Office for National Statistics

Article

UK Natural Capital Freshwater Ecosystem Assets and Services Accounts

This paper is a first attempt by the Office for National Statistics (ONS) to develop initial experimental statistics on UK freshwater ecosystem assets and ecosystem services. Selecting a number of indicators, this paper shows the condition of UK freshwaters between 2008 and 2012. On an experimental basis, ONS also estimates that the monetary value of UK freshwaters was £37 billion in 2012, 26% higher than in 2008. This is mainly due to an increase in the monetary value of UK open waters. It is important to emphasise this monetary value is based on a limited number of ecosystem services that are covered by these accounts. The methodology to develop these indicators and monetary estimates remains under development and the estimates reported should be considered experimental. Further work will be undertaken to develop and improve them.

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1 . Correction

An error in the application of deflators has caused errors in the monetary values in the key points of this release and the monetary freshwater ecosystems services account section of this paper. Errors also affected table 8, table 9 and figure 3. The affected components have since been corrected. ONS apologises for any inconvenience.

Thursday 4 June 2015 11:00

2 . Abstract

This paper is a first attempt by the Office for National Statistics (ONS) to develop initial experimental statistics on UK freshwater ecosystem assets and ecosystem services. Selecting a number of indicators, this paper shows the condition of UK freshwaters between 2008 and 2012. On an experimental basis, ONS also estimates that the monetary value of UK freshwaters was £37 billion in 2012, 26% higher than in 2008. This is mainly due to an increase in the monetary value of UK open waters. It is important to emphasise this monetary value is based on a limited number of ecosystem services that are covered by these accounts. The methodology to develop these indicators and monetary estimates remains under development and the estimates reported should be considered experimental. Further work will be undertaken to develop and improve them.

3 . Acknowledgements

This paper has benefitted from the valuable comments from Colin Smith, Julian Harlow and Rocky Harris (Department for Environment, Food and Rural Affairs), and Geoff Bright (ONS).

We would like to thank Vahé Nafilyan and Helen Lofts from the ONS for their valuable contributions.

We would also like to thank colleagues from ONS, Other Governments Departments and organisations that provided us with the data to develop these initial accounts.

4 . Introduction

In December 2012, the Office for National Statistics (ONS) published a roadmap for the development of Natural Capital Accounts. The roadmap outlined a timetable for developing eight broad habitats accounts in addition to developing aggregate natural capital estimates. One of the broad habitats proposed for development in the roadmap was ecosystem accounts for open waters, wetlands and floodplains (which can collectively be viewed as freshwater habitats) during 2013-2015.

This paper develops initial experimental statistics on UK freshwater ecosystem assets and ecosystem services. These accounts are developed in accordance with the guidelines of the System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA EEA). The SEEA EEA guidelines were published in 2012 by the United Nations Statistical Division and since then the UK has developed a number of ecosystem accounts [1], which has helped to address some of the challenges and issues that are now part of the SEEA EEA research agenda. Since SEEA EEA is still developing, ONS and the Department for Environment, Food and Rural Affairs published a principles paper in August 2014 that set out the basic principles to be followed when developing ecosystems accounts. This paper has taken the suggestions and recommendations from the principles paper into account, while following the SEEA EEA guidelines for developing UK freshwater ecosystem accounts.

This paper starts with a brief description of freshwater. It then provides the purpose for developing freshwater ecosystem accounts. The next two sections present the initial freshwater non-monetary ecosystem assets and services accounts respectively. It then provides a monetary valuation of freshwater ecosystem services, which is capitalised for 50 years by calculating the Net Present Values to obtain the asset value of these services. The final section discusses the future work needed to improve the initial freshwater ecosystem accounts.

Notes for introduction

1. Please see user guidance.

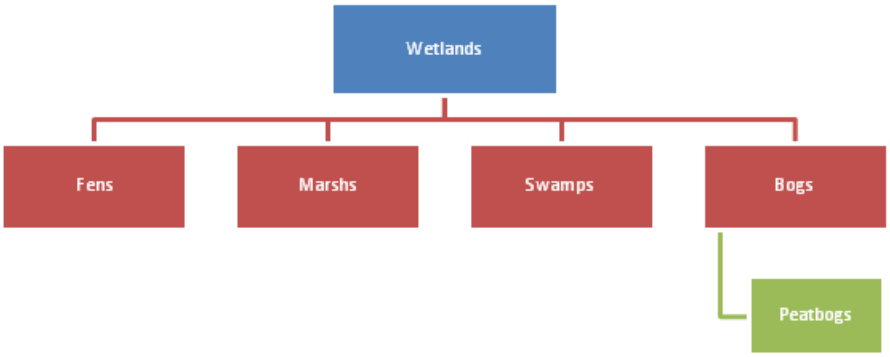
5 . What is freshwater?

Freshwater can be broadly divided into wetlands, open waters and floodplains [1].

Wetlands

There are various definitions of wetlands that broadly define them as areas of land covered by shallow water at or near the surface level. A number of types of wetlands exist in the UK. These are inland wetlands and coastal wetlands. This paper only considers inland wetlands (figure 1) as coastal wetlands can overlap with marine ecosystems as they are subject to tidal changes. Therefore, it makes sense to include coastal wetlands in a wider account of the coastal and marine ecosystems to avoid double counting.

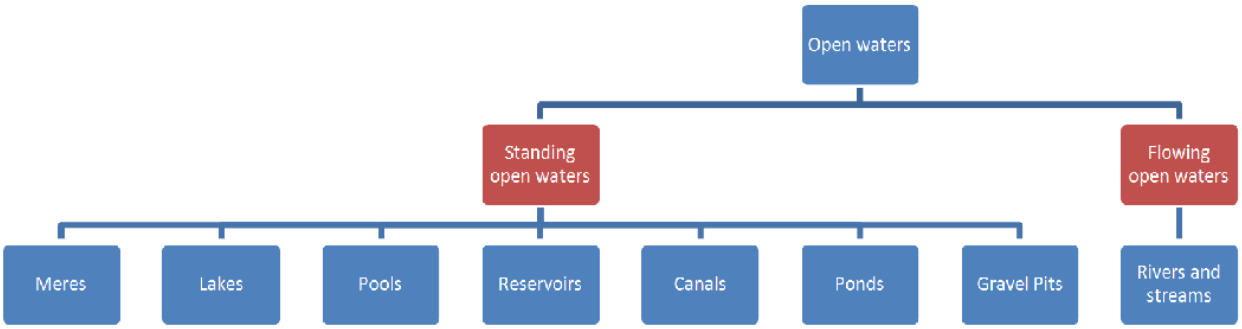
Figure 1 - Types of wetlands



Open Waters

Open waters can be divided into two categories – standing waters and flowing waters [2] - which are shown in Figure 2 below. Standing waters include natural systems - such as lakes, meres and pools - and man-made waters such as reservoirs, canals [3], ponds and gravel pits. Flowing waters include rivers and streams that flow into the sea or a lake. Both standing waters and flowing waters are included in the freshwater ecosystem accounts.

Figures 2 - Types of open waters



Floodplains

Floodplains are generally located beside rivers and streams and act as a natural soak for floodwater if a river or stream overflows. A floodplain can be broadly defined as:

“an area that would naturally be affected by flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas” (Environment Agency, 2013).

In the UK, floodplains are often not identified as separate habitats but instead are included under several different categories. For example, some areas of natural grassland lie on floodplains. Therefore, it poses a challenge to identify what percentage of that category consists of floodplain. For this reason, it is very difficult to obtain reliable data for floodplains and to avoid double counting with other habitats, such as grasslands, this paper has not included floodplains in freshwater ecosystem accounts.

Notes for what is freshwater?

1. Source: UK National Ecosystem Assessment (2011)
2. Source: Joint Nature Conservation Committee (JNCC)
3. Canals are classified as a category of standing water, but some canals could also be classified as flowing water where they are closely integrated into the river system. Furthermore, many rivers have historically been canalised for navigation purposes.

6 . Purpose of freshwater ecosystem accounts

Freshwater ecosystem accounts offer a consistent way of looking at the significance of UK wetlands and open waters, beyond simply a compilation of disparate facts and figures. They can help identify drivers of ecosystem change within the wider economy and society and they can help us understand whether the UK’s freshwaters are being used sustainably. By linking the accounts to the National Accounts they provide a more comprehensive, integrated and consistent data set, bringing together economic and environmental information which is relevant to policy. The development of monetary accounts has a particularly important role to play in this respect, as they enable the value of different services to be monitored and comparisons to be made with the value of other economic assets. The valuation estimates in this paper aims not only to raise awareness of the economic significance of UK freshwaters, but also to provide a basis for recording changes in the value of services provided by the UK freshwaters.

7 . Freshwater ecosystem assets accounts

This section presents the non-monetary freshwater ecosystem assets account for wetlands and open waters for two accounting periods – 2008 and 2012. There are two components of a non-monetary ecosystem asset account – extent and the characteristics of the ecosystem.

The extent is the size of the asset and refers to the area of the land cover by an environmental asset (for example, the land cover area of freshwater ecosystems in thousands of hectares that exists in the UK); whereas, the key characteristics are intended to identify changes in the capacity of the ecosystem to deliver the most important services. Due to the differences in the characteristics of ecosystems, separate accounts have been produced for wetlands and open waters.

The ecosystem extent and the metrics that are indicators of the key characteristics of wetlands and open waters are discussed below.

a) Freshwater ecosystem extent

As the extent of an asset is the area of the land, the extent of UK freshwater ecosystems is the area of land covered by freshwater in the UK. As discussed in the previous section, freshwater has been divided into wetlands, open waters and floodplains. These are presented in Tables 1 and 2 respectively. However, due to data limitations, floodplains are not included in this paper.

The data source for measuring the extent of freshwater ecosystems in the UK is the Countryside Survey relating to 2007. This survey was conducted by the Centre for Ecology and Hydrology. It is a randomised field survey of a number of squares (each square measuring $1km^2$). The Countryside Survey provides the latest data for 2007 only and therefore these data are assumed to be equivalent to 2008. Since the data for 2012 are not available, for illustrative purposes they have been projected by using the rate of change in freshwater ecosystem extent between 1998 (the previous Countryside Survey) and 2007. The rate of change is applied to 2008 data to project 2012 data.

Another possible source of the extent of wetland and open water ecosystems in the UK is the Land Cover Map, which is produced by analysing satellite images of the UK land cover. This is not preferable because it is unable to distinguish between certain habitats, for example, areas of bog and montane, which could result in double counting when other habitat accounts are produced. The Countryside Survey provides a better distinction between different habitats, reducing the risk of double counting.

b) Freshwater characteristics and indicators

Identifying and measuring the key characteristics of freshwater ecosystems is not straightforward. In principle, the capacity to continue to deliver services should be monitored using information about the condition of the asset. However, assessing the condition of an asset is a complex matter and in practice the choice of characteristics and indicators is largely dependent on data availability. The data for indicators selected in this paper are obtained from various sources; however, there are some data gaps for certain categories relating to Northern Ireland. The data sources and the gaps are discussed in the section below.

Three key characteristics have been selected (discussed below) for wetland and open water ecosystems that reflect the condition of UK freshwaters. For wetlands, they are accessibility, ecological condition and soil; whereas, for open waters, they are accessibility, ecological condition and water. Table 1 shows a number of indicators to measure key characteristics of wetlands and Table 2 shows the indicators used to measure key characteristics of open waters. Since conditions are not readily represented by a single indicator, multiple indicators have been selected for some characteristics.

Ecological condition

Ecological condition is an important characteristic that influences both wetland and open water ecosystems. The indicators selected for measuring ecological condition of wetlands are wetland birds and mean species richness; whereas, for open waters the indicators are surface water status.

The number of wetland birds can be an indicator of the birds that use wetlands for feeding and resting and changes in their number can indicate changes in the habitat. The mean species richness measures the average number of species in a particular area and includes the number of native and non-native plant species.

The data for wetland birds for 2008 and 2012 are from the British Trust for Ornithology. The number of birds at inland wetlands sites is a simple headcount and does not take into consideration coverage of sites for undercounts or missing counts for birds. The Wetland Bird Survey (WeBS) recording year runs from July until June, and the figures for 2008 and 2012 refer to WeBS recording years which encompass the final 6 months of one year and the first 6 months of the following year. The data are available at the UK level. The data for mean species richness are from the Countryside Survey, which is quite comprehensive. However, it acknowledges an underestimation of certain types of vegetations due to the survey method employed. As discussed earlier, the Countryside Survey provides the latest data for 2007 only and therefore these data are assumed to be equivalent to 2008. The rate of change between 1998 and 2007 has been used to project the data for 2012 for illustrative purposes. Data for Northern Ireland are not available.

Surface water status shows the percentage of water bodies in each status class and the change in percentage points of water bodies in the UK awarded a good or high surface water status class between 2008 and 2012, under the Water Framework Directive. Surface water status is a composite measure that looks at both the chemical status and the ecological (including biological and habitat condition) status of a water body. Open waters in high or moderate ecological condition are able to support a diverse range of fish, aquatic mammals and birds. Whereas open waters in bad ecological condition can have a detrimental impact on the habitats of fish, aquatic mammals and birds which depend on open waters. The data for surface water status are from the Joint Nature Conservation Committee - a public body which advises the UK government and devolved administrations - and are at UK level. Table 2 (see footnote) shows that in 2012, 33% rivers and canals in the UK were in high or good status, whereas, 21% were in bad or poor status. The table also shows that 37% lakes in the UK were in high or good status, whereas, 16% were in bad or poor status.

Soil

Soil quality is an important characteristic of wetlands as the chemical make-up of wetland soils reflects changes in the use of fertilisers in agriculture. It is also a relevant indicator of the impact of climate change on wetlands. The indicators selected for measuring soil quality for wetlands are mean total nitrogen stock and mean carbon concentration. Nitrogen stock in wetland soils indicates the number of denitrifying bacteria in the soils. These bacteria break down nitrates and release nitrogen into the atmosphere, which has an impact on the climate. The mean level of carbon concentration in wetlands indicates the absorption of carbon from the environment, which could indicate the relative health of wetlands and how they may be affected by human activities.

The data for both indicators are taken from the 2007 Countryside Survey soil report. The data refers to only Great Britain as the data for Northern Ireland are not available. Similar to the Countryside Survey, the soil report provides the latest data for 2007 only and therefore these data are assumed to be equivalent to 2008. To estimate the data for 2012, a rate of change between 1998 (the previous Countryside Survey) and 2007 is calculated and applied to the 2008 data.

Water

The volume of water is an important characteristic of open waters because it is not only used for drinking but is also used to provide benefits such as hydroelectric power generation and irrigation. The indicators selected for measuring the stock of water in open waters are the mean stock of reservoirs and the flow of rivers.

The primary functions of reservoirs in Europe are for hydroelectric power production, storage for public water supply and irrigation[1]. River water flow estimates indicate whether a river is flowing at normal level or below or above the normal level. An exceptionally high river flow could be prone to flooding; whereas, an exceptionally low river flow could be prone to drought. However, water flow in a river needs to be interpreted with caution because a river flow above a normal level may reflect rainfall for that year and may not tell much about the longer term trend in the capacity of the assets to deliver services.

The data for the mean stock of reservoirs in the UK are taken from the Hydrological Summary published by the Centre for Ecology and Hydrology (CEH). They show the number of rivers (of the 31 rivers monitored in the UK) which are above or below the mean capacity in a particular year. To measure this indicator, the average of the mean capacity of reservoirs was used as the basis for the indicator. The data are un-weighted and provide the same weight to a long river or a large river as a small river. Further work is required to develop an indicator which could provide more information about normal variation. This is an area for future work.

Accessibility

Cultural services provided by freshwaters are many and include opportunities for recreation, boating, fishing, tourism, education, history, religion, inspiration and art[2]. Since freshwaters are commonly used for recreational activities, access to them directly influences cultural service flows. If freshwaters are close to residential areas, people may visit them more frequently. Access to freshwaters could be measured in terms of the population with access to wetlands and open waters within certain kilometres of their homes. This indicator is chosen because it takes into account the distance between these habitats and the residential area, which might affect someone's decision to visit them and thus increase or reduce their cultural benefit. The data to measure accessibility are currently not available. This is an area of future research.

c) Initial accounts for UK freshwater ecosystem assets

Tables 1 and 2 present initial UK freshwater ecosystem assets accounts for both wetlands and open waters. The tables show opening and closing stocks between two accounting periods – 2008 and 2012. Due to limited data, it is challenging to measure any fluctuation in the condition due to improvements and reductions between these two accounting periods and therefore any changes in condition are recorded as net change. Not all the data in Tables 1 and 2 refer to 2008 and 2012 due to different frequencies of various data sources. The frequency of the data varies from annual to 9 years. Therefore, the latest available data are used as a proxy whenever the data for 2008 and 2012 are not available.

Table 1 - Wetland ecosystems assets account

Ecosystem Extent	Characteristics of condition				
Land cover	Ecological condition		Soil		Accessibility
Indicators	Wetland birds	Mean species richness	Mean total nitrogen stock	Mean carbon conc.[6]	Accessible wetlands - population with access to wetlands within X kilometres[1]
Units of measure	Size of area (hectares in '000)	No. of wetland birds at inland wetland sites in the UK ('000)	Diversity of species per pond	Mean total nitrogen in soil(% of dry soil)	Mean level of carbon in soil in (gram/kilogram $^{-1}$)	-
Year 2008	2833 (2007)[2]	4666	39.1 (2007)	1.5 (2007)	401.2 (2007)	-
Net change[3]	0	163	-5.4	[4]-0.2	-17.2	-
Year 2012	2833[5]	4829	33.7	1.3	384.0	-

Notes:

1. Further analysis is required to develop this indicator.

2. The bracket shows the year of the data.

3. Net change is the difference between the opening and the closing period.

4. Expressed in percentage points.

5. These numbers are based on extrapolating from 1998 – 2007. The rate of change between 1998 and 2007 was not statistically significant and therefore the area of land cover is estimated to have remained the same.

6. Mean carbon concentration.

Table 2 - Open water ecosystems assets account

Ecosystem Extent	Characteristics of condition				
Land cover	Water		Ecological condition		Accessibility
Indicators		Mean reservoir stock	River Flow	Surface water status	Accessible open waters - population with access to open waters within X kilometres[3]
Units of measure	Size of area (hectares in '000)	Average number of reservoirs above or below mean normal capacity	Percentage of rivers recorded as normal and abnormal	Percentage of rivers and canals in high, moderate or bad ecological condition[1]	Percentage of lakes in high, moderate or bad ecological condition[2]	-
Year 2008	331 (2007)[4]	19 / 12	[5]47 / 53	2 / 50 / 4	6 / 44 / 3	-
Net change	6	2 / -2	[6]- 21 / 21	0 / -4 / 0	0 / 2 /-1	-
Year 2012	337	21 / 10	26 / 74	2 /46 / 4	6 / 46 / 2	-

Notes:

1. In 2008, 2% of rivers were in high ecological condition, 30% in good, 50% in moderate, 14% poor and 4% bad. Whereas in 2012, 2% of rivers were in high ecological condition, 31% in good, 46% moderate, 17% poor and 4% in bad ecological condition.

2. In 2008, 6% of lakes were in high ecological condition, 37% in good, 44% in moderate, 10% in poor and 3% in bad. Whereas in 2012 6% of lakes were in high ecological condition, 31% in good, 46% in moderate, 14% in poor and 2% in bad - figures may not sum to 100% due to rounding.

3. Further research is required to develop this indicator.

4. Figures in brackets show the year the data were produced.

5. In 2008, 10% of all rivers assessed recorded exceptionally high levels of river flow, 21% above normal, 15% notably high, 47% normal, 6% below normal, 1% notably low and 0% recorded expectionally low levels. In 2012, 16% of all rivers assesed recorded exceptionally high levels of river flow, 17% notably high, 20% above normal, 26% normal, 6% below normal, 8% notably low and 7% exceptionally low levels.

6. Expressed in percentage points.

Notes for freshwater ecosystem assets accounts

1. Source: European Environment Agency

2. Source: National Ecosystem Assessment (chapter 9)

8 . Freshwater non-monetary ecosystem services accounts

A freshwater ecosystem services account assesses the contribution of the services that it provides to the economy and society. This section presents the freshwater ecosystem services accounts in non-monetary terms. The non-monetary ecosystem services accounts capture the flow of services in physical units.

This section starts with a discussion on the services that have been selected for developing freshwater non-monetary ecosystem accounts. It then discusses the data sources and presents the initial freshwater non-monetary ecosystem services accounts for both wetlands and open waters. Ecosystem services that contribute to human well-being can be classified into[1]:

1. **Provisioning services** – products such as: food (crops, meat and dairy products, fish and honey); water; fibre (timber and wool); and fuel.

2. **Regulating services** – provide benefits such as: water purification; climate regulation; noise and air pollution reduction and flood hazard reduction.

3. **Cultural services** – provide non-material benefits, for example: through cultural heritage; recreation or aesthetic experience.

4. **Supporting services** – such as biodiversity, soil function – these may not feature in the accounts to avoid double-counting, but information on these services will be needed in order to understand changes in the stock of ecosystem assets.

Ecosystem services that were assessed by ONS for developing freshwater non-monetary ecosystem services accounts are given in Tables 3 and 4 below.

Table 3 - Open water ecosystems services assessed by ONS

Provisioning services	Regulating services	Cultural services
Fish extraction (X)	Carbon sequestration (X)	Recreational (X)
Water abstraction (X)	Hydrological regimes	Educational (X)
Hydropower	Pollution and detoxification	Recreational fishing
Navigation	Flood protection	Spiritual, inspirational and aesthetic
Plants	Fire regulation	

Note:

1. Only "X" open waters ecosystem services are included in the initial accounts developed in this paper.

Table 4 - Wetlands ecosystem services assessed by ONS

Provisioning services	Regulating services	Cultural services
Peat extraction (X)	Carbon sequestration (X)	Recreational (X)
Plants	Hydrological regimes	Educational (X)
	Pollution and detoxification	Spiritual, inspirational and aesthetic
	Erosion protection	
	Flood protection	
	Fire regulation	

Note:

1. Only "X" wetlands ecosystem services are included in the initial accounts developed in this paper.

It is challenging to measure some of the services listed in Tables 3 and 4 due to data limitations and further work is required to identify reliable data sources. Therefore, this paper has only included those services, for which either data are available or could be readily estimated. The services that are not selected are equally important. For example, the traded price of electricity generated by hydropower was over £300 million in 2012. In England and Wales, £8 million worth of navigation licences were issued in 2012-13. Landscape amenity values are also important benefits provided by proximity to canals and rivers and can be derived from analysis of property price premia[2].

Further work is required before these services could be incorporated into the initial accounts. The ecosystem services that are selected in this paper for the development of initial UK freshwater non-monetary ecosystem services account are discussed below. Table 5 below summarises the data sources for these selected services.

Provisioning services

Fish extraction (open waters)

Fish as a food is the most prominent service provided by open waters. Fish also provides recreational activities, which is a cultural service. However, the permanent extraction and production of fish is a provisioning service. The data for fish extraction from inland waters for 2008 and 2012 are from the Food and Agricultural Organisation [3] (FAO). The data are broken down into wild capture fishing and aquaculture [4]. Only wild capture fishing has been considered in this paper. The FAO provides data at the UK level, which is used only for food and therefore there is no overlapping with the recreational service. Fish as a recreational service (Table 3) is not measured in this paper because apportioning the value of fish taken by recreational anglers and the value of the recreational service is likely to be difficult to estimate. However, this is an important cultural service which needs to be measured and is an area for future work.

Water abstraction (open waters)

Freshwaters supply water for use in the economy. This service is mainly provided by open waters and includes water for drinking, agricultural and industrial production purposes. The data for 2008 and 2012 for water abstraction in England and Wales, and Scotland are from the Department for Environment, Food and Rural Affairs (Defra), and Scottish Water respectively. The data for England and Wales cover non-tidal surface water which is for all purposes, such as public water supply and electricity supply used for industrial cooling purposes. The data for Scotland are for public water supply only and are not available for 2008; hence an ordinary least square[5] trend (2009 to 2013) is used to back cast the data. The data for Northern Ireland are not available.

Hydroelectric power is an important provisioning service and is also worth measuring; therefore, it is listed in Table 4. However, due to data gaps, this has not been measured separately in this paper. This is an area for future research.

Peat extraction (wetlands)

Peatlands are an important part of the freshwater habitat and provide a broad range of ecosystem services, for example, plant vegetation, compost, fibre, flood management and recreation. Due to the importance of the ecosystem services provided by peatland and the fact that they have diminished in condition and size significantly over time, it would be worth developing natural capital accounts for peatlands separately. Therefore, a scoping study to develop natural capital accounts for peatland was commissioned by Defra, which will be published in Spring 2015. While, there is an ambition set out in the Natural Environment White Paper to end the use of peat in horticulture in England by 2030[6], it remains a relevant service provided by wetlands and therefore is measured in this paper as part of the freshwater ecosystem services account. The data for measuring peat extraction for 2008 and 2012 are from the UK Mineral Year Book 2013 produced by the British Geological Survey.

Regulating services

Carbon sequestration (open waters, wetlands)

Carbon sequestration and storage of carbon are not the same. Carbon storage is a stock concept and involves the long term storage of carbon, keeping it out of the atmosphere. Greenhouse Gas (GHG) storage (i.e. carbon currently locked away in ecosystems in various forms) has not been considered in these accounts.

Carbon sequestration is a flow concept and refers to the net emission or capture of carbon from the atmosphere for long term storage. For the purpose of this account, this refers to the net annual flow of GHG in the Land Use, Land Use Change and Forestry sector. In essence, it shows the net amount of GHG that has been taken out of the atmosphere by terrestrial ecosystems in a particular year. The problem with this data source is that it mainly relates to anthropogenic activities such as emissions arising from peat extraction, which cannot be attributed to the functioning of the ecosystem itself. Therefore, this service will not be measured as part of the ecosystem accounts.

Cultural services

Outdoor recreation (open waters, wetlands)

Recreation is one of the most important cultural ecosystem services provided by both wetlands and open waters. People visit freshwater ecosystems, for example wetlands, for walking and other recreation related activities and they experience numerous non-material benefits. Outdoor recreation to freshwater ecosystem habitats is measured by the number of visits to wetlands and open waters in the UK.

Data on the number of visits to inland wetlands in England are from the Monitoring of Engagement with the Natural Environment (MENE) survey. This survey is conducted by Natural England on an annual basis. The MENE survey began in 2009 and therefore the data for annual visit are not available for 2008. To estimate the values for 2008, average values for 2009 to 2013 are used. As the visitor data relates to England only, they are scaled up to the UK level using population alone [7]. This is required as there are not comparable data available for England, Northern Ireland, Scotland and Wales. Hence, data for England are used as they would have the largest weighting and the required data were available.

Data on the number of visits to UK open waters are from various sources. The data for England for 2012 are from the MENE survey and, as discussed above, to estimate the values for 2008, average values for 2009 to 2013 are used. The data for Scotland are from the Scottish Recreation Survey and the data for Wales are from the Welsh Outdoor Recreation Survey. Data for Northern Ireland are not available.

Educational visits (open waters, wetlands)

Educational services are provided by both wetlands and open waters and are measured by estimating the number of school pupils visiting wetlands in the UK. The data for number of school pupils visiting open waters are not available and therefore are not included in these initial accounts. The data for the number of school pupils visiting wetlands are only available for the nine sites that are managed by the Wildfowl and Wetlands Trust. The data are from 2008 to 2012 and are available at the UK level. These visits are underestimated as there could be more sites which are used for educational purposes. Further work is required to identify these sites.

Table 5 - Freshwater ecosystem services - data sources and frequency

Ecosystem Services	Data sources	Frequency
Provisioning services		
Fish abstraction	Food and Agricultural Organisation	Annual
Water abstraction	DEFRA, Scottish Water	Annual
Peat extraction	British Geological Survey	Annual
Regulating services		
Carbon sequestration	Department for Energy and Climate Change	Annual
Cultural services		
Recreational visits	MENE survey – Natural England.	Annual
	Scottish Recreaton Survey – Scottish Natural Heritage[1]	Annual
	Welsh Outdoor Recreation Survey – Natural Wales	Infrequent – Conducted in 2008 and 2011.
Educational visits	Wildfowl and Wetlands Trust	Annual
	MENE survey – Natural England	Annual

Notes:

1. To be replaced by the Scottish People and Nature Survey in 2015.

Initial accounts for freshwater non-monetary ecosystem services

Table 6 presents the initial accounts for freshwater non-monetary ecosystem services account for both wetlands and open waters. The table shows estimates of flows from 2008 to 2012. This paper has also produced an outline account of the beneficiaries and suppliers of ecosystem services (ONS-Defra Principles Paper, 8.3). Suppliers are those sectors which own the freshwater assets and beneficiaries are those sectors that use or benefit from the services, recognising that the beneficiaries may not be located in the same area as the location of the asset. Table 7 sets out which sectors are thought to be the main sectors involved. Non-profit Institutions Serving Households often plays a key role in the provision of services and ideally need to be accounted for separately.

Table 6 - UK freshwater non-monetary ecosystem services account (2008-2012)

	Freshwater ecosystems						
Services	**Units of measure**	**Coverage**	**2008**	**2009**	**2010**	**2011**	**2012**
Provisioning service (s)							
Fish extraction	Tonnes	UK	13,092	13,203	15,194	13,578	13,360
Water abstraction	m^3 (millions)[2]	GB	12,311	10,890	10,984	9,950	12,377
Peat extraction	Tonnes ('000)	UK	572	668	756	621	428
Cultural service(s)							
Recreational visits	Number of visits (millions)	UK[1]	349	344	295	333	310
Educational visits	Number of visits ('000)	UK	56	57	67	57	46

Notes:

1. Recreational visits to open waters do not include figures for Northern Ireland.

2. Millions of cubic metres

Table 7 - Outline table for the generation and use of freshwater ecosystem services

	Generation of ecosystem services				Use of ecosystem services			
	Enterprise	HH[1]	NPISH[2]	Govt.	Enterprise	HH	NPISH	Govt.
Provisioning service (s)								
Fish extraction	X		X	X		X		
Water abstraction	X			X	X			X
Peat extraction	X				X	X	X	
Regulating service (s)								
Carbon sequestration	X		X	X	X	X	X	X
Cultural service(s)								
Recreational visits	X		X	X		X		
Educational visits	X		X	X		X		

Notes:

1. Households.

2. Non-profit Institutions Serving Households

Notes for freshwater non-monetary ecosystem services accounts

1. Source: Millenium Ecosystem Assessment (2005).

2. For example, there is evidence that waterside properties attract a premium of up to 5% based on their location. See JBA Consulting, Payments for Ecosystem Services- Canal & River Trust Pilot Study (2014).

3. Source: Fisheries and Aquaculture Statistics (2014).

4. Farm fishing is part of aquaculture and is not considered in this paper.

5. The ordinary least square method is a statistical technique that provides a best fit estimate of a missing value based on actual values.

6. The planning policy in England is to grant no new permissions for peat extraction. This does not affect existing planning permissions. Different policies apply in the rest of the UK.

7. A similar methodology was used to value recreational services in the "UK Initial and Partial Natural Capital Estimates" published by the ONS in May 2014.

9 . Valuation of UK freshwaters

This section provides a monetary valuation for the freshwater ecosystem services presented in 'Freshwater non-monetary ecosystem services accounts'. It then capitalises the flow values for 50 years by using the Net Present Value (NPV) approach to obtain the asset value of these services. This section starts with a brief discussion on the methodology used to value freshwater ecosystem services. It then discusses the data sources and presents the initial freshwater monetary ecosystem services account in 'Freshwater monetary ecosystem services account'.

The NPV approach is used to estimate the monetary value of UK freshwaters. The same methodology was employed in the UK Initial and Partial Natural Capital estimates, which was published in May 2014. In order to estimate the value of an environmental asset (natural capital) for national accounting purposes, ideally, observable market prices should be used. Where market prices do not exist, an attempt should be made to estimate what the prices would be if regular markets did exist and the assets were to be traded on the date to which the asset valuation relates.

The System of Economic and Environmental Accounts (SEEA) Central Framework states that an important principle in the valuation of environmental assets is to value them in situ – the value of the asset after all human inputs are subtracted from the market price. Since price in situ is not common for natural capital, an attempt should be made to estimate its value using the market prices that are observable.

The NPV approach uses projections of the expected profile of service flow from the asset, together with projections of its price, to generate a time series of expected future returns. These streams of expected returns are then discounted to estimate the value of an asset now rather than in the future. The NPV approach is recommended by the SEEA and is used here to value UK freshwater.

Net Present Value (NPV)

Methodology

There are five main aspects of the NPV:

1. **Resource rent**

The overall value of a service from a product typically includes a number of other elements, such as wages and returns to the investment made by investors that do not stem from the value of the asset. Once these costs and normal returns are deducted from the market price, the resulting element or net benefit is known as the resource rent. Therefore, a resource rent needs to be calculated to estimate the in situ price of freshwater ecosystem services – the price after all human inputs are subtracted from the market price.

The steps involved in calculating the resource rent for each freshwater ecosystem service estimated in this paper are given in Box 1 below:

Box 1: Derivation of resource rent

	Output
Less	Operating costs
	Intermediate consumption
	Compensation of employees
	Other taxes on production PLUS other subsidies on production
Equals	Gross operating surplus – SNA basis
Less	Specific subsidies on extraction
Plus	Specific taxes on extraction
Equals	Gross operating surplus – resource rent derivation
Less	User costs of produced assets (consumption of fixed capital + return to produced assets)[1]
Equals	Resource rent

Notes:

1. The rate of return on produced assets is required to estimate the user cost of the produced assets used in the extraction of the environmental assets. If this cost is not deducted the resulting estimates of resource rent will be overstated.

The data sources for gross operating surplus are from various sources and are discussed in the next section. The data for capital stock that feeds into “user cost of produced assets” are from the Office for National Statistics (ONS), except the data for the average real ten year government bond yield used to calculate “cost of capital”, which is from the Bank of England.

2. **Pattern of expected resource rent**

A critical factor in the valuation of natural capital is determining the expected pattern of the resource rent. These resource rent paths are not observed and hence assumptions concerning the flows must be made. A simplified way to determine the expected resource rent is to assume that the current flow is constant over the asset life, but this might not be the case. There may be cases where more information is available on future rates of extraction or prices. Where there is compelling evidence for this information, deviations should be made from the standard constant resource rent assumption (ONS-Defra Principles paper, 14.4).

The pattern of expected resource rent is assumed to be constant based on the latest 5 years data. The formula used to derive future resource rent (for 2013) is given in equation 1 below. Where data for the last 5 years are not available, the latest available data are used to estimate the expected resource rent. The derived resource rent of each service, except peat extraction, is then assumed constant until the end of its asset life.

Equation 1

$$\overline{RR_t} = \frac{RR_{t-4} + RR_{t-3} + RR_{t-2} + RR_{t-1} + RR_t}{5}$$

Where:

RR = resource rent t = year

3. **Asset life**

   The asset life is the expected time over which the services from a natural resource can take place. It is important to estimate the asset life in the NPV model because it determines the expected time over which an asset should be discounted. A 25 year asset life was assumed by ONS for all components of natural capital in the initial natural capital estimates published in May 2014 while recognising that it was an initial working assumption and would be revisited in the future. ONS and Defra principles paper published in August 2014 discussed various asset lives and suggested that ONS and Defra will keep the appropriate time period to asset valuation under review as they produce initial accounts.

   ONS has assumed a 50 year asset life for all freshwater ecosystem services valued in this paper. We did not assume a 25 year asset life because this is considered quite short for renewable assets such as freshwaters. Another option could be to assume an infinite asset life, but a non-negligible discounting would render the additional future values relatively immaterial.

4. **Choice of discount rate**

   A discount rate is required to convert the expected stream of resource rents into a current period estimate of the overall value. A discount rate expresses a time preference - the preference for the owner of an asset to receive income now rather than in the future. It also reflects the owner's attitude to risk. The use of discount rates in NPV calculations can be interpreted as an expected rate of return on the environmental assets. Similar to UK initial natural capital estimates, this paper has used a declining discount rate from the HM Treasury Green Book throughout the calculations to estimate the value of individual freshwater ecosystem services (ONS-Defra Principles paper, 16.1).

5. **Deflating – constant prices**

   The estimates presented in this paper are in 2012 prices. All prices and data used for the resource rent calculations are deflated using a GDP deflator to convert them into 2012 prices.

10 . Freshwater monetary ecosystem services account

This section provides the methodology for valuing individual ecosystem service of freshwater selected in this paper. It discusses the data sources and presents the initial freshwater monetary ecosystem services account in Table 8; whereas Table 9 presents the asset value of these services.

The following NPV formula is used to calculate the monetary asset value for each natural capital component:

NPV formula

$$\text{Value of service} = \sum_{t=0}^{N} \frac{\text{resource rent in year t}}{(1+r)^t}$$

Where:

N = total number of periods (typically 50 years) t = year r = discount rate

Provisioning services

Fish extraction

Box 1 is used to estimate the resource rent for fish extraction from UK freshwaters from 2008 to 2012. The data for Gross Operating Surplus (GOS) for industrial classification “freshwater fishing and aquaculture” are used to estimate the resource rent for fisheries. A proportion of freshwater fishing from net capital stock is applied to this classification to estimate the GOS for freshwater fishing only. The proportion is applied to exclude aquaculture and therefore fish farming is not included in the calculations. The GOS is then adjusted for user cost of the produced assets to derive the resource rent for fisheries. The data for net capital stock and consumption of fixed capital for the standard industrial classification “freshwater fishing” are taken from ONS. The rate of return on produced assets is calculated by using the ten year government bond yield. The user cost of produced asset for each year is deducted from the GOS to derive the resource rent for fisheries for each year from 2008 to 2012.

By applying the NPV under the following assumptions:

- actual and projected resource rent applied for 50 years using equation 1
- the gross operating surplus figure includes all wage costs

The monetary valuation of fish extraction from UK freshwater in 2008 and 2012 is estimated to be £807 million and £822 million in 2012 prices, respectively. These are shown in Table 9.

Water abstraction

As noted in the Initial and Partial Natural Capital Estimates, the resource rent calculations for water abstraction is very challenging. In that paper, monetary estimates of water abstracted for Public Water Supply were derived from UK National Accounts data based upon the water supply industry. One way to value water abstraction from UK freshwaters is to follow the same methodology employed in the Initial and Partial Natural Capital Estimates. The alternative is to collect the price data for various uses, such as irrigation, drinking water and electricity generation, and apply them to the quantity of water abstracted from UK freshwaters. The second option is preferable but due to data limitations, it is currently not possible to employ this method. As such, for the initial accounts presented in this paper, the approach adopted in the Initial and Partial Natural Capital Estimates is used.

Similar to fish extraction, Box 1 is used to estimate the resource rent for water abstraction from UK freshwaters from 2008 to 2012. The data for Gross Operating Surplus (GOS) in the standard industrial classification “water collection, treatment and supply” are used to estimate the resource rent for water abstraction for Public Water Supply purposes. To calculate the user cost of the produced assets, the data for net capital stock and consumption of fixed capital for the standard industrial classification “water collection, treatment and supply” are taken from ONS. The user cost of produced asset for each year is deducted from the GOS to derive the resource rent for water abstraction for each year from 2008 to 2012.

By applying the NPV under the following assumptions:

- actual and projected resource rent applied for 50 years using equation 1
- constant extraction for Public Water Supply

The monetary valuation of water abstraction for Public Water Supply from UK freshwaters in 2008 and 2012 is estimated to be £14.6 billion and £22.4 billion in 2012 prices, respectively. These are shown in Table 9.

Peat extraction

Due to data limitations on cost, resource rent for peat extraction is not calculated by using the formula in Box 1. This paper has used the same methodology that was used in the Initial and Partial Natural Capital Estimates which calculates a general resource rent ratio for the “mining and quarrying” sector, which is then used to isolate the resource rent from the market prices of peat extraction. The resource rent ratio is calculated by dividing the resource rent of the “mining and quarrying” sector by the total output of this sector.

To calculate the market values of peat extraction, data on extraction and prices for 2008 to 2012 are taken from the UK Mineral Yearbook 2013 produced by the British Geological Survey. The data are based on export values and volume for the respective year. The unit price of peat extraction is derived by dividing the export values of a year by export volumes of that year. The prices for all the years are deflated using GDP deflators to obtain the values in 2012 prices.

The 'mining and quarrying' resource rent ratio is then applied to this flow value to isolate the value accruing from peat extraction itself. The resulting flow values are then capitalised and are discounted for 50 years to estimate the asset value of peat.

By applying the NPV under the following assumptions:

- declining extraction rate for 50 years
- export prices are a proxy for the resource price and held constant from 2013 onwards
- a general 'mining and quarrying' resource rent ratio

The monetary valuation of peat extraction from UK freshwaters at the end of 2008 and 2012 is estimated to be £356 million and £247 million in 2012 prices, respectively.These are shown in Table 9.

Cultural services

Outdoor recreation

In the Initial and Partial Natural Capital Estimates, ONS estimated the outdoor recreation as a cultural service provided by the natural environment. Since freshwaters are the subset of natural environment, the main task is to disentangle the aggregate monetary value of outdoor recreation into different categories. This is done by identifying the number of recreational visits to UK freshwaters instead of the natural environment as a whole. Once these visits are identified, employing the same methodology used (discussed below) in the initial natural capital estimates, the monetary value of outdoor recreation provided by UK freshwaters could be calculated.

In the initial natural capital estimates, the travel cost method was used to value ecosystem services associated with recreational sites. This method estimates the value of the recreational ecosystem service based on the amount consumers may be willing to pay as reflected in the costs of visiting a recreational site, for example transport costs, travel time and visiting time. This is based on the understanding that to enjoy the recreational site one has to pay the travel costs of getting to that site and there is an opportunity cost to their time. From this, the demand for a recreational site can be determined based on the cost of visiting and the number of visits.

To obtain an estimate for the value of recreation that stems from the natural environment, the Initial Natural Capital Estimates paper estimated two components of travel costs – private transport fuel costs and visiting time to estimate part of the value of the sites that provide outdoor recreation. Due to data limitations, other costs, such as parking and public transport expenditure were not included in these calculations.

To estimate the monetary value for outdoor recreation provided by UK freshwaters, these additional components have been included for valuing outdoor recreation provided by UK freshwaters, but the visit time has been excluded. Though visit time should be included in the estimates, it was identified as an area for future research in the initial and partial natural capital estimates. This issue is still under research and therefore has not been considered in our calculations.

The following components are used as a proxy to estimate part of the value of the freshwater sites that provide outdoor recreation:

- travel cost – private transport fuel costs, public transport expenditures, parking fees
- admission fees

SEEA Central Framework and SEEA Experimental Ecosystem Accounting principles state that when there are no observable prices because the items in question have not been purchased or sold on the market in the recent past, 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 asset relates. Therefore, it has been assumed that there is a price to visit UK freshwater recreational sites and the price is the travel cost and the entrance fees. At this price, the quantity demanded is the actual number of visits to the site. It is also assumed that all visitors have the same average willingness to pay and they would pay this price. This method is based on the assumption that there could be some mechanism whereby visitors might be charged their average willingness to pay if a market did exist.

Data on the number of visits to UK wetlands for recreational purposes from 2009 to 2012 are taken from the Monitoring of Engagement with the Natural Environment (MENE) survey. This survey is conducted by Natural England on an annual basis. The MENE Survey does not publish a breakdown of the number of visits to wetlands and open waters; however, using a Geographic Information System, Natural England provided an estimate of the split of these visits for the purpose of this exercise. The definitions used to breakdown the data into these two habitats might not be consistent with the definitions used in this paper; however, it provides an indication on the number of visits to UK wetlands.

The MENE survey began in 2009 and therefore the data for annual visits are not available for 2008. To back cast the values for 2008, a five year average from 2009 to 2013 is used. As the visitor data relates to England only, they have been scaled up to the UK level using population alone [1]. This is required as there are not comparable data available for England, Wales, Northern Ireland and Scotland.

Data on the number of visits to UK open waters for recreational purposes are from various sources. The data for England for 2012 are from the MENE survey and, as discussed above, to estimate the values for 2008, average values for 2009 to 2012 are used. The data for Scotland are from the Scottish Recreation Survey and the data for Wales are from the Welsh Outdoor Recreation Survey. The data for Wales are only available for 2008 and 2011 and therefore 2011 data are assumed to be equivalent to 2012.

To calculate the travel cost for 2009 to 2012, data on expenditures on petrol and diesel, public transport and parking fees are from the MENE survey. Data on costs for Scotland and Wales are not available and to estimate the data, per capita expenditures of people visiting wetland and open waters in England are calculated and are multiplied by the number of visits to wetlands and open waters in Scotland and Wales. A similar approach is adopted to estimate admission fees.

Travel costs and admission fees are added together to provide the yearly flow of benefits from the outdoor recreation provided by UK freshwaters. Due to lack of data on capital inputs, gross benefits are calculated and therefore no resource rent ratio is applied. However, it is recognised that there are a number of costs related to outdoor recreation provided by freshwaters that should be deducted, for instance the roads and car parks which allow visits to take place. It could be argued that some of the capital inputs or wages might be reflected in admission fees. This is an area for further research.

Using the NPV method and applying a declining discount rate, the flow values of outdoor recreation from UK freshwaters from 2008 to 2012 are capitalised for 50 years. The flow values are adjusted using GDP deflators to obtain values in 2012 prices.

By applying the NPV under the following assumptions:

- visitors incur this expenditure for the sole intention of enjoying the outdoor recreation provided by the freshwaters (rather than primarily to visit friends or enjoy a good meal)
- actual and projected gross benefits for 50 years

The monetary asset value of recreational ecosystem services provided by UK freshwater ecosystems in 2008 and 2012 is estimated to be £13.5 billion and £13.4 billion in 2012 prices, respectively. These are shown in Table 9.

Educational visits

Similar to outdoor recreation, the travel cost method has been applied to estimate the monetary value of educational visits to UK freshwater areas. However, unlike outdoor recreation, only admission fees to wetlands are included in the calculation. Visit time is not included in the monetary valuation because these visits are undertaken by school pupils and the opportunity cost of their visiting time could be assumed as zero. The data sources for the number of school pupils visiting wetlands in the UK are discussed in an earlier section (Freshwater non-monetary ecosystem services accounts). Other expenses such as transport costs and parking fees are also not included because it is assumed that these pupils visit wetlands as part of a school trip and do not pay other costs separately.

By applying the NPV under the following assumptions:

- admission fees are the best proxies for expenditures incurred by educational visits
- actual and projected gross benefits for 50 years

The monetary asset value of educational ecosystem services provided by UK freshwater ecosystems in both 2008 and 2012 is estimated to be £1.3 million in 2012 prices, respectively. These are shown in Table 9.

Table 8 - UK freshwater monetary ecosystem services account (2008-2012) – Annual flow values (2012 prices)

Freshwater ecosystem services (£ million)					
	2008	2009	2010	2011	2012
Provisioning service(s)					
Fish extraction	53	10	15	102	9
Water abstraction	958	553	717	1022	1511
Peat extraction	33	45	39	33	16
Cultural service(s)					
Recreational visits	659	640	537	595	544
Educational visits[1]	0	0	0	0	0
Total[2]	1704	1249	1307	1752	2080

Notes:

1. The actual figures for education in ('000's) are as follows; (2008) £39.3.1, (2009) £37.3, (2010) £44.6.0, (2011) £37.3 and (2012) £29.9

2. Figures may not sum due to rounding.

Notes for freshwater monetary ecosystem services account

1. A similar methodology was used to value recreational services in the "UK Initial natural capital estimates" published by the ONS in May 2014.

11 . Aggregate monetary value of UK freshwaters

By applying the Net Present Value to the following ecosystem services:

- fish extraction
- water abstraction
- peat extraction
- outdoor recreation
- educational visits
- carbon sequestration

The monetary value of UK freshwaters is estimated to be £ 37 billion in 2012; 26 % higher than in 2008. These estimates are presented in table 9 below.

Table 9 - Asset values [1] of UK freshwaters, 2008 – 2012 (in 2012 prices)

Freshwater ecosystems £ billion					
Services	2008	2009	2010	2011	2012
Provisioning service(s)					
Fish extraction	1.1	0.9	0.8	1.2	0.9
Water abstraction	18.5	18.7	19.3	20.8	23.9
Peat extraction	0.3	0.3	0.3	0.3	0.2
Cultural service(s)					
Recreational visits	16.2	15.8	14.9	14.9	14.5
Educational visits[2]	0.0	0.0	0.0	0.0	0.0
Total	36.1	35.8	35.3	37.1	39.5

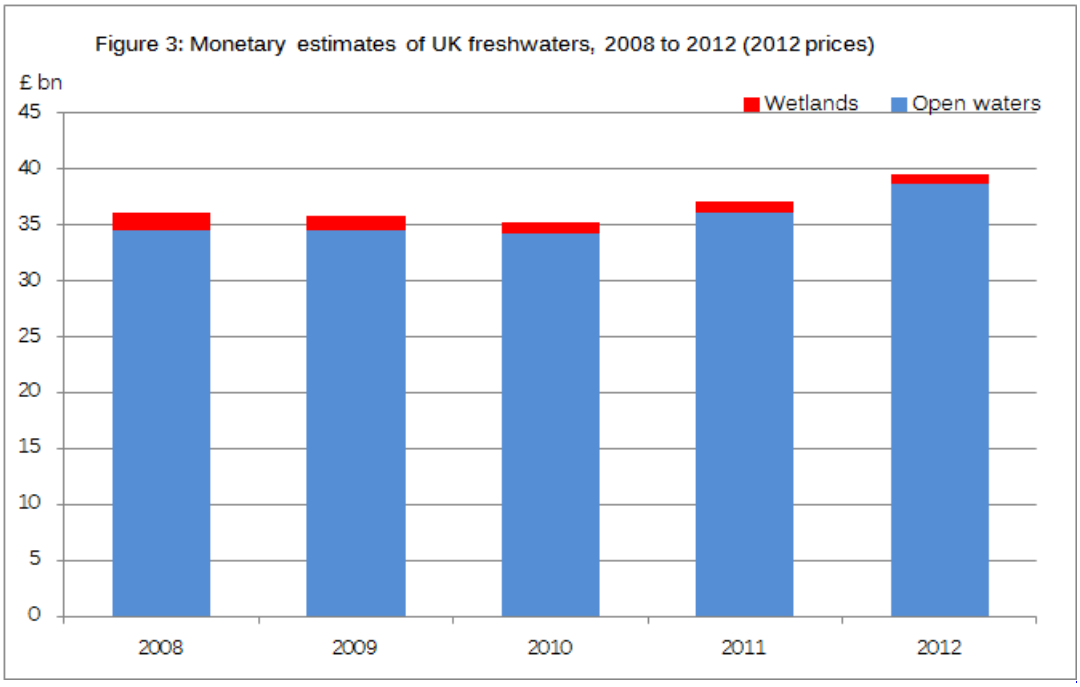
Notes:

1. Annual flows (table 8) are capitalised for 50 years to calculate the asset value.

2. The actual figures for the NPV of educational visits are as follows; (2008) £1.0m, (2009) £1.0m, (2010) £1.0m, (2011) £1.0m and (2012) £0.9m.

Figure 3 shows the monetary value of UK freshwaters. The calculated monetary value of UK freshwaters has increased every year since 2008. This is mainly due to an increase in the monetary value of UK open waters.

Figure 3 - Monetary estimates of UK freshwaters, 2008 to 2012 (2012 prices)



12 . Future work

This paper is a first attempt by the Office for National Statistics (ONS) to develop UK Freshwater ecosystem assets and services accounts. There are a number of challenges and issues that need to be addressed in improving these accounts over time. These estimates are developed as part of the roadmap " Accounting for the value of nature in the UK", which set out a strategy to incorporate natural capital into the UK Environmental Accounts by 2020. As such, the methodology of these accounts will be improved before they are fully incorporated into the UK Environmental Accounts. ONS is publishing an updated roadmap for the next five years (2015 – 2020) alongside this document. The updated roadmap highlights that the freshwater accounts would be improved and data gaps would be addressed during the next five years.

There are five main areas for future work:

- Explore data sources and methods to measure accessibility as a characteristic of freshwater ecosystem assets
- Investigate the inclusion of additional characteristics for monitoring changes in the capacity of freshwater ecosystem assets to provide services
- Explore the inclusion of other ecosystem services that are listed in Tables 3 and 4 but are not included in this paper
- Refine the methodology and address the data gaps to improve the monetary estimates for water abstraction and outdoor recreation
- Address the data gaps to breakdown freshwater into wetlands and open waters for all services for each country in the UK

13. References

1. Bank of England (2014), Interest and exchange rates data
2. Calbrade, N. (2014), British Trust for Ornithology - Wetlands Bird Survey
3. Centre for Ecology and Hydrology (2014), National River Flow Archive
4. Centre for Ecology and Hydrology (2014), Hydrological Summary
5. Food and Agriculture Organisation (2014), Fisheries statistics: Global production by production source 1950-2012 (FishstatJ).
6. Carey, P.D.; Wallis, S.; Chamberlain, P.M.; Cooper, A.; Emmett, B.A.; Maskell, L.C.; McCann, T.; Murphy, J.; Norton, L.R.; Reynolds, B.; Scott, W.A.; Simpson, I.C.; Smart, S.M.; Ullyett, J.M.. (2008) Countryside Survey: UK Results from 2007. NERC/Centre for Ecology & Hydrology, 105pp. (CEH Project Number: C03259).
7. Countryside Survey: England Results from 2007 (published September 2009). NERC/Centre for Ecology & Hydrology, Department for Environment, Food and Rural Affairs, Natural England, 119pp. (CEH Project Number: C03259).
8. Norton, L.R.; Murphy, J.; Reynolds, B.; Marks, S.; Mackey, E.C. (2009) Countryside Survey: Scotland Results from 2007. NERC/Centre for Ecology & Hydrology, The Scottish Government, Scottish Natural Heritage, 83pp. (CEH Project Number: C03259).

9. Smart, S.M.; Allen, D.; Murphy, J.; Carey, P.D.; Emmett, B.A.; Reynolds, B.; Simpson, I.C.; Evans, R.A.; Skates, J.; Scott, W.A.; Maskell, L.C.; Norton, L.R.; Rossall, M.J.; Wood, C. (2009) Countryside Survey: Wales Results from 2007. NERC/Centre for Ecology & Hydrology, Welsh Assembly Government, Countryside Council for Wales, 94pp. (CEH Project Number: C03259).

10. Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C. (2010) Countryside Survey: Soils Report from 2007. Technical Report No. 9/07 NERC/Centre for Ecology & Hydrology 192pp. (CEH Project Number: C03259).

11. Environment Agency (2013), Flood Map for Planning (Rivers and the sea)

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

13. Khan, J; Greene, P; Johnson, A (2014), Initial and Partial Natural Capital Estimates, Office for National Statistics

14. Natural England (2012), Monitor of Engagement with the Natural Environment

15. Joint Nature Conservation Committee (2014), Biodiversity Indicators 2014 - surface water status

16. Office for National Statistics and Department for Environment Food & Rural Affairs (2014), Principles of ecosystems accounting (1.25 Mb Pdf)

17. Office for National Statistics (2012), Consultation on accounting for the value of nature in the UK

18. Office for National Statistics (2014), "Capital Stocks, Capital Consumption and Non-Financial Balance Sheets"

19. Office for National Statistics (2012), "Accounting for the Value of Nature in the UK: A Roadmap for the development of Natural Capital Accounts within the UK Environmental Accounts"

20. Office for National Statistics (2013), Annual Business Survey, 2013 Provisional Results

21. Scottish National Heritage, Scottish Recreation Survey

22. United Nations (2013), System of Environmental-Economic Accounting Experimental Ecosystem Accounting

23. Natural Resources Wales (2014), Welsh Outdoor Recreation Survey

24. Department for Environment Food & Rural Affairs (2014), Water abstraction tables

25. British Geological Survey (2013), UK Mineral Yearbook 2013

26. Wildfowl & Wetlands Trust (2014), Financial Reports

14. Background notes

1. Details of the policy governing the release of new data are available by visiting www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html or from the Media Relations Office email: media.relations@ons.gsi.gov.uk