



**Cyfoeth
Naturiol
Cymru**
**Natural
Resources**
Wales

**The State of Natural Resources
Report (SoNaRR): Assessment
of the Sustainable Management
of Natural Resources.
Technical Report.
Chapter 2. Understanding
drivers of change in natural
resource use**

Natural Resources Wales

Final Report

About Natural Resources Wales

We look after Wales' environment so that it can look after nature, people and the economy.

Our air, land, water, wildlife, plants and soil – our natural resources - provide us with our basic needs, including food, energy, health and enjoyment.

When cared for in the right way, they can help us to reduce flooding, improve air quality and provide materials for construction. They also provide a home for some rare and beautiful wildlife and iconic landscapes we can enjoy and which boost the economy.

But they are coming under increasing pressure – from climate change, from a growing population and the need for energy production. We aim to find better solutions to these challenges and create a more successful, healthy and resilient Wales.

Evidence at Natural Resources Wales

Natural Resources Wales is an evidence based organisation. We seek to ensure that our strategy, decisions, operations and advice to Welsh Government and others are underpinned by sound and quality-assured evidence. We recognise that it is critically important to have a good understanding of our changing environment.

We will realise this vision by:

- Maintaining and developing the technical specialist skills of our staff;
- Securing our data and information;
- Having a well resourced proactive programme of evidence work;
- Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and
- Communicating our evidence in an open and transparent way.

The State of Natural Resources Report (SoNaRR) Report Contents

This document is one of eight chapters of the State of Natural Resources Report.

| | |
|-----------|---|
| Chapter 1 | Introduction to the State of Natural Resources Report (SoNaRR): An assessment of sustainable management of natural resources |
| Chapter 2 | Understanding drivers of change in natural resource use |
| Chapter 3 | Summary of extent, condition and trends of natural resources and ecosystems in Wales |
| Chapter 4 | Resilient Ecosystems |
| Chapter 5 | Well-being in Wales |
| Chapter 6 | Identifying Unsustainable Management |
| Chapter 7 | Towards sustainable management of natural resources |
| Chapter 8 | Assessment of the sustainable management of natural resources |
| Annex | Technical Annex for Chapter 3 |
| Annex | Technical Annex for Chapter 7 (Part 1) |
| Annex | Technical Annex for Chapter 7 (Part 2) |
| Annex | Method for assigning confidence to evidence presented |
| Annex | Record of confidence assessments |
| Annex | Acronyms and Glossary of terms |

All of the SoNaRR documents can be downloaded from the NRW website:
www.naturalresources.wales/sonarr.

Recommended citation for this report:

Natural Resources Wales. 2016. State of Natural Resources Report (SoNaRR):
Assessment of the Sustainable Management of Natural Resources. Technical
Report. Natural Resources Wales.

Copyrights

All graphs, maps, tables and other images are © Natural Resources Wales unless
otherwise stated.

All maps containing the Wales boundary:
© Crown Copyright and database right 2016. Ordnance Survey licence number
100019741.

All maps containing marine aspects:
© British Crown and OceanWise Ltd, 2016. All rights reserved. License No. EK001-
20120402. Not to be used for Navigation.

Contents

- 2. Understanding drivers of change in natural resource use6
 - Introduction6
 - 2.1. Drivers of Change.....7
 - 2.2. Indirect Drivers7
 - 2.3. Direct Drivers.....10
 - Variability and change in climate.....11
 - Land use change and habitat change14
 - Nutrient enrichment and pollution of air, land and water15
 - Overexploitation of natural resources19
 - Invasive Non-Native Species, pests and diseases.....20
 - 2.4. What does this all mean?21
 - References for Chapter 2.....23

List of Figures

| | |
|---|----|
| Figure 2.1 The relationships between ecosystems, well-being and broader social and economic change..... | 6 |
| Figure 2.2 Greenhouse gas emissions from Wales by sector..... | 11 |
| Figure 2.3 Significant (Category 1 & 2) pollution incidents by source affecting air in Wales | 16 |
| Figure 2.4 Significant (Category 1 & 2) pollution incidents by source affecting water in Wales..... | 17 |
| Figure 2.5 Significant (Category 1 & 2) pollution incidents by source affecting land in Wales..... | 18 |
| Figure 2.6 Relationships between the drivers and broad habitats at a UK level. Also shows the trends at the time of writing the UK NEA..... | 22 |

2. Understanding drivers of change in natural resource use

Introduction

The purpose of this chapter is to provide an overview of the social, economic, cultural and technological drivers of change to natural resources and ecosystems in Wales.

How society operates through personal and political decision making influences the way and rate at which natural resources and ecosystems are used and therefore managed. This chapter analyses and describes the key 'drivers' affecting the use and management of natural resources and ecosystems in Wales. Figure 2.1, taken from the UK National Ecosystem Assessment (UK NEA), shows the relationships between ecosystems, well-being and broader social and economic change.

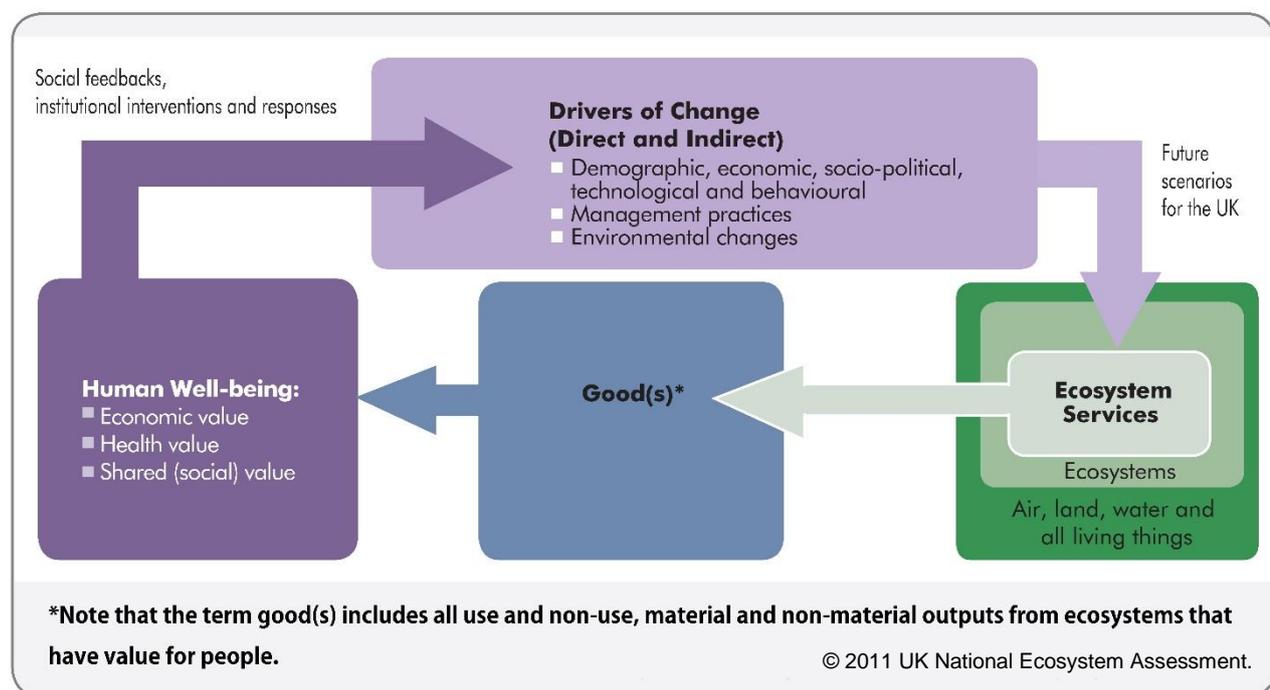


Figure 2.1 The relationships between ecosystems, well-being and broader social and economic change¹.

It is important to understand both the indirect and direct drivers of change and, where possible, their interrelationships and impacts. In line with the new ways of working set out in the Well-being and Future Generations (Wales) Act and Environment (Wales) Act, working with and managing those drivers will be critical to understanding the root causes of problems and designing interventions and management responses that help to:

- maximise the benefits for well-being in the long term, by showing the interaction between the delivery of different ecosystem services
- build more resilient ecosystems
- minimise negative impacts by showing the “invisible” ecosystem services and the interactions between them
- use natural resources more efficiently

Much of this chapter draws upon the conclusions of the UK National Ecosystem Assessment¹.

2.1. Drivers of Change

Drivers are natural or human-induced factors that cause changes to ecosystems and can be either direct (causing physical change that can be measured) or indirect (less measurable in terms of causality)^{2,3}. The combined effects of these drivers have resulted in significant changes in our natural resources and ecosystems throughout the UK since World War Two¹. Sustainable management requires a better understanding of these drivers to fully appreciate the root causes of unsustainable management.

2.2. Indirect Drivers

The key **indirect drivers** (UK NEA, 2011 – Chapter 3⁴) which have resulted in significant change (positive and negative) both for natural resources and ecosystems and their benefits are:

- Demographic changes
- Economic changes
- Socio-political changes, especially in policies and incentive mechanisms
- Cultural and behavioural changes – including purchasing preferences
- Technological changes

Whilst all of these indirect drivers influence and are influenced by global trends, it is important to understand the nuances within Wales that can help us identify opportunities for sustainable management.

Whilst Figure 1 offers a useful summary, it is very difficult to map all of the causal relationships between these drivers, the changes to ecosystems and impacts on society. There is inevitably a time lag between a specific social, economic or technological change and the resulting impacts on our ecosystems.

This report will not attempt to quantify in detail these indirect drivers as there are other reports that do this (such as economic forecasts, population trends, etc.). However, considering elements of these indirect drivers will be an important part of the assessment, in Chapters 6 and 7, of the extent to which the sustainable management of natural resources is being achieved.

Demographic changes

Population, age structure, and consumption patterns are important variables which influence trends in ecosystem condition². A growing population and changing household dynamics (such as a rise in single-occupancy households) require more energy and water, and can put additional pressure on land to provide for housing as well as food production. Welsh Government population projections show that the number of people living in our cities is likely to increase significantly over the next 20 years⁵ – Cardiff, Wrexham and Swansea will be particularly affected – with consequent impacts on urban ecosystems.

Some of these pressures can be managed, for example, by favouring redevelopment of brownfield land for housing, and more innovative design, such as walkable neighbourhoods, better insulation in buildings and water efficiency measures.

Economic changes

Market forces influence the proportion of land or marine areas under different uses. Food and timber imports and exports; cattle, sheep and dairy prices and renewable energy tariffs all affect the intensity of land and sea use with consequent impacts on the use and management of natural resources and ecosystems. Market forces shape and are shaped by the spatial distribution of settlements, transport routes and the density of human population.

Food and biomass from land and sea

Over 90% of land in Wales is used for agriculture and forestry⁶. Wales also has a significant freshwater and marine fisheries resource with £2.8 million (1,213 tonnes) of fish and £12.0 million (10,500 tonnes) of shellfish landed in Wales by UK vessels in 2014 (mainly scallops, whelks and crabs/lobsters)⁷. As global demand for food and other biomass rises, there is increasing demand for land and seas to be used for the provision of goods and services. Depending on how the food sector responds, this could put pressure on the resilience of ecosystems and displace the provision of other ecosystem services and the benefits derived from them⁸.

This report acknowledges that using land for food, fibre and biomass production is an essential part of natural resource use and management. But these land and sea uses do not have to be exclusive – sustainable land management can ensure the provision of other services and benefits. There are many examples of good practice guidance to ensure this, such as the UK Forestry Standard⁹, MSC Fisheries Standard¹⁰, and Code of Good Agricultural Practice¹¹.

Over the last 60 years, Wales has moved towards a knowledge based economy. Current policies promote low-carbon and high technology sectors. Most businesses in Wales are small and medium-sized enterprises (SMEs) – many linked to agricultural, forestry or tourism sectors. Some communities which previously prospered from primary and secondary industries have been left with high levels of long term unemployment, low levels of economic activity and a legacy of contaminated soils and polluted mine water.

Procurement and supply chain activities can have a major role in resource use and management with consequences for ecosystems. There are many examples of sustainable procurement policies that have been implemented to help minimise resource use and maximise wider social and environmental responsibility¹².

Socio-political changes

The evolution and development of legislation, regulation and policy, as well as associated financial incentives, have a significant impact on the condition and extent of ecosystems. Many of the legislative tools put in place over the last 60 years, both at the

UK and EU level, have served to address specific problems with the quality of biodiversity, air, land or water in isolation, or tried to ensure the continued supply of timber and food. These functional approaches to legislation or policy have often resulted in unintended consequences. For example, the impact in the past of production-based subsidies and capital grants for the agricultural sector has contributed significantly to increases in agricultural production, but has also led to habitat and species loss and/or the decline in populations of species as well as adverse impacts on soils, water quality and air ¹³.

With increased devolved powers in Wales, and the passing of the Well-being of Future Generations Act, Planning Act and Environment Act, there is greater opportunity to influence behavioural changes by organisations, communities and individuals in the future.

The UK referendum result supported the proposal to leave the EU. It is far too early to understand fully the implications of potential changes to environment, agriculture, fisheries and other policy and legislation on the natural resources of Wales, particularly given the current devolution settlement and the proposed additional powers set out in the Wales Bill. In the short-term all existing legislation and many funding streams will continue to remain in force until such time as the UK has left the European Union.

Cultural and behavioural changes

Knowledge, attitudes and purchasing preferences can have an influence on ecosystems. For example, travel choices directly impact on air quality. The media and, more recently, social media can also have a big influence on the attitudes and behaviours which impact on the environment. Growing public awareness of environmental issues can lead to change in political views.

There have been many positive changes in public behaviours towards minimising use of natural resources, such as the rise of domestic solar panel installations and increases in household recycling - Wales leads the UK in recycling municipal waste by a significant margin, achieving 56.2% in 2014/15¹⁴. These are particularly successful when they are accompanied by incentives (such as cost savings) or disincentives. An example of changing attitudes is the increase in time spent by people volunteering for environmental charities.

Technological changes

Mechanisation in farming and fisheries¹⁵ has long been associated with landscape and habitat change in the past, along with the development and use of chemicals to increase yield, reliability and quality of produce. More recently, technological innovation has led to the development of precision farming techniques, which allow more precise application of nutrients and pesticides while continuing to meet our food production needs.

A variety of new technologies have been developed for renewable energy and fuels; wind, solar and tidal energy, bio-digestion and biomass fuels have created new demands for land and sea use. These may have the potential to reduce fossil fuel use and present opportunities for enterprises based on permaculture, aquaculture and marine tourism.

Advances in technology for computer processing, crowd sourcing of data and the availability of satellite imagery have significantly increased the opportunities for social and environmental modelling and analysis, which future SoNaRR reports will be able to utilise better.

2.3. Direct Drivers

The indirect drivers set out in 2.1 have influenced the following direct drivers which mirror those set out in the UK NEA, 2011^a:

- Variability and change in climate
- Land and sea use change, leading to fragmentation of habitats and biodiversity loss
- Nutrient enrichment and pollution
- Over exploitation of natural resources
- Introduction of invasive species, pests and diseases

These direct drivers are often interlinked - changes in one potentially lead to changes in another.

Both direct and indirect drivers vary in their importance in influencing change within and among natural resources and ecosystems and their benefits, but in general the scale and extent of their impact is increasing as time goes on.

Why are we using these drivers?

Using these drivers helps us to focus on how the resilience of ecosystems is being affected. They have been determined by previous studies which observed the key changes occurring in our environment. We will need to continue to refine our understanding of how they play out in Wales.

We will focus on where the resilience of ecosystems and the benefits we get from them are at greatest risk from these drivers due to unsustainable management. However, we are not attempting to prioritise them.

The objective here is **not** to remove all pressures – we will always need natural resources and ecosystems to deliver benefits, such as food, water, timber and energy. The objective is to better understand how to manage them in more sustainable ways so that:

- Risks and opportunities are known and managed
- The pressures are managed
- The benefits are sustained for future generations, so that they continue to have a choice about the way natural resources are managed

It is therefore important to recognise which framework of regulation and market forces, within which we manage natural resources, offers the greatest opportunity to manage threats to ecosystem resilience and to maximise contributions to well-being.

^a Chapter 20 of the UK NEA set out more specific drivers of biodiversity loss in Wales

The next part of this chapter breaks down the five direct drivers further to summarise how those drivers manifest themselves in Wales. Chapter 3 then looks at the state of natural resources and ecosystems, using the UK NEA broad habitat types, and discusses their extent, condition and trends. Chapter 4 looks more specifically at how we use that information to get a better understanding of resilience.

Variability and change in climate

The rising global concentration of greenhouse gases (GHGs) in the atmosphere is driving climate change. The concentration of carbon dioxide has recently crossed the 400 ppm threshold. In its most recent assessment, the Intergovernmental Panel on Climate Change (IPCC) concluded:

Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems ¹⁶.

Defra publishes an annual Greenhouse Gas Inventory for the UK which reports emissions of greenhouse gases to the atmosphere, including statistics for Wales. While global emissions have risen steadily over the last few decades, Welsh emissions have shown some decline since 1990 (Figure 2.2).

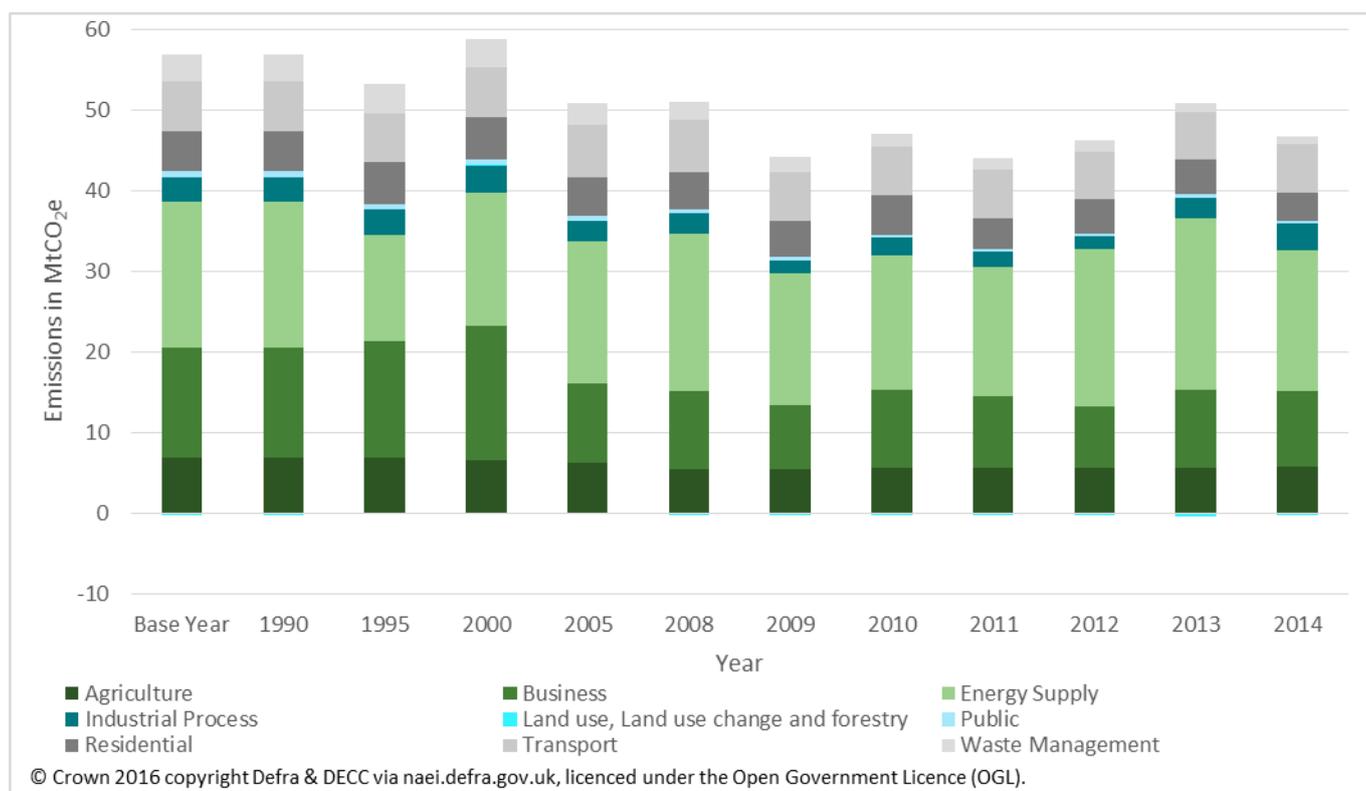


Figure 2.2 Greenhouse gas emissions from Wales by sector¹⁷.

What are the key climatic trends and projections?

There is clear evidence of climate change in Wales:

- Daily mean temperature rose by 0.7°C between 1914 and 2006,
- There has been a 22.4 day reduction in air frosts per year between 1961 and 2006
- There has been a significant 24% decline in summer rainfall in Wales between 1914 and 2006
- heavy precipitation events have increased in winter and decreased in summer between 1961 and 2006¹⁸

In 2009, climate projections for the UK were published for three emissions scenarios (high, medium and low) and data was presented for seven overlapping 30-year periods (2010-39 to 2070-99)¹⁹. Future climatic changes are projected to be greater than those experienced to date. The Welsh Government summarised the projected climatic changes for Wales²⁰ as:

- More frequent and intense rainfall events
- Hotter, drier summers
- More extremely warm days
- Milder, wetter winters
- Ocean acidification
- Less snowfall and frost

The three UKCP09¹⁹ emissions scenarios are viewed as equally plausible, so a range of risk and severity of impact are possible. To provide context here, if the international commitments to emissions reduction made in Paris in December 2015 were met, this would likely approximate to the Medium emissions scenario.

What are the key risks and impacts ?

Under the Climate Change Act 2008, the UK Government is required to publish a Climate Change Risk Assessment (CCRA) covering the UK every five years. Using the climate projections to 2080, the report for Wales²¹ identified the following key **risks**:

- Changes in soil conditions, biodiversity and landscape due to warmer, drier summers
- Reductions in river flows and water availability during the summer, affecting water supplies and the natural environment
- Increases in flooding on the coast and inland, affecting people, property and infrastructure
- Changes in coastal evolution including erosion and coastal squeeze, affecting beaches, intertidal areas and other coastal features
- Changes in species including a decline in native species, changes in migration patterns and increases in invasive species
- Increases in the risk of pests and diseases affecting agriculture and forestry. The risk to livestock was a particular concern

It also identified the following **opportunities**:

- Increases in grass yields, allowing a potential increase in livestock production

- Increases in tourist numbers and a longer tourist season
- Reductions in cold-weather related illness and death

The scientific evidence of climate change impacts in the UK has been reviewed and summarised in a series of report cards covering water, biodiversity, infrastructure, human health, agriculture and forestry²².

The UK Climate Change Risk Assessment 2017 (UK CCRA17) Synthesis Report²³ has updated this analysis and identified the top areas of inter-related climate change risks for the United Kingdom. More action is needed to address:

- Flooding and coastal change risks to communities, businesses and infrastructure
- Risks to health, well-being and productivity from high temperatures
- Risk of shortages in the public water supply, and for agriculture, energy generation and industry
- Risks to natural resources, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity
- Risks to domestic and international food production and trade

More research is required to understand new and emerging pests and diseases, and invasive non-native species affecting people, plants and animals.

The UK CCRA17 Evidence Report Summary for Wales²¹ identifies 56 climate-related risks facing Wales. Of these, 43 impact either on the natural environment or on the services that it provides. The particular impact of each of these risks is discussed in Chapter 3 and Section 5.2 of this SoNaRR report, where they can be considered in context.

In summary, the challenges posed by climate change require natural resource management practices that:

- Reduce net GHG emissions – for example: using energy and resource efficient practices and renewable energy generation to minimise use of fossil fuels; managing ecosystems to maintain stocks and enhance sequestration of carbon
- Maintain vital ecosystem services by improving the resilience of ecosystems
- Design adaptive management responses that are flexible and help Wales to prepare better for future impacts by harnessing opportunities and minimising risks.

There are opportunities to reduce greenhouse gas emissions, for example, from smarter technology and making use of Wales' 'flow resources' – wind, tides and sea currents – as well as nature-based solutions such as restoration of GHG emitting degraded peat bogs and woodland planting. This can help make Wales more resilient to higher temperatures, extreme weather events and the risk of flooding and drought. (Chapter 5 explores these benefits in more detail).

Land use change and habitat change

Ecosystems by their nature are dynamic and evolving systems. The UKNEA identifies that:

human-induced change in the use and cover of habitats has been a key driver in altering ecosystem extent and condition of all habitat types and the ecosystem services they provide”.

How are land use and habitat change observed?

The Countryside Survey²⁴ has been one method to monitor habitat and land use change nationally. A number of other baseline survey datasets include: the Phase 1 Habitat Survey of Wales²⁵, the more detailed Phase 2 level surveys for selected habitats; local monitoring programmes (such as those used for Natura 2000 sites^{26, 27}) and LANDMAP²⁸(the national programme of landscape assessment in Wales). Only recently have concerted attempts been made to describe, quantify and map the range of services that we obtain from various land uses. These allow us better to evaluate the impacts of land use and habitat change on ecosystems and their benefits, especially where detailed data can be collected and collated from sentinel sites.

What are the key risks?

Changing land management practices can lead to the deterioration or loss of ecosystems as well as to their enhancement. For example, the role and management of woodland has led to long term changes in woodland ecosystems. Outside the Welsh Government Woodland Estate (WGWE), less than a quarter of all woodland is under any systematic management^{29, 30}. There are a number of societal and economic explanations for this, but clear opportunities for maximising benefits could be missed if woodlands are not appropriately managed (see Chapter 5).

Some improvements in the diversity of upland vegetation have been detected as a result of changing land management²⁷. Attempts are now being made to promote the restoration of upland habitats for their carbon storage, water quality and water storage benefits.

Development is a big driver of land use and habitat change in certain areas of Wales. The expansion of settlements, commercial and industrial development, expansion of quarries, road improvements, onshore and offshore wind-farms and recreational developments have been key drivers of landscape and seascape change in Wales.

Examples in the marine environment are renewable energy installations such as wind-farms, tidal lagoons and arrays of wave and tidal stream devices. These can affect the seabed adversely in a number of ways, including causing habitat loss or alteration. Conversely they have potential to create new habitat or exclusion zones. Installations require cabling to a grid connection, which exerts a secondary pressure on subtidal habitats. Modelling suggests that tidal lagoon developments and large arrays of tidal stream devices could affect some hydrodynamic and sediment processes^{31 32 33}.

Climate change is likely to amplify and complicate the impacts of land use and habitat change as set out in the section above. Changes in the natural range of species are

already being observed, for example the Dartford Warbler spreading within Wales. There are also changes in migration patterns, for example reductions in overwintering wader populations on Welsh estuaries and increases in invasive species³⁴.

When managing land-use change and habitat change it is essential to explore the opportunities that nature-based solutions can offer. Nature-based solutions (working with natural processes – such as the use of wetlands to help clean up water) can provide sustainable, cost-effective, multi-purpose and flexible alternatives to help address a variety of societal challenges. They can maximise benefits for well-being and maintain and enhance resilience of ecosystems. This is explored further in Chapter 5.

Nutrient enrichment and pollution of air, land and water

Pollution is the effect of any substance or material that causes harm to human health and the environment. It can be emitted through air, water or on land. Pollution can be point-source (from a particular installation or event) or diffuse (occurring in many places, where the exact cause or source is unknown). Nutrient enrichment generally refers to nitrogen, phosphorus and sulphur (and their derivatives) limiting the productivity of ecosystems.

How are levels of pollution and nutrient enrichment observed?

NRW and other public bodies operate a number of routine monitoring programmes to assess:

- Water chemistry and pollutants in rivers, lakes, groundwaters and coastal waters
- Physical and biological condition of terrestrial and aquatic habitats
- Air quality

Whilst there is a selective sampling programme as part of Glastir monitoring, there is no comprehensive monitoring programme for soils across the whole of Wales.

NRW records and responds to pollution incidents across Wales.

What are the key risks?

Air pollution

Air pollution derives from a number of sources (Figure 2.3), including industry, transport, agriculture, and energy production. Emissions of many air pollutants have decreased substantially in Wales and across Europe in recent decades, resulting in improved air quality. However, air quality problems persist and air pollutant concentrations remain high in some areas. For example, nitrogen compounds and particulate matter are key contributors to poor air quality in urban areas. Air pollution also adversely affects grasslands, soils and all types of woodland, which can present risks to a wide range of potential future benefits. (Noise in the land, freshwater and marine environments can also be an issue – creating disturbance for both people and other species living there).

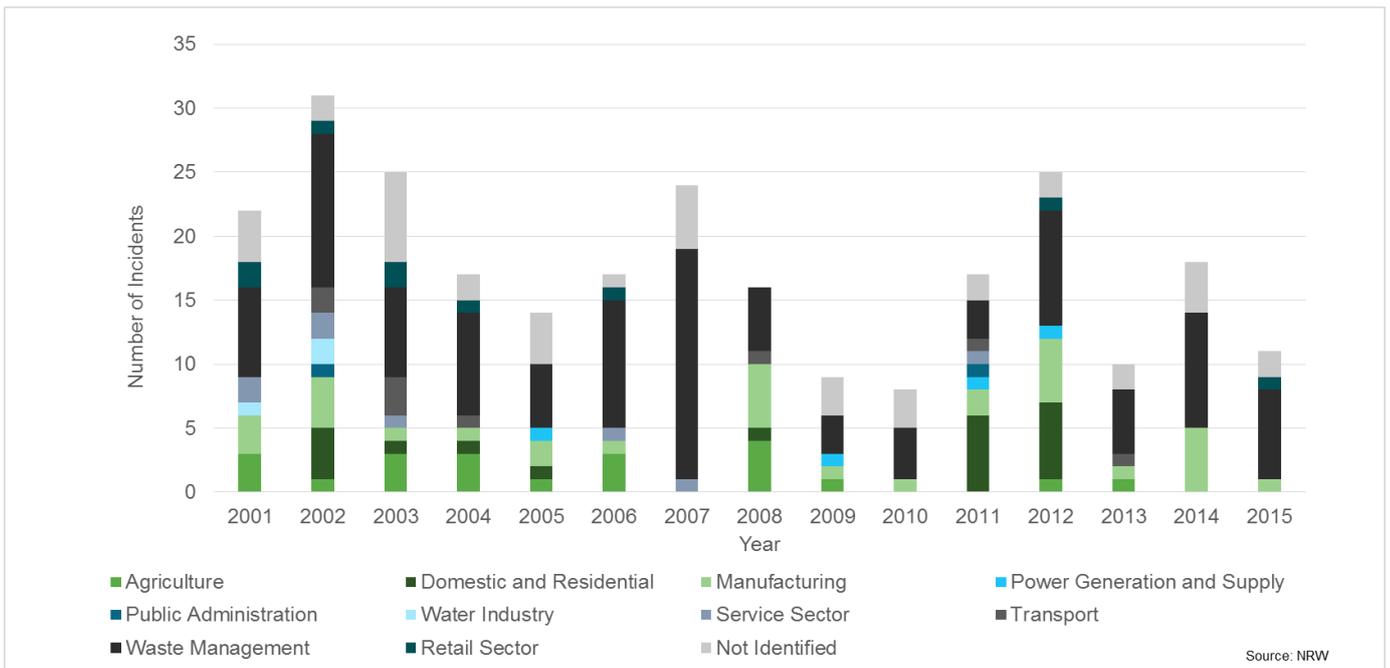


Figure 2.3 Significant (Category 1 & 2) pollution incidents by source affecting air in Wales³⁵

Source: NRW

Nutrient enrichment and pollution of water

Wales' River Basin Management Plans³⁶ identify four significant water management issues under this driver which are: pollution from sewage and waste water; pollution from towns, cities and transport; pollution from rural areas and pollution from mines.

Pollution from sewage and waste water can introduce large amounts of nutrients, such as phosphorus and nitrates as well as ammonia, bacteria and other substances into waterways. Poorly located or maintained sewerage systems have the potential to pollute surface and ground waters. In un-sewered catchments, areas with a high density of private systems present a risk of nutrient enrichment and pollution.

Surface water run-off from urban areas can carry pollutants, toxic substances and waste water from properties that are misconnected to surface water drains rather than sewers. Liquid leaching from poorly constructed and managed landfill sites can pollute the land, groundwater and waterways. Although recovering, acidification of upland lakes and rivers remains a significant pressure in Wales. The cause of acidification is the emission of sulphur and nitrogen from a range of sources, including power stations and refineries, transport and shipping, the burning of domestic fuel, and releases from agriculture.

In rural areas, pollution by nitrates, phosphates and soil entering surface waters can lead to poor ecological status in rivers, lakes and other freshwater habitats. Both point source and diffuse pollution risks have increased. Diffuse pollution also arises from the trampling of riverbanks and the poaching of fields by livestock. Recorded pollution incidents from all sources affecting water quality are shown in Figure 2.4.

Groundwater discharged from abandoned mines is often contaminated with dissolved metals, such as iron, lead, copper, zinc and cadmium. This contaminated water can find its way into adjacent rivers and subsequently to estuarine and coastal waters.

Further information on the major sources and impacts of water pollution, and prioritised action to address them, is contained in the River Basin Management Plans.

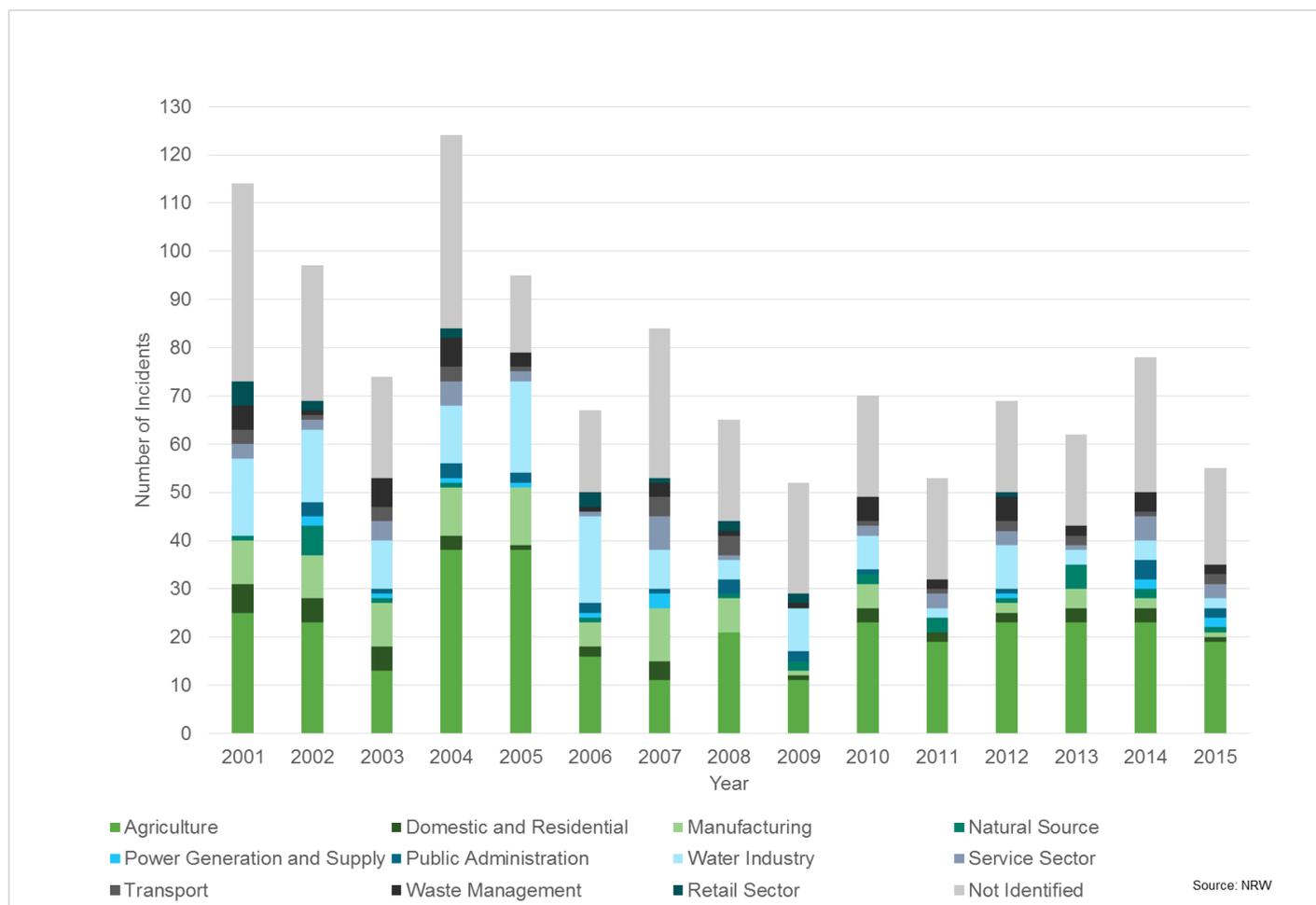


Figure 2.4 Significant (Category 1 & 2) pollution incidents by source affecting water in Wales³⁵.

Pollution in the Marine Environment

Inputs of potentially harmful discharges and activities in estuarine and coastal waters are assessed by a wide range of legislative responsibilities which are collated within River Basin Management Plans every 6 years. The marine environment receives inputs from a wide range of sources including direct discharges from sewage treatment works and industry as well as inputs from rivers and catchments. Inputs include nutrients, chemicals and microbiological contamination. The marine environment also acts as an end point for litter from a variety of sources, including microplastics, which can originate from sewage systems or arise from the fragmentation of larger plastic items. Further monitoring and research in the marine environment is required to fully understand the resultant impacts.

Nutrient enrichment and pollution of land

Pollution incidents on land occur from poor management practices. Some of the more commonly reported incidents include slurry spills, illegal dumping and fly tipping, and waste fires (which have an impact on air quality). Recorded pollution incidents from all sources affecting land quality are shown in Figure 2.5.

Changes in grazing regimes can result in both positive and negative impacts. Increased stocking rates can increase farm profitability, enabling further investment in pollution mitigation measures, such as slurry store expansion. However, where land is currently more intensively managed, a reduction in the stocking levels can help reduce run-off and erosion, improve water quality, reduce flooding and increase baseflows and enhance carbon storage. Stock reduction can also improve the permeability of compacted land, reducing the risk of flooding and low river flows.

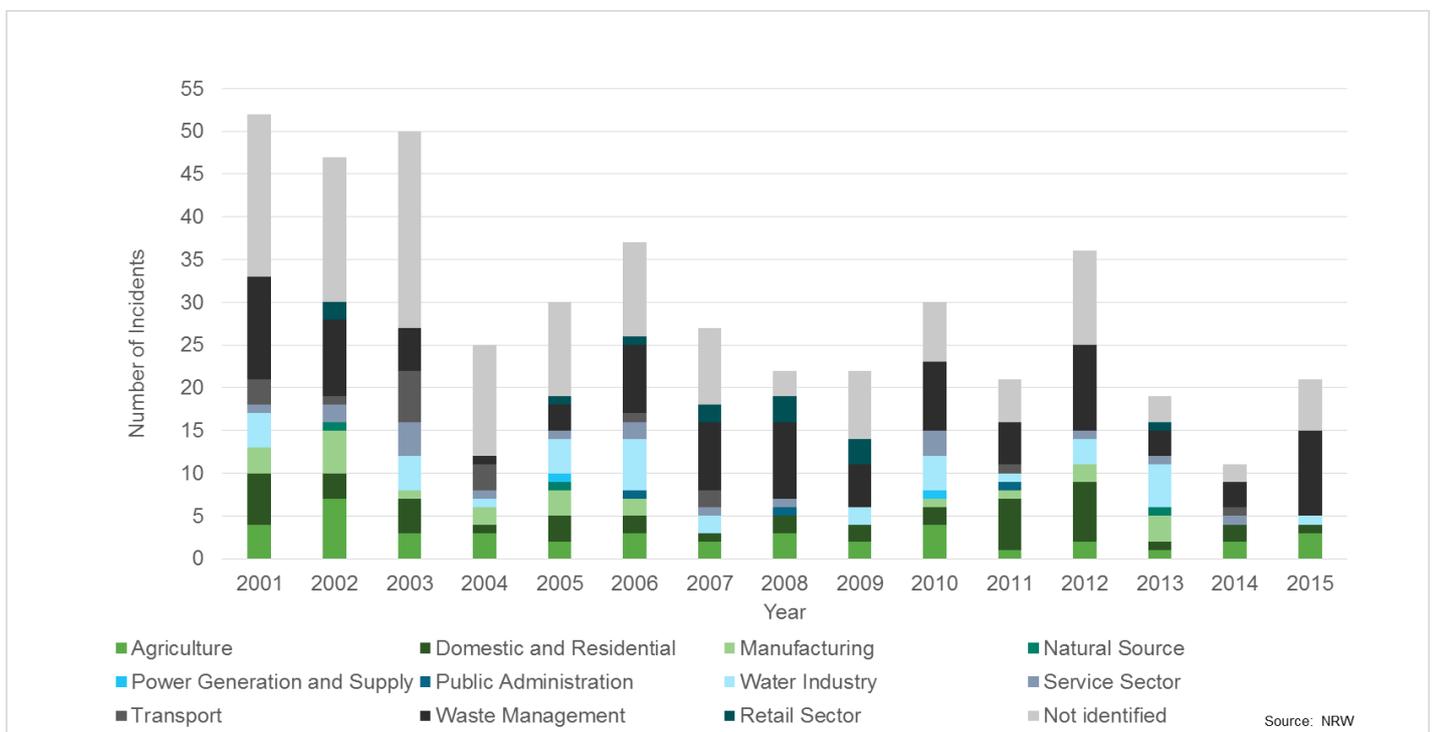


Figure 2.5 Significant (Category 1 & 2) pollution incidents by source affecting land in Wales³⁵.

There are opportunities to address the pollution and chemical changes to our natural resources, for example, through redesigning systems to better deal with waste or by-products. This includes the opportunity to manage waste through processes that both recover energy and improve the ability to manage pollutants. Another example might be the potential opportunities for agricultural enterprises to save costs by keeping fertilisers on the land and preventing loss to water and air.

Overexploitation of natural resources

The intensity of natural resource use has already severely affected habitat quality and biodiversity³⁷. The potential for future generations to enjoy the same benefits from natural resources and ecosystems that we experience today could reduce if we continue to use or manage our land at an intensity which leads to over-exploitation of stocks.

How is the exploitation of natural resources observed?

We have little information on over-exploitation, or the point at which society's use of natural resources becomes unsustainable. Typically, we could look at production figures for primary resources, such as timber, commercial fish stocks, or aggregate and soil extractions; consumption figures, such as energy use, waste produced, and water abstraction; and secondary uses, such as livestock densities and recycling rates. However, it is difficult to assess when sustainable utilisation becomes unsustainable. This is why we need to improve our understanding of ecosystem resilience (See Chapter 4).

Ecological foot-printing sets out to measure the impact of our consumption and to compare this to estimates of what the planet can cope with. Carbon footprints have also been constructed to measure our use of fossil fuels. The Office for National Statistics is developing experimental environmental accounts that measure our use of raw material.

Along with land-uses and consequential habitat changes, the way we use and exploit our natural resources is the most prominent pressure on biodiversity³⁷. Increased intensity of use and overexploitation also reduce the potential of our habitats to adapt to the changing climate.

What are the key risks?

Society's needs, the demand for essential and material goods, and inappropriate or inadequate regulation or incentives can drive over-exploitation. There are significant measures in place to plan, manage or limit the extent and amount of resources used. For example, there are strategic planning and assessment processes, such as Strategic Environmental Assessment (SEA), plan level Habitats Regulations Assessment (HRA), water abstraction licences, waste management permits and marine fisheries quotas.

Overfishing is an historical example of an unsustainable rate of resource use. For example, there were major fisheries for native oysters in South Wales in the 19th Century but these had collapsed by the early 20th Century, possibly as a result of over-fishing, pollution and disease. Learning from historical events is important to help inform more sustainable management.

There will always be a need for our natural resources to deliver benefits – so we need to ensure that we do not diminish the resilience of ecosystem to the point where they can no longer deliver those benefits. The key to this is reducing unnecessary demand and finding opportunities for firms to develop markets for current wastes and recycled materials, moving us to a more circular economy.

Anti-social behaviour, such as fly-tipping and arson, may also be considered over-exploitation. As well as the potential for an impact on ecosystems, they can prevent us from maximising the benefits we get from them (for example, fly-tipping could deter the local community from using a green space).

Invasive Non-Native Species, pests and diseases

Invasive non-native species or INNS are broadly defined as species whose introduction and/ or spread threaten biological diversity and have other unforeseen impacts. They are generally species introduced by human action that cause negative impacts and have become established through a period of expansion in range and population to become self-sustaining.

How is the spread of INNS, pests and diseases observed?

There is some location specific information for some INNS but this distribution knowledge is patchy, particularly on a Wales-wide basis. However, we know INNS are a risk in Wales because of the impacts that can be observed from current INNS - especially those which have become well established and increasingly widespread such as Himalayan Balsam or Japanese Knotweed. The GB Non Native Species Secretariat is also preparing GB level risk assessments for new INNS. We want to build more comprehensive knowledge about where INNS are and about the likely rate of or risk of spread. We need to develop more sophisticated tools and techniques to support this.

What are the key risks?

INNS are an increasingly significant and growing problem which have negative effects on our economy, environment and our health. The UK NEA notes the impact of INNS is expected to intensify in the coming decades.

Some of the key impacts include:

- **Environmental:** Disrupting habitats and ecosystems, preying on or out-competing native species, spreading disease and interfering with the genetic integrity of native species.
- **Economic:** The current economic cost is a result of impacts on the operation and production activities of many sectors, including agriculture, transport, construction, aquaculture, tourism, recreation and utilities like water companies.
- **Social:** Some species (for example giant hogweed) cause problems to human health or are a nuisance to landowners by damaging property (e.g. Japanese knotweed). Some invasive plants (e.g. floating pennywort) can clog reservoirs, lakes or canals, preventing access for navigation and recreation, including angling.

Approximately 10-15% of non-native species in Great Britain cause significant adverse impacts³⁸, and INNS in Wales already cost at least £125 million to tackle annually³⁹. The economic impact is expected to increase over the next few decades as INNS become more widespread, exacerbated by a combination of climate change and increased national and global movement of people and goods. Studies indicate that an exponential increase in control costs can be expected as an invasion progresses³⁹.

This underlines the importance of taking early intervention to:

- Prevent the spread of high impact species
- Reduce the risk of new introductions
- Raise awareness and influence behaviour

We also need to create more effective means of detecting and monitoring the spread of INNS in Wales. These actions require a collaborative and integrated approach across all sectors and will help secure cost savings from long-term expected impacts.

Plant Health policies and regulation are designed to prevent the introduction or spread of serious plant pests and diseases which threaten agriculture and the environment. Both native and introduced trees in Wales are potentially susceptible to a wide range of pests and pathogens.

In terms of pests and disease, the use of chemicals such as pesticides, vermicides or veterinary products can impact negatively on a number of insects and in turn affect both the food chain and, potentially, pollination services. However, perhaps the real issue behind the trends in use are the pests and pathogens that the chemicals are being used to protect against in the first place. There have been significant developments in non-chemical alternatives, but climate change could still increase demand for chemicals, whether for animal health and welfare, or plant protection.

By working collaboratively and taking preventative actions, we can help create ecosystems that are more resilient to future risks and save business and public sector money.

2.4. What does this all mean?

The table below from the UK NEA (Figure 2.6) shows the relative relationships between each of the direct drivers and the UK broad habitats. It shows where pressures were considered most acute at the UK level. In some localities in Wales the trends may be different to those reported at a UK level.

As many of the datasets underpinning the assessment are still the most recent, the main messages will not have changed significantly since the UK NEA.

For SoNaRR, this analysis helps to identify the areas of greatest risk in terms of the resilience of ecosystems. By better understanding the drivers of change and particularly the markets and regulatory frameworks within which they operate, we can help prioritise where a change of approach is needed.

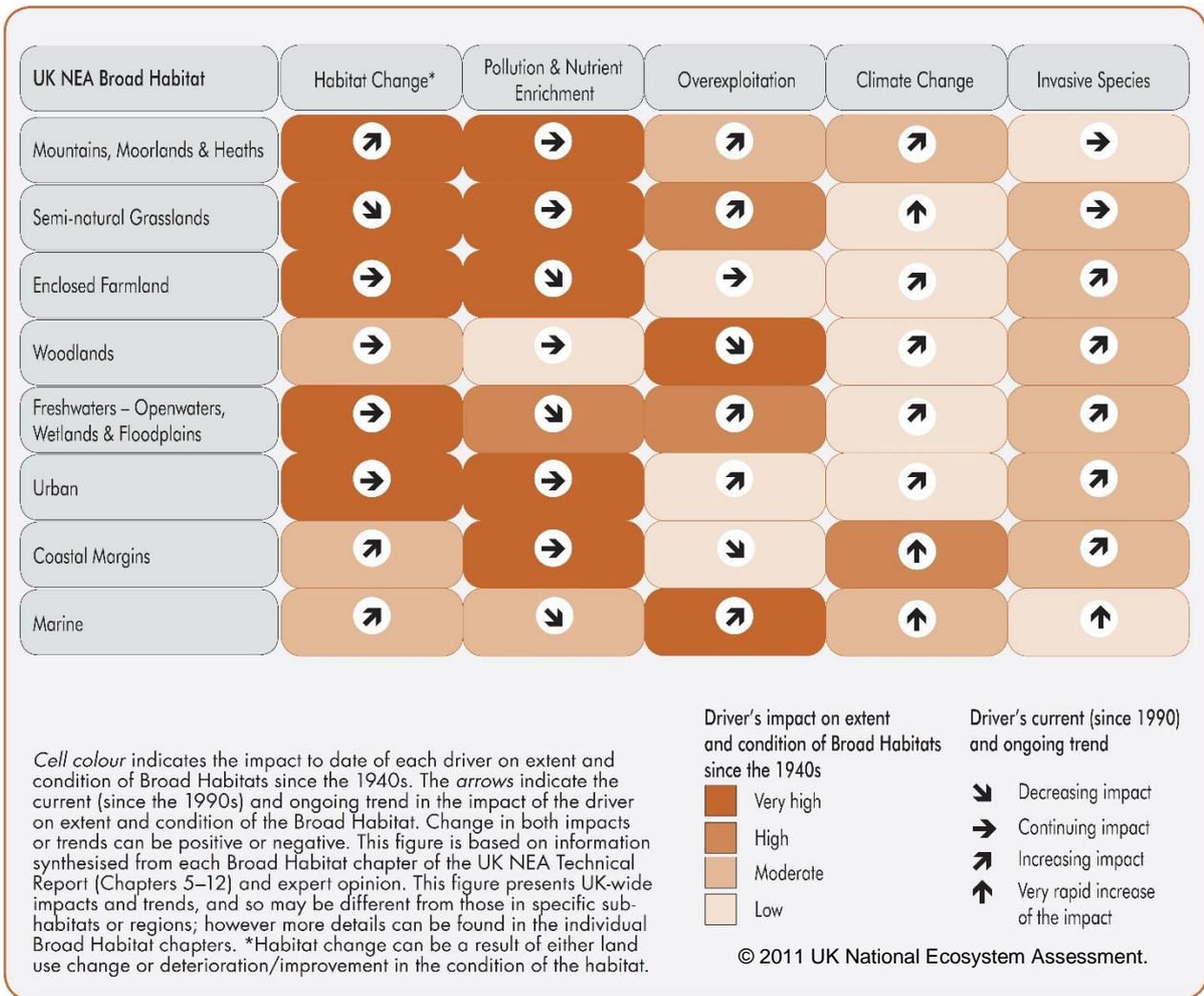


Figure 2.6 Relationships between the drivers and broad habitats at a UK level. Also shows the trends at the time of writing the UK NEA⁴.

References for Chapter 2

(“Accessed” refers to the date the link was last accessed)

-
- ¹ UK NEA. 2011. The UK National Ecosystem Assessment (UK NEA) – Technical report. Cambridge, UNEP-WCMC
- ² Nelson GC, Bennett E, Berhe AA, Cassman KG, DeFries R, Dietz T, Dobson A, Dobermann A, Janetos A, Levy M, Marco D, Nakićenović N, O’Neill B, Norgaard T, Petschel-Held G, Ojima D, Pingali P, Watson R & Zurek M. 2005. *Drivers of change in ecosystem condition and services. Ecosystems and Human Well-being: Scenarios*. (eds S.R.Carpenter, P.L. Pingali, E. Bennett, & M. Zurek). Island Press, Washington D.C., USA. pp. 173–222.
- ³ MA (Millennium Ecosystem Assessment). 2005. *Ecosystems and Well-being: biodiversity synthesis*. World Resources Institute, Washington D.C., USA. pp. 86.
- ⁴ UK NEA. 2011. The UK National Ecosystem Assessment (UK NEA) – Technical report. Chapter 3 Drivers of Change in UK Ecosystems and Ecosystem Services. Cambridge, UNEP-WCMC.
- ⁵ Welsh Government, Statistics for Wales. 2013. *Local Authority Population Projections for Wales, July 2013*.
- ⁶ Welsh Government, Statistics for Wales. 2015. *June 2015 Survey of Agriculture and Horticulture*.
- ⁷ Welsh Government. 2015. *Wales’ Marine Evidence Report* [online]. Available at: <http://gov.wales/topics/environmentcountryside/marineandfisheries/marine-planning/other-supporting-evidence/wales-marine-evidence-report/?lang=en>. [Accessed 12th July 2016].
- ⁸ Bateman IJ. 2011 *Economic Values from Ecosystems*. [Chapter 21]. In: UK National Ecosystem Assessment. 2011. Understanding nature’s value to society. Technical Report. Cambridge, UNEP-WCMC, 1045-1066.
- ⁹ Forestry Commission. 2011. The UK Forestry Standard. ISBN: 978-0-85538-830-0. Available at: <http://www.forestry.gov.uk/ukfs>.
- ¹⁰ Marine Stewardship Council. 2015. Marine Fisheries Standard and Guidance V2.0. Available at: <https://www.msc.org/documents/scheme-documents/fisheries-certification-scheme-documents/fisheries-standard-version-2.0>.
- ¹¹ Welsh Assembly Government. 2011. The Code of Good Agricultural Practice for the Protection of Water, Soil and Air for Wales. Available at: <http://gov.wales/topics/environmentcountryside/farmingandcountryside/farming/code-good-agricultural-practice-cogap/?lang=en>. [Accessed 19th August 2016].
- ¹² DEFRA. 2006. Procuring the Future Sustainable Procurement National Action Plan: Recommendations from the Sustainable Procurement Task [online] Available at: <http://www.wrap.org.uk/content/sustainable-procurement>.
- ¹³ Donald PF, Pisano G, Rayment MD, Pain DJ. 2002. The Common Agricultural Policy, EU enlargement and the conservation of Europe’s farmland birds. *Agriculture, Ecosystems & Environment* 89 (3), 167-182.
- ¹⁴ Welsh Government. 2015. Local authority municipal waste management report for Wales, 2014-15, [online]. Available at: <http://gov.wales/statistics-and-research/local-authority-municipal-waste-management/?tab=previous&lang=en>. [Accessed 29th July 2016].
- ¹⁵ Clarke S & Tulley O. 2014. BACI monitoring of effects of hydraulic dredging for cockles on intertidal benthic habitats of Dundalk Bay, Ireland. *Journal of the Marine Biological Association of the United Kingdom*, 94, pp 1451-1464.
- ¹⁶ IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. Available at: <http://www.ipcc.ch/>
- ¹⁷ Salisbury E, Hampshire K, Brook R, Buys G, Bailey R, Thistlethwaite G, Walker C, Wakeling D, Brown P, Pang Y & Cardenas L. 2016. Greenhouse gas inventories for England, Scotland, Wales and Northern Ireland: 1990-2014. National Atmospheric Emissions Inventory. Aether and Ricardo-AEA Report to DECC, Scottish Government, Welsh Government and Northern Ireland Department for Agriculture, Environment and Rural Affairs. Report number: Ricardo Energy & Environment/R/3463.
- ¹⁸ Jenkins, GJ, Perry, MC, Prior MJO. 2009. *The climate of the United Kingdom and recent trends*. Met Office Hadley Centre, Exeter, UK. p.121.
- ¹⁹ The Environment Agency, UK Meteorological Office. 2016. *UKCP09: UK climate projections* [Online] Available at: <http://ukclimateprojections.metoffice.gov.uk/> [Accessed 7th September 2016]
- ²⁰ Welsh Assembly Government. 2009. *Climate Change: its impacts for Wales* [online]. Available at:

<http://gov.wales/topics/environmentcountryside/climatechange/publications/impactsforwales/?lang=en>

²¹ Committee on Climate Change. 2016. *UK Climate Change Risk Assessment 2017 Evidence Report, Summary for Wales* [online]. Available from: <https://documents.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Wales-National-Summary.pdf> [Accessed 29th July 2016]

²² NERC. 2016. *LWEC - Climate change impacts report cards* [online]. Available at: <http://www.nerc.ac.uk/research/partnerships/lwec/products/report-cards/> [Accessed 7th September 2016]

²³ Committee on Climate Change. 2016. *UK Climate Change Risk Assessment 2017. Synthesis report: priorities for the next five years*. Available from: <https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017/synthesis-report/>. [Accessed 24th August 2016].

²⁴ *Countryside Survey 2007: Results for Wales* [online]. Available from: <http://www.countryside.gov.uk/outputs/wales-results-2007> [Accessed on 7th September 2016]

²⁵ Blackstock TH, Howe EA, Stevens JP, Burrows CR & Jones PS. 2010. *Habitats of Wales: a comprehensive field survey, 1979-1997*. Cardiff: University of Wales Press.

²⁶ Stevens DP, Smith SLN, Blackstock TH, Bosanquet SDS & Stevens JP. 2010. *Grasslands of Wales. A survey of lowland species-rich grasslands, 1987-2004*. University of Wales Press, Cardiff.

²⁷ Centre for Ecology and Hydrology. 2016. Glastir Monitoring and Evaluation Programme [online]. Available from: <https://gmep.wales/> [Accessed on 7th September 2016]

²⁸ NRW. 2016. *LANDMAP – the Welsh Landscape baseline* [online]. Aberystwyth: Natural Resources Wales <https://naturalresources.wales/guidance-and-advice/business-sectors/planning-and-development/evidence-to-inform-development-planning/landmap-the-welsh-landscape-baseline/?lang=en> [Accessed 19th August 2016]

²⁹ Welsh Assembly Government. 2010. *Policy Position in support of Woodlands for Wales, the Welsh Assembly Government's strategy for woodlands and trees. Welsh woodlands – their extent, nature and character*. Available at: <http://gov.wales/docs/drah/publications/130424-welsh-woodland-en.pdf> [Accessed on 7th September 2016]

³⁰ Welsh Assembly Government. 2009. *Woodlands for Wales. The Welsh Assembly Government's Strategy for Woodlands and Trees*. Available at: <http://gov.wales/docs/drah/publications/090324-woodlands-for-wales-strategy-en.pdf> [Accessed on 7th September 2016]

³¹ Neill SP, Litt EJ, Couch SJ, Davies AG. 2009. The impact of tidal stream turbines on large-scale sediment dynamics. *Renewable Energy* 34, 2803-2812.

³² Ramos V, Carballo R, Sanchez M, Veigas M, Iglesias G. 2014. Tidal stream energy impacts on estuarine circulation. *Energy Conversion and Management* 80, 137–149.

³³ DECC. 2010. *Severn Tidal Power - Hydraulics and Geomorphology Topic Paper* [online]. Bristol: Parsons Brinckerhoff Ltd. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69902/39_Hydraulics_and_Geomorphology_-_NTS.pdf [Accessed 11th July 2016]

³⁴ Morecroft MD, Speakman L. 2015. *Biodiversity Climate Change Impacts Summary Report. Living With Environmental Change*

³⁵ NRW. 2016. Pollution incidents affecting air. Internal database. Natural Resources Wales.

³⁶ NRW. 2016. *River Basin Management Plans* [online]. Natural Resources Wales. Available at: <https://naturalresources.wales/evidence-and-data/research-and-reports/water-reports/river-basin-management-plans-published/?lang=en> [Accessed 7th September 2016]

³⁷ EEA. 2015. *The European environment – state and outlook 2015: synthesis report*. European Environment Agency, Copenhagen.

³⁸ GB non-native species secretariat. 2015. *The Great Britain Invasive Non-native Species Strategy* [online]. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/455526/gb-non-native-species-strategy-pb14324.pdf [Accessed on 7th September 2016]

³⁹ Williams F, Eschen R, Harris A, Djeddour D, Pratt C, Shaw RS, Varia S, Lamontagne-Godwin J, Thomas SE, Murphy ST. 2010. *The economic cost of invasive non-native species of Great Britain*. Wallingford, UK: CABI.