APPLYING VALUES IN ECOSYSTEM ACCOUNTING

Discussion Paper

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SUMMARY

S.1 Introduction

This paper has been prepared as part of the project '*Development of 'look-up' environmental value estimates for initial appraisal within cost-benefit analysis*'. It has two main aims:

1. To summarise the principal issues around applying valuations in ecosystem accounts; and

2. To consider the conditions under which look-up values could be used in ecosystem accounts.

The discussion focuses on the use of exchange values (monetary transaction prices) in accounting exercises, which is in contrast to welfare values that are required for policy and project appraisals. In particular, the paper considers the challenge of estimating exchange values for non-market goods, such as those associated with the provision of ecosystem services.

S.2 Ecosystem accounting

The System of National Accounts (SNA 2008) forms the central framework for measuring and presenting information about the stocks and flows within the economy. The framework combines information about units in the economy (including government, households and various industry sectors) and transactions (expenditures, payments) in order to describe production, consumption, income, accumulation and wealth. The accounts underpin several key economic indicators, including gross domestic product (GDP), which measures the size of the economy in terms of aggregate production.

National accounts primarily focus on traded goods and services and do not reflect several fundamental factors that underpin economic activity. In particular, depletion of resource stocks are 'invisible' to GDP accounts, and changes in non-traded natural capital and ecosystem services are not included. Ecosystem accounting seeks to address important parts of these shortcomings, by measuring the value of non-marketed natural services, and taking into account changes in the condition and value of natural capital stocks. Ecosystem accounts focus on a subset of natural capital assets ('ecosystem assets'), which includes species, ecological communities, soils, rivers and land (SEEA-EEA 2012). Natural capital accounting represents a broader scope that incorporates the wider elements of the natural environment including atmosphere, minerals, sub-soil assets and oceans (Defra and ONS, 2014).

There has been a growing interest in natural capital accounting and ecosystem accounting at international and European levels. This includes the adoption by the UN Statistical Commission of the System for Environmental and Economic Accounts Central Framework (SEEA-CF 2012) and Experimental Ecosystem Accounting (SEEA-EEA 2012). Developments in the UK include the ONS Roadmap for natural capital (ecosystem) accounts (ONS, 2012; 2015). The general goal is to encourage and enable greater consideration of natural assets, and the services they provide, in monitoring and planning relating to economic activity. Physical ecosystem accounts – which record the stocks and flow of services from environmental assets - go some way to supporting these activities, but monetary valuation provides a common metric for assessing overall value and trade-offs concerning the provision of ecosystem services, and ready comparison with stocks and flows already included in the SNA.

S.3 Welfare value and exchange value concepts

The purpose of measuring non-market values, such as those derived from the provision of ecosystem services, is to include this information in decision-making processes. The two main analytical frameworks in economics are based on different sets of value judgements:

- **Economic value**: founded in economic theory using welfare-based assessments of value that can be used in the cost-benefit analysis (CBA) framework[1]. For the most part, this is the underpinning framework for conventional policy-making contexts such as demonstrating the economic importance of an issue, policy and project appraisal, priority setting, and setting taxes. The economic value of a good or service and its contribution to human welfare is measured in terms of 'total economic value' (TEV)[2]. This requires theoretically consistent assessments of consumer surplus (the excess of consumer welfare from a good or service over and above what consumers actually have to pay) and producer surplus (the excess of payment received over and above the opportunity cost of providing a good or service).

- **Economic impact assessment**: used to estimate economic activity and the impact that a particular project or industry has in the area within which it is located. This usually measures changes of output, GDP, employment and tax revenues associated with changes in the level of economic activity resulting from the project or industry being analysed. It also measures changes in business revenue and profits, personal wages, and/or jobs. In general, economic impacts can be estimated at the direct, indirect and induced levels. These impacts are often estimated using multipliers derived from Input-Output (I-O) analysis.

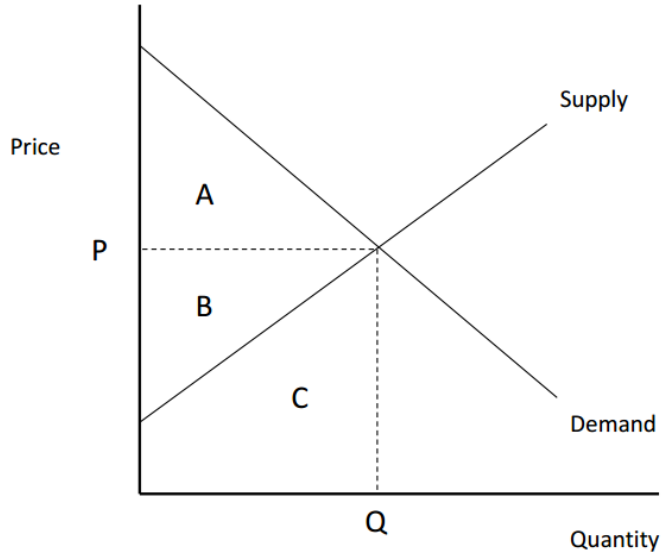
The TEV framework and the (economic) welfare value perspective differ from the concept of 'exchange value' that is used in economic impact assessment, the SNA, and - by extension of the principles of SNA - in ecosystem accounting (SEEA-EEA 2012). Exchange value is defined as "the total value of income, production and expenditure as evidenced by transactions" (Brouwer et al. 2013) and measured as the product of market prices and quantities.

The difference between welfare value and exchange value is illustrated in Figure S.1 via a conventional supply-demand diagram for a market good. This presents the familiar downward sloping demand curve for the good, signifying an increasing quantity demanded as its price decreases, and an upward sloping supply curve, signifying an increasing quantity supplied as the price of the good increases. The market equilibrium is given by the intersection of supply and demand, giving price P at quantity supplied/consumed Q.

[1] CBA is widely used and is the basis of UK Government guidance for policy and project appraisal as laid out in the HM Treasury Green Book (2003), where the focus of public sector appraisal is getting the best "public value" from government investments and decisions. CBA helps to achieve this by examining a policy or decision in terms of its consequences and costs and benefits, and by weighing up the costs and benefits of a decision to determine if the benefits outweigh the costs.

[2] See Section 3.1 of this paper for further detail of the components of TEV.

Figure S.1: Total economic value versus exchange value



A = consumer surplus;
B = producer surplus;
A+B = total surplus = welfare-economic definition of value (TEV);
C = opportunity cost of production;
Q = market equilibrium quantity
P = market equilibrium price = consumers' marginal willingness to pay at quantity Q;
P×Q = exchange value = sum of producer surplus (B) and resource costs (C).

Source: Brouwer et al. (2013)

In Figure S.1 the welfare value and exchange value is shown as follows:

- **Welfare value**: is the total surplus derived, which is denoted by Area A+B and corresponds to the welfare-economic definition of value (i.e. TEV). It is comprised of consumer surplus (Area A) and producer surplus (Area B);

- **Exchange value:** is represented by Area B+C (i.e. the product of market price and quantity, P×Q), comprised of producer surplus (Area B) and resource costs (Area C), which represent the cost of production of the good (i.e. the opportunity cost).

The distinction between welfare value and exchange value is therefore the inclusion (or not) of consumer surplus and production costs[3]. This stems from the underlying perspective that is adopted in relation to property rights. Economic (welfare) value is based on individual's willingness to pay (WTP) for a good, whilst the exchange value for marketed goods and services is based on what people actually have to pay, and so depends partly on demand and partly on property rights and market institutions. Hence exchange values represent amounts of money that willing purchasers pay to acquire goods, services, or assets from willing sellers.

The issue for ecosystem accounting is that many ecosystem services are not traded in markets and therefore do not have observable exchange values. It is the existence of property rights that generates the potential for a stream of economic benefits that in turn gives assets their exchange value. Often quantities can be observed (e.g. number of visitors to an open access site), but not prices, since services are often provided without any transaction and with no clear property rights. The challenge therefore is to 'produce' exchange values for non-market goods and service for use in

[3] In the case of welfare values, a change in value represents a change in welfare (surplus) for producers and/or consumers. Since consumer surplus is outside the definition of exchange value, it is possible for exchange value to increase (e.g. due to suppliers exercising market power or price discrimination) even if total surplus remains static or declines due to a reduction in quantity at higher prices. Welfare value is therefore considered as a theoretically valid measure of economic value, contrary to exchange value (Brouwer et al., 2013).

ecosystem accounts; i.e. to answer the question, what *would* willing purchasers pay to acquire ecosystem services and assets if they did in fact have to pay for them?

S.4 Approaches to estimating exchange values for ecosystem accounts

There are a number of examples of services that are within the boundaries of the SNA but do not have readily observable exchange prices through monetary transactions. Examples include many health and education services, as well as the services of financial intermediaries. In these cases imputed (i.e. estimated) prices are calculated, based on aspects such as the cost of provision (e.g. labour and other capital inputs) or via indirect methods (e.g. determining service charges for financial services).

In the absence of markets for ecosystem services there are three broad options concerning missing exchange values in ecosystem accounts (Day, 2013):

1. **Assume zero price**: this represents a strict application of the exchange values concept within the SNA and would result in valuing consumption of non-traded goods at zero. Whilst physical quantities would be recorded for ecosystem service provision, monetary accounts would not record any ecosystem service provision. This outcome is implicitly widespread (i.e. for all non-market goods and services that are not included in monetary accounts) but is essentially unsatisfactory as it contradicts the purpose of ecosystem accounting, which is to assess the overall value and trade-offs concerning ecosystem service provision in order to facilitate comparison with the SNA.

2. **Impute (estimate) a representative price**: this requires a modelling approach to estimate the price that would be obtained in a (perfectly competitive) market for the ecosystem service. This is the basis of the 'simulated exchange value' approach (Oviedo et al. 2010), which estimates the value of ecosystem services in terms of the income that would occur in a market if ecosystem services were bought and sold. It involves estimating a demand and supply curve for the ecosystem service in question – as per Figure S.1 – and determining the price that would be charged in order to estimate the revenue associated with the simulated transaction.

   Practical examples of simulated exchange values and their application in ecosystem accounts are, however, not readily available. One example that can be considered, though, is the DECC carbon values (DECC, 2014). The traded and non-traded values that are set out by DECC can be thought of as a simulated exchange value, representing the prices that would be observed if all the emissions fell within the bounds of a carbon market that was constrained to meet UK emissions targets.

3. **Impute (estimate) a representative set (of discriminatory) prices**: the simulated exchange value approach, however, can be subject to a logical inconsistency in an ecosystem accounting setting. In particular, introducing the assumption of a single (marginal) price implies that consumers would demand a lower quantity of the ecosystem service than is actually observed in reality (i.e. as recorded in the physical flow account). For example, with a paid market in recreation, it is reasonable to expect lower numbers of visits compared to the case of free access. This has the potential to give rise to an inconsistency between the monetary and physical accounts, with the former over-stating the value of some units of provision of the ecosystem by valuing those units above maximum WTP (as represented by the demand curve).

   Using a set of discriminatory prices would avoid this problem. In effect, this option matches each unit of provision of the service with a price that theoretically could exist (in the sense of being

less than or equal to the maximum WTP for that unit), dependent on the assumption that some conceivable market institution could mimic the price function used[4].

One approach would simply be to use the demand curve for the ecosystem service to represent the price function. This has the advantage that estimating demand curves is the aim of economic valuation methods, so the tools and methods already exist. It also side-steps the potential for confusion and discrepancy between values recorded in ecosystem accounts and welfare-based values used in CBA. On the other hand, however, it may be viewed as a too convenient solution from an SNA perspective, as it effectively captures all consumer surplus within the estimate of the exchange value. Much depends on the suitability of the assumption of a (perfectly) price discriminating supplier of ecosystem services, and how this is viewed in comparison to the assumptions that underpin imputed prices for other services that are not traded in monetary transactions but are included in national accounts (e.g. health and education, financial intermediaries). It should also be noted that it is more complex to apply a price function rather than a single price estimate, since it implies using different prices for different units of the good or service.

In summary, it may be concluded that none of the potential options for establishing exchange values for ecosystem accounts are completely satisfactory. However, the concept of an exchange value for market goods and services is fundamentally dependent on market institutions and structures including property rights. Whilst there is only one correct measure of welfare values (which does not depend on the market institutions used to allocate resources), there are multiple possible measures of exchange value, any one of which would be an output of some feasible set of market arrangements.

The more useful conclusion, therefore, is that similar flexibility is needed in the approach to determining exchange values for non-market goods and services. This could be based on pragmatic considerations concerning the role and use of ecosystem accounts, along with practical issues such as data availability, rather than strict adherence to conceptual principles. Whilst well intended, in terms of maintaining comparability with SNA, these principles do not fit well with the property rights and market institution characteristics of ecosystem assets (i.e. their public good attributes).

S.4 Use of look-up values in ecosystem accounts

The primary intended use of environmental look-up values is in policy and project appraisals, particularly in terms of first-cut assessments, and for valuing secondary or incidental impacts in appraisals and assessments that might otherwise overlook environmental impacts. Since they are intended to be interpreted as broad generalisations of the values that have been observed for different ecosystem goods and services, these indicative values may also be appropriate inputs to ecosystem accounts.

High level (top-down) ecosystem accounting exercises place more emphasis on understanding the scale of values in terms of the order of magnitude and tracking these over time, rather than focusing on the precision unit value estimates. Conceivably this is an objective that could be supported by the use of indicative values. Conversely, if considerable effort is to be expended on developing ecosystem accounts at the national level, the valuation evidence used for these accounts might be an ideal

[4] Note that discriminatory pricing is a feature of many marketed goods. Many suppliers are able to use discriminatory pricing to vary prices, according for instance to the age of purchaser (e.g. child and senior citizen discounts), family size (large family discounts), education or employment status (student and unemployed discounts), time (cheaper midweek deals), volume of purchase (bulk deals), club memberships, and so on.

source of look-up values (in the future) for use in other accounting hierarchies (e.g. protected area accounts, corporate accounts, etc.) and in some appraisals.

The use of look-up values is likely to be less appropriate in spatially disaggregated accounts where more emphasis is placed on understanding the distribution of ecosystem service flows and how benefits vary by spatially explicit factors such as proximity to user populations and availability and quality of substitute sites. This is primarily because the application of indicative environmental values does not permit the required sensitivity to the spatial context of valuations at the local scale.

Recognising the potential role for using indicative values does not, however, resolve the conceptual challenge that is highlighted in Section S.3 above (i.e. how to determine exchange values). For the most part, the indicative values for non-market goods and services associated with ecosystem services are derived using economic valuation methods that estimate welfare values. In principle, the underlying valuation perspective is inconsistent with the exchange value concept for ecosystem accounts. However, indicative values are also included for some provisioning services and market goods from ecosystems (e.g. timber, crops). Given these look-up values are based on observed market prices, this subset is consistent with the SNA exchange value concept and thus could more readily be incorporated for use in ecosystem accounts (recognising, of course, that transactions associated with these goods are already recorded in national accounts).

There are broad generalisations that are made in compiling indicative environmental values for non-market ecosystem goods, which mean they must be interpreted with care[5]. On balance, though, given the unresolved issue of determining the approach to estimating exchange values (e.g. zero price, simulated price, simulate price function), the inconsistency of indicative values with the SNA perspective may be less of a concern at this stage. This is particularly the case if the alternative to using indicative values is assuming a zero price in monetary accounts for the provision of an ecosystem service.

The limit, however, is likely to be the intended use of the account, and the degree of uncertainty that can be accommodated in valuations. Where the intention is to indicate the order of magnitude of ecosystem values at an aggregate level, indicative values may be regarded as suitable. This would be consistent with the principles set out for the use of indicative values in an appraisal context, where they are intended as an 'entry-level' tool and not a replacement for detailed assessments of policy and projects with significant environmental impacts.

S.5 Conclusions

It is evident that further research is required into the approach and validity of developing exchange values for use in ecosystem accounts. Whilst there are several precedents for non-traded values being included in the national accounts via imputed values (e.g. health, education, and intermediate financial services), there are different ways in which exchange values could be imputed or simulated for ecosystem goods and services. At present, though, examples of applications in ecosystem accounts are not readily available and no practical tests of the conceptual approaches have been identified. This makes it difficult to offer explicit guidance on how practical ecosystem accounting exercises should deal with the challenge of imputing exchange values when much of the available valuation evidence is welfare value based and intended for use in a CBA-setting.

Further research could include assessments of the actual and likely uses of simulated exchange values – both single prices and sets of discriminatory prices in accounts - and in particular how these would

[5] Refer to the Technical Report and User Guide for further detail.

be interpreted and received by users and stakeholders. A key issue also to address is the potential for confusion between welfare-based analyses (such as CBA for projects and investments) and the exchange value based accounts, and the risk of sending mixed signals of value as a result of having differing estimates underpinned by different conceptual bases.

Key concluding points include:

- **Use of ecosystem accounts**: the primary usefulness of ecosystem accounts is likely to be in the trends that they reveal over time, rather than the specific values recorded at a given point in time. Specific values can be hard to interpret, but observing a significant change in those values over a period of years gives a clear signal that something important is happening that should be of concern to policy-makers.

- **Ecosystem accounting is a complementary tool to policy and project appraisal (i.e. CBA)**: Observing trends over time can reveal that some intervention may be required, but this does not directly address the question of what that intervention should be. For that appraisal methods are required to examine the costs and benefits of different options for addressing the problems identified by accounting.

- **Exchange values**: monetary transaction prices are not an unchanging feature of markets. Whilst accounts reflect traded quantities and monetary flows, they also reflect the institutional setting through which the exchange takes place. This is recognised in the treatment of imputed prices in national accounts that 'correct' for specific features of institutional structures (e.g. the use of imputed values for the services of financial intermediaries). At present there is a lack of clarity as to the appropriate assumptions and adjustments that can be made with respect to the provision of ecosystem services and the estimation of exchange values.

- **Exchange values for ecosystem services**: currently there are no practical examples of how missing exchange values in ecosystem accounts can be imputed via the simulated exchange method (either as a single price or a price function). Practical examples and tests are needed to improve understanding of both the application of the method and the acceptability of results and key assumptions by users of accounts and decision-makers. This should form the basis for providing more authoritative guidance on how exchange values should be determined for ecosystem accounts.

- **Proxies for exchange values**: in the interim there are various approaches using economic valuation methods that can provide proxies for exchange values. Cost-based techniques (e.g. avoided cost, replacement/restoration cost) may be more readily accepted as proxies for exchange values, if it is assumed that the estimated cost is one that would actually be incurred (i.e. the buyer would be willing to pay that price). However, the welfare-based methods (for measuring non-market costs and benefits) should still be preferred for use in cost-benefit analyses.

The inconsistency of welfare-based values with ecosystem accounting principles is subject to increasing attention (e.g. Pittini et al., 2013; Defra and ONS, 2014; Obst et al., 2014). To date though, the issue has largely been addressed as one of concept with little in the way of practical attempts to trial and test methods to simulate exchange values. The next steps should be to encourage future ecosystem accounting applications to be more explicit about the assumptions that are made in applying ecosystem values, and encouraging further research effort to develop approaches for imputing exchange values that are consistent with SNA principles and the way in which value is derived from natural assets with public good attributes. With respect to the latter, existing non-market valuation methods would seem to provide a ready starting point.

1. INTRODUCTION

1.1 Overview

This discussion paper has been prepared for the Department for Environment Food and Rural Affairs (Defra) as part of the project '*Development of 'look-up' environmental value estimates for initial appraisal within cost-benefit analysis*'[6]. The paper has two main aims:

1. To summarise the principal issues around applying valuations in ecosystem accounts; and

2. To consider the conditions under which look-up values could be used in ecosystem accounts.

This discussion paper has been prepared for Defra as part of the project aiming to develop 'look-up values' for use in first-cut assessments, and for valuing secondary or incidental impacts for appraisals and assessments that might otherwise overlook environmental impacts. In the main, the discussion paper considers the use of exchange values (prices) in accounting exercises rather than welfare values that are required for policy and project appraisals, and the challenge of estimating exchange values for non-market goods, such as those associated with the provision of ecosystem services.

The focus of the paper is ecosystem accounting, which is intended to provide a coherent and integrated approach to the assessment of the environment through the measurement of: (i) ecosystems; and (ii) flows of services from ecosystems into economic and other human activity. Ecosystem accounts focus on a subset of natural capital assets ('ecosystem assets'), which include, for example, species, ecological communities, soils, rivers and land (SEEA-EEA 2012; Defra and ONS, 2014). Natural capital accounting represents a broader scope that incorporates the wider elements of environmental accounting covered by the System of Environmental-Economic Accounting Central Framework (SEEA-CF 2012). Natural capital assets not covered by ecosystems accounts include atmosphere, minerals, sub-soil assets and oceans.

1.2 Structure

The paper is structured as follows:

- Section 2: provides an overview of national accounting frameworks and their extension to environmental and ecosystem accounting to set the background for understanding the use of valuations in ecosystem accounts;
- Section 3: sets out the discussion of the principle issues concerning the valuation of non-marketed goods and services in ecosystem accounting; and
- Section 4: provides conclusions, including the potential for using look-up values in ecosystem accounts.

This paper is supported by two accompanying annexes:

- Annex 1: provides a short survey of the treatment of other types of non-traded services in national accounts; and
- Annex 2: discusses the treatment of further issues that arose over the course of the development of this paper.

[6] Refer to the Technical Report for further details of project objectives and scope.

2. ECOSYSTEM ACCOUNTING

The System of National Accounts (SNA, 2008) forms the central framework for measuring and presenting information about the stocks and flows within the economy. The framework combines information about units in the economy (including government, households and various industry sectors) and transactions (expenditures, payments) in order to describe production, consumption, income, accumulation and wealth. The accounts underpin several key economic indicators, including gross domestic product (GDP), which measure the size of the economy in terms of aggregate production.

Standard national accounts, however, primarily focus on traded goods and services - with some exceptions where imputed values are used (see Section 2.2.3) - and do not reflect several fundamental factors that underpin economic activity. In particular, depletion of resource stocks are 'invisible' to GDP accounts, and changes in non-traded natural capital and ecosystem services are not included. Environmental accounting and ecosystem accounting seek to address important parts of these shortcomings, by measuring the value of non-marketed natural services, and taking into account changes in the condition and value of natural capital stocks.

To set the context for examining the requirements of valuation in ecosystem accounts, it is useful to outline the use of ecosystem accounting in the context of a wider trend towards fuller integration of ecosystem services and natural capital in decision-making. The following describes the scope of the SNA and how ecosystem accounting seeks to improve the coverage of national accounts.

2.1 Background

In recent years, there has been a growing interest in natural capital accounting and ecosystem accounting at international and European levels. This can be understood in the wider context of a series of initiatives for improved measurements of economic activity, including:

- Millennium Ecosystem Assessment (2005) and various National Ecosystem Assessments[7];
- Beyond GDP Conference (2007)[8], EC Communication "GDP and beyond: Measuring progress in a changing world" (European Commission, 2009) and Parliament Resolution (European Parliament, 2011);
- Potsdam Initiative[9] and the resulting The Economics of Ecosystems and Biodiversity (TEEB) studies[10];
- Stiglitz/Sen/Fitoussi report (Stiglitz et al., 2009) on the measurement of economic performance and social progress;
- Simplified Ecosystem Capital Accounts fast track project in Europe (2009-2012) by the European Environment Agency (EEA) (for ecosystems) and Eurostat (for economic sectors);

[7] See the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) catalogue of ecosystem assessments at: http://catalog.ipbes.net/
[8] See: http://ec.europa.eu/environment/beyond_gdp/2007_conference_en.html
[9] See: http://www.g-8.de/Content/EN/__Anlagen/2007-03-18-potsdamer-erklaerung-en,property=publicationFile.pdf
[10] See: http://www.teebweb.org/

- Adoption by the UN Statistical Commission of the System for Environmental and Economic Accounts Central Framework (SEEA-CF 2012) and Experimental Ecosystem Accounting (SEEA-CF 2012;
- Wealth Accounting and the Valuation of Ecosystem Services (WAVES) partnership[11]; and
- Mapping and Assessment of Ecosystem Services (MAES) initiative[12].

Developments in the UK have followed a similar pattern, and indeed have often fulfilled a leading or driving role. Important initiatives include the UK National Ecosystem Assessment (UKNEA, 2011) and Follow On (UK NEA, 2014); the work of the Natural Capital Committee (NCC); and the Office of National Statistics work on developing quality of life indicators[13] and natural capital accounting (ONS, 2012; 2015), as well as government guidance on valuing ecosystem services (Defra, 2007) and accounting for the environment in appraisal (HM Treasury and Defra, 2012).

Ecosystem accounting can therefore be understood as part of this more general trend towards a more complete integration of the environment in decision-making. Accounting aims to improve understanding of the ways in which ecosystems support human economic activity and well-being, and the ways in which human activity impacts ecosystems. The goal is to encourage and enable greater consideration of natural assets and the services they provide, in monitoring and planning relating to economic activity. Physical accounts go some way to supporting these activities, but monetary valuation is important in providing a common metric to assess overall value and trade-offs, and to allow comparison with stocks and flows already included in the SNA.

Linking ecosystem accounts to the SNA is intended to provide comprehensive, integrated and consistent data sets. If sufficient scientific data are available, natural capital accounting and ecosystem accounting can highlight drivers and consequences of ecosystem change within the economy and society. Valuation and accounting extend the production and asset boundaries of the SNA, and in effect, lead to a more comprehensive definition of income and wealth within an economy (Pittini et al., 2013).

2.2 The System of National Accounts (SNA)

The System for Environmental and Economic Accounts (SEEA-CF 2012 and SEEA-EEA 2012) must be understood as extensions to the System of National Accounts (SNA 2008). In developing these methods high priority has been placed on compatibility with the SNA. This is not the case, however, for other approaches, such as wealth accounting (WAVES). To understand how SEEA-CF and SEEA-EEA function, and their requirements for monetary values, it is helpful to explain how the SNA works, the values it uses, and what it includes and omits. This then provides the basis for interpreting SEEA-CF and SEEA-EEA and how they extend the SNA.

[11] See: http://wavesproject.org/

[12] MAES was established by the European Commission, with support of Member States, the EU Joint Research Centre and the EEA and aims to contribute to the mapping and assessment of ecosystems and ecosystem services, in biophysical, and in a later stage possibly also monetary terms, by providing a coherent analytical framework to the EU and Member States, and includes a module on natural capital accounting. See: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm

[13] See: http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Quality+of+Life

2.2.1 Principles

The current version of the System of National Accounts (SNA 2008) explains that:

- In order to understand the workings of the economy, it is essential to be able to observe and analyse the economic interactions that take place between different sectors of the economy.
- The SNA is designed to provide information about the behaviour of institutional units and the activities in which they engage, namely production, consumption and the accumulation of assets, in an analytically useful form.
- This is achieved by recording the exchange of goods, services and assets between institutional units in the form of transactions.
- At the same time, other transactions are recorded that represent the form of payment for the exchange (usually, but not always, financial payment).

The SNA is based on the fundamental supply-use identity; goods and services produced in the economy must be consumed, used for capital formation or exported and all goods and services used within the economy must be produced in the economy or imported.

This identity is reflected via a sequence of interconnected flow accounts. These are linked to different types of economic activity taking place within a given period of time, and balance sheets that record the values of the stocks of assets and liabilities held by institutional units or sectors at the beginning and end of the period. Specifically:

- The current accounts record the production of goods and services, the generation of incomes by production, the subsequent distribution and redistribution of incomes among institutional units, and the use of incomes for purposes of consumption or saving.
- The accumulation accounts record flows that affect the entries in the balance sheets at the start and end of the accounting period. There are four accumulation accounts: the capital account; the financial account; the other change in the volume of assets account; and the revaluation account.
- The balance sheets show the values of the stocks of assets and liabilities held by institutional units or sectors at the beginning and end of an accounting period.
- Detailed supply and use tables record how supplies of different kinds of goods and services originate from domestic industries and imports and how those supplies are allocated between various intermediate or final uses, including exports.

2.2.2 Uses of SNA

The SNA provides information not only about economic activities taking place within a given period of time but also about the levels of an economy's assets and liabilities, and thus the wealth of its inhabitants. In addition, the SNA includes an external account that displays the links between an economy and the rest of the world. The SNA also compiles the accounts for a succession of time periods. This gives a continuous flow of information for the monitoring, analysis and evaluation of the performance of an economy.

National accounts use data from many different sources, providing different perspectives on the economy. In particular, information on expenditures, production and incomes can be compared and contrasted. Together, the accounts provide a picture of the economy that is consistent, coherent and fully integrated. Many common economic statistics are produced within the national accounts, including GDP, the household saving ratio, public sector net borrowing, the balance of trade and household consumption. In the UK, the national accounts are heavily used by policy makers and analysts. For example (ONS, 2014a):

- By the Monetary Policy Committee when setting interest rates;
- By the Office for Budgetary Responsibility in forecasting economic growth and public sector debt;
- By European institutions (via Eurostat);
- To determine most of the UK's contribution to the EU budget (via gross national income);
- To determine EU payments to 'deprived' regions (via GDP per capita); and
- By decision-makers and advisers across the whole of society, including corporations, private individuals and government, in a wide variety of ways.

2.2.3 Imputed prices in national accounting

Values in the SNA use exchange values (prices) rather than welfare values (which include consumer surplus – see Section 3.2) (Obst et al., 2014). The SNA recognises explicitly that "GDP is often taken as a measure of welfare, but the SNA makes no claim that this is so and indeed there are several conventions in the SNA that argue against the welfare interpretation of the accounts"[14]. For example, the SNA excludes all production of services for own final consumption within households (e.g. own housework, cooking, gardening, DIY). This does not imply, however that only goods and services traded in monetary transactions, that have observable exchange values, can be included in the SNA. Various other services are supplied, but not traded in monetary transactions: for example, many health and education services, as well as friends and relatives helping with childcare, transactions internal to large companies, and the services of financial intermediaries. Some of these services are considered to be included within the 'production boundary' of the SNA, and to be included in the accounts, the value of these non-monetary transactions must be indirectly measured or otherwise estimated. Imputed transactions are recorded when there are flows that are considered analytically useful to treat as transactions.

Health and education services both exhibit public good characteristics and can be either market or non-market goods. In the former case, market transactions are used to value health and education in the accounts. In the latter, the SNA classifies them as transfers in kind[15], recognising that "the goods and services involved are produced by activities that are no different from those used to produce goods or services for sale" (SNA 2008; 1.36). The treatment of valuation is as follows: "when non-financial resources are provided without a quid pro quo [i.e. a flow in one direction is not linked to a counterpart flow in the opposite direction], such resources should be valued at the market prices that would have been received if the resources has been sold in the market. In the absence of a market price, the donor's view of the imputed value of the transaction will often be quite different from that of the recipient". In this context, the use of the value assigned by the supplier is suggested as a rule of thumb for valuing transfers in kind. This then places the emphasis on imputing values based on input markets for health and education (e.g. labour) and the costs of provision. Annex 1 provides a brief summary of the options for valuing health and education services in the SNA.

[14] It should also be noted that Kuznets (1934), when developing the first comprehensive system of national accounts, also stated explicitly, "Economic welfare cannot be adequately measured unless the personal distribution of income is known. And no income measurement undertakes to estimate the reverse side of income, that is, the intensity and unpleasantness of effort going into the earning of income. The welfare of a nation can, therefore, scarcely be inferred from a measurement of national income as defined above."

[15] The SNA defines a transfer as "a transaction in which one institutional unit provides a good, service or asset to another unit without receiving from the latter any good, service or asset in return as a direct counterpart". Social transfers in kind "consist of goods and services provided by general government and non-profit institutions serving households (NPISHs) that are delivered to individual households". In the case of health and education, "rather than provide a specified amount of money to be used to purchase medical and educational services, the services are often provided in kind to make sure that the need for the services is met" (SNA 2008; 3.83).

A further important imputed transaction in the national accounts is the measurement of consumption of fixed capital (depreciation). This is "constructed" since the flow is one that is internal to an institutional unit and no actual monetary flows occur. Similarly, the services of financial intermediaries are considered to be within the SNA boundaries, and their value is measured indirectly. Financial intermediaries are "institutional units that incur liabilities on their own account for the purpose of acquiring financial assets by engaging in financial transactions on the market" (SNA 2008; 4.101); for example, insurance companies and pension funds. Full discussion of this technical area is beyond the scope of this paper (see, for example, Akritidis, 2007). However to give some examples, interest payable by and to financial intermediaries on deposits and loans is split into two components: interest proper, and the purchase of financial intermediation services. The intermediaries do not charge explicitly for these services, and the purpose of the partitioning is to make the service item explicit in the accounts (SNA 2008; 3.67). Similarly, foreign exchange dealers buy and sell at different rates, the differences between those rates and the mid-point represent service charges paid by the customers (SNA 2008; 17.230).

Not all productive services are considered to be within the "production boundary" of the SNA. For example, most services produced and consumed by households (such as housework, cooking, gardening, childcare, etc.) are not included, though when these services are directly paid for, for example through employing domestic staff, they do then fall within the production boundary and should be recorded. One rationale is that "the decision to produce services for own consumption is not influenced by and does not influence economic policy because the imputed values are not equivalent to monetary flows. For example, changes in the levels of household services produced do not affect the tax yield of the economy or the level of the exchange rate. This reasoning is incomplete, however, since a key reason for reducing household services is formal employment for the household members who had previously provided the services, and when these services are shifted to the economy – e.g. through increased use of professional childcare and domestic staff – that does have an impact on tax revenues and employment. The counterpoint, though, is that "inclusion of all activity which is productive (in the economic sense) but which does not have a monetary value would swamp the monetary flows, obscure what is happening in the markets, and reduce the usefulness of National Accounts data for analysis" (ONS, 2014b).

In the UK, one exception to this rule is the imputed rental of owner-occupied and rent-free dwellings: "owner-occupiers' housing services for their own final consumption have always been included within the production boundary, based on imputed values" (ONS, 1998). The primary reason is that the ratio of owner-occupied to rented housing varies considerably over time and between countries. Comparisons of accounting figures would be distorted if no allowance were made for variations in the owner-occupied element. Additionally, in many countries the imputed values of owner-occupied housing are used as a basis for taxation (rates). Similarly, the non-trading use of fixed assets owned by the government and by private non-profit-making bodies, for example, school buildings, requires estimation using imputed values.

The ONS bases the imputation on the principle that the value should be the same as the rental that would be paid for a similar property in the private rented sector[16]. Imputed owner-occupier rent is calculated from an average rent per room being multiplied by the total number of rooms in owner-occupied dwellings, with values based on actual rental values and number of rooms rented derived from the Living Cost and Food (LCF) survey. The total rooms' value is calculated using DCLG (Department for Communities and Local Government) housing stock multiplied by average rooms in a household from LCF. One additional consequence is that financial services associated with

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

borrowing for house purchase (primarily mortgage fees and 'Financial Intermediation Services Indirectly Measured' on the outstanding stock of mortgages) are classed as intermediate consumption by another industry, not as consumption by the household sector, and do not directly contribute to GDP (Bank of England, 2011).

Imputed values can also be used for asset valuation. Where markets exist for trading used assets (for example, used cars) direct observations of prices can be made. But, when there are no observable prices, an attempt should be made to estimate what the prices would be if a regular market existed and the assets were to be traded on the date to which the estimate of the stock relates. Two main approaches are described in the SNA to deal with this situation:

1. The first is to use the written down replacement cost (2008 SNA, 13.23). This recognises that the value of an existing asset is equal to the current acquisition price of an equivalent new asset less the accumulated consumption of fixed capital on the existing asset over its life. This approach can be used for most depreciating assets for which no significant/observable markets exist; for example commercial fixtures and fittings.

2. The second is to use the discounted value of future returns or net present value approach (SNA 2008; 13.24). This is useful when returns to the asset are delayed (for example, timber production) and/or are spread over a lengthy period (for example, subsoil assets, fish stocks). Although market prices can be used to value the final output, discounting must be used to compute the present value of the expected future returns, using projections of the future returns from the use of the asset.

In principle, other non-traded goods, services and assets could be treated in a similar way. The SNA notes (SNA 2008; 1.42) that "a balance has to be struck between the desire for the accounts to be as comprehensive as possible and the need to prevent flows used for the analysis of market behaviour and disequilibria from being swamped by non-monetary values." In other words, the rationale for the boundaries chosen, recognised as a compromise, is the practical need to make the accounts useful for studying market transactions and behaviours. This does, however, have particular implications for the way in which environmental goods and services are treated in the accounts, making them less useful for understanding the ways in which economic activity both depends on, and impacts, ecosystems. This has led to the development of the international standard for System for Environmental-Economic Accounting (Central Framework (SEEA-CF 2012) and a framework for Experimental Ecosystem Accounting (SEEA-EEA 2012).

2.3 Natural capital accounts and ecosystem accounts

2.3.1 System of Environmental-Economic Accounting

The institutional 'sectors' in the SNA do not include environmental features such as the atmosphere or ecosystems. Some parts of ecosystems can be reflected, but only to the extent that they and the services they provide are owned and traded. A necessary condition for an activity to be treated as productive is that it must be carried out under the "instigation, control and responsibility of some institutional unit that exercises ownership rights over whatever is produced" (SNA 2008). Similarly, the ownership criterion is important for determining which natural resources are treated as assets in the SNA. This means that many of the ecosystem services that contribute to human/societal welfare are completely ignored in the accounts. While some ecosystem services such as agricultural and forestry production are included in market transactions, many other services are not (Obst and Vardon, 2014).

Natural capital accounting and ecosystem accounting seek to address important parts of these shortcomings, by accounting for the value of non-marketed natural services, and taking into account changes in the condition and value of natural capital stocks. The objective is to make national accounting a more useful tool for guiding sustainable development, which is a process of accumulation and sound management of the whole portfolio of national assets (manufactured capital, natural capital, and human and social capital).

The System of Environmental-Economic Accounting (SEEA) provides methodological guidance for the creation of environmental-economic accounts. The United Nations Statistical Commission (UNSC) published the first version in 1993, which then went through a revision process led by the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA)[17]. Three volumes have been produced through this process (Table 2.1).

The SEEA Central Framework (SEEA-CF 2012) includes measurement in three main areas:

- The physical and value flows of materials and energy: supply and use tables in physical terms and in monetary terms (where trades take place) showing flows of natural inputs, products and residuals; these tables must respect the "supply-use identity" (i.e. that all output from within the production boundary, plus imports, must be accounted for in either consumption of goods and services or accumulation of goods and services);
- Stocks of environmental assets: accounts for individual environmental assets in physical and monetary terms showing the stock of environmental assets at the beginning and end of each accounting period and the changes in the stock; and
- Economic activity and transactions related to the environment: sequence of economic accounts that highlight macroeconomic aggregates (e.g. GDP, GNP, National Disposable Income) adjusted for depletion in environmental assets, and functional accounts which record transactions and other information about economic activities undertaken for environmental purposes.

In monetary terms, the asset boundaries of the SEEA-CF 2012 and the SNA are the same. Thus, only those assets that have a monetary exchange value following the valuation principles of the SNA are included in the framework. In physical terms, the asset boundary is broader and includes all natural resources and areas of land of an economic territory that may provide resources and space for use in economic activity. Thus the scope in physical terms is not limited to those assets with economic value.

[17] Group of countries and international agencies under the auspices of the UN Statistical Commission.

Table 2.1: Details on SEEA volumes

SEEA	Scope	Accounting Standard	Contents
Volume 1 Central Framework (SEEA-CF 2012)	Physical flows of natural resources, stocks of natural resources, contributions to economic activity, impacts of economic activity on resources.	Yes: adopted by the United Nations Statistical Commission (UNSC) in 2012 as the international statistical standard for environmental-economic accounting	Flow accounts in physical terms, for energy, water, material flows, air emissions, waste water and solid wastes. Asset accounts in physical and monetary terms for mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources and water resources. Environmental activity accounts in monetary terms for environmental protection expenditures, environmental goods and services sector, and environmental taxes and subsidies. Combined physical and monetary accounts, giving a framework for derived indicators such as resource efficiency and productivity.
Volume 2 Experimental Ecosystem Accounting (SEEA-EEA 2012)	Condition of ecosystems and flows of ecosystem services.	No: endorsed by the UNSC in 2013 but experimental and not (yet) an agreed standard.	Physical accounting for ecosystem services. Physical accounting for ecosystem assets, especially carbon and biodiversity. Main methods, challenges and options for valuing ecosystem assets and ecosystem services in monetary terms.
Volume 3 Applications and Extensions of SEEA (SEEA-EA 2012)	Guide to the use of SEEA-based data in decision making, policy review and formulation, analysis and research, and to possible extensions.	No: not intended that this become an international statistical standard. Rather, it is a companion to the SEEA-CF, for promoting and supporting implementation and providing a bridge between compilers and analysts.	Common applications of SEEA: use of environmental indicators; analysis of resource use and intensity; analysis of economic flows, expenditures and taxes/subsidies relating to environmental activities; analysis of environmental assets, net wealth, income and depletion of resources. Analytical techniques: Environmentally Extended Input-Output tables (EE-IOT) and techniques for the analysis of input-output data (multiplier analysis; attribution of environmental pressures to final demand; decomposition analysis; computable general equilibrium analysis). Extensions of SEEA, including spatial disaggregation, extension to household sector and environmental accounts for specific sectors.

In the SEEA-CF 2012 environmental assets are measured as individual assets, such as timber resources, land, mineral and energy resources, and water resources. In contrast, SEEA Experimental Ecosystem Accounting (SEEA-EEA 2012) measures environmental assets from the perspective of ecosystems and considers how different individual environmental assets interact as part of natural processes within a spatial area to provide a range of services for economic and other human activity. While ecosystem accounting does consider ecosystems and the economy to be different systems, they are analysed jointly reflecting the fundamental connections between them. The accounts include the following tables of information:

- Physical account of ecosystem condition and extent (stock account): reporting bio-physical data on the condition of ecosystem assets through key ecosystem characteristics;
- Physical account of ecosystem service provision (flow account): reporting data on the physical flow of ecosystem services linking ecosystems assets to economic and other human activity;

- Monetary account of ecosystem stock and flow: reporting the value of goods and services derived from the provision of ecosystem services; and
- Generation and use of ecosystem services: reporting on the beneficiaries of ecosystem service provision distinguishing between the (spatial) area within which the ecosystem services are generated and the areas in which ecosystem services are used.

2.3.2 Use of ecosystem accounts

The use of an (ecosystem) accounting framework enables the stock of ecosystems – *ecosystem assets* – and flows from ecosystems – *ecosystem services* – to be defined in relation to each other and also in relation to a range of other environmental, economic and social information. Ecosystems are thereby linked explicitly to economic and other human activity, both in terms of the services provided by ecosystems and in the impacts that economic and other human activity may have on ecosystems and their future capacity for supporting and supplying services.

Physical ecosystem accounts are useful in providing information about physical scarcity of resources ('quantity') and the physical condition of ecosystems for supporting provision of ecosystem services ('quality'). However, physical accounts do not directly address economic scarcity or conditions of human demand for services, or supply of manufactured capital and labour required to realise services. For assessing trends in the economic use of ecosystem services, monetary valuation fulfils several roles (Hamilton, 2013). Through consideration of the impacts (both positive and negative) of economic and other human activity on ecosystems, the accounts highlight the different values arising from ecosystems as current flows, and in the future through the asset values, and changes in them. They can also be used to explore the potential trade-offs between the different mixes of ecosystem services that arise from alternative uses of ecosystems. Valuation is essential for top-down accounts at the national level seeking to provide aggregate values of natural capital (Pittini et al., 2013) but can also be useful for smaller scale and cross-cutting accounts.

Ecosystem accounts can provide national-level monitoring and comparison to the economic flows and assets in the national accounts. Accounts can also be used to develop indicators to support different phases of the policy cycle. This includes the diagnosis and prioritisation of environmental issues, the definition of objectives and associated targets, the design of policies for conservation and other sectors, and the monitoring and assessment of their impacts. By integrating data in a common framework, accounts facilitate assessment of trade-offs and synergies across policies, in particular where the accounts are based on spatially-explicit mapping.

The primary usefulness of ecosystem accounts is likely to be in the trends that they reveal over time, rather than the specific values recorded at a given point in time. The specific values can be hard to interpret, but observing a significant change in those values over a period of years can signal important issues and/or areas which should be of particular concern for policy-makers. This is similar to the observation that Costanza et al's (1997) attempt to value global ecosystem services produced numbers that were eye-catching but of little or no direct policy relevance, whereas the update (Costanza et al. 2014) revealed changes, and helpfully broke these down into components of physical changes and changes due to revised economic values for services.

Even then, the observation of trends through ecosystem accounting or similar exercises only reveals that some intervention may be required. This does not directly address the question of what that intervention should be. To this end, policy and project appraisal methods are required in order to examine the costs and benefits of different options for addressing the problems identified by accounting. It remains possible that CBA using estimates of the opportunity costs of each option for action could suggest that the options to combat the decline may not be as attractive as alternative

uses of resources. Accounting could therefore help indicate where appraisal is needed, but does not replace the need for project appraisal. These are complementary tools, not alternatives.

One potential area of use for ecosystem accounts is in tracking targets associated with restoration of degraded ecosystems and halting the loss of biodiversity. Information on the physical state of ecosystems and the stocks of ecosystem assets are central to this, and information on flows is important in identifying pressures. Ecosystem accounts can track this information at a broad scale. This could be complementary to existing reporting at smaller scales, for example Natura 2000 site-level reporting, which could potentially inform trade-offs across sites (e.g. if ongoing loss of wading bird habitats through coastal squeeze could justify conversion of other habitats).

Assessing the value of natural capital assets could provide more comprehensive information on a nation's balance sheet as well as at smaller spatially-disaggregated scales (eftec, 2015). SNA indicators of long-term living standards only take into account stocks of produced capital such as buildings, machinery, and other infrastructure. Broader definitions of wealth, including natural capital, provide a more complete picture. UK research into the value of natural capital has been carried out by ONS (2013) and the Natural Capital Committee has produced guidelines for corporate natural capital accounting, for example (eftec et al., 2015).

There are many other potential areas of application, for example mapping and tracking information under the Water Framework Directive compliance, identifying areas of water stress, and informing the next round of River Basin Management Plans. Accounts could be compiled at the river basin/catchment level. Extended analysis using accounts could also be useful in scenario planning exercises, as an alternative framework for presenting information. The usefulness of accounts for policy processes should grow over time as accounts become more robust and comprehensive, and also more familiar to policy makers. However for the most part these uses remain hypothetical, and it remains to be seen how useful accounts prove to be in practice, and whether issues regarding proper uses and interpretations of accounts lead to problems.

3. VALUATION IN ECOSYSTEM ACCOUNTING

The ultimate aim of defining and measuring non-market values, such as those derived from the environment and the provision of ecosystem services, is to include this information in decision-making processes. Particular areas where valuation can assist include, for example:

- The demonstration of the economic importance of a good or service;
- Policy, programme and project appraisal;
- Setting priorities within a sector plan or across different sectors;
- Natural capital accounting and ecosystem accounting;
- Setting socially desirable levels for taxes, subsidies, permits and other instruments; and
- Determining compensation when economic or environmental damages are caused.

Values can be defined and measured in different ways, and the appropriate choices will depend on the purpose of the assessment. A particularly important distinction is between exchange values and welfare values. This is discussed in the next section, followed by issues regarding spatial scales, differences between actual and potential values, assumptions about future flows and time horizons, and the correct valuation concepts to apply. The implications for valuation for ecosystem accounting are then considered, along with the different requirements of look-up values for accounting and for policy appraisal purposes.

3.1 Exchange and welfare values

There are two major analytical frameworks in economics, each predicated on a different set of value judgements. The frameworks are:

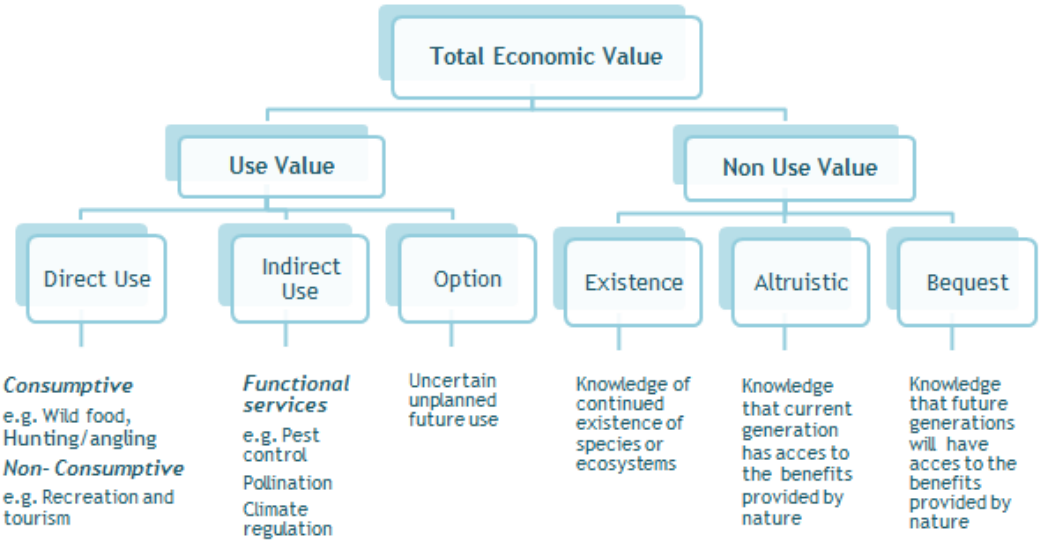
- Economic impact assessment: a quantitative method used to estimate economic activity and the impact that a particular project or industry has in the area within which it is located. It usually measures changes of output, GDP, employment and tax revenues associated with changes in the level of economic activity resulting from the project or industry being analysed. It also measures changes in business revenue and profits, personal wages, and/or jobs. In general, economic impacts can be estimated at the direct, indirect and induced levels. These impacts are often estimated using multipliers derived from Input-Output (I-O) analysis (Miller and Blair, 2009). For most applications, use of published I-O tables and associated multipliers is likely to be the most practical solution; guidance for doing this for UK economic impact assessments is provided by ONS (2010).

- Economic value: based on economic theory using welfare-based assessments of value that can be used in the cost-benefit analysis (CBA) framework. CBA is a widely used technique, and the basis of UK Government guidance on policy and project appraisal as laid out in the HM Treasury Green Book (2003) where the focus of public sector appraisal is on getting the best "public value" from government investments and decisions. CBA helps to achieve this by examining a policy or decision in terms of its consequences and costs and benefits, and by weighing up the costs and benefits of the policy to determine if the benefits outweigh the costs. The purpose of CBA is to provide a consistent and transparent procedure for evaluating decisions in terms of their consequences.

Generally, when economists refer to the economic value of a good or service they mean "a measure of its contribution to human welfare" (Brouwer et al. 2013) under the assumptions of economic theory. Economic analysis applied to (changes in) ecosystem services aims to measure (changes in)

'total economic value' (TEV), usually via theoretically valid assessments of consumer and producer surpluses, and sometimes via proxy measures. Figure 3.1 sets out the components of TEV.

Figure 3.1: Total economic value (TEV) framework

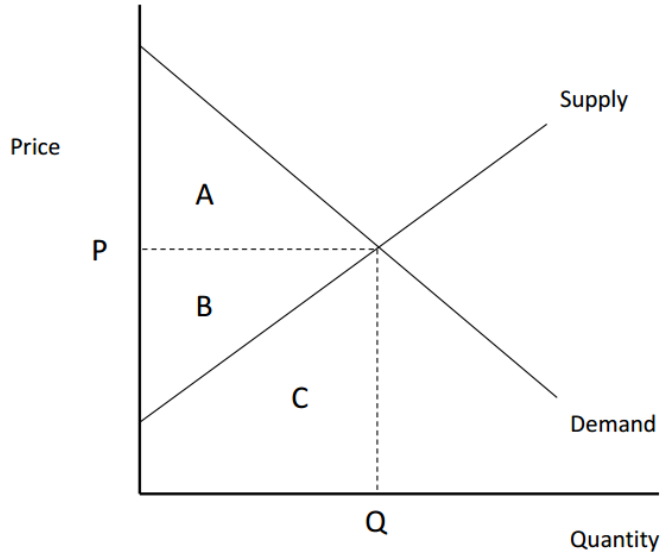


The TEV framework for measuring surpluses is different from the notion of exchange value, defined as "the total value of income, production and expenditure as evidenced by transactions" (Brouwer et al. 2013) and measured as the product of market prices and quantities. Exchange values are used in economic impact assessment, generally adjusted for indirect and induced effects via the use of multipliers derived from input-output analysis.

Figure 3.2 and the following text outline the difference between exchange and welfare values where:

- Area A represents the consumer surplus, the excess of consumer welfare from the good or service over what consumers actually have to pay;
- Area B represents the producer surplus, the excess of payment received over the opportunity cost of providing the good or service;
- A+B is total surplus which corresponds to the welfare-economic definition of value (TEV);
- Area C is the production cost – the opportunity cost or resource cost of production;
- The market equilibrium is at quantity Q, price P;
- P represents consumers' marginal willingness to pay at quantity Q; and
- The exchange value P×Q is equal to the sum of producer surplus (B) and resource costs (C).

Figure 3.3: Markets, surpluses, exchange value and welfare value



A = consumer surplus;
B = producer surplus;
A+B = total surplus = welfare-economic definition of value (TEV);
C = opportunity cost of production;
Q = market equilibrium quantity
P = market equilibrium price = consumers' marginal willingness to pay at quantity Q;
P×Q = exchange value = sum of producer surplus (B) and resource costs (C).

Source: Brouwer et al. (2013)

For national accounting purposes, the exchange value is equal to the area B+C. What changes when comparing the welfare value concept and the exchange value is the involvement of either consumer surplus in the first case (area A), and the production costs in the latter case (area C). In the case of welfare values, a change in value represents a change in welfare for the considered producers and/or consumers. This is not always true when considering a change in exchange values, since consumer surplus (area A) is outside the definition of exchange value, it is possible for exchange value to increase, due for example to suppliers exercising market power or price discrimination, even if total surplus remains static or declines due to a reduction in quantity at higher prices. Welfare value is therefore considered as a theoretically valid measure of economic value, contrary to exchange value (Brouwer et al., 2013).

It should be noted that the difference here is not one of fundamental 'content' but rather a matter of institutions and property rights. Economic value is based on individual's willingness to pay (WTP), and the locus of WTP forms the demand curve for a good or service. Exchange value for marketed goods and services is based on what people actually have to pay, and so depends partly on demand and partly on property rights and market institutions. Clearly defined property rights and well-functioning markets are more common for direct use values, but there are many examples of direct use where markets do not exist. There are also examples where individuals do make payments corresponding to option or non-use values; for example payments to conservation NGOs involved in protection of natural resources people are unlikely ever to use or witness directly.

The SNA uses exchange values not welfare values and the same basis is called for in ecosystem accounting (SEEA-EEA 2012). There is a clear problem, however, since many ecosystem services and assets are not traded in markets and therefore do not have observable exchange values. Exchange values are defined as amounts of money that willing purchasers pay to acquire goods, services or assets from willing sellers. The exchanges should be made between independent parties on the basis of commercial considerations only, sometimes called "at arm's length" (SNA 2008; 3.119). One option for ecosystem accounting purposes is to attempt to simulate exchange values – in other words, answer the question, what *would* willing purchasers pay to acquire ecosystem services and assets if they did in fact have to pay for them?

In this context, it should be noted that even for market goods and services exchange values can be complex. For example, the discussion above assumes that all purchasers pay the same price P. In reality, many suppliers are able to use discriminatory pricing, according, for instance, to the age of purchaser (e.g. child and senior citizen discounts), family size (large family discounts), education or employment status (student and unemployed discounts), time (cheaper midweek deals), volume of purchase (bulk deals), club memberships, and so on.

In some cases this could in principle be treated as cases of different markets/goods (e.g. a midweek flight can be seen as a different good and different market from a Friday evening flight). However, the point stands that "prices are not some unchanging feature of market exchange, but reflect as much on the institutional setting through which exchange takes place as on the underlying structure of preferences" (Day, 2013). This is important because for the same quantity Q, the exchange value (recorded in the accounts) may vary depending on how exactly the exchanges take place. At the extreme, a 'perfectly discriminating' supplier, able to charge each customer his or her maximum WTP, would claim all surplus. Day (2013) points out, however, that although the interpretation in terms of welfare is vague/variable, the accounts do accurately reflect traded quantities and monetary flows. There are, though, precedents for adjusting or imputing values to 'correct' for specific features of institutional structures. For example, the use of imputed values for the services of financial intermediaries, discussed previously in Section 2.2.3, where it is clear that the *services* exist and are transacted, and an imputed value is needed in order to ascribe an exchange value to these transactions.

There are, therefore, clear issues regarding the distinction between welfare and exchange value measurements of activities. In principle, the SNA can allow imputed prices for a whole range of un-marketed natural resource provisioning services, such as private production/consumption of wood fuel, fishing, water abstraction, food production, and solar power. These could all fall within the production boundary of the SNA, but in practice they are generally omitted - for practical reasons (lack of data) and because they are relatively minor compared to industrial sectors and are not directly relevant to monetary policy. However, in moving to environmental and especially ecosystem accounting, it becomes important to estimate exchange values for these goods and services.

It would of course be possible to carry out accounting using welfare-economic concepts of value rather than exchange values. However, for comparisons, this would require a re-estimation of SNA based accounting valuations from an exchange value concept to a welfare economic concept of value. This possibility is explored in approaches such as inclusive wealth accounting where, in concept, shadow prices for all assets (including ecosystems) are compared. In practice, the estimation of shadow prices is a challenging task and often market prices (based on exchange value concepts) are used as proxies for shadow prices. There are also problems associated with estimating total welfare values for essential goods and services (such as drinking water). Welfare analysis is best suited to looking at marginal changes and can struggle to cope with large or total changes. Ecosystem accounts are in effect reporting total "baseline" values, and for this purpose exchange values may be more useful. What needs to be clearly understood is that accounts are not attempting welfare valuation and do not replace the need for CBA appraisal of policy changes.

3.2 Approaches to estimating exchange values

In the SNA and the SEEA-CF 2012, the valuation of assets is limited to those assets over which property rights can be enforced. It is the existence of property rights that generates the potential for a stream of economic benefits that in turn gives economic assets their exchange value. This is problematic in the context of ecosystem accounts, where ecosystem services are often provided without any transaction and with no clear property rights. Quantities can often be observed, but not prices.

In the absence of markets for ecosystem services, there is a need to reveal the marginal WTP of consumers for the services involved – with consumers in this case, including, for instance, agricultural and industrial producers. Conceptually, if access to these services is not otherwise constrained, people faced with a zero price will make use of them up to the point at which their marginal WTP is equal to the marginal (opportunity) costs they incur in using the service. These costs are often non-zero, even if there is no direct market price; for example, people incur travel and time costs to enjoy outdoor recreation. Costs of use can form the basis of welfare-based valuation via the travel cost method (see Section 3.5).

Day (2013) identifies three options for proceeding where no price can be observed:

- Zero price: a strict application of the SNA use of exchange values, valuing consumption of non-traded goods at zero;

- Representative marginal price: using modelling to estimate the price that would be obtained in a perfectly competitive market for the service. This is the basis of the 'simulated exchange value' approach, and seems to be the most likely option for use in practice; or

- Representative discriminatory prices: choose *any set* of discriminatory prices that fall below the demand curve and pass through the observed quantity. This is feasible, but could be seen as too arbitrary, and/or as confusing due to the use of different prices for each unit of the good or service.

The first option of zero price maintains maximum compatibility with the SNA. It is implicitly widespread (i.e. for all non-traded goods and services that are not included in accounts) but is essentially unsatisfactory, since it is tantamount to excluding ecosystem services provision from the monetary (though not physical) accounts. This rather defeats the object of ecosystem accounting by recording observed quantities at zero value. In particular, this could create perverse dynamic incentives (or interpretations) since moves to create markets in environmental goods and services would result in higher values recorded in accounts – even if in fact aggregate welfare values fell by excluding (pricing out) some consumers.

The simulated exchange value approach estimates the value of ecosystem services in terms of potential revenue (Oviedo et al. 2010). This arguably represents a more consistent basis for including their value in national accounts alongside monetary transactions. The method aims to measure the income that would occur in a hypothetical market, were ecosystem services to be bought and sold. It involves estimating a demand and a supply curve for the ecosystem service in question and then making further assumptions on the price that would be charged by a profit-maximising resource manager under alternative market scenarios. The method then takes the hypothetical revenue associated with this transaction (excluding the associated consumer surplus) as a measure of value of the flow of ecosystem services.

Practical examples of simulated exchange values are yet to be developed widely, although one example that can be considered is the DECC carbon values (DECC, 2014). These are split into traded and non-traded series. The non-traded values are based on estimates of marginal abatement costs associated with meeting UK abatement commitments. The rationale is that the damage costs are extremely difficult to calculate, and efficient abatement requires equating marginal abatement costs. The traded values are based on assumptions about trades for emissions that are covered by the EU Emissions Trading Scheme (ETS). Both sets of values rise over time, and eventually converge. This can be thought of as a simulated exchange value, considering what the prices would be if all the emissions fell within the bounds of a carbon market constrained to meet UK emissions targets.

It should be noted, however, that the simulated exchange value option introduces a logical inconsistency, since at a given marginal price consumers would demand a lower quantity of the environmental service compared to when it is free at the point of use. For example, with a paid market in recreation, it is reasonable to expect lower numbers of visits compared to the case of free access. This has the potential to add confusion between the monetary and physical accounts. Using the simulated price with the existing quantity would overstate the value of the service by valuing some units at a price above the maximum WTP. Using the simulated price with the simulated quantity would avoid this, but would then involve a fictitious quantity, which could be seen as introducing an inconsistency between the physical and monetary accounts (though in practice the simulated quantity would not appear directly in the accounts, but only as a simulated exchange value).

The third option of using a set of discriminatory prices would avoid this problem, in effect matching each unit of the service with a price that theoretically could exist (in the sense of being less than or equal to the maximum WTP for that unit); where some conceivable market institution could mimic the price function used. However, since the choice of any specific function is essentially arbitrary, this could be seen as too vague, or even open to manipulation, and as weakening comparability across different accounting exercises. Day (2013) argues that, while the choice of function is arbitrary so long as it satisfies this constraint, one option would be to use the demand curve. If use of the full demand curve is considered too undesirable for accounting purposes (by including all consumer surplus in the estimate of value, à la TEV / CBA), then potentially a simple rule of thumb could be derived, based on other markets, for splitting total expenditure into 'exchange' and consumer surplus portions.

Using the full demand curve would have three main practical advantages. Firstly, estimating demand curves is the existing aim of non-market valuation methods, so the tools and methods exist. Secondly, this approach would remove any confusion or inconsistency between values recorded in accounts, and surplus values used in welfare assessments and cost-benefit analysis. Thirdly, it would combat the issue of arbitrariness and enhance comparability, if all accounting adopted this approach. On the other hand, it would not be practical where marginal WTP rises very high for first units of a service, as would be the case for essential services. It could also be seen as confusing to apply price functions rather than a single price estimate, since it would imply using different prices for different units of the good or service.

The most general point to take from Day (2013) is that the notion of exchange value for market goods and services is dependent on market institutions and structures including the distribution / definition of property rights, in a way that the welfare values are not. This is in some ways analogous to the distinction between economic (Pareto) efficiency, which clearly requires the equation of marginal values, and fairness/equity, which is a distributional issue that is largely independent of the efficiency question; i.e. any efficiency gain is a potential Pareto improvement, and any desired distribution can be achieved through lump-sum redistributions. Day (2013) is pointing out, in effect, that there is only one correct measure of welfare values (which do not depend on the market institutions used to allocate resources) but multiple possible measures of exchange value, any one of which would be an output of some feasible set of market arrangements. Therefore, it is conceivable that similar flexibility could be allowed in how exchange values are defined for non-traded goods and services.

If the actual market price is zero (the good/service is not traded for money), but it is decided not to use that value in accounts (on the very reasonable grounds that that would be a pointless exercise), there is no particular reason to select any other specific price or function – any of those meeting the Day (2013) conditions would 'do'. The use of a simulated exchange value based on a profit-maximising

resource manager, however, would not do this in most cases[18], because the profit maximisation involves exclusion of consumers with lower WTPs in order to reap super-normal profits on infra-marginal units. This does not necessarily matter too much merely for accounting purposes, however, provided the methods are applied consistently.

3.3 Boundaries of assessment

Ecosystem accounts extend the production and asset boundaries compared to the SNA. Once feedbacks with ecosystems and their condition are taken into account, the consequences of resource use and economic activity can reach beyond the immediate area and time, so in developing the accounts, spatial and temporal boundaries of analysis also need to be considered.

3.3.1 Spatial boundaries and resolution

Purely for comparison with national SNA figures, aggregate national-level data for ecosystem accounts may be sufficient, and detailed bottom-up modelling and mapping may not be required – though it should be noted that exchange values for some goods and services can be location-dependent. More generally, however, ecosystem accounting holds great potential for structuring information, communication and decision-support at a variety of scales and governance levels. To achieve these ends, and to take proper account of trade-offs across different services at local scales, spatially disaggregated accounts are needed. This then is of significance for assessing the potential to use look-up values in ecosystem accounts, since these represent broad and generalised values – accommodating both exchange values and welfare values - that are not spatially sensitive.

The Defra and ONS (2014) principles state that "Accounts should be compiled initially at UK level" (P5.1), but also note (A5.1) that the usefulness of accounts for other geographic areas such as UK countries or regions, specific protected landscapes (e.g. National Parks) and specific landholdings (e.g. the Public Forest Estate) should be explored. For any accounting application, the SEEA Experimental Ecosystem Accounts defines three nested scales of analysis: basic spatial units (BSU), land cover/ecosystem functional units (LCEU) and ecosystem accounting units (EAU). BSU are fairly small-scale tessellations formed either by a standard grid (e.g. 1km^2 cells, this is the most likely approach for UK accounts) or by land parcels delineated by the cadastre. LCEU is defined as the set of contiguous BSU satisfying a pre-determined set of factors relating to the characteristics and operation of an ecosystem (such as land cover type, water resources and soil type), defined in such a way that the set of BSU within a LCEU operate in a relatively joint manner and independently from neighbouring LCEUs. EAUs are larger scale and rather fixed areas, taking account of administrative/management boundaries and large scale natural features (e.g. river basins).

The problem for monetary valuation and even physical stock/flow purposes is that the proposed LCEU are already highly aggregated – for example, all forest land would be classed under "Forest tree cover". Some cross-classification may be needed to reflect the extent of human activity, and that LCEU classifications may need to reflect variations in climatic conditions, geophysical conditions, and land use. This remains highly aggregated, but would be sufficient for national-level monitoring and comparison to the SNA. For this purpose alone, it would be disproportionate to develop highly spatially disaggregated estimates, even where ecosystem services are sensitive to location and quality. For example, aggregate data on timber harvests/sales may be sufficient to deal with the timber provisioning service. This context may be an appropriate context for applying look-up values

[18] The exception being a perfectly price discriminating monopolist, but this coincides with Day's third option.

- particularly if based on top-down estimates - as at the aggregate level much information on spatial sensitivity is lost. This level of (in)accuracy in valuation estimates may be acceptable, particularly if the interpretation of accounts is mainly to understand orders of magnitude of values.

For spatially disaggregated accounts, various ecosystem modelling and valuation approaches could be useful. For example, the InVEST suite[19] includes seventeen modules related to specific ecosystem functions and services but demands detailed local modelling, including a full hydrological map. ARIES[20] uses artificial intelligence and Bayesian networks for value transfer based on land use and land cover, and the SERVES[21] toolkit similarly uses value transfer to provide high and low values by ecosystem service and land cover type. eftec (2015) develop a typology-based approach using logic chains that link underlying ecosystem characteristics with the provision of ecosystem services. These approaches build up representations of the ways in which ecosystem condition, location and extent determine the level of ecosystem services and the value of natural capital to human society. For most services these approaches can be applied to data at the BSU level, though some services are better defined or measured at the LCEU or even EAU level. For example, watershed protection / flood risk benefits may be best assessed at catchment level, where the benefits could be estimated in terms of reduced damages at the catchment level. Value transfer to the BSU level can detect differences in quality/condition across the parcels that go together to make up the extent of land in a particular LCEU, while at the same time matching the requirements of the SEEA at aggregated levels (for example, maintaining a clear distinction between cultivated and non-cultivated timber resources).

Similarly, the land cover classifications used in the SEEA are generally too aggregated to use as categories for valuation. A bottom-up approach with much more detailed and spatially disaggregated LCEU classification can be matched better with appropriate valuation data - noting in particular that proximity to human populations and economic activities is a key determinant of the value of many ecosystem services. These values can then be aggregated to totals that match the classification and there can be a clean mapping from the LCEU 'characteristics' used in the logic chains to the service flows and values, and on to the aggregates presented in the table/accounts. In this setting look-up values may not be appropriate since explicitly capturing spatial sensitivity in values is a fundamental purpose of spatially disaggregated accounts.

It is also worth noting that there can be different hierarchies of accounts, with some potential for overlapping / double-counting. This could be the case, in particular, where broad habitat accounts are used to build up an overall picture of natural capital at the national level, while local multi-habitat accounts are used for informing the management and reporting of protected areas or administrative divisions.

3.3.2 Asset values: time horizons

The intent of asset accounts is to record the opening and closing stock of environmental assets and the different types of changes in the stock over an accounting period. As discussed previously, there are different ways in which asset values can be measured, including:

- Values observed in markets (capitalised exchange values);
- Written down replacement cost (a cost-based valuation method that may or may not reflect the economic value of an asset); and

[19] See: http://www.naturalcapitalproject.org/models/models.html
[20] See: http://www.ariesonline.org/
[21] See: http://esvaluation.org/values-reporting

- Discounted value of future returns (i.e. a flow of either exchange-based values or welfare-based values over time).

The latter involves estimating the present value of a stream of future flows of services, and is often the most practical approach for ecosystem asset valuation. In principle, assets should be valued over an 'infinite' time horizon. In practice, assumptions about flows over long horizons are likely to be extremely uncertain, and the impact of discounting means that distant years contribute relatively less to present values. Arguably the change in value between accounting periods is of greater interest than the absolute value (which would be higher for a longer asset life).

For consistency across accounts, any arbitrary time period could be used (e.g. 25 years) but there also needs to be consistency within accounts. For example, if timber a 50 year lifespan has been used, so other woodland services should also be capitalised over 50 years, taking into account the current life of the asset. Sensitivity analysis is relatively straightforward and different options could be explored – Defra and ONS (2014) paper notes that "we will keep the appropriate time period for asset valuation under review as we produce initial accounts" (A15.1). Current plans are to update this to a default value of 50 years, for consistency[22].

This need for consistency also applies to physical accounts - it is incorrect to assume that discounting only applies to monetary values. Discounting could be applied to any measurement system, including physical quantities, since it is concerned with real time preference, not money (which is simply a convenient metric for comparing values). However, it is important not to double-discount (i.e. if physical measures are discounted, monetary values applied to the discounted physical measures should not also be discounted).

3.4 Treatment of actual and potential flows

Another important extension brought into focus by ecosystem accounting is the potentially large difference between actual service flows and potential flows. This can apply both in the context of 'spare capacity' (services that could be economically valuable but that are not actually used at present) and in the context of changing asset condition, where deterioration or recovery of natural resources can effect major changes in future flow potential.

3.4.1 Flow values: actual use

To the extent that flows are traded (timber, fish landings, agricultural production and so on) they are already included in the accounts through the SNA and SEEA-CF 2012. The purpose of ecosystem accounts is to develop a more holistic, ecosystem-based assessment. The accounts need to record changes in the status/condition of the assets that support service flows, as well as changes in flows. Defra and ONS (2014) sets out three key principles here:

- Aim to reflect wherever possible the contribution of ecosystems to goods and services that benefit people (P9.1);
- Wherever possible to value actual use of services (P9.2); and
- View the ecosystem as an asset in recording monetary flows (P9.3).

[22] Pers. comm. Defra, May 2015.

This suggests that valuation should assess the value of goods and services produced during an accounting period (for flow accounts) and at the present value of current and future goods and services (for asset accounts). The rationale given for favouring actual use is that it is more consistent with general national accounting principles and because many regulating and cultural services will provide greater value where there are more people or businesses making use of the service.

This is often true, and it will often be appropriate to reflect this difference. However, there can be some exceptions, in particular where the interest is at smaller spatial scale, or in spatial distribution of services/benefits, and the precise location of benefits is highly variable or uncertain over time. For example, timber harvests may average out to a roughly constant flow at the national level, but at local scales will vary hugely, with any given stand being thinned periodically and harvested only once every 60 or more years. In such a situation, a more representative picture of ecosystem service flows may be derived by focusing on the annual increment[23], not on the actual timber extraction. This is potentially an important difference between environmental accounts and ecosystem accounts. Other examples could include habitat provision for rare bird species, and associated recreational values – the specific locations used by the species may vary year-to-year, and the appropriate service may be provision of *suitable* habitat rather than actual habitat occupation.

The woodland and marine accounts prepared by eftec (2015) are consistent with the above principles through use of logic chains with direct links between ecosystem characteristics and ecosystem service provision. By reporting on the aggregate condition of the stock, the approach also considers 'capacity' to produce ecosystem service. The actual realisation of ecosystem services is then based on the harvesting rate or use of the stock to produce ecosystem service flows. The physical state of a system is a strong determinant of potential value, but realised value depends on human inputs and demand.

One interesting option for research would be to consider the 'slack' between potential and realised values as a form of insurance/resilience value, or an option value. This is one way in which accounts could: (i) take uncertainty partly into account; and (ii) give credit/cost for changes in natural capital states that do not directly convert into final service flows at present, but that do influence national natural wealth (future opportunities). This may be relevant to both exchange and welfare-based measures of value. However the conditions under which this approach could be considered valid would require careful consideration and research. It might be best applied at the ecosystem asset level, since for individual ecosystem services there is often a trade-off (taking less than capacity for a given service, e.g. timber, allows greater levels of other services, e.g. recreation and biodiversity).

3.4.2 Asset values: constant flows

Ecosystems are also assets that may be capable of producing enhanced services in future – or that may be suffering unsustainable exploitation, leading to unavoidable decline in flows. In the SNA, consumption of fixed capital is tracked to account for some aspects of declining capital values. However depletion of non-produced assets (land, minerals etc.) is not accounted for.

One option is to take the position that accounts should not cover issues related to irreversible depletion of natural capital, ecological thresholds, non-linear relationships and hysteresis, so that to assess these issues accounts must be combined with other analytical tools and data. However, it is possible to some extent to consider sustainability directly with SEEA and in ecosystem accounting. While it can be convenient to assume constant ecosystem service flows for the purposes of estimating

[23] Annual increment is the increase in volume of a tree or a stand over a year or annualised over a specified period measured either in m^3 per year or in m^3 per hectare per year.

asset values, this ignores any potential for changes in the capital values. For this, it is necessary to focus on capacity and likely future changes in flows.

The accounting principles imply that asset values would be based on expected service flows, generally based on the current pattern of use unless there is strong evidence to think otherwise. Defra and ONS (2012) Principle 14.1 states that "Any departure from a constant service flow assumption would need to be justified and evidenced". However, this appears to reverse the appropriate burden of proof in some cases (c.f. the precautionary principle), in particular for exploitation of ecosystem goods and services that may not be sustainable.

Where current flows are sustainable, the constant flow assumption is relatively unproblematic, even though it ignores the capacity for enhanced future flows (in fact, it is appropriate that any claim of increased future flows should be justified and evidenced). When current flows may not be sustainable (e.g. over-fishing, soil erosion, and so on), the constant flow assumption could be dangerously wrong. It would be appropriate, therefore, that the burden of proof be to demonstrate that the sustainability of a constant flow is a reasonable assumption. Where this cannot be established, that begs the question of what future decline should be assumed. It may be preferable to use dynamic models of ecosystem service provision to account for possible changes and risks. Although uncertainty in these models is likely to be significantly greater than that in current flow measurement, it does not necessarily follow that the assumption of constant flows is less uncertain, or justified. It should also be noted that flows could change for exchange value rather than physical output reasons. Further examining the link between ecosystem condition and its capacity to produce future ecosystem service flows represents an area for further development in the SEEA[24].

3.5 Valuation methods for accounts

Pittini et al. (2013) identify some important principles for valuation of non-marketed goods and services for national accounting:

- Accounting frameworks will never capture all values for the natural environment. The point is to "expand the production and asset boundaries of the national accounts, starting with values that are as close as possible to the market and proceeding to include non-market values that probably still reflect direct and indirect use values";

- Some loss of precision in value estimates may be acceptable, for the sake of greater inclusiveness;

- Monetary valuation (using either exchange or welfare values) does not fully address sustainability concerns: challenges such as non-linearity, irreversibility and the limitations of marginal valuation "point to the need for complementing monetary valuation and wealth accounting approaches with assessments of critical stocks, as well as to the importance of developing physical accounts and indicators"; and

- Monetary accounting depends upon and must be developed in parallel with physical accounting.

Brouwer et al. (2013) reviewed EU national ecosystem assessments, and reported that while most studies cover several different kinds of provisioning, regulating, cultural and sometimes supporting services, relatively few services are assessed using non-market valuation techniques. Most

[24] See for example: Forum of Experts in SEEA Experimental Ecosystem Accounting, April 2015. http://unstats.un.org/unsd/envaccounting/workshops/eea_forum_2015/lod.asp

provisioning services are valued using market prices. Regulating services are generally 'valued' using cost-based methods. Cultural and supporting services are much less commonly valued in monetary terms. A summary of methods is provided in Table 3.1.

In most cases, the focus of attempts to measure values for non-market goods and services is welfare analysis (using the TEV framework for cost-benefit analysis purposes). Therefore most valuation methods and applications developed in the field of environmental economics attempt to include consumer surplus. Without adjustment, these estimates may be considered less applicable in the context of estimating exchange values for comparison with standard economic accounting estimates. However, there is also considerable potential for utilising these methods to estimate exchange values, particularly since - when fully applied - they aim to estimate demand curves, which is a core element of the simulated exchange value approach[25].

A notable case is the use of cost-based proxies, such as the replacement cost approach, which is commonly used in the case of regulating services. While these often have the advantage of being relatively easy to apply, they do not have any particular relationship with the value of services – in particular, it is possible that the costs to replace a service could exceed the maximum willingness to pay for it. However, where it can be assumed that the expenditures would take place – i.e. the costs do not exceed maximum WTP – then the costs could be used as a simulated exchange value, on the grounds that buyers who had to buy the service would be willing to do so at that price. This means that these methods will often give a reasonable estimate of (simulated) exchange value, whereas they would only be good estimates of welfare values by coincidence.

[25] Obst (2015) and Obst et al. (2014) caution against the use of stated preference methods and some applications of the travel cost method since they measure consumer surplus. The point to make however is that these methods can be used to estimate demand curves for non-market goods (as too other variants of revealed preference method). For example, discrete choice models can be used to estimate 'market shares' (i.e. demand at a given 'price') using either stated or revealed preference data. This information can then be used to simulate an exchange value in line with the options set out by Day (2013). So while valuations produced to date through stated preference methods may not be readily consistent with the SNA exchange value concept, this does not discount the use of the methods in the future for estimating exchange values through a simulated market exchange approach.

Table 3.1: Valuation methods

Family and methods	Description	Suitability for ecosystem accounts	Potential ecosystem accounts examples
Market-based methods: • Market prices • Production functions • Resource rent (residual value approach)	Market prices are appropriate for exchange values. There may be a need to correct for taxes and subsidies, or to estimate how values change with quantity.	Actual market transactions should already be in the SNA. Where market prices exist for equivalent or similar goods or services, this is likely to be suitable for deriving estimates of imputed values. Where the value could rather be derived from considering a non-marketed service as part of a production function, this could be appropriate, but if the final output is itself marketed there is a risk of double-counting, depending on the boundaries of assessment, and the service might be better considered as intermediate consumption.	Imputed values for non-traded provisioning services (e.g. gathered foods) based on prices of marketed equivalents.
Revealed preference • Travel cost • Hedonic pricing • Random utility model • Avertive behaviour	Methods based on values for environmental resources that are 'revealed' by behaviour in associated markets.	Applicable to non-marketed goods/ services that are part of marketed goods, or include marketed components ('weak complementarity'). Fully applied, these methods seek to estimate demand curves (and therefore consumer surplus) but could also be used in estimation of simulated exchange values.	Potentially applicable to recreation, aesthetic values and also for mitigations e.g. to value role of natural services in screening noise, disagreeable views, air or water pollutants. While most applications seek surplus measures, the methods could be used to estimate simulated exchange values or price functions other than demand curves. For example a basic component of travel cost method is the use of values for travel time and in some cases on-site time, generally based on wage rates. These estimates can be treated as imputed values, and in principle it is possible to take account of different individual values for different types of user (e.g. using MENE survey data) e.g. allowing for different values of time.
Stated preference • Contingent valuation • Choice experiments	Methods based on surveys in which people express preferences through responses to hypothetical payment questions or choices about alternative states of the world.	Capable of covering non-use as well as use values. Double-counting is a risk, in particular due to embedding / part-whole bias. Generally focused on welfare values, but methods could be developed to estimate simulated exchange values.	Applicable to all goods and services. Most applications seek surplus measures, but the methods could be used to estimate full demand curves and therefore any simulated exchange value.

Family and methods	Description	Suitability for ecosystem accounts	Potential ecosystem accounts examples
Cost-based techniques • Avoided costs • Replacement/ restoration costs	Proxies that do not assess economic value, but rather the costs that are avoided due to some ecosystem asset, or the costs that would be incurred to replace or restore the asset.	Risk of double counting if these combined with values of services supported by the systems. Could be used as proxies for exchange values, if it is assumed that the estimated cost is one that would actually be incurred if necessary (i.e. the buyer would be willing to pay that price).	DECC greenhouse gas values based on the marginal costs of achieving UK emissions targets. Many other services could be treated using avoided or replacement cost techniques, for example flood regulation. Widely applicable to restoration of ecosystems, potentially where targets for conservation/restoration exist
Expenditure measures • Expenditures • Gross value added	Measure expenditure, not economic value: the bases of estimating regional economic impacts through input-output modelling and multipliers.	Actual expenditures will appear already in the SNA. Could be used for simulated exchange values in some cases.	Commonly used to assess the economic impact nature-based recreation and tourism, but not directly appropriate for valuing the ecosystem service. Could be used in studies of simulated exchange values (but more a form of travel cost).

3.6 Use of look-up values in ecosystem accounts

The primary intended use of environmental look-up values is in policy and project appraisals, particularly for first-cut assessments, and for valuing secondary or incidental impacts in appraisals and assessments that might otherwise overlook environmental impacts[26]. The look-up values are intended to be interpreted as 'indicative values' that represent broad generalisations of the values that have been observed for different environmental goods and impacts. Such indicative values may also be appropriate inputs to ecosystem accounts.

High level (top-down) ecosystem accounting exercises place more emphasis on understanding the scale of values in terms of the order of magnitude and tracking these over time. Conceivably this is an objective that could be supported by the use of indicative values. Conversely, if considerable effort is to be expended on developing ecosystem accounts at the national level, the evidence base of value estimates compiled for these accounts might be an ideal source to update the look-up values for use in other accounting hierarchies (e.g. protected area accounts, corporate accounts, etc.) and in some appraisals.

The use of look-up values is likely to be less appropriate in spatially disaggregated accounts where more emphasis is placed on understanding the distribution of ecosystem service flows and how benefits vary by spatially explicit factors such as proximity to user populations and availability and quality of substitute sites (see for example eftec, 2015). This is primarily because the application of indicative environmental values does not permit much sensitivity to the spatial context of valuations at the local scales.

Recognising the potential role for using indicative values does not resolve the conceptual challenge highlighted in Section 3.1 (i.e. establishing exchange values). For the most part, the indicative values for non-market goods and services associated with ecosystem services are derived from economic valuation methods that estimate welfare values. Hence the underlying valuation perspective is inconsistent with the exchange value concept for ecosystem accounts. That said indicative values are also included from some provisioning services and marketed goods from ecosystems (e.g. timber, crops). Given these are based on observed market prices this subset of values is consistent with the SNA exchange value concept and could be considered for use in ecosystem accounts (recognising, of course, that transactions associated with these goods are already recorded in national accounts).

Broad generalisations have been made in compiling the set of indicative look-up values, which mean they must be interpreted with care. On balance, however, given the unresolved issue of determining the approach to estimating exchange values (e.g. zero price, simulated price, simulate price function) the inconsistency of indicative values with the SNA perspective may be less of a concern, at this stage. This is particularly the case if the alternative to using indicative values is assuming a zero price in monetary accounts for the provision of an ecosystem service.

The limit, however, is likely to be determined by the intended use of the account, and the degree of uncertainty that can be accommodated in valuations. Where the intention is to indicate the order of magnitude of ecosystem values at an aggregate level, indicative values may be regarded as suitable. This would be consistent with the principles set out for the use of indicative values in an appraisal context, where indicative values are intended as an 'entry-level' tool and not a replacement for detailed assessments of policy and projects with significant environmental impacts.

[26] Refer to the Technical Report for further details of project objectives and scope.

4. CONCLUSIONS

4.1 Summary

The need to develop and improve the application of valuation in ecosystem accounting is subject to increasing attention (e.g. Pittini et al., 2013; Defra and ONS, 2014; Obst et al., 2014). Whilst the valuation of non-market ecosystem goods and services is well established, there is a crucial inconsistency between the welfare-based values that are usually derived for use in CBA and the exchange values used according to the SNA principles that underpin ecosystem accounting.

A strict interpretation of the exchange value criterion would see non-marketed goods included at zero value. However, there are notable precedents for non-traded values being included in the national accounts via imputed values (e.g. health, education, and intermediate financial services). Here, different treatments are applied to reflect the specific circumstances of the flows of services for which exchange values are estimated. This plurality is also evident in the different ways in which exchange values could be imputed or simulated for ecosystem goods and services.

All options for imputing values for ecosystem goods and services involve introducing a fictitious exchange, so no individual option is 'better' from that perspective. A (monotonic) price function approach - passing through the current quantity and everywhere below the demand curve - would be logically consistent in representing one feasible market structure for efficient use of the service, but could be seen as arbitrary, as reducing comparability, and as confusing due to the use of different prices for different units. The simulated exchange value suffers from introducing a logical inconsistency (the single simulated price will often be inconsistent with the actual quantity), but has the advantage of providing a clear single price.

However, practical examples of these possible approaches are not readily available and it is evident that further research is required. Indeed, Obst (2013)[27] reported that economists involved in the SEEA editorial process "felt that the simulated exchange value approach had not been sufficiently tested in the economic literature", flagging this as a potentially important area for research. More generally, there are multiple issues surrounding the choices of values for use in the flow and asset accounts. Further research in this area could also explore the actual and likely uses of ecosystem accounts and how simulated values – both single prices and sets of discriminatory prices - would be interpreted and received by users and stakeholders. Another key issue to address is the potential for confusion between welfare-based analyses (such as CBA for projects and investments) and the exchange value based accounts, and the risk of damage to decision processes as a result from having differing valuations – underpinned by different conceptual bases - that may send mixed signals about the value of ecosystem assets.

[27] Valuation for Natural Capital Accounting: A Seminar organised by the UK Department of Environment, Food & Rural Affairs and the UK Office for National Statistics, November 2013.

4.2 Concluding points

Key concluding points include:

- **Use of ecosystem accounts**: the primary usefulness of ecosystem accounts is likely to be in the trends that they reveal over time, rather than the specific values recorded at a given point in time. Specific values can be hard to interpret, but observing a significant change in those values over a period of years gives a clear signal that something important is happening which policy-makers should be concerned about.

- **Ecosystem accounting is a complementary tool to policy and project appraisal (i.e. CBA)**: Observing trends over time can reveal that some intervention may be required, but this does not directly address the question of what that intervention should be. For that appraisal methods are required to examine the costs and benefits of different options for addressing the problems identified by accounting.

- **Exchange values**: monetary transaction prices are not an unchanging feature of markets. Whilst accounts reflect traded quantities and monetary flows, they also reflect the institutional setting through which the exchange takes place. This is recognised in the treatment of imputed prices in national accounts which 'correct' for specific features of institutional structures (e.g. the use of imputed values for the services of financial intermediaries). At present there is a lack of clarity as to the appropriate assumptions and adjustments that can be made with respect to the provision of ecosystem services and the estimation of exchange values.

- **Estimating exchange values for ecosystem services**: for many non-traded goods and services, non-market valuation methods could be applied to derive welfare measures, and could perhaps be adapted to estimate part-estimates of exchange values (e.g. simulated exchange, or other 'below-demand-curve' functions). The methods and evidence base are not perfect, however, and data availability and gaps in understanding are a barrier to the development of reliable valuations and accounts in many cases. This applies both to the bio-physical understanding of ecosystem functions and the economic understanding of how humans benefit from them. Some modelling, transfer and approximation will likely be appropriate where relevant data exist at other locations or scales.

- **Proxies for exchange values**: there are various approaches that can provide proxies for exchange values. Use of valuations that are welfare-based (e.g. revealed preference and stated preference) may be less favoured even though it is not the case that these values are 'invalid'. The differences depend on the assumptions that can be made with respect to market institution and provision of ecosystem services. Cost-based techniques (e.g. avoided cost, replacement/restoration cost) may be more readily accepted as proxies for exchange values, if it is assumed that the estimated cost is one that would actually be incurred (i.e. the buyer would be willing to pay that price). Care is needed to ensure that the use of cost-based proxies for ecosystem accounting purposes does not lead to confusion as to the appropriate inputs to welfare-based analyses such as CBA (where the cost of supplying a service has no relationship to the benefit derived from its consumption).

- **Conflicting valuations**: one concern with ecosystem accounting is the potential for multiple hierarchies of accounts to exist simultaneously – national ecosystem accounts, protected area accounts, corporate ecosystem accounts and so on. There is a risk of confusion when comparing across these accounts if the valuations are carried out under different assumptions. It can also be argued that accounts do not necessarily have to be strictly accurate so much as consistent

across space and time. For CBA focused on comparing options and maximising net present value, making accurate valuations important. Accounting is more about monitoring and tracking trends and changes. This does not mean 'anything goes', but it does suggest that the standards of accuracy for evidence may entail a lower threshold for accounting.

- **Role for look-up values**: high level (top-down) ecosystem accounting is potentially a suitable candidate for an area in which the use of look-up values might be appropriate. The limit will be determined by the intended use of the account and the degree of uncertainty that can be accommodated in valuations. If top-down accounts are primarily concerned with tracking levels of ecosystem service provision over time at broad orders of magnitude in terms of monetary values, then the use of look-up values is likely to be considered proportionate.

Further steps are needed to encourage future ecosystem accounting applications to be more explicit about the assumptions that are made in applying ecosystem values, and encouraging further research effort to develop approaches for imputing exchange values that are consistent with SNA principles and the way in which value is derived from natural assets with public good attributes. With respect to the latter, existing non-market valuation methods would seem to provide a ready starting point.

REFERENCES

Akritidis, L (2007) Improving the measurement of banking services in the UK national accounts, *Economic and Labour Market Review*, Vol. 1, No. 5, pages 29–37.

Aizcorbe, A. (2013) Recent research on disease-based prices indexes: Where do we stand?, *Survey of Current Business 93*, (July): 9–13. [Accessed August 2015] https://www.bea.gov/scb/pdf/2013/07%20July/0713_disease_based_price_indexes.pdf

Bank of England (2011) Measuring financial sector output and its contribution to UK GDP, Quarterly Bulletin 2011 Q3.

Bos, F. (2011) A national accounts satellite for human capital and education, CPB Netherlands Bureau of Economic Policy Analysis. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1935369

Brouwer R., Brander L., Kuik O., Papyrakis E. & Bateman I. (2013) A synthesis of approaches to assess and value ecosystem services in the EU in the context of TEEB. TEEB follow-up study for Europe.

Champ, P. A., Boyle, K. J., & Brown, T. C. (Eds.). (2012) *A primer on nonmarket valuation* (Vol. 3). Springer Science & Business Media.

Costanza, R., dArge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., Oneill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., (1997) The value of the world's ecosystem services and natural capital, *Nature* 387, 253–260.

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S. & Turner, R. K. (2014) Changes in the global value of ecosystem services, *Global Environmental Change*, 26, 152-158.

Day, B. (2013) An overview of valuation techniques for ecosystem accounting, University of East Anglia, Produced for Defra-ONS, "Valuation for Natural Capital Accounting Seminar".

DECC (2014) Valuation of energy use and greenhouse gas (GHG) emissions, Supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government.

Defra (2007) An introductory guide to valuing ecosystem services. [Accessed July 2015] https://www.gov.uk/government/publications/an-introductory-guide-to-valuing-ecosystem-services

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

Dunn, A., Rittmueller, L., and Whitmire, B. (2015) Introducing the new BEA health care satellite account, Survey of Current Business, 111 (January): 1-21. [Accessed August 2015] http://www.bea.gov/scb/pdf/2015/01%20January/0115_bea_health_care_satellite_account.pdf

eftec (2015) Developing UK Natural Capital Accounts: Woodland Ecosystem Accounts, for the Department for Environment, Food and Rural Affairs (Defra).

eftec (2010) Valuing Environmental Impacts: Practical Guidelines for the Use of Value Transfer in Policy and Project Appraisal, report to Defra.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182376/vt-guidelines.pdf

eftec, RSPB and PwC (2015) Developing Corporate Natural Capital Accounts: Guidelines, report to the Natural Capital Committee [Accessed July 2015]
http://www.naturalcapitalcommittee.org/corporate-natural-capital-accounting.html

European Commission (2009) GDP and beyond: measuring progress in a changing world, Communication from the Commission to the Council and the European Parliament, COM/2009/0433 final

Eisner, R. (1988) Extended accounts for national income and product, *Journal of Economic Literature*, 26(4):1611–1684.

Eisner, R. (1989) The total incomes system of accounts, University of Chicago Press.

European Parliament (2011) GDP and beyond - Measuring progress in a changing world, European Parliament resolution of 8 June 2011, 2010/2088(INI)

Hamilton K (2013) presentation to "Valuation for Natural Capital Accounting", a Seminar organised by the UK Department of Environment, Food & Rural Affairs and the UK Office for National Statistics. Monday 11 November 2013.

Hanley, N and Barbier, EB (2009) *Pricing Nature: Cost-benefit analysis and environmental policy* Edward Elgar, Cheltenham.

HM Treasury. (2003) The Green Book: Appraisal and Evaluation in Central Government. London: HM Treasury.

HM Treasury and Defra (2012) Accounting for environmental impacts: Supplementary Green Book guidance.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191500/Accounting_for_enviornomental_impacts.pdf

Hynes, S, Hanley, N and O'Donoghue, C (2009) Alternative treatments of the cost of time in recreational demand models: an application to whitewater kayaking in Ireland, *Journal of Environmental Management*, 90 (2009) 1014–1021

Kendrick, J. W. (1976) The formation and stocks of total capital, National Bureau of Economic Research.

Khan J., Greene P., Johnson A. (2014) UK Natural Capital – Initial and Partial Monetary Estimates, Office of National Statistics.

Kuznets, S (1934) "National Income, 1929–1932", 73rd US Congress, 2d session, Senate document no. 124.

Landry CE and McConnell KE (2007) Hedonic Onsight Cost Model of Recreation Demand, *Land Economics* 83 (2): 253-267.

McConnell, K. E. (1992) Onsite Time in the Demand for Recreation, *American Journal of Agricultural Economics* 74 (4): 918-25.

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: Biodiversity Synthesis. World Resources Institute, Washington, DC.

Miller, R. E., and Blair, P. D. (2009) Input-output analysis: foundations and extensions. Cambridge University Press.

Ministère de l'Éducation Nationale, de la Jeunesse et de la Vie Associative (2011). The French education account – principles and methods. Les Dossiers, 199 (May). [Accessed August 2015] http://cache.media.education.gouv.fr/file/199/02/6/DEPP-Dossier-2011-199-compte-education_english_239026.pdf

Nix Farm Management Handbook (2013) The John Nix Farm Management Pocketbook, Agro Business Consultants Ltd, 43rd revised edition, September 2012.

Obst, C. (ed.) (2015) SEEA Experimental Ecosystem Accounting: Technical Guidance, Draft.

Obst, C., Hein, L. and Edens, B. (2015) National Accounting and the Valuation of Ecosystem Assets and Their Services, *Environmental Resource Economics*, May 2015. DOI 10.1007/s10640-015-9921-1

Obst, C., & Vardon, M. (2014) Recording environmental assets in the national accounts, *Oxford Review of Economic Policy*, 30(1), 126-144.

ONS (1998) United Kingdom National Accounts Concepts, Sources and Methods. London: The Stationery Office.

ONS (2008) Proposals for a satellite account on human capital resource formation, Office for National Statistics, May 2008.

ONS (2010) Measuring the economic impact of an intervention or investment - Paper Two: Existing sources and methods, Office for National Statistics, December 2010.

ONS (2012) Accounting for the value of nature in the UK: A roadmap for the development of natural capital accounts with UK Environmental Accounts, Office for National Statistics, December.

ONS (2013) Monetary Valuation of UK Timber Resources, Office for National Statistics.

ONS (2014a) UK National Accounts – a short guide, Office for National Statistics, September.

ONS (2014b) Household Satellite Accounts – Valuing Household Clothing and Laundry Services in the UK, Office for National Statistics, November.

ONS (2014c) Human capital estimates 2013, Office for National Statistics, August.

ONS (2015) Natural capital accounting 2020 roadmap - Interim review and forward look, Office for National Statistics, 2015.

Oviedo, J. L., Campos, P., Caparrós, A. (2010) Simulated Exchange Value Method: Applying Green National Accounting to Forest Public Recreation, Documentos de trabajo (CSIC. Unidad de Políticas Comparadas), (16), 1-23.

Pittini M., Smith C., Harlow J., Khan J. and Harris R. (2013) Towards a valuation strategy for natural capital accounting in the UK Roadmap. Produced for Defra-ONS, "Valuation for Natural Capital Accounting Seminar".

Rusche K., Wilker J., Blaen P. & Benning A. (2013) Economic Valuation Methods: Overview of existing economic valuation methods to capture ecosystem service benefits of quarry restorations. RESTORE project: Work Package 4, Action 21.

Sen, A., Darnell A., Crowe, A., Bateman, I., Munday, P. & Foden, J. (2011) Economic assessment of the recreational value of ecosystems in Great Britain. *Report to the Economics Team of the UK National Ecosystem Assessment*.

Sen, A., Harwood, A., Bateman, I.J. Munday, P., Crowe, A., Brander, L., Raychaudhuri, J., Lovett, A.A. Foden J. and Provins, A. (2012) Economic Assessment of the recreational value of ecosystems in Great Britain, CSERGE Working Paper, Centre for Social and Economic Research on the Global Environment (CSERGE), School of Environmental Sciences, University of East Anglia.

Sen, A., Harwood, A. R., Bateman, I. J., Munday, P., Crowe, A., Brander, L., Raychaudhuri, J., Lovett, A.A. Foden J. and Provins, A. (2014) Economic assessment of the recreational value of ecosystems: Methodological development and national and local application, *Environmental and Resource Economics*, 57(2), 233-249.

SEEA-CF (2012) System of Environmental-Economic Accounting - Central Framework, White cover publication, European Commission, Food and Agriculture Organization, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank, 2012.

SEEA-EA (2012) System of Environmental-Economic Accounting 2012 – Applications and Extensions, Food and Agriculture Organization, European Commission, Organisation for Economic Co-operation and Development, United Nations, World Bank, 2014.

SEEA-EEA (2012) System of Environmental-Economic Accounting 2012 – Experimental Ecosystem Accounting, European Commission, Organisation for Economic Co-operation and Development, United Nations, World Bank, 2013.

SHA (2011) A System of Health Accounts – 2011 Edition, Organisation for Economic Co-operation and Development, European Union, World Health Organisation, 2011.

SNA (2008) System of National Accounts 2008, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank, 2009.

Stiglitz J.E., Sen A., Fitoussi JP (2009) Report by the Commission on the Measurement of Economic Performance and Social Progress.

TEEB (2011) The Economics of Ecosystem and Biodiversity in National and International Policy Making, edited by Patrick ten Brink. Earthscan, London, and Washington.

UK National Ecosystem Assessment (2011) The UK National Ecosystem Assessment: Synthesis of the Key Findings, UNEP-WCMC, Cambridge.

UK National Ecosystem Assessment (2014) The UK National Ecosystem Assessment: Synthesis of the Key Findings, UNEP-WCMC, LWEC, UK.

ANNEX 1: IMPUTED PRICES IN NATIONAL ACCOUNTING

The SNA includes a number of services that are not traded in monetary transactions. These include many health and education services, and the services of financial intermediaries, which are included within the production boundary of the SNA. In these instances imputed prices are applied. The following outlines the case of health and education services since, like ecosystem services, these also exhibit public good characteristics.

A1.1 Transfers in-kind – health and education services

Health and education services can either be market or non-market goods. In the former case, market transactions can be used to value health and education. In the latter case the SNA classifies them as transfers in kind[28]. In this case, the valuation of transfers in kind is described as follows: "when non-financial resources are provided without a quid pro quo [i.e. a flow in one direction is not linked to a counterpart flow in the opposite direction], such resources should be valued at the market prices that would have been received if the resources had been sold in the market. In the absence of a market price, the donor's view of the imputed value of the transaction will often be quite different from that of the recipient". In this context, the use of the value assigned by the donor is suggested as a rule of thumb for valuing transfers in kind (SNA 2008; 3.130).

A1.2 Education and human capital

The treatment of education as a transfer in-kind in the SNA follows the logic that "the acquisition of knowledge is not a process of production even though the instruction conveyed by education services is". As such "education services produced by schools, colleges, universities, etc. are thus treated as being consumed by students in the process of their acquiring knowledge and skills". In this way, education is treated as a form of final consumption. This is distinct from education as a form of intermediate consumption when it is given by an employer to enhance the effectiveness of staff (SNA 2008; 1.54).

Treating education in the SNA as a form of final or intermediate consumption is consistent with the production and asset boundaries of the SNA. However, this may not be suitable for all countries' accounts, for example, in cases where education is a more nuanced good. In this respect, it is possible to explore alternative conventions of compiling education accounts in the form of satellite accounts. There are two types of satellite accounts serving two different functions. In certain cases, satellite accounts may include features of both of the following types of accounts (SNA 2008):

- Internal satellite accounts: these accounts take the full set of accounting rules and conventions of the SNA but focus on a particular aspect of interest by moving away from the standard classifications and hierarchies. Examples include tourism and environmental protection expenditure;
- External satellite accounts: these accounts may add non-economic data and/or vary some of the accounting conventions of the SNA. They are useful in exploring new areas for research purposes. Examples include the role of volunteer labour in the economy.

[28] The SNA defines a transfer as "a transaction in which one institutional unit provides a good, service or asset to another unit without receiving from the latter any good, service or asset in return as a direct counterpart". Social transfers in kind "consist of goods and services provided by general government and non-profit institutions serving households (NPISHs) that are delivered to individual households". In the case of health and education, "rather than provide a specified amount of money to be used to purchase medical and educational services, the services are often provided in kind to make sure that the need for the services is met" (SNA 2008).

In examining the treatment of education in national accounts, it is also useful to look at human capital in an accounting context. Human capital stock can be measured from a cost-based approach, an income-based approach or using educational attainment methods (SNA, 2008; ONS, 2008). The cost-based approach in particular can be compared to the use of cost-based methods in an ecosystem accounting context. In accounting for human capital, the approach involves calculating the human capital stock as the depreciated value of the monetary amount spent on investment in human capital. Kendrick (1976) and Eisner (1985; 1989) provide early examples of this approach.

In the UK, a human capital satellite account has yet to be developed. The ONS does however publish human capital estimates (most recently in ONS, 2014c). Bos (2011) also includes the development of a national satellite account for human capital and education for the Netherlands using expenditure on education and training as human capital formation. Other European examples include the French education account compiled on an annual basis by the French Department of National Education (for principles and methods, see: Ministère de l'Éducation Nationale, de la Jeunesse et de la Vie Associative, 2011).

A1.3 Health care

Health accounts feature as part of the SNA or they can be developed as separate satellite accounts (internal and/or external satellite accounts). Much like ecosystem accounts follow the SEEA framework, health accounts follow the System of Health Accounts (SHA 2011).

Again, health care services can be private or public services. In both cases, it is possible to capture the value or activity in the health care industry using estimates of expenditure on inputs. In this way, the objective of the SHA is to describe the health care system from an expenditure perspective both for international and national perspectives. It focuses on the final consumption of health care goods and services which, when traded in a market can be valued at purchasers' prices. The aggregate "current health expenditure" combines in a single figure the monetary value of the final consumption of all health care goods and services by residents of a given country during a given period (OECD et al., 2011). A breakdown of health expenditure can also be presented as part of health accounts (e.g. by health provider, by function, etc.).

Overall though, accounting for health, in satellite accounts or otherwise, is still a work in progress. The development of the SHA is on-going with practical examples still in development and ranging from different levels of coverage of the health care industry to the development of price indices to enable the tracking in changes in the volume of health care services. Relevant examples include experimental UK health accounts by the ONS and work by the US Department of Commerce's Bureau of Economic Analysis (e.g. Dunn et al., 2015; Aizcorbe, 2013).

A1.4 Summary

When health and educational services are traded in markets, market prices can be used to value them in an accounting context. When they are transfers in-kind, "the goods and services involved are produced by activities that are no different from those used to produce goods or services for sale" (SNA 2008). In this way, their value can still be inferred from market equivalents and is captured in transactions that occur in supplying them as services.

The main difference between the valuation of health and education versus ecosystem services is that the value of the former is captured in some form of market (for the service itself or inputs to it). It follows that health and education can ultimately be valued at cost or using expenditure estimates,

while the benefits from the provision of non-market ecosystem services ordinarily cannot since property rights are less well-defined or non-existent. Hence current approaches to compiling health and education accounts have limited insight with respect to imputing prices for the provision of ecosystem services for ecosystem accounting.

ANNEX 2: FURTHER ISSUES RELATED TO ECOSYSTEM ACCOUNTING

This annex explores the treatment of further issues that arose over the course of the development of this paper based on feedback from Defra (July 2015).

A2.1 Value of time in recreation demand/ travel cost models

The data requirements of 'travel cost' analyses depend substantially on the specific type of analysis: i.e. zonal travel cost model, individual travel cost model (ITCM), discrete choice/random utility models (RUM), or trip-generating functions (TGF). Further detail is set out in the eftec (2010) report for Defra 'Scoping study into the use of recreational surveys for economic valuation' (NEE0906).

The use of these methods, particularly RUM, ITCM and TGF, is well-established. With the exception of the TGF, these methods provide estimates of consumer surplus (welfare values). However, it can be argued that the major challenge for estimating recreation demand is predicting changes in trip numbers and taking account of substitute sites. This is where the methods developed by the University of East Anglia (UEA) for the UK NEA using the MENE (Monitor of Engagement with the Natural Environment) data, are a significant step forward.

Monetary valuation of leisure time is one of the key problems for ITCM and RUM. Since time is scarce, there is an opportunity cost associated with time spent travelling, and this needs to be included in estimates of travel cost. There are two issues: (i) estimating the travel and on-site times; and (ii) valuing the time:

- Estimating time: simple approaches assume constant speeds (e.g. Landry and McConnell (2007) estimate travel time based on an average speed of 50 miles per hour for all households); more sophisticated estimates can be made that allow for different speeds on different road types using GIS, but this is more difficult and data-intensive. Travel time can also be established directly through a question in the survey.

- Valuing time: early applications of travel cost methods generally used a proportion of the wage rate, although there is no consensus on what the proportion should be. However, for most people, labour markets are not so flexible that there is a direct trade-off between working time and leisure time. There are also complications that there may be some direct enjoyment of travel time (for example a scenic drive to a recreation site) and that the values need not be linear.

Champ et al. (2012) summarise: "Time traveling to the site as well as time spent on-site should be included in any calculation of time cost. While the time of getting to and from the site is more or less fixed [*for any particular person - ed.*], time at the site is chosen by each individual and may vary across the sample. Nevertheless, on-site time is typically assumed to be constant across individuals and valued the same as travel time. Sometimes analysts use the sample average length of stay on the last trip as an estimate of the fixed on-site time. Others allow the on-site time to vary across the sample using last trip data as each person's on-site time estimate for each site. It should be evident that measuring trip cost calls for considerable researcher judgement."

In summary, there is no single 'correct' solution to the valuation of time. It is not possible directly to observe the opportunity cost of time to any individual; more generally, the analyst does not observe a utility function, but rather assumes one, both in terms of parameters and functional form. This also applies to other variables in ITCM/RUM, and econometric tests are often inconclusive in selecting

from competing assumptions and functional forms, which can result in considerable uncertainty about consumer surplus estimates from a given study.

For example, Hynes et al (2009) explore the use of various methods of incorporating the opportunity costs of time in travel cost models: excluding opportunity cost of travel time; the individual's reported wage rate; and use of wage estimates from secondary data sources. They apply the different methods in a conditional logit model for whitewater kayaking in Ireland, noting that statistically significant differences emerge. Their results demonstrate how decisions about how to measure the value of time can have a strong influence over consumer surplus estimates, which are significantly lower when the opportunity cost of time is excluded, and significantly higher when time is included at 100% of reported gross wage, compared to valuing time at 100% of the estimated net wage derived from the secondary dataset. However, it is not clear which method is "correct". Hynes et al. favour the use of an auxiliary data set to estimate wage regressions, which are then used to estimate a net hourly wage for each individual in the recreation data set. McConnell (1992) suggests allowing on-site time to be endogenous. Hanley and Barbier (2009) suggest that these problems mean it is preferable to include travel time as a separate variable alongside travel cost.

A2.2 Use of MENE data in ecosystem accounts

MENE records recreation visit information from around 45,000 interviews each year. For each interviewee it captures the total number of out-of-doors visits during the past seven days, the leisure activity type, and approximate information about the type of environment visited[29]. A more detailed part of the survey captures information, for one randomly selected trip during the past seven days, about the total time spent (combining both travel time and on-site time), distance travelled and form of transport (from which it would be possible to estimate very approximate travel times), specific location and so on.

MENE data cannot be used directly to estimate visits to any specific site (with the possible exception of some very major sites) because there are too many sites and not enough observations. Estimates for specific sites need to come either from on-site surveys (including automatic car or footfall counters) or from predictive models. MENE data can be used to construct a predictive model, though not at the site level, and this is what the UEA / UK NEA studies do. There are some differences in methodology - the earlier papers first predicted the number of potential visit sites in each 5km square (based on land cover characteristics and population density), then combined that with output from a trip generation function to estimate the number of visits to each cell (Sen et al., 2011; Sen et al., 2012). The 2014 paper does not define sites separately, but rather treats each 1km × 1km cell as a 'site', described by its percentage (%) land cover, and predicts visits from each outset area to that cell (Sen et al., 2014). The number of trips predicted to each cell is a function of the land cover in that cell (as well as other variables, in particular population in outset cells and characteristics of substitute cells) but it does not directly break the visits down into habitat types.

However, for aggregate reporting - e.g. for accounts at national level - there is no particular problem. The MENE survey will directly give a reasonable estimate of total visits of all types to each habitat type, and will cover both low value/high volume local visits and high value/low volume visits to more 'formal' sites. Indeed, MENE estimates are used by UEA for calibrating their TGF. The information

[29] Outdoors is described to interviewees as: open spaces in and around towns and cities, including parks, canals and nature areas; the coast and beaches; and the countryside including farmland, woodland, hills and rivers. Time outdoors is described as: anything from a few minutes to all day, including time spent close to home or workplace, further afield or while on holiday in England.

that is missing is the value of per visit to go with the quantity. The UEA model uses a meta-analysis to provide this value, but it is a welfare estimate, not an exchange value.

A2.3 On-site time as an imputed value for recreation in ecosystem accounts

The gap for ecosystem accounts is the estimation of an exchange value for non-market recreation, which reflects the (notional) intersection of the demand and supply curves for a good. In conventional welfare analyses, travel time to a site and time spent at a site represent opportunity costs that provide information on the demand for recreation. They are a factor in the utility function and have no relationship to the opportunity cost of supply of the good. One option, therefore, is to consider a simulated exchange value method to address the gap with respect to the supply side.

A further option is to consider an imputed value perspective, which might allow on-site visit time to be considered as part of the supply of a good. This requires the assumption that a visitor to a site is purchasing the service from themselves, in effect, by paying the out of pocket expenses (travel, entrance fee) and also 'buying' their own time for travel and on-site (essentially paying an economic rent for time). Out of pocket costs are already counted in the accounts as market transactions, but the purchase of time from the household could be included as an imputed value, potentially in a similar way to the services of financial intermediaries.

From this perspective, both travel and on-site time are in principle relevant since both are needed for the good to be supplied. On the other hand, this perspective is conceptually questionable, since on-site time can be considered part of the recreation benefit and the utility gained. The opportunity cost of travel time can more easily be taken to be part of the price, on the assumption that there is no direct utility from the journey itself.

Counting the opportunity cost of travel time plus financial costs of travel as the price of visits would likely give some counter-intuitive results. In particular, the further travelled, the higher the price. This contrasts strongly with a welfare perspective, where in surplus terms the biggest surplus is for those living very near a site who have low/zero costs of access. That said, a higher price for a further distance travelled would be consistent with the national accounts, which are measuring flow/throughput and not welfare. And it can also be argued that if people are travelling further to visit a site, it is probably appropriate to record a higher value than for a site that attracts only local visits. There is, though, an inconsistency in using a quasi-imputed time value for recreation outdoors, but not for other activities in accounts.

In summary, this really reflects the basic problem of deriving exchange values for things that are not, in fact, exchanged (or that are exchanged for free because they are public goods). The crux of the problem is that the SNA does not include non-market welfare generation; and the SEEA, though it aims to go beyond SNA, also aims to remain consistent with the valuation principles in the SNA. But the desire to stick closely to the valuation principles of the SNA, including only exchange values, and the desire to reflect values of non-market goods that are free of charge and valued via their contributions to human welfare, are in a sense incompatible.

The use of imputed values, such as simulated exchange values, can provide a work-around. But the work-around is never going to be entirely satisfactory or internally coherent, for two main reasons. Firstly, any answer to the question 'what would the price be if there were a market?' begs the further question 'and how would the quantity demanded change?'. Secondly, any use of an estimated exchange value based on the opportunity cost of time (whether travel time, on-site time or both) introduces the inconsistency of not including that value for time spent on recreational experiences that are traded.

Taking the above discussion into account, some simple rules of thumb concerning travel time and travel cost estimates could be:

Measure	SNA applications (including ecosystem accounts)	Welfare applications (CBA and wealth accounting)
Financial costs (travel and on-site payments)	Include in accounts	All part of opportunity cost that can be used to estimate surplus
Travel time	Exclude from accounts	
On-site time		

A2.4 Wealth accounting

The discussion above applies specifically to accounts following the SEEA framework and seeking exchange-value based measures of value.

If the context for an ecosystem accounting exercise is wealth accounting then the way ahead is rather clearer, since a surplus measure of value is appropriate and travel-cost / random-utility methods are available for estimating these surplus values.

However, as noted above, there is no clear agreement on exactly how to account for travel and on-site time in these models. In any case, obtaining estimates of values from individual travel cost models for each site would not be feasible. The best approach would depend on the level of spatial detail required, but at a national or regional level, with respect to keeping analytical effort proportionate, there would be significant merit in a simple value transfer approach. This approach would develop a welfare value for accounting purposes by multiply total visits at the relevant scale to average surplus values estimated from meta-analysis of valuation studies, ideally accounting for different values for different site types (e.g. beach visits, woodland visits) and activities (e.g. walking, mountain biking) .

It should be recognised that such an approach will not give 'exact' values for the welfare value of recreation. The state of knowledge is limited, both in terms of the weight of evidence available and the extent of disagreement over details of methods (such as the best way to account for time). However, it can also be argued that the primary policy interest and use for accounts is not so much the absolute value of the estimate, but rather the ability to track in consistent terms how the values change over time, and the level of accuracy demanded should be considered in this context.