014. *UK Natural Capital - Initial and Partial Monetary Estimates,* s.l.: s.n.

ONS, 2015. *UK Natural Capital- Freshwater Ecosystem Assets and Services Accounts,* s.l.: ONS.

Oviedo, J., Campos, P. & Caparros, A., 2010. *Simulated Exchange Value Method: Applying Green National Accounting to Forest Recreation,* s.l.: CSIC Working Paper.

Oxera, 2013. *What is the economic impact of GEO services? A report prepared for Google,* s.l.: s.n.

Pittini, M., 2011. *Monetary Valuation for Ecosystem Accounting.* London: s.n.

Pittini, M. et al., 2013. *Towards a valuation strategy for natural capital accounting in the UK Roadmap.* s.l.:s.n.

Provins, A., 2013. *Accounting for the Value of Wetland Services.* s.l.:s.n.

Provins, A. et al., 2015. *Applying Values in Ecosystem Accounting.* s.l.:s.n.

Remme, R., Edens, B., Schroter, M. & Hein, L., 2015. Monetary accounting of ecosystem services: A test case for Limburg. *Ecological Economics,* Volume 112, pp. 116-128.

Sen, A. et al., 2014. Economic Assessment of the Recreational Value of Ecosystems: Methodological Development and National and Local Application. *Environmental Resource Economics,* pp. 233-249.

Smith, C., 2016. *Valuing recreation in the aggregate accounts.* s.l.:s.n.

UK NEA, 2011. *Chapter 16 Cultural Services,* Cambridge: UNEP WCMC.

United Nations, European Commission, Food and Agricultural Organization of the United Nations, Organisation for Economic Co-operation and Development, The World Bank, 2014. *System of Environmental-Economic Accounting 2012 – Experimental Ecosystem Accounting.* New York: United Nations.

Ver Ploeg et al., 2000. The Importance of Time-Use Data. In: *Time-Use Measurement and Research: Report of a Workshop.* s.l.:National Academies Press, p. 128.

White, C. et al., 2015. *Developing ecosystem accounts for protected areas in England and Scotland - Technical Appendix,* s.l.: Defra and the Scottish Government.

Appendices

Appendix 1: Principles

Appendix 2: Assumptions and data sources

Appendix 3: Hedonic pricing

Appendix 1 – Principles

We present our notes made when going through the literature related to principles of ecosystem accounts

Key consideration	Source
Ecosystem services	
P2.1 Subsoil assets are not part of the ecosystem accounts.	(Defra & ONS, 2014)
P7.1 We will make full use of the UK NEA's matrix of services and habitats for assessing the state / risk and significance / value of services within a habitat.	(Defra & ONS, 2014)
P8.1 The Common International Classification of Ecosystem Services (CICES) should be adopted in a flexible way.	(Defra & ONS, 2014)
P8.2 We should use birds and other relevant indicators *pro tem* for biodiversity.	(Defra & ONS, 2014)
Spatial scale and scope of ecosystem service	
P3.1 Ecosystem accounts should be constructed around the categories of the Land Cover Map (LCM). However, where there is more detailed and relevant data available on land use, this should be used instead, with the results reconciled with the LCM.	(Defra & ONS, 2014)
P4.1 The ecosystem accounts should continue to be developed for each of the NEA Broad Habitats, with a formal link where possible to the classifications used in the LCM.	(Defra & ONS, 2014)
P5.1 Accounts should be compiled initially at UK level.	(Defra & ONS, 2014)
Include logic chain	(Cryle, et al., 2015)
Valuation	
P9.1 We should aim to reflect wherever possible the contribution of ecosystems to goods and services that benefit people.	(Defra & ONS, 2014)
P9.2 Our approach wherever possible will be to reflect *actual* use of services.	(Defra & ONS, 2014)
P9. 3 We should view the ecosystem as an asset in recording monetary flows	(Defra & ONS, 2014)
P10.2 We will not rule out stated preference methods but only use them where they are consistent with SEEA concept of exchange value, and where they can capture values that other methods cannot, in particular non-use values.	(Defra & ONS, 2014)
P13.1 We will adopt a net present value approach to estimating the accounting value of ecosystem assets in order to be consistent with SEEA asset valuation principles.	(Defra & ONS, 2014)
P14.1 Any departure from a constant service flow assumption needs to be justified and evidenced.	(Defra & ONS, 2014)
P16.1 We propose to use the recommended Green Book Discount Rate whilst allowing for sensitivity analysis to assess the effect of different rates.	(Defra & ONS, 2014)

Key consideration	Source
NPV approach is generally favoured over cost based measures	(Defra & ONS, 2014)
Values provided by natural capital are dependent on a large variety of variables (quantity, quality, trend in habitats, scarcity). How does value change with changes in quantity and quality of ecosystem	(Provins, 2013)
Fundamental issue is appropriate control for factors that cause monetary values to vary across spatial locations.	(Provins, 2013)
Difficulties can arise where relationship between marginal value and stock size in not linear.	(Pittini, 2011)
Moving from stocks to flows introduces uncertainties as to the level of stock going forward and substitutability with other forms of capital	(Pittini, 2011)
Thresholds and irreversibility not taken into account	(Pittini, 2011)
Ruling out welfare values seems restrictive	(Pittini, 2011)
Some economic benefits are attributable with ES such as kayak hiring. Some economic benefits are not all attributable to the ES (hotels).	SEEA (2014)
Assets should be valued using discounted NPV of future flows	SEEA (2014)
In order to develop an ecosystem approach for a specific ES one must understand i) how the service leads to benefits 2)the recording of related activity in the SNA (but decomposition of production functions for what is recorded in SNA is difficult)	SEEA (2014)
Many CES generate consumer surplus therefore cannot be used with exchange values. But some of these may be embedded in existing markets	SEEA (2014)
Simulate exchange values provide exchange values	SEEA (2014)
Aggregating to NPV – requires a prediction of future ecosystem flows, and an asset life, dependencies need to be understood, selection of discount rate. How is degradation taken into account	SEEA (2014)
Market prices used for economic activity as with the rest of the SNA do not provide an accurate measure of the welfare generated by that activity. Concludes nothing logically inconsistent with using surplus measures.	(Day, 2014)
Burden of proof is for the future flows to remain constant	(Provins, et al., 2015)
Ecosystem Accounts likely to be concerned with trends over time, and therefore standards potentially lower standards for accuracy.	(Provins, et al., 2015)
The benefits from recreation are not accurately represented by these expenditures on travel because they do not measure the actual use value associated with a recreational visit, either in exchange price terms or welfare (instead they represent the exchange price for the complementary goods).	(Cryle, et al., 2015)
The most important determinant of changes in values of recreation are changes in the number of visitors, and this has been relatively overlooked.	(Cryle, et al., 2015)
Compilation and presentation of accounts and calculation	
P6.1 The standard format for asset accounts in physical terms should be adopted.	(Defra & ONS,

Key consideration	Source
	2014)
P7.2 For each account, a brief transparent red-amber-green (RAG) assessment will be made of all relevant services against these criteria, which will identify which services to include and exclude.	(Defra & ONS, 2014)
P6.2 The reference condition should not be adopted and changes should simply be measured as differences between opening and closing stocks.	(Defra & ONS, 2014)
P8.3 We should adopt the standard structure for tables for ecosystem services in non-monetary and monetary terms.	(Defra & ONS, 2014)
P10.1 A range of established valuation techniques can be used to estimate exchange as well as welfare values, but the rationale for using particular techniques will be clearly explained within each account, and where possible breaking values down into their “price” and “quantity” elements.	(Defra & ONS, 2014)
P11.1 Derivation of values should be transparently set out in relevant annexes to accounts.	(Defra & ONS, 2014)
P12.1 In drawing up accounts we will seek explicitly to highlight conceptual and empirical overlaps between market and non-market values, linkages and consistency with SNA within each account	(Defra & ONS, 2014)
P13.2 We will state explicitly the assumptions underlying asset valuation, and undertake sensitivity analysis to test the range of possible values.	(Defra & ONS, 2014)
P17.1 We should adopt a flexible approach to periodicity, aiming for annual accounts wherever possible.	(Defra & ONS, 2014)
P18.1 An assessment of uncertainty needs to be made against a range of quality criteria.	(Defra & ONS, 2014)
P18.2 We will indicate the degree of coverage of ecosystem services and total value clearly in the final presentation of the accounts.	(Defra & ONS, 2014)
Travel cost method	
Does not add new item to the accounts	(Defra & ONS, 2014)
No risk of double counting	(Binner, et al., n.d)
Opportunity cost of time should be excluded to ensure consistency with other SNA items.	(Defra & ONS, 2014)
An accounting price may be reached if travel costs to each of those recreational sites and calculating the probability weighted sum of expenditures across the year which would be the lower bound of an accounting price.	(Defra & ONS, 2014)
Not sensible to consider values by site, more sensible for a single aggregate account that cuts across habitats	(Day, 2014)
Careful consideration needs to be given to travelling time [and how this fits in with SEEA and SNA more generally]	(Smith, 2016)
FOR SNA financial costs should only be included.	(Provins, et al., 2015)

Appendix 2 – Assumptions and data sources

Value	Purpose	Calculation	Range of values	Sources
Car running costs (cost/mile) **Car total running**	To calculate the running costs (cost/mile) for both petrol and diesel cars for 2010 - 2015	For the given year, we: * We found the running costs and cars for both petrol and diesel cars. Based on the average price of a new car we were able to identify the running costs for both petrol and running cars (running cost data is presented for different prices of cars). *We identified the percentage of petrol and diesel cars for Great Britain. As such, we could calculate the weighted running cost/mile (petrol + diesel) There was no data for the running cost/mile for the year 2015. But was calculated by taking the 2014 data and inflating according to the fuel price change between 2014 and 2015.	**Cost per mile (p) between 2010-2105** Car running costs: 23 – 29 (not adjusted for inflation)	Car price in the UK: http://drivendata.inluk.com/wp-content/uploads/2012/04/DD_Car_Index_June_2011-2.pdf Running costs + total running and standing costs http://www.theaa.com/motoring_advice/running_costs/ Mileage of petrol and diesel cars in England https://www.gov.uk/government/statistical-data-sets/nts09-vehicle-mileage-and-occupancy (Table NTS0902) Percentage of diesel vs. petrol cars in GB https://www.gov.uk/government/statistical-data-sets/veh02-licensed-cars#table-veh0203 (Table VEH0203)
Taxis	Average cost of a taxi per mile	Not necessary	**255p/mile in 2015**	TfL Taxi Fare and Tariff Review https://consultations.tfl.gov.uk/tph/taxi-fare-and-tariff-review-

Value	Purpose	Calculation	Range of values	Sources
				2016/user_uploads/all-in-one-document.pdf
Average speed (mph)	To calculate the average mph for cars and buses for 2010-2015	For the given year: *We calculated the mile split (%)for road class in Great Britain data for 2010-2015 * We used data on free flow vehicle speeds by road type and vehicle type in Great Britain to identify the flow speed (mph) for cars and buses in 2015. Since the data was provided for 2015 we assumed this same flow speed for all years. *Having identified the mile split for roads and the flow speed for each one of those, we are able to calculate a representative average speed (mph) by multiplying the percentage of miles travelled with the flow speed for each category of road.	**Average speed (mph) between 2010-2015** Car: 45.0 - 45.3 Bus: 40.9 - 41.1 Based on no data trains were assumed to travel at 60 mph	Motor vehicle traffic (vehicle miles) by road class in Great Britain, annual from 1993: www.gov.uk/government/organisations/department-for-transport/series/road-traffic-statistics (Table TRA0102) **Motor vehicle traffic (vehicle miles) by road class in Great Britain, annual from 1993:** https://www.gov.uk/government/organisations/department-for-transport/series/speeds-statistics Table SPE0111 (formerly SPE0101 and SPE0102)
Discount rate	Discounting future values of service	Not applicable	**3.5% (0-30 years)** **3% (over 30 years)**	The Treasury Green Book https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf
Inflation	Providing constant prices in the model	Not applicable	**Indexed values**	CPI All Items Index https://www.ons.gov.uk/economy/in

Value	Purpose	Calculation	Range of values	Sources
				flationandpriceindices/timeseries/d7bt/mm23
WebTAG	Provides a value of time	Put into 2013 values, assumed constant	**Proposed values for non work travel** **£4.57 (2010 values)**	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470998/Understanding_and_Valuing_Impacts_of_Transport_Investment.pdf
Median wage	Provides basis of opportunity cost of time	Put into 2013 values	**FT and PT from £7.81 - £13.36**	**ASHE 1997 to 2015 selected estimates** http://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/ashe1997to2015selectedestimates
Population growth	Provides population growth for asset life	Growth rates calculated	**From 65m in 2014, to 95m in 2114**	UK Population Projection https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/tablea11principalprojectionuksummary
Scaling factor	Scaling factor for England to UK	Calculating population proportions	Very close to 1.2 across all years	Population estimates https://www.ons.gov.uk/timeseriestool?topic=/peoplepopulationandcommunity/populationandmigration/populationestimates

Appendix 3 – Hedonic pricing

Hedonic pricing is a revealed preference method that extracts values for environmental services from market-based transactions (such as housing transactions). Its common application is to use variation in house prices to estimate the value of local environmental attributes.

In the UK context, Gibbons *et al.* (2014) used a large and representative dataset of housing transactions for a 13-year period to estimate the value of natural capital. Despite having multiple years of transactions in the house price data, the study is fundamentally a cross-sectional analysis because the data available only provide limited information on changes over time in natural amenities and land cover for the period under study.

The key assumption is that housing prices not only reflect the characteristics of the house but also the local environment and services (such as distance to national parks, access to schools). The data sample used in the study consists of around one million housing transactions from the Nationwide Building Society, which include the post code. This allowed the authors to calculate the distance of the flat/house to various environmental attractions. Authors' constructed a wide range of land cover variables and variable capturing access to environmental amenities and these were matched to housing transactions using GPS methods.[25] Regression analysis was then applied to estimate the correlation between natural capital and housing prices.

What impact does the hedonic pricing method capture; amenity values or also wider recreational values? The title of the study refers to amenity values. However, the price premium could also reflect some recreational values, so the estimated impact is ambiguous. Close proximity and easy access to recreational sites means that the travel-cost method could underestimate the value of natural capital for consumers who are likely to pay a premium on their property prices instead of paying travel costs to reactional sites. Hedonic-price analysis will likely capture this omitted value, although, as already discussed, it may be difficult to disentangle the recreation component from benefits provided by proximity to trees and nature, such as amenity value and health benefits (Binner, et al., n.d).

The estimated coefficients for natural-capital variables are implicit prices/capitalised values rather than annual willingness to pay. The estimated coefficients also represent changes at the margin. However, the relationship between house prices and environmental amenities might not be linear, i.e. more drastic changes in the availability of natural capital may be associated with larger changes in house prices. However, coefficients could be used to provide rough estimates of larger changes. For example, a 1% increase in distance to national parks decreases the house prices by 0.24%. We can use this coefficient to estimate the impact of the change from mean distance to maximum distance on average house prices (29% or £ 55 k) and the estimated impact could also be applied to the value of the whole housing stock.

Without access to the underlying data, it is not possible to translate the estimated coefficients/impacts for national accounting purposes. However, the question of how much environmental amenities contribute to the value of UK housing is an interesting research question and could be further explored.

[25] Although the housing transaction data was UK wide the land cover variable and environmental amenities are only available for England)

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