CQuEL

Character and Quality of England's Landscapes

# Preparing a detailed project plan for CQuEL

## Work package 4: Sources of Data

## Final Report

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**Supported by:**

NATURAL ENGLAND

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# Preface

CQuEL, Character and Quality of England's Landscapes, is Natural England's principal integrated monitoring project. CQuEL will provide place-based evidence about the character and function of landscapes and the provision and quality of selected ecosystem services delivered by England's natural environment.

CQuEL will provide an enhanced and up-to-date understanding of Natural England's contribution to enhancing and improving the condition of the natural environment. CQuEL will also provide evidence to key strategic partners, particularly Defra. Defra has been a funding partner of the project planning stage.

The work to prepare the CQuEL project plan has been carried out by a consortium comprising Countryscape, Fabis Consulting and Land Use Consultants. The work has been guided by a Project Board at Natural England. The findings have been informed by Expert Panel workshops and the project team gratefully acknowledge the input of stakeholders at the workshops.

**List of reports**

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**Recommendations**

**Key recommendations are shown in bold with a grey highlight.** Each recommendation is referenced with a code to identify the Work Package and recommendation number, for example the second recommendation of Work Package 1 is referenced **[R1.2]**.

# Executive Summary

Recommendations are shown in **bold.** The recommendations are split into three groups: those relevant to both CQuEL and the assessment of ecosystem services; those relevant to CQuEL only; and those relevant to ecosystem services only.

## Recommendations relevant to both CQuEL and ecosystem services

### Relationship with the National Ecosystem Assessment

- **It is recommended that there should be consistency of approach and complementarity in the use of data between CQuEL and the National Ecosoystem Assessment (NEA), where this is appropriate to the needs of CQuEL [R4.1].** Work Package 1 (recommendation **[R1.10]**) has identified the need for the methodology developed for CQuEL to be consistent with the NEA but to extend the understandings that the NEA seeks to provide. Similarly, CQuEL must use data that is consistent with that used within the NEA, although CQuEL will inevitably use additional and more refined datasets.

### Sharing of data and development of common platforms

- **It is recommended that there is close liaison between CQuEL and other projects exploring the measurement of ecosystem services allowing the development of common platforms for gathering and sharing data [R4.2]**. There are now a number of projects being run within and outside Natural England that are exploring the measurement of ecosystem services and there is therefore considerable potential for shared working and exchange of intelligence.

## Recommendations relevant to CQuEL only

### Revisions to the assessment of CQC themes

- Revisions to key datasets in the last five years means that there will be discontinuities with some of the data streams used by CQC (e.g. agri-environment and woodland schemes and water quality) although these should not invalidate conclusions on long term trends. **It is recommended that CQuEL continues to use the same or compatible datasets as those used in CQC for the assessment of change in landscape character accepting that there have been some changes in how these data are recorded [R4.3].**

## Recommendations relating to ecosystem services only

### Definition of services in relation to Natural England's remit

- In order to identify appropriate datasets, work undertaken in Work Package 4 has developed precise and succinct definitions of the ecosystem services (based on a two tier hierarchy). This has extended the work carried out within Work Package 2 (Appendix 6). **It is recommended that these definitions of ecosystem services should undergo a process of consultation and endorsement through peer review before final decisions on the data used to measure them are made [R4.4].**

## Measurement of environmental quality and service delivery

- In terms of the use of data to measure service delivery, it should be recognised that there is an important difference between the measurement of the outputs of services (such as water quality or flood risk management) and the contribution that ecosystems play in delivering these. Therefore **it is recommended that key metrics (such as the ecological status of water bodies) used by organisations such as Natural England and the Environment Agency are interpreted by CQuEL, rather than being directly adopted as measures of service delivery [R4.5]**.

## Distinguishing different populations benefiting from services

- **It is recommended that, for many of the services, assessments should take account of the size of populations that are the beneficiaries of the service [R4.6]**. For some services (particularly the cultural services) the proximity of these populations will be an important factor in determining the level of the benefit achieved. Whereas, for others (such as some of the regulating services), the beneficiaries may be located remotely from the locations in which the services are generated. One example that would be invaluable for several services is the measurement of urban greenspace in relation to population density (on the basis of Accessible Natural Greenspace Standards).

## Taking account of the management and precise location of natural assets

- Data on the extent and quality of natural assets will be needed for the assessment of many services. In some cases this is because there is no suitable data to measure service delivery. In other cases it is because an understanding of the role of natural assets in service delivery is needed to understand Natural England's level of influence. **It is recommended that where data on natural assets is used to assess service provision, this will need to take account of the location and management of these assets as key determinants of the service provided [R4.7]**.

## Key gaps in scientific understanding

- There are several of the regulating services (particularly the control of flood run off and recharge of aquifers) where there is currently insufficient scientific confidence in the contribution of ecosystems to the delivery of the service to justify their assessment by CQuEL. In these cases factors such as climate and geology may be the determining influences and the role of habitats and soils may be less important. **It is recommended therefore that CQuEL keeps up to date with emerging research on ecosystem service delivery and contributes to debate on areas requiring further research [R4.8]**.

## Requirements for new data analysis

- There are several of the services (such as soil erosion control, reduction in green house gas emissions, and local climate amelioration) where new data gathering and analysis will be required before well-evidenced judgements of service delivery can be made at the scale of National Character Areas (NCAs). In many cases, work is ongoing to collect these data. **It is recommended that later work under CQuEL includes the further collection and detailed analysis of data to allow well-evidenced judgements to be made on service provision [R4.9]**.

## The role of expert judgement

- In order for reasoned assessments to be made by CQuEL on the delivery of many services in individual NCAs, scope needs to be built in to allow the use of expert judgement to assess the quality of service delivery, building on empirical data on the extent and location of assets. Wherever possible, it is assumed that such judgements can be made at a regional level, through a process of stakeholder consultation, and applied to NCAs based on data that describes the extent and location of key environmental assets. **Therefore it is recommended that judgements on service provision are tested and scrutinised through CQuEL by relevant experts and stakeholders at the regional level [R4.10]**.

## Use of uptake data from Environmental Stewardship

- Data on the uptake of individual Environmental Stewardship options will prove an invaluable source of information for many (particularly the regulating) services. The results of new research by Defra will be needed to confirm the findings of earlier work, before these links can confidently be made in all cases. (Defra is proposing work on this between 2010 and 2014, which may be mirrored by other work within NE). **It is recommended therefore that CQuEL keeps up to date with all work that is assessing the delivery of ecosystem services through Environmental Stewardship [R4.11]**.

# Introduction

***CQuEL seeks to provides 'place-based' evidence about the character and function of landscapes and the provision and quality of selected ecosystem services delivered by England's natural environment***

This paper focuses on the sources of evidence needed to fulfil two separate needs for CQuEL. As outlined in more detail in the Methodological Review report (Work Package 1), these are as follows:

- Firstly, the CQuEL methodology should retain the ability to report change in landscape character in ways consistent with the earlier phases of CQC. In particular, CQuEL should retain the capability of fulfilling Defra's wish that Natural England continues to report on an indicator of Countryside Quality, as required by the Rural White Paper 2000.
- Secondly, CQuEL should provide 'place-based' evidence about the provision and quality of selected ecosystem services, delivered by England's natural environment, in ways that are consistent with Natural England's remit and responsibilities. In this respect, CQuEL should support Natural England's strategic monitoring activities needed to assess the successes of its policy interventions, including its responsibilities under the European Landscape Convention (ELC) in the UK[1].

The data will need to be available according to a sequential timetable as the CQuEL programme is rolled out. This timetable is as follows (set out in the Methodological Review report):

- an 'historic' assessment of trends in ecosystem services using existing NEA and CQC data in 2010, possibly linked to the production of the 'England Synthesis' for the NEA, being led by Natural England;
- an assessment of future landscape and ecosystem service trends for NCAs as part of the 'Vision 2060' exercise in mid-2011;
- the update of the CQC landscape indicator in the first quarter of 2012; and
- an updated review of landscape and ecosystem service trends by NCA in mid-2012.

Within this context, this short report describes the outputs of Work Package 4 of the research to identify the data available to CQuEL. As set out in the contract specification, it describes the detailed review of the available data and evidence, identifies gaps and suggests potential analytical protocols and other spatial frameworks. It makes recommendations about what is, and is not, feasible for the assimilation of data into the CQuEL programme.

The report is split into nine sections covering:

- The scope of what needs to be assessed
- The method followed
- The principles adopted in considering the data that needs to be collected
- The relationship between data and ecosystem service delivery

[1] Council of Europe (2000) European Landscape Convention, Strasbourg (which came into force in the UK in March 2007)

- Summary of the CQC themes and services that are most and least easily measured
- Identification of key datasets for both CQC and service provision
- Summary of services that are more difficult to measure
- Identification of data gaps
- The presentation of data in ways that are accessible to different audiences.

The analysis is supported by three appendices:

Appendix 1. Scoping of assessment of individual ecosystem services

Appendix 2. Summary of metadata relating to key datasets

Appendix 3. Cross-reference to data assessed by the NEA

# The Scope of what needs to be assessed

There are two ways in which the scope of the evidence needed by CQuEL can be defined. These are the topics and spatial coverage of the data.

## The topics covered

This report covers the data that will needed to measure the seven landscape themes under CQC (See Table 1) and the ecosystem services that will be monitored under CQuEL (see Table 2). The selection of ecosystem services was described in the *Which Ecosystem Services?* Report (Work Package 2). It is important to understand that the services recommended by that work focus on those services selected for inclusion in CQuEL - it is not an exhaustive list of all potential ecosystem services. The services selected for inclusion in CQuEL have been presented as a hierarchy, working from general classes of services (which are broadly akin to the services described by the Millennium Assessment (MA)), through types of services to more specific categories which are concisely defined and for which examples are given.

In most cases, this report uses the detailed categories of services since it is at this level that it is easiest to identify the precise data needs. However, where service types are sufficiently concise for data to be gathered at this level, this is done.

It must be emphasised that how data is used to measure the services depends entirely on how these services are defined. **It is recommended that these definitions should undergo a process of consultation and endorsement through peer review before final decisions on the data used to measure them are made.**

**Table 1: The seven themes of CQC**

| | |
|---|---|
| 1. Trees and woodland | 5. Semi-natural habitats |
| 2. Boundary features | 6. Historic features |
| 3. Agricultural land cover | 7. River and coastal features |
| 4. Settlement and development patterns | |

**Table 2: The Hierarchy of Ecosystem Services recommended for CQuEL (from Work Package 2, Appendix 6)**

| CLASS | GROUP | TYPE | DEFINITION | EXAMPLES |
|---|---|---|---|---|
| **Provisioning services** | | | | |
| Nutrition | Terrestrial agricultural products | Sustainable cropping | The provision of food and drink for human consumption from plant products derived directly or indirectly from English ecosystems, through agriculture or horticulture, in ways that do not damage environmental quality. | Arable habitats providing wheat for bakery products; allotments providing vegetables and fruit |
| | | Sustainable animal husbandry | The provision of food and drink for human consumption from animals reared in English ecosystems, through agriculture, in ways that do not damage environmental quality. | Pastoral livestock farming providing beef and lamb; dairy production producing milk, butter and cheese. |
| | | Sustainable freshwater aquaculture | The production of freshwater fish in rivers, canals, ponds and reservoirs for human consumption in ways that do not damage environmental quality. | Farming of trout in ponds or reservoirs to assured standards for sale to the food supply chain. |
| | | Sustainable coastal fisheries | The provision of fish, shellfish and crustaceans in coastal waters for human consumption in ways that do not damage environmental quality. | Line fishing of sea bass; Lobster potting; The cultivation and harvesting of oysters in estuaries. |
| | Harvesting from the wild | Sustainable harvesting of wild food and drink | The provision of food and drink products from English ecosystems by collection from the wild, in ways that do not damage environmental quality. | Honey production from bees foraging on heather moorland; Collection of marsh samphire from salt marshes. |
| Fibre / mater-ials | Production of biotic materials | Sustainable provision of natural building materials | The provision of natural materials used for the construction of buildings and other structures. | The provision of timber for building construction and thatching straw or water reed for roofing buildings. |
| Ener gy | Renewable biotic sources | Biomass/ plant and animal wastes | The provision of energy from heat from the combustion of plant material or animal wastes, or of liquid or gaseous fuels derived from these materials. | The harvesting of woodfuel; the harvesting of oilseed crops to produce biodiesel; and the anaerobic digestion of pig slurry to produce methane. |
| Water | Provision of potable water | Sustainable provision of stored water | The supply of water for public and industrial consumption by abstraction from aquifers and reservoirs in ways that do not deplete water reserves or damage natural systems. | Upland blanket bogs supply clean water that are used directly by industry – e.g. Scottish whiskey industry; reservoirs store water for public water supply. |
| | | Provision of river waters | The supply of water for public and industrial consumption by abstraction from rivers in ways that do not damage natural systems. | Abstraction from rivers for irrigation of crops, for use in power stations or for public water supply. |

| CLASS | GROUP | TYPE | DEFINITION | EXAMPLES |
|---|---|---|---|---|
| **Regulating services** | | | | |
| Regulation of flows | Regulation of erosion | Soil erosion control | The conservation of soil quantity and quality where the erosive effect of water flow, wind and wave action and thus the potential erosion hazard is regulated. | Heathland habitats regulating soil erosion and maintaining soil cover on thin, infertile acidic soils. |
| | | Coastal erosion control | The control of land erosion at the coast, as a result of the wearing away of land or the removal of beach or dune sediments by wave action or currents. | Coastal saltmarsh and sand dune habitats regulating coastal erosion levels by dissipating wave energy and protecting the land behind. |
| | Regulation of terrestrial water flows | Flood generation control | The regulation of flood run-off from land across whole catchments through the interception of precipitation and overland water flow by vegetation, and the infiltration of water into soils. | Woodland habitats slow the movement of water runoff and increase infiltration levels. |
| | | River flood propagation control | The regulation of flood events by the provision of storage for water in soils and wetland habitats, thereby influencing the potential magnitude of flood events. | Peat soils in the uplands regulating the flow of rivers, wet woodland in flood plains receiving flood water. |
| | | Aquifer recharge | The regulation of ground water levels by infiltration of precipitation through vegetation and soils. | Rough grassland and permeable soils enabling rainfall to enter the groundwater. |
| | Regulation of coastal waters | Coastal flood control | The regulation of the potential hazard posed by coastal flooding, where the extent, condition and configuration of ecosystems influence the timing or magnitude of flood events through the interception of tidal flow. | Sand dune and saltmarsh habitats regulate the effect of coastal flooding during storm events and peak tides. |
| Regulation of physical environment | Climate regulation | Reduction in GHG outputs | The regulation of green house gas emissions from ecosystems. | The rewetting of organic soils to reduce oxidisation of soil carbon; use of soil tillage techniques to reduce emissions of nitrous oxide from soil organic matter. |
| | | Carbon storage and sequestration | The capture and storage of carbon from the atmosphere in ecosystems including woodland, wetlands and soils. | Upland blanket bog habitats store carbon in biomass; growing trees store carbon in timber and roots. |
| | | Local climate amelioration | The modification of local micro-climates, where ecosystems influence precipitation levels and temperature in the immediate area. | Woodland habitats provide heat regulation to dwellings and adjacent farmland. |
| | Regulation of freshwater quality | Purification of ground water | The regulation of groundwater chemistry by ecosystems where they influence water quality through the origin and amelioration of chemicals and particles affecting water quality. | Soils breaking down potential pollutants such as fertilisers and pesticides. |
| | | Purification of surface water | The regulation of surface water ecology and chemistry by ecosystems where they influence water quality through the origin and amelioration of chemicals and particles affecting water quality. | Wetland habitats filter and capture pollutants from fresh water. |
| | Regulation of coastal | Purification of estuarine and | The regulation of estuarine and coastal water ecology and chemistry by ecosystems where they influence water quality through the origin | Marine habitats decompose organic wastes. |

| CLASS | GROUP | TYPE | DEFINITION | EXAMPLES |
|---|---|---|---|---|
| | water quality | coastal waters | and amelioration of chemicals and particles affecting water quality. | |
| | Regulation of air quality | Filtering aerial particulates | The regulation of particulate matter carried in the air, where ecosystem influence air quality levels through the interception of natural and human origin particles. | Woodland habitats and urban trees intercept particulate pollution from air. |
| | Regulation of soil quality | Build up of soil organic content | The accumulation of soil organic matter to support a good soil structure and healthy biota. | Extensively managed grassland habitats accumulate organic matter from root growth. |
| Regulation of biotic environment | Pest and disease control | Biological control of pests and diseases | The regulation of human, animal and crop pests and disease by the action of natural predators and pathogens. | Insects such as lacewings and ladybird larvae reduce aphids in commercial crops. |
| | Maintaining natural lifecycles | Pollination | The regulation of production levels of agricultural, ornamental and native flora species by UK ecosystems through the effects of ecosystem extent, condition and configuration on the presence and abundance of natural pollinators. | Semi-natural grasslands support inspects that pollinate agricultural crops. |
| | Gene pool conservation | Conservation of wild genetic resources | The conservation of genetic resources from natural and semi-natural habitats. | Grassland habitats provide rare breeds of domestic livestock; orchard habitats provide stocks of rare fruit tree species. |
| | | Conservation of domesticated genetic resources | The conservation of the breeds of animals and varieties of plants and animals that have been selected by humankind. | The keeping of pedigree herds of rare native breeds; the maintenance of plant collections. |

# Spatial coverage

Evidence also needs to be obtained that shows patterns of supply and demand for ecosystem services, the links between different places or areas, and the geographical flows of services across space. The primary spatial units of measurement for CQuEL are the National Character Areas (excluding NCAs 112, Inner London, and 159, Lundy), but including adjoining coastal areas as explained below. As will be explored later in this report, an understanding of the spatial relationship between where services are delivered and where the benefiting populations are located will be helpful in policy terms.

The project specification for CQuEL, as described in more detail in the Methodological Review report, states that the geographical scope of CQuEL includes:

- rural and urban areas: thus urban green space (and the service it provides) and peri-urban areas and their relationship with the main centres of population should be considered; and
- those aspects of the marine and coastal environment that are directly or indirectly affected by terrestrial activity – namely physical coastal processes, biophysical processes influenced by inter-tidal habitats, and water quality issues relating to pollution derived from terrestrial sources.

# Method followed

Work Package 4 has followed the following key stages.

## 1. Scoping of potential data sources

A large and increasingly sophisticated amount of information is being collected about the natural environment in England. Fortunately, initiatives to share evidence between public bodies are improving access to these data. However, there is no single compendium from which all potentially suitable datasets can be drawn. The following sources that have used, or that list, a variety of different data about the natural environment have been reviewed:

- Data used in CQC phases 1 and 2
- An inventory of spatial datasets held by Natural England
- Natural England's State of the Natural Environment 2008 Report
- The National Ecosystems Assessment (using Briefing Note 3: Data sources, version 18th September 2009)
- Defra's Sustainable Farming and Food Strategy Indicators (under Outcome 4 - The environmental cost of the food chain; Outcome 5 - Better use of natural resources; and Outcome 6 – Landscape and biodiversity)
- The MAGIC website (www.magic.gov.uk)
- The Environment Agency's on-line 'State of the Environment' resource (linking to regional observatories)
- Datasets held by the Environment Agency (based on consultation with Environment Agency data handlers)
- Countryside Survey 2007
- Additional data suggested by Steering Group members

## 2. Assessment of data needs against Landscape Character themes and Ecosystem Services

The types of data that are needed to assess each of the seven themes that underpinned CQC and the 21 ecosystem services (with provisioning and regulating services further split into the 27 service categories) were assessed. The task for the Landscape Character (CQC) themes was relatively simple, involving a review of the data sources used in Phases 1 and 2 of the project, checking for changes in data availability. The task for the ecosystem services was more complex, requiring an examination of the most effective means of measuring service delivery (see further below). The detailed written outputs from this stage are included in **Appendix 1**.

# 3. Identification of key datasets against Landscape Character themes and ecosystem services

Following the conclusions from the Work Packages 1 and 2, the requirements for measuring the Landscape Character (CQC) themes and ecosystem services were matched against existing datasets that should be accessible to the CQuEL project. Priority datasets were identified and a proforma recording key items of metadata such as the source and ownership of the data, the spatial resolution and frequency of updating, was completed. These proformas are included in **Appendix 2**.

# 4. Analysis of data gaps and actions to address them

The final stage explored the topics for which the data needs are likely to be more problematic. This focussed on the ways that existing data sources could be used to fill gaps, on the role of expert opinion and on the need for new data collection.

# Principles adopted

The starting point for this part of the contract has been the statement, agreed with the Natural England Project Board in January 2010, that "*CQuEL should provide 'place-based' evidence about the provision and quality of selected ecosystem services delivered by England's natural environment, in ways that are consistent with Natural England's remit and responsibilities*". Based on this requirement, five criteria were developed (and submitted to the Natural England Project Board in March 2010) to define the data needs of the project. These are that the data should be:

- **Relevant** – Addressing landscape character and/or the delivery of ecosystem services in ways that are consistent with Natural England's remit and responsibilities and with other complementary work being undertaken (see below for further consideration of this).
- **Objective** – Authoritative and capable of withstanding critical scrutiny – ideally having been subjected to suitable levels of peer review that does not require CQuEL to do this.
- **Accessible** to Natural England – With any additional costs for data licensing being justifiable by the value of the information.
- **Spatial** – Ideally providing a resolution that allows patterns of data to be distinguished between different NCAs. As noted earlier, this includes urban green space and marine and coastal environments that are directly or indirectly affected by terrestrial activity. Other aspects of the spatial distribution of services, assets and beneficiaries are explored further below.
- **Regularly updated** – So that future change in landscape character and/or ecosystem service delivery can be compared to the current recent past situations. As noted earlier, the first job of CQuEL in 2010 will be to make an 'historic' assessment of trends using NEA and CQC data.

# Issues affecting the relevance of data to CQuEL

## Relevance to Natural England's remit and responsibilities

This issue has been considered under Work Package 2 (Appendix 2) of this study in relation to the definition of ecosystem services of relevance to Natural England. It was noted that services would be relevant where Natural England exerts direct 'leverage' over their provision through grant schemes, particularly Environmental Stewardship (ES) or where Natural England seeks to influence their delivery more broadly through working in partnership with others. This recognises that there are aspects of ecosystem service delivery that are not relevant to Natural England's remit and, conversely, that data measuring service delivery should specifically record those aspects of service delivery that are consistent with Natural England's interests.

This is particularly the case for the provisioning services. For most of these services (for instance the provision of food, fibre and energy), Natural England has no direct interest in maximising the provision of these services but is concerned about the impacts of the means of production. Services that are delivered in a way that leads to positive environmental benefits (for instance the maintenance of semi-natural habitats) or that avoids significant environmental harm are therefore of interest to Natural England and should be measured in CQuEL, whereas those that are delivered in ways that damage the environment should not. This issue has been recognised by

using the word ‘sustainable’ in the name of the services. As noted further below, the way in which sustainable production is defined can be more problematic.

That is not to say that the delivery of each of the provisioning services in their totality is of no relevance to CQuEL. In many cases, these services act as forces for change on the landscape. For instance, food production and energy generation from ecosystems are powerful factors shaping land use and management. So, whereas CQuEL is interested in assessing the extent to which landscapes are contributing positively to these services, CQuEL will also need to be aware of the (often negative) impacts of these services on landscape character and quality.

# Relationship to the National Ecosystems Assessment

It will also be important that there is a strong ‘read across’ between CQuEL and other work being undertaken, particularly the NEA. As noted in the Methodological Review Report (Work Package 1, page 14), further work is required to understand how the range of services identified by the NEA will be made operational, but it seems evident that the selection of ‘things to measure’ within CQuEL might usefully be done in ways that nest within the broad NEA methodology.

The specific requirements of CQuEL to measure landscape character and quality, and the contributions that landscapes and their natural assets are making to service delivery within Natural England’s remit, mean that the way the services are defined by CQuEL will inevitably be more narrowly defined than those used by the NEA. However, the focus on the role of natural assets in both the NEA and CQuEL mean that many of the things that need to be measured (for instance different types of land cover) will be the same. It is important the services and data used in CQuEL, wherever it is appropriate, ‘nest’ under those used by the NEA. This report has been prepared before the NEA methodology has been confirmed and a further review of the datasets recommended by this report will therefore be required when the NEA has reported.

**It is recommended that there should be consistency of approach and complementarity in the use of data between CQuEL and the NEA, where this is appropriate to the needs of CQuEL.** This requires close liaison with the NEA as its methodology is finalised and implemented, although CQuEL will inevitably use additional and more refined datasets.

# The relationship between data and service delivery

The use of data to measure landscape character is well understood, having been well developed by CQC. This requires no further debate here. On the other hand, the way that data can and should be used to measure levels of service delivery is a developing area of work and requires further consideration. Critical to this is an understanding of the functional pathway through which services are derived from the natural assets of landscapes, influenced by management and realised as natural processes/ functions. This pathway can be conceived as a cascade as shown in **Figure 1** (which is an adapted version of the schematic diagram previously developed by Roy Haines-Young and his colleagues). The terms used in bold in each of the boxes are those used by the NEA. As noted in the Methodological Review report (Work Package 1, page 12), the critical point this diagram seeks to convey is that a given ecosystem capability (process) only becomes a service if a beneficiary or beneficiaries attach some value to the outputs of an ecosystem.

**Figure 1. The cascade from natural assets to human benefits implicit in the concept of ecosystem services *(using services from woodland as examples)***

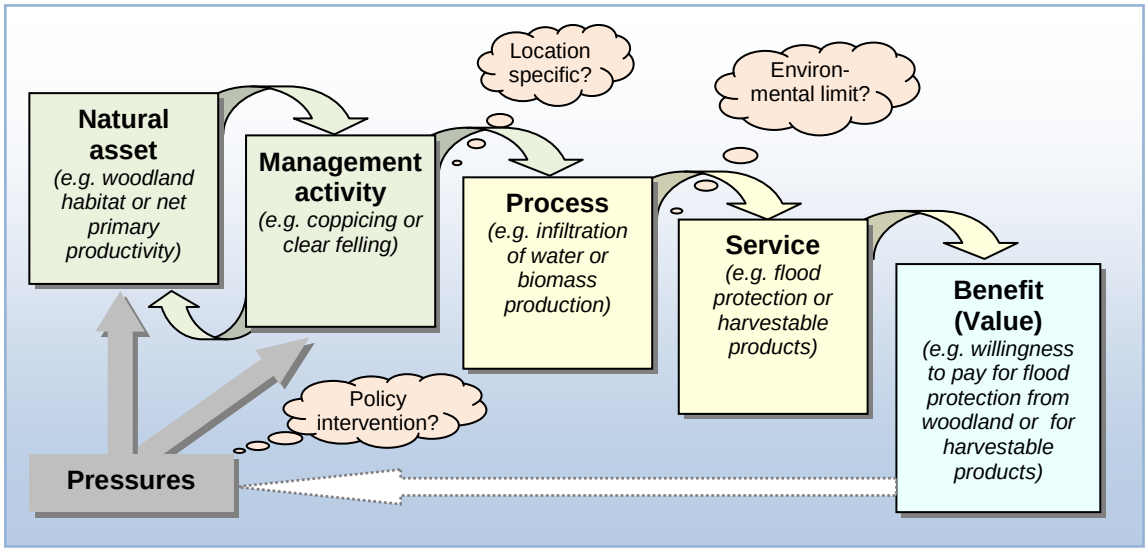


Figure adapted from Haines-Young and Potschin, 2010.

The ecosystems 'cascade' is helpful in that it recognises that the most reliable way of measuring the delivery of an ecosystem service is by measuring the service itself or, failing that, by measuring the natural processes that lead to the service. An important difference between the measurement of the process (the functional activity taking place in the natural environment) and the service (the usefulness of that process to people) is that the service may be measured against a defined environmental limit (the level below which delivery of the service is judged to be unacceptable). Metrics of service delivery are therefore defined by public policy objectives (which may be subject to change as the policy framework changes) whereas metrics of process are usually defined by scientific principles (which may also change due to advances in scientific understanding or technology).

An important consideration, here, as already noted, is that Natural England's remit and responsibilities do not necessarily cover the entirety of service delivery (for instance the regulation of water quality or conservation of the historic environment are the responsibility of the

Environment Agency and English Heritage respectively), but that the way natural assets contribute to these services is firmly within Natural England's remit (such as through the administration of Environmental Stewardship).

Furthermore, there is an important difference between the measurement of the outputs of services (such as water quality or flood risk management) and the contribution that ecosystems play in delivering these. For instance, taking the water quality example, sources of poor quality water (such as from domestic sewage, industrial processes) will be as much (if not more) of a determining factor of measures of water quality than the impact of ecosystem processes on the ecological and chemical status of water. It is assumed that CQuEL is most interested in measuring the latter.

This means that, while measures of service outputs will be useful to CQuEL, measures of the extent and quality of the natural assets that contribute to service delivery will also be relevant, both because they relate directly to Natural England's remit and because they demonstrate the influence that ecosystem processes are having on service delivery.

**Therefore it is recommended that key metrics (such as the ecological status of water bodies) used by organisations such as Natural England and the Environment Agency are interpreted by CQuEL, rather than being directly adopted as measures of service delivery**.

Where suitable data on the extent and quality of the natural assets that contribute to services is available, it is clear that this will also be potentially useful to CQuEL. In these circumstances, it will be important to understand that a range of factors, particularly the way the assets are managed, or their precise location in the landscape, may have a strong influence over the service that is actually delivered. These issues of management and location are also pertinent to the measurement of landscape quality within CQuEL.

# The influence of management of assets on service delivery

The way in which habitats and soils are managed is critically important in a qualitative sense. For instance, the timing and density of grazing and the type of grazing animals has a huge impact on the characteristics of grassland vegetation and soils. In turn this impacts on landscape quality and service provision such as water purification and carbon storage. Similarly the types and levels of inputs (e.g. fertiliser and pesticides) to agricultural crops and the types and intensity of woodland management activities (e.g. ride management, felling or coppicing) have a significant impact on the nature of services delivered, so woodlands that are coppiced, for example, will sequester significantly greater amounts of carbon dioxide compared to those that are not.

Whereas the distribution of natural assets such as land cover can be measured remotely (for instance by aerial photography) and often change relatively slowly over time, differences in management, leading to differences in the condition and quality of assets, are much less amenable to remote measurement and can vary over short timescales.

# Issues affecting the spatial definition of data

## The influence of location of assets on landscape character and service delivery

For some services and aspects of landscape character, the precise location of assets is not important. For instance, woodland is potentially able to supply biomass for energy production wherever it is sited. For other services, particularly some of the regulating services and for aspects of landscape quality, the spatial context of the natural asset is critical. For services which involve a natural 'pathway' such as the movement of water or air, habitats will contribute much more positively to the service if they are located appropriately along that pathway. For instance, the impact of hedgerows or woodland to reducing pollution of aerial particulates originating from road traffic will be much greater if they occur close to and in parallel with roads.

This means that where the location of natural assets is important, ways need to be found of measuring spatial distribution rather than simply the overall extent of the asset.

**It is recommended that where data on natural assets is used to assess service provision, this will need to take account of the location and management of these assets as key determinants of the service provided**.

## Relating services to the location of benefits

There is a further important spatial relationship implied in the cascade (Figure 1) that will need to be taken into account by CQuEL. This concerns the relationship between where services are delivered and where their benefits are received or consumed. As stated in the Methodological Review report (Work Package 1, page 16), the beneficiaries of a service may be located far from the point where a service is generated (such as the regulation of water quality and quantity), or may benefit all populations near and far, now and in the future, as in carbon sequestration and in the conservation of genetic resources.

This means that, for some services (particularly the cultural services) the proximity of these populations will be an important factor in determining the level of the benefit achieved, whereas for others (such as some of the regulating services), the beneficiaries may be located remotely from the locations in which the services are generated. One example that would be invaluable for several services is the measurement of urban greenspace in relation to population density (on the basis of Accessible Natural Greenspace Standards).

**It is recommended that, for many of the services, assessments should take account of the size of populations that are the beneficiaries of the service**.

## The functional units in which services are delivered

As noted earlier, one of the primary spatial units by which data will be analysed through CQuEL will be the NCAs. However, as noted in the Methodological Review report (Work Package 1, page 16), NCAs considered in isolation may not be the appropriate functional units for the analysis of all ecosystem services. It is clear, for example, that the boundaries of NCAs cut across important functional units (e.g. catchment, ground water protection zones, designated areas).

This means that, while NCAs are a key part of the analytical framework to be used in CQuEL the approach should be sufficiently flexible to permit analysis and reporting for a variety of other types of spatial unit, such as major catchments, administrative regions or more generic types of landscape such as the 'uplands' or 'coastal landscapes'.

It also means that CQuEL will need to collate data collected at other scales (for instance by river stretches or soil series) and then relate these to NCAs.

## Assessments of the potential for, and actual generation of, ecosystem services

Drawing together these different aspects of the way that ecosystem services can be measured, it can be concluded that:

- Where information is available on the outputs of service delivery (e.g. water quality), CQuEL will have a good measure of the benefit delivered, but will not necessarily have a good measure of the contribution that natural assets have made in providing this output.
- Where information is available on the broad extent of natural assets that contribute to delivery of each service, CQuEL will have a good measure of the potential for each service to be delivered, but not necessarily the level of delivery actually achieved.
- Where information is available on the extent, precise location and management of the natural assets, and there is good understanding of the way that this contributes to service delivery and the benefiting populations, CQuEL should have a good measure of the level of service delivery achieved.

# Summary

The questions that need to be asked of data at each stage in the cascade are different. In summary, these questions are as follows, starting with assets:

- measurement of the extent of those environmental assets that provide the service – How much of it is there?
- measurement of those assets under the right management condition for the provision of that service – How good is it?
- measurement of those assets in the right locations either relative to the function that they are required to perform or relative to the populations that they are serving – Is it in the right place?
- measurement against environmental limits / thresholds – Is there enough of it?
- measurement of service outputs – What is being achieved?

# The CQC themes and services that are most and least easily measured

This section summarises the results of analysis of each of the landscape quality themes and ecosystem services in turn, examining the ways in which they can most effectively be measured.

## Measurement of CQC themes

To ensure continuity of reporting, the CQuEL Project Board has decided to retain the CQC framework of themes developed during the previous CQC phases. The issues of which datasets can be used to measure which aspect of landscape quality has already been thoroughly explored in the first and second phases of CQC development and reporting. A total of 24 separate datasets were used in these phases of CQC, with each tracking one or more of CQC's seven themes, or provided contextual data (**Table 3**). The majority of datasets have been used to track change since 1990, with five additional datasets being added in the second phase (as well as an additional four added to provide contextual information). For each dataset, Table 3 identifies the current data owner and notes the current status of the data.

In terms of their current status, the Table shows that the majority of datasets remain relevant and are subject to regular or periodic updating so that ongoing trends can be monitored (coded CT in the third column). Some datasets have experienced no or little significant change but they remain valid because the extent of the environmental asset or characteristic has experienced no, or insignificant, change (for instance the area of ancient semi-natural woodland, the rural-urban morphology and the area of historic parks).

Some datasets have been superseded by new metrics because of changes in land management schemes (for instance the replacement of the Environmentally Sensitive Area and Countryside Stewardship Schemes with Environmental Stewardship) or methodologies for measuring the extent or condition of features (the introduction of the Heritage at Risk Register and water quality monitoring data for the Water Framework Directive). In these cases the new data are not directly comparable with the previous data. However, it is hoped that some degree of equivalence can be established so that judgements can be made about long term trends in these indicators.

**Table 3: Summary of CQC datasets, their current status and the seven CQC themes they relate to**

| Dataset | Data owner | Current status of data<br>NM = New metric<br>CT = comparable trend data | CQC themes | | | | | | | Contextual data |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1. Trees & woodland | 2. Boundary features | 3. Agric. land cover | 4. Settlement & develop. patterns | 5. Semi-natural habitats | 6 Historic features | 7. River & coastal features | |
| National Invent of Woodlands and Trees | FC | NM. Nat. Forest Invent. rel. June '10 | ● | | | | | | | |
| Ancient Woodland Inventory | NE | Static extent – No change | ● | | | | | | | |
| Woodland Grant Scheme Data | FC | NM. Now EWGS. Regularly updated | ● | | | | | | | |
| EN Habitat Inventory Data | NE | CT. Infrequently updated | ❍ | | | | ❍ | | | |
| FC Legal ownership | FC | No significant change | ❍ | | | | | | | |
| Countryside Survey 2000 | CEH | CT. Now CS2007 | | ● | | | | | | |
| Countryside Stewardship Monitoring | NE | Not updated – of historical interest | | ● | | | | | | |
| ESA Monitoring | NE | Not updated – of historical interest | | ● | | | | | | |
| Agricultural Census | Defra | CT. Annual. Minor changes in method | | | ● | | | | | |
| Land Use Change Statistics (LUCS) | CLG | CT. Annual – some change in method | | | | ● | | | | |
| 2001 Urban Boundaries | ONS | CT. Updated with mapping revisions | | | | ● | | | | |
| PO Address File (ref barn conversions) | R'yl Mail | CT. Continuously updated | | | | ❍ | | | | |
| Rural Urban Morphology | Defra | Not updated since 2003 | | | | ● | | | | |
| Wind Farms | BWEA | CT. Regularly updated | | | | ● | | | | |
| LCM 2000 | CEH | CT. Now LCM 2007 | | | | | ● | | | |
| Countryside Stewardship & ESA agreements | NE | NM. Replaced by ES agreements | | | | | ● | ● | ● | |
| SSSI Condition | NE | CT. Regularly updated | | | | | ● | | | |
| Farm Buildings at Risk | EH | NM. Now Heritage At Risk reports | | | | | | ❍ | | |
| Historic Parks | EH | Minor changes? | | | | | | ❍ | | |
| National River Water Quality Monitoring | EA | NM. Replaced by WFD assessments | | | | | | | ● | |
| ODPM previously developed land | CLG | CT. Infrequently updated | | | | | | | | ❍ |
| JCA Designated Area, LFA boundaries, landscape nature protection (SSSI, NNR) | NE | Infrequently updated. No significant change likely | | | | | | | | ❍ |
| Extent of common land | Defra | Not updated, still relevant | | | | | | | | ❍ |
| Extent of Access Land | NE | Minor updates. No significant change | | | | | | | | ❍ |

● Dataset used in both phases of CQC (1990-1998 and 1999-2003) ❍ Datasets added in second phases of CQC (1999-2003)

The conclusions arising from **Table 1** for each of the seven themes are as follows:

***1. Trees & woodland***. The National Inventory of Woodland and Trees is being replaced by the National Forest Inventory (due for release in June 2010). It is likely that most of the individual metrics within this will continue (a copy of the method statement for the National Forestry Inventory has been sought from Forestry Commission and should be available in May). The Woodland Grant Scheme has been replaced with the English Woodland Grant Scheme and the new uptake data are unlikely to be directly comparable since the eligibility criteria for the new scheme are somewhat different. The other three datasets remain valid but will show no change since they have not been updated (in all cases it is expected that the extent of the asset they are measuring has undergone little change).

***2. Boundary features***. Countryside Survey 2000 has been updated by Countryside Survey 2007 which it is expected will provide directly comparable data on trends at a national level. The other two datasets (Countryside Stewardship and Environmentally Sensitive Area monitoring) are not being updated following the closure of these schemes but uptake data for the boundary management options in Environmental Stewardship agreements will be available.

***3. Agricultural land cover***. Defra's June agricultural survey is undertaken annually and will provide data on long term trends in agricultural land cover. There have been a few minor changes in the methodology, including the redefinition of some data fields (for instance relating to livestock) but it is not thought these will significantly affect the utility of the data for CQuEL.

***4. Settlement and development patterns***. Four of the five of the CQC datasets are updated regularly and the fifth (the rural urban typology) remains valid as a measure of settlement character but has not been revised.

***5. Semi-natural habitats*.** Three of the four CQC datasets remain valid with updated trend data. The fourth (uptake of the Countryside Stewardship and ESA schemes) has been replaced by uptake of Environmental Stewardship (Entry and Higher Levels). The new Environmental Stewardship uptake data will not be directly comparable with that from the previous schemes but will provide new data on the area under the various management options.

***6. Historic features***. Two of the three datasets have changed (the uptake of agri-environment scheme agreements as above, and the introduction of the Heritage at Risk Register), while the third dataset (areas of registered parks and gardens) has been updated but is expected to have changed relatively little (such that significant trends since 2003 are unlikely).

***7. River & coastal features***. Both of the two datasets have changed (the uptake of agri-environment scheme agreements as above, and the introduction of water quality monitoring in line with the Water Framework Directive).

Overall, a significant number of the key datasets used in the last phase of CQC are no longer available. However, in all these cases, new metrics have been introduced which should replace them. As a result there will be discontinuities with some of the data streams used by CQC (e.g. agri-environment and woodland schemes and water quality) but these should not invalidate conclusions on long term trends. **It is recommended that CQuEL continues to use the same datasets as those used in CQC for the assessment of change in landscape character accepting that there have been some changes in how these data are recorded**.

# Measurement of ecosystem services

There are a number of ongoing projects examining the way in which the delivery of ecosystem services may be quantified or qualitatively assessed. These include the following

- The NEA seeks to record spatially the extent of five provisioning, six regulating, and two cultural final services across the UK. A work package within the NEA has scoped a wide range of data sources and this study has reviewed the early outputs of that work[2]. As noted earlier, it will be important that, wherever appropriate, the data used by CQuEL is complementary to that used by the NEA.
- Natural England is co-ordinating a project in four pilot upland areas[3] examining how ecosystem services can be measured to meet local as well as national needs. A scoping study looking at the monitoring and modelling of service delivery in these pilot areas has taken place during February and March 2010 and the results should be available shortly.
- Work by Research Box and others for Natural England is also ongoing into the assessment of the cultural services. This is described in more detail in the report *Which Ecosystem Service?* (Work Package 2, page 18)
- Defra may be commissioning new research on the delivery of ecosystem service by Environmental Stewardship (to run from 2010 – 2014), taking forward the findings of earlier research[4]. It is expected that this will be accompanied by similar work on the development of Environmental Stewardship by Natural England.

Early outputs of these ongoing projects have informed this study. Because of the way the services covered in this study have been defined, particularly in relation to Natural England's remit, none of these projects as yet provide an 'off the shelf' methodology that can be adopted by CQuEL but it may be that future outputs, particularly from the Research Box study in relation to the cultural services, will have valuable findings for CQuEL. Equally, it is hoped that the research undertaken here will be of interest to these other projects. It will be important that there is close liaison between CQuEL and all these projects to exchange intelligence and, where possible, to develop common platforms for gathering and sharing data.

**It is recommended that there is close liaison between CQuEL and other projects exploring the measurement of ecosystem services allowing the development of common platforms for gathering and sharing data.**

The remainder of this section reviews the types of data that are needed to measure each of the services, distinguishing between the assessment of assets and of services.

[2] UK NEA Briefing Note 3 – Version 18 September 2009

[3] These four pilot areas are the Bassenthwaite Lake catchment, the Southern Pennines NCA and the two South West uplands of Dartmoor and Exmoor.

[4] LUC et al. (2009). Provision of ecosystem services through the Environmental Stewardship scheme (Defra research contract NR0121).

**Appendix 1** provides more detailed analysis in which the following topics are covered for each service in turn:

- Definition of service
- Ways of assessing service delivery
- Definition of natural assets
- Ways of assessing natural assets
- Factors influencing delivery by natural assets (focussing on location and management)
- Recommendation for data

**Table 4** provides a summary of the findings from **Appendix 1** for each of the provisioning and regulating services. The cultural services are not covered in the table since these are the subject of ongoing research by Research Box. The table reviews the issues governing the suitability of different types of data for assessing the services themselves and, where these are not available, for assessing the extent and quality of assets delivering the services. Identification of individual datasets is covered in the following section.

**Table 4. Means of assessing service delivery and extent of assets**

Text shaded in green shows where existing data is likely to be available to enable a good estimate to be made of service delivery. Text shaded in yellow shows where existing data could be used to give a partial estimate of service delivery. See **Table 2** for the definitions and examples of services.

| Service | Assessment of service delivery | Assessment of assets | Relationship between assets and service delivery |
|---|---|---|---|
| **Provisioning services** | | | |
| Sustainable cropping | Data below regional level unlikely to be available or reliable because of complexities of supply chain. | Good data for areas of crops available at NCA level. | Judgements needed on areas of crops used for food production (cf animal feed). A key issue is definition of sustainable cropping. Various farm assurance schemes exist but production data are not available for these, with exception of organic farming. ES uptake shows sustainable practices, but not food production related to this. |
| Sustainable animal husbandry | See above. | Good data on numbers of livestock available at NCA level. | Judgements needed on proportion of animals destined for human consumption (excluding animals reared for breeding). See above for issue of sustainable production. |
| Sustainable freshwater aquaculture | National estimates of fisheries production only – nothing at NCA level. | Number of aquaculture businesses is available at SOA level. | Judgements needed to convert number of businesses to estimate of production in each NCA. Consultations with regional EA fisheries staff needed to assess environmental impacts. |
| Sustainable coastal fisheries | Annual quantities of fish landed at coastal ports and data on bivalve production is available at sufficient resolution for NCAs. | Number of fisheries businesses could be obtained – but provides no advantage over catch data already available. | Consultations with regional fisheries and EA staff needed to assess environmental impacts. |
| Harvesting of wild foods | Diverse and dispersed nature of the service (not an industrial process) means reliable data hard to come by at national level. No NCA level data available. | Location of habitats with high potential for wild food collection could be mapped by NCA. | Judgements needed to assess levels of wild food collection taking place. |
| Sustainable provision of natural building materials | As for cropping, complexity of supply chains means data below regional level unlikely to be reliable. Exception is timber from FC estate where harvesting & marketing data are available from Forest Districts | Area of woodland/forestry and other specialist habitats (water reed) provide starting point. | Judgements needed to estimate volumes of building materials produced. For semi-natural habitats, judgement needed on sustainability of production. |
| Energy from biomass and animal wastes | Regional forecasts of woodfuel resource available from Forest Research. No data available on other biomass or animal waste. | Energy Crops Scheme gives area of biomass crops established with grant each year.<br>Potential animal waste resource can be estimated from numbers of livestock (dairy cows, pigs and poultry).<br>Total woodland cover provides a measure of potential woodfuel production | FSC certification provides means of estimating sustainable woodfuel production (but most private sector not certified). Expert judgement needed to estimate sustainable biomass crop or animal waste production. |
| Sustainable provision of stored water | Catchment scale assessments made of water availability by EA (CAMS). Water Resource Management Plans forecast future demand and supply. | Volume stored in reservoirs and area of upland peat soils can be estimated. Aquifer reserves more difficult. | Understanding of demand is needed to estimate service delivery from volume of water in reservoirs and groundwater. An indirect measure might be the numbers of river reaches suffering from low flow conditions.<br>Data on uptake of ES options on upland peat soils can be used to infer their positive condition for water storage. |

| Service | Assessment of service delivery | Assessment of assets | Relationship between assets and service delivery |
|---|---|---|---|
| Provision of river water | As above. | As above for CAMS data. Volume of river water can be estimated from flow rates. | As above, for rivers. |
| **Regulating Services** | | | |
| Soil erosion control | Assessments of soil vulnerability to erosion have been undertaken (EA) but these don't describe the delivery of the service which needs to take account of land cover and soil quality/ management.<br>Uptake of soil management options in ES (primarily ELS) could be used as a proxy measure (but providing only partial coverage of beneficial practices). | Land cover data can be linked to soil vulnerability (see left). No data available on soil condition. | Factors affecting soil erosion are complex. Precise location of habitats and other landcover has big impact on control of erosion. Management of soils (cultivation) and land cover (e.g. grazing) are critical to determining impacts.<br>Sampled data (not complete NCA coverage) on the condition of soils from Countryside Survey 2007 provides useful contextual (and some trend) data. |
| Coastal erosion control | Concept of positive delivery of this service is complex. Data measuring failure of service is patchy. | Data on coastal geology and habitats could provide assessment of vulnerability of coastline to erosion and natural protection provided. | External factors such as wave fetch and storm surge will influence the erosion risk. The presence of man-made coastal defences will influence role of habitats in erosion control. The nature of coastal land use means that agriculture (and ES) will have less of a role to play. Defra Shoreline Management Plans might be used to identify those coastal stretches where reliance will be placed on natural processes. |
| Flood generation control (reducing run-off in the wider catchment) | Service is not directly measured,. Research for EA (JBA Consulting) modelled spatial distribution of flood generation. The service is a complex interaction between ecosystems and climatic, topographical and geological factors. The overall contribution of land cover and soils to reducing water run-off are not well understood. | Extent of vegetation cover (particularly woodland and extensive grassland) indicates areas likely to deliver this service. | Factors such as slope, precipitation, underlying geology and the position of vegetation cover relative to water runoff are important. Great care is needed to attribute any influence of ecosystems on control of flood generation, particularly for extreme events.<br>Some EWGS and ES options could indicate favourable management, but location is a critical issue. |
| River flood propagation control (storage of flood waters) | Areas liable to flooding are recorded (Flood Map) and these are the areas potentially available for service delivery. Contextual information needed at local level to know whether (a) ecosystems are providing a positive service and (b) where flooding poses a threat to property. | Habitats capable of storing floodwater are wetlands, wet grassland, wet woodland and good quality soils with water storage capacity. But location of these habitats and their ability to reduce flooding downstream is critical. | Location of properties and other assets needing flood protection will determine whether the function of storing water is also a service of flood control. The hydrographic properties of the catchment will also determine the nature of river flood responses (timing of flood peaks at particular locations, etc).<br>Some EWGS and ES options could indicate favourable management, but location is a critical issue. |
| Coastal flood control | Same issues apply as above. | Coastal habitats capable of holding back floodwater are saltmarsh, grazing marsh and mudflats. | Same issues apply as above. The hydrographic properties of coasts and estuaries (e.g. tidal height curves) and the location of suitable habitats in relation to these will be critical. |
| Aquifer recharge | Data on groundwater availability is available but aquifer recharge by ecosystems is only a small part of what contributes to groundwater availability (demand, size of aquifer and groundwater flows are likely to be as significant). | High quality soils and extensively managed grassland and broadleaved woodland will contribute most strongly to the service.<br>These can be measured from soils and land use data. | Land management has a strong role to play. Compaction of soils from grazing livestock, machinery and soil treatments affect levels of infiltration.<br>Land under some ES options (e.g. permanent grassland with low inputs) provides good measure of positive management. Precise location not a major issue. |

| Service | Assessment of service delivery | Assessment of assets | Relationship between assets and service delivery |
|---|---|---|---|
| Reduction in green house gas emissions | Tools for measuring GHG emissions from land are becoming available (Carbon Accounting for Land Managers), based on site-based land use and management practices. No such data exists across NCAs. | Assets related to emissions include cultivated soils, intensively managed grassland (both producing nitrous oxide) and ruminant livestock numbers (producing methane). These can be measured through land use and management data. | Complex factors such as process of fertiliser application (direct injection), cultivation (minimum tillage) and livestock diets will influence emissions from different land uses.<br>Land under some ES options and EWGS agreements could provide good measure of positive management, but work needed to determine which options. Precise location not a major issue.. |
| Carbon storage and sequestration | Levels of carbon stored in soils and vegetation can be estimated from existing data (see right). But modelling of carbon flux is complex and the science is not well understood. | Woodland and wetland cover data, and soils mapping provide indications of where stored carbon is highest. | Levels of sequestration depend on the rate of growth of woodland, the condition of sphagnum moss in blanket bog (whether actively growing) and the condition of soils (in relation to accumulation of organic matter) will be important.<br>Uptake of certain ES options (e.g. low input permanent grassland, wetlands such as blanket bog) provides indication of positive management increasing soil organic matter.<br>Sampled data (not completed NCA coverage) on the condition of soils from Countryside Survey 2007 provides useful contextual (and some trend) data. |
| Local climate amelioration | The impact of local ecosystems on climate is not monitored directly. Measurement of this service at a micro-scale (around individual trees) would be much easier than measurement at a larger (NCA) scale. | The science of climate amelioration is complex. Habitats such as trees (at a micro scale), woodland and wetland (at a larger scale) are likely to be significant. | A complex array of factors such as topography, airflow and the density and height of vegetation will all be significant, with the location of habitats in relation to airflow being important. |
| Purification of groundwater | Chemical quality of groundwater is monitored for the Water Framework Directive. But this does not distinguish the role of ecosystems in purifying ground-water relative to the sources of poor water quality. | Soil type and land cover influence changes in the chemistry of water as it moves into the groundwater. | Land management factors such as cultivation of soils, inputs to cropped land (fertilisers and pesticides), treatment of 'dirty' water in sewage treatment works and land drainage will be significant.<br>Uptake of certain ES options (e.g. low input permanent grassland) provides indication of positive management in place. |
| Purification of surface water | Ecological and chemical quality of surface waters are monitored for the Water Framework Directive. As above, this does not distinguish the role of ecosystems. | As above. | As above. |
| Purification of estuarine and coastal water | Bathing water quality around coasts is measured for the Bathing Water Directive. As above, this measures sources of pollution as well as ecosystems impact on these. | Habitats such as saltmarsh and mudflats are likely to have some impact on this service. | Factors such as sources of pollution and tidal movements are likely to be more significant than the presence of the habitats mentioned in the previous column.<br>Uptake of certain ES options (e.g. salt marsh and wet grassland) provides indication of positive management in place |
| Filtering of aerial particulates | Measurements of particulates in air (PM10) are available but will be a poor indication of the delivery of this service by ecosystems. As for local climate amelioration, the scale at which the service is measured is important. | Trees, hedgerows and woodland intercept particulate pollution from air, but see right for issue of location. | Sources of pollution (road traffic and industrial sources) are much more significant contributors to air quality than the role of ecosystems in filtering aerial particulates.<br>The precise (field scale) location of habitats (trees, hedgerows and woodland) in relation to sources of pollution determines the benefits they provide. This is complex to map. |

| Service | Assessment of service delivery | Assessment of assets | Relationship between assets and service delivery |
|---|---|---|---|
| Build up of soil organic matter | Soil maps can be interpreted to determine typical levels of soil organic matter but don't show where organic matter is accumulating. | Woodland, wetlands and extensively managed grassland are likely to accumulate soil organic matter. | Soil cultivation for crop establishment, compaction from high levels of grazing, and drainage will all tend to reduce organic matter levels.<br>Uptake of certain ES options (e.g. low input grassland) provides indication of positive management on farmland.<br>Sampled data (not complete NCA coverage) on the condition of soils from Countryside Survey 2007 provides useful contextual (and some trend) data. |
| Biological control of pests and diseases | There is no direct measurement of this service. The only data (not very relevant) will be related to outbreaks of pests that are vectors of notifiable diseases (such as Culicoides midges –vector of Blue Tongue). The concept of this service does not easily lend itself to direct measurement. | Habitats supporting 'beneficial' organisms on farmland include rough grassland, flower-rich strips, hedgerows and woodland. | Management of habitats supporting beneficial insects, and their location in relation to cropped areas will be important factors.<br>Uptake of certain ES options (e.g. beetle banks, conservation headlands and buffers strips) provides indication of positive management on arable farmland. |
| Pollination | Populations of bees and other pollinators are monitored nationally but no finer spatial data is currently recorded. | Habitats supporting pollinating insects include semi-natural grassland, heathland, moorland and sea lavender and some agricultural crops such as orchards and field beans. | Factors include the location of habitats in relation to cropped areas, weather and climatic conditions and the health of pollinator populations.<br>Sampled data (not complete NCA coverage) on species change within selected habitats from Countryside Survey 2007 provides useful contextual and trend data. |
| Conservation of wild genetic resources | No measure of total genetic diversity available at NCA level. | Area and range of semi-natural (BAP priority) habitats provide good indicator for overall diversity. | Note that the range of different habitats present is as important as the area (an NCA with a lot of one habitat may be less biodiverse than one with a smaller area of a greater range of habitats).<br>Sampled data (not complete NCA coverage) on species change within selected habitats from Countryside Survey 2007 provides useful contextual and trend data. |
| Conservation of domesticated genetic resources | National data are available on rare breeds of livestock – but very patchy data on regional and sub-regional distribution. Uptake of ES traditional breed options could be used as a proxy (but only partial data). Less data available on cultivated plants. | Breed society memberships could be researched for location of rare breed herds/flocks. Ditto national plant collections for cultivated plants. | New research needed to assimilate data from a variety of sources and overall judgements needed to compare significance of different breeds and plant varieties. |

**Table 4** does not include an assessment of the ways in which the cultural services can be measured. This is because ongoing research for Natural England led by Research Box is examining this in more detail (see the *Which Ecosystem Services?* Report)

However, spatial datasets that will almost certainly be valuable for the measurement of these services will include:

- The extent of urban green space
- Open access land
- Density of footpaths
- Tranquillity and dark night skies

# Summary

The conclusions from **Table 4** can be summarised in relation to the cascade of ecosystem services (Figure 1), below under the following headings. The issues affecting how the data at each level is used are considered further in the final section of this paper (page 41).

A. Services where existing data allow direct measurement of **service delivery**

B. Services where existing data on **environmental quality** are closely related to ecosystem delivery or the potential for service delivery

C. Services where existing data assessing the extent and condition of **environmental assets** can reliably be used to measure service delivery or the potential for delivery

D. Services for which available data are unlikely to provide a sufficiently robust assessment of potential or actual service delivery or the environmental assets that contribute to service delivery

## A. Services where existing data allow direct measurement of service delivery

- **Sustainable coastal fisheries** – Data on catches landed at ports kept by the Marine Fisheries Agency and areas covered by bivalve fisheries kept by the Centre for Environment, Fisheries and Aquaculture Services (Cefas).
- **Sustainable provision of natural building materials** – Timber harvesting and marketing data for the Forestry Commission's estate provides partial coverage only.
- **Energy from biomass and animal wastes** – Estimates of the woodfuel resource at a regional level from Forest Research provide partial coverage only.
- **Carbon storage and sequestration** – Data on the organic content of soils, but currently limited data on rates of carbon sequestration or of carbon storage in vegetation (see below for use of data on environmental assets).
- **Build up of soil organic matter** – Soil datasets such as the Soilscape from the National Soils Research Institute can be used to map levels of soil organic matter but don't show where organic matter is accumulating.
- **Conservation of domesticated genetic resources** – Uptake data on traditional breed options in Environmental Stewardship will provide partial coverage of this service (but only measuring a proportion of a large delivery of this service by livestock breeds and plant collections which are not covered by this source).

## B. Services where existing data on environmental quality are closely related to ecosystem delivery or the potential for service delivery

- **Sustainable provision of stored water and provision of river water** – Catchment scale assessment from the Environment Agency's Catchment Abstraction Management Strategies (CAMS).
- **Soil erosion control** – Soil management options, and other options that provide benefits to soil quality, in Environmental Stewardship provide partial coverage only. Countryside Survey 2007 provides national (possibly regional) level data on trends in soil condition.
- **River flood propagation control and coastal flood control** – The Environment Agency's Flood Map data records areas at risk of flooding, but this does not indicate a) where ecosystems are providing a positive service or b) where flooding poses a threat to property.
- **Purification of ground water and surface water** – Monitoring of the ecological and chemical status of water bodies by the Environment Agency for the Water Framework Directive measures water quality but does not distinguish the role of ecosystems in improving water quality.
- **Filtering of aerial particulates** – Monitoring of particulates coordinated by the UK National Air Quality Archive measures this aspect of air quality but does not distinguish the role of ecosystems in improving it.

## C. Services where existing data assessing the extent and condition of environmental assets can reliably be used to measure service delivery

- **Sustainable cropping** – the area of crops are recorded by Defra's annual June Agriculture Survey but further assessment is needed to define what means of production are considered sustainable.
- **Sustainable animal husbandry** – the numbers of livestock are recorded by Defra June Agricultural Survey. The same issue as above applies to definitions of sustainable production.
- **Sustainable freshwater aquaculture** – the numbers of businesses engaged in freshwater aquaculture are recorded by the Annual Business Inquiry. The same issue as above applies to definitions of sustainable production.
- **Harvesting of wild foods** – the areas of semi-natural habitats from which wild foods can be obtained would identify *potential* service delivery.
- **Sustainable provision of natural building materials** – the areas of woodland (from the Forestry Commission's National Forest Inventory), suitable crops (From Defra's June Agricultural Survey) and suitable semi-natural habitats (from Natural England's Habitat Inventories) show the *potential* for land to provide the service.
- **Energy from biomass and animal wastes** – the areas of grant-funded energy crops from Natural England's Energy Crops Scheme provide a good record of energy crops. The area of woodland (from the National Forest Inventory) and numbers of livestock from which energy could be obtained (Defra's June Agricultural Survey) show the *potential* resource – which in both cases is likely to be much greater than that actually being used.
- **Sustainable provision of stored and river water** – Data on uptake of Environmental Stewardship options on upland peat soils can be used to infer their positive condition for water storage.
- **Aquifer recharge** – Land cover data (e.g. Land Cover Map 2007) will show the extent of potential service delivery by suitable habitats, and uptake data for the English Woodland Grant Scheme and certain options of Environmental Stewardship could be used to record their condition. Other factors such as level of water demand from aquifers will be needed to put these data in context.
- **Reductions in green house gas emissions** – Land cover data (Land Cover Map 2007), combined with the emerging results of research on emissions from different land use regimes, can be used to estimate the level of emissions. Uptake data for English Woodland Grant Scheme and Environmental Stewardship options can be used to provide indications of positive management. Work will be needed to determine which Environmental Stewardship options do so.
- **Carbon storage and sequestration** – The areas of woodland (from the National Forest Inventory), hedgerows (e.g. Land Cover Map 2007) and wetlands such as blanket bog (from Land Cover Map and Natural England's Habitat Inventories) could be used to estimate the extent of key habitats in which carbon is stored but do not measure levels of active carbon

sequestration. Uptake of certain Environmental Stewardship options provides an indication of positive management increasing soil organic matter and of English Woodland Grant Scheme will indicates positive woodland management enhancing carbon sequestration. Countryside Survey 2007 provides national (possibly regional) level data on trends in soil condition.

- **Purification of ground, surface, estuarine and coastal water** – Land cover data (e.g. National Forest Inventory and Land Cover Map 2007) for key habitats can be used to measure the extent of *potential* service delivery and uptake of certain Environmental Stewardship options could be used to indicate their positive management. But the complexity of the delivery of this service means that these are likely to be relatively crude measures.
- **Local climate amelioration** – Here the primary benefit is likely to derive from tree cover both to reduce the heat island effect and provide a buffer to winds. The distribution of trees and woodland, particularly close to urban centres where their benefits will be greatest, could provide a measure of this service. The distribution of urban tree cover will be particularly important.
- **Build up of soil organic matter** – Land cover data (e.g. National Forestry Inventory and Land Cover Map 2007) for key habitats can be used to measure the extent of potential service delivery and uptake of English Woodland Grant Scheme and certain Environmental Stewardship options could be used to indicate their positive management. Countryside Survey 2007 provides national (possibly regional) level data on trends in soil condition.
- **Biological control of pests and diseases** – Land cover data and particularly uptake data for certain Environmental Stewardship options could be used to indicate the extent of certain habitats known to support 'beneficial pest predator' species. But this is likely to be a partial assessment of this service as there will be many relevant habitats that will not be under Environmental Stewardship.
- **Pollination** – Land cover data to identify suitable habitats (Natural England's Habitat Inventories are likely to be most suitable, but the extent of certain agricultural crops can be obtained from the Defra June Agricultural Census) should provide a good indication of the land that can *potentially* provide this service, but it will not record the activity of pollinating insects themselves.
- **Conservation of wild genetic resources** – Natural England's Habitat Inventory data should provide a good indicator of overall diversity. Land under SSSI designation will also be relevant. Countryside Survey 2007 provides regional level data on trends in species changes in key habitats. It will be the range of habitats, as much as their areas, which will need to be measured.

## D. Services for which available data are unlikely to provide a sufficiently robust assessment of potential or actual service delivery or the environmental assets that contribute to service delivery

There is a fine judgement to be made about whether these services should be listed here, or whether they can be listed under C, above. This depends partly on the way that individual services are defined and on the 'burden of proof' that is required before reliable estimates of service delivery can be made.

- **Flood generation control** – Land cover data (such as from Land Cover Map 2007) will identify habitats such as rough grassland, hedgerows and woodland that can potentially contribute to this service, but their field-scale location (for instance whether hedgerows lie across or down slopes) will be critical. Data on the uptake of the English Woodland Grant Scheme and certain Environmental Stewardship options could indicate favourable management, but again the field-scale location will be critical. Also the catchment scale impacts of habitats, even when positively managed is unclear.
- **River and coastal flood propagation control** – Land cover data (e.g. Land Cover Map 2007) will show extent of *potential* service delivery by suitable habitats, and uptake data for the English Woodland Grant Scheme and certain options of Environmental Stewardship could be used to record their condition. But again the precise location of this land will be critical to its delivery of this service.

This analysis emphasises the importance of good, spatially fine-grained, land cover data for the assessment of the majority of services for which there is not reliable data on service delivery itself. Such data often provides a good indication of the ***potential*** for service delivery.

In a number of cases, analysis of the land cover data needs to be combined with other spatial factors such as topography and proximity to beneficiaries or sources of harm before a good reliable indication of actual service delivery can be made.

# Identification of key datasets for both landscape character and service provision

This section draws on the previous analysis under this Work Package and identifies the specific sources of data that can be used to assess landscape character (updating the data used in CQC) and environmental services. It briefly describes the key datasets that are recommended to be used to measure landscape character through the seven CQC themes and/or the selected ecosystem services. All these datasets are described more fully in **Appendix 2** which consists of a completed proforma of the metadata for each of the main datasets.

In the following section, key datasets are listed under the headings of:

- Data describing land cover
- Data describing land management and designations
- Data describing the condition of natural resources
- Other types of data.

# Data describing land cover

| Datasets | Summary of metadata | Examples of CQC themes (Landscape Character) & Ecosystem services |
|---|---|---|
| Land Cover Map (LCM) 2007 | National remote sensed survey distinguishing between 26 sub-classes of vegetation cover. Resolutions down to 25m$^2$. Undertaken by CEH, updates previous surveys in 2000 and 1990. Data due to be released in 2010. | Landscape character: Semi-natural habitats; Ecosystem services: Soil erosion control; Coastal erosion control; Flood generation control; River Flood propagation control; Coastal flood control; Aquifer recharge, Purification of ground, surface, estuarine and coastal water, Reductions in green house gas emissions. |
| June Agricultural Survey | Annual survey of all agricultural holdings (June each year) undertaken by Defra. Records types of farm enterprise, area of crops, numbers of livestock and numbers of agricultural workers. Data can be obtained clipped to bespoke boundaries from Defra e.g. NCAs. | Landscape character: Agricultural land cover; Ecosystem services:: Sustainable cropping; Sustainable animal husbandry; Energy from biomass and animal wastes; Sustainable provision of natural building materials. Data on livestock densities also potentially useful in relation to soil erosion control, control of flood generation; reductions in green house gas emissions and aquifer recharge. |
| Habitat Inventories | The extent of semi-natural habitats, including the BAP Priority Habitats (and others) held by NE. Various origins (field survey and remote sensing). | Landscape character: Trees and woodland; CQC Semi-natural habitats; Ecosystem services: Harvesting of wild foods; Sustainable provision of natural building materials; Conservation of wild genetic resources; Carbon storage and sequestration, Prevention of soil erosion, Water quality, Flood alleviation, Pollination; Pest and disease control. |
| National Forest Inventory | National remote sensed survey undertaken by Forestry Commission. Updates the National Inventory of Woodland and Trees. Due to be released in June 2010. Ongoing rolling programme of field survey will update NFI in future. | Landscape character: Trees and woodland; Ecosystem services:: Sustainable provision of natural building materials; Carbon storage and sequestration, Prevention of soil erosion, Water quality, Flood alleviation |
| Ancient Woodland Inventory | The extent of ancient woodland held by Natural England. Not updated. | Landscape character: Trees and woodland; See above for other ecosystem services where measure of woodland cover is important. |
| Land Use Change Statistics (LUCS) | Point data (recording areas of land relating to centre point) collected for CLG on land changing use. Updated annually but changes in method can make .comparison of data difficult. | Landscape character: Settlement and development patterns. Location of populations relative to the delivery of cultural services. |
| 2001 Urban Boundaries | Boundaries of urban areas as defined by Ordnance Survey. Updated periodically. | Landscape character: Settlement and development patterns Location of populations relative to the delivery of cultural services. |
| National Land Use Database of | Boundaries of land under existing or previously development (e.g. residential or industrial) use. Held by CLG. | Landscape character: Contextual data. |

| | | |
|---|---|---|
| Previously-Developed Land | | |

# Data describing land management and designations

| Datasets | Summary of metadata | Examples of CQC themes & Ecosystem services |
|---|---|---|
| Flood map | The boundaries of land at risk of flooding (Flood zone 2: medium risk; Flood zone 3: High risk). Held by the EA. Distinguishes between fluvial and marine flooding. Updated periodically. | Ecosystem services: River flood propagation control; Coastal flood control. |
| Woodland schemes | The boundaries of woodland scheme (WGS and EWGS) agreements. Held by FC. Updated annually. | Landscape character: Trees and woodland, Ecosystem services: Carbon storage and sequestration, prevention of soil erosion, water quality, flood alleviation. |
| Agri-environment scheme agreements | The boundaries of agri-environment scheme (HLS, ELS, ECS, ESA and CSS) agreements, including the land management options. Held by NE. Updated. annually. | Depending on the land management options chosen: Landscape character: Semi-natural habitats; Ecosystem services: Energy from biomass and animal wastes (ECS). Soil erosion control; Sustainable provision of stored and river water; Aquifer recharge; Reductions in green house gas emission, Carbon storage and sequestration; Purification of ground, surface, estuarine and coastal waters, Build up of soil organic matter, Biological control of pests and diseases; Pollination. |
| Historic Parks and Gardens | The boundaries of registered parks and gardens. Held by EH. Updated. periodically. | Landscape character: Historic features, cultural services. |
| LFA boundaries | Boundaries of land designated under EC Directive 75/268, distinguishing between Severely Disadvantaged Areas and Disadvantaged Areas. Not updated since 1985. Moorland line added in 1995. | Landscape character: Contextual data. |
| SSSI boundaries | Boundaries of SSSIs. Held by NE. Updated when required (rarely) | Landscape character: Contextual data. Ecosystem services: Conservation of wild genetic resources. |
| Extent of common land | Boundaries of registered common land (Commons Registration Act 1965 as updated by the Commons Act 2006). Held by NE. Not updated. | Landscape character: Contextual data. Access provision under the cultural services. |
| Extent of Access Land | Boundaries of land classified for public open access under the Countryside and Rights of Way Act 2000. Held by NE. Updated as required. | Landscape character: Contextual data Access provision under the cultural services. |
| Rural Urban Morphology | Classification of census output areas into eight categories of rural and urban character based on the morphology (density) and context (clustering) of settlements. Produced for Defra in 2004. Not updated. | Landscape character: Settlement & development patterns Ecosystem services: Location of populations relative to the delivery of services. |

## Data describing the condition of natural resources

| Datasets | Summary of metadata | Examples of CQC themes & Ecosystem services |
|---|---|---|
| SSSI Condition | The biological condition of all SSSI units classified into five categories. Held by NE. Updated regularly. | Landscape character: Semi-natural habitats. Ecosystem services: may act as a proxy for the condition of some services especially services dependent on the favourable condition of blanket bogs. |
| Heritage at Risk Register | The condition of Scheduled Monuments at risk (CHECK). Held by EH. Updated periodically. | Landscape character: Historic features; cultural services |
| Countryside Survey 2007 | Third generation of the national sampled survey undertaken by CEH. A wide variety of technical reports produced and in progress. | Landscape character: Boundary features; Contextual (land use condition) Ecosystem services: data for many of the regulating services including Soil erosion control; Build up of soil organic matter; conservation of wild genetic resources |
| Ecological and chemical status of waters | Classification of all controlled surface and ground water bodies in terms of chemical status and ecological status (surface waters only). Monitoring undertaken by the EA. First rounding of reporting published in 2009. Will be updated in 2015. | Landscape character: River & coastal features; Ecosystem services: Purification of groundwater; Purification of surface waters |
| Bathing water quality | Sampling of bathing water quality at key sections of coast (beaches) is undertaken by the Environment Agency. Sampling takes place throughout the summer months and is published annually. | Ecosystem services: Purification of estuarine and coastal waters |
| CAMS water availability | Catchment Abstraction Management Strategies (CAMS). Classification of catchments into four categories based on the availability of water for abstraction. Held by the EA. First cycle of CAMS published in 2008. Will be regularly updated. | Ecosystem services: Sustainable provision of stored water; Provision of river water. |
| Soil vulnerability to erosion | Provisional mapping of soils at high risk of erosion undertaken by the Environment Agency to inform the Water Framework Directive and used by NE to inform targeting of Environmental Stewardship (CHECK) | Ecosystem services: Soil erosion control. |

## Other types of data

| | | |
|---|---|---|
| FC harvesting and marketing data | Projected volumes and types of timber to be harvested from the FC forestry estate. Recorded by FC Districts and held nationally. Updated annually. | Ecosystem services: Sustainable provision of natural building materials |
| Annual Business Inquiry | Numbers of VAT registered businesses in each Super Output Area categorised by business type (Standard Industry Classification). Held by NOMIS on behalf of BERR. Updated annually. | Ecosystem services: Sustainable freshwater aquaculture |

| | | |
|---|---|---|
| Soilscape | National datasets recording the boundaries and characteristics of soil types held by the National Soils Research Institute at Cranfield University. Rolling programme of field survey updates key characteristics of soils. | Ecosystem services: Carbon storage and sequestration |

# Conclusion on key datasets

These lists show that a wide variety of datasets will be needed to measure the majority of services. Priority sources of evidence that will provide information for a number of services are:

- **Land Cover Map 2007**. The land cover data, at a fine resolution, that will be available from CEH during 2010, will be invaluable both for assessing landscape character and for many of the regulating services. Services where it will provide information on *potential* delivery will require further data, either on the outputs of service delivery (e.g. water quality), or contextual information about the management or condition of land cover to give an assessment of service delivery. Comparison with previous versions of Land Cover Map will give useful trend data.
- **Defra's June Agricultural Survey**. This provides data both on areas of agricultural crops and numbers of livestock (mapped to the point location of farm holdings not bounded areas of land). These data will be useful for several of the provisioning and many of the regulating services where agricultural land use or management is involved in service delivery. Annual trend data is available, although sampling error means that reliable comparisons will only be available at larger sampling areas (probably at NCA level).
- **National Forest Inventory.** This will be released by the Forestry Commission during the summer of 2010. It will provide more detailed and accurate land cover data on woodland than that available from Land Cover Map 2007. It will update the National Inventory of Woodland and Trees (2001) and should provide compatible data but at a finer spatial resolution (to blocks of woodland 0.25 ha in size rather than 2 ha). This change in scale is a major breakthrough as much of England's landscape is characterised by small woodlands under 2ha in size. This spatial data will provide evidence of the *potential* for delivery of services by different types of woodland. Technical reports will be produced in future based on field sampling that should give information about woodland management and condition.
- **Countryside Survey 2007.** A wealth of technical reports is being produced by the Centre for Ecology and Hydrology (CEH) on a range of topics such as species changes in key habitats and soil condition. These are based on sampled data which will not allow patterns between NCAs to be distinguished. But regional level data and trend information will be useful in providing context to land cover data for many of the regulating services.

# Summary of data interpretation issues and gaps that need to be resolved

This section draws conclusions on those ecosystem services that will be more problematic for CQuEL to report on. Given that relatively few of the services can be measured directly and reliably using existing data sources, data that measures the extent and/or condition of the natural assets must be used for most services. Because of the functional gap that exists between the assessment of natural assets and the delivery of services (as illustrated by the 'cascade' in Figure 1), there remain a number of important issues that remain to be resolved before existing data measuring these assets can confidently be used by CQuEL.

## Resolving issues for groups of services

### Defining and measuring standards of sustainable production

For all of the provisioning services (with the exception of the sustainable provision of stored water, provision of river water, conservation of wild genetic resources and conservation of domesticated genetic resources), the requirement that the services should measure only production that is environmentally sustainable means that ways need to be found of defining production systems that meet this criterion.

A judgement is needed about the level of negative impacts arising from the production system which are unacceptable. At a basic level, all production that meets legal requirements could be deemed acceptable. At a more enhanced level, the outputs of production systems that have higher environmental standards might be considered more appropriate. A variety of environmental assurance schemes exist that set down the requirements of these enhanced environmental standards. In general, data about the outputs or spatial extent of these schemes are difficult to obtain, even at a national level, the exception being organic production which could be measured through the area receiving payments under the Rural Development Programme. While data on the uptake of Environmental Stewardship provides a good measure of farmland managed to environmental standards, there is no reliable way in which the outputs (e.g. food or energy) produced by this land can be assessed.

Further evidence could be sought on the production outputs, or areas under production, from accredited quality assurance schemes (such as the Red Tractor, organic and Forestry Standards Council schemes). Of these, data on land under organic certification could be measured from the areas receiving payments from the Organic tiers of Environmental Stewardship. Data on other schemes would be more difficult to obtain.

### Estimating NCA level values from national or regional data

For many of the provisioning services, including food, building materials and energy, there are national and/or regional level data measuring or estimating the delivery of the service but resolving the national data to the finer spatial scale of NCAs is more difficult because of the complexities of supply chains. In these cases, data are available on the extent of the assets supplying the services (such as the area of crops or numbers of livestock) which provide a good indication of potential

service delivery, but these will need to be tempered by other data or expert judgement to enable assessments to be made of actual service delivery.

## Distinguishing between potential and actual service delivery

For several of the provisioning services (Harvesting of wild foods, Sustainable provision of natural building materials, and Energy from biomass and animal wastes) and some of the regulating services (for instance flood generation control), data on the distribution of natural assets can be used to measure the areas that could ***potentially*** provide the services, but no reliable sources of information are available on actual service delivery. For these services, it is suggested that expert judgements could be obtained (perhaps at a regional level and applied to the areas of assets in each NCA) to estimate the levels of service delivery (possibly covering both potential and estimated actual delivery).

## Interpreting measures of environmental quality – understanding the role of other factors

For many of the regulating services, there are well established monitoring programmes reporting on aspects of environmental quality or risk. But it is important to understand that these measures do not necessarily provide a reliable way of assessing how well the services to which they relate are being delivered.

Measurements of water and air quality record the overall condition of these natural resources which are a result of the sources of pollution as well as the purifying influence of ecosystems (the latter being the service that should be assessed). An indication of poor water or air quality for a given area does not necessarily mean that there are low levels of water and air purification taking place if there are significant sources of pollution. A related, but somewhat different, issue affects the way that the service of flood generation control can be linked to the data on flood risk and the service of soil erosion control can be linked to the data on soil erosion risk – where these data cannot on their own be used to say if the service is being positively delivered. In these cases, existing indicators of environmental quality provide a measure of the *potential* for service delivery, but not a reliable way of showing where the service is currently being delivered by ecosystems. This issue may seem an issue of fine detail, but it will be important if the elements of landscape character assessed by CQuEL are to be linked to the delivery of these regulating services.

## Interpreting measures of environmental quality – understanding the role of other factors

The natural processes by which some regulating services are delivered are currently not understood sufficiently to allow confident assessments of the level of service delivery. For example, the extent to which ecosystems can reduce flood events, recharge aquifers or ameliorate local climates, relative to the overall challenge of climate events or human influence, is not well understood (or research to date has not demonstrated a consistent or significant link). Significant advances are taking place in the area of climate science and the role of ecosystems in regulating the climate. This means that, while there is currently relatively little spatial data available to measure the services of reduction in greenhouse gas emissions and of carbon sequestration, this situation is likely to improve rapidly in coming years, and it is possible that analysis for CQuEL,

using current principles, could be used to make a first of estimate service delivery from land cover data.

## The benefits and limitations of Environmental Stewardship uptake data

Previous research for Defra[5] has shown that, while the uptake of different land management options under Environmental Stewardship potentially provides a good indicator of the delivery of many of the regulating services (and also some of the provisioning and cultural services), important limitations to this data must be taken into account. **Appendix 4** shows a table from this previous research that makes a first attempt to show how different ELS and HLS options may potentially deliver different ecosystem services. These limitations can be summarised as follows.

a) The data on uptake of Environmental Stewardship options is likely to provide only partial coverage of the extent of positive management, partly because of the way the uptake data is recorded (while some 66% of agricultural land in England is under Environmental Stewardship agreement, the spatial data on individual options analysed in the research covered less than 12%) and partly because it can be expected that positive management is taking place outside the scheme.

b) While services such as regulation of water quality and soil erosion are included as objectives of Environmental Stewardship, others are not and more work needs to be done (and is being commissioned by Defra) to identify the service benefits arising from different options; and

c) For many services (such as flood propagation control and filtering of aerial particulates) the precise field-scale location of options will be critical in determining whether options deliver positive benefits.

To take account of these issues **it is recommended that CQuEL keeps up to date with all work that is assessing the delivery of ecosystem services through Environmental Stewardship.**

# Issues for specific services

The final section summarises limitations in the way that the delivery of individual services can be measured using existing sources of information.

## The harvesting of wild foods

The harvesting of wild foods covers a broad spectrum of activities for which no single source of data on the provision of the service is available. A large number of semi-natural habitats are capable of providing wild food. These habitats will need to be more precisely identified before an attempt could be made to collect data on the extent to which they contribute to the service provision. Once this is done, it would be relatively simple to measure the area of the selected habitats in each NCA. However, it is questionable whether a measure of wild food harvesting is currently central to the needs of CQuEL.

[5] LUC et al. (2009). Provision of ecosystem services through the Environmental Stewardship scheme (Defra research contract NR0121).

## Conservation of domesticated genetic resources

The diversity of rare breeds and plant collections and the lack of compendia of spatial data present problems for the measurement of this service. The herd and flock books of rare breed societies and the list of national collections of plants provide a starting point but until these were explored more fully it is not clear that they would provide sufficient information on which to base a robust judgement of the delivery of this service in each NCA. A proxy measure (which is likely to significantly underestimate the full situation) can be provided by the uptake of traditional breed and restoration of traditional orchard options) within Environmental Stewardship.

## Reduction in green house gas emissions

Although land cover data from Land Cover Map 2007 and information on agricultural land use from the June Agricultural Survey provide a good starting point for assessment of this service, it is detailed land and livestock management practices (such as types of soil cultivation, levels of fertiliser application, the specifications of livestock housing and their diets) that determine the extent to which green house gas emissions are being regulated (and also the amount of carbon being sequestered). Carbon footprinting tools, such as the Carbon Accounting for Land Managers (CALM) package are being used by growing numbers of land managers but the results of these will not be available to CQuEL.

An alternative, but much less rigorous approach would be to make assumptions about the green house gas emissions from different forms of land use (measured by Land Cover Map 2007) and numbers of livestock (from the June Agricultural Survey). Research such as the Carbon Survey Baseline Project[6] could be used to estimate the overall levels of green house gas emissions from agricultural land use in each NCA. But this is not strictly a measure of the delivery of this service.

## Carbon storage and sequestration

Information is available to allow reasonable estimates of the organic carbon held in soils (NSRI Soilscape data) and vegetation (National Forest Inventory). However, there is currently no reliable data on the levels of active carbon sequestration taking place in either soils (although for blanket bogs designated as SSSIs, the condition of the SSSI could be used as a proxy indicator of bogs in a healthy condition) or vegetation (with the age of the woodland and its management) being determining factors).

## Filtering of aerial particulates

The ability of ecosystems to improve air quality by filtering aerial particulates depends on the precise location of suitable habitats such as woodland and large hedgerows in relation to sources of poor air quality such as from roads and mineral workings. Spatial models could be developed linking the distribution of habitats recorded by Land Cover Map 2007 to sources of emissions (based on buffer zone distances from urban areas, major transport routes, industry, mineral workings etc).

[6] Natural England (2008). Carbon Survey Baseline Project NE Research contract FST20-63-025

## Biological control of pests and diseases

Although there is guidance available from organisations such as the Game Conservancy, Farming and Wildlife Advisory Group (FWAG) and Linking Environment and Farming (LEAF) on the creation and maintenance of habitats (such as rough grassland banks) that harbour beneficial insects capable of controlling crop pests and diseases, there is no source of data on the spatial distribution of these habitats. The uptake of appropriate options in Environmental Stewardship (such as buffer strips, conservation headlands and beetle banks) gives an indication of positive management of habitats that harbour beneficial insects in arable farming situations. But this provides only a partial picture of overall contribution to this service.

# Services for which issues of data interpretation are more problematic

It was noted earlier (p 33) that there are two services for which there is unlikely to be sufficient knowledge to interpret the data on the role of natural assets in delivering the services. These are flood generation control and river and coastal flood propagation control.

## Flood generation control

As noted earlier, land cover data from Land Cover Map 2007, and environmental management data from schemes (Environmental Stewardship and English Woodland Grant Scheme) will identify the habitats and forms of management that can potentially contribute to this service, but their field-scale location will be critical to understanding where this potential is being translated into actual service delivery. This is not something that can easily be automated at the level of NCAs and without this essential step, it will be impossible to give a reliable assessment of the delivery of this service.

## River and coastal flood propagation control

The same issues apply as for flood generation control. There is also the additional issue of the extent to which the flooding of a particular area is regarded as a desirable ecosystem service (for instance providing space for flood water, relieving pressure on other areas downstream) or is an environmental hazard (threatening the flooding of important economic or environmental assets). These are judgements that can, at the moment, only be made on the basis of site-by-site assessments.