



**JNCC Report  
No: 583**

**Realising Nature's Value: Living With Environmental Change (LWEC) Ecosystem Task  
Force (ETF)**

**Monitoring for Biodiversity, Natural Capital and Ecosystem Services:  
Development of a Monitoring Action Plan**

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## Summary

This document was produced for the Living with Environmental Change (LWEC) Ecosystem Task Force (ETF) and is a 'Monitoring Action Plan' (MAP) for Biodiversity, Natural Capital and Ecosystem Service. The MAP provides a review of current data requirements from three user groups (national agencies, local authorities and businesses), illustrates how existing data supply may meet these demands, and provides recommendations on actions to take to improve accessibility, discoverability and utilisation of monitoring data.

The opening section provides the context in which the MAP has been developed, its objectives, and presents the conceptual framework which underpins the MAP. Section two gives an account of current application of monitoring at different scales, current data user requirements, and general aspirations as to where users would like to progress towards in terms of monitoring capabilities in the medium-to-long term. Section three presents some generic questions that have been formulated by synthesising the information about user requirement to provide an indication of the types of challenges and questions that data is being applied to. Section four provides an overview of current data supplies and attempts to demonstrate where current supply can meet demands. Section five sets out seven key recommendations that have been identified as potential priority actions to help meet the MAP stated objectives.

The recommendations section provides suggested actions on how to meet different users monitoring requirements. These have been formulated by considering requirements that have been stipulated by the three focal user groups and prioritised according to the following criteria: presents a practically achievable 'quick win'; has a UK focus; makes better use of existing data, knowledge and tools; and represents a step towards key changes in unlocking capabilities in all sectors.

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# 1. Introduction

## 1.1 The LWEC Challenge and the Monitoring Action Plan Aims and Objectives

This “Monitoring Action Plan” forms part of LWEC’s Ecosystem Task Force (ETF) “Roadmap for Realising the Value of Nature” (2014), the aim of which is to make evidence, knowledge and tools, including those created by LWEC, available to practitioners and other stakeholders in forms that readily support everyday decision making for managing natural resources sustainably.

A key part of the Roadmap is the production of a Monitoring Action Plan (MAP) which aims to improve the supply of reliable and useful data to support the application of the Ecosystem Approach in decision making. (“Monitoring” is usually defined as repeated observations over time. This plan also includes one-off or irregularly repeated surveys that provide baseline measures of the “state” of ecosystems.) The MAP covers the evidence needed to assess ecosystems; including their state, changes in state, the drivers of ecosystem change, the benefits flowing from them and, very briefly, the ways in which benefits are valued. The MAP will identify key monitoring data for natural capital, ecosystems, ecosystem services and biodiversity to advise on their maintenance and development and how to improve their accessibility. It is particularly relevant to the development of integrated data, mapping and modelling platforms. The scope of the MAP covers terrestrial and freshwater ecosystems, but not marine.

The main outputs of the initial phase of the MAP will be a set of recommendations and actions, based upon immediate needs and future aspirations of data users. These outputs will guide actions that aim to make the range of existing monitoring data more accessible to potential users; both in terms of data discovery and providing clarity on potential application to help support decision making necessary for implementing the Ecosystem Approach within the UK.

The MAP will:

- reflect business and strategic policy demands;
- take into account scale issues (local solutions and transferability of information);
- include biodiversity, physical, economic and social data;
- clearly articulate the status of data availability, quality and access; and
- engage potential business and other users in co-design and delivery.

The MAP has made good inroads at engaging with a select number Local Authorities and other local data users (see Section 2.3) and reflecting some of the policy demands from Country Agencies, UK Government and Devolved Administrations (see Section 2.2). The MAP reflects the data demands from a select number of businesses sectors, who have been engaged via a separate contracted research project led by JNCC (see Section 2.4).

Whilst the MAP provides a general indication of the type of data demands and aspirations that exist within these three user groups, the information contained herein should not be considered to be exhaustive. Data demand information has been gathered through a limited number of stakeholder meetings and has been drawn from recent related work being undertaken by colleagues (e.g. JNCC’s consultation on future requirements for UK Surveillance and Monitoring’ and CEH’s work on the NCC’s review of monitoring data for reporting on natural capital).

This first phase of MAP delivers an initial set of recommendations and proposed actions in order to seek opinion from the ETF, data users and data providers to prioritise next steps to progress work in this area, whilst recognising potential links with Natural Capital Committee's review of monitoring data requirements for natural capital.

## **1.2 The Ecosystem Approach**

The Ecosystem Approach is a framework that integrates the management of land, water and living resources and aims to reach a balance between three objectives: conservation of biodiversity; its sustainable use; and equitable sharing of benefits arising from the use of natural resources. It is the main implementation framework of the Convention on Biological Diversity (CBD) and can be adapted to suit various issues and situations at any scale. It enables an adaptive management approach to deal with the complex and dynamic nature of ecosystems.

Taken together, the 12 principles of the Ecosystem Approach (see Box 1) require a systematic approach to measuring, understanding and managing the environmental, economic, and social systems that affect the sustainable use of biodiversity. This places a heavy demand on data from monitoring systems (Box 1) which we can safely say at the outset of this report cannot be met at present. Currently the availability of data is patchy, far from comprehensive and, in most instances, difficult to use and access. The MAP will identify the generic 'demands' for data to answer questions or inform decisions related to the Ecosystem Approach and recommend steps to improve the availability of data to meet these 'demands'. Although this report is primarily about data from monitoring, the Ecosystem Approach also requires that these data should also be combined with all relevant knowledge; including expert opinion and local and traditional knowledge.

## Box 1. The Twelve Principles of the “Ecosystem Approach” and their Monitoring Implications

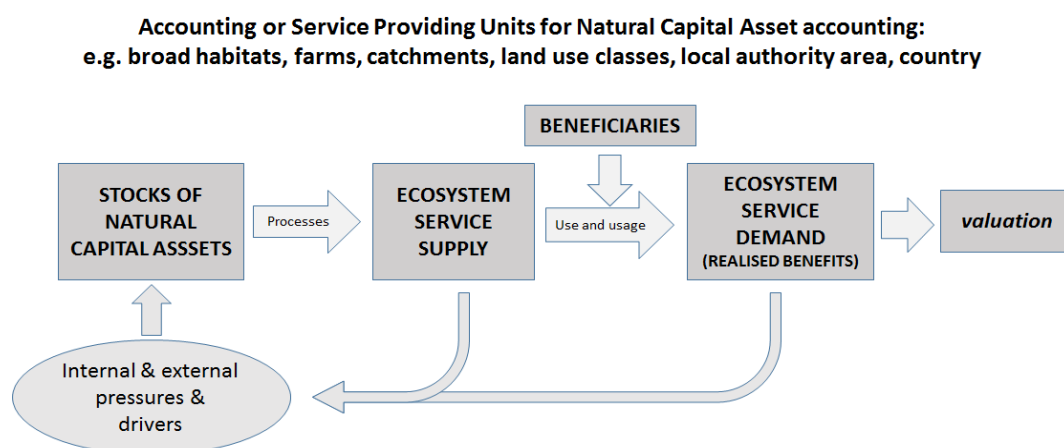
Principles of the Ecosystem approach	Implications for Monitoring
<p><b>Principle 1: <i>Recognise objectives as society’s choice.</i></b> Human rights, interests and cultural diversity must be taken into account and ecosystems should be equitably managed for their intrinsic, tangible and intangible benefits.</p>	Include key beneficiaries in assessing targets for natural capital and goods/benefits derived from it.
<p><b>Principle 2: <i>Aim for decentralised management (i.e. subsidiarity).</i></b> Management should involve all stakeholders, balance local interests and wider public interests, ensure management is close to the ecosystem, and encourage ownership and accountability.</p>	Ensure products from monitoring and assessments are available to all in forms that can guide personal, public and corporate decision making.
<p><b>Principle 3: <i>Consider the extended impacts, or externalities.</i></b> Managers should take into account and analyse effects (actual or potential) that activities have on other ecosystems.</p>	Adopt a systems approach and measure trade-offs between ecosystem services over time.
<p><b>Principle 4: <i>Understand the economic context and aim to reduce market distortion.</i></b> Market distortions that adversely affect biodiversity must be avoided. Incentives should support conservation and sustainable use and costs and benefits ought to be internalised within the focal ecosystem.</p>	Monitoring activities need to deliver data in a form that enables practitioners to use it in valuation tools and perform natural capital asset checks.
<p><b>Principle 5: <i>Prioritise ecosystem services.</i></b> Ecosystem functions and structures that supply services must be conserved.</p>	Measure stock and change of natural capital components and relationships to services.
<p><b>Principle 6: <i>Recognise and respect ecosystem limits.</i></b> Management strategies must consider environmental conditions that limit productivity, ecosystem structure, functioning and diversity.</p>	Adopt a systems approach and measure ecosystem functions and sustainability over time.
<p><b>Principle 7: <i>Operate at an appropriate scale, spatially and temporally.</i></b> Cross-boundary connectivity should be promoted where necessary. Management options must consider the interaction and integration of genes, species and ecosystems.</p>	Adopt a multi-scale approach.
<p><b>Principle 8: <i>Manage for the long-term, considering lagged effects.</i></b> Characteristic temporal scales and lag-effects within ecosystems must be taken into consideration. Preference of favouring immediate benefits over future ones should be avoided.</p>	Adopt a systems approach that measures trade-offs between ecosystem services over time and measures time-lags between action and perceivable results.
<p><b>Principle 9: <i>Accept change as inherent and inevitable.</i></b> Adaptive management must recognise the dynamic and complex nature of ecosystem properties and anticipate change. Managers need to avoid decisions that limit future options and actions should consider long-term protracted global change.</p>	Record, monitor, analyse and evaluate effects of management and policy changes.
<p><b>Principle 10: <i>Balance use and preservation.</i></b> It is important to adopt a flexible management approach that takes conservation and use into context and apply a continuum of measures from fully protected to sustainably managed ecosystems.</p>	Measure the contribution of biodiversity in providing ecosystem services, goods and benefits. Monitoring should seek to ensure ‘tipping points’ are not exceeded
<p><b>Principle 11: <i>Bring all knowledge to bear.</i></b> Relevant information should be shared with all stakeholders. All assumptions should be made explicit and checked against available knowledge and stakeholder views.</p>	Draw upon and include expert, local and indigenous knowledge in monitoring and assessment activities.
<p><b>Principle 12: <i>Involve all relevant stakeholders.</i></b> To address management complexities decision making should draw upon necessary expertise and involve relevant stakeholders at all levels.</p>	Adopt a trans-disciplinary approach to monitoring by including key stakeholders in decisions on why, what, who and how to monitor.

### 1.2.1 Conceptual Frameworks for Assessing Data Requirements for the Ecosystem Approach

The Conceptual Framework (Figure 1) underpinning the MAP combines some of the features of that used by the Natural Capital Committee (Natural Capital Committee 2014) and the conceptual model for Scotland’s Natural Capital Asset Index, with its emphasis on natural capital assets (Scottish Natural Heritage 2015), and some features from the UK National Ecosystem Assessment (NEA) framework that represent feedback loops within a system (UKNEA 2014). Together these encapsulate most of the features required by the Ecosystem Approach. The key features of the MAP framework are that:

- **Natural assets** are the basis for reporting on the state of natural capital, its condition and trends. Assets include species, ecological communities, soils, sub-soils, minerals, land, freshwater, coasts, oceans and atmosphere (Maskell *et al* 2014).
- These natural assets function as a system to provide **potential ecosystem services**, which are classified as: **provisioning** (nutrition, materials, energy); **regulation and maintenance** (mediation of waste, toxins and other nuisances; mediation of mass, liquid, and gas flows; maintenance of physical, chemical, biological conditions); and **cultural** (physical, intellectual, spiritual and symbolic interaction with environmental settings) (European Environment Agency 2013).
- **Beneficiaries** use these services to realise **goods, products and benefits** (food, fibre, energy, drinking water, medicines, recreation, pollution control, disease and pest control, flood protection, equable climate, erosion control, spiritual and intellectual enrichment) (UKNEA 2012) and gain value (both monetary and non-monetary) from the service.
- The use of goods and services may affect **drivers of change**; these may be **direct drivers** influencing ecosystem processes or **indirect drivers** that operate diffusely by altering one or more direct drivers (Millennium Ecosystem Assessment 2005).
- **Drivers** may be **positive** (e.g. restoration or enhancement) or **negative** (e.g. degradation) and feedback on the natural capital assets. These feedbacks influence the **trade-offs** between services and the sustainability of the system under consideration.

**Figure 1.** Conceptual Framework for the Ecosystems Approach in the MAP.





The NCC has selected the UKNEA "Broad Habitat" classification system as the basis for determining relationships between land-use and benefits; such as quantity, quality and spatial configuration. In the MAP conceptual framework, 'broad habitats' are viewed as part of a larger set of linked accounting units that can be applied to meet different user requirements at varying scales.

### 1.2.2 General objectives

The MAP will provide a plan (*or roadmap*) outlining the delivery of the following:

- Outputs or actions that can be implemented quickly through current activities to facilitate best use of available data from existing monitoring activities to support decision making at the required scale(s):
  - a. a "demand-led" framework for meeting the data needs based on the types of decision makers, their scale of interest and the types of decisions they need to make to implement the Ecosystem Approach;
  - b. a high level summary and assessment of sources of key monitoring series for natural capital (including biodiversity), ecosystem services, societal benefits and their beneficiaries;
  - c. links to portals and directories of data covering:
    - i. Spatial and contextual data: environmental and socio-economic.
    - ii. Change over time: natural capital trend data, ecosystem service trend data, trends in drivers, (future scenarios are outside the scope of this work);
  - d. recommended classifications and typologies of natural capital, ecosystem services, benefits and beneficiaries, aimed at facilitating data discovery from monitoring schemes.
  - e. guidelines for discovering data sources needed to make best use of selected decision support tools (DSTs) or information systems (*No action to meet this objective has been taken due to resource constraints*).
- Recommendations (to the LWEC community, data users and data providers) on longer-term co-ordination activities that could be undertaken to:
  - f. maintain, develop and improve the accessibility to datasets;
  - g. provide consistent metadata descriptions to enable users to discover datasets relevant to their decision making task; and
  - h. modify or adapt current survey and monitoring programmes to deliver data in more cost-effective ways, including the use of new technologies and citizen science.
- An assessment of the main gaps in monitoring and data management and associated DSTs (see objective e.) that need to be filled through additional research and development.

### 1.3. Beneficiaries and targeted stakeholders

The final deliverables from the MAP and future outcomes in terms of improvements to data availability should be relevant to decision makers and practitioners who have an interest in realising nature's value and developing nature based solutions. The ultimate beneficiaries will be local and national decision makers who should get better access to data needed to inform their decisions. However, the initial target for the MAP is the LWEC community of data providers and data users, as these are the ones most likely to be able to undertake the

actions necessary to bring about any agreed changes in the way in which monitoring is undertaken and data are delivered to end users.

## 2. User requirements

This section provides an overview of requirements of three main stakeholder groups from their perspective as users of data and information. A general overview from a European perspective is provided, followed by a synoptic view of needs from the main stakeholder groups addressed. The focal stakeholder groups were agreed by the ETF in July 2014 and include:

- i. UK Government Agencies, Central Government and Devolved Administrations (covering England, Northern Ireland, Scotland and Wales).
- ii. Local Authorities (including land use planning departments, National Park Authorities, Local Nature Partnerships and related consultancies).
- iii. Businesses (agriculture, forestry, fisheries, electricity supply, wholesale and retail).

Feedback from these user groups were sought via a range of avenues including: telephone meetings, email exchange and a number of structured questionnaires that were conducted by AECOM as part of JNCC commissioned study investigating how UK businesses are incorporating nature's value in their operations (JNCC 2015). Information obtained from literature review, interviews and a webinar with experts working in the field of Integrated Reporting and natural capital accounting as part of during the production of the JNCC commissioned report 'Integrated Reporting and Natural Capital Accounting' also contributed to this report (JNCC 2016a).

Throughout the stakeholder engagement process it became apparent that there was a distinct separation between existing data needs and perceived needs to meet future aspirations. The MAP defines two different classifications of 'needs' in the following sections and aims to provide a separate set of recommendations and potential actions meet them.

### 2.1. European Context

Action 5 of the EU 2020 Biodiversity Strategy requires Member States (MS) to map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems by 2020. The Working Group on Mapping and Assessment of Ecosystems and their Services was set up to provide guidance for Member States on how to do this (MAES 2014).

The emphasis of the European approach to date has been on mapping the current state of ecosystems and the services they provide and on making use of the best available information in ways that can be implemented across all Member States (see "Mapping of Ecosystems and their Services in the EU and its Member States" (MESEU 2013). The MESEU report concludes that approaches to mapping ecosystem services across Europe do not give comparable end products and recommends that "*minimum standards for data collection could be proposed at European level based on a feasibility assessment*" and that "*there is a need to improve monitoring systems in order to improve the components of biodiversity with high capability to supply ecosystem services*". The report also recognises that relying on biodiversity alone provides a narrow view of ecosystem services and integrated environmental monitoring would be a preferred option.

## **2.2 UK and country level decision making requirements**

The information presented in this section summarises existing information needs for practitioners applying the natural capital and ecosystem service concepts in response to policy drivers at the UK and individual country level.

This Section draws upon information that has been provided by colleagues at the Country Agencies, devolved administrations and other key stakeholders who provided information via engagement events facilitated by JNCC as part of their UK coordination obligations.

### **2.2.1 UK National Ecosystem Assessment and Follow-on**

The UKNEA Follow-on Phase (2014) calls for more evidence to demonstrate how effective management of natural capital can deliver multiple benefits for the environment, society and economy. Evidence should enable decision makers to make better informed decisions taking into account trade-offs between different ecosystem services.

Data and knowledge need to be accessible and robust and be fit-for-purpose in providing an accurate picture on the state of the UK's natural capital assets, ecosystem functioning and how ecosystem service delivery responds to changes in environmental pressures. This knowledge should support and encourage agencies, researchers and practitioners to adopt a joined-up collaborative approach to monitoring and assessment activities.

Future research priorities that monitoring activities should aim to contribute towards include:

- i. Quantifying functional relationships between ecosystem service delivery and natural capital asset condition and improve understanding of ecosystem thresholds.
- ii. Assist in developing a greater understanding of the capacity for different degraded natural capital assets to recover to inform management and restore productivity.
- iii. Inform horizon scanning and deliver knowledge for developing adaptive management strategies.
- iv. Information gathered from land-use monitoring should be better integrated with biogeochemical information to improve understanding of ecological impacts and the implications for ecosystem services.

### **2.2.2 Natural Capital Accounts**

The UK Government has already pledged to develop full UK Environmental Accounts by 2020. This work is being led by the Office for National Statistics (ONS) and DEFRA and is supported by the Natural Capital Committee. The incorporation of natural capital into the UK's national accounts will enable a high level picture to be obtained of trends in the state of the nation's natural assets through time. This in turn will help demonstrate the implications of actions impacting on the natural environment and allow the UK to fulfil its commitments under the 2020 Aichi Biodiversity Targets, specifically Target 2 and 4 (Convention on Biological Diversity 2010).

The Natural Capital Accounts within the UK's 2016 Environmental Accounts (Office for National Statistics 2016) describe the changes in stocks and values of natural capital, highlighting how economic activity and environmental pressures are interlinked and informing investment and management decisions for natural capital. They currently include: oil and gas reserves and resources; carbon stocks, monetary value of hydropower, standing timber resources, air pollution absorption and woodland ecosystem asset and services. Data supply for National natural capital accounting is discussed in greater depth in Section 4.2 of this report.

### 2.2.3 Current Application of Monitoring and Surveillance Information at a National Level

Some of the current general applications of surveillance and monitoring data at a national level include:

- Ecosystem condition assessment to determine impact(s) of interventions (e.g. protected area management, agri-environment schemes).
- Impact assessments.
- Natural capital assessment and valuation.
- Meeting reporting obligations (e.g. EU Nature Directives, MSFD, WFD).
- Integration and planning of rural payment schemes.
- Wider countryside surveillance of drivers of environmental change.
- Understanding the dynamics of habitats in agricultural landscapes.
- Assessment of water quality and supply.
- Applications of land cover data and aerial imagery in managing water quality, flood prevention and flood risk.
- Assessing soil carbon levels through strategic sampling.
- Improving knowledge of peat distribution and depth to inform Peatland restoration and carbon accounting.
- Assessing widespread habitats and species indicative of ecosystem condition, structure, and function.
- Monitoring non-native species occurrence and spread.

#### England

England is seeking to effectively interpret change in components of biodiversity, identify drivers of change, and assess resulting impacts on the provision of ecosystem services, and identify key components of biologically diverse communities that support ecosystem services. In addition, there is a recognised need to monitor and evaluate the effectiveness of biodiversity policy and delivery measures.

There is a requirement to report the status and trends in components of biodiversity at national levels and provide a robust evidence base on status and trends in biodiversity as necessary for European and domestic reporting obligations. Data about biodiversity is required to support local delivery and decision making which necessitates better access to data on habitat and species for local decision makers, such as Local Government and Local Nature Partnerships.

Monitoring in England is undertaken by core Defra and at least nine of the 35 organisations within the Defra network. Whilst good examples of collaboration across the network exist, the planning and delivery of monitoring is often fragmented with requirements being generated at a Directorate or organisational level. This fragmentation is seen to lead to duplication at an activity and site based level across the network, variation in approach, and missed opportunities to deliver greater value from investment in monitoring

Defra are developing a new approach to facilitate better coordination across the network (Defra 2014). The first phase started in summer 2015 and involved reviewing monitoring programmes by five themes: air; land; water; marine; and animal and plant health, and managing them more collaboratively across the network. The second phase will build on this collaboration and is planned to begin in summer 2016. One organisation within the network will lead each particular theme and work with other network organisations to agree what activities should be carried out. Other network organisations may carry out monitoring work under the same theme but the lead organisation will take the recommendations from

others and co-ordinate work in line with an overall network-wide monitoring strategy and Network Evidence Action Plans.

Proposals for Centres of Excellence will also be developed for areas of specialist monitoring; such as remote sensing (e.g. Use of satellite data or aerial imagery) and detection and analysis (e.g. DNA sequencing, laboratory analysis). More needs to be done to detail how this will work in practice. The Monitoring work stream is closely linked with a number of other work streams.

Following their assessment of the potential for mapping ecosystem services in England based on existing habitats (Natural England 2014), Natural England in collaboration with the Centre of Ecology and Hydrology have produced a suite of 10 publically available maps of terrestrial natural capital in England (Natural England 2016). The 1km resolution maps were produced using CEH's Ecomaps statistical model and each show a different aspect of natural capital, e.g. soil carbon, nectar plant richness for bees or headwater stream quality. They can be viewed and downloaded as images or GIS compatible data and are each accompanied by a brief report.

Natural England's Review of Natural Capital Indicators will assess the suitability of indicators for measuring change in natural capital, against a number of criteria, based on a literature review of potential indicators. It will help develop robust and representative metrics and indicators to improve assessment and reporting of changes in natural capital assets.

## **Northern Ireland**

Centre for Environmental Data and Recording (CEDaR) is the Local Records Centre for Northern Ireland, and facilitates the collection, collation, management and dissemination of biodiversity and geodiversity information.

Northern Ireland Biodiversity Strategy calls for: compilation of existing data into accessible baseline and trend information; targeted fieldwork to obtain data not currently available; and mapping seabed topography, marine habitats and documenting marine species (DOENI 2015). The outcome of this work has formed a key element in the CEDaR 10 year programme that ran up to 2012.

The Department of Agriculture, Environment and Rural Affairs is required to monitor environmental effects brought about through implementation of the Northern Ireland Rural Development Programme 2014 – 2020. The Strategic Environmental Assessment commissioned in 2013 assessed the usefulness of the common context indicators as a means of monitoring key issues currently affecting Northern Ireland's environment (Davies & Image 2015). The report identifies: existing baseline issues; relevant common context indicators; appropriate measurement units; and highlights how indicators can assess impact of mitigation and/or enhancement measures and assist in identifying issues causing adverse environmental impacts. Suggested monitoring parameters include: ecology and nature conservation, health and quality of life, soil and land use, water, air, climate, material assets, cultural heritage, landscape, green infrastructure and ecosystem services.

## **Scotland**

Scotland are developing a new biodiversity indicator framework, setting out the metrics required for informed decision taking, reporting and monitoring up to 2020. This is will be achieved through making more effective use of existing data, results, expertise and resources.

Bringing information together, keeping it up-to-date and making it accessible for use across sectors, policies and purposes, has been made possible through Scotland's Environment Web (SEWeb). The results of indicator monitoring are available for use in combination with other environmental data across the full spectrum of policy purpose; at a local, catchment and national scale. This improved access to existing information will provide a sharper focus on genuine knowledge gaps.

SEWeb lists numerous initiatives reflecting and fostering volunteer based monitoring and provides advice on how people can engage with wildlife monitoring. A key function of SEWeb is to ensure data is collected consistently, notably through the National Biodiversity Network (NBN) and the Marine Environmental Data and Information Network (MEDIN).

Cross-sectoral approaches to information gathering and cooperative working are being promoted through the Coordinated Agenda for Marine, Environment and Rural Affairs Science (CAMERAS) Environmental Monitoring Coordination Group.

The Scottish Biodiversity Information Forum has been established to guide discussions between those involved in data collection and data users. Scotland recognises that access to reliable, quality-assured information about the country's environment, and how it is changing, is crucial to inform decision-making by government as well as public bodies, businesses and others.

Scotland is working to publish a land habitats map, which is based upon the EUNIS-Annex 1 classification. This map (to be completed in 2019) will be used to support surveillance and monitoring and is expected to become an essential tool in making decisions on planning, policy and land management issues.

Scotland's Natural Capital Asset Index (NCAI) was developed by SNH in 2010 and aims to:

- Provide a robust and consistent framework for measuring and monitoring changes in Scotland's natural capital (in line with proposals contained in the NCC's third report (NCC 2015)).
- Provide a tool that can be easily adapted and applied to specific habitats, at diverse spatial scales and in different countries beyond Scotland.

The James Hutton Institute carried out a systematic evaluation of the NCAI, and recommended a number of refinements to its method; the revised NCAI was released in 2015 (SNH 2014). The Index now uses European Nature Information Systems (EUNIS) land cover classification and includes the following habitats: coastal; inland surface waters; raised and blanket bogs; grasslands; heathland; woodland and forest; un-vegetated or sparsely vegetated; cultivated agricultural; montane; and artificial habitats.

As in other countries, there have so far been few attempts to link or re-design monitoring programmes to fit natural capital or ecosystem services requirements; the establishment Scottish Environmental Monitoring Programme is seen as the opportunity to achieve this (Scottish Government 2011).

Ecosystem Health Indicators for Scotland are also under development. These spatial indicators of ecosystem health will operate at both a national and regional level and represent a shift towards tackling biodiversity at a species or habitat level, towards focussing on the drivers of loss and adopting an Ecosystem Approach (Scottish Natural Heritage 2013).

Ecosystem Health Indicators will measure of the status of ecosystems through three inter-related elements:

- Condition of components - ascertaining how far they are from a 'good' state.
- Function – the extent to which ecosystems retain their natural function and therefore have the capacity to deliver a range of benefits.
- Sustainability and resilience – the extent to which ecosystems are resilient and their capacity to deliver benefits can be sustained under different pressures.

## **Wales**

Natural Resource Management Trials are underway in the Rhondda, Dyfi, and Tawe catchments. Trials are designed to provide an understanding of how natural resource management issues interact within catchments; how issues affect local benefits and future natural resource use; how best to involve local stakeholders in making decisions through sharing evidence; and how to prioritise action.

The GLASTIR Monitoring and Evaluation Project (GMEP) conduct a rolling annual survey across Wales using an ecosystem approach (Welsh Government 2014). Measurements include: a range of soil and water quality metrics; landscape features; plant and freshwater diversity; condition assessment of historic features; and two pollinator and four bird surveys. These parameters are then mapped to GLASTIR intervention measures to evaluate effectiveness. Work looking at past data on impacts of agri-environment schemes and on-going trends is central to GMEP data and evidence activities.

Building on GMEP, Welsh Government is developing a proposal to bring together the various existing Welsh monitoring strategies to create a single, integrated monitoring programme. Options for the future programme are currently being assessed but it will cover the needs of national and international legislation.

Under the Environment (Wales) Act 2016, NRW is producing the first state of natural resources report (SoNaRR) to consider the pressures on ecosystems and natural resources in Wales and how they are managed. It will assess four key elements: the use and rate of use of natural resources; resilience of ecosystems; the well-being of current and future generations; and the relationships and causal links between them. In gaining a better understanding the drivers of impacts, and the consequences that may have for well-being, SoNaRR will help better plan for the future.

Examples of wider data and evidence utilisation within Wales include historic data held by the Biological Record Centre, British Trust for Ornithology avifauna records and Centre for Ecology and Hydrology's Countryside Survey. Wales recognises that the utilisation of wider evidence and data enhances the power of evaluation and provides a long-term historic backdrop within which to gauge current activities.

Computer modelling of GLASTIR outcomes is a key decision making tool and is being used in a quantitative assessment of the schemes impacts. Field surveys sit at the heart of the GMEP programme and provide the main evidence base for ongoing change in the countryside, against which the impact of interventions is evaluated.

Citizen Observatory Web (COBWEB) is a project designed to empower everyday people with the ability to collect environmental information using mobile devices (COBWEB Citizen Observatory Web 2016). It aims to develop an "observatory framework" which is designed to enhance the suitability of crowd sourced environmental data for use in research, decision

making and policy formation. COBWEB is built around UNESCO's World Network of Biosphere Reserves, with tests initially concentrated on the Welsh Dyfi Biosphere Reserve.

#### **2.2.4 Direct Data Requirements: Current Practices and Future Needs at a National Level**

- In order to effectively monitor change in natural capital and ecosystem services practitioners require data that improves their ability to begin ascertaining accurate baselines.
- There is a need to determine which data are suitable for use as proxies for monitoring and assessing natural capital and ecosystem services, as well as providing clear guidance on risks and uncertainty associated when applying proxies to inform decision making.
- There is a need to identify datasets that can be used as appropriate Natural Capital indicators; such as those used in Scotland's Natural Capital Asset Check and those identified in the Natural Capital Committees review of monitoring data for natural capital.
- The scope and quality of indicators currently used to report progress on Biodiversity 2020 need to be improved so that they are more robust and provide a representative assessment of biodiversity and natural capital change.
- Data are needed to assess the condition of protected sites; the effectiveness of agri-environment and woodland grant schemes; and the extent and condition of priority habitat on sites that are covered by these schemes.
- A better understanding is required of what information is available to monitor and assess natural capital stocks preserved in, and services delivered by, UK Protected Areas.
- Improvements are needed in the monitoring and surveillance of Species of Community Interest and species listed in the Annexes of the Birds Directive, as well as those listed on the draft European Regulation on Invasive Non-Native Species.
- Improvements are needed in the assessments of the status and trends of species of principal importance under the NERC Act (2006) ('priority species'), particularly for those species at greatest risk of extinction.
- There is a need to be able to describe trends in pollinator populations and their status with greater confidence.
- A better understanding is required of how ecosystem service goods and benefit flows operate across administrative boundaries (e.g. between countries, between administrative districts).
- Development of a cost-efficient capability for effectively monitoring soil erosion rates in the UK is seen to be a potentially challenging data demand that will need to be met in the near future.
- It should be ensured that data and information can be readily used to develop modelled approaches to predict future ecosystem service provision in response to different scenarios (e.g. management regimes, drivers of environmental change).



- The coordination and quality control of structured sampling schemes undertaken by volunteers should be supported.

### **2.2.5 General Aspirations among Practitioners at National Level**

- Monitoring programmes should aim to deliver data in formats that enable easy and meaningful application in simple decision support tools. Additionally, clear links between data and tools should be developed to provide clarity on what data is suitable to use with specific tools.
- Monitoring activities should seek to define and monitor risks posed to ecosystems, ecosystem health and ecosystem resilience to shocks and stressors; as well as provide clear guidance on the suitability of data for use in monitoring these different parameters.
- There is a general aspiration to explore how citizen science and mobile data technologies can be more effectively used in monitoring programmes.
- Natural England ecosystem service pilots found lag-effects in ecosystem service provision (e.g. following interventions or being impacted by drivers of change) that added complexity to determining levels of change in ecosystem service provision. There is a general aspiration for monitoring activities to improve knowledge on lag-effects so as to take better account of them when monitoring and managing ecosystems.
- Advances in Earth Observation capabilities should be used to target monitoring effort on the ground.

### **2.2.6 Specific Aspirations at National Level**

- Monitoring activities should begin exploring the possibility of identifying 'functional units' that portray an accurate picture of ecosystem state, condition, drivers of change and the affect this has on goods and services. This will help in moving away from focusing on single assets and features, towards providing a clearer picture on how ecosystem components interact and deliver services to various beneficiaries at different scales.
- Changes in societal attitudes, perceptions and understanding towards natural capital and ecosystem service concepts should be monitored to assess societal acceptance of those concepts, the impacts of interventions, and drivers of behavioural change.
- Social deprivation and human health are increasingly being integrated into environmental policy and practice; monitoring strategies should consider collecting data that express the social and cultural services being provided by ecosystems.

### **2.2.7 Data Access at National Level**

- Existing datasets should link with ecosystem service classifications to enable practitioners to identify which data can be used to monitor and assess particular natural capital assets and ecosystem services. An example of this is demonstrated by the JNCC Ecosystem Service Spatial Framework (JNCC 2012, 2014).

- There is a general recognition for the need to develop a common approach to collecting, cataloguing and storing national and country level monitoring data to facilitate data amalgamation and integration across agencies. This could support the production of a UK-wide audit on the state and condition of ecosystems and natural capital.
- The analytical capability of monitoring data needs to be improved, as opposed to simply making data open access.
- It is seen by some to be potentially beneficial to move towards an open access analytical hub. There is some interest in creating a data delivery platform similar to the *Atlas of Living Australia* (Atlas of Living Australia 2010). This approach could reduce access controls, act as a 'front door' to information archives, and serve as a digital online records centre and is recognised as being able to provide a coherent tool that enables a wide range of users to interface with environmental data. This type of application could be further developed to include methods of statistical analysis that can be applied to specific data products to make data more contextually applicable. There may also be scope to develop analytical tools that enable users to run replicable models to monitor change.
- A greater flow of data is needed from research, academic and commercial sectors into the NBN Gateway data infrastructure.
- England specifically want to secure ongoing access to species data to support priority objectives by further rationalising the collective National Biodiversity Network (NBN) data infrastructure, built around the NBN Gateway, so that it provides the primary means for standardising and sharing data. In addition, there is a desire to improve the visibility and access to species data available through the wider NBN, ensuring that any data collected using public money are free and openly available.

## **2.3 Local Authority and Local Scale Decision Making Requirements**

In order to begin understanding local user data requirements and the issues related to data access and use, Local Authorities, Local Nature Partnerships, National Park Authorities and NGOs administering projects at a local scale were contacted and posed questions regarding how their respective organisations are monitoring biodiversity and ecosystems services and integrating this information into strategic planning. Practitioners were also asked to identify limitations or barriers to implementation and how these have been overcome. The synthesis below summarises the responses received.

### **2.3.1 Current Application of Monitoring and Surveillance Information by Local Authorities**

Some examples of current local use of monitoring and surveillance data include:

- Informing sub-regional Green Infrastructure strategies.
- Mapping ecosystem service flows in urban landscapes.
- Identifying hotspots vulnerability and sensitivity to environmental change.
- Distinguishing areas of significant cultural importance.
- Using ecosystem mapping to identify opportunities such as: enhancing wetland flood management; ecological network development and conservation; improved

carbon sequestration management; creating public recreation spaces; improving drinking water quality.

Decision support tools employed at a local scale using national habitat and land cover data are often too coarse in scale to be used effectively in decision making and differences in resolution make it challenging to integrate national and local datasets. In general, mapping exercises attempt to produce normative models of habitat networks and then attempt to design management strategies around these models, which can sometimes fail in identifying needs and aspirations of local stakeholders.

### 2.3.2 Direct Data Requirements: Current practices and future needs at local level

- Habitat data are commonly used to inform spatial planning to avoid ecologically sensitive areas. Increasingly, local users want to gain a more comprehensive picture on how surveillance can better inform spatial planning, biodiversity offsetting and managed realignment interventions to improve the coherence of ecological networks across the wider landscape.
- Land Cover Map 2007 is currently being used by the Environment Agency to prioritise areas for potential ecological restoration management (CEH 2007).
- The Woodland Trust are using Bluesky's National Tree Mapping (Bluesky International Ltd. 2015) dataset to assess tree cover on individual farm holdings thereby ascertaining farm level benefits associated with tree cover to inform future tree planting. There is recognition that current mapping is insufficient and that data needs to be supplemented with sound local knowledge of economic drivers and systems which influence land management decisions.
- Ecosystem assessments are being carried out using broad habitat maps as the base; with these being supplemented with locally available economic, cultural and ecological datasets to define the spatial context of ecosystem service delivery. More work is required to ascertain what these local datasets consist of, how they are collected and who maintains them. In some instances these assessments are being combined with the Local Environment and Economic Development (LEED) Toolkit and other conservation planning software, such as Marxan®.
- To support the Ecosystem Approach for local plans some practitioners have been combining viewshed analysis; tranquillity mapping; settlement hierarchy<sup>1</sup>; integrated

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<sup>1</sup> **Viewshed** identifies the cells within a GIS raster layer that can be seen from one or more observation points or lines. Viewshed is useful when you want to know how visible objects might be from or to other locations in a landscape ([Environmental Systems Research Institute](#)).

**Tranquillity mapping** is the identification and mapping of relative tranquillity. These are areas where physical and experiential characteristics of the landscape provide countryside users with the space and conditions to relax, achieve mental balance and a sense of distance from stress and are characterised by a low density of people, minimal levels of artificial noise and a landscape that is perceived as relatively natural, with few signs of human influence (MacFarlane, R., Haggett, C., Fuller, D., Dunsford, H. & Carlisle, B. 2004. *Tranquillity Mapping: developing a robust methodology for planning support*. Available online at: [https://www.northumbria.ac.uk/static/5007/lifepdfs/appdf/Tranq\\_Main\\_Technical\\_Rep.pdf](https://www.northumbria.ac.uk/static/5007/lifepdfs/appdf/Tranq_Main_Technical_Rep.pdf).)

**Settlement hierarchy** is a way of categorising an area's settlements to recognise their different roles. A hierarchy groups settlements that have similar characteristics. At the top of the hierarchy are the larger settlements that fulfil the most functions, have the best infrastructure (facilities and services) and are most easy to get to by sustainable forms of travel. The smaller settlements, with least functions, infrastructure and transport links, are nearer the bottom of the hierarchy. This helps planners decide which settlements are most suitable to

landscape character assessments; water cycle studies; ecological network maps and ecosystem service maps.

- Local Nature Partnerships (LNP) have been using vegetation cover maps (e.g. *Axiophyte* species richness) as proxies for biodiversity richness and areas of high ecosystem service provision potential. Some practitioners express the view that the National Habitat Inventory holds too many errors to be considered reliable for use in ecosystem assessments.
- LIDAR Digital Surface Model is being used to model surface run-off and, combined with Land Cover Map, to identify areas where naturally occurring run-off mitigation is present and where interventions are required. Undertaking regular updates of surface models can provide a monitoring function for surface-runoff interventions.
- The British Trust for Ornithology is currently using volunteer networks to collect county-wide data for bat species distributions across Norfolk in order to analyse and monitor human impacts on the environment. The Norfolk Bat Survey Project has found that bat distributions provide a good proxy for human environmental disturbances. There is scope to begin looking at the suitability of using other species as proxies for environmental pressures.

### 2.3.3 General Aspirations amongst Practitioners at Local Level

- Monitoring and surveillance methods need to improve in capturing rates of change in ecosystems. This is likely to require datasets that represent key drivers of change that can be readily overlaid onto land cover or land use maps to identify areas of high concern, as well as monitoring effectiveness of existing interventions.
- Metadata or raw datasets would benefit from being linked to briefing notes that notify users on: methods used to collect the data; which parties collected the data; how often it is updated; limitations for use; and, levels of certainty. This would enable users to produce concise explanatory notes to accompany decision support products, ensuring maximum transparency and providing clarity on evidence quality.
- Information on future infrastructure development planning, socio-economic factors, human well-being indicators, and habitat and species data should be made available in a format that ensures they are simple to overlay onto digital terrain maps. This will enable users to better monitor and assess various trade-off scenarios, ascertain potential vulnerability to particular pressures and threats, and determine the effectiveness of any interventions in place.
- Local practitioners would like to see a move towards accessible and user orientated interactive online mapping platforms that utilise nationally available datasets that are easily updated or overlaid with supplementary local scale data. The aspiration is that these platforms will provide an evolving picture of ecosystem change across the landscape. Resulting outputs would need to be sufficiently scalable to inform decision making at a local level.

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accommodate additional development and growth. Guildford Borough Settlement Hierarchy (2014). Available online at: [http://www.guildford.gov.uk/media/16930/Guildford-borough-Settlement-hierarchy-May-2014/pdf/Settlement\\_hierarchy\\_May\\_2014.pdf](http://www.guildford.gov.uk/media/16930/Guildford-borough-Settlement-hierarchy-May-2014/pdf/Settlement_hierarchy_May_2014.pdf).

### 2.3.4 Specific Aspirations at Local Level

- Some practitioners are keen to see more linking of datasets to Natural Capital valuation tools.
- There is also recognition of the need for finer resolution data and imagery to improve analysis of nutrient enrichment pathways across the catchments to contribute to WFD monitoring.
- Modelled outputs could achieve greater impact with decision makers if it was possible to accompany the models with recent aerial imagery. Practitioners, on the whole, agreed that aerial imagery enabled non-technical stakeholders to place modelled outputs into a context with which they are familiar.

### 2.3.5 Data Access at Local Level

- One Local Nature Partnership described the problems they experienced in obtaining readily useable catchment level data. Issues arose because availability and scalability vary between counties across a catchment and mapping exercises at a local level typically rely on low resolution national data.
- Language and terminologies differ between data providers making data discovery complex and difficult for users to articulate data requirements to providers. Additionally, criteria for defining land classes can often vary between Local Authorities making amalgamation of datasets difficult. For example, a National Park Authority discovered that the definition of '*green space*' attributes varied greatly between local authorities (e.g. some authorities combined sports fields and parkland, where as other separated these classes), which meant that existing land cover data had to be manually checked and amalgamated under a common classification before use.
- National Park boundaries cover areas managed by multiple Local Authorities; some National Park Authorities find that spatial datasets vary significantly across authorities as there are currently no national data collection standards.

## 2.4 Business Decision Making Requirements

The direct risks that Natural Capital declines pose to business continuity is a key driver for action in many sectors, given the need to maintain or increase production in response to rising national and global demand (BBSRC 2015). Different industries rely upon a multitude of natural capital stocks and ecosystem services. To ensure businesses preserve these valuable assets, effective monitoring and surveillance of management interventions and the pressures and impacts exerted upon these natural assets is imperative.

Businesses are increasingly recognising dependencies on a wide variety of species and ecosystem services including soil micro-organisms, nutrient cycling, pollinators, pest predators, the genetic diversity of crops and livestock, freshwater supplies, and climate regulation (TEEB 2010; Natural Value Initiative 2008).

The information contained in Section 2.4 has been summarised from a recent study undertaken by AECOM and commissioned by JNCC which aims to identify motivations that are driving UK businesses to consider '*nature's value*' in their operations (JNCC 2015). It is important to note that this information is drawn from a small sub-set of UK industries (agriculture, forestry, fisheries, electricity supply, wholesale and retail) and may not be fully representative of UK industry as a whole.

### 2.4.1 Current Application of Monitoring and Surveillance Information by Business

- The Forestry Sector implements the Woodland Carbon Code, a voluntary standard for accounting for CO<sub>2</sub> sequestration. This requires data on: tree biomass (above and below ground); litter and deadwood; non-tree biomass (above and below ground); soil; and monitoring of activities that can cause 'leakage' of carbon stocks. In addition, there is a requirement to complete five year monitoring of stratified sample plots for tree stocking density (number and height of seedlings and saplings) and tree health, tree damage, weed growth and tree protection (e.g. shelters, fencing).
- Landholders and the agriculture sector are implementing Integrated Farm Management to comply with industry standards such as the LEAF (Linking Environment and Farming) Marque, an assurance system for sustainably farmed products. To obtain the LEAF Marque, agri-businesses are required to produce environmental action plans, monitor farm improvement activities, and identify areas where future interventions can further improve the farm's sustainability. Typical areas where ecosystem surveillance and monitoring can underpin these types of accreditation schemes include:
  - monitoring quality and condition of drainage ditches and watercourses;
  - mapping drainage schemes for land holdings;
  - mapping and monitoring land drainage and water flow outlets;
  - monitoring grazing levels to limit soil erosion and runoff;
  - monitoring effective management of environmentally-sensitive areas;
  - monitoring retention of traditional field boundaries, landscape features and other natural habitats;
  - monitoring the timing and frequency of field boundary management (e.g. hedge cutting) and water course management;
  - monitoring the occurrence of deep cultivation under the tree canopy of in-field trees and tree removal; and
  - ensuring the retention of a minimum of 5% farm area as natural habitat not used in production.

### 2.4.2 Direct Data Requirements for Business Users

- Factors which affect ecosystem services that lead to declines in primary production, outside of wider trends such as global climate change (e.g. pressure stemming from local and exported pollution) need to be better understood.
- Businesses need to ensure that standards and accreditation are underpinned by sound knowledge; which includes monitoring of sustainable environmental practices (Sainsbury's 2012; Marine Stewardship Council 2014; Greenpeace 2006). However, cost of traceability and verification remains a concern of some parties (Fauna & Flora International & UNEP 2009; DG ENV 2010).
- Improved monitoring of operational risks to UK agriculture sector (e.g. pollinator decline and water availability) is needed to inform 'sustainable intensification' practices (BBSRC 2014; University of Leeds 2015).
- Better monitoring is needed of the impacts linked to increased demand for biomass to meet renewable energy targets. A majority of this demand will be met through

international supply chains, with some UK sites likely to support small and medium scale biomass installations (DECC 2014; Ecosystem Markets Task Force 2013b).

- There is a desire to monitor risks posed to fresh produce supply chains. This has already been undertaken by ASDA (Wal-Mart 2014) and through Kingfisher's 'net positive' approach to sustainability (2013).
- Businesses with stakes in woodland planting schemes are looking to better understand the wider benefits these schemes provide beyond carbon sequestration (e.g. maintaining high quality soils, water quality, flood relief, natural habitat) and wider social benefits (e.g. public access, recreation and education opportunities).
- Agricultural and forestry businesses are keen to better understand negative impacts upon natural capital, such as: wastewater flows; nutrient runoff; indirect impacts from energy and fuel consumption; and external impacts along supply chains.
- Fish farming business want to improve their ability to monitor direct impacts caused by increased carbon loading that occurs in close proximity to fish farms.
- Business sectors involved in infrastructure development recognise the need for improved surveillance to strengthen planning applications, as well as monitoring of the effectiveness of mitigating interventions and other management measures.
- Food retailers identified the main natural capital related risks to their business as being extremes of water availability (drought and floods) in the short-term and soil quality and genetic variation in the medium to long term. This sector is keen to incorporate ecosystem monitoring information into their risk management strategies.
- Some of the existing data sources that businesses are utilising include: the MAGIC website; datasets and reports held by the statutory conservation bodies; on-the-ground survey data; NBN Gateway; and aerial photography.

### **2.4.3 General Aspirations amongst Business Users**

- There is interest in developing approaches based on 'key indicator species' to enable landholders to conduct rapid surveys to ascertain the biodiversity status of sites quickly and avoid costly ground surveys.
- Some businesses are beginning to take greater account of their supply chain impacts and dependencies. For example, some leading beverage manufacturers (e.g. DIAGEO, Nestle, and Heineken) have pledged that by 2020 their companies will only purchase from sustainable supply chains (AECOM, *in press*). Surveillance and monitoring to help with managing natural capital is likely to be crucial in ensuring these ambitions can be met and substantiated.
- There is interest in the use of remote controlled aerial vehicles for monitoring issues that cannot be easily analysed at ground level, such as mapping weeds and disease hotspots, to enable targeted responses and reduce the use of chemical treatment.
- Some companies identified the possibility of mapping and monitoring risks associated with interrelated materials, thus developing a comprehensive

understanding of the 'supply web' and a clearer understanding of where action to conserve natural capital is most relevant.

#### **2.4.4 Specific Aspirations of Business Users**

- Agricultural businesses want more accurate monitoring and assessment of the impacts linked with particular ploughing methods and crop planting regimes (e.g. water runoff, soil erosion and downstream flooding).
- The forestry sector highlighted the critical need for industry recognised metrics for natural capital and the potential utility of tools such as the USA iTree which quantifies the ecosystem service benefits provided by trees in monetary terms by using a Mobile Data Collection system on a Smart Phone (iTree 2015). There is interest in exploring the potential for developing a UK equivalent of this tool.

#### **2.4.5 Data Access for Business Users**

- There is general agreement that finding the relevant knowledge and data is a key challenge. This could be improved through the creation of a centralised data hub that also contains information on best practice and case study materials.
- There is an urgent need to convert the mass of natural capital research into understandable, practical outputs that are tailored to different industries and will assist those industries in implementing natural capital focused approaches.
- Detailed worked examples that people are willing to discuss openly are seen to be in short supply. Some practitioners identified the need to encourage more open, detailed dialogues around natural capital projects and encourage widespread sharing of honest feedback.

#### **2.4.6 Other Barriers for Business Users**

- Many businesses are very open to considering doing systematic natural capital valuations, but feel that a lack of appropriate tools and drivers (e.g. political, economic, and social) is slowing the rate of progress. Barriers or constraints to integrating natural capital thinking within business operations include:
  - availability of appropriate tools that measure hard-to-capture ecosystem services;
  - intellectual and practical challenge of understanding natural capital baselines and establishing Key Performance indicators;
  - financial cost of implementing new systems that integrate natural capital thinking;
  - the slow rate of advance in technologies that enable businesses to value natural capital and integrate the concept into business models and strategies; and
  - regulatory barriers (e.g. as new technologies emerge, regulators require time to develop a position on what approaches are acceptable).
- Within the Forestry sector there is not a perceived lack of knowledge or lack of access to suitable data, metrics or tools. However, there is a need for a tool to efficiently verify and monitor the growth of new woods. There is hope that a simple, easy to use, cost effective, remote sensing method will become available, using satellite or remotely operated aircraft data.



- The resource implications for measuring and valuing natural capital impacts in multiple products and supply chains are perceived to be problematic. This could be rectified by collecting more supply chain information, coupled with improved sharing of this information across supply chains.
- Some businesses are using tools such as the Price Waterhouse Cooper 'Total Impact Measurement and Management (TIMM) guide (2013). Environmental impact analysis measures emissions to air, land and water and the use of natural resources and values the resulting impacts on society. This is an emerging area with a few leading examples in business. Information being used in models such as TIMM include: environmental impact assessments, measured project specific data (e.g. CO<sub>2</sub>, mileage) and secondary data (e.g. IPPC, Defra models and conversion factors for CO<sub>2</sub> and other GHGs). In some instances, businesses are finding that existing data do not fit the tools that they need to identify natural capital impacts and dependencies. Future monitoring and surveillance activities should seek to provide data that can be readily used in commonly utilised decision support tools, such as TIMM, to enable more businesses to monitor impacts on natural capital at an individual project level.

### 3. Generic questions on data needs

This section provides an outline of some generic questions (in relation to monitoring activities) that are being posed by the three focal user groups. These generic questions have been formulated by conducting a synthesis of the information provided by users that is outlined in Section 2. The objective of this task is to begin linking data requirements to generic questions in an attempt to identify the types of existing data that are available to answer common challenges. This will lead onto the discussion in Section 4 that identifies the types of data available to answer these common questions, and will inform the subsequent MAP recommendations for improved utilisation and collection of surveillance and monitoring data in Section 5.

#### 3.1 National Level Data Users

- How can we better improve understanding of how biodiversity focused interventions (e.g. protected area management) are influencing natural capital and ecosystem services?
- What are the most effective indicators for monitoring changes in 'habitat condition', what does this tell us about *risks* posed to ecosystems, ecosystem *health* and *resilience*, and how does this translate to impacts to ecosystem services and the goods and benefits they provide?
- Is there a practical way in which we can establish national baselines for natural capital and ecosystem services in order to monitor future change?
- How can existing decision support mechanisms based upon land cover information be improved? What supplementary data can be integrated to ensure decision options are bringing greater social, economic, and environmental knowledge to bear? What does this mean for future monitoring activities?
- How can environmental monitoring reporting become better coordinated across the UK? What would be the most effective means of improving access to national and country datasets?

- What easy practical steps can national and country level data providers take to begin adopting a common UK-wide approach to the collection, cataloguing and storing of national and country level monitoring data to improve accessibility, discoverability and integration with other relevant data?
- How can monitoring be used to better understand and identify time-lags between interventions (e.g. ecological restoration) and observing perceptible change (e.g. increases in goods and benefits)?
- How can cost effective citizen science and volunteer networks be capitalised to improve monitoring activities?

### **3.2 Local Authorities**

- Can it be ensured that future infrastructure development better accounts for natural capital and ecosystem services by improving the integration of their surveillance and monitoring with national and local planning regulations?
- What are the best ways to ensure that data from national environmental monitoring schemes can be readily supplemented with local knowledge and data (e.g. economic, cultural, human health, ecological) to better define the spatial context of ecosystem service delivery and the location of beneficiaries?
- How can we obtain data that measures directly (or indirectly via proxies) anthropogenic disturbance on species, communities and ecosystems (e.g. use of existing species monitoring data such as BTO National Bat Monitoring data as a proxy for human disturbance)?
- Are there some short to medium term actions that can be taken to improve the ability for current monitoring and surveillance activities to better capture rates of change in Natural Capital and ecosystems and associated goods and services?
- Can existing knowledge be drawn upon to begin improving our understanding of how functional traits of particular ecosystem assets can change under varying spatial and temporal scenarios? What are the important challenges and questions this can help us answer? What are the specific traits that we would be interested in? What are the key data needs to address these questions?
- What quick fixes are there to rectify current flaws in national data collection standards that will help to improve data discovery and data integration between local bodies (e.g. standardised data set tagging)?

### **3.3 Business**

- How does the scope and context of present monitoring and surveillance activities and data match the scope within which businesses need to operate (e.g. does the current knowledge lend itself to use at an appropriate scale)?
- How can we obtain spatial data that elucidates unsustainable use of natural capital and ecosystem change and can be used to identify common risks affecting a broad spectrum of industry sectors?

- What existing environmental data can be readily supplemented with existing corporate data to improve monitoring and assessment capabilities?
- Can existing corporate data be used in conjunction with existing environmental monitoring data to enable businesses to better monitor their environmental impacts and risks?
- What environmental data and knowledge can be readily used by industry to prioritise action on ecosystems and natural capital so that predicted future risks and impact are minimised? How can these data be used to better demonstrate 'nature's value' to business?
- Are there existing methodologies and monitoring activities that can be easily adopted by individual businesses to demonstrate tangible positive impact on ecosystems and natural capital (e.g. simple and cost effective ways to demonstrate biodiversity benefits from improved natural capital management)?
- What surveillance and monitoring capabilities and environmental data exist that can be used to effectively analyse and monitor supply chains? How can this be best used to develop and underpin environmental standards and accreditation schemes?
- Can we make better use of existing monitoring knowledge and data to help inform more straightforward qualitative natural capital assessments, as opposed to the more complex economic valuations being undertaken by some larger corporations?
- Is it possible for existing surveillance and monitoring capabilities and data to be used to provide proxies for the wider benefits that are realised from the UK's natural capital (e.g. high quality soils; water quality; flood relief; natural habitat; natural pest control; public access; recreation; and education opportunities *etc*)?

## 4. Data availability

This section provides an overview of the availability of environmental, contextual and socio-economic data relevant to the implementation of the Ecosystem Approach with the aim of identifying improvements that could be made in monitoring, surveying, data management and data access. This will inform the recommendations set out in Section 5

This overview relates directly to the user requirements described in Section 3 for our targeted stakeholder groups and the high level concepts shown in the conceptual framework in Section 1 (Figure 1). We consider the availability of data in relation to monitoring required for assessments of:

- i. stocks of natural capital and flows of ecosystem services and benefits derived from them;
- ii. changes in stocks of natural capital and flows of ecosystem services and benefits derived from them;
- iii. pressures and drivers of change affecting natural capital and flows of ecosystem goods and services; and their impacts on supply chains;
- iv. risk assessments (e.g. identifying areas providing ecosystem services most in need of protection or restoration); and
- v. natural capital accounting and valuation.

## 4.1 European Level

European level requirements are mainly concerned with national scale mapping of the current state of natural capital and ecosystem services. Data availability differs widely between countries and at its simplest level involves the use of land cover or land use maps as surrogates for natural capital and biodiversity. UK data are generally much more useful for these purposes than common European products such as CORINE land cover. The main exception will be the supply of remote sensing data from the European Commission's Copernicus programme, which aims at achieving a multi-level operational Earth observation capacity that combines remote sensing with in-situ observations. The space component is being built around the Sentinel missions of which Sentinel 2 (which was launched in 2015) will provide high-resolution optical imaging for land services (e.g. imagery of vegetation, soil and water cover, inland waterways and coastal areas).

## 4.2 UK and National Scale Data Availability

### 4.2.1 The UK Environmental Observation Framework Data Catalogue

The most comprehensive and up-to-date catalogue of environmental monitoring and observation activities in the UK is provided by UK Environmental Observation Framework's (EOF) Catalogue<sup>2</sup>. As of March 2015 this contained details on over 2100 ongoing and historical activities, programmes, networks and facilities undertaking data collection in the UK. It included information on:

- 316 programmes (related groups of monitoring campaigns)
- 924 activities (monitoring campaigns with specific equipment or method)
- 1122 facilities (sites, stations, platforms or sensors)
- 11 networks (groups of facilities)

The Catalogue provides an overview of environmental observations as well as a place to: (i) discover who is doing what, where, why and when; (ii) make contact with observation managers; and (iii) find out where the data is held and if it is available for re-use. In detail, the catalogue records: location information; information on who is responsible for managing, using and funding the monitoring; information on costs and funding; the relationships between facilities/activities/programmes and networks for answering questions such as "what monitoring activities is sensor X being used for"; links to the datasets which originate from the monitoring feature; and can record all this information at various levels of resolution. Currently the catalogue mainly covers in situ data monitoring activities but there are now plans to extend it to provide more comprehensive coverage of data sets derived from remote sensing.

Although the UK EOF catalogue provides a useful general starting point for data discovery, it was originally constructed mainly to meet the needs of the environmental data providing community and its funders rather than potential data users. It therefore has some limitations that reduce its effectiveness in relation to this MAP. These include:

- incomplete records and lack of updating – a general problem with data catalogues of this type;

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<sup>2</sup> UK EOF was founded in 2008 and is a partnership of public sector organisations with an interest in using and providing evidence from environmental observations. Its mission is to work collaboratively to maximise the value of the UK's environmental observations. Available online at: <http://www.ukeof.org.uk/catalogue>.

- difficulty in using the catalogue to find data sets specifically related to natural capital or ecosystem service measures or concepts because there are currently no standard natural capital “vocabularies” for data providers to use – if these existed it would be a relatively simple matter to use them in the catalogue;
- the catalogue does not provide direct access to data; and
- monitoring schemes rarely make measurements or provide data that map directly onto user requirements – raw data from monitoring must usually be adapted by users to create derived products, often involving combinations of data sets or re-scaling.

However, the catalogue infrastructure was designed to be very flexible and multiple applications can be built on top of the data. This means targeted applications could be built for different user communities offering different views and tools but all using the same dataset information. With some development investment, it should be reasonably easy to extend the catalogue and develop new apps to meet the needs of various user groups.

#### **4.2.2 Other National Data Catalogues and Portals**

In its current form, the UKEOF catalogue does not provide an easy route to the discovery or the direct data access necessary to meet the requirements of local authorities and businesses summarised in Section 2. Furthermore there is little evidence from the user requirements presented in Section 2 that, with the exception of some research applications, users wish or are able to make use of the raw data that might be provided through the catalogue even if data were to be made more easily available. The main reason for this is that raw data usually require a lot of post-processing to be of use. Access to thematic portals that specialise in particular kinds of environmental or socio-economic data are one way of simplifying this process and providing direct access to off-the-shelf data products.

In addition to the UKEOF Catalogue, there are many other environmental and non-environmental datasets and sources of information which can be used to support natural capital or ecosystem assessments or related environmental research and development. A document on “Places to look for environmental data” has been developed by the UKEOF Data Advisory Group (UKEOF 2012). This site provides web-links to possibly relevant data sets on (number of links to web-sites in brackets):

- large UK and EU public environmental data sources (5);
- multi domain/funder sources (6);
- agriculture and farming (4);
- atmosphere, weather and climate (6);
- biodiversity (4);
- earth observation (satellite data) (7);
- earth science (3);
- energy (2);
- freshwater (2);
- geospatial (2);
- health and medical (10);
- housing and planning (5);
- social and economic (8); and
- waste (2)

This UKEOF document does not claim to be comprehensive and was last updated in 2012. Since then other sites or portals have been developed that are relevant to the MAP. For example, the UK Soil Observatory is a collaboration of institutions providing information about the diverse soil types of the UK, and delivering that information to the wider public and

science communities (NERC 2016). The site provides information on monitoring activities at national, regional and local levels and links to some data products. Other relevant portals include the Water Security Knowledge Exchange Portal which provides a novel overview of UK national-scale water-related datasets – both spatial and time-series (NERC 2014).

### 4.2.3 Data for National Natural Capital Accounts

Section 3 identifies that at European, national and local levels there is a common requirement for simple procedures and data for producing natural capital accounts.

The Natural Capital Committee (NCC) has proposed an assessment framework for natural capital based on accounting units comprised of UK NEA broad habitat types. These are areas of: mountains, moors and heaths; enclosed farmland; semi-natural grasslands; woodland; freshwaters; urban; coastal margins; and marine. Each of these is assessed in terms of 3 attributes: quality (habitat condition); quantity (spatial extent); and spatial configuration (the proximity of the broad habitat to its 'optimal' position to deliver maximum benefits).

In a review commissioned by the NCC, Maskell *et al* assessed which monitoring data currently collected (by the DEFRA network and other research and monitoring institutions like the Centre for Ecology and Hydrology) could be used to report on Natural Capital Assets (2013). This required collation of potential datasets and their links to each Natural Capital Asset. The list of assets used for reporting was provided by the NCC and included species, ecological communities, soils, freshwaters, land, atmosphere, minerals, sub-soil assets, oceans and coasts. For each Natural Capital Asset, potential datasets were identified and, if necessary, broken down into components of assets that could be reported in relation to: source, extent, spatial configuration, monitoring frequency, accessibility, ease of use, quality, and uncertainty. Summary tables were created for each asset that identified key sources of data classified according to the availability of data and appropriateness to spatial or temporal scales.

A list of the main datasets that could potentially be used to report on each Natural Capital Asset is provided in the Annex of Maskell *et al* (2013). In summary:

**Ecological Communities:** To capture information on all habitats in GB it was decided to use the Broad Habitat Classification for Natural Capital reporting (JNCC 2016b). Priority habitats can be nested inside of this classification. There are reasonable national surveys of broad habitats but data on the extent of priority/Annex 1 habitats is less consistent. It is difficult to find consistent data on the stock of priority habitats outside of designated areas and there is also a lack of reliable trend data.

**Species:** The primary mechanism for reporting on species was through the UKBAP. The last report for both species and habitats was in 2008. There tends to be more data on frequency and distribution than on abundance because recording abundance for many species can prove challenging. There also tends to be spatial and temporal bias in recording effort with some areas and taxa being under-recorded. Still, there are many recording schemes in existence and it is possible that in the future reporting will be possible for a greater number of taxa. Responsibility has now devolved to individual countries and all have produced their own biodiversity strategies.

**Freshwater:** Data are generally available for reporting on freshwater extent and condition from the reporting requirements for the Water Framework Directive.

**Soils:** There are good data for reporting on soils at a national scale although some components may require additional data collection or collection at a different resolution. There are limited data on soil biota.

**Coasts:** Data are available on coastal habitats from similar sources as the ecological communities' asset. Additional information is available on specific habitats e.g. the Sand Dune survey of Great Britain, JHI survey of Machair and sand dune sites, EA and SEPA extent and condition data for saltmarshes and transitional waters. However, there is often inconsistency in the data collected for different components of coastal habitats either spatially or temporally.

**Atmosphere:** Data are available on individual atmospheric components as annual extent and trends from the National Atmospheric Emissions Inventory.

**Minerals:** Data are available from the British Geological Survey on the geological distribution of onshore mineral resources in England, Wales and the central belt of Scotland.

**Land:** Data on topography and land height are available from Nexmap DEM, OS DTM and OS landform panorama.

**Sub-soil:** Data on the potential resources for different minerals are available from the British Geological Society as maps or as reports by county. Data on geology and sub-soil components are used in CSM reporting on geological features on SSSI's.

Maskell *et al* (2013) conclude that it was fairly straightforward to identify multiple datasets that could be listed under an asset and that might provide useful information. However, the next step, extracting the most appropriate dataset to report on an asset and understanding the components of an asset that should be reported on, was much more difficult. For some (e.g. soils) the choice of datasets and how to break down the asset into components has been proposed in peer reviewed publications (Robison *et al* 2013), but for others it is more speculative and may require further consultation and iteration. They also found that gaining access to the data took more time than expected and did not pursue this.

### ***Relating Natural Capital to Benefits and Risks***

One of the NCC's aims is to provide an assessment of risk and the benefits provided by natural capital and, amongst other things, to use this to help prioritise restoration or remediation programmes. To facilitate this, they recommend that all the natural capital asset classes (above) are considered within a set of "accounting units" based on broad habitats and their relationship to the delivery of goods and benefits. The NCC considers the following categories of benefits: food, fibre, energy, clean water, clean air, recreation, aesthetic, hazard protection, wildlife and equable climate. This means we need to identify and measure which broad habitats are decreasing in extent, quality and spatial configuration and where this coincides with a loss of a particular benefit.

It is reasonable to ask what current monitoring and data we have that contribute to meeting this requirement. Unfortunately, even at national level there is no easy way of answering this question through current data catalogues, repositories, or data portals. But, to illustrate some of the issues, Maskell (*pers. Comm.*) has undertaken an assessment (based on expert judgement) looking at the extent to which Countryside Survey (CS)<sup>3</sup> (a systematic sample –based survey of the countryside based on five repeat surveys of 1km squares from 1978 to 2007) combined with a Land Cover Map.

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<sup>3</sup> Countryside Survey is carried out by the Centre for Ecology and Hydrology. Defra and the Natural Environment Research Council (NERC) commissioned the 2007 survey – the fifth since 1978 – on behalf of a partnership of governments, departments and agencies in the UK. The scientists conducted an in-depth study of the habitats, soils and landscape features in each one-kilometre square, and recorded plants in a number of vegetation plots.

At national (GB) level, Table 4.1 shows that CS can provide estimates of trends in all the broad habitats (through habitat mapping) but only in a few cases can it provide independent (co-located) data on trends in the benefits associated with them. The main example is wildlife, in which detailed recording of species in plant communities provides a measure relevant to “wildlife” benefits. In most other cases CS can only provide surrogate measures of benefits (i.e. based on an assumption that certain features provide certain benefits). This assessment would need to be repeated for all other data sets to provide a complete picture of what data are available. Even for experts, at national level there is currently no easy way of doing this and at local level the task is even more difficult.

Mace *et al* (2015) take this one step further and propose the use of a simple system for compiling a risk register of benefits at risk through loss or degradation of natural capital. They also propose that this approach could help simplify the complicated and challenging task of undertaking systematic monitoring of natural assets by providing a focus for current and future efforts.

#### **4.2.4 Data for integrated assessments**

The previous example addresses one of the key requirements expressed by users at national level. Businesses, and to some extent local authority users, wish to be able to evaluate the effects of changes in natural capital on benefits delivered by ecosystem services and analyse trade-offs for benefits and beneficiaries. As the example above shows, there is no single monitoring programme that is able to address this question and meeting this challenge will require so called “integrated assessments” that draw together data from a range of sources.

Quantifying ecosystem services and understanding the interactions between them provides a significant challenge for scientists, one which we’re only just developing techniques to investigate. An early example of this was provided by the Countryside Survey “Integrated Assessment report” which examined the status and trends of key ecosystem services within Great Britain (2010). Headline messages from the report concern ecosystem services, including: pollination, soils, and the quality of freshwaters and their relationship with biodiversity. The analysis involved assessment of CS data, together with large amounts of data accumulated from other sources. It enabled scientists to map changes in the features of our landscape, draw out possible relationships between the changes in wildlife and the causes of those changes and to test possible policy solutions for the benefits they bring.



	<i>Moor Mounts. Heath</i>			<i>Enclosed Farmland</i>			<i>Semi-natural Grassland</i>			<i>Woods</i>			<i>Fresh Water</i>			<i>Urban</i>			<i>Coastal</i>			
	<i>Qn</i>	<i>Ql</i>	<i>sp</i>	<i>Qn</i>	<i>Ql</i>	<i>sp</i>	<i>Qn</i>	<i>Ql</i>	<i>sp</i>	<i>Qn</i>	<i>Ql</i>	<i>sp</i>	<i>Qn</i>	<i>Ql</i>	<i>sp</i>	<i>Qn</i>	<i>Ql</i>	<i>sp</i>	<i>Qn</i>	<i>Ql</i>	<i>sp</i>	
<i>Food</i>	2	2	2	2	2	2	2	2	2													
<i>Fibre</i>	2	2	2	2	2	2	2	2	2	2	2	2										
<i>Energy</i>																						
<i>Clean water</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
<i>Clean air</i>																						
<i>Recreation</i>	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2				
<i>Aesthetics</i>	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2							
<i>Hazard Protection</i>	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2							
<i>Wildlife</i>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
<i>Climate</i>	1	1	1	1	1	1	1	1	1	1	1	1										

**Table 1.** Adapted from NCC Report by Maskell (pers.Comm, 2016) to illustrate link between Countryside Survey measurements and the risk assessment matrix proposed by the NCC. 1 = good, providing a reasonably direct measure of the broad habitat and independent measure of the benefit, 2 = something possible – usually a direct measure of the broad habitat but no independent measure of the benefit; zero= nothing possible.

### ***Social and economic data for integrated assessments***

The CS approach to integrated assessment made generous use of proxies and surrogates of ecosystem services and their benefits that are difficult to measure directly or obtain from other sources. A complete integrated assessment requires the use of social and economic data on the distribution of beneficiaries from ecosystem services and the values (monetary or non-monetary) they place upon them.

The UKEOF web-site provides links to “social and economic information” which are outside of the UKEOF remit but may provide supporting or additional evidence when addressing key questions and issues related to the Ecosystem Approach (UKEOF 2011). This web-site (last updated May 2011) lists data sets in the following categories:

- major data sources (5)
- agriculture and farming (3)
- domesticated plants (1)
- health data (9)
- social and economic information (3)
- housing and planning (4)
- energy technologies (1)
- international statistics (2)

Probably the most useful source of information on social and economic data is provided by the UK Data Service (The Economic and Social Research Council 2012). It is designed to provide seamless access and support to meet the current and future research demands of both academic and non-academic users. It provides a unified point of access to an extensive range of high quality social and economic data, including UK census data, government funded surveys, longitudinal studies, international data, qualitative data and business micro data. It also enables access to large-scale government surveys, such as: the Labour Force Survey; major UK surveys that follow individuals over time, such as the population census data; social attitudes since 1983; British Household Survey since 1983;

and the Lifestyle survey (1971-2012). Separate survey data are available for England, Wales, Scotland and Northern Ireland. The UK Data Service also allows direct downloads of data.

A full assessment of the social and economic data available through these sources has not been completed. Therefore, it has not yet been ascertained whether the limitations that have been described above for environmental data, and whether the associated recommendations outlined in Section 5, also apply to social and economic data.

## **4.3 Data Availability for Local Authority Use**

### **4.3.1 National Data for Local Use**

The EOF Catalogue has a search facility that enables data to be located for specific areas. But the limitations that apply to the national searches in relation to natural capital would also apply here with the added issue that most national datasets are too coarse or inaccurate at a local scale for use in local-level decision making. But there are exceptions. For example, the UK National Biodiversity Network (NBN) is especially valuable as a source of data for local assessments requiring information on the location of biodiversity related assets. The NBN is committed to making biodiversity information available through various media, including the internet via the NBN Gateway. As of July 2016, the NBN Gateway held over 128 million records from 956 different datasets. Data on the NBN Gateway can be accessed by anyone interested in UK and Ireland wildlife and can be searched at many different levels, as it allows the viewing of distribution maps and the downloading of data by using a variety of interactive tools. For instance, users can look at a specific area (e.g. on an ordnance survey grid map or a vice-county). The maps can be customised by date range and can show changes in a species' distribution.

### **4.3.2 Local Data for Local Use**

Local Environmental Record Centres (LRCs) can be found in each county in England and are usually supported by partners like Natural England, the Environment Agency, Local Authorities and Wildlife Trusts (Association of Local Environmental Record Centres 2009).

LRCs provide data to the NBN but also provide a range of direct services to their local areas. They are responsible for collating, managing and sharing information about animal and plant species, habitats and other landscape features, such as geological or protected sites. The

LRCs are the first port of call for ecological information and a valued resource for the local community working with local authorities, environmental consultants, conservation organisations, educational institutions and the general public.

LRCs also:

- Disseminate information about the distribution of legally protected, rare or threatened species, habitats and geodiversity sites to organisations in the public sector and business whose actions affect the environment. This includes: planning policy and development control, land and waste management, control of invasive species, highway maintenance and Local Wildlife Sites monitoring and reporting.
- Provide a range of products and services to meet the requirements of data users (e.g. data searches, habitat mapping, green infrastructure projects and planning list searches).
- Support the network of county recorders and other groups and individuals that help record habitat and species information.

For local assessments it will usually be most practical to build from easily accessible nationally datasets and add locally available data (or specifically commissioned survey information).

## **4.4 Data Availability for Business Use**

The Natural Capital Coalition's report on "Valuing Natural Capital in Business" summarises the importance of natural capital to business interests and the key role that industry has to play in future efforts to protect and enhance natural capital (2014a). 'Business users' operate in a wide range of sectors and have a complex set of requirements for data from monitoring (see Section 3.3). These breakdown into the need to understand, quantify and minimise the: (i) direct effects on natural capital (e.g. through resource use, production of waste products); (ii) indirect impacts effects on natural capital through supply chains and use of their products; and (iii) the effects of external drivers and pressures on their supply chains. In relation to natural capital, direct effects are particularly important for primary or extractive industries (e.g. extractive industries including mining, agriculture, water companies, forestry, fishing) whereas supply chain issues are more important for secondary (manufacturing) and tertiary (service) industries. Improving the resilience and sustainability of supplies, profitability and brand image are strong motivators of action in this area.

The Natural Capital Coalition's handbook on "Taking Stock: Existing Initiatives and Applications" provides an overview of assessment and valuation techniques that could be used by business, including a brief section on data and databases (2014b). It concludes that a number of early stage databases can be built on but significant further data collection and database development is needed. Furthermore, the quality, currency and easy availability of the data are inconsistent and limited at present. Most of the databases listed in this report are global scale with a correspondingly coarse level of resolution or are "work in progress". Few would be helpful with supply chain assessments.

### **4.4.1 Local Data for Business Use**

The general points made for local authority users also apply for many business users. But in addition:

- i. Businesses need to be confident in the value of investing in natural capital and need rigorous evidence that doing so will increase sustainability, profitability and brand image. This evidence is not yet available consistently.
- ii. Businesses need to be able to judge the sustainability of the natural capital resources on which they depend. A key requirement would be the development of business led certification schemes that can guarantee that suppliers are operating sustainably. This gets complicated for long supply chains.
- iii. Businesses need to judge future trends in resource supplies. This requires a data based modelling approach.
- iv. Business can contribute a great deal in helping to fill data gaps that can inform decision making. The extent to which those data could be made available to a wider community of users is unclear.

## **5. Recommendations and Action Planning**

In Sections 3 and 4 we provided an overview of the demand and supply of data from survey and monitoring activities that are required to implement natural capital assessments and the Ecosystem Approach. This information has been used to develop a set of 47 recommendations for how data supply can better meet user demands. There is some

overlap between these recommendations because in some instances similar recommendations emerged from the different user groups.

The recommendations fell into 7 main areas and covered improvements and suggestions concerning:

- data discovery and access;
- data relationships and system understanding (e.g. how does one factor (e.g. a driver of change) affect another (e.g. a natural capital asset);
- bespoke data products and portals;
- links to models and decision support tools (DSTs);
- opportunities to improve existing monitoring with new approaches and supplementary data;
- need for further understanding of data usage;
- operational frameworks; and
- partnerships for co-ordinated approaches to monitoring.

The full list of recommendations which shows which user group the recommendation stems from is provided in Annex A. These recommendations are mainly targeted at the monitoring and data providing communities but some also rely on the involvement of other practitioners. Here we provide a summary of the 7 main areas and consider a few options for addressing them, some of which are based on existing work in progress.

## 5.1 Data discovery and access

### 5.1.1 Data discovery

Example recommendation: *“Develop a common UK approach to collecting, cataloguing and storing national and country level monitoring data to improve accessibility, discoverability and integration with other relevant data”.*

An essential requirement for data users, especially new ones, is that they should be able to locate monitoring data, judge whether it is suitable for their purposes and access them easily and cheaply. The main facility would be a catalogue, which would provide a Web query interface enabling search functions to be inputted from various viewpoints, for example:

- Data sets for quantifying changes in quantity and quality of carbon storage potential between 1980 and 2010.
- Data suitable for quantifying benefits delivered by moorland heath species in Scotland.

#### Optional solutions:

- The most comprehensive catalogue of the UK’s monitoring activities is provided by the UK EOF and this could be updated and customised to meet the needs of the natural capital user community.

### 5.1.2 Judging fitness for purpose

Example recommendation: *“Develop methods that facilitate the linking of existing datasets with corresponding ecosystem and natural capital classifications to improve data discovery and utilisation.”*

Existing data cannot be located for specific uses because they are not suitably tagged with concepts or search terms that enable them to be identified within existing data repositories. Currently there is no consistent ‘tagging’ of data within the EOF catalogue making it hard for data providers to ‘tag’ their data with useful terms or key words and for users to find data related to the natural capital assets or ecosystem services that are of relevance to them. Standard terminology for natural capital assets, ecosystem services need to be adopted. Wherever possible these should be structured hierarchically to accommodate the different levels of detail required by users and data availability.

Most current monitoring activities collect data on biophysical variables that do not usually equate directly with user requirements for information on natural capital or ecosystem services. The development of simple metrics and indicators linking biophysical variables to natural capital and ecosystem services is a priority. Metrics should be simple and easily aligned with particular policy or management targets (e.g. as part of adaptive management process) (Collen & Nicholson 2014). They should also be appropriate for businesses to apply at a local level or to aggregate over all of their operations and value chains and be credible, practical to use, easy to understand and relevant to industry (Natural Capital Leaders Platform 2015).

### **Optional solutions:**

- The community needs to agree on the use of some standard systems for classifying natural capital, ecosystem services, and goods and benefits. These could include:
  - NCC terms
  - CICES (CICES v3.4, 2013)
  - Final Ecosystem Goods and Services Classification System (FEGS-CS) (United States Environmental Protection Agency 2014b)
- Monitoring projects in the EOF catalogue should be tagged to identify sources of data meeting user requirements. This should cover all relevant survey and monitoring activities and associated data sets and be searchable through queries defined in the terms and concepts from the on-line dictionary.
- A citation mechanism should be developed to link ecosystem accounts to source data for evidence tracking (e.g. Digital Object Identifiers [DOIs] or links to literature).
- Construction should be undertaken for a Web-based dictionary natural capital and ecosystem service metrics that can be related to biophysical measurements and referenced within reports, results tables, survey protocols, and within data tables (c.f. Catalogue of Life (ITIS and Species 2000, 2016).

### **5.1.3 Data access and open data policies**

Data from most publicly funded monitoring should be available within a reasonable time period (e.g. 1 year after collection). For example, the key principles of NERC’s Data Policy Statement state that “*the environmental data produced by the activities funded by NERC are considered a public good and they will be made openly available for free for others to use, apart from a few special cases as detailed in the policy*” (NERC 2011).

However, despite these policies the expectations of users seem to rarely be met and steps need to be taken for users to discover useful data that are easily available.

### Optional solutions:

- Develop a system for monitoring the use of data and a facility for recording user endorsements on the ease of accessibility and application of data.

## 5.2 Data relationships and system understanding - how does one factor affect another

Example recommendation: “Observations and data are required for validating and quantifying how suitable particular datasets are for use in monitoring and assessing benefits delivered by natural capital assets and ecosystem services.”

Many of the users covered in Section 3 wished to make simple use of data to assess the state (and more occasionally change) in natural capital and ecosystem services. However, many users were also asking more complicated questions that required understanding the relationships between natural capital, ecosystem services, benefits and drivers of change (see conceptual framework [Figure 1]). This was particularly true in the national and business sectors. For example, businesses need to assess the depletion and degradation of the goods and services that they rely upon and how this is affected by their own activities and multiple external drivers, such as climate change and land conversion.

A system to address these issues needs to be developed in close consultation with the natural capital community and made as accessible as possible through Web interfaces.

### Optional solutions:

- Develop a semantically enabled Web catalogue that contains information on monitoring schemes and surveys that can address the metrics required to quantify different aspects of natural capital such as quantity, quality and trends and their relationships to ecosystem service supply, goods and benefits, and drivers of change.
- Construct summary tables quantifying important relationships. For example, a database for valuing benefits based on “benefit transfer” data from published examples.
- Develop a citation mechanism to link the supporting scientific evidence for stated relationships (e.g. DOIs or bibliographic links).
- Develop systems like the USA’s Eco-Health Relationship Browser Health that illustrates scientific evidence for linkages between human health and ecosystem services (United States Environmental Protection Agency 2014a).
- Open publication of linked data making it easier to connect information from different sources, resulting in new and innovative applications.

## 5.3 Bespoke data products and portals

Catalogues such as that provided by EOF can be developed to provide useful information on sources of data that are relevant to the Ecosystem Approach. However, in most cases the data would require substantial processing in order to be made useful for most purposes. For this reason, outside of the research community, we found that there was little interest amongst local authority and business users in gaining access to primary data but great interest in access to derived data products that related more directly to their needs.

End users usually express their requirements through questions such as “*where can I find maps showing the stock and change in natural capital in my area?*” rather than “*where can I find data that might help me construct maps of stock and change of natural capital in my area?*” Local authorities and businesses usually prefer to make use of readily available data products based on processed data. This is borne out by the BESS Ecosystem Service Mapping Gateway which provides information on projects that have mapped ecosystem services (NERC-BESS 2013). Typically these examples use local sub-sets of national data sets such as the Land Cover Map.

In summary, local users would like to have bespoke products that directly meet their requirements and a single point through which they can access these products. There are also other advantages to this approach, including evidence tracking and increased comparability of ecosystem assessments and accounts between local authorities or between businesses.

### 5.3.1 Data products

Example recommendation: “*Provide data in a manner that enables businesses to better understand the factors affecting ecosystem services ...*”

Where suitable metrics do not yet exist, web based eco-mapping tools will allow portal users to create new datasets out of existing source data (CEH 2014). Utilising a suite of on-line modelling software, it will be possible for users to locate and obtain compatible source datasets and combine/scale them to produce national level metrics. This novel approach will include the ability to simultaneously generate associated “measures of confidence” - facilitating evaluation and selection of the most effective modelling methods.

#### Optional solutions:

- Develop the Ecomaps approach to mapping natural capital (Henrys *et al* 2014). Ecomaps is an example of how a statistical model-based approach can be used to map natural capital by combining different data sets, such as two national survey datasets. For example: the Land Cover Map (LCM) and the British Geological Survey’s (BGS) Parent Material Model (PMM) and sample data on natural capital from field surveys.
- Explore how to make better use of existing species and habitat data as proxies for monitoring pressures and threats (e.g. bat species occurrence as an indicator of human disturbance).

### 5.3.2 Portals

Example recommendation: “*The system needs to make it easy for users to find and directly access data or data products that meet their specific requirements*”.

There is a demand for a single point of access providing access to data, information and knowledge.

#### Optional solutions:

- Create a single portal that sign-posts relevant data sources and data sets in relation to agreed metrics. Potential hosts for this portal could be the Environmental Observation Framework, the Environmental Data Exchange (Digital Catapult 2015), and the Ecosystem Knowledge Network

- There are clearly advantages to users if most or all relevant data could be accessed directly through one portal. The technology to do this by connecting to a distributed network of data repositories is now available. There is also a need to address the practical issues related to data ownership and the non-technical organisational and cultural issues that inhibit effective linking of distributed databases.
- A Natural Capital portal could potentially be developed under the auspices of the Natural Capital Committee. In addition to background information on concepts, frameworks and metrics, it could also provide:
  - products from Eco-Mapping (see 5.3.1);
  - prototype tools to assist with identifying and accessing datasets that hold information about specific concepts, variables or indicators;
  - geo-spatial entry points into linked data based on (for example) monitoring sites;
  - a risk assessment matrix showing where benefits derived from ecosystem services are at risk and where management or policy options are available to reduce the risk;
  - a data sourcing knowledge base to hold the findings from surveys of potential sources of information about assets and their status;
  - asset metrics identifying what is known about the extent and condition of natural capital stocks;
  - benefits metrics data about the financial value of the benefits we derive from ecosystem services; and
  - a citable resources database that provides an audit trail for the data used to construct natural capital accounts and the relationships between natural capital assets and benefits.

NB: At the time of writing CEH was in the process of developing a Natural Capital Portal to provide customised access to products for natural capital users: <http://www.ceh.ac.uk/our-science/science-areas/natural-capital>

## 5.4 Links to models and decision support tools (DSTs)

*Example recommendation: "Take steps to identify ways in which national and country level ecosystem and socio-economic datasets can be used collectively in tools or modelling to facilitate more effective monitoring of: societal impacts; goods and benefits being realised from natural capital; shifts in societal aspirations or attitudes; and wider anthropogenic behaviours and motivation influencing natural capital and ecosystems services".*

The recommendation requires an assessment of which DSTs and information systems are most useful for the application of the Ecosystem Approach followed by an assessment of the availability of data needed to use them.

### Optional solutions:

- Develop the National Ecosystem Approach Toolkit (NEAT-Tree) to provide links to relevant data sets (Scott *et al* 2014). NEAT-Tree contains information on a wide variety of tools that can be used to address aspects of the Ecosystem Approach. These cover: corporate ecosystem evaluation, cost-benefit analysis, ecosystem assessment, ecosystem mapping, environmental impact assessment, futures tools, natural capital asset check, payments for ecosystem services, and strategic environmental assessment. It provides a very useful introduction to the range of



tools that are available but does not in most cases describe either the data needed to apply them or where and how they may be obtained.

- Use case studies from the Ecosystems Knowledge Network for project examples in England, Scotland and Wales that illustrate examples of the Ecosystem Approach in action and the types of data and DSTs that are being utilised.
- Explore the use of biodiversity metrics platforms, such as the Ecometrica Platform's Our Ecosystem interactive mapping platform (Ecometrica 2012).
- Use lists of existing tools, such as the Natural Capital Coalition's 'Valuing Nature in Business' publication (2014), to begin identifying links between existing data.

## 5.5 Opportunities to improve existing monitoring with new approaches and supplementary data

Example recommendation: "Provide recommendations on how existing monitoring data can be supplemented and made more robust through intelligent use of Mobile Data Collection Systems and citizen science".

For local applications existing maps or data available at national level often provide a coarse framework or starting point for local level applications. One example of this might be maps of natural capital generated from the Land Cover Map that are used to provide a first approximation of the state of natural capital and ecosystem service goods and benefits. However, particularly in the case of ecosystem service and benefit metrics, these maps do not take into account inaccuracies caused by using land cover as a surrogate measure of ecosystem services or local preferences that affect the demand for, and therefore the value of, these services. In some cases local data may be available, or could be collected to replace or supplement generalised products. There is now an increasing body of work to support this kind of approach.

### Optional solutions:

- Review and recommend approaches for participatory monitoring of ecosystem services. For example:
  - Dick *et al* described a rapid assessment method for a set of 83 ecosystem services delivered at sites and tested the results against long-term data available from the sites (2014). The assessment revealed that it was relatively easy for site managers to score the test parameters with a high level of certainty. This approach could easily be applied by many sectors of civil society to provide an initial screening of the natural capital stocks and ecosystem services delivered by a site.
  - The USGS's GIS Application for Assessing, Mapping, and Quantifying the Social Values of Ecosystem Services (SoLVES) is designed to assess, map, and quantify the perceived social values of ecosystem services, such as aesthetics and recreation (2015). These non-monetary values, often corresponding to cultural ecosystem services, can be analysed for various stakeholder groups distinguished by their attitudes and preferences.
  - In the UK, the James Hutton Institute is also working towards the spatial mapping of aspects of cultural ecosystem services. It will initially be based on

the Common International Classification of Ecosystem Services (CICES) classification.

- Review other approaches to local mapping using citizens as sensors, mobile apps or local remote sensing technologies.
- Develop systems for combining local surveys with other available data.

## 5.6 The need for further understanding of data use and usage

Example recommendation: *“Data providers should seek to gain a more in-depth understanding into how different sectors are drawing upon existing data sources such as the MAGIC website, datasets and reports held by the statutory bodies, on-the-ground survey data, NBN Gateway, Lle Geo-Portal for Wales, and aerial imagery etc.”*

Throughout the work undertaken to develop the MAP, an attempt was made to examine specific examples or case studies of the Ecosystem Approach in action and their successes and failures in relation to getting hold of the data they required to implement the approach. From this we hoped to build up a picture of data needs (e.g. from monitoring) and data access issues. This level of detail proved hard to obtain and understanding of how social and economic data are being used is particularly weak.

### Optional solutions:

- Collate a suite of case studies based upon generic user needs that are relevant to specific sectors and/or monitoring activities and provide clear links to the existing data that can be drawn upon by users to meet their own similar requirements.
- Commission an expert review of social and economic data in relation to the aims of the MAP.

## 5.7 Frameworks for collaboration and implementation of the Ecosystem Approach

Example recommendation: *“Businesses need to work with each other and with the research community and government agencies to review existing data and coordinate new research to understand how their resource requirements and the commodities they produce impact upon natural capital and what interventions are most appropriate to their situation”.*

The Natural Capital Leaders Platform state that *“Companies that depend on natural capital do not have sufficient information on which to assess their material exposure to risk”* (2014). The Platform is keen to work with other stakeholders to address this deficiency.

Businesses also need to work with others to develop better frameworks for applying the Ecosystem Approach. They are currently encouraged to report against the Global Reporting Initiative (GRI) framework, which includes a number of biodiversity indicators. Not all of these are well designed to assess natural capital health and its connections to ecosystem service delivery. Businesses recognise that biodiversity is complex, but they need simpler ways of reporting on their dependency, impact and responses if they are to better incorporate natural capital thinking into their decision making. The UK’s “Green Book” provides a useful general framework from which businesses can evaluate proposals for incorporating the Ecosystem Approach into business planning (HM Treasury 2003).

This MAP also provides some understanding of the extent to which the Ecosystem Approach (*sensu* CBD) is a desirable or workable framework for achieving favourable outcomes across different stakeholder groups. Initial investigations have found that current approaches to natural capital accounting and ecosystem service assessments are usually done in very simple and parsimonious ways and rarely consider the more complex principles of the Ecosystem Approach. Aspirations within all three groups were found to be ambitious and based on a clear understanding of the more complicated whole-systems aspects of the Ecosystem Approach. However, it remains a challenge to translate the 12 Principles of the Ecosystem Approach into a simple implementation framework.

### **Optional solutions:**

- Build upon the work being undertaken by the Natural Capital Leaders Platform exploring the key themes of water, biodiversity and soil through a series of Action Research Collaboratories (ARCs).
- Consider and recommend appropriate frameworks for the application of the Ecosystem Approach. For example:
  - The JNCC Spatial Framework Approach for Assessing Evidence Needs for Operational Ecosystem Approaches demonstrated the process and outcomes of taking a pragmatic approach to ecosystem service assessment (2012). It emphasises the use of the large body of data already available to inform policy decisions at national, regional and local levels. Using these datasets, an ecosystem service ‘Spatial Framework’ was developed to assist users in conducting ecosystem service assessments and demonstrate what is currently possible (as of 2014) regarding mapping and modelling of ecosystem services. JNCC sought to further develop the spatial framework approach in Phase Two of the Project to create a more practical framework that can be used under different decision scenarios and is applicable at different spatial scales (2014). The outputs from this study are designed to support users in embedding an ecosystem services framework in decision making processes.

## **6. Concluding remarks**

The MAP considers actions that could be taken to improve the use of data from monitoring by considering all points along the chain, from monitoring activities to data supply to data use. The MAP has been developed mainly from the perspective of the users of data, therefore most of the recommendations relate to the immediate challenge of making best use of available information to address questions such as: what data are available and are they accessible and can we have the data in different formats? There are relatively few recommendations that relate directly to the execution or redesign of monitoring programmes in order to address such questions. It is now the responsibility of organisations that undertake or fund monitoring to consider the implications and recommendations of the MAP to inform monitoring activities and data supply.

The need to develop monitoring systems that are better adapted for reporting on natural capital and ecosystem service benefits comes at a time when many organisations are reviewing their monitoring activities to reduce costs through efficiency savings (e.g. new methods) and partnership working. In this process, the balance between expanding existing data sets and developing new, more appropriately designed, monitoring programmes and metrics will be important.

Several organisations have already developed plans and strategies for monitoring and most include specific reference to natural capital accounting or related issues. For example:

- Scotland - “Scottish Environmental Monitoring Strategy” (Scottish Government 2011).
- England - Biodiversity Monitoring and Surveillance Strategy (unpublished).
- Wales – Glastir Monitoring and Evaluation Programme (Welsh Government 2014) and proposed integrated monitoring programme CEH – Monitoring and Observation Systems.
- JNCC - Future Options for Countryside Observations (unpublished).

As these plans move into implementation stages there is a chance to work collaboratively to consider how these plans can be implemented.

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## Annex A.

This table contains all 47 recommendations that stemmed from the different data demands that stemmed from the different groups of data users and data suppliers. Recommendations that are *italicised* are those that have stemmed from data supply.

Demand Source	Recommendation in Report
<b>DATA DISCOVERY AND ACCESS</b>	
UK / Country Level Demand	Existing data and analytical capabilities should be better utilised in enhancing understanding of, and capability to ascertain, baselines for natural capital (e.g. stock take of assets) and ecosystems (e.g. condition, health, capability to deliver services).
UK / Country Level Demand	Develop a common UK approach to data collection, cataloguing and storing national and country level monitoring data to improve accessibility, discoverability and integration with other relevant data.
UK / Country Level Demand	Identify what socio-economic data are available that can be analysed with ecosystem data to create effective assessments of societal changes (e.g. attitudes, well-being, realisation of nature's value).
UK / Country Level Demand	Develop methods that facilitate the linking of existing datasets with corresponding ecosystem and natural capital classifications to improve data discovery and utilisation.
UK / Country Level Demand	Build upon existing work identifying surveillance and monitoring data for use in developing Natural Capital Indicators. In particular, what data are suitable for identifying, defining and monitoring <i>risks</i> posed to ecosystems, ecosystem <i>health</i> , and <i>resilience</i> to shocks and stressors. A first step would be to identify the most pressing issues and/or those that are easy to assess using currently available data, or build on knowledge from existing case studies.
UK / Country Level Demand	Elucidate on the data and monitoring capabilities that exist for monitoring soil erosion rates.
UK / Country Level Demand	Identify monitoring activities and other existing knowledge that can be drawn upon to improve understanding of lag-effects between impacts or intervention and perceptible change in ecosystems (e.g. condition and health, delivery of services, provisions of goods and benefits).
Local Authorities	Link existing ecosystem data to other data that is held regarding the key pressures and threats that are known drivers of environmental change.
Local Authorities	Investigate how existing species data can be used as proxies for monitoring pressures and threats (e.g. bat presence / absence as an indicator of human disturbance).

Local Authorities	Explore the potential for developing a national glossary that can be used for data discovery, building upon the Natural Capital Committee work.
Business	Recommend processes through which to improve data discovery and provide more sector specific case studies that can guide practitioners on how to consider Natural Capital in their operations and explore the potential for linking existing monitoring and surveillance data with existing tools being used by business.
UK / Country Level Demand	<i>The EOF catalogue should be updated and customised to meet the needs of the natural capital user community.</i>
UK / Country Level Demand	<i>EOF records will need to be "tagged" with concepts and keywords that describe the measurements made in relation to natural capital and ecosystem service requirements. This could be with free-text keywords or by the use of controlled vocabularies.</i>
UK / Country Level Demand	<i>A prior requirement for 'tagging' datasets is to have an agreed list of concepts and definitions for describing natural capital, ecosystem services and benefits so that monitoring schemes can be tagged consistently.</i>
UK / Country Level Demand	<i>Maskell et al (2014) recommend developing a process that could be used by data providers to identify the relationships in their datasets to aspects of Natural Capital reporting and create a tool or search engine so they can be identified by others.</i>
<b>INVESTIGATING SYSTEMS AND QUANTIFYING DATA RELATIONSHIPS</b>	
UK / Country Level Demand	Collate existing information on UK Protected Area Network and provide recommendations on how this can be utilised in assessing and monitoring natural capital stocks and ecosystem service provision from protected sites.
Local Authorities	Establish a method for amalgamating knowledge collected through ground truthing of remote surveillance and monitoring to provide indication of accuracy and confidence in particular monitoring methods.
Business	Provide information, data and methods that can be used by different businesses to assess the trade-offs between short term productivity and wider ecosystem service provision.
Business	Identify information required to enable businesses to identify and monitor the different (dis)benefits between using green and grey infrastructure in mitigation or adaptation.
Business	Identify ways in which existing knowledge can be utilised to identify and monitor natural capital baselines and establish Key Performance Indicators for natural capital management and preservation.
UK / Country Level Demand	<i>From MAES: There is a need to improve the monitoring systems in order to incorporate the components of biodiversity with high capability to supply ecosystem services.</i>

UK / Country Level Demand	<i>Observations and data are required for validating and quantifying how suitable particular datasets are for monitoring and assessing benefits delivered by natural capital assets and ecosystem services.</i>
Business	<i>To simplify business data uses, a more detailed framework document is required. This would include: impact and dependency of business on natural capital, business applications of valuation, impacts and indicators, materiality and an accepted nomenclature for classification of natural capital metrics.</i>
Business	<i>There is an urgent need for trusted data that enables companies to make commercially interesting arguments for investing in natural capital.</i>
UK / Country Level Demand	Investigate whether monitoring for natural capital and ecosystem services also provides robust biodiversity monitoring, and identify risks and benefits associated with different approaches.
UK / Country Level Demand	<i>The system needs to make it easy for users to find and directly access data or data products that meet their specific requirements.</i>
UK / Country Level Demand	Explore options and conduct benefit analysis for developing a UK-wide 'hub' that provides open access and analytical tools.
Business	Provide data in a manner that supports businesses to better understand the factors affecting ecosystem services that contribute to declines in primary production beyond wider drivers, such as global climate change.
Local Authorities	Link data to existing policy frameworks to enable users seeking to meet policy objectives discover suitable data for informing decision support mechanisms.
<b>DATA FOR MODELS AND DECISION SUPPORT TOOLS</b>	
UK / Country Level Demand	Take steps to identify ways in which national and country level ecosystem and socio-economic datasets can be used collectively in tools or modelling to facilitate more effective monitoring of: societal impacts; goods and benefits being realised from natural capital; shifts in societal aspirations or attitudes; and wider anthropogenic behaviours and motivation influencing natural capital and ecosystems services.
UK / Country Level Demand	Identify existing data that can be used in models or assessments that monitor goods and benefits flows across varying temporal and spatial scales ( <i>potential join-up with business supply chain monitoring</i> ).
Local Authorities	Improve the compatibility between habitat network data and socio-economic data to enable incentives schemes to better meet different stakeholder needs and aspirations.

Business	Link existing surveillance and monitoring to Regional Planning Policy requirements to demonstrate how data can be used to inform planning strategies.
Business	Provide recommendations on how ecosystem monitoring information can be used to inform application of chemical treatments and interventions in agricultural systems to limit negative impacts on Natural Capital.
Business	Explore the potential application of monitoring and surveillance capabilities for assessing impact of particular land management practices on Natural Capital (e.g. ploughing and planting regimes on soil erosion or surface run-off).
Local Authorities	<i>Tools for linking local data into general, nationally available data products.</i>
<b>MONITORING OPPORTUNITIES</b>	
UK / Country Level Demand	Identify how best to increase the effectiveness of citizen science in monitoring activities, including identifying the scope to extend and improve capabilities of exiting volunteer and citizen networks using cost-effective technologies (e.g. online data repositories, mobile data devices) to enhance UK environmental monitoring programmes, and potentially beyond (e.g. collection of human health and well-being data).
Business	Identify key data series that will improve the monitoring of operational risks and inform future 'sustainable intensification' practices (e.g. pollinator monitoring, linking water quality monitoring with hydrological pathways and land management).
Business	Make business stakeholders more aware of the types of ecosystem indicators that are available for use in Monitoring and Surveillance. There may be potential for exploring how existing ecosystem indicators can be used to meet businesses Natural Capital monitoring and assessment aspirations (e.g. supply chain impact analysis).
Business	Provide recommendations on how existing monitoring data can be made more robust through intelligent use of Mobile Data Collection Systems and citizen science.
Business	Gain a better understanding of the types of information that Corporate Social Responsibility Departments are relying upon for accounting for environmental health, safety and risk and ascertain whether options exist for national surveillance and monitoring schemes to work in partnership with UK businesses to satisfy data requirements better .
UK / Country Level Demand	<i>The UK should prepare to make early use of Sentinel data for mapping stocks and change in land cover and habitats for natural capital assessments.</i>

Local Authorities	<i>Explore the use of citizens and community use for providing data using new technologies. One area for which locally sourced information may be particularly useful might be in relation to the use of “crowd-sourcing” to assess the value of cultural services (e.g. biodiversity, green spaces, recreation) provided by local ecosystems. Increased use of “environmental sensors” on mobile phone applications might also open up opportunities for local relevant measurements of other natural capital assets, such as air and water.</i>
Business	<i>The complexity of biodiversity and its measurement has led to companies using ‘land area’ as a proxy for biodiversity. Simple metrics need to be defined and measured that better reflect the key elements of biodiversity.</i>
<b>BETTER UNDERSTANDING OF DATA USE</b>	
Business	Data providers should seek to gain a more in-depth understanding into how different sectors are drawing upon existing data sources such as the MAGIC website, datasets and reports held by the statutory bodies, on-the-ground survey data, NBN Gateway, and aerial imagery etc.
UK / Country Level Demand	<i>A separate review of social and economic data in relation to the aims of the MAP should be completed by experts in the area.</i>
<b>FRAMEWORKS AND PARTNERSHIPS FOR COLLABORATION</b>	
Business	<i>Businesses need to work with each other and with the research community and government agencies to review existing data and coordinate new research to understand how their resource requirements and the commodities they produce impact upon natural capital and what interventions are most appropriate to their situation.</i>