



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

The State of Natural Resources
Report (SoNaRR): Assessment
of the Sustainable Management
of Natural Resources.
Technical Report.
Chapter 3. Summary of extent,
condition and trends of natural
resources and ecosystems in
Wales

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:
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Contents

- 3. Summary of Extent, Condition and Trends of Natural Resources and Ecosystems in Wales8
 - Introduction8
- PART A – NATURAL RESOURCES 10
 - 3.1. Animals, Plants and other organisms 10
 - 3.2. Air Quality 16
 - 3.3. Water resources and hydrological processes 20
 - 3.4. Soils..... 24
 - 3.5. Geodiversity, geological features and processes (including minerals) 29
- PART B – WELSH ECOSYSTEMS 32
 - Overview 32
 - Habitats of principle importance 34
 - European and UK protected sites 35
 - 3.6. Mountains, moors and heaths 36
 - 3.7. Semi-natural grasslands 41
 - 3.8. Enclosed farmland 44
 - 3.9. Woodland 48
 - 3.10. Freshwater 54
 - 3.11. Urban Environments 60
 - 3.12. Coastal margins 64
 - 3.13. Marine 67
- PART C – PRESENTING INTEGRATED EVIDENCE AROUND PLACE 77
 - 3.14. Landscape information in Wales 77
 - 3.15. Assessing extent, condition and trends at an area scale 79
- References for Chapter 3 81

List of Figures

Figure 3.1 Overview of condition of Habitat and Bird Directive species features on SACs and SPAs. Number of features in assessment shown in brackets. [H]	12
Figure 3.2 Assessment of the state of some of the Welsh priority species at broad taxonomic group level. [H]	13
Figure 3.3 Wales PM ₁₀ emissions by source sector. [H]	17
Figure 3.4 PM _{2.5} concentrations in Wales. [H]	17
Figure 3.5 Nitrogen dioxide (NO ₂) concentrations in Wales. [H]	17
Figure 3.6 Wales nitrogen oxides (NO _x) emissions by source sector. [H]	18
Figure 3.7 Number of days background ozone concentration was over target value in 2014. [M]	18
Figure 3.8 Wales ammonia (NH ₃) emissions by source sector. [H]	19
Figure 3.9 Water resource availability in Wales in 2014 (percentage of time) . [H] .	22
Figure 3.10 Map of peak spring tidal flow for Welsh waters reproduced from: Atlas of UK Marine Renewable Energy Resources (2008). [H]	23
Figure 3.11 Maps of wave height for Welsh waters reproduced from: Atlas of UK Marine Renewable Energy Resources (2008). [H]	23
Figure 3.12 'Soilscapes', the National Soil Map of Wales (UK Soil Observatory (UKSO), 2016). [H]	25
Figure 3.13 Distribution of soil carbon in Wales, shown as carbon density (t/ha): a) depth 0-30 cm; b) depth 30-100 cm; c) depth 0-100 cm	26
Figure 3.14 Contaminated Land sites in Wales identified under the Part 2A regime of the Environmental Protection Act 1990 (determinations reported by local authority). [L]	27
Figure 3.15 Glastir Monitoring and Evaluation Programme (GMEP) data for topsoil: (a) Long term trends in carbon concentration (1978 to 2013); (b) Long term trends in topsoil pH; (c) Long term trends in topsoil phosphorus availability (Olsen-P); (d) Trend in topsoil mesofauna abundance. Solid blue line = Countryside Survey data (CS data); Dashed blue line = GMEP 2013 Wider Wales Survey. [M]	28
Figure 3.16 Welsh Geodiversity Sites [H]	30
Figure 3.17 Potential unconventional gas resources in Wales. [H]	31
Figure 3.18 Summary of the representation of semi-natural habitats and modified land-cover types in Wales [M]	32
Figure 3.19 Percentage of Special Area of Conservation (SAC) habitat features in favourable and unfavourable condition. Number of habitat features in assessment shown in brackets. [H]	35
Figure 3.20 Breakdown of the component habitats of mountain, moorland and heath in Wales. All numbers are in hectares (ha). [M]	37
Figure 3.21 Distribution map of (left) unimproved neutral grassland in Wales compared with that of (right) improved grassland. The unimproved neutral grassland includes only stands confirmed by thorough floristic survey (from Blackstock et al. 2010).	42

Figure 3.22 New planting in Wales (hectares, ha), by woodland type (broadleaves and conifers), 1971-2015. [H]	50
Figure 3.23 Distribution of <i>Phytophthora ramorum</i> in Wales in 2016. [H]	51
Figure 3.24 Modelled Suitability change in Sitka spruce and Sessile oak based on predicted climate change by 2080, based on UK Climate Change Projections 2002 (UKCIP02) predictions (High scenario). [M]	52
Figure 3.25 Water Framework Directive classification, overall status 2015: surface waters. [H]	55
Figure 3.26 Water Framework Directive classification, overall status 2015: groundwaters. [H]	56
Figure 3.27 Water Framework Directive classification, element status, 2015: rivers. [H]	56
Figure 3.28 Water Framework Directive classification, element status, 2015: lakes. [H]	57
Figure 3.29 Hectares (ha) of accessible natural greenspace per 1,000 population by local authority (ha), July 2012. [M]	61
Figure 3.30 Distribution of land use classes across Wales' urban areas (2013). [M] 61	
Figure 3.31 Distribution of tree canopy cover across Wales' urban land use classes. [M]	62
Figure 3.32 Cardiff ward by ward (Lower Super Output Area, LSOA) tree canopy cover distribution – Communities First Cluster Areas (most deprived areas in Cardiff) highlighted. [M]	62
Figure 3.33 Noise map for major roads, major railways and roads, railways and industry in agglomerations, 2012. [M]	63
Figure 3.34. Annex I SAC feature condition (% of total area ha) derived from Article 17 reporting. Total hectares of each habitat in assessment shown in brackets. [H] . 66	
Figure 3.35 Water Framework Directive classifications for estuarine and coastal elements, 2015. [H]	69
Figure 3.36 Percentage of designated bathing waters complying with the original Bathing Water Directive 1990 – 2014. [H]	69
Figure 3.37 Bathing Water Directive classification 2015 (revised Directive). [H]	70
Figure 3.38 Marine (intertidal and subtidal) habitats listed under Annex I of the Habitats Directive. The 12 nautical mile limit of Welsh territorial waters is shown. [L-H]	72
Figure 3.39 Broadscale subtidal habitats. The 12 nautical mile limit of Welsh territorial waters is shown. [L-H]	75

List of Tables

Table 3.1 Mineral production for 2014 [H]	30
Table 3.2 What is included in each broad habitat.....	33
Table 3.3 Summary of the representation of mountain, moorland and heathland habitats within the SSSI series based on data up until 2010; data are rounded to the	

nearest 10 ha [M] . Data in the final column are based on Allen (2004) and in most cases relate to a subset of the SSSI sites notified for each feature [L]	37
Table 3.4 Summary of the conservation status of Habitats and Species Directive Annex I habitats associated with mountain, moorland and heath [H] . * Indicates Habitats Directive priority status. Key: = decreasing less than 1% per year; = decreasing more than 1% per year; = decreasing rate unknown; = increasing; - = unknown.	38
Table 3.5 Extent of different semi-natural grasslands in Wales. Extent figures from Blackstock et al (2010) except * Stevens et al (2010) and JNCC (2013). Note that 'upland marshy grassland' (29,204 ha) is included in the 'mountain, moorland and heath' section.	42
Table 3.6 Summary of lowland grassland SSSI feature condition assessments (from Allen, 2004). * Includes calaminarian grassland.....	43
Table 3.7 Recorded losses of semi-natural grasslands.....	43
Table 3.8 Classification of woodland in Wales, by type, including area in hectares (ha). [H]	49
Table 3.9 Forecast of timber availability in Wales (thousand m ³ overbark standing – 000s m ³ obs), 2017-2061. S = softwood, H = hardwood. [H]	51
Table 3.10 Summary of the representation of lowland terrestrial wetland habitats within the SSSI series * in most cases relates to a subset of the SSSI sites notified for each feature.	57
Table 3.11 Status of Habitats Directive Annex I Freshwater Habitats in Wales Key: = stable; = decreasing; = increasing; - = no information; = low. S = short-term trend; L = long-term trend.	57
Table 3.12 Status of Habitats Directive Annex I Wetlands Habitats in Wales. Key: = stable; = decreasing less than 1% per year; = decreasing more than 1% per year; = decreasing rate unknown; = increasing; - = unknown.....	58
Table 3.13 Short and long term trends in range and extent of Annex I coastal margin habitats in Wales. All information from 2013 Article 17 reporting. Key: = stable; = decreasing; = increasing; - = no information. [H] . * Vegetated Sea Cliffs of the Atlantic to Baltic Coasts are composed of the following habitats; Coastal grassland, Coastal heath and Vertical sea cliffs. ¹ Short term trend = in the last 12 years. ² Long term trend = in the last 24 years.....	64

List of Boxes

Box 1 How we chose the evidence and identified evidence gaps	9
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3. Summary of Extent, Condition and Trends of Natural Resources and Ecosystems in Wales

Introduction

In this Chapter we present a summary of the available evidence on the extent, condition and trends of natural resources and ecosystems in Wales. This is our assessment of biodiversity as required under section 6 of the Act.

Part A presents a synthesis of the evidence we have analysed on the state of **natural resources**. This is presented as follows:

1. Animals, plants and other organisms
2. Air
3. Water as a resource or hydrological system. Part B deals with freshwater and marine ecosystems
4. Soil
5. Geological features and processes

Other climatic resources, such as flow resources (anything that replenishes itself without human intervention) and physiological features have not been separated out as they form part of all of the above.

Part B presents a synthesis of the evidence we have analysed on the extent, condition and trends occurring within ecosystems or broad habitats. This is presented as follows:

6. Mountains, moors and heaths (including upland marshy grassland, lowland heaths and fridd)
7. Semi-natural grassland
8. Enclosed Farmland (primarily intensively managed grasslands and arable, but also including orchards and field boundaries)
9. Woodland (including semi-natural woodland and coniferous plantations);
10. Freshwater (including groundwater, rivers and streams, lakes and standing water, and lowland fens and bogs)
11. Urban environments (including previously developed land)
12. Coastal margins (including saltmarsh, sand dunes and seacliffs)
13. Marine (including coastal and estuarine, intertidal, inshore /subtidal)

Table 3.2 in Part B explains what is included in each grouping, building on the NEA approach. Wherever possible we have tried to consider extent, condition and trends for each broad habitat and sub-habitats. We have also highlighted evidence gaps. Each section focuses on the key messages which have come out of a process of synthesising and analysing a broad spectrum of evidence. Evidence sources are presented as references as it is not possible to include all of the detail here. A technical Annex provides further information from which we have drawn out the key messages (See SoNaRR: Technical Annex for Chapter 3). Box 1 provides information about the methodology used in this chapter. The key messages and supporting evidence have a confidence level assigned to them – Low [L], Medium

[M] or High [H]. In some cases, L-H is used to show that confidence is variable (normally associated with maps using several different data sources). The full methodology used to assign confidence can be found in SoNaRR: Annex methodology for assigning confidence to evidence presented.

Part C briefly explores ways in which evidence on the extent, condition and trends can be brought together in a place-based context. This part draws upon landscape information and evidence as well as the three natural resource ‘area trials’ that NRW ran between 2014 and 2016. This information begins to draw together the techniques that will be required to look at the interface between natural resources and human influences. In turn this can inform the development of area statements and the planning and management of land and sea at a national, regional and local scale.

Box 1 How we chose the evidence and identified evidence gaps

Method Statement

This first SoNaRR was developed by NRW with input from NRW specialists and external experts. The methodology used to collate evidence follows the “Expert Consultation” methodology outlined in Tables 1 and 2 of Pullin *et al.* (2016)¹. Future SoNaRRs will draw on the other methodologies outlined by Pullin *et al.* to ensure the most appropriate methodology is adopted in the longer term.

The specialists in NRW carried out a concise time-limited exercise to review the literature available and known to them based on their current knowledge as specialists. A full method statement for this exercise is provided in the Technical Annex for Chapter 3.

The NRW specialists pulled out the main key messages that provided a good representation of the current extent, condition and trends of Wales’ natural resources based on the best available evidence. The key messages in this chapter are generally already well-known and widely published but part of the purpose of this exercise was to collate them to show the whole picture. Graphs, maps, tables and photographs were used where appropriate to illustrate the key messages.

Baseline

Chapter 3 is the evidence base of the state of Wales’ natural resources. It is recognised that whilst the key messages have associated references, it is not always clear to which year the evidence relates and therefore what the baseline is. We intend that future documents will show the specific date range of the evidence so wherever possible baselines are set and available for comparison.

Evidence Gaps

The evidence gaps highlighted in Chapter 3 are not a comprehensive list, are not all focussed at the same level, and do not necessarily reflect the priorities between subject areas. They are specific to the natural resources and broad habitats being discussed in the relevant section. In future, they will be reviewed, set out at similar levels and prioritised according to the outcomes of the National Natural Resources Policy (NNRP).

PART A – NATURAL RESOURCES

3.1. Animals, Plants and other organisms

(See section 3.1 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Extent:

- Wales has a wide representation of species across a broad range of taxonomic groups with estimates varying from 25,000 to 50,000 different species of animals, plants and other organisms^{2, 3, 4} [H].
- There are 20 Special Protection Areas (SPAs) for internationally important populations of birds and 92 Special Areas of Conservation (SACs) for other threatened species and natural habitats⁵.
- 562 of the total 1,016 Sites of Special Scientific Interest (SSSI) (as of 2010) have individually qualifying species and 54 have species assemblages which qualify⁶. Many of the same species are also found on sites that qualify for their habitat.
- The list of species and habitats of principal importance in Wales (the interim Section 7 list) includes 557 species⁷.

Condition:

- The condition of SAC and SPA species features on sites in Wales, as reported in 2013, remains mostly unfavourable (55%), with the exception of birds and mammals of which 86% and 68% were in favourable condition, respectively⁵ (Figure 3.1) [H].
- Between 2002 and 2008, fewer than half of the species on the interim Section 7 list were considered to be stable or increasing⁸ (Figure 3.2) [H].
- Wales (along with the UK as a whole) did not meet the 2010 international and national biodiversity targets⁹ [H].

Trend:

- Trends of extent and population for terrestrial, freshwater and marine species vary enormously within taxonomic groups; with some species increasing and some decreasing. For instance, both increases and decreases can be seen in birds, bats and many pollinator species (e.g. bees, butterflies) whilst for many species we do not have sufficient data on which to base any conclusions^{8, 10, 11, 12, 13} [H].
- There has been a marked reduction in the abundance of salmon in recent years, particularly in the southern regions of the species' range which is linked to increased mortality at sea^{14, 15}. Although stocks in many of our industrial rivers have improved in the last 30 years, most stocks in Wales are severely challenged [H].
- All species are directly affected by changes in habitat quantity and quality. These changes are directly related to changes in the intensity of management regimes. Fragmentation and eutrophication create particular problems for many species (see sections 3.6-3.13¹⁶) [H].
- The CCRA17 Evidence Report¹⁷ has identified risks to species and habitats due to their inability to respond to changing climatic conditions. There may also be opportunities from new species colonisations.

KEY MESSAGES

Conversely, native wildlife may be increasingly at risk from pests, pathogens and invasive species. There are also risks from change in the frequency and/or magnitude of extreme weather and wildfire events. Climate change is influencing the expansion or contraction of some species' ranges and populations, and the increasing frequency of extreme climatic events, predicted in many climate change scenarios, may have serious implications¹⁸ [H] .

Evidence gaps:

- Despite the long history of observing and recording animals and plants in the UK and Wales, there are many significant gaps in the breadth and quality of distribution, condition and trend data.
- Understanding the ecological interactions and dependencies between many species, their habitats and the management of habitat is crucial, but is a particular area where data is lacking.
- Although we have some very specific information for some Invasive Non-Native Species (INNS) in Wales, it is patchy, particularly on a Wales-wide scale.

Extent:

The suite of species in Wales reflects its position on a small island on the edge of the Atlantic Ocean subject to influences from the European land mass with a generally temperate climate. Many species reach the northern or southern limits of their distribution here, and the generally mild conditions also attract summer and winter migrants from many parts of the western Palearctic.

The diversity of habitats across Wales, from sea level to over 1000 m, has been moulded by a long history of land management changes, and has resulted in a wide representation of species across a broad range of taxonomic groups with estimates varying from 25,000 to 50,000 species. Many rare species rely on small fragments of scarce habitats; particularly important are the calcareous fens and raised bogs alongside the more extensive dune systems and ancient oak woodland which characterise Welsh habitat cover.

Where SSSIs are designated for their habitats, these act as extra protection for species and vice versa.

Condition:

In a report such as this it would be impossible to provide information on the extent, status and condition of even a fraction of our fauna and flora (even if the information were available), but some examples where we have good long term and reliable datasets are included in Annex 1 section 1.

The protected site network in Wales includes the Natura 2000 sites of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) and RAMSAR sites in addition to the national designations of National Nature Reserves, Marine

Conservation Zones and Sites of Special Scientific Interest (SSSI). All of these designations provide protection for a wide variety of species and the habitats they depend on.

The 2013 reports on the Annexes of the Habitats Directive (Article 17 report) and Birds Directive (Article 12 report) summarise the UK status and trends of the selected habitats and species and are important evidence resources^{19, 20}. A summary of the Welsh results for species in Figure 3.1. For many of the freshwater species, Water Framework Directive monitoring information in addition to SAC, SPA and wider countryside data were used.

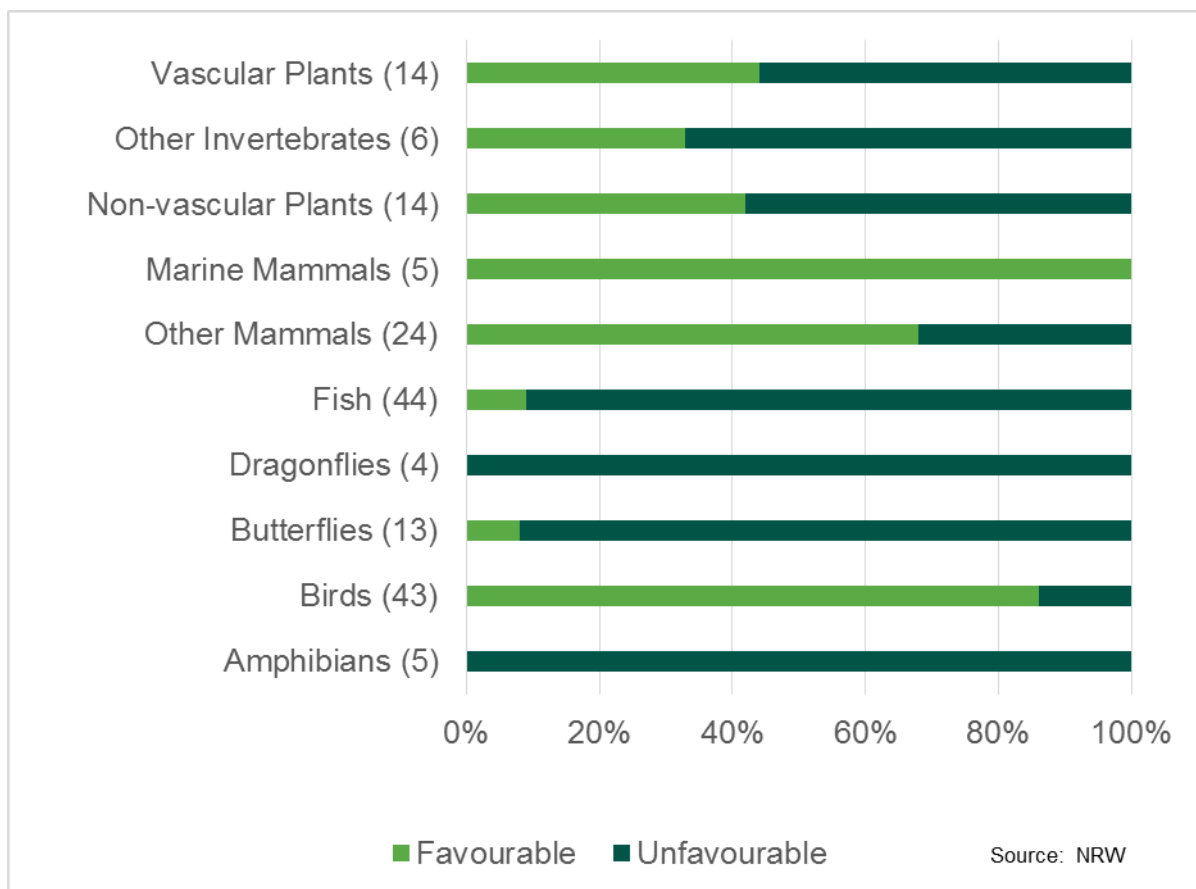


Figure 3.1 Overview of condition of Habitat and Bird Directive species features on SACs and SPAs⁵. Number of features in assessment shown in brackets. [H]

From monitoring data collected for species features on Natura 2000 sites, we can report that the overall condition of SAC and SPA species features on these sites in Wales, as reported in 2013, was mostly unfavourable (55%) with the exception of birds and mammals of which 86% and 68% were in favourable condition respectively⁵ (Figure 3.1).

In Wales, the interim Section 7 list of the Environment (Wales) Act has 557 species and 55 habitats of principle importance. These were originally selected for the Section 42 list of the Natural Environment and Rural Communities Act 2006 for prioritised action from the UK Biodiversity Action Plan using criteria based on the

level of threat they face, the level of responsibility in Wales for their populations and whether remedial action could be taken to improve their status. The list includes species as diverse as slow-worm (*Anguis fragilis*), hornet robber fly (*Asilus crabroniformis*) and long-snouted seahorse (*Hippocampus guttulatus*).

The State of Nature Wales report³ includes an assessment of the status of some of the interim Section 7 species in comparison to their condition at the time of the last Biodiversity Action Plan report in 2008 (Figure 3.2).

- Of the 104 invertebrate species listed as priorities, 67 were assessed. **21% of these were declining**, the outlook was **improving for 25%**, and the remaining **54% showed little change** in their status.
- 83 vertebrate species appear on the list of priority species and we assessed 78 of them. **37% of these were declining** and the outlook was **improving for 21%**. The remaining **42% showed little change** in their status.
- Of the 87 fungi and lichens listed as priorities, 55 were assessed. **29% of these were declining**, the outlook was **improving for 27%** and the remaining **44% showed little change** in their status.
- 52 bryophytes feature on the priority species list and we assessed 49 of them. **47% of these were declining**, the outlook was **improving for 24%** and the remaining **29% showed little change** in their status.

Figure 3.2 Assessment of the state of some of the Welsh priority species at broad taxonomic group level³. [H]

Trend:

The extent, condition and trends of terrestrial species in Wales are influenced primarily by habitat management and by climate change.

Habitat management directly influences plant community composition, amounts of bare substrate, shading and vegetation structure. Shading due to scrub encroachment, following changes in grazing regime, can be as damaging for butterflies¹¹ and many other species groups as overgrazing or agricultural improvement. These effects are compounded by direct habitat loss which leads to fragmentation of suitable habitat types or conditions and the increasing influence of nutrient enrichment which leads to changes in plant communities and patterns of growth. [H]

The latest studies (2015) suggest that climate change may pose more of a threat to UK species than had been previously realised¹¹ [H]. A study of the impact of the 1995 drought on butterfly abundance^{21, 22} showed that some widespread species, including large skipper (*Ochlodes sylvanus*) and green-veined white (*Pieris napi*),

were particularly drought-sensitive. The impact of extreme weather events is also relevant to many invertebrates and birds on a yearly basis.

Climate change impacts such as acidification, sea temperature rises and extreme weather events have the potential to affect marine species through a number of factors including prey population dynamics, reproduction and distribution^{17, 23}.

Evidence gaps:

Despite the long history of observing and recording animals and plants in the UK, there are many significant gaps in the breadth and quality of distribution, condition and trend data for our fauna and flora. The very specialised nature of identifying some groups poses a challenge and this contributes to the often sporadic nature of records. Monitoring data for many of the species listed in the Habitats Directive and Birds Directive outside SACs and SPAs, and for many of the priority species across Wales, is not available. Additionally, the ecological interactions and requirements between many species, their habitats and habitat management are crucial to our understanding, but this is an area where data is lacking.

Our evidence base is constantly improving through the efforts of dedicated volunteer recorders and citizen scientists. The records created by these individuals are collated by organisations such as Local Environmental Record Centres, Recording Groups and Schemes and Societies and many of them are made publicly available through the NBN Gateway web portal (soon to be replaced with the NBN Atlas and Atlas of Living Wales).

Limited data makes assessing the extent, condition and trends of commercially targeted marine fish and shellfish species at a Welsh level challenging. Commercially targeted fin fish, elasmobranchs and shellfish species are managed through a combination of European, UK and Welsh legislation with a number of Welsh initiatives in place to contribute valuable information on the sustainability of marine fisheries activities and their locations in Welsh waters.

Although we have some very specific information for some Invasive Non-Native Species (INNS) in Wales, it is patchy. We need more comprehensive distribution data and also information on the likely rate or risk of INNS spread so that we can develop better knowledge about anticipated economic and social impacts and support more effective INNS management actions. The GB Non Native Species Secretariat's²⁴ Great Britain level risk assessments for new INNS will help, but we need more data, tools or techniques, and research to fill the Wales-level information gaps on INNS that we currently have.

KEY EVIDENCE SOURCES

- NBN-Gateway (to be replaced by the NBN Atlas)²⁵
- Local Environmental Records Centres (LERCs)²⁶
- UK Habitat Directive Reports (Article 17)¹⁹
- UK Birds Directive Reports (Article 12)²⁰
- Wales Marine Evidence Report²⁷
- Wales Marine Planning Portal²⁸

KEY EVIDENCE SOURCES

- UK Marine Strategy Part One: Initial Assessment and Good Environmental Status²⁹
- ICES Stock Condition Assessments³⁰
- Marine Management Organisation Fisheries Statistics³¹
- CEFAS Fisheries Reports³²
- Marine Environmental Data and Information Network (MEDIN)³³
- Pollinator indicator³⁴
- State of Nature report 2016³
- Glastir Monitoring and Evaluation Programme (GMEP)¹³.
- Non-native species secretariat website²⁴

3.2. Air Quality

(See section 3.2 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Condition and Trend:

- Targets for nitrogen dioxide, particulate matter, nickel and polycyclic aromatic hydrocarbons are being breached in Wales³⁵ thereby posing a threat to human health and the natural environment³⁶ [H].
- The decline in heavy industry alongside regulation has resulted in a reduction in emissions of some pollutants, such as particulate matter (PM) Figure 3.3 and Figure 3.4). Other sources, that are subject to less or no regulatory control, such as transport, agriculture and domestic heating, have become more of a concern³⁷ [H].
- Particulate matter (PM) and nitrogen dioxide concentrations (Figure 3.3, Figure 3.4, Figure 3.5 and Figure 3.6) in urban areas and adjacent to major roads are an issue for health³⁸ [H].
- Peak ground level ozone concentrations have declined over the past 30 years. Over the same period, background concentrations have been steadily increasing across northern Europe by about 0.2ppb annually³⁸, leading to damage to some plant species (Figure 3.7) [M].
- Ammonia remains an issue (Figure 3.8), both as a local air pollutant and as a contributor to the formation of secondary particulate matter. Concentrations of secondary particulate matter have risen in Wales in recent years, largely due to changes in agricultural practice³⁷ [H].
- 90% of semi-natural nitrogen sensitive Welsh habitats are subject to nitrogen deposition in excess of critical load limits³⁹ [H].
- Since controls on air pollution were introduced in the 1980s there has been a significant recovery in surface water quality from the effects of acidification⁴⁰ [H].

Evidence gaps:

- The data on which we have based our evidence are collected for specific legislative drivers such as the Air Quality Directive and Environmental Noise Directive. The monitoring and modelling for these purposes is not required to cover the whole of Wales. Therefore, there are likely to be areas that are not being assessed where both air quality and noise are having adverse impacts. Pollution from agricultural sources such as ammonia is not specifically measured.
- Monitoring of PM_{2.5} in air has been limited to date and there is insufficient data to accurately assess the status of this fraction of particulate matter in Wales.

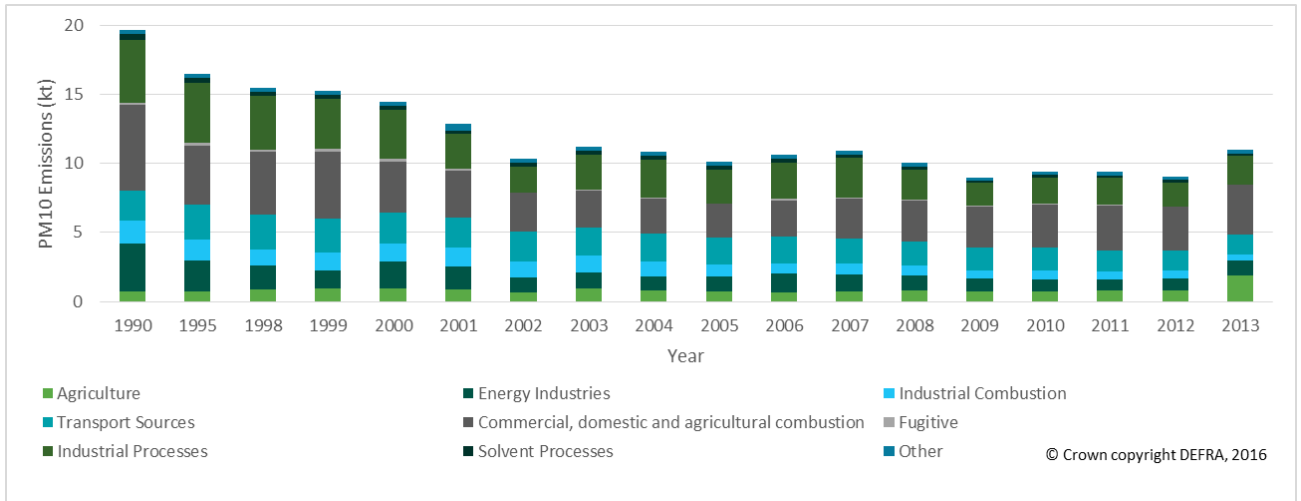


Figure 3.3 Wales PM₁₀ emissions by source sector³⁷. [H]

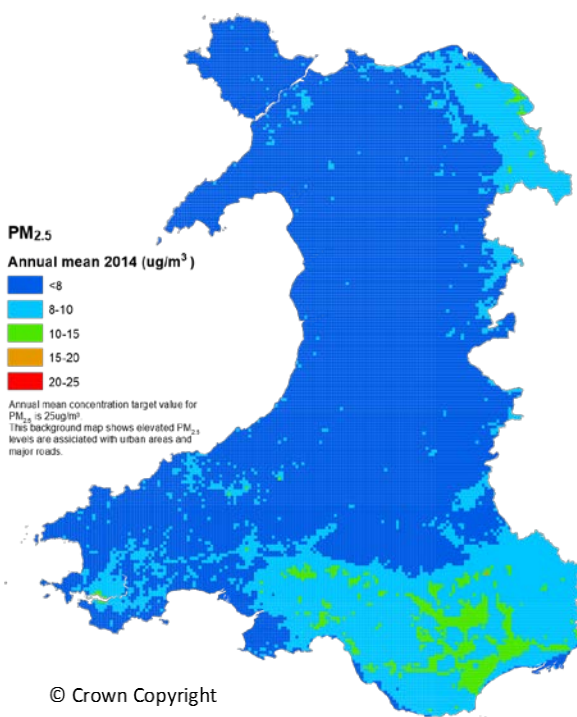


Figure 3.4 PM_{2.5} concentrations in Wales⁴¹. [H]

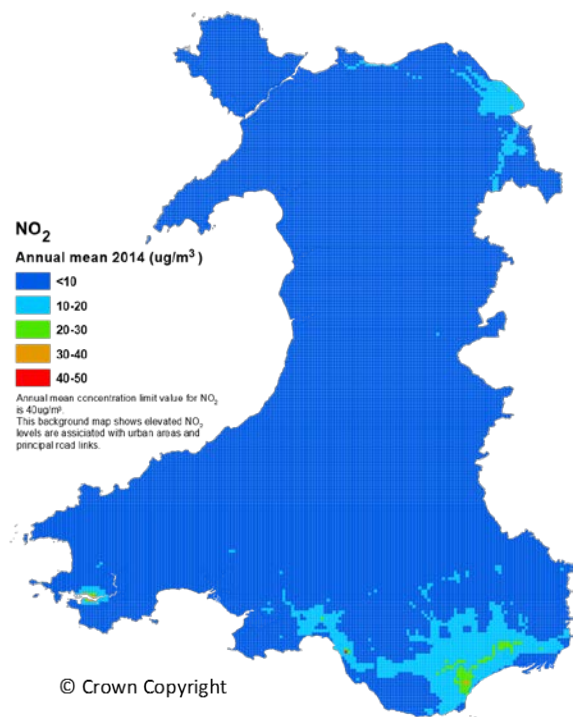


Figure 3.5 Nitrogen dioxide (NO₂) concentrations in Wales⁴¹. [H]

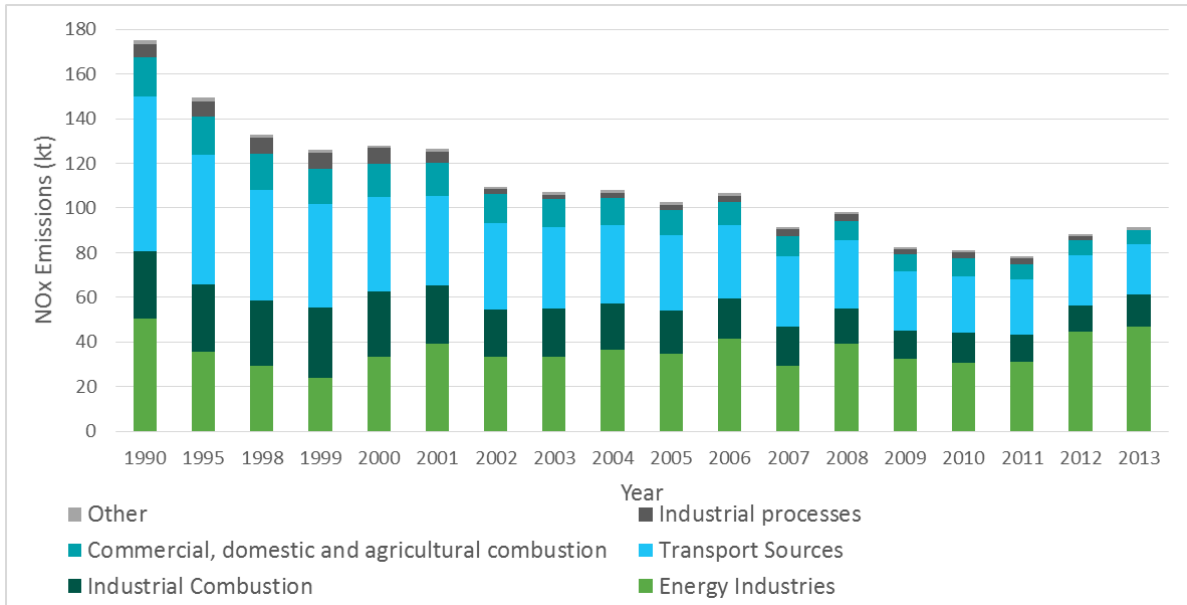


Figure 3.6 Wales nitrogen oxides (NOx) emissions by source sector³⁷. [H]



Figure 3.7 Number of days background ozone concentration was over target value in 2014⁴¹. [M]

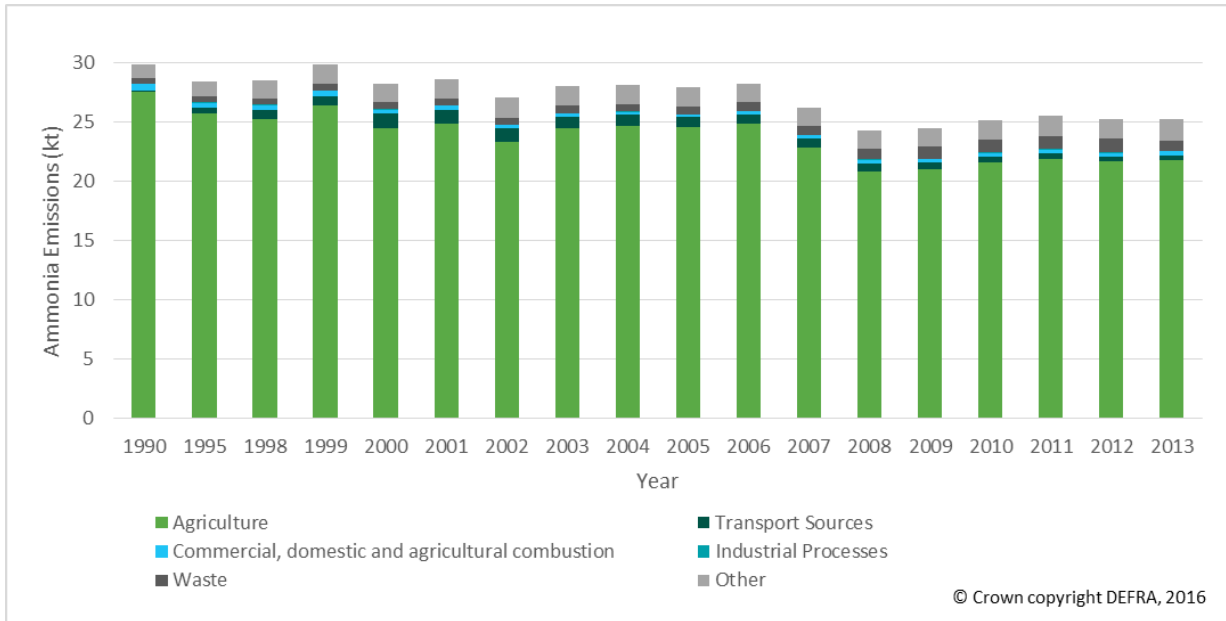


Figure 3.8 Wales ammonia (NH₃) emissions by source sector³⁷. [H]

KEY EVIDENCE SOURCES

- National Air Emissions Inventory⁴²
- Air Quality in Wales³⁵
- Defra UK-Air⁴³

3.3. Water resources and hydrological processes

(See section 3.3 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Freshwater

Extent:

- The landscape and geology of Wales provide few natural stores of water either in aquifers or soils⁴⁴ [H].
- This means that rainfall generally travels quickly to our rivers and streams and little is held back to slowly pass through the ground to maintain river flows (base flows) in drier periods. Rivers rise rapidly when it rains and drop quickly afterwards. As a consequence, the flows in all Welsh rivers can change particularly quickly leading to flood conditions, but also as importantly, to very low flows whenever we have extended periods of dry weather⁴⁴ [H].
- The lack of natural water storage in Welsh catchments means that reservoirs are useful to ensure reliable sources of water during drier periods⁴⁴ [H].
- Although Wales is perceived to be water rich, we are facing challenges. For example, in 7% of our water bodies water is only reliable for people to abstract 30% of the time for new consumptive abstractions. In approximately 60% of water bodies, water is reliable for people to abstract for at least 95% of the time for new consumptive abstractions^{45, 46} (Figure 3.9) [H].
- Changes to hydraulic conditions are identified as having an impact or likely to have an impact on 45 of 112 (40%) Natura 2000 protected sites⁴⁷. Reduced flows caused by abstraction present risks to migratory fish and wider biodiversity. Water Framework Directive (WFD) investigations have identified 29 (3%) water bodies that have failed to meet objectives because of changes to flows and water levels⁴⁸ [H].

Trend:

- Climate change is predicted to affect the amount and distribution of rainfall; this has an impact on flows and water levels, drought and flood events⁴⁹ [H]. Work carried out in 2002 showed that by 2050 river flows in winter may rise by 10-15% but in the summer and early autumn could reduce by over 50% and as much as 80% in some places⁴⁴ [M]. Droughts and flood events may become more common⁴⁹ [H].
- Climate change may affect groundwater recharge. By 2025 it is likely that groundwater recharge will decrease, resulting in decreased dry weather river flows and a general lowering of groundwater levels. This may have impacts on base-flow to rivers and wetlands in dry periods and affects small domestic and agricultural water supplies⁴⁴ [H]. The CCRA17 Evidence Report⁴⁹ has identified risks to aquifers and habitats from salt water intrusion.

Evidence gaps:

- Understanding of the impacts of land use change and climate change on river flows and water levels needs to be improved.

KEY MESSAGES

Marine & coastal

Extent:

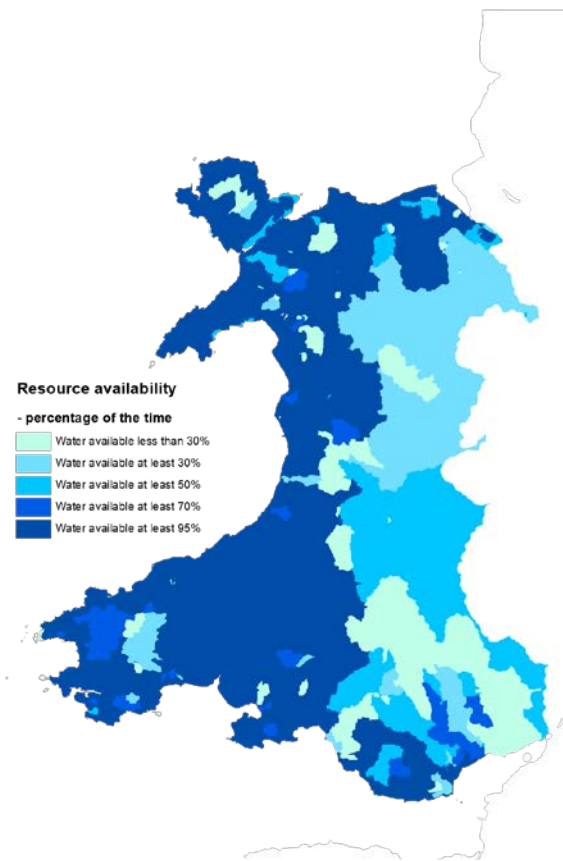
- Hydrological processes such as tides, waves and water temperature are influenced primarily by large scale oceanographic processes but with the potential for small to medium-scale effects from anthropogenic influences⁵⁰. [H]

Trend:

- Climate change effects are the main broad scale driver of change for coastal and marine hydrological processes^{51, 52} [H] and include changes to tidal levels due to sea-level rise [H] and increased storminess [M] leading to increases in wave energy. The CCRA17 Evidence Report has identified risks to offshore infrastructure from storms and high waves.
- Climate change is also predicted to increase sea surface temperatures, to affect salinity to a lesser degree and may increasingly affect mixing and stratification over time^{51, 52} [H].
- Changes to hydrological processes from either climate change or, at a smaller scale, from infrastructure development in the marine and coastal environment can affect seabed and coastal geomorphology and associated habitats and species^{53, 54, 55, 56} [H].
- Hydrological processes provide an important resource for wave, tidal stream and tidal range renewable energy⁵⁷ (Figure 3.10). [H]

Evidence gaps:

- There is insufficient understanding of hydrological processes (waves in particular) for the nearshore environment which is partly because of the lack of monitoring.
- Limited understanding of shoreline response (erosion and accretion) to changes in hydrological conditions (e.g. sea level rise and wave activity from storms).



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Figure 3.9 Water resource availability in Wales in 2014 (percentage of time)^{45, 46}. [H]

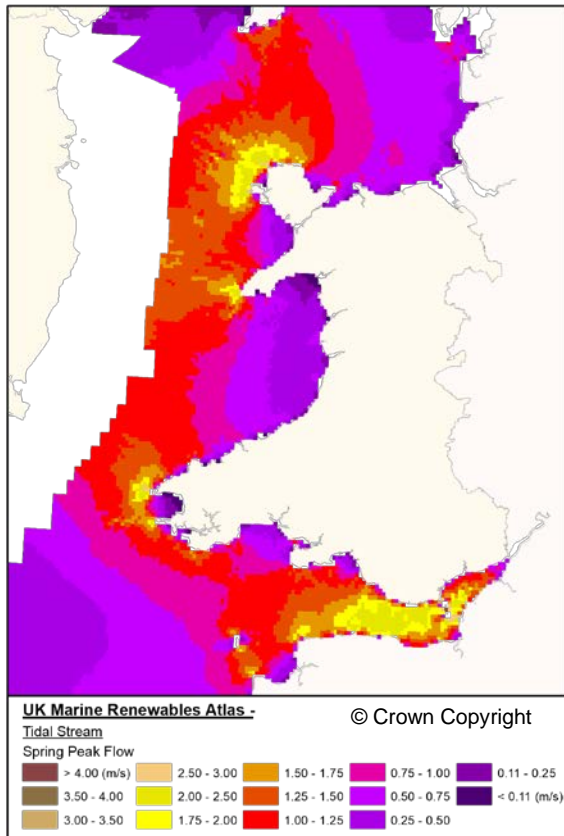


Figure 3.10 Map of peak spring tidal flow for Welsh waters reproduced from: Atlas of UK Marine Renewable Energy Resources (2008)⁵⁷. [H]

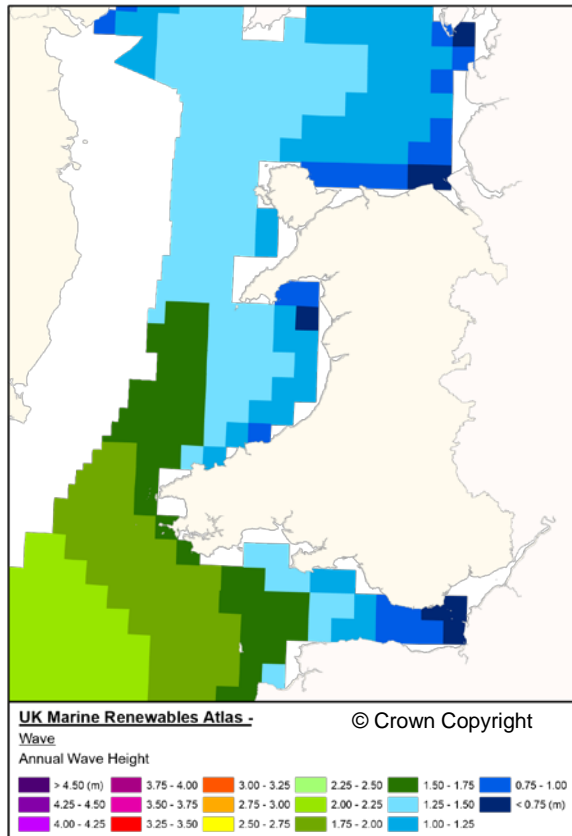


Figure 3.11 Maps of wave height for Welsh waters reproduced from: Atlas of UK Marine Renewable Energy Resources (2008)⁵⁷. [H]

KEY EVIDENCE SOURCES

- River Basin Management Plans⁵⁸
- The case for change - current and future water availability⁵⁹
- LIFE Natura 2000 programme⁴⁷
- Water Strategy for Wales⁶⁰
- Water Resources Strategy for Wales⁴⁴
- Climate Change Risk Assessment for Wales⁴⁹
- UK Climate Projections 2009 (UKCP09)⁶¹
- Wales' Marine Evidence Report⁵⁰
- Charting Progress 2: The State of UK Seas⁶²
- Marine Climate Change Impacts Annual Report Card⁵²
- UK Climate Projections Science Report: Marine and Coastal Projections⁵¹
- Atlas of UK Marine Renewable Energy Resources⁵⁷
- Shoreline Management Plans^{53, 54, 55, 56, 53}

3.4. Soils

(See section 3.4 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Extent:

- Soils are diverse; over 400 different soil types found in Wales⁶³ are contributing to, reflecting, and supporting our rich geodiversity and biodiversity, landscapes and land uses (Figure 3.12) [H].
- Welsh soils contain 410 million tonnes of carbon⁶⁴ (Figure 3.13) [M].

Condition:

- The soils of best quality and most productive agricultural land are a scarce and finite resource in Wales; accounting for less than 7% of land area⁶⁵ [H].
- Soil quality has deteriorated across all habitats apart from woodlands where there has been some improvement⁶⁶ [M].
- The severity and spatial extent of soil erosion has not been directly quantified in Wales⁶⁷. Around 10-15% of grassland fields in England and Wales are thought to be affected by severe soil compaction and 50-60% are in moderate condition⁶⁸ [L]. No data exists on compaction in grassland and arable land across Wales specifically.
- Only 30% of the Welsh peat soil area is considered to be in 'good condition'⁶⁹ [M]. It is estimated that 74% of acid sensitive habitat soils receive acidic deposition in excess of their capacity to neutralize air pollution⁷⁰ [H].
- Remediation has been completed at 97 of the 111 Contaminated Land sites identified in Wales (Figure 3.14) [H], but around 9,330 potentially contaminated sites have yet to be investigated⁷¹ [L]. There is no evidence that has collated land use change statistics at sufficient resolution to identify the extent of soil sealing in Wales⁶⁷.

Trend:

- Topsoil carbon concentrations are generally stable and there is ongoing recovery from soil acidification⁷² [M]. Although a significant decline in soil phosphorus levels has been seen for Improved Land⁷² [H], it remains above the optimum levels in many (44%) agricultural fields⁷³ [M]. Soil invertebrate (mesofauna) numbers indicate no overall trend⁷² [L]. There has been little or no decline in elevated levels of soil contaminants from industry and transport⁷⁴ [M] (Figure 3.15).
- The CCRA17 Evidence Report⁷⁵ has identified risks to soils from increased seasonal aridity and wetness. Climate change related risks are threatening the many services that soils provide, notably those that relate to soil biota, soil organic matter, and soil erosion and compaction⁷⁶ [M].

Evidence Gaps:

- Compared to air and water, for example, there is a general lack of information on the current state and trends of soils in Wales and their vulnerability and resilience to land use, land management and changing weather patterns and climate^{67, 77}.

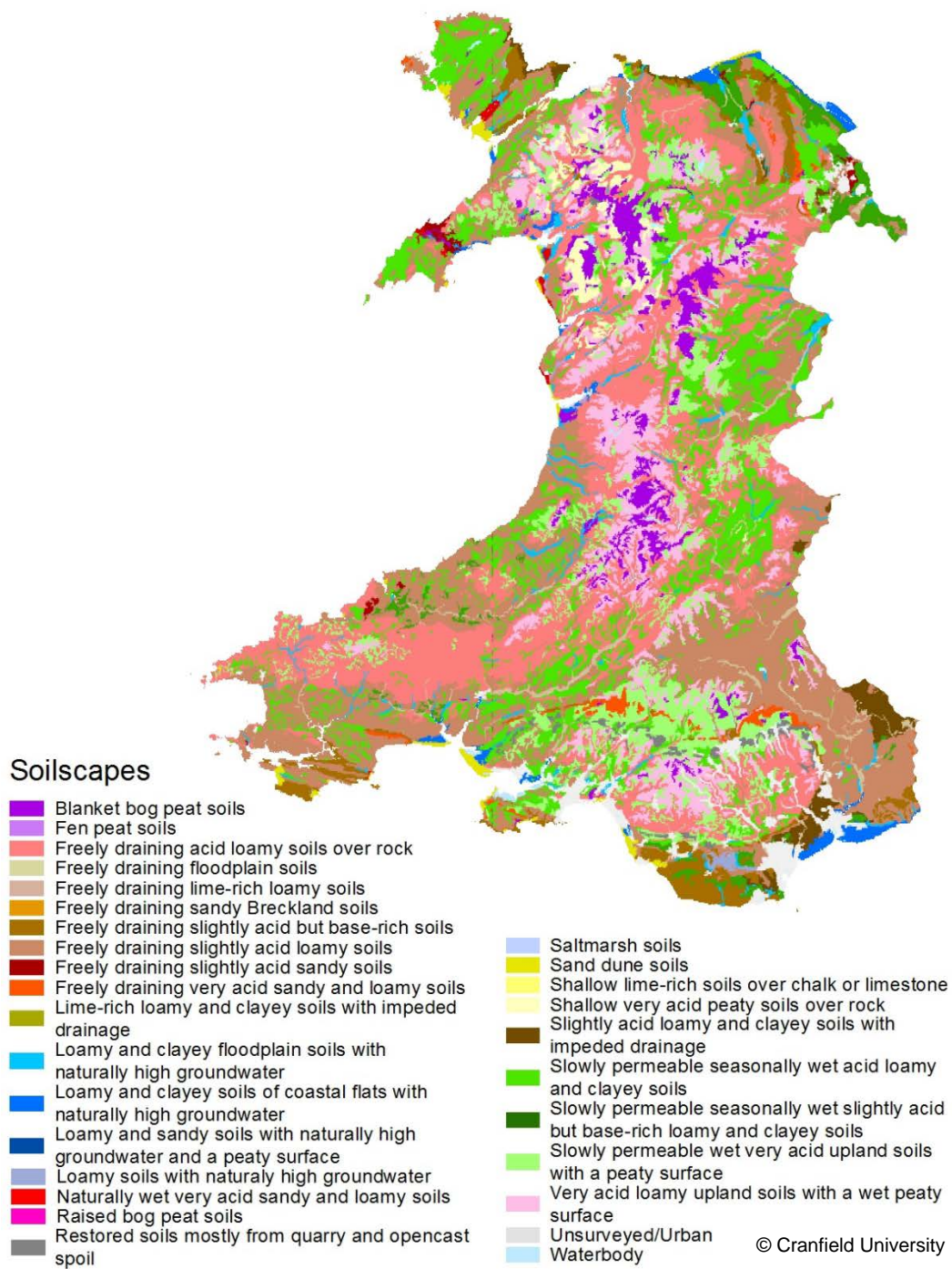
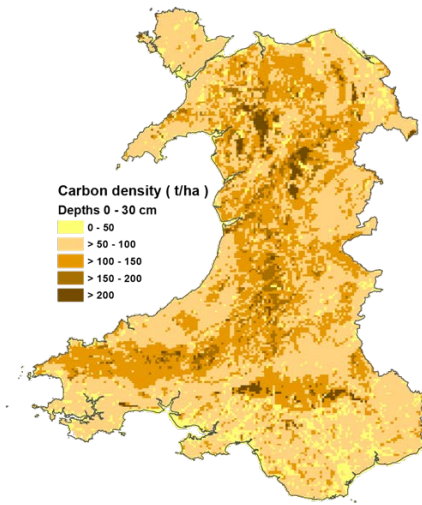
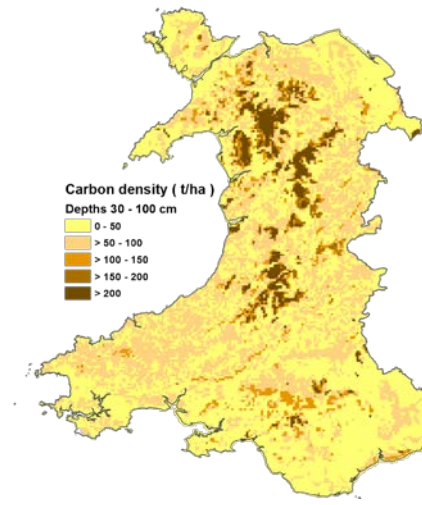


Figure 3.12 'Soilscapes', the National Soil Map of Wales (UK Soil Observatory (UKSO), 2016⁷⁸). [H]

a)



b)



c)

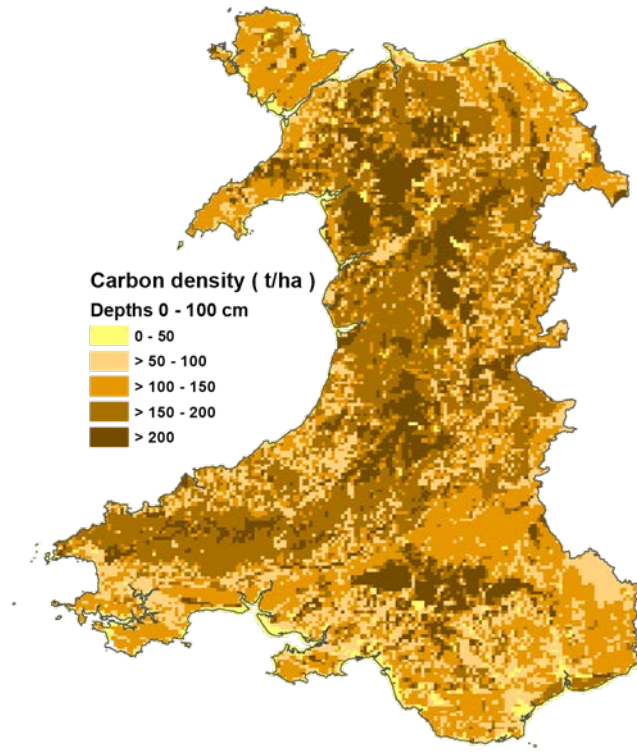


Figure 3.13 Distribution of soil carbon in Wales, shown as carbon density (t/ha): a) depth 0-30 cm; b) depth 30-100 cm; c) depth 0-100 cm⁷⁹.

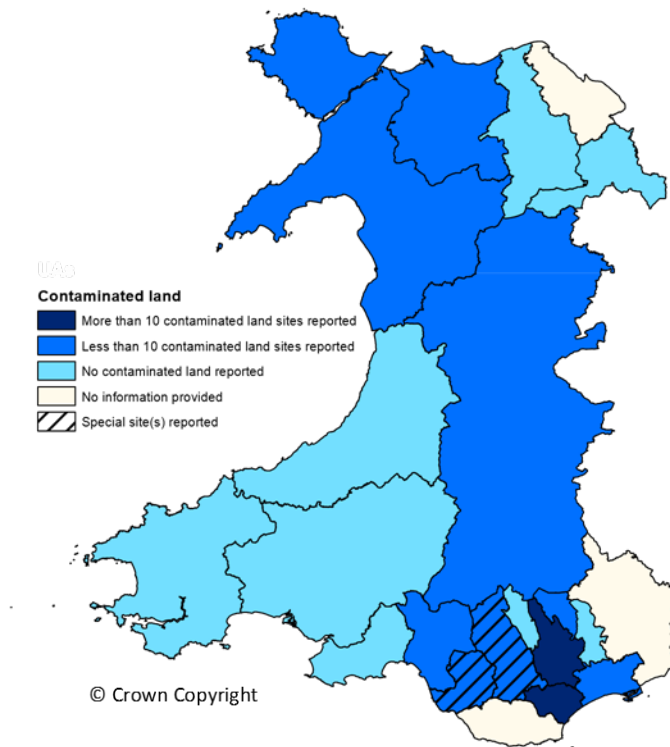


Figure 3.14 Contaminated Land sites in Wales identified under the Part 2A regime of the Environmental Protection Act 1990 (determinations reported by local authority)⁷¹. [L]

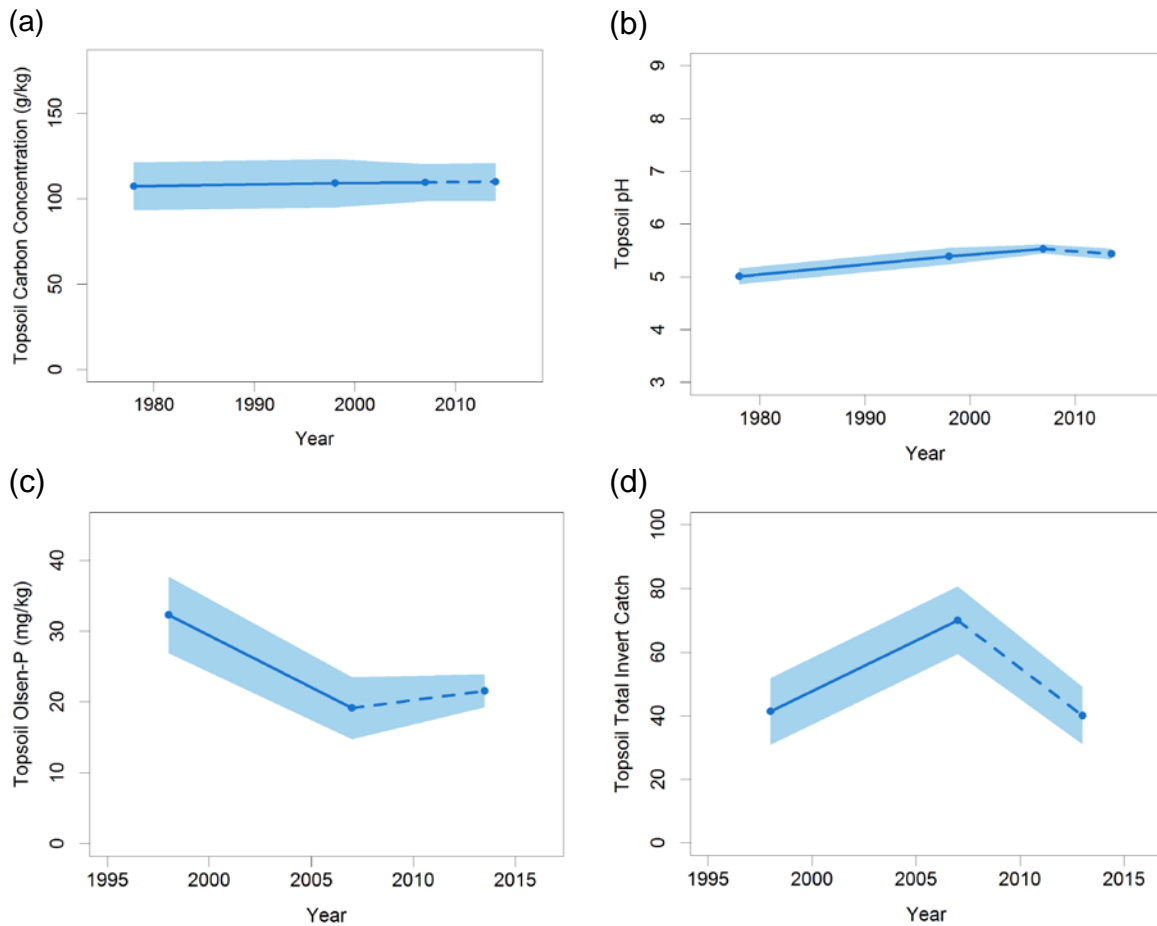


Figure 3.15 Glastir Monitoring and Evaluation Programme (GMEP) data for topsoil: (a) Long term trends in carbon concentration (1978 to 2013); (b) Long term trends in topsoil pH; (c) Long term trends in topsoil phosphorus availability (Olsen-P); (d) Trend in topsoil mesofauna abundance. Solid blue line = Countryside Survey data (CS data); Dashed blue line = GMEP 2013 Wider Wales Survey⁷². [M]

KEY EVIDENCE SOURCES

- Glastir Monitoring Evaluation Programme (GMEP)⁸⁰
- UK Soil Observatory (UKSO)⁷⁸

3.5. Geodiversity, geological features and processes (including minerals)

(See section 3.5 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Extent:

- Wales has some of the most varied geology in the world representing all geological periods and spanning 1.4 billion years of the Earth's history. This diverse geology not only underpins our biodiversity and landscape but also provides important mineral resources⁸¹ [H].
- Two UNESCO Global Geoparks, GeoMôn and Fforest Fawr, cover 1,483 km² of Wales and are designated for the primary purpose of promoting geotourism⁸² (Figure 3.16) [H].
- 300 SSSIs in Wales, covering 48,815 ha⁸³ [H], contain some 500 geological features and 93% of these features are in favourable condition⁸⁴ (Figure 3.16) [L-H].

Trend:

- Following a long history, metal mining has ceased and there is only localised coal mining and slate quarrying in Wales. The aggregates industry is now the main mineral extraction industry in Wales, including marine and terrestrially derived aggregates⁸⁵ (Table 3.1) [H].
- Geological hazards may change as a response to climate change. For example, coastal erosion, landslides and pollution from former mine sites⁸⁶ [H]. The CCRA17 Evidence Report⁸⁷ has identified risks to transport networks from slope and embankment failure. There is also a subsidence risk to subterranean infrastructure caused by falling and rising moisture levels – particularly in clay-rich soils.
- Exploration for conventional and unconventional sources of oil and gas remains a possibility in Wales⁸⁸ (Figure 3.17) [H].

Evidence Gaps:

- Some areas of Wales have no recent geological mapping carried out by the British Geological Survey. This includes one area in mid-Wales where there is no published 1:50,000 scale map.
- The British Geological Survey has identified a number of geological formations in Wales that might potentially yield unconventional oil and gas supplies. The extent of the potential unconventional oil and gas resources remains unclear and can only be fully ascertained through exploratory work.

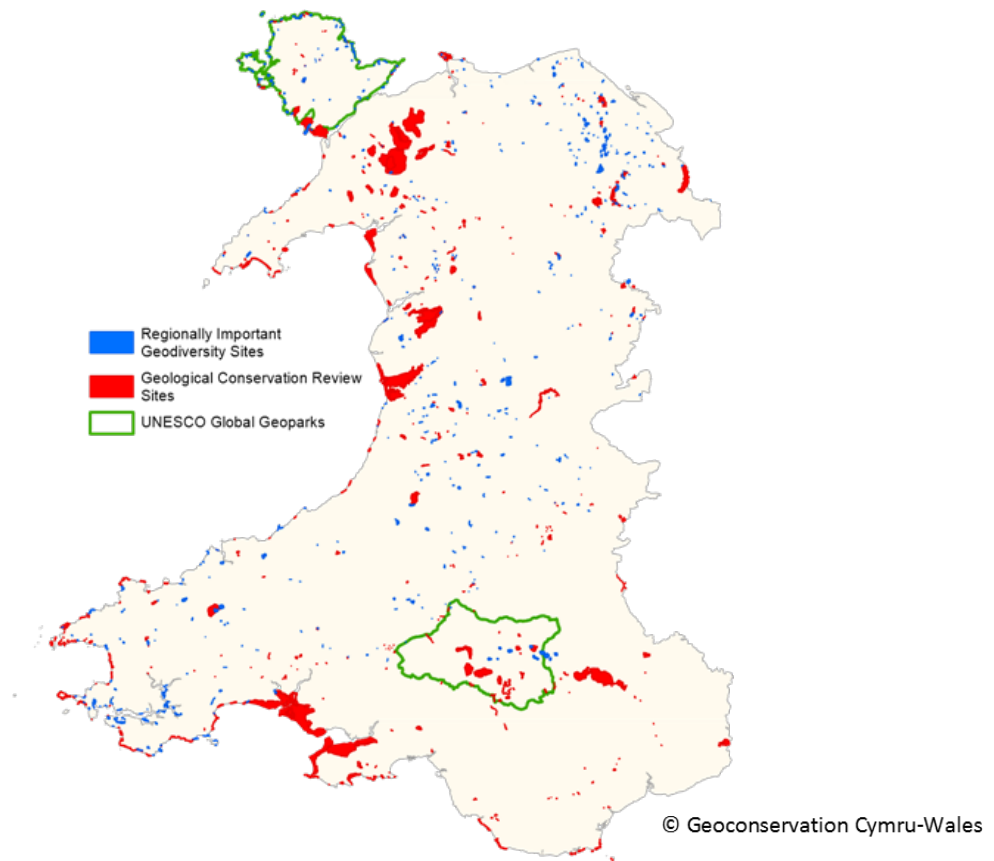


Figure 3.16 Welsh Geodiversity Sites⁸⁹ [H].

Table 3.1 Mineral production for 2014⁸⁵ [H].

Mineral	Thousand Tonnes Extracted 2014
Coal (deep-mining)	91
Coal (opencast)	2,343
Igneous Rock	1,905
Limestone & Dolomite	8,934
Sand & Gravel (land)	673
Sand & Gravel (marine)	632
Sandstone	2,774
Total	17,352

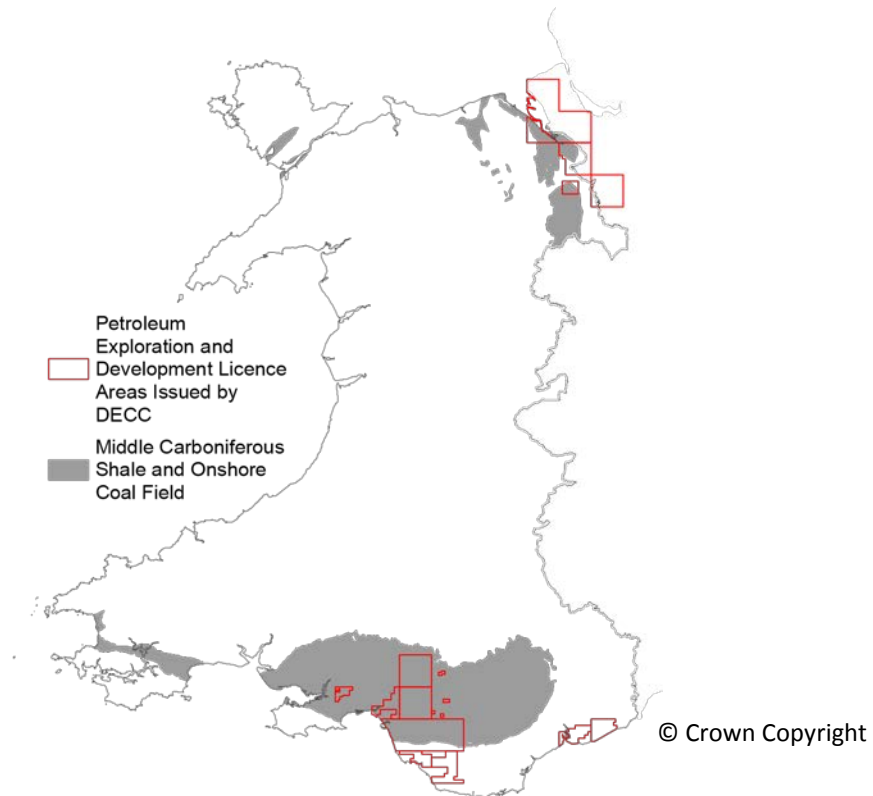


Figure 3.17 Potential unconventional gas resources in Wales⁹⁰. [H]

KEY EVIDENCE SOURCES

- British Geological Survey study of potential unconventional gas resources in Wales⁸⁸
- British Geological Survey (BGS) Geological Data^{81, 91}
- Wider value of UNESCO to the UK report⁸²
- UNESCO Global Geoparks Celebrating Earth Heritage, Sustaining local Communities report⁹²
- Fforest Fawr Geopark website⁹³
- GeoMôn Geopark website⁹⁴
- The UK Mineral Extraction Industry Report⁹⁵
- British Geological Survey United Kingdom Minerals Yearbook 2014⁸⁵
- Information on the Geological Conservation Review⁹⁶

PART B – WELSH ECOSYSTEMS

Overview

The land area of Wales covers 2,078,224 ha⁹⁷. The Welsh marine area extends out to 12 nautical miles, covering just under 15,000 km² or 41% of the territory of Wales⁹⁸.

The Habitat Survey of Wales⁹⁹ provides complete coverage of the country and was undertaken between 1979 and 1997. Updates in survey coverage have resulted from refined earth observation methods and the Glastir Monitoring and Evaluation Programme¹⁰⁰. More detailed information for habitats which are a priority for conservation measures is provided by NRW's ongoing Phase 2 Habitat Survey.

The land-cover of Wales can be divided broadly into semi-natural habitats and modified land-cover types. Semi-natural habitats retain many of their characteristic species. Modified land-cover types include the built environment as well as land where ecological processes and species composition have been hugely altered, for example, improved grassland, arable land and conifer plantations. The representation of semi-natural habitat varies significantly across Wales. The Welsh lowlands are highly modified (Figure 3.18). Of the lowlands 17.3% is semi-natural habitat, whereas of the upland area 84% is semi-natural habitat. Semi-natural habitats in Wales cover a total of 626,100 ha (30% of the Welsh land surface)⁹⁹ [M].

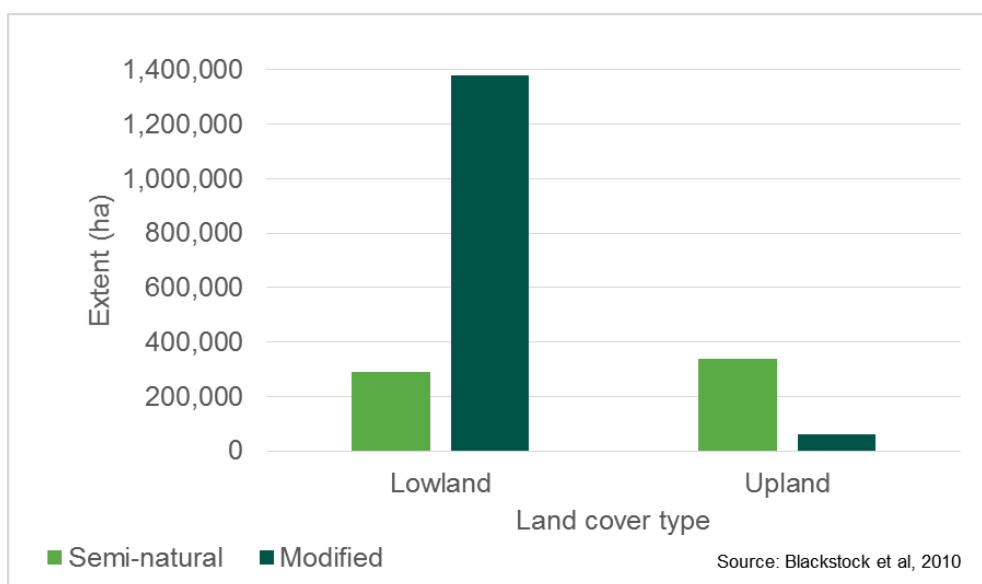










Figure 3.18 Summary of the representation of semi-natural habitats and modified land-cover types in Wales⁹⁹ [M].

The marine environment includes 2,740 km of coastline¹⁰¹ [H]. The marine ecosystems in Wales form part of two wider biogeographic regions: the Irish Sea, and the Western Channel and Celtic Sea. There is a high diversity of habitats and species including sediment and biogenic habitats, sessile and highly mobile species. A proportion of marine habitats are surveyed and mapped¹⁰², but for some areas our understanding only comes from modelling¹⁰³.

The way in which habitats are grouped in SoNaRR follows the system of the National Ecosystem Assessment (NEA), which combines the separate habitat types of the Habitats of Wales scheme into 'broad habitats'. These are effectively broad ecosystem units. Table 3.2 describes what is included in the remainder of this Chapter in relation to the NEA groupings.

Table 3.2 What is included in each broad habitat.

NEA broad habitat	Description (UK NEA, unless otherwise stated)
<p>Mountains, Moors and Heaths</p> 	<p>Mountainous habitats are those above the climatic tree-line. Moorlands and heaths are predominantly open and unenclosed. Includes: upland and lowland heathlands (including dwarf shrub heath), moorlands, blanket bog, montane habitats (including ffridd or the upland fringe that encompasses land occurring between the intensively managed lowlands and the open moor), inland rock habitats (exposures) and stands of bracken in the lowlands. Often interspersed with other habitats such as semi-natural grasslands, woodlands and surface water.</p>
<p>Semi-natural grasslands</p> 	<p>A mixture of grasses and herbaceous plants, along with sedges, rushes, mosses and other low-growing species, often created by low-intensity, traditional farming or natural vegetation on poor soils or in exposed locations. They often contain a rich variety of grasses and herbs.</p>
<p>Enclosed farmland</p> 	<p>Agricultural land surrounded by hedges, walls, fences and other field boundaries. Includes: arable crops, horticulture, orchards and temporary grasslands as well as agriculturally improved permanent grasslands. Excludes: the ffridd, areas of enclosed semi-natural grassland, scrub and farm woodland.</p>
<p>Woodland</p> 	<p>Land where the ecological condition is, or will be, strongly influenced by the tree canopy. In terms of land cover statistics (in the UK), woodland is currently defined as land with trees where the mature trees would cover more than 20% by area. Large tracts are generally called forests, smaller units are described in a variety of terms such as woodlands, woods, copses and shelterbelts, but</p>

	there is no minimum size for a woodland (UK Forestry Standard).
<p>Freshwaters</p> 	<p>Freshwater-habitats occur wherever rainfall, snowmelt or groundwater collects into flowing channels (rivers and streams), standing waters, or associated bogs, fens, grazing marshes, wetlands and floodplains. Groundwater is the water stored in soil and rocks. It provides base flow to springs, rivers and wetlands. This broad habitat includes groundwater, wetlands, rivers and streams, and standing waters (lakes and ponds).</p>
<p>Urban</p> 	<p>The built environment. Includes: buildings, roads, gardens, parks and informal green spaces, waste sites and any other structure or space installed for human activities¹⁰⁴.</p>
<p>Coastal Margins</p> 	<p>Habitats around the coastline of Wales. Includes: sand dunes, saltmarsh, sea cliffs, saline or coastal lagoons and shingle.</p>
<p>Marine</p> 	<p>Includes: coastal and marine waters, the intertidal area and the inshore subtidal area. The intertidal area covers the shore from the high water mark down to the low water mark. The marine inshore subtidal area is the area of the sea bed that is always covered by water, from the low water mark out to 12 nautical miles.</p>

Habitats of principle importance

In Wales the interim Section 7 list has 55 habitats of principle importance which were originally selected for the Section 42 list of the Natural Environment and Rural Communities Act 2006. These habitats cover terrestrial, freshwater and marine. They include blanket bog, ponds and seagrass beds and were selected for prioritised action from the UK Biodiversity Action Plan (BAP) using criteria based on the level of threat they face, their relative importance as habitat in Wales and whether remedial action will be able to improve their status. Terrestrial habitats of principle importance extend over a total area of 387,300 ha¹⁰⁵ [M]. The most extensive of these in Wales (each with a resource of >30,000 ha) include upland heathland, blanket bog, upland oak woodland, purple moor-grass and rush pasture, lowland dry acid grassland and

coastal and floodplain grazing marsh [M]. However, some key habitats of conservation importance are scarce, small in extent and highly vulnerable [M]. Marine Intertidal BAP habitats extend over 15,000 ha¹⁰² [H]. The most extensive intertidal BAP habitat, mudflats, covers over 14,000 ha and is found all around the coast of Wales [H]. Honeycomb worm reefs cover 476 ha and are mainly found in South and West Wales [H]. More than 50% of all BAP habitats were in decline in Wales in 2008¹⁰⁶ [M].

European and UK protected sites

European protected sites are designated either as exemplars of listed habitat and species types or specifically to conserve wild birds that are listed as rare and vulnerable. The protection of these sites makes a significant contribution to conserving the habitats and wildlife species that live there. Protected sites also exist in the marine environment, and work continues to ensure these sites contribute to an ecologically coherent network of marine protected areas in UK seas. Together with our nationally designated sites (SSSIs) they are a good indicator of the health of semi-natural habitats across Wales and contribute to the understanding and practice of sustainable management of natural resources in Wales.

Natural Resources Wales has a responsibility to report on these sites. The figures used in this Chapter are based on the most recent reported condition assessments. As an overview, roughly a quarter of Special Areas of Conservation (SAC) habitats in Wales are in a favourable condition¹⁰⁷ (Figure 3.19).

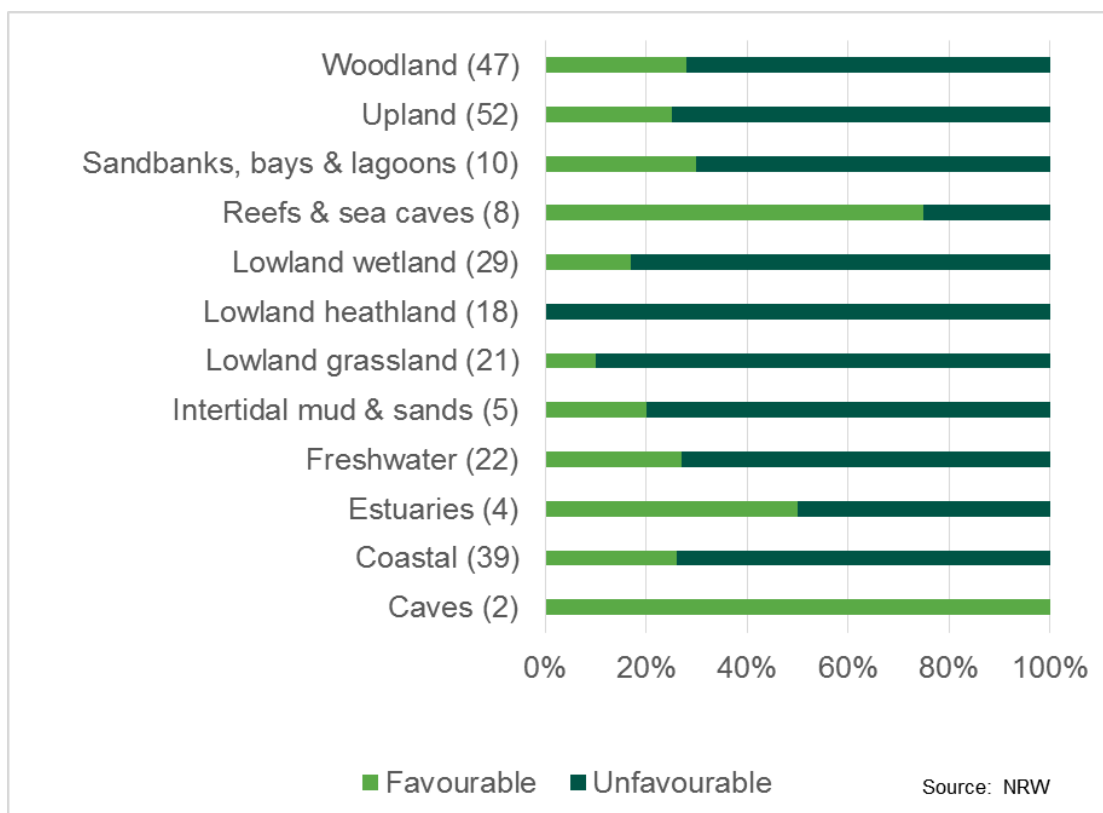


Figure 3.19 Percentage of Special Area of Conservation (SAC) habitat features in favourable and unfavourable condition¹⁰⁷. Number of habitat features in assessment shown in brackets.

[H]

3.6. Mountains, moors and heaths

(See section 3.6 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Extent:

- Mountain, moorland and heath habitats extend over 261,824 ha in Wales¹⁰⁸ (Figure 3.20) [M].
- 70,130 ha (27% of the total) of mountain, moorland and heath habitat occur as SSSI features across Wales on 118 SSSI¹⁰⁹ (Table 3.3) [M]. Extensive areas are included within the Glastir scheme with grazing prescriptions helping to ensure appropriate grazing regimes¹¹⁰ [H].
- The most extensive Habitats and Species Directive Annex I habitats of mountain moor and heath are blanket bog, European dry heaths and northern Atlantic wet heaths with *Erica tetralix*; 12 other Annex I habitats also occur with a collective total area of 147,700 ha¹¹¹ (Table 3.4) [M].

Condition:

- The condition of the most extensive semi-natural habitats of mountain, moorland and heath within SSSIs ranges between 63 and 73% unfavourable¹¹² (Table 3.3) [L]. The overall assessment of the conservation status of the 15 Annex I habitats associated with mountain, moorland and heath is either bad or inadequate (Table 3.4). For many habitats this assessment relates mainly to condition, with habitat area judged as stable for 11 of habitats, but unknown or declining for 4 (including blanket bog)¹¹³ [H].
- Habitat fragmentation has resulted in poor connectivity for lowland examples of mountain, moorland and heath habitats (notably lowland heathland)¹¹⁴ [H].
- There is high habitat diversity and good connectivity within the ffridd¹¹⁴ [M].
- Some 60% of the Welsh deep (≥ 0.5 m) peat resource occurs within the mountain, moorland and heath habitat suite with most of it represented by blanket bog. Some 59% of the blanket bog resource displays signs of modification resulting from drainage and other land-use impacts. Significant areas of deep peat occur elsewhere in the uplands, chiefly in conifer plantations¹⁰⁸ [M], acid grassland, heathland and improved grassland. Exposed peat resulting from erosion extends over less than 100 ha but affects over 180 sites¹¹⁵ [M].
- Approximately 2,000 km of drainage ditches occur on upland peatlands¹¹⁶ [M] with at least 742 km blocked already [H] contributing to improvements in biodiversity, carbon storage and sequestration and flood risk management¹¹⁷ [M].

Trend:

- Agri-environment measures continue to be effective in helping to protect some of the most extensive mountain, moorland and heath habitats, with encouraging trends noted for blanket bog and heathland, though less strong for flush and spring^{118, 119}. A significant increase in *Sphagnum* cover has been noted between 2007 and 2013/14¹¹⁶ but this is based on a relatively limited sample size.

KEY MESSAGES

- Data from the Glastir Monitoring and Evaluation Programme (GMEP)¹¹⁶ indicate that the extent of dwarf shrub, heath and bracken has declined significantly since 2007, with a slight increase in the area of blanket bog since 1990 [L]. The area of upland bog restored following plantation is steadily increasing as a result of NRW activity on sites prioritised for this measure and also through the wind energy programme. There has been no overall improvement in condition for this broad habitat as a whole since 1990¹¹⁶ [L].
- The CCRA17 Evidence Report¹²⁰ has identified climate change risks to natural carbon stores and carbon sequestration, emphasising that upland and lowland deep peat soils represent Wales' largest terrestrial store of carbon. [H]

Evidence gaps:

- We only have limited information on the current distribution, extent and condition of Mountain, Moor and Heath habitats in Wales.
- There are limited recent data on condition of mountains, moorlands and heaths features on SSSIs in Wales.

Extent:

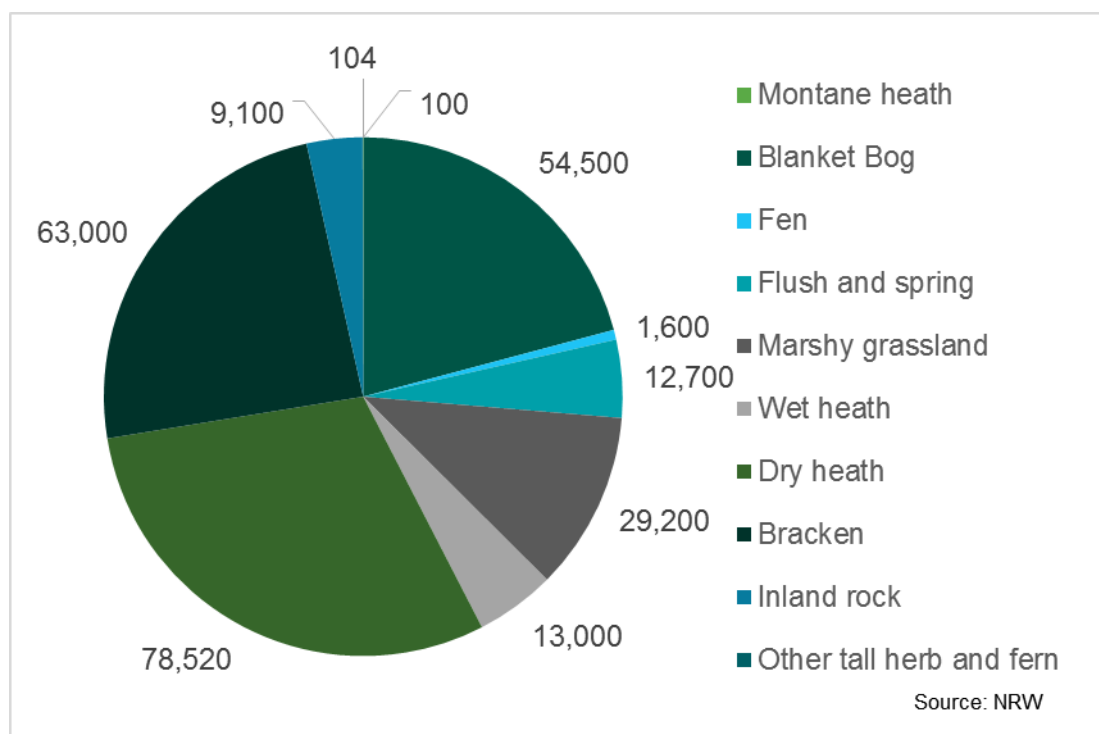


Figure 3.20 Breakdown of the component habitats of mountain, moorland and heath in Wales. All numbers are in hectares (ha)¹⁰⁸. [M]

Condition:

Table 3.3 Summary of the representation of mountain, moorland and heathland habitats within the SSSI series based on data up until 2010; data are rounded to the nearest 10 ha¹⁰⁹

[M]. Data in the final column are based on Allen (2004)¹¹² and in most cases relate to a subset of the SSSI sites notified for each feature [L].

Habitat	Area of qualifying features within SSSI (ha)	Number of SSSI qualifying features	% assessed features unfavourable
Blanket bog	25,900	27	67
Flush	3,470	7	12
Fen	50	8	Insufficient data
Marshy grassland	760	4	50
Dry heath	31,220	83	73
Wet heath	4,290	54	63
Montane	230	8	100
Inland rock	3,900	30	33
Tall herb and fern	70	5	33

Trend:

Table 3.4 Summary of the conservation status of Habitats and Species Directive Annex I habitats associated with mountain, moorland and heath¹²¹ [H]. * Indicates Habitats Directive priority status. Key: → = stable; ↓ = decreasing less than 1% per year; ↓↓ = decreasing more than 1% per year; ↘ = decreasing rate unknown; ↑ = increasing; - = unknown.

Habitat name	Surface area (ha) - Wales	Proportion (%) of UK Surface Area in Wales	Short-term trend direction – Wales (area)	Short term trend direction – UK (area)	Overall assessment of conservation status – UK
Alkaline fens*	120	3.6	-	→	Bad
Alpine pioneer formations of the <i>Caricion bicoloris-atrofuscae</i>	3	3.8	-	→	Bad
Blanket bogs (* if active bog)	53,200	2.4	-	↓	Bad
Alpine and subalpine calcareous grasslands*	1.7	0.2	→	→	Bad
Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	65	22.6	-	→	Bad
Siliceous alpine and boreal grasslands*	84	0.1	→	→	Bad

Habitat name	Surface area (ha) - Wales	Proportion (%) of UK Surface Area in Wales	Short-term trend direction – Wales (area)	Short term trend direction – UK (area)	Overall assessment of conservation status – UK
Species-rich Nardus grassland, on siliceous substrates in mountain areas (and submountain areas in continental Europe)*	138	2.7	→	↓	Bad
Calcareous and calcshist screes of the montane to alpine levels (<i>Thlaspietea rotundifolii</i>)*	34.3	5.7	-	-	Bad
Calcareous rocky slopes with chasmophytic vegetation	270	38.6	-	-	Bad
Limestone pavements	75	2.9	→	→	Bad
Siliceous rocky slopes with chasmophytic vegetation	1,200	3.0	-	→	Inadequate
Siliceous scree of the montane to snow levels (<i>Androsacetalia alpinae</i> and <i>Galeopsietalia ladani</i>)	317	0.5	-	→	Inadequate
Alpine and Boreal heaths	35	0.1	-	→	Bad
European dry heaths	77,740	8.7	→	→	Bad
Northern Atlantic wet heaths with <i>Erica tetralix</i>	14,414	3.1	↓	→	Bad

KEY EVIDENCE SOURCES

- Habitats of Wales (Blackstock et al, 2010)¹⁰⁸
- JNCC (2013) 3rd UK Habitats Directive Reporting 2013¹²²
- Glastir Monitoring Evaluation Programme (GMEP)¹¹⁶

3.7. Semi-natural grasslands

(See section 3.7 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Extent:

- Grassland makes up nearly two thirds of the land cover of Wales¹²³ [H]. The majority (more than 1,000,000 ha) is agriculturally improved [H] and only about 192,000 ha is semi-natural grassland (9% of the land cover of Wales)¹²³ (Table 3.5, Figure 3.21) [M].
- There are some 78,000 ha of grassland Priority Habitat (Table 3.5) [M], more than 90% of which is in the lowlands^{123, 124} [H].

Condition:

- All 8 forms of European protected grassland occurring in Wales have an unfavourable conservation status in the UK - 92% of grassland SAC features in Wales are considered to be in unfavourable condition¹²⁵. [H]
- A rapid review of grassland features on SSSIs in Wales in 2003 estimated that only 43% were in favourable condition¹²⁶ (Table 3.6). [L]

Trend:

- The extent of lowland semi-natural grasslands has decreased dramatically since the 1930s^{124, 127, 128} [H]; an estimated 91% was lost in Wales between the 1930s and the 1990s¹²⁴ (Table 3.7) [M]. Dry lowland grassland habitat has been particularly badly affected, with an estimated 97% decline in that period, so that, for example, only 1,600 ha of unimproved neutral grassland remain¹²⁴ [M].
- Semi-natural lowland grasslands have become highly fragmented in most areas¹²⁴ greatly restricting movement of less mobile species between habitat patches [H].
- The rate of loss of semi-natural grassland is thought to have slowed^{124, 129} [L], although losses of high quality lowland semi-natural grassland have continued into the 21st Century¹²⁴ [H].

Evidence gaps:

- There are limited recent data on condition of grassland features on SSSIs in Wales.
- There is limited information on current extent and condition of grasslands outside protected sites.

Table 3.5 Extent of different semi-natural grasslands in Wales. Extent figures from Blackstock et al (2010)¹²³ except * Stevens et al (2010)¹²⁴ and JNCC (2013)¹²⁵. Note that 'upland marshy grassland' (29,204 ha) is included in the 'mountain, moorland and heath' section.

Grassland habitats in Wales	Semi-natural grassland (ha)	Priority Grassland Habitat (ha)
Unimproved neutral grassland (Lowland Meadows)*	1,605	1,605
Lowland dry acid grassland	39,517	39,517
Upland dry acid grassland	113,204	-
Lowland calcareous grassland	1,158	1,158
Upland calcareous grassland	653	653
Lowland marshy grassland (Purple Moor-grass and Rush Pastures)	35,341	35,341
Calaminarian grassland [#]	49	49
TOTAL	191,527	78,323

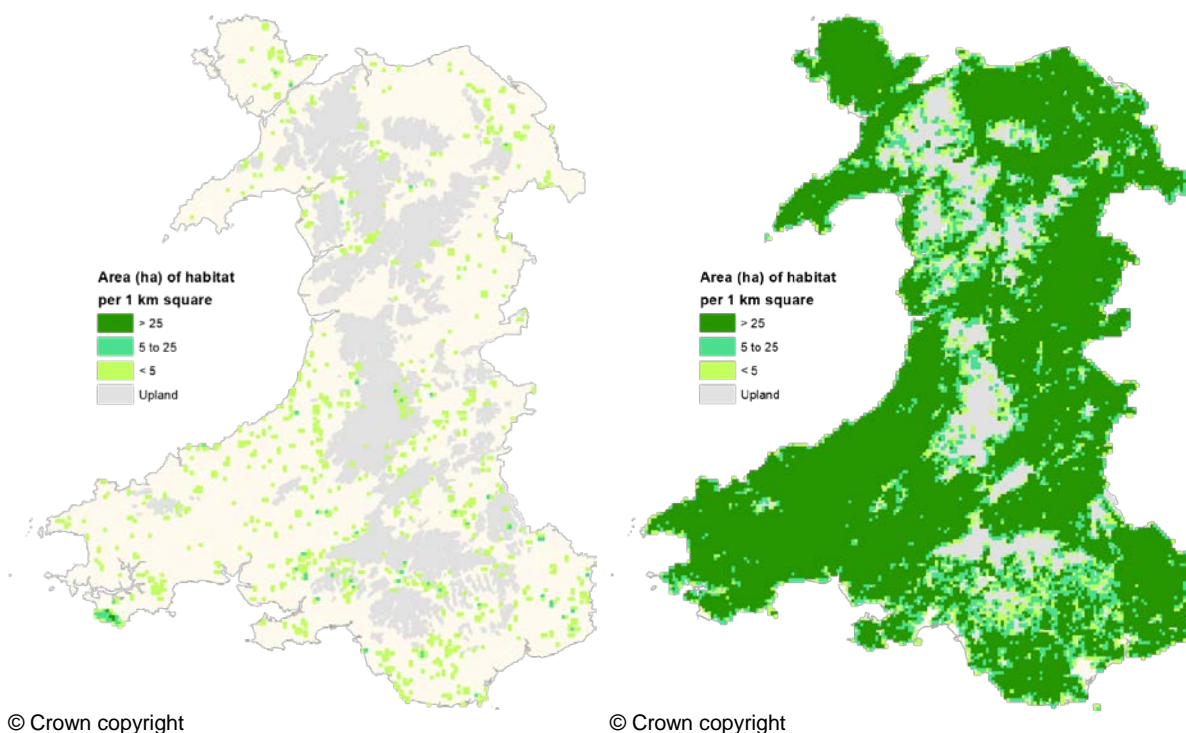


Figure 3.21 Distribution map of (left) unimproved neutral grassland in Wales compared with that of (right) improved grassland. The unimproved neutral grassland includes only stands confirmed by thorough floristic survey (from Blackstock et al. 2010¹⁰⁸).

Table 3.6 Summary of lowland grassland SSSI feature condition assessments (from Allen, 2004¹²⁶). * Includes calaminarian grassland.

SSSI feature	Number of assessed features	% favourable
Neutral grassland	145	37
Calcareous Grassland	29	31
Acid Grassland	34	62
Marshy grassland	125	45
Rock and spoil*	9	78
ALL	342	43

Table 3.7 Recorded losses of semi-natural grasslands.

Area	Timeframe	Loss of semi-natural grassland habitat	Main reason for change	Reference
England and Wales	1930-1984	97%	Drainage, ploughing and fertiliser use	Fuller 1987 ¹²⁷
Wales	1930s-1990s	91% (including semi-improved grassland)	Conversion to agriculturally improved grassland	Stevens et al 2010 ¹²⁴
Wales	1996-2004	Significant damage/deterioration at 25% (24 out of 96) of unprotected sites.	Agricultural improvement (62% sites); under-management (30% sites)	Stevens et al 2010 ¹²⁴
England	1960-2013	73% (on unprotected land) 9% (on protected land) by area	Conversion to agriculturally-improved grassland or arable cultivation	Ridding et al 2015 ¹²⁸

KEY EVIDENCE SOURCES

- Grasslands of Wales: A survey of lowlands species rich grasslands¹²⁴
- Habitats of Wales (Blackstock et al, 2010)¹²³
- JNCC (2013) 3rd UK Habitats Directive Reporting 2013¹²⁵

3.8. Enclosed farmland

(See section 3.8 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Extent:

- Enclosed Farmland covers around 1 million ha or c.54% of agricultural land¹³⁰; it plays a major role in food production¹³¹ with resulting impacts on soil, water, biodiversity and GHG emissions¹³². [H]
- The area of arable and horticultural crops (87,000 ha) has increased by 35% over the last ten years but still only represents some 8.7% of Enclosed Farmland¹³³. [H]

Condition:

- Our arable-associated flora is the most threatened group of plants in the UK with 54 species considered rare or threatened and 7 species extinct in the arable setting^{134, 135} [H].
- The total length of hedgerows in Wales has been estimated at 106,000 km but 78% of this is in unfavourable condition¹³⁶ [M]. Some 5,800 km has been restored or is planned for restoration under agri-environment schemes^{137, 138} [H].
- Work by the Glastir Monitoring and Evaluation Project suggests there has been a small increase in the number of species of lower soil fertility levels¹³⁹ [H]. In contrast, soil sampling on intensively managed farms, carried out as part of Glastir Water Management Planning, revealed that over 75% of enclosures sampled were too acidic for optimum plant growth whilst over a third of agriculturally improved fields in the study exceeded the optimum phosphate level¹⁴⁰ [M].

Trend:

- Traditional orchards have become increasingly rare due to neglect, agricultural intensification and development pressures; all of which threaten their characteristic biodiversity¹⁴¹. [H]
- *Chalara* (ash die-back) is a major threat to hedgerows. Welsh hedgerows contain a considerable quantity of ash, both in the shrub layer and as standard trees. As ash declines over the coming years, gaps will form in hedgerows and a significant proportion of the mature trees in our landscape will be lost. This is likely to have a major impact on other species dependent on both hedgerows and free-standing trees¹⁴². [H]
- The CCRA17 Evidence Report¹⁴³ has identified risks and opportunities from changes in agricultural productivity and land suitability. There are also risks associated with water scarcity and flooding; from pests, pathogens and invasive species; and from change in frequency and/or magnitude of extreme weather and wildfire events. Projected climate change may provide new cropping opportunities [H], but more agricultural land is likely to suffer from water deficits in summer and waterlogging in winter¹⁴³ [M].

Evidence gaps:

- Limited information on the current condition of Enclosed Farmland habitats in Wales.
- Limited information on the distribution of *Chalara* infected ash trees within Wales.

Extent:

Although comprised primarily of intensively managed arable land and improved grassland, enclosed farmland also includes the following priority habitats:

Priority Habitat	Extent in Wales	Welsh Government Rural Communities Rural Development Programme
Hedgerows	Length 106,000 km ¹³⁶ [M]	Just under 3,530 km restored under the Tir Gofal agri-environment scheme ¹³⁷ . A further 2,300 km has been restored or is under a current management commitment within Glastir ¹³⁸ . [H]
Arable field margins	Overall extent unknown. Limited information on the extent of arable field margins in Wales but just over 20 ha of arable land has been notified as SSSI ¹⁴⁴ . [H]	Glastir contracts for fallow land, unsprayed cereals and roots now cover 8,203 ha ¹³⁸ . In addition, organic arable farming covers around 2,800 ha ¹⁴⁵ although some of this land is also under Glastir contract. [H].
Traditional orchards	Estimated to be 4,687 individual sites, covering 653 ha in total at an average of only 0.14ha each ¹⁴¹ . [H]	Some 51 ha of existing traditional orchards and 5.5 ha of newly created, traditionally managed orchards are now included within Glastir ¹³⁸ . [H]

Trend:

Habitat	Trends
Hedgerow	<ul style="list-style-type: none"> Continued decline in length of managed hedgerows, despite progressive uptake of agri-environment schemes, resulting in increase in both relict and overgrown hedges¹³⁹. [H] Number of hedgerow trees reduced by 3.9% (1998-2007)¹³⁶. [M]
Arable	<ul style="list-style-type: none"> Significant decrease in arable species richness in Wales between 1998 and 2007¹³⁶. [M] Arable weed/field margin habitats were widespread and abundant until 1950s when herbicides became widely used. A gradual decline in such communities and their associated fauna has occurred since then as cultivation became more intensive¹⁴⁶. Species loss slowed in recent years due to an increase in organic farming and support from agri-environment schemes¹³⁶. [M] Cultivated area declined by 75% between the 1930s/40s and 1980s/90s¹⁴⁶. Area of arable and horticultural cropping expanded by 34% (65,000 ha to 87,000 ha) over the last ten

Habitat	Trends
	years (2005-2015) but still represents less than 5% of the Welsh agricultural area ¹³³ . [H]
Traditional orchards	<ul style="list-style-type: none"> The area covered by orchards was estimated to have declined by 94% between 1958 and 1992¹⁴¹. [H] The modern orchard area has recently expanded in response to the growth of the cider market, but most modern orchards are efficiently managed plantations with relatively limited biodiversity value¹⁴¹. [H]
Improved grassland	<ul style="list-style-type: none"> There has been a small increase in the number of species indicative of lower soil fertility levels¹³⁹. [H]

Projected changes in the climate are likely to impact on Enclosed Farmland as follows^{143, 147}:

- More areas experiencing water deficits during the summer months [H].
- Wetter winters will increase the prevalence of waterlogged soils [M].
- Increased risks from pests, pathogens and invasive species [H].
- New opportunities to grow alternative forage crops and diversify existing grassland swards [M].

In addition to these risks, future climate-related changes in global food supply are likely to impact on Welsh agriculture and may increase the comparative advantage of specific commodities and lead to land use change. Such global changes could present both opportunities and risks for the Welsh agricultural sector¹⁴³.

The effects of climate change on highly productive grass species are reasonably well understood, but much less is known about the impacts on species characteristic of permanent semi-natural pastures. Changes in these habitats could have substantial knock-on effects on the livestock industry because of the strong inter-relationships between enclosed farmland and mountain, moor and heath.

ENCLOSED FARMLAND KEY EVIDENCE SOURCES

- AHDB Dairy (Agriculture and Horticulture Development Board)¹⁴⁸
- Business Wales report on the poultry sector¹⁴⁹
- Estimates from Welsh Agricultural Survey, June 2015¹³³
- Countryside Survey 2007. Results for Wales¹³⁶
- Glastir Monitoring and Evaluation Programme (GMEP)¹³⁹
- Glastir Advanced Water Quality Report, 2014: Results from 2013-2014 visits. Accessible from Natural Resources Wales¹⁴⁰.
- Great Britain Poultry Register Statistics, 2013¹⁵⁰
- Preliminary atlas of field boundary types in Wales, Gwynedd Archaeological Trust, 2002¹⁵¹
- Habitats of Wales (Blackstock et al 2010)¹³⁰
- Flying the Flag: Decade of Success for the Welsh Red Meat Brands, Hybu Cig Cymru, 2013¹⁵²
- The impact of climate change on the capability of soils for agriculture as defined by the Agricultural Land Classification report¹⁵³
- Extent of arable SSSI's (NRW 2016)¹⁴⁴.
- Traditional Orchard Habitat Inventory of Wales¹⁴¹.

ENCLOSED FARMLAND KEY EVIDENCE SOURCES

- Wales' Important Arable Plants (Plantlife)¹⁴⁶
- Orchards in Wales (TACP, 1994)¹⁴¹.
- Tir Gofal - Report presented by the Auditor General to the National Wales 15 November 2007¹³⁷
- Welsh Government Rural Payments Agency, 2016¹³⁸.
- LANDMAP Statistics 2016: Visual and Sensory Aspect¹⁵⁴.

3.9. Woodland

(See section 3.9 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Extent:

- Woodland area in Wales has nearly tripled since the 1800s, now covering 306,000 ha¹⁵⁵ (94,940 ha of which comprises ancient woodland) (Table 3.8). However, Wales is one of the least wooded countries in Europe (14.8% of land area compared to EU average of 38%) [H].

Condition:

- At least 203,000 ha of woodland in Wales is managed to the UK Forestry Standard (the standard for sustainable forest management in the UK and a proxy measure of woodland condition in woodlands that are managed); this is an increase from 123,000 ha in 2001¹⁵⁵. However, around 40% of Wales' woodlands have little or no management which reduces their resilience and ability to provide well-being benefits [M].
- Whilst the overall conservation status of designated woodland habitats in Wales is regarded as unfavourable, favourable management is increasing with local recovery in response to targeted management actions^{156, 157} [H]. GMEP uses a number of ancient woodland indicator species as a measure for condition and found an increase between 2007 and 2014¹⁵⁸.
- Fragmentation is a significant pressure affecting native woodland condition - there are nearly 22,000 woodlands identified as being smaller than 2.0 ha¹⁵⁹. Woodland condition is negatively impacted by browsing and grazing pressures from domesticated and wild animals, especially wild deer¹⁶⁰, and is also affected by INNS, including the grey squirrel and *Rhododendron ponticum* (common rhododendron) [H].

Trend:

- The total area of woodland in Wales has changed little in the past 20 years. The total amount of new planting between 2009 and 2015 was 3,392 ha¹⁵⁵ (Figure 3.22). The rates of new woodland creation are low, of small average size and highly dependent on public funding. New planting is mainly of native broadleaves which impact both on Welsh woodland's capacity in the medium and long term for softwood timber production and its potential for overall carbon abatement [H].
- As a productive resource, Welsh woodlands contribute a GVA of £499.3M per annum¹⁵⁵ to the Welsh economy [H]. Forecasts of future timber production show a drop in availability from current levels unless more woodland is brought into sustainable management, replanting rates are increased and more new woodland is created that is capable of producing utilisable timber^{161, 162} (Table 3.9) [H].
- Woodland condition and extent in Wales has already been (to a limited *known* extent) and will in the future (to a greater *predicted* extent) be affected by climate change. Tree health is already declining with over 70% of larch in Wales infected with *Phytophthora ramorum*¹⁶³ (Figure 3.23) and *Chalara fraxinea* (*Chalara* dieback of Ash); this has been detected at 100 individual sites across Wales¹⁶⁴ [H]. The pressures from pests and diseases will increase in the future.

KEY MESSAGES

- The CCRA17 Evidence Report¹⁶⁵ has identified risks and opportunities from changes in forestry productivity and land suitability. There are also risks associated with water scarcity and flooding; from pests, pathogens and invasive species; and from change in frequency and/or magnitude of extreme weather and wildfire events.
- Woodland productivity and carbon sequestration rates are also likely to be impacted by climate change. Current carbon sequestration by Welsh woodlands is estimated to be about 1,419,000 tonnes annually¹⁵⁵. Forestry is predicted to remain a net sink for atmospheric carbon [H].

Evidence Gaps:

- Measuring woodland condition is expensive, and data on extent and condition – including of our coniferous forests – is limited. The National Forest Inventory (NFI) will provide a sample based indication of condition at a Wales scale when it publishes its official report on woodland condition in 2017.
- There is currently very limited information about the distribution of pest and disease outbreaks throughout Wales and Britain. There is information about the known spread of quarantine pests and diseases but the vast majority of pests and diseases are not mapped. Although a data management project is being developed across GB to gather all the current and future information together, there will still be limitations due to the level of resource required to undertake surveillance to provide data across such a wide range of pests and diseases.

Table 3.8 Classification of woodland in Wales, by type, including area in hectares (ha). [H]

Woodland type		Definition	Current Area (ha)
Ancient Woodland (AW)	Total Ancient woodland	Ancient Woodland is defined as land that has had continuous woodland cover since at least 1600 AD. The Ancient Woodland Inventory ¹⁶⁶ (AWI) for Wales was updated in 2011 using Epoch 1 maps from the 1800s. Ancient woodland is subdivided into ASNW, PAWs and RAW according to the management of the woodland on the site.	94,940
	Ancient Semi Natural Woodland (ASNW)	These woodlands have a continuous history of being managed as semi-natural woodland on ancient sites. The trees and shrubs are native to the site and not generally obviously planted. They have high ecological diversity supporting a high proportion of scarce or rare woodland flora and fauna (often those with limited dispersal ability) and as such are our most important woodland type.	41,790

Woodland type		Definition	Current Area (ha)
	Plantations on Ancient Woodland (PAWS)	Former Ancient Semi-natural Woodland (ASNW) that has been more or less completely replanted, often but not exclusively with conifers and many in the 20 th century. These are widely distributed through Wales.	25,750
	Restored Ancient Woodland (RAW)	These are PAWs that have been/are being restored to mainly native tree species with a more natural woodland structure.	21,960
	Ancient woodland site of Unknown category (AWSU)	Woodlands which may be ASNW, PAWS or RAW. These areas are predominantly in transition where the existing tree cover is described as shrubs, young trees, felled or ground prepared for planting.	5,440
Non-Ancient Woodland	Total non-ancient woodland	Recent woodland that has not been in continuous woodland cover as defined by the AWI (2011). Non-ancient woodland is sub-divided into:	211,060
	Non-Ancient native woodland	Recent woodland which has a tree canopy that consists of more than 50% tree species native to Wales.	52,005
	Non-Ancient non-native woodland	Recent woodland which has a tree canopy that consists of more than 50% species which are not native to Wales	159,055
Total Woodland area			306,000

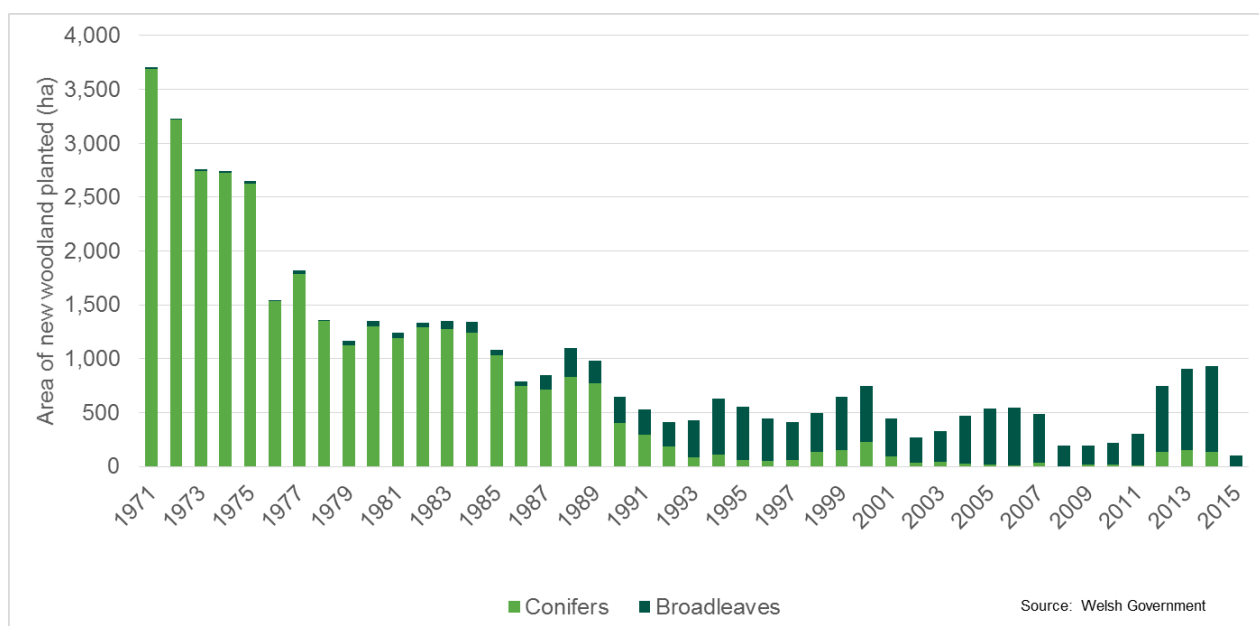


Figure 3.22 New planting in Wales (hectares, ha), by woodland type (broadleaves and conifers), 1971-2015¹⁵⁵. [H]

Table 3.9 Forecast of timber availability in Wales (thousand m³ overbark standing – 000s m³ obs), 2017-2061¹⁶². S = softwood, H = hardwood. [H]

Year	WGWE		Private		Total		Total
	S	H	S	H	S	H	
2017-21	991	11	949	46	1,940	58	1,998
2022-26	895	17	1,087	77	1,982	94	2,076
2027-31	778	12	775	100	1,553	112	1,665
2032-36	934	14	736	115	1,670	130	1,800
2037-41	794	19	679	153	1,473	171	1,644
2042-46	531	56	490	243	1,021	299	1,320
2047-51	585	19	521	227	1,106	246	1,352
2052-56	495	28	734	197	1,229	227	1,456
2057-61	679	28	694	139	1,373	167	1,540

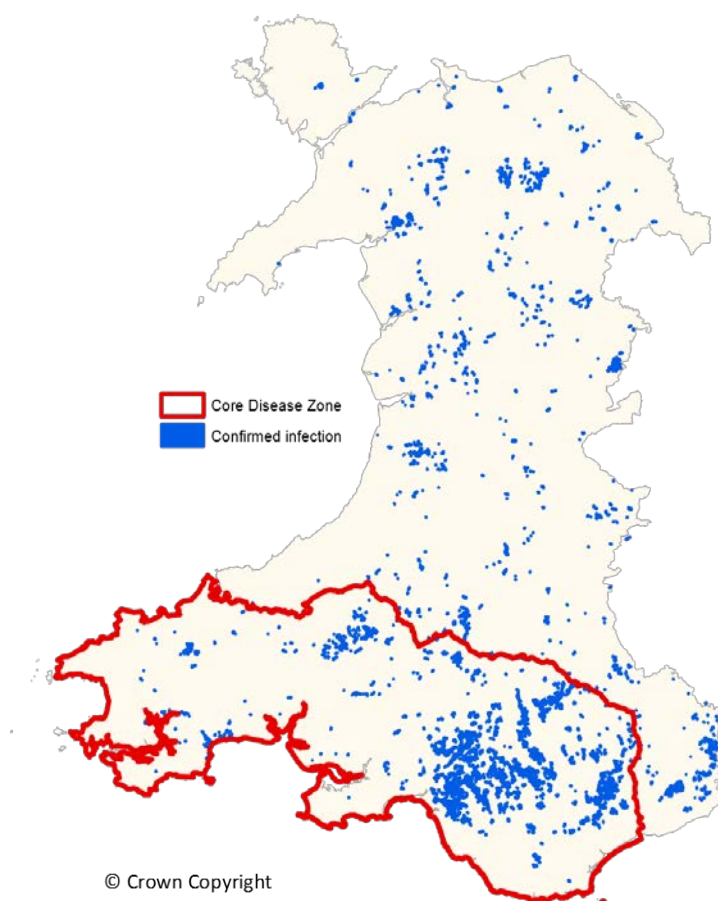


Figure 3.23 Distribution of *Phytophthora ramorum* in Wales in 2016¹⁶³. [H]

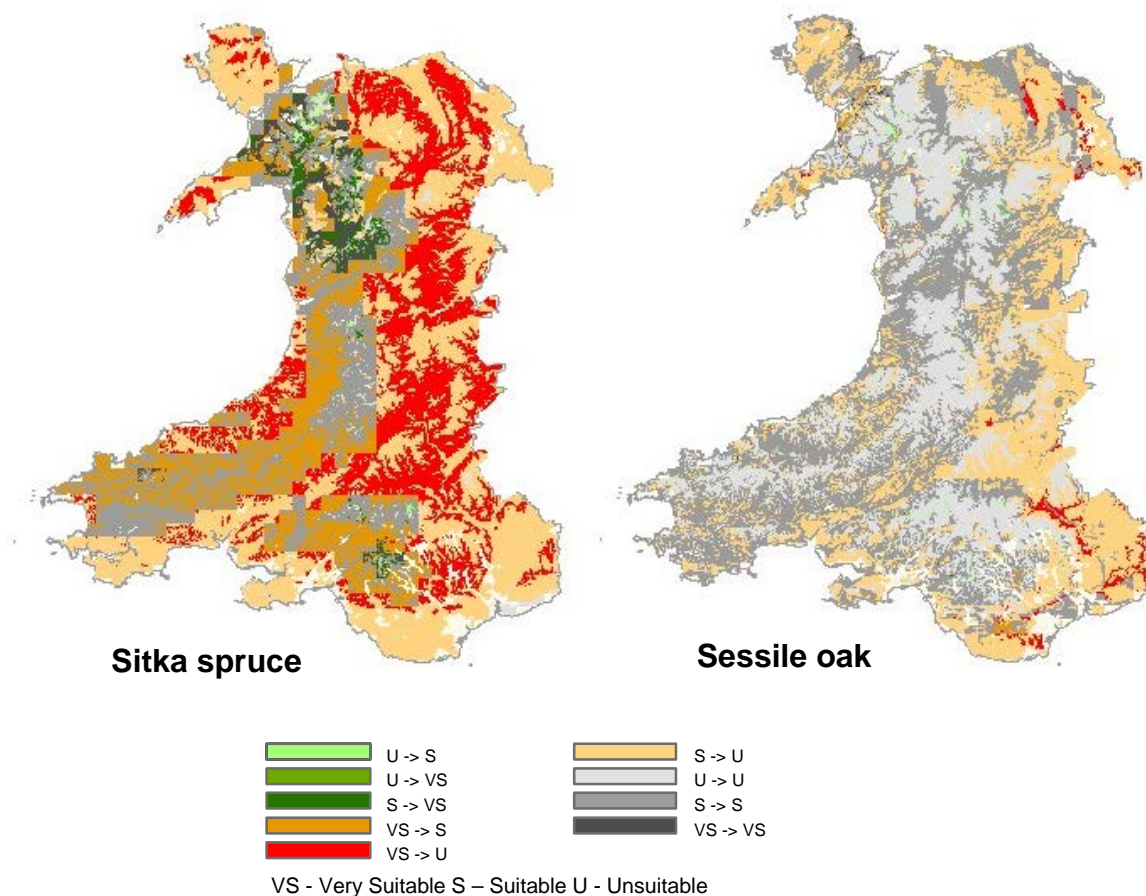


Figure 3.24 Modelled Suitability change in Sitka spruce and Sessile oak based on predicted climate change by 2080, based on UK Climate Change Projections 2002 (UKCIP02) predictions (High scenario)¹⁶⁷. [M]

KEY EVIDENCE SOURCES

- Woodlands for Wales – the Welsh Assembly Government’s Strategy for Woodlands and Trees¹⁶⁸
- Forestry Statistics (Forestry Commission 2015)¹⁶⁹
- Combating climate change - a role for UK forests report¹⁷⁰
- Impacts of climate change on forestry in Wales (FC Information Note 301)¹⁷¹
- Ancient Woodland Inventory¹⁶⁶
- Upland forestry Wales study - Welsh Analysis of Land-use Economics & Subsidies¹⁷²
- ConFor. Welsh Softwood Timber Supplies and our Green Economy¹⁶¹
- The Role of Productive Woodland in Water Management report¹⁷³
- Inquiry into the public forestry estate in Wales¹⁷⁴
- UK NEA Chapter 8 Woodlands¹⁷⁵
- British Woodlands Survey 2015¹⁷⁶
- Welsh Assembly Government’s strategy for wild deer management in Wales¹⁶⁰
- Wales’ Tree Health Strategy¹⁷⁷

KEY EVIDENCE SOURCES

- Understanding GHG balance in Britain's forests report¹⁷⁸
- Sustainable forest management in a time of ecosystem services frameworks: common ground and consequences. *Journal of Applied Ecology*¹⁷⁹
- The State of the UK's Forests, Woods and Trees. Perspectives from the sector. Policy Paper¹⁸⁰
- Woodland Indicators by Local Authority. Unitary and county councils. Research Report¹⁸¹
- Glastir Monitoring and Evaluation Programme (GMEP)¹⁵⁸

3.10. Freshwater

(For more information see section 3.10 of the Technical Annex for Chapter 3)

KEY MESSAGES

Extent:

- Wales has approximately 24,000 km of rivers and streams¹⁸². Around 15% of the land area of Wales drains into 558 lakes (defined as ≥ 1 ha), including over 150 large scale reservoirs which cover 8,143 ha¹⁸³ [H].
- Raised bog and fen are the main lowland peatland types in Wales; 81% and 59% respectively of the SSSI resource of these habitats are in unfavourable condition¹⁸⁴ (Table 3.10) [L].
- Most floodplain areas are heavily modified in Wales, with semi-natural habitats accounting for only 16% of the total area¹⁸⁵ [M].

Condition

- In 2015, 63% of all freshwater water bodies defined by the Water Framework Directive were not achieving good or better overall status^{186, 187} (Figure 3.25, Figure 3.26, Figure 3.27, Figure 3.28) [H]. One out of six freshwater habitat types are in Favourable Conservation Status¹⁸⁸ [H]. 2.4% of Wales' land area is designated as a Nitrate Vulnerable Zone (NVZ) as a result of agriculture; this contributes to the risk of nitrate polluted waters¹⁸⁹ [H].
- The Loughor Estuary, River Loughor, River Wye, Tawe Estuary, Cardiff Bay, River Alyn are all designated as Urban Waste Water Treatment (UWWT) Directive Sensitive Areas (eutrophic). In these areas better sewage treatment has been installed to remove nutrients and so protect waters that are threatened by eutrophication¹⁹⁰ [H].

Trend:

- Water quality in rivers has generally improved over the last 25 years, mainly as a result of improvements to sewage discharges. Connectivity has been restored at some sites by removing redundant weirs or installing fish passes^{186, 191} [H]. However, the area of land designated as NVZ is likely to increase due to evidence of nutrient enrichment of surface and groundwaters resulting from agricultural practices¹⁹² [H].
- Upland lakes and rivers show sustained recovery from the harmful effects of acid rain^{193, 194} (Table 3.11) [H].
- Loss of lowland wetland habitat has declined greatly since the turn of the century^{194, 195} (Table 3.12) [H].
- Climate change is predicted to affect the amount and distribution of rainfall with subsequent impacts on flows and water levels, drought and flood events and an increase in water temperatures. These changes may lead to a decline in water quality, impact some species negatively, increase the risk from invasive species and lead to changes in the way ecosystems function; for example, there may be an increased likelihood of algal blooms¹⁹⁶ [M]. The CCRA17 Evidence Report¹⁹⁶ has identified the risks to freshwater species from higher water temperatures and also the risk from land management practices that exacerbate flood risk.

Evidence Gaps

- Ecological impacts resulting from sediment and hydromorphological changes.
- Impacts of new and emerging chemicals and substances, such as neonicotinoid pesticides, nanoparticles and pharmaceuticals, on water quality and ecology.
- Assessment of the condition of the wetland resource.
- Understanding the impacts of climate change on water quality and the vulnerability of ecosystems, water dependent habitats and species.

Condition:

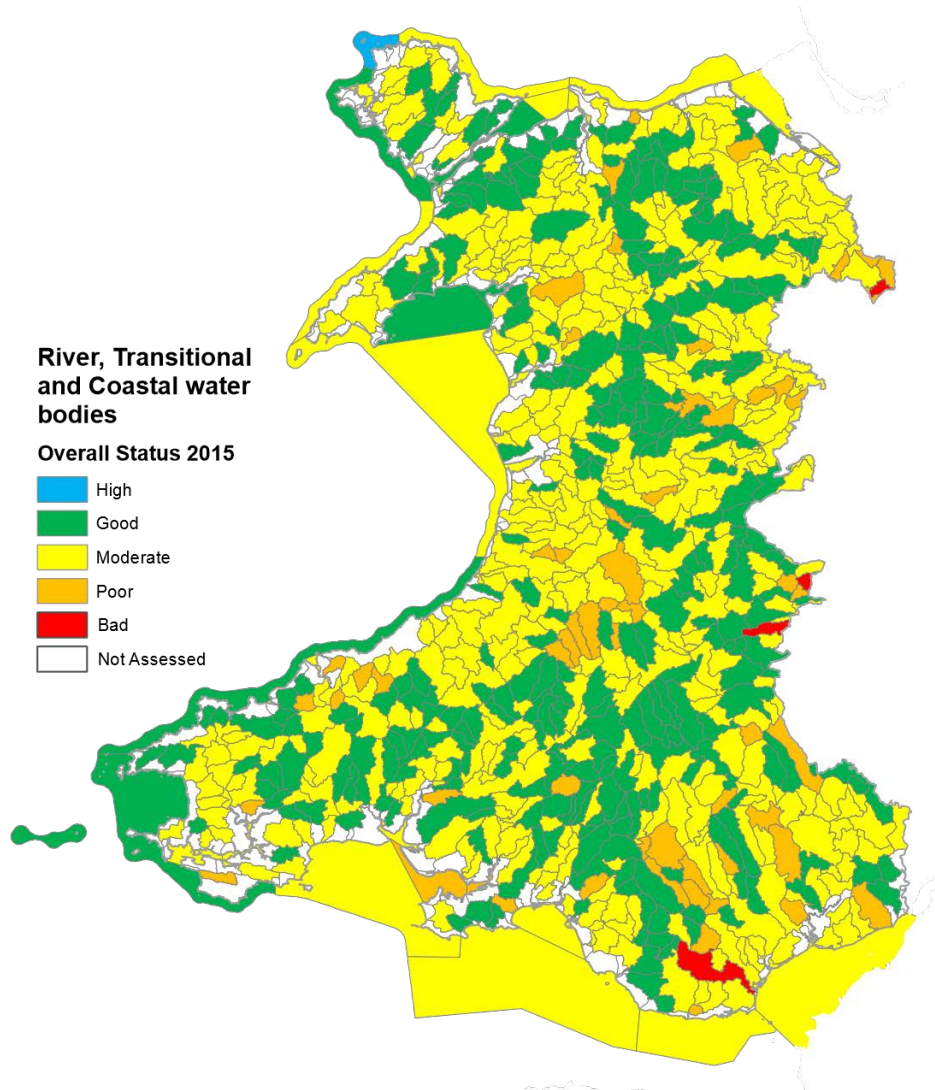


Figure 3.25 Water Framework Directive classification, overall status 2015: surface waters¹⁸⁶.
[H]

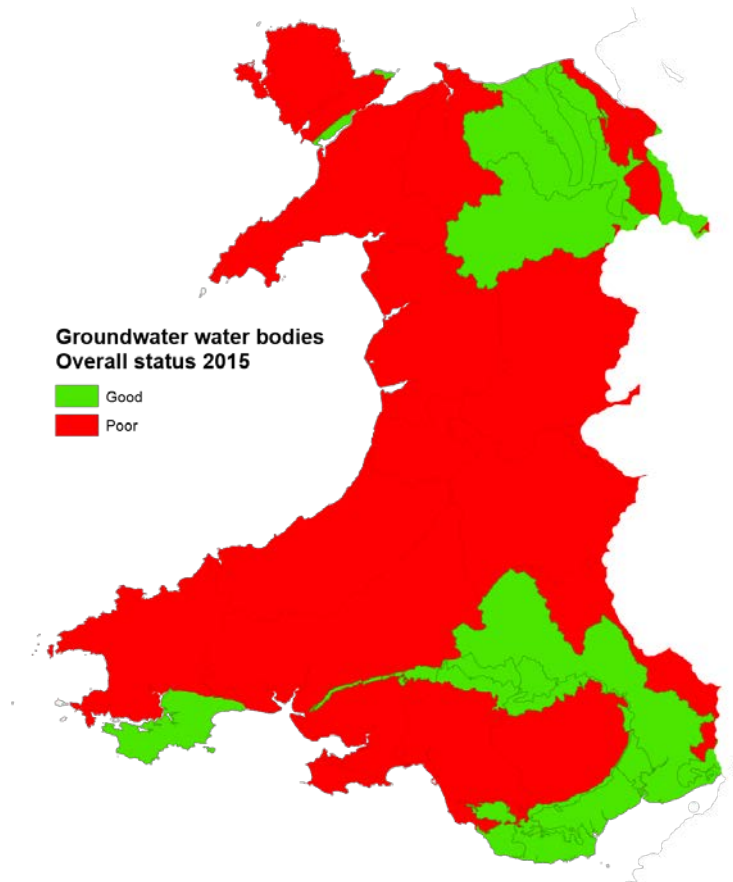


Figure 3.26 Water Framework Directive classification, overall status 2015: groundwaters¹⁸⁶. [H]

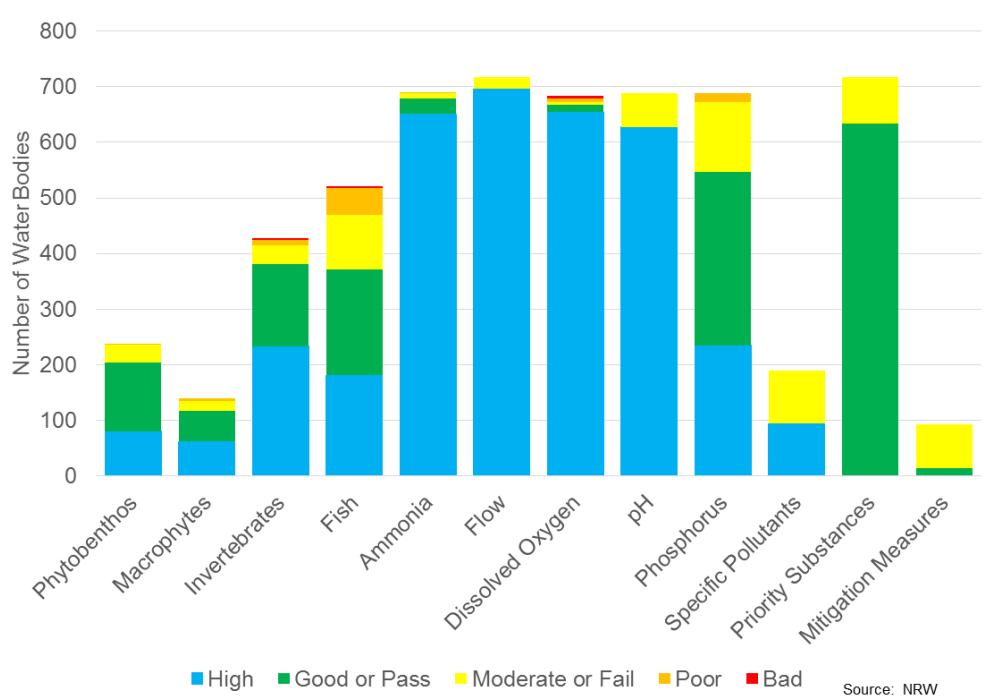


Figure 3.27 Water Framework Directive classification, element status, 2015: rivers¹⁸⁶. [H]

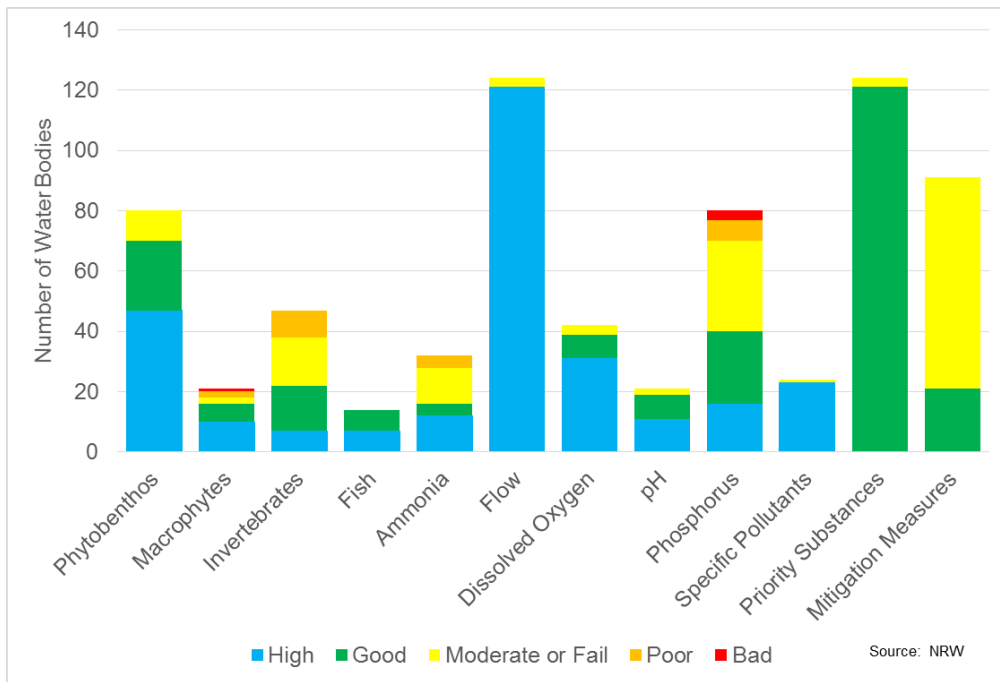


Figure 3.28 Water Framework Directive classification, element status, 2015: lakes¹⁸⁶. [H]

Table 3.10 Summary of the representation of lowland terrestrial wetland habitats within the SSSI series¹⁹⁷ * in most cases relates to a subset of the SSSI sites notified for each feature.

Habitat	Area (ha) of qualifying feature within SSSI	Number of SSSI qualifying feature	% assessed features unfavourable* ¹⁹⁸ [L]
Lowland raised bog	1,994	23	81
Fen (topogenous)	812	72	59
Flush & spring (soligenous)	133	6	27
Swamp	595	57	51

Trend:

Table 3.11 Status of Habitats Directive Annex I Freshwater Habitats in Wales¹⁹⁴ Key: → = stable; ↓ = decreasing; ↑ = increasing; - = no information; greyed arrows = low. S = short-term trend; L = long-term trend.

Habitats	Range Trend		Area Trend		Structure & Function			Notes
	S	L	S	L	Qual	S	L	
Oligotrophic to mesotrophic lakes with <i>Littorelletea</i>	→	→	→	→	Mod	↑	↓	Oligotrophic examples in uplands are more common and are showing marked evidence of recovery from acidification that occurred during the 20 th century. The more lowland mesotrophic

								examples are rare and threatened by eutrophication and are still declining.
Hard oligo-mesotrophic waters with <i>Chara</i>	→	-	→	-	Poor	→	↓	Mainly within protected sites. The main issues are nutrient-related pressures and invasive species.
Natural eutrophic lakes with <i>Magnopotamion</i>	-	-	-	-	Poor	→	↓	The main issues are nutrient-related pressures, invasive species and recreation.
Natural dystrophic lakes and ponds	-	-	↑	↑	Mod	↑	↓	This habitat type has mainly been affected by acidification and, less often, forestry.
Turloughs	→	→	→	→	Good	-	-	Pant-y-Llyn in Carmarthenshire is the only example of this rare habitat in Britain.
Rivers with Ranunculion vegetation	-	-	→	→	Mod	↑	↓	A widespread habitat type in Wales. There is some evidence of recovery from long-term degradation during the 20 th century.

Table 3.12 Status of Habitats Directive Annex I Wetlands Habitats in Wales¹⁹⁴. Key: → = stable; ↓ = decreasing less than 1% per year; ↓↓ = decreasing more than 1% per year; ↓ = decreasing rate unknown; ↑ = increasing; - = unknown.

Habitat name	Surface area (ha) , Wales	Proportion (%) of UK Surface Area in Wales	Short-term trend direction (area) (Wales)
Active raised bog	1,645	10.6	→
Degraded raised bog	751	3.6	→
Transition mire	336	-	↓
Rhynchosporion	17	-	↓
Alkaline fens	120	3.6	↓
Calcareous fen with <i>Cladium mariscus</i> and species of the <i>Caricion davallianae</i>	63	16.6	→
Petrifying springs	5.6	-	↓

KEY EVIDENCE SOURCES

- River Basin Management Plans¹⁸⁷
- The case for change - current and future water availability¹⁹⁹
- LIFE Natura 2000 programme¹⁹⁵
- Water Strategy for Wales²⁰⁰

KEY EVIDENCE SOURCES

- Water Resources Strategy for Wales²⁰¹
- Climate Change Risk Assessment for Wales¹⁹⁶
- UK Climate Projections 2009 (UKCP09)²⁰²

3.11. Urban Environments

(See section 3.11 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES

Extent:

- 2.5 million people – 81% of Wales’ population - live in towns and cities²⁰³ [H].
- Towns and cities cover less than 10% of the land area of Wales²⁰⁴ [H].
- Well-managed, high quality parks and green spaces are critical elements of accessible natural green space²⁰⁵ (Figure 3.29) [H]. 110 public green spaces won Green Flag Awards²⁰⁶ in 2015/16 [H].
- In 2013, open space provided 22% and private gardens 35% of the total land area within Wales’ towns and cities²⁰⁷ (Figure 3.30). [M]

Condition:

- In 2013, urban tree canopy in Wales was 16.4% - mid range in world rankings - and covered 14,145 ha (Figure 3.31). High cover in the South Wales Valley towns contrasts with low levels of canopy in coastal communities²⁰⁷. [M]
- 160 out of our 220 towns (73%) showed an overall decline in canopy cover between 2009 and 2013 with the loss of 7,000 large amenity trees between 2006 and 2013²⁰⁷. Tree cover in deprived areas tends to be lower and relatively less rich in amenity trees (Figure 3.32). [M]
- Urban noise pollution (Figure 3.33) is one of the most common causes of nuisance complaints in Wales and contributes to the environmental burden of ill-health²⁰⁸ [M].

Trend:

- The number of people living in our cities is likely to increase significantly over the next 20 years – Cardiff, Wrexham, Newport and Swansea will be particularly affected²⁰⁹ [M].
- The expansion of our towns, home improvements and the trend of paving over our gardens has removed large areas of land and thereby its ability to soak up rain, and provide a greenspace and a home for wildlife²¹⁰ [H].
- Urban surfaces heat up quickly making our towns up to 3°C degrees warmer than the surrounding countryside²¹¹ [H].
- The rate of habitat creation on brownfield land has decreased since the closure of coal mines, the demolition of derelict metal works, the increased re-profiling and stabilisation of coal tips and house building²¹² [M].

Evidence gaps:

- Limited up-to-date information on the quantity and quality of green infrastructure assets.

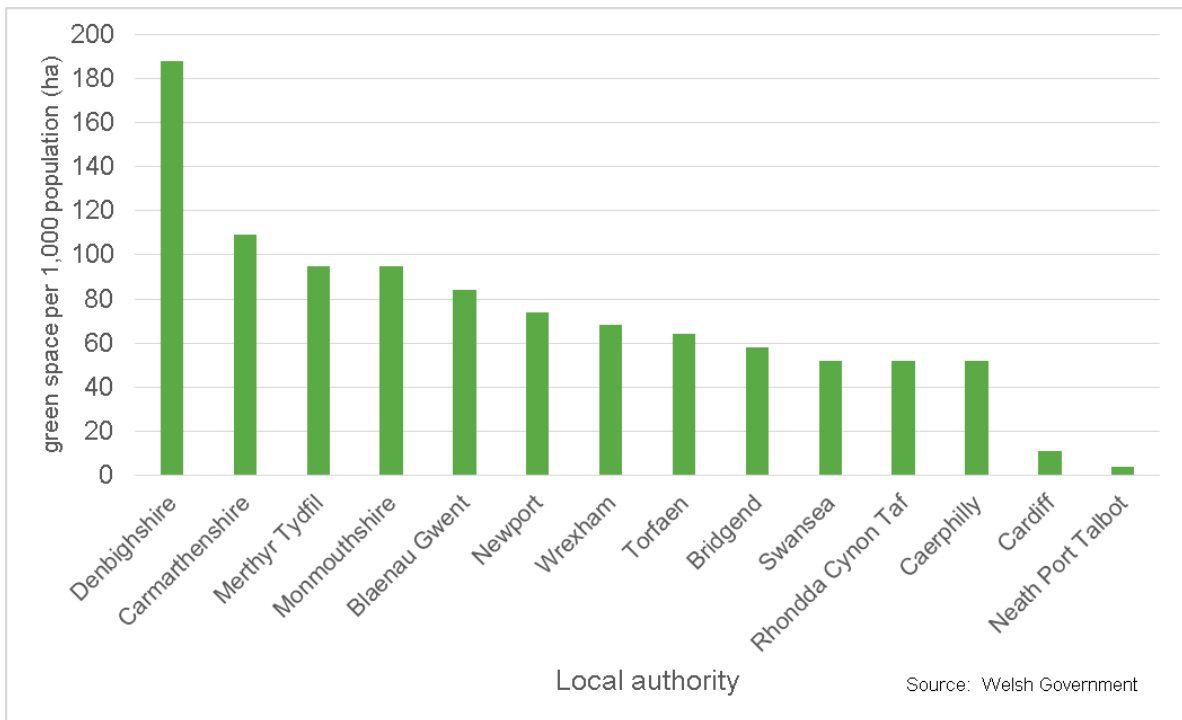


Figure 3.29 Hectares (ha) of accessible natural greenspace per 1,000 population by local authority (ha), July 2012²¹³. [M]

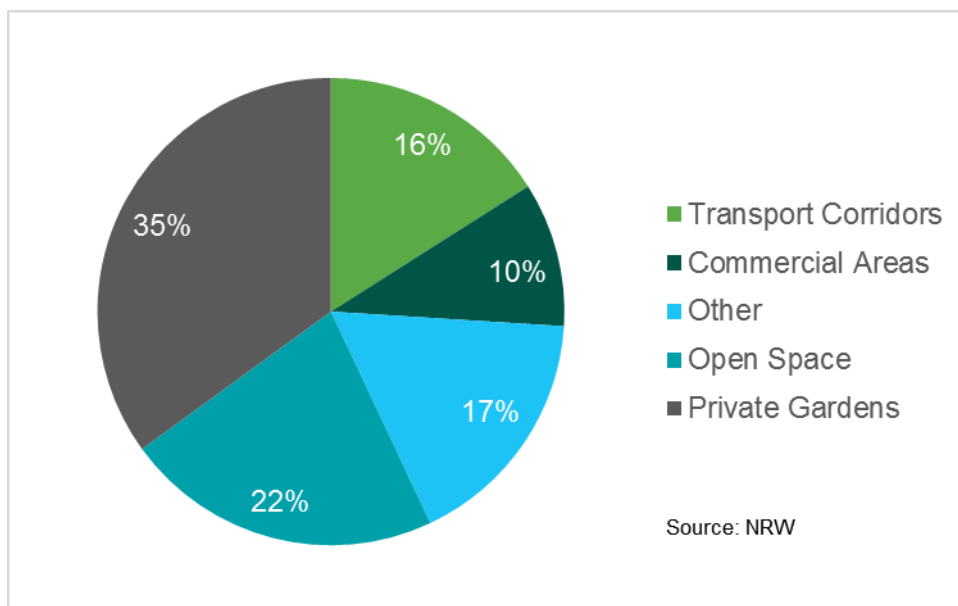


Figure 3.30 Distribution of land use classes across Wales' urban areas (2013)²⁰⁷. [M]

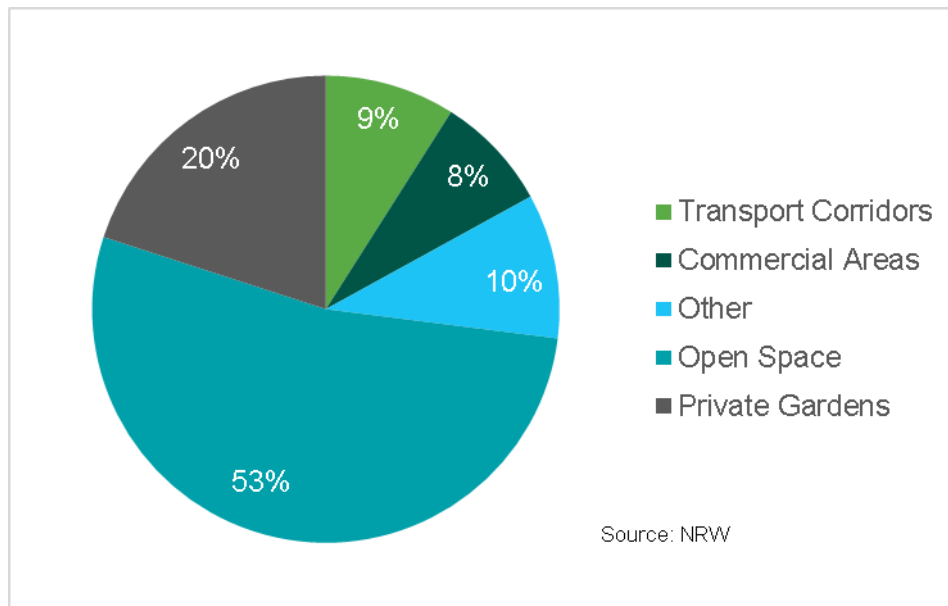


Figure 3.31 Distribution of tree canopy cover across Wales' urban land use classes²⁰⁷. [M]

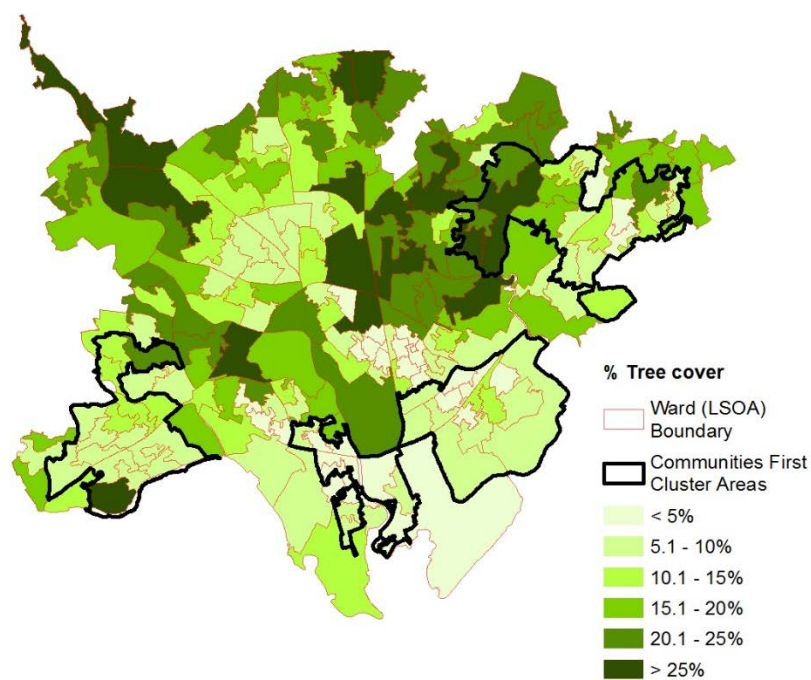


Figure 3.32 Cardiff ward by ward (Lower Super Output Area, LSOA) tree canopy cover distribution – Communities First Cluster Areas (most deprived areas in Cardiff) highlighted²⁰⁷. [M]

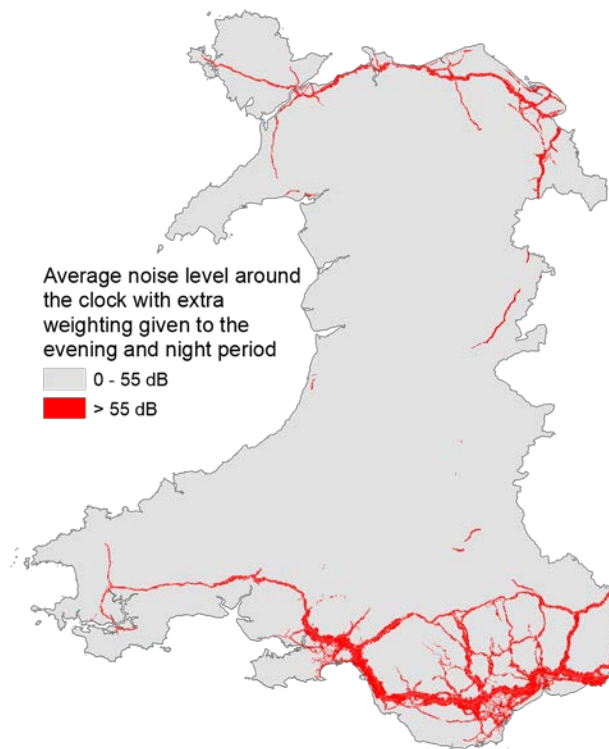


Figure 3.33 Noise map for major roads, major railways and roads, railways and industry in agglomerations, 2012²¹⁴. [M]

KEY EVIDENCE SOURCES

- Welsh Government Local Authority Population Projections for Wales²⁰³
- Tree Cover in Wales' Towns and Cities study summary (NRW, 2014)²¹⁵
- The reclamation of former coal mines and steelworks book (Richards et al 1993)²¹²
- Wales Noise Action Plan²⁰⁸
- Wildlife Trusts Wales (2016) Green infrastructure: A catalyst for the Well-being of Future Generations in Wales²¹⁶
- Green Infrastructure's contribution to economic growth (review by Sheffield Hallam University)²¹⁷

3.12. Coastal margins

(See section 3.12 of the Technical Annex for Chapter 3 for more information)

KEY MESSAGES
<p>Extent:</p> <ul style="list-style-type: none">The coastal margins of Wales are primarily made up of sand dunes, saltmarsh and sea cliffs. Vegetated shingle and coastal lagoons make up a far smaller proportion of this broad habitat type²¹⁸ (Table 3.13) [H].
<p>Condition:</p> <ul style="list-style-type: none">Four of the eleven coastal SAC features were reported as wholly unfavourable in 2013²¹⁸ (Figure 3.34) [H]. Whilst the sand dunes, coastal grassland and heath SSSI features are generally unfavourable, the hard vertical sea cliffs SSSI features are generally favourable²¹⁹ [L].The habitats of the coastal margin provide some unique ecosystem services; for example, they play an important role in contributing to flood protection over much of the Welsh coast, either acting as a barrier or by wave attenuation²²⁰ [H].
<p>Trend:</p> <ul style="list-style-type: none">Coastal habitats have declined in extent and quality since 1945 mainly due to habitat change²²⁰ [M].The majority of the Annex I habitats which make up the coastal margins are declining in range and extent in the short term²¹⁸ [H].The CCRA17 Evidence Report²²¹ has identified risks to habitats and heritage in the coastal zone from sea-level rise and the loss of natural flood protection. A combination of the effects of climate change on hydrological processes and the proposed management of our coasts set out in Shoreline Management Plans is predicted to lead to a decline in extent of coastal margin habitats^{222, 223} [H].
<p>Evidence gaps:</p> <ul style="list-style-type: none">There is limited understanding of how vulnerable and resilient our coastal margins are to climate change factors, such as increased storminess, changing rainfall and temperature. We do not have much knowledge of how coastal margin habitats recover after storm events, which prevents us from making an evidence-based prioritisation of climate change adaptation measures.An understanding of the impact of coastal defences on adjacent coastal margin habitats and the value of coastal margin habitat in providing / contributing to soft sea defences, including system thresholds which govern that role.There is limited understanding of the condition and long-term trends in range and extent of coastal margin habitats, particularly outside of protected sites.

Table 3.13 Short and long term trends in range and extent of Annex I coastal margin habitats in Wales. All information from 2013 Article 17 reporting²¹⁸. Key: → = stable; ↓ = decreasing; ↑ = increasing; - = no information. [H]. * Vegetated Sea Cliffs of the Atlantic to Baltic Coasts

are composed of the following habitats; Coastal grassland, Coastal heath and Vertical sea cliffs.¹ Short term trend = in the last 12 years. ² Long term trend = in the last 24 years.

Habitats Directive Annex I habitat	Area of habitat in Wales			
	Surface area of habitat (ha)	Proportion (%) of UK Surface Area in Wales	Short term trend ¹	Long term trend ²
Coastal lagoons	83	1.7	→	Unknown
Salicornia and other annuals colonising mud and sand	211	10.1	↓	Unknown
Atlantic salt meadows (<i>Glauco-Puccinellietalia maritimae</i>)	7,128	23.4	↓	Unknown
Mediterranean and thermo-Atlantic halophilous scrubs	7	6.3	Unknown	Unknown
* Vegetated sea cliffs of the Atlantic and Baltic coasts	3,838	17.3	↓	Unknown
Annual vegetation of drift lines	16	8.1	↓	Unknown
Embryonic shifting dunes	100	33.9	↓	↓
Shifting dunes along the shoreline with <i>Ammophila arenaria</i> (white dunes)	480	22	↓	Unknown
Fixed dunes with herbaceous vegetation (grey dunes)	2,700	12.1	↓	↓
Humid dune slacks	390	21.7	↓	↓
Dunes with <i>Salix repens</i> ssp. <i>argentea</i> (<i>Salicion arenariae</i>)	229	35.8	↑	Unknown
Atlantic decalcified fixed dunes	40	4.4	↓	Unknown
Perennial vegetation of stony banks	93	1.7	→	Unknown

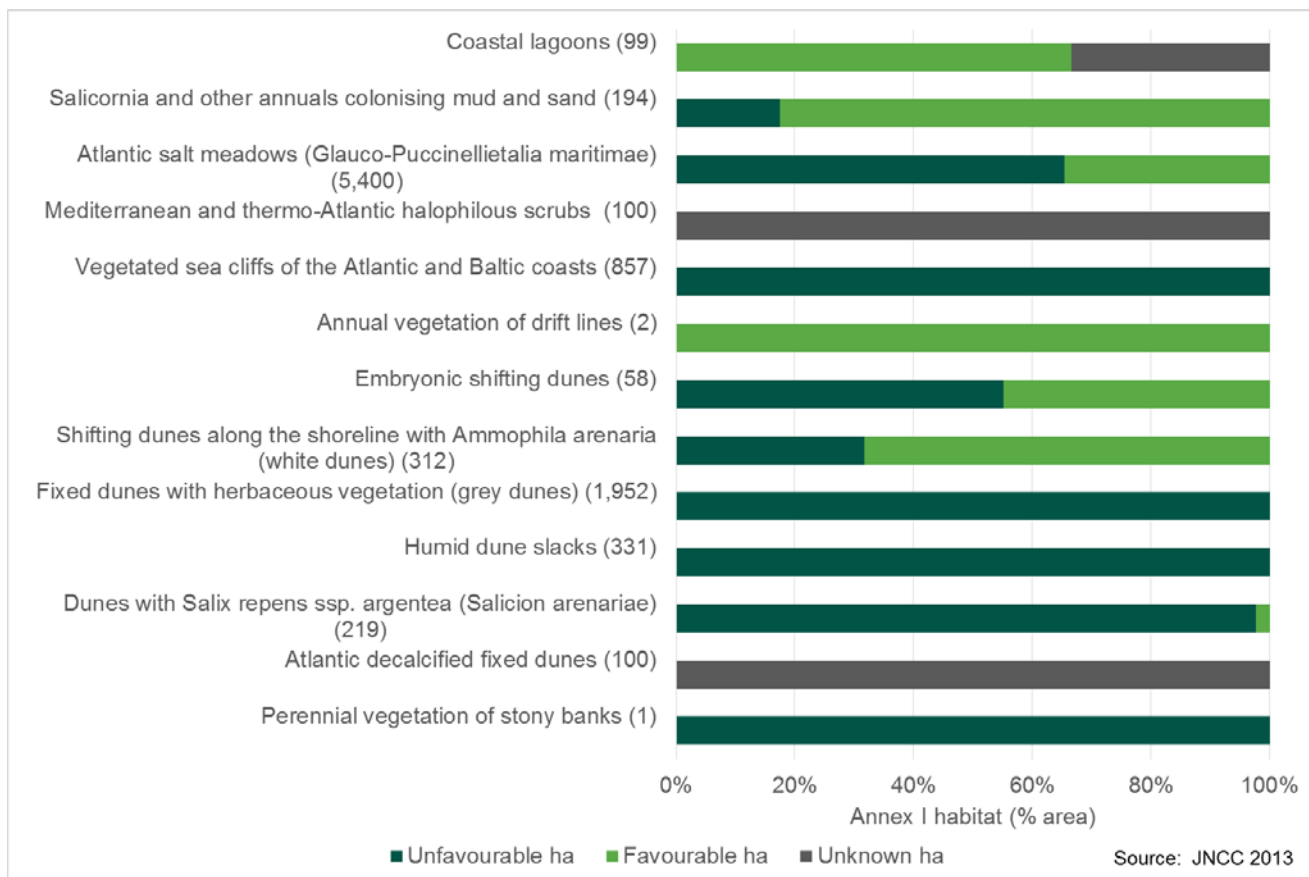


Figure 3.34. Annex I SAC feature condition (% of total area ha) derived from Article 17 reporting²¹⁸. Total hectares of each habitat in assessment shown in brackets. [H]

KEY EVIDENCE SOURCES

- JNCC Article 17 reporting 2006 and 2013²¹⁸
- CCW's Rapid Review of SSSI Features²¹⁹
- UK National Ecosystem Assessment²²⁰
- Futurecoast: Future coastal evolution around England and Wales. A report to DEFRA²²²
- Shoreline Management Plans^{223, 224, 225, 226}

3.13. Marine

(See section 3.13 of the Technical Annex for Chapter 3 for more information)

The habitats of the marine environment are reported here under the following broad categories:

- Coastal and marine waters: the waters along our coast and in the wider marine environment to 12 nautical miles.
- Intertidal: the area of shore between the low water mark and high water mark, excluding saltmarsh.
- Subtidal: the area of the sea bed that is always covered by water (i.e. below low tide). For the purposes of SoNaRR this extends 12 nautical miles out to sea.

Marine (in general)

KEY MESSAGES
<p>Extent:</p> <ul style="list-style-type: none">• The Welsh marine area extends out to 12 nautical miles, covering just under 15,000 km² or 41% of the territory of Wales²²⁷ [H].• 35% of Welsh marine waters are designated as marine protected areas (Special Areas of Conservations, Special Protection Areas, Sites of Special Scientific Interest with intertidal features, Marine Conservation Zones and Ramsar sites)²²⁷ [H].
<p>Condition:</p> <ul style="list-style-type: none">• The marine environment remains highly diverse²²⁷. There have been improvements in water quality in recent years.^{228, 229, 230} [H].• Evidence suggests marine habitats are in variable condition^{231, 232} but they are able to support healthy populations of many species of seabirds and marine mammals^{233, 234} [H].• Wales has contributed to the good progress made towards achieving Good Environmental Status for UK waters by 2020, as defined in the UK Marine Strategy Part One^{235, 236}.
<p>Trend:</p> <ul style="list-style-type: none">• A number of further marine SACs and SPAs have been proposed in Welsh waters and, if designated, these additional sites would increase the combined coverage of marine protected areas in Welsh waters²³⁷ [H].• Historically, the marine environment around Wales has suffered significant habitat loss, with key examples being coastal habitat (particularly saltmarsh) and subtidal native oyster beds. A key issue is to understand opportunities to restore or facilitate the recovery of these ecosystems as well as to identify the wider social and economic benefits that such projects could provide for Wales.^{227, 238, 239} [H].• The CCRA17 Evidence Report²⁴⁰ has identified risks to and opportunities for marine species, fisheries and marine heritage from ocean acidification and higher water temperatures [H].
<p>Evidence Gap:</p>

- There is limited understanding of ecosystem health, although the Monitoring Programme established through the UK Marine Strategy Part Two will improve our understanding.

Coastal and marine waters

KEY MESSAGES

Extent:

- The Water Framework Directive covers the entire Welsh coastline out to 1 nautical mile with 32 estuarine and 23 coastal water bodies²²⁸ [H].

Condition:

- Coastal and marine water quality is fair with 29% of our estuarine and coastal waters in good or better ecological status²²⁸ (Figure 3.25) [H].
- Failures to achieve Good Ecological Status are primarily due to elevated concentrations of nutrients derived from diffuse and point sources²²⁸ [H].
- Only 3 of 22 Shellfish Waters met guideline quality standards in 2014 due to a complex interrelationship of factors²⁴¹. However, there have been improvements in our most economically important shellfish waters²²⁹ [H].
- Marine litter is an issue because of effects on biodiversity, commercial and recreational activities and the visual amenity of the coastal and marine environment²³⁵ [H].

Trend:

- There have been improvements in water quality in recent years²³⁰ [H].
- The number of designated bathing waters has increased from 50 in 1990 to 102 in 2015. Over this period, their quality has improved due to significant investment to improve discharges from water company assets and to address diffuse pollution in and around bathing waters (Figure 3.36). In 2015, 82 bathing waters were excellent, 16 good and 4 sufficient (Figure 3.37). This was 100% compliance with the directive²³⁰ [H].

Evidence Gaps:

- Understanding the dynamic of bacterial loading in water and shellfish bacterial flesh quality;
- Improved understanding of the dynamics between nutrients and accelerated algae growth in dynamic estuaries and coastal waters;
- Understanding in-combination and long-term impacts of chemicals on ecological status.

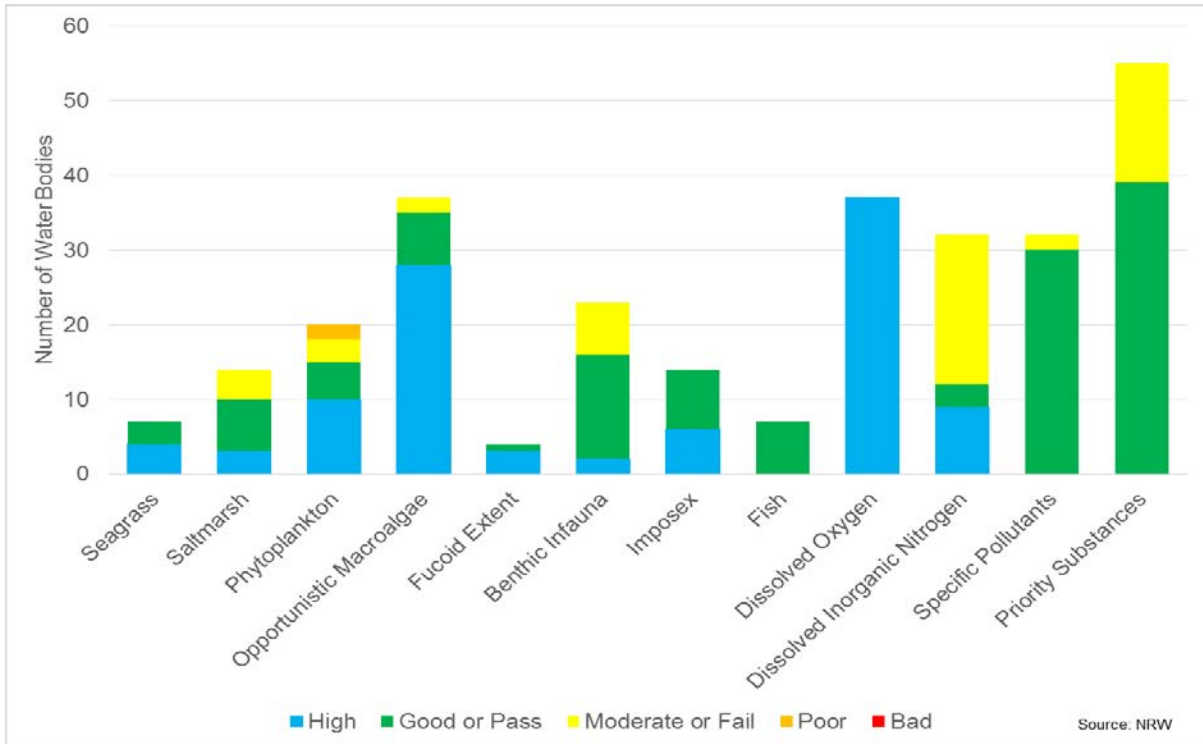


Figure 3.35 Water Framework Directive classifications for estuarine and coastal elements, 2015²²⁸. [H]

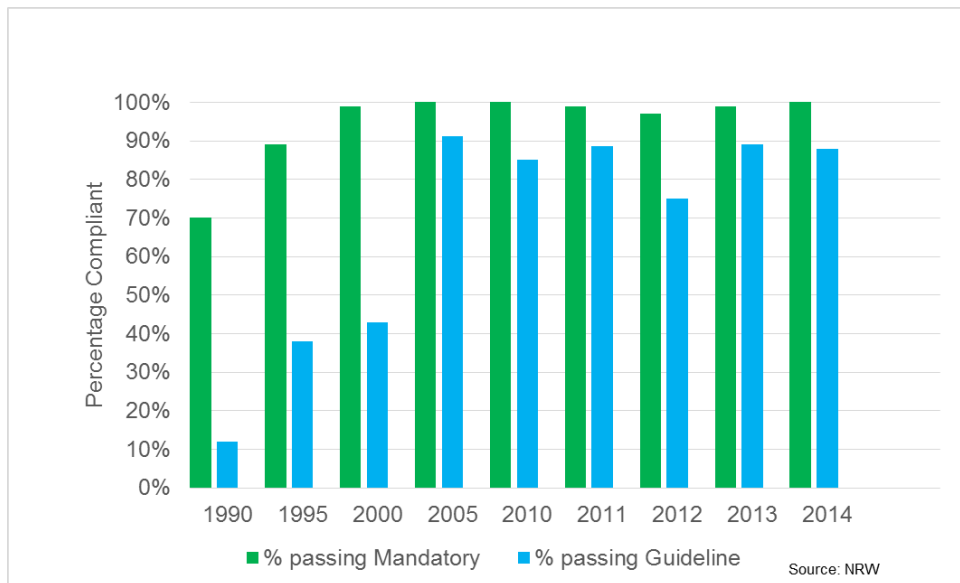


Figure 3.36 Percentage of designated bathing waters complying with the original Bathing Water Directive 1990 – 2014²²⁸. [H]

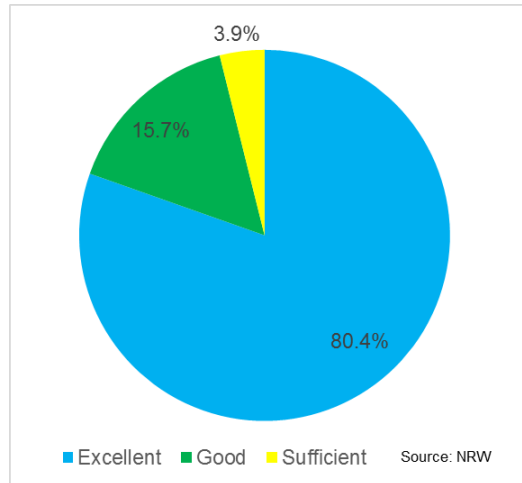


Figure 3.37 Bathing Water Directive classification 2015 (revised Directive)²²⁸. [H]

KEY EVIDENCE SOURCES

- River Basin Management Plans²⁴²
- Wales' Marine Evidence Report²²⁷
- Wales Marine Planning Portal²⁴³
- UK Marine Strategy Part One: Initial Assessment and Good Environmental Status²³⁵
- Water Framework Directive reporting²²⁸
- Wales Bathing Water Data Explorer²⁴⁴

Intertidal

KEY MESSAGES

Extent:

- The Welsh coastline is approximately 2,740 km in length²⁴⁵, covers around 56,856 ha of intertidal habitat²⁴⁶ and includes sheltered and exposed rocky shores, wide mudflats, and sandy macrotidal estuaries (Figure 3.38) [H].
- 75% of the intertidal habitat of Wales is designated as a Site of Special Scientific Interest (SSSI)²⁴⁶ [H].
- Biogenic reefs are relatively common in Wales and honeycomb reefs have recently re-established in north Wales after a long absence^{247, 248} [H].

Condition:

- There are indications of improvement in the condition and extent of some smaller intertidal features. All seven estuarine and coastal water bodies with intertidal seagrass beds were in high or good status in 2015 (Water Framework Directive)²²⁸ [H].

Trend:

- Broader scale intertidal habitat features have shown losses in recent years. Extent of estuaries has been stable over the short term (2001 – 2012), but losses have been recorded over the longer term (1989 – 2012). Mudflats and sandflats show gradual decline in extent over the short and long term²³¹ [H]. Intertidal seagrass beds (*Zostera noltii*) have increased in extent^{249, 250, 251} [H].
- Sea-level rise and increased storm frequency are likely to have a significant coastal squeeze impact on intertidal sand, mud and habitats particularly around estuaries and along sections of defended coast²⁵² [H].
- Introduction and establishment of invasive non-native species is expected to increase in future due to climate change^{253, 254, 255} [H].

Evidence Gaps:

- There are gaps in our understanding of the condition of intertidal habitats particularly outside of protected sites and in terms of how condition has changed over time. The gaps in our understanding are most prevalent outside of protected sites

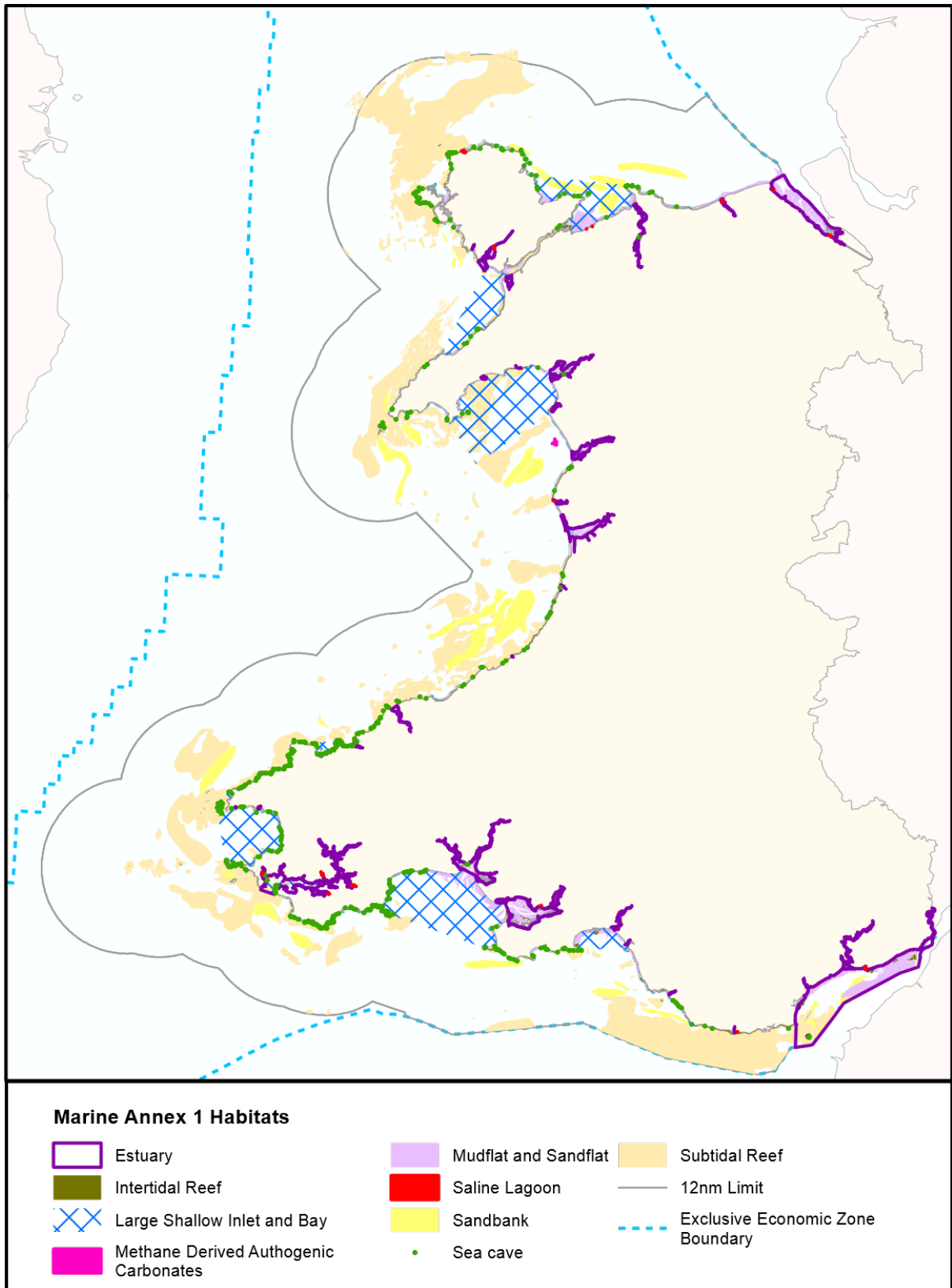


Figure 3.38 Marine (intertidal and subtidal) habitats listed under Annex I of the Habitats Directive. The 12 nautical mile limit of Welsh territorial waters is shown²²⁷. [L-H]

KEY EVIDENCE SOURCES

- Wales' Marine Evidence Report²²⁷
- When the tide goes out: The biodiversity and conservation of the shores of Wales - results from a 10 year intertidal survey of Wales²⁴⁶
- Charting Progress 2: The State of UK Seas²⁵⁶
- Wales Marine Planning Portal²⁴³
- UK Marine Strategy Part One: Initial Assessment and Good Environmental Status²³⁵
- River Basin Management Plans²⁴¹
- UK National Ecosystem Assessment²⁴⁵

KEY MESSAGES

Extent:

- The extensive marine subtidal area is an important resource, covering 41% of the territory of Wales²²⁷ [H].
- Current estimates are that 75% of the Welsh seabed to 12 nautical miles comprises sands and gravels, 5% is mixed sediments, 2% mud and 10% rock^{227, 257} (Figure 3.38, Figure 3.39) [L].
- There are subtidal reefs to the north and west of Anglesey, around the Llŷn Peninsula and off the Pembrokeshire Coast²³¹ (Figure 3.38, Figure 3.39) [H].
- There are highly productive kelp forests (brown algae) along the majority of the Welsh coastline²⁵⁸; subtidal biogenic horse mussel (*Modiolus modiolus*) and Ross worm (*Sabellaria spinulosa*) reefs; and seagrass meadows known to be important for juvenile fish^{259, 260} (Figure 3.38, Figure 3.39) [H].

Condition:

- Whilst there is a rich diversity of subtidal habitats, available evidence for their extent, condition and trends paint a mixed picture^{227, 231, 232} [L-H].
- Important and sensitive habitats such as Maerl, *Modiolus modiolus* (horse mussel) beds, tidal rapids and sublittoral sands and gravels were all reported as declining in condition in 2008²²⁷ [L-H].
- The majority of water bodies achieved high or good status for subtidal Water Framework Directive elements in 2015. 70% of the water bodies assessed achieved good or high for benthic invertebrates; 75% achieved good or high for phytoplankton; 100% achieved good or high for estuarine fish²²⁸ [H].

Trend:

- The extent of both sandbanks and reefs was found to be declining over the short (2001-2012) and long (1989-2012) term in Wales²⁶¹ [H].
- Large shallow inlets and bays were stable, with no significant habitat losses in extent over the short term²⁶¹ [H].
- The *Zostera marina* seagrass bed within the Skomer Marine Conservation Zone appears to have increased in extent between 1997 and 2014²⁶² [H].

Evidence Gap:

- There are gaps in our understanding of the extent, condition and trends of subtidal habitats, particularly in terms of how the extent and distribution of habitats has changed over time and outside of protected sites, where we have least knowledge.

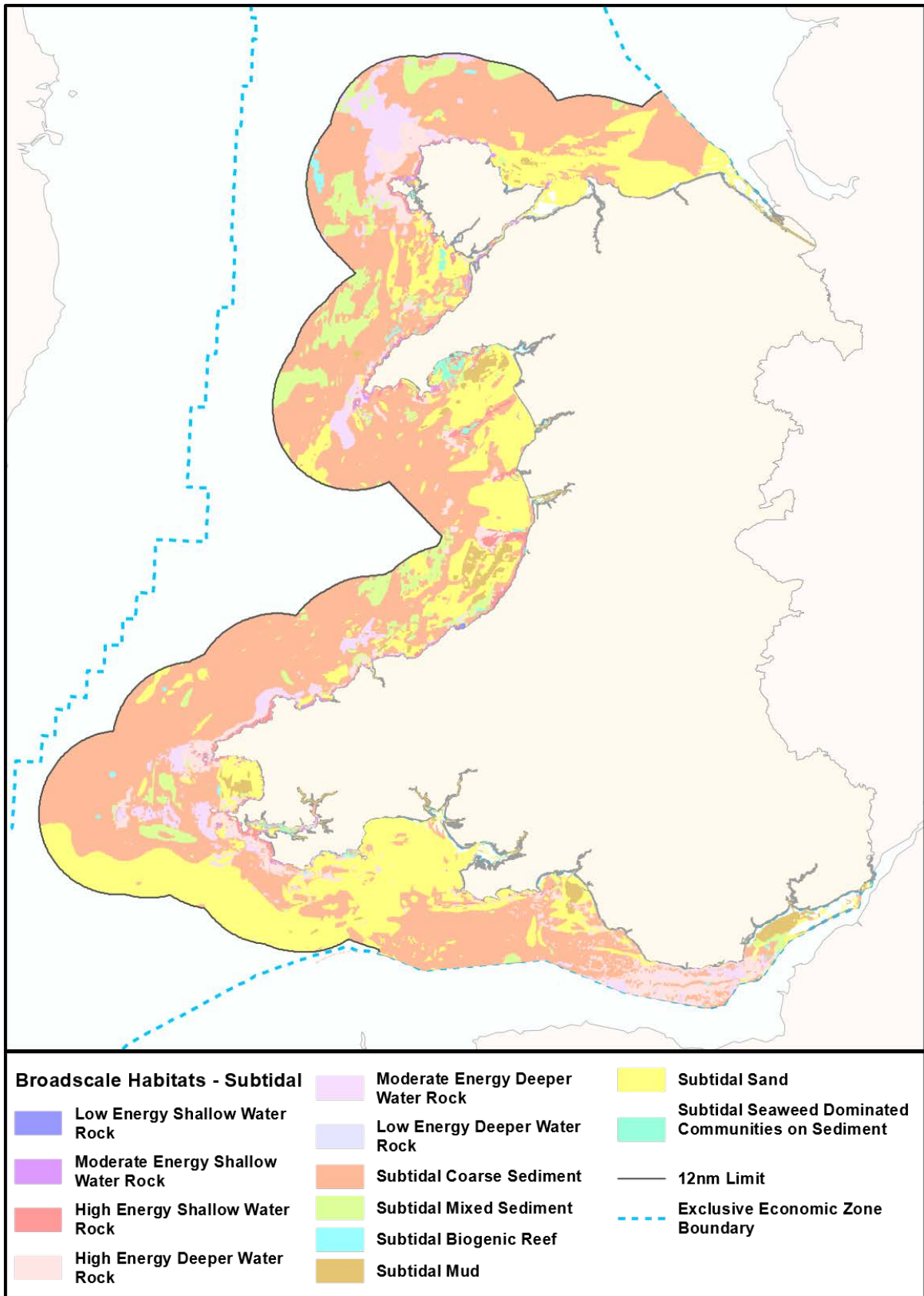


Figure 3.39 Broadscale subtidal habitats. The 12 nautical mile limit of Welsh territorial waters is shown²⁶³. [L-H]

KEY EVIDENCE SOURCES

- Wales' Marine Evidence Report²²⁷
- Charting Progress 2: The State of UK Seas²⁵⁶
- Wales Marine Planning Portal²⁴³
- UK Marine Strategy Part One: Initial Assessment and Good Environmental Status²³⁵
- River Basin Management Plans²⁴²
- UK National Ecosystem Assessment²⁴⁵

PART C – PRESENTING INTEGRATED EVIDENCE AROUND PLACE

(See Part C of the Technical Annex for Chapter 3 for more information)

3.14. Landscape information in Wales

Landscapes are the culmination of both natural and human influences on our natural resources and ecosystems. Welsh landscapes reflect the extent and condition of a range of natural resources and ecosystems against the complexity of human influences and land use decisions.

Diverse landscapes where ecosystems are maintained in good condition are often (but not always) a clear indication that sustainable land management practice is being undertaken; these more resilient landscapes tend to provide a broader range of ecosystem services with social and economic benefit.

We are fortunate in Wales to have excellent, readily-available landscape information which captures and records this diversity in landscape character and quality at a local, regional and national scale. The most detailed landscape baseline in Wales is LANDMAP²⁶⁴, our national programme of landscape assessment [H]. LANDMAP describes the physical, geological, ecological, visual, historic and cultural landscape. By capturing multi-dimensional landscape information, it ensures that all aspects of the landscape can be taken into account. LANDMAP information is also the starting point for Landscape Character Assessments (LCAs) in Wales, which provide a simple representation of the nature and extent of places possible at different spatial scales [M]. These are normally prepared in connection with place-based initiatives about management, development planning policy or design. LCAs have been identified for Wales at both a local planning authority level and at a national level with 48 National LCAs identifying regional landscapes [H]. They offer overall landscape summaries linked to the 5 LANDMAP layers, key characteristics, and forces for change. Some Local Authorities have identified areas of high landscape importance, often linked to LCA's.

Seascape information complements our landscape information and together the two types of information provide an understanding of the cultural benefits to be had from the marine environment. The 29 national Marine Character Areas (MCAs)²⁶⁵ [H], the 50 Regional Seascapes²⁶⁶ [H] and the local Seascape Character Assessments (SCA) [H] of Pembrokeshire²⁶⁷, Snowdonia²⁶⁸ and Ynys Mon²⁶⁹ provide unrivalled seascape information in Wales.

Other sources of evidence include the Register of Landscapes of Historic Interest in Wales and National Park and Area of Outstanding Natural Beauty (AONB) Management Plans [H].

Collectively, there is a wealth of information to hand all of which is accessible and available to use, either as web based maps and surveys or as reports. Using this information can aid our understanding of natural resources and ecosystems at a variety of scales. This is an important communication tool because people relate to

landscapes as places to live, work and enjoy and as areas which contribute to a sense of place, identity, well-being and quality of life as well as delivering multiple benefits.

A key challenge for sustainable management is to retain the distinctiveness of our places and historic landscapes, as recognised in the Welsh Government Natural Resources Policy Statement. This recognises that the natural and historic components of landscape are important to both place and the cultural value of landscape (see Chapter 5 for further information on benefits to well-being).

National landscape change to 2015^{270, 271, 272} has been small overall, but some changes have been substantial locally [H]. The key contributors to landscape change in the built environment include: the expansion of settlements, commercial and industrial developments, quarries and road improvements, onshore wind-farms, turbines and large recreational related developments. In the rural environment examples include: the felling of conifers and replanting with broadleaves, woodland expansion and changing bracken cover.

Climate change is likely to have significant impacts on landscape character, local distinctiveness and quality, directly through changing land cover (migrating habitat and species ranges) and indirectly by influencing land use decisions^{273, 274} [H]. Landscape changes may also be evident from mitigation measures, such as renewable energy generation, water resource management and adaptation through the planned expansion of woodland.

KEY MESSAGES (Landscape)

- 25% of Wales is designated as either National Park or Area of Outstanding Natural Beauty²⁷⁵ [H].
- Over 50% of Wales is nationally valued for its scenic quality and character, many Welsh landscapes are iconic with a clear sense of place and recognisable identity²⁷⁶ [H].
- 55% of Wales was identified as tranquil in 2009 (11,600 km²), but 1,500 km² of tranquil landscapes were lost in the preceding 12 years²⁷⁷ [M].
- 46% of the total land area was identified as having a negligible level of night time light pollution in 2015²⁷⁶. However, where we have substantial levels of night time light pollution (501 km²) this finding contributes to our evaluation of the landscape as low value [H].
- Wales is predominantly a rural landscape: 60% of the landscape is defined as Field Pattern/Mosaic whilst 20% is categorised as Open Land²⁷⁶ [H].
- Quality-assured landscape evidence tracks state and trend, identifying changes in landscape quality and diversity. Key factors determining landscape change between 2003 and 2015^{270, 271, 272} are, in particular, the expansion of settlements; commercial and industrial development, including the expansion of quarries; road improvements; onshore wind-farms and turbines; and recreational related developments [H].
- Key changes in the natural environment observed through landscape change^{270, 271, 272} include: replacement of conifers with broad-leaved trees, woodland expansion, changes in bracken cover, reduced habitat diversity

in places, reduced bog, but also evident improvements in upland vegetation [H].

- The CCRA17 Evidence Report²⁷³ and other evidence²⁷⁴ has identified risks to landscapes from pests, pathogens and invasive species and from changes in frequency and/or magnitude of extreme weather and wildfire events. More generally, there are risks and opportunities from changes in landscape character [H].

3.15. Assessing extent, condition and trends at an area scale

SoNaRR provides the extent, condition and trends of natural resources and ecosystems at a national scale - but it recognises that those trends are not necessarily uniform in every part of Wales or across all aspects of ecosystems. A key principle of the Environment Act is to *consider the appropriate spatial scale for action* – this is reflected in the facilitation of the National Policy through Area Statements. This will need to be done by following a very similar approach to the one employed for SoNaRR: presenting evidence in relation to state, resilience and benefits, and identifying the specific variations against national condition and trend data.

As a precursor to Area Statements, NRW ran three area natural resource management trials – in the Rhondda and Tawe in South Wales, and Dyfi in Mid Wales.

The purpose of the trials was to:

- Investigate what sustainable management of natural resources means within a local context;
- Consider how we apply our new duties under the Environment Act and the Well-being of Future Generations Act;
- Inform changes to NRW's ways of working, in line with the new legislation.

The trials were a particular opportunity to explore how NRW applies the principles of sustainable management in practice.

Each of the trials took a different approach to assessing extent, condition and trends of the natural resources and ecosystems in those areas. The Dyfi trial attempted to capture as much spatial data as possible to map both natural resources and ecosystems, and the benefits they provide. The Tawe used a mix of both formal data sets and expert opinion to inform the development of an evidence pack that could be used in discussions with stakeholders, then be added to and refined. This focused on seeking out opportunities for better management of natural resources. The Rhondda trial began by meeting and working with a wide range of partners and people in the Rhondda. Open dialogue was used to encourage discussions, knowledge sharing and creative ideas, and enabled us to build our evidence base in perhaps a less traditional, but equally fruitful way.

Each of these trials has produced results, and the knowledge and experience gained from the different approaches is continually being evaluated. When it comes to

preparing the first statutory Area Statements, we will need to adopt some common standards for the way we collate and present evidence on the state and resilience of natural resources and ecosystems and the benefits derived from them. However, one of the key lessons from the trials is that the approach taken needs to reflect the characteristics of, and evidence relevant to, a particular place. We do not wish to make this an overly prescriptive process, particularly if there are local evidence gaps, or if conversations with local people and landowners give a better perspective on what is really happening. We need to ensure those thoughts and views are captured to add resonance and a more in- depth understanding of a place.

References for Chapter 3

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

¹ Pullin A, Frampton G, Jongman R, Kohl C, Livoreil B, Lux A, Pataki G, Petrokofsky G, Podhora A, Saarikoski H, Santamaria L, Schindler S, Sousa-Pinto I, Vandewalle M, Wittmer H. 2016. Selecting appropriate methods of knowledge synthesis to inform biodiversity policy. *Biodiversity and Conservation*. 25 (7), 1285-1300.

3.1 Animals, plants and other organisms

² North Wales Environmental Information Service (Cofnod). 2016. Current environmental records datasets.

³ Hayhow DB, Burns F, Eaton MA, Bacon L, Al-Fulaij N, Bladwell S, Brookman E, Byrne J, Cheesman C, Davies D, DeMassimi S, Elding C, Hobson R, Jones J, Lucas SR, Lynch S, Morgan L, Rowe A, Sharp R, Smith RG, Stevenson K, Stretton TA, Taylor R, Gregory RD. 2016. *State of Nature 2016: Wales*. The State of Nature Partnership.

⁴ Wales Biodiversity Partnership. 2015. Species information [online]. Available from: <http://www.biodiversitywales.org.uk/Species-in-Wales>. [Accessed 26th August 2016].

⁵ NRW. 2015. *Current data on SAC and SPA Annex I habitats and Annex II species*. Internal data source. Natural Resources Wales.

⁶ NRW. 2010. NRW features database.

⁷ Wales Biodiversity Partnership 2015. Section 7 lists (online). Available from : <http://www.biodiversitywales.org.uk/Environment-Wales-Bill>. [Accessed 12th September 2016].

⁸ Burns F, Eaton MA, Gregory RD, ed.. 2013. *The State of Nature Report*. The State of Nature partnership. Available from: <http://www.rspb.org.uk/forprofessionals/science/research/details.aspx?id=363867> [Accessed 14th July 2016].

⁹ National Assembly for Wales. 2011. *Sustainability Committee: Inquiry into Biodiversity in Wales, January 2011* [online]. Available from: <http://www.assembly.wales/Laid%20Documents/CR-LD8384%20-%20Sustainability%20Committee%20Inquiry%20into%20biodiversity%20in%20Wales-31012011-208859/cr-ld8384-e-English.pdf> [Accessed 26th August 2016].

¹⁰ Eaton MA, Aebischer NJ, Brown AF, Hearn RD, Lock L, Musgrove AJ, Noble DG, Stroud DA, Gregory RD. 2015. Birds of Conservation Concern 4: the population status of birds in the United Kingdom, Channel Islands and Isle of Man. *British Birds* 108, 708–746.

¹¹ Fox R, Brereton TM, Asher J, August TA, Botham MS, Bourn NAD, Cruickshanks KL, Bulman CR, Ellis S, Harrower CA, Middlebrook I, Noble DG, Powney GD, Randle Z, Warren MS, Roy DB. 2015. *The State of the UK's Butterflies 2015*. Wareham: Butterfly Conservation and the Centre for Ecology & Hydrology.

¹² Bat Conservation Trust. 2016. *The National Bat Monitoring Programme. Annual Report 2015* [online]. London: Bat Conservation Trust. Available from: http://www.bats.org.uk/pages/nbmp_annual_report.html. [Accessed 14th July 2016].

¹³ GMEP. 2016. *Glastir Monitoring and Evaluation Programme (GMEP) portal* [online]. Available from: <https://gmep.wales> [Accessed 14th July 2016].

¹⁴ Cefas. 2016. *Salmon Stocks and Fisheries in England and Wales 2015* [online]. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/525662/Annual_Salmon_Stock_Status_Report_2015_final.pdf. [Accessed 26th July 2016].

¹⁵ Cefas. 2016. *Assessment of salmon stocks and fisheries in England and Wales. Standing report on methods, approaches and wider stock conservation and management considerations* [online]. Available from: <https://www.gov.uk/government/publications/assessment-of-salmon-stocks-and-fisheries-in-england-and-wales> [Accessed 14th July 2016].

¹⁶ Great Britain Parliament. House of Commons. Department of Environment. 1994. *Biodiversity: The UK action Plan*. London: The Stationery Office HC 1994.

¹⁷ 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].

-
- ¹⁸ Living with Environment Change (LWEC). 2015. Biodiversity Climate Change Impacts, Report Card 2015. Available from: <http://www.nerc.ac.uk/research/partnerships/lwec/products/report-cards/biodiversity/>. [Accessed 9th August 2016].
- ¹⁹ JNCC. 2013. *3rd UK Habitats Directive Reports* [online]. Peterborough: Joint Nature Conservation Committee. Available from: <http://jncc.defra.gov.uk/page-6387> [Accessed 14th July 2016].
- ²⁰ JNCC. 2013. *10th Report by the United Kingdom under Article 12 on the implementation of the Directive on the conservation of wild birds (2009/147/EC) from January 2008 to December 2012*. Peterborough: Joint Nature Conservation Committee.
- ²¹ Jonsson B, Jonsson N. 2009. A review of the likely effects of climate change on anadromous Atlantic salmon *Salmo salar* and brown trout *Salmo trutta*, with particular reference to water temperature and flow. *Journal of Fish Biology* 75, 2381–2447.
- ²² Oliver TH, Marshall HH, Morecroft MD, Boreton T, Prudhomme C, Huntingford C. 2015. Interacting effects of climate change and habitat fragmentation on drought sensitive butterflies [online]. *Nature Climate Change* 5, 941-945. Available from: <http://www.nature.com/nclimate/journal/v5/n10/full/nclimate2746.html> [Accessed 14th July 2016].
- ²³ Defra. 2014. Charting Progress 2: The State of the UK's Seas [online]. Archived content, Department for Environment, Food and Rural Affairs (DEFRA). Available from: <http://webarchive.nationalarchives.gov.uk/20141203181034/http://chartingprogress.defra.gov.uk/>. [Accessed 17th August 2016].
- ²⁴ GB Non-native Species Secretariat. 2016. GB Non-native species Secretariat (NNSS) website [online]. Available from: <http://www.nonnativespecies.org/home/index.cfm>. [Accessed 26th August 2016].
- ²⁵ NBN Gateway. 2016. NBN Gateway website [online]. National Biodiversity Network. Available from: <https://data.nbn.org.uk/>. [Accessed 23rd August 2016].
- ²⁶ Local Environmental Records Centres Wales (LERCs). 2016. LERCs website [online]. Available from: <http://www.lrcwales.org.uk/?AspxAutoDetectCookieSupport=1> [Accessed 12th August 2016].
- ²⁷ Welsh Government. 2015. *Wales' Marine Evidence Report* [online]. Available from: <http://gov.wales/topics/environmentcountryside/marineandfisheries/marine-planning/other-supporting-evidence/wales-marine-evidence-report/?lang=en> [Accessed 12th July 2016].
- ²⁸ Welsh Government. 2013. Wales Marine Planning Portal [online]. Available from: <http://lle.gov.wales/apps/marineportal/#lat=52.5145&lon=-3.9111&z=8>. [Accessed 12th August 2016].
- ²⁹ HM Government. 2012. Marine Strategy Part One: UK Initial Assessment and Good Environmental Status.
- ³⁰ ICES. 2016. ICES stock assessments database [online]. International Council for the Exploration of the Seas (ICES). Available from: <http://www.ices.dk/marine-data/tools/Pages/stock-assessment-graphs.aspx>. [Accessed 12th August 2016].
- ³¹ MMO. 2016. Statistics at MMO [online]. Marine Management Organisation. Available from: <https://www.gov.uk/government/organisations/marine-management-organisation/about/statistics>. [Accessed 12th August 2016].
- ³² Cefas. 2016. FishDAC. Cefas DataHub. Centre for Environment, Fisheries and Aquaculture Science. Available from: <https://www.cefas.co.uk/cefas-data-hub/fishdac/>. [Accessed 12th August 2016].
- ³³ MEDIN. 2016. MEDIN: Marine and Environmental Data and Information Network website [online]. Hosted by British Oceanographic Data Centre (BODC). Available at: <http://www.oceannet.org/>. [Accessed 12th August 2016].
- ³⁴ JNCC. 2015. D1c. Status of pollinating insects. [online]. D1. Biodiversity and Ecosystem Services. Joint Nature Conservation Committee. Available from: <http://jncc.defra.gov.uk/page-6851>. [Accessed 12th August 2016].

3.2 Air Quality

- ³⁵ Welsh Air Quality Forum. 2016. *Air Quality in Wales* [online]. Available from: <http://www.welshairquality.co.uk/> [Accessed 14th July 2016].
- ³⁶ Royal College of Physicians. 2016. Every breath we take: the life long impact of air pollution. Available from: <https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution>. [Accessed 1st August 2016].
- ³⁷ Salisbury E, Thistlethwaite G, Pang Y, Misra A. 2015. *Air Quality Pollutants Inventories for England, Scotland, Wales and Northern Ireland: 1990-2013* [online]. National Atmospheric Emissions Inventory. Available from: http://naei.defra.gov.uk/reports/reports?report_id=829. [Accessed 14th July 2016].

-
- ³⁸ Centre for Ecology and Hydrology (CEH) 2012. *Review of transboundary air pollution (RoTAP). Acidification, eutrophication, heavy metals and ground-level ozone in the UK*. Report for Defra.
- ³⁹ Hall J, Smith R. 2015. *Trends in critical load exceedances in the UK*. Centre for Ecology and Hydrology report to Defra, Contract AQ0826.
- ⁴⁰ Shilland EM, Monteith DT, Millidine K, Malcolm IA. 2016. *United Kingdom Upland Waters Monitoring Network: Data report for 2014-2015*. Report to Defra. Available from: <http://awmn.defra.gov.uk/resources/annualreports/year27annRpt.pdf> [Accessed 14th July 2016].
- ⁴¹ Defra. 2016. Modelled background pollution data. Available on Defra website via Data Archive, Modelled Air Quality Data. Available from: <https://uk-air.defra.gov.uk/data/pcm-data>. [Accessed 28th July 2016].
- ⁴² NAEI. 2016. National Atmospheric Emissions Inventory [online]. Department for Business, Energy and Industrial Strategy (BEIS), Department for Environment, Food and Rural Affairs (Defra), Scottish Government, Welsh Government, Department of the Environment Northern Ireland (DOE). Available from: <http://naei.defra.gov.uk>. [Accessed 17th August 2016].
- ⁴³ Defra. 2016. UK Air: Air Information Resource [online]. Available from: <https://uk-air.defra.gov.uk/>. [Accessed 17th August 2016].

3.3 Water Resources and Hydrological Processes

- ⁴⁴ Environment Agency. 2009. *Water for people and the environment – water resources strategy for Wales* [online]. Available from: <http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/research/library/publications/40731.aspx>. [Accessed 11th July 2016].
- ⁴⁵ Environment Agency and Natural Resources Wales. 2013. Current and future water availability – addendum: A refresh of the Case for Change analysis.
- ⁴⁶ NRW. 2016. Water resource availability in Wales data. Internal data source. Natural Resources Wales.
- ⁴⁷ NRW. 2015. *LIFE Natura 2000 Programme for Wales* [online]. Cardiff: Natural Resources Wales. Available from: <https://naturalresources.wales/about-us/our-projects/life-n2k-wales/life-n2k-wales/?lang=en> [Accessed 14th July 2016].
- ⁴⁸ NRW. 2015. *Natura 2000 Thematic Action Plan. Man-made changes to hydraulic conditions. LIFE Natura 2000 programme for Wales*. LIFE N2K Wales: LIFE Nat11/UK/385. Available from: <https://naturalresources.wales/media/676005/life-n2k-thematic-action-plan-man-made-changes-to-hydraulic-conditions.pdf>. [Accessed 11th August 2016].
- ⁴⁹ 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]
- ⁵⁰ Welsh Government. 2015. *Wales' Marine Evidence Report*. Available from: <http://gov.wales/docs/drah/publications/151008-wales-marine-evidence-report-master-october-2015-en.pdf> [Accessed 12th July 2016].
- ⁵¹ Lowe JA, Howard T, Pardaens A, Tinker J, Jenkins G, Ridley J, Met Office, Leake J, Holt J, Wakelin S, Wolf J, Horsburgh K, Proudman Oceanic Laboratory, Reeder T, Environment Agency, Milne G, Bradley S, University of Durham, Dye S & Marine Climate Change Partnership (MCCIP). 2009. *UK Climate Projections science report: Marine and coastal projections*.
- ⁵² Baxter JM, Buckley PJ, Wallace CJ. 2008. *Marine climate change impacts – Annual report card 2007-2008* [online]. Lowestoft: MCCIP. Available from: www.mccip.org.uk/arc. [Accessed 11th July 2016].
- ⁵³ Halcrow Group. 2012. *SMP 22 Great Ormes Head to Scotland (North West England and North Wales) Shoreline Management Plan SMP2*. Available from: http://www.allerdale.gov.uk/downloads/nw_shoreline_management_plan_2.pdf [Accessed 15 July 2016]
- ⁵⁴ Atkins. 2010. *SMP 19 Anchor Head to Lavernock Point (Severn Estuary) Shoreline Management Plan (SMP) Review*.
- ⁵⁵ Halcrow. Group. 2012. *SMP 20 Lavernock Point to St Ann's Head (South Wales) Shoreline Management Plan SMP2*. Available from: [http://www.npt.gov.uk/ldpexamination/SWW03%20Shoreline%20Management%20Plan%202%20Main%20Document%20\(2012\).pdf](http://www.npt.gov.uk/ldpexamination/SWW03%20Shoreline%20Management%20Plan%202%20Main%20Document%20(2012).pdf). [Accessed 15 July 2016]
- ⁵⁶ Royal Haskoning. 2012. *SMP 21 St Ann's Head to Great Ormes Head (West of Wales) Shoreline Management Plan 2*. Available from: <http://www.westofwalesmp.org/>. [Accessed 15 July 2016]

-
- ⁵⁷ ABPmer. 2008. *Atlas of UK Marine Renewable Energy Resources: Technical Report* [online]. Available from: <http://www.renewables-atlas.info/> [Accessed 11th July 2016].
- ⁵⁸ NRW. 2015. River Basin Management Plans, Published 2015-2021 [online]. Available from: <https://naturalresources.wales/water/quality/river-basin-management-plans-published/?lang=en>. [Accessed 29th July 2016].
- ⁵⁹ Environment Agency. 2014. The Water White Paper and Case for Change [online]. Archived content. Available from: <http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/research/planning/135501.aspx>. [Accessed 17th August 2016].
- ⁶⁰ Welsh Government. 2015. *Water strategy for Wales* [online]. Available from: <http://gov.wales/topics/environmentcountryside/epq/waterflooding/publications/water-strategy/?lang=en> [Accessed 14th July 2016].
- ⁶¹ UK Climate Projections. 2014. UK Climate Projections 2009 (UKCP09) [online]. Available from: <http://ukclimateprojections.metoffice.gov.uk/22530>. [Accessed 19th August 2016].
- ⁶² Defra. 2014. Charting Progress 2: The State of the UK's Seas [online]. Archived content, Department for Environment, Food and Rural Affairs (DEFRA). Available from: <http://webarchive.nationalarchives.gov.uk/20141203181034/http://chartingprogress.defra.gov.uk/>. [Accessed 17th August 2016].

3.4 Soils

- ⁶³ Rudeforth CC, Hartnup R, Lea JW, Thompson TRE, Wright PS. 1984. *Soils and their use in Wales*. Soil Survey Bulletin No. 11. Harpenden: Soil Survey.
- ⁶⁴ Welsh Government. 2008. *Sustaining the Land - a Review of Land Management Actions under Axis 2 of the Wales RDP 2007 - 2013*. Cardiff: Welsh Government.
- ⁶⁵ Natural England. 2009. *Agricultural Land Classification: protecting the best and most versatile agricultural land (TIN049)* [online]. Available from: <http://publications.naturalengland.org.uk/publication/35012> [Accessed 14th July 2016].
- ⁶⁶ UK NEA. 2011. *The UK National Ecosystem Assessment - Technical Report. Chapter 20: Status and changes in ecosystems and their services to society: Wales*. Cambridge: UNEP-WCMC.
- ⁶⁷ Hannam J, Niziolowski J, Rickson J, Keay C. 2016. *An analysis of the extent and severity of soil degradation in Wales*. (Welsh Soils Evidence Review). Cranfield University on behalf of Welsh Government.
- ⁶⁸ Newell-Price P, Chambers B, Whittingham M. 2012. *Characterisation of soil structural degradation under grassland and development of measures to ameliorate its impact on biodiversity and other soil functions*. Defra Project BD5001 Final Report. Grassland soil compaction assessment – Stage 1 and 2.
- ⁶⁹ Evans C, Rawlins B, Grebby S, Scholefield P, Jones P. 2015. *Glastir Monitoring & Evaluation Programme. Mapping the extent and condition of Welsh peat*. Welsh Government. NERC/Centre for Ecology & Hydrology (CEH Project: NEC04780)
- ⁷⁰ Hall J, Smith R. 2015. *Trends in critical load exceedances in the UK*. Centre for Ecology and Hydrology report to Defra, Contract AQ0826.
- ⁷¹ NRW. 2016. *The state of contaminated land in Wales*. Cardiff: Natural Resources Wales.
- ⁷² Emmett BE, Abdalla M, Anthony S, Astbury S, August T, Barrett G, Beckman B, Biggs J, Botham M, Bradley D, Chadwick D, Collier R, Cooper D, Cooper J, Cosby BJ, Creer S, Cross P, Dadam D, Edwards F, Edwards M, Evans C, Ewald N, Garbutt A, Giampieri C, Goodwin A, Grebby S, Greene S, Halfpenney I, Hall J, Harrower C, Henrys P, Hobson R, Hughes P, Hughes S, Isaac N, Jackson B, Jarvis S, Jones DL, Jones P, Keith A, Kelly M, Kneebone N, Lallias D, Lebron I, Malcolm H, Maskell L, MacDonald J, Maxwell D, Moxley J, Norton L, Oliver T, Owen A, Parkhill KA, Pereira MG, Peyton J, Powney G, Prochorskaite A, Rawlins B, Reuland O, Robinson DA, Rorke S, Rowland C, Roy D, Scarlett P, Scholefield P, Scott L, Smith GR, Siriwardena G, Smart S, Smith P, Swetnam R, Taft H, Taylor R, Tebbs E, Thomas A, Tordoff G, Turner G, Van Breda J, Vincent H, Wagner M, Waters E, Walker-Springett K, Wallace H, Webb G, Williams B, Williams P & Wood C. 2015. *Glastir Monitoring & Evaluation Programme. Second Year Annual Report to Welsh Government* (Contract reference: C147/2010/11). NERC/Centre for Ecology & Hydrology (CEH Project: NEC04780).
- ⁷³ NRW. 2015. *Response by Cyfoeth Naturiol Cymru/Natural Resources Wales to Welsh Government Consultation Document: A Strategic Framework for Welsh Agriculture* [online]. Natural Resources Wales. Available from: <http://naturalresources.wales/media/5551/strategic-framework-for-welsh-agriculture.pdf> [Accessed 13th July 2016].

-
- ⁷⁴ UK NEA. 2011. *The UK National Ecosystem Assessment - Technical Report. Chapter 14: Regulating Services*. Cambridge: UNEP-WCMC.
- ⁷⁵ 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]
- ⁷⁶ UK NEA. 2011. *The UK National Ecosystem Assessment - Technical Report. Chapter 13: Supporting Services*. Cambridge: UNEP-WCMC.
- ⁷⁷ Stevens PA, Reynolds B, Emmett BA, Thompson TRE, Loveland PJ, Jarvis SC, Haygarth P, Thomas HR, Owen DH, Roberts R, Marsden T. 2002. *Critical Appraisal of State and Pressures and Controls on the Sustainable Use of Soils in Wales*. CEH Project C01920. Report for Environment Agency and National Assembly for Wales.
- ⁷⁸ UK Soil Observatory (UKSO). 2016. *The Soils of England and Wales* [online]. The UK Soil Observatory. Available from: <http://www.ukso.org/SoilsOfEngWales/home.html> [Accessed 14th July 2016].
- ⁷⁹ Scottish Executive and Welsh Assembly Government. 2007. ECOSSE: Estimating Carbon in Organic Soils - Sequestration and Emissions: Final Report. Scottish Executive Environment and Rural Affairs Department Environmental Research.
- ⁸⁰ GMEP. 2016. *Glastir Monitoring and Evaluation Programme (GMEP) portal* [online]. Available from: <https://gmep.wales> [Accessed 14th July 2016].

3.5 Geodiversity, Geological Features and Processes (including Minerals)

- ⁸¹ British Geological Survey. 2016. British Geological Survey (BGS) website. Online source. Available from: <http://www.bgs.ac.uk/home.html>. [Accessed 29th July 2016].
- ⁸² UK National Commission for UNESCO. 2013. *Wider value of UNESCO to the UK 2012-13*. United Nations Educational Scientific and Cultural Organisation (UNESCO).
- ⁸³ NRW. 2016. Geological SSSI boundaries, Easimap, Natural Resources Wales database.
- ⁸⁴ NRW. 2005-present. Various individual geological site reports. Internal data sources. Natural Resources Wales.
- ⁸⁵ British Geological Survey. 2015. *United Kingdom Minerals Yearbook 2014*. Available at <https://www.bgs.ac.uk/downloads/start.cfm?id=3030>. [Accessed 29th July 2016].
- ⁸⁶ British Geological Survey. 2015. *Summary Applied Geology of the Dyfi Catchment*. Report for Natural Resources Wales. British Geological Survey.
- ⁸⁷ 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]
- ⁸⁸ British Geological Survey. 2013. *A study of potential unconventional gas resources in Wales*. Geology and Regional Geophysics Commissioned Report CR/13/142. A BGS (component body of the Natural Environment Research Council, NERC) report for Welsh Government.
- ⁸⁹ NRW. 2016. Corporate datasets with geological sites boundary details. Natural Resources Wales.
- ⁹⁰ BGS. 2016. *GIS layers of potential unconventional gas resources in Wales (updates from 2016)*. British Geological Survey.
- ⁹¹ British Geological Survey. 2016. *Geology of Britain Viewer* [online]. Available from: <http://mapapps.bgs.ac.uk/geologyofbritain/home.html>. [Accessed 17th August 2016].
- ⁹² UK National Commission for UNESCO. 2016. *UNESCO Global Geoparks*. Celebrating Earth heritage, sustaining local communities. Available from: <http://unesdoc.unesco.org/images/0024/002436/243650e.pdf>. [Accessed 17th August 2016].
- ⁹³ Brecon Beacons National Park. 2016. *Forest Fawr UNESCO global geopark* [online]. Available from: <http://www.fforestfawrgeopark.org.uk/>. [Accessed 17th August 2016].
- ⁹⁴ GeoMôn Anglesey Geopark. 2016. *GeoMôn Anglesey Geopark* [online]. Available from: <http://www.geomon.co.uk/>. [Accessed 17th August 2016].
- ⁹⁵ Mineral Products Association. 2016. *The UK Mineral Extraction Industry*. CBI The Voice of Business. Prepared by the Mineral Products Association for the CBI Minerals Group on behalf of the UK mineral extraction industry. Available from: http://www.mineralproducts.org/documents/CBI_UK_Mineral_Extraction_Industry_2016_2.pdf. [Last accessed 17th August 2016].
- ⁹⁶ JNCC. 2015. *The Geological Conservation Review (GCR)* [online]. Joint Nature Conservation Committee. Available from: <http://jncc.defra.gov.uk/default.aspx?page=2947>. [Accessed 19th August 2016].

Part B – Welsh Ecosystems

⁹⁷ Welsh Government Statistics 2016. Area of Wales derived from Ordnance Survey Boundary line under Open Government Licence (OGL).

⁹⁸ Welsh Government. 2015. *Wales' Marine Evidence Report* [online]. Available from: <http://gov.wales/topics/environmentcountryside/marineandfisheries/marine-planning/other-supporting-evidence/wales-marine-evidence-report/?lang=en> [Accessed 12th July 2016].

⁹⁹ 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, Cardiff.

¹⁰⁰ GMEP. 2016. *Glastir Monitoring and Evaluation Programme (GMEP) portal* [online]. Available from: <https://gmep.wales>. [Accessed 14th July 2016].

¹⁰¹ Welsh Government. 2015. *Wales' Marine Evidence Report* [online]. Available from: <http://gov.wales/topics/environmentcountryside/marineandfisheries/marine-planning/other-supporting-evidence/wales-marine-evidence-report/?lang=en> [Accessed 12th July 2016].

¹⁰² Brazier, P, Birch, K, Brunstrom, A, Bunker, A, Jones, M, Lough, N, Salmon, L and Wyn, G (2007) When the tide goes out. The biodiversity and conservation of the shores of Wales - results from a 10 year intertidal survey of Wales. Countryside Council for Wales

¹⁰³ Welsh Government 2016. HABMAP – Habitat Mapping for Conservation and Management of the Southern Irish Sea. Lle – A geoportal for Wales. Online source: <http://lle.wales.gov.uk/catalogue/item/HabitatMappingForConservationAndManagementOfTheSouthernIrishSeaHABMAP/?lang=en>. [Accessed 26th July 2016].

¹⁰⁴ ONS. 2015. UK Natural Capital – Land Cover in the UK. Office for National Statistics. Available at <http://www.ons.gov.uk/ons/index.html>. [Accessed 18th May 2016].

¹⁰⁵ Jones PS, Stevens DP, Blackstock TH, Burrows CR, Howe EA. 2003. Priority Habitats of Wales – a Technical Guide. Countryside Council for Wales, Bangor.

¹⁰⁶ Welsh Government, Statistics for Wales. 2012. State of the Environment 2012 report. Available from: <http://gov.wales/docs/statistics/2012/120725stateofenvironment12en.pdf>. [Accessed 1st September 2016].

¹⁰⁷ NRW. 2016. *Current data on SAC and SPA Annex I habitats and Annex II species*. Internal data source. Natural Resources Wales.

3.6 Mountains, Moorlands and Heaths

¹⁰⁸ 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, Cardiff.

¹⁰⁹ NRW. 2016. *Qualifying Features of SSSI*. Corporate GIS Data-set (based on data collated 2008-2010). Cardiff: Natural Resources Wales.

¹¹⁰ Welsh Government. 2015. *A Review of the Contribution the Glastir Scheme to the Sustainable Management of Peatlands*. Cardiff: Welsh Government Soils & Landuse Division.

¹¹¹ NRW. 2015. *Analysis of data collated for 2012 Article 17 Reporting Round*. Cardiff: Natural Resources Wales.

¹¹² Allen D. 2004. *A Rapid Review of SSSI Feature Condition in Wales*. Bangor: Countryside Council for Wales.

¹¹³ NRW. 2015. *Current data on SAC and SPA Annex I habitats and Annex II species*. Internal data source. Natural Resources Wales.

¹¹⁴ Latham J, Sherry J, Rothwell J. 2013. *Ecological Connectivity and Biodiversity Prioritisation in the Terrestrial Environment of Wales*. CCW Staff Science Report No. 13/3/3. Bangor: Countryside Council for Wales.

¹¹⁵ NRW. 2016. *An assessment of the extent and distribution of peat erosion in Wales*. Bangor: Natural Resources Wales.

¹¹⁶ GMEP. 2016. *Glastir Monitoring and Evaluation Programme (GMEP) portal* [online]. Available from: <https://gmep.wales>. [Accessed 14th July 2016].

¹¹⁷ NRW. 2016. *Analysis of grip blocking activity undertaken to date in Welsh peatlands*. Bangor: Natural Resources Wales.

¹¹⁸ Medcalf K, Whittick E, Turton, N, Cross, D. 2012. *Wales Agri-Environment Monitoring Lot 1: Habitats*. Final Report. Welsh Government. . A report produced for the Welsh Government by Environment Systems and Thompson Ecology.

¹¹⁹ Emmett BE, Abdalla M, Anthony S, Astbury S, August T, Barrett G, Beckman B, Biggs J, Botham M, Bradley D, Chadwick D, Collier R, Cooper D, Cooper J, Cosby BJ, Creer S, Cross P, Dadam D, Edwards F, Edwards M, Evans C, Ewald N, Garbutt A, Giampieri C, Goodwin A, Grebby S, Greene S,

Halfpenney I, Hall J, Harrower C, Henrys P, Hobson R, Hughes P, Hughes S, Isaac N, Jackson B, Jarvis S, Jones DL, Jones P, Keith A, Kelly M, Kneebone N, Lallias D, Lebron I, Malcolm H, Maskell L, MacDonald J, Maxwell D, Moxley J, Norton L, Oliver T, Owen A, Parkhill KA, Pereira MG, Peyton J, Powney G, Prochorskaite A, Rawlins B, Reuland O, Robinson DA, Rorke S, Rowland C, Roy D, Scarlett P, Scholefield P, Scott L, Smith GR, Siriwardena G, Smart S, Smith P, Swetnam R, Taft H, Taylor R, Tebbs E, Thomas A, Tordoff G, Turner G, Van Breda J, Vincent H, Wagner M, Waters E, Walker-Springett K, Wallace H, Webb G, Williams B, Williams P & Wood C. 2015. Glastir Monitoring & Evaluation Programme. Second Year Annual Report to Welsh Government (Contract reference: C147/2010/11). NERC/Centre for Ecology & Hydrology (CEH Project: NEC04780).

¹²⁰ 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]

¹²¹ JNCC. 2013. *Third report by the United Kingdom under Article 17 on the implementation of the Habitats and Species Directive from January 2007 to December 2012: Habitat Accounts*. Peterborough: Joint Nature Conservation Committee.

¹²² JNCC. 2013. *3rd UK Habitats Directive Reports* [online]. Peterborough: Joint Nature Conservation Committee. Available from: <http://jncc.defra.gov.uk/page-6387>. [Accessed 14th July 2016].

3.7 Semi-natural Grasslands

¹²³ 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, Cardiff.

¹²⁴ Stevens DP, Smith SLN, Blackstock TH, Bosanquet SDS, Stevens JP. 2010. *Grasslands of Wales. A survey of lowland species-rich grasslands, 1987-2004*. Cardiff: University of Wales Press.

¹²⁵ JNCC. 2013. *3rd UK Habitats Directive Reports* [online]. Peterborough: Joint Nature Conservation Committee. Available from: See <http://jncc.defra.gov.uk/page-6387> [Accessed 14th July 2016].

¹²⁶ Allen D. 2004. *A Rapid Review of SSSI Feature Condition in Wales*. Bangor: Countryside Council for Wales.

¹²⁷ Fuller RM. 1987. The changing extent and conservation interest of lowland grasslands in England and Wales: a review of grassland surveys 1930-84. *Biological Conservation* 40(4), 281-300

¹²⁸ Ridding LE, Redhead JW, Pywell RF. 2015. Fate of semi-natural grassland in England between 1960 and 2013: A test of national conservation policy [online]. *Global Ecology and Conservation* 4, 516-525. Available from: <http://nora.nerc.ac.uk/512095/>. [Accessed 7th July 2016].

¹²⁹ UK NEA. 2011. *The UK National Ecosystem Assessment - Technical Report. Chapter 6: Semi-natural Grasslands*. Cambridge: UNEP-WCMC.

3.8 Enclosed Farmland

¹³⁰ Blackstock TH, Howe EA, Stevens JP, Burrows CR, Jones PS. 2010. *Habitats of Wales: A Comprehensive Field Survey, 1979-97*. Cardiff: University of Wales Press.

¹³¹ UK NEA. 2011. *The UK National Ecosystem Assessment - Technical Report. Chapter 20: Status and changes in ecosystems and their services to society: Wales*. Cambridge: UNEP-WCMC.

¹³² UK Government. The Government Office for Science. 2011. *The Future of Food and Farming. Final Project Report*. London: The Government Office for Science.

¹³³ Welsh Government. Statistics for Wales. 2015. *Estimates from Welsh Agricultural Survey, June 2015* [online]. Available from: <http://gov.wales/statistics-and-research/survey-agricultural-horticulture/?lang=en>. [Accessed 14th July 2016].

¹³⁴ Preston CD, Pearman D, Dines TD & Botanical Society of the British Isles. 2002. *New atlas of the British & Irish flora: An atlas of the vascular plants of Britain, Ireland, the Isle of Man and the Channel Islands*. Oxford University Press.

¹³⁵ Cheffings C & Farrell L (Eds). 2005. The vascular plant red data list for Great Britain. Species Status, No. 7. ISSN 1473-0154. Available from: http://jncc.defra.gov.uk/pdf/pub05_speciesstatusvpredlist3_web.pdf. [Accessed 8th August 2016].

¹³⁶ Countryside Survey. 2007. *Countryside Survey 2007: Results for Wales* [online]. Available from: <http://www.countryside.gov.uk/outputs/wales-results-2007>. [Accessed 13th July 2016].

¹³⁷ Wales Audit Office. 2007. *Tir Gofal - Report presented by the Auditor General for Wales to the National Assembly for Wales on 15 November 2007*. Available from: <http://www.assembly.wales/Laid%20Documents/AGR-LD6870%20-%20Tir%20Gofal-15112007-65632/agr-ld6870-e-English.pdf>. [Accessed 14th July 2016].

-
- ¹³⁸ Welsh Government Rural Payments Division. 2016. Glastir statistics - personal communication with all figures based on the information available in May 2016.
- ¹³⁹ GMEP. 2016. *Glastir Monitoring and Evaluation Programme (GMEP) portal* [online]. Available from: <https://gmep.wales>. [Accessed 14th July 2016].
- ¹⁴⁰ Glastir Advanced Water Quality Report. 2014: Results from 2013-2014 visits. Accessible from Natural Resources Wales.
- ¹⁴¹ Oram S, Alexander L, Sadler E. 2014. *Traditional Orchard Habitat Inventory of Wales*. Natural Resources Wales Evidence Report No: 18. Bangor: Natural Resources Wales.
- ¹⁴² Woodland Trust. 2015. Chalara in Non-woodland Situations: Findings from a 2014 Survey. Defra Report
- ¹⁴³ 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]
- ¹⁴⁴ NRW. 2016. Extent of arable SSSI's. Internal database. Natural Resources Wales.
- ¹⁴⁵ Lampkin N, Owen D, Gerrard C. 2016. Welsh Organic Producer Survey 2015. Organic Research Centre, Newbury a partner in Organic Centre Wales. Report for Welsh Government.
- ¹⁴⁶ Shellswell CH. 2015. Wales' Important Arable Plants. Plantlife.
- ¹⁴⁷ Living with Environment Change (LWEC). 2016. Agriculture and Forestry Climate Change Impacts, Report Card 2016. Available from: <http://www.nerc.ac.uk/research/partnerships/lwec/products/report-cards/agriculture/report-card/>. [Accessed 29th July 2016].
- ¹⁴⁸ AHDB. 2016. *AHDB Dairy: UK Cow Numbers 2016* [online]. Agriculture and Horticulture Development Board. Available from: <http://dairy.ahdb.org.uk/market-information/farming-data/cow-numbers/uk-cow-numbers/> [Accessed 13th July 2016].
- ¹⁴⁹ Welsh Government. 2015. Food and Drink Wales. Business Wales report on the poultry sector. Available from: <http://businesswales.gov.wales/foodanddrink/poultry-and-eggs>. [Accessed 28th July 2016].
- ¹⁵⁰ Animal and Plant Health Agency. 2014. Great Britain Poultry Register Statistics, 2013. Official Statistics. Available from: <https://www.gov.uk/government/statistics/great-britain-poultry-register-statistics>. [Accessed 19th August 2016].
- ¹⁵¹ Gwynedd Archaeological Trust. 2002. *Preliminary atlas of field boundary types in Wales*. Countryside Council for Wales Research policy report 02/6 report no.458. Bangor: Countryside Council for Wales.
- ¹⁵² Hybu Cig Cymru/Meat Promotion Wales. 2013. *Review 2003-2013: Flying the Flag: Decade of Success for the Welsh Red Meat Brands* [online]. Available from: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwi37rn1qNLMAhVKF8AKHWWRApcQFggcMAA&url=http%3A%2F%2Fhccmpw.org.uk%2Findex.php%2Ftools%2Frequired%2Ffiles%2Fdownload%3FfID%3D4410&usq=AFQjCNG3gUqYeOmSSBS3IIOA_jzanLO1-A. [Accessed 13th July 2016].
- ¹⁵³ Keay CA, Jones RJA, Procter C, Chapman V & Barrie I. 2014 *The impact of climate change on the capability of soils for agriculture as defined by the Agricultural Land Classification* [online]. Report to Defra. Available from: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjx4abGoe7NAhVBPRoKHeupAfsQFggcMAA&url=http%3A%2F%2Frandd.defra.gov.uk%2FDocument.aspx%3FDocument%3D13364_SP1104Finalreport.pdf&usq=AFQjCNEUTYW5PLMhHi6pdtxp_kRfk1Jd7Q&bvm=bv.126130881,d.d2s [Accessed 13th July 2016].
- ¹⁵⁴ White Consultants. 2016. LANDMAP Statistics 2016: Visual and Sensory Aspect.

3.9 Woodland

- ¹⁵⁵ Welsh Government (Official Statistics). 2015. Woodlands for Wales Indicators 2014-15. December 2015 – Available from: <http://gov.wales/statistics-and-research/woodlands-wales-indicators/?lang=en> [Accessed 11th August 2016].
- ¹⁵⁶ NRW. 2015. Natura 2000 Thematic Action Plan Woodland Management. October 2015. Natural Resources Wales.
- ¹⁵⁷ Allen D. 2004. *A Rapid Review of SSSI Feature Condition in Wales*. Bangor: Countryside Council for Wales.
- ¹⁵⁸ GMEP. 2016. *Glastir Monitoring and Evaluation Programme (GMEP) portal* [online]. Available from: <https://gmep.wales>. [Accessed 14th July 2016].

-
- ¹⁵⁹ Forestry Commission. 2011. *National Forest Inventory* - Forestry Commission, Edinburgh – Available from: <http://www.forestry.gov.uk/inventory> [Accessed 15 July 2016]
- ¹⁶⁰ Welsh Assembly Government. 2011. *Welsh Assembly Government's strategy for Wild deer management in Wales*. Available from: <http://gov.wales/docs/drah/publications/120222wilddeermanagementen.pdf>. [Accessed 15 July 2016]
- ¹⁶¹ Confor 2014. Welsh softwood timber supplies and our green economy – Summary. Workshop November 2014. Available from: <http://www.confor.org.uk/media/246181/welsh-softwood-timber-supplies-and-our-green-economy-workshop-nov-2014-summary-report.pdf>. [Accessed 25th July 2016].
- ¹⁶² Forestry Commission 2014. Statistical Analysis Report: 50 year forecast of softwood / hardwood availability. April 2014. - Available from: [http://www.forestry.gov.uk/pdf/50_YEAR_FORECAST_OF_SOFTWOOD_AVAILABILITY.pdf/\\$FILE/50_YEAR_FORECAST_OF_SOFTWOOD_AVAILABILITY.pdf](http://www.forestry.gov.uk/pdf/50_YEAR_FORECAST_OF_SOFTWOOD_AVAILABILITY.pdf/$FILE/50_YEAR_FORECAST_OF_SOFTWOOD_AVAILABILITY.pdf). [Accessed 15 July 2016].
- ¹⁶³ NRW. 2016. *Phytophthora ramorum* survey and monitoring data (unpublished internal report). Natural Resources Wales.
- ¹⁶⁴ NRW. 2016. *Chalara* dieback in Ash survey and monitoring data (unpublished internal report). Natural Resources Wales.
- ¹⁶⁵ 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]
- ¹⁶⁶ NRW. 2015. Ancient Woodland Inventory 2011. Natural Resources Wales. Available from: <https://naturalresources.wales/forestry/woodlands-and-the-environment/ancient-woodland-inventory/?lang=en>. [Accessed 15 July 2016].
- ¹⁶⁷ Forest Research. 2016. Climate change in Wales: tree species suitability. Available from: <http://www.forestry.gov.uk/fr/infid-7fxc3j>. [Accessed 15 July 2016].
- ¹⁶⁸ Welsh Assembly Government. 2009. Woodlands for Wales – the Welsh Assembly Government's Strategy for Woodlands and Trees. Available from: <http://gov.wales/docs/drah/publications/090324-woodlands-for-wales-strategy-en.pdf>. [Accessed 19th August 2016].
- ¹⁶⁹ Forestry Commission. 2015. *Forestry Statistics* [online]. Available from: <http://www.forestry.gov.uk/statistics>. [Accessed 19th August 2016].
- ¹⁷⁰ Read DJ, Freer-Smith PH, Morison JIL, Hanley N, West CC & Snowdon P (eds). 2009. Combating climate change – a role for UK forests. An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change. The synthesis report. The Stationery Office, Edinburgh.
- ¹⁷¹ Ray D. 2008. *Impacts of climate change on forestry in Wales*. FC Information Note 301, July 2008. Forest Research.
- ¹⁷² ConFor. 2015. *Upland forestry Wales study - Welsh Analysis of Land-use Economics & Subsidies*. Available from: <http://www.confor.org.uk/media/79583/upland-forestry-in-wales-report.pdf>. [Accessed 19th August 2016].
- ¹⁷³ ConFor & Forest Research. 2015. The Role of Productive Woodland in Water Management. Available from: <http://www.confor.org.uk/media/79557/1208-confor-productive-woodlands-plus-water-12pp-aw-sml.pdf>. [Accessed 19th August 2016].
- ¹⁷⁴ National Assembly of Wales. 2014. Inquiry into the public forestry estate in Wales. *Record of proceedings, evidence, letters and Ministerial response*. Available from: <http://www.senedd.assembly.wales/mglIssueHistoryHome.aspx?lId=9573&Opt=0>. [Accessed 19th August 2016].
- ¹⁷⁵ UK NEA. 2011. *The UK National Ecosystem Assessment - Technical Report. Chapter 8: Woodlands*. Cambridge: UNEP-WCMC.
- ¹⁷⁶ British Woodlands Survey. 2015. Awareness, action and aspiration among Britain's forestry community relating to environmental change: Report of the British Woodlands Survey 2015. Available from: <https://sylva.org.uk/forestryhorizons/bws2015>. [Accessed 19th August 2016].
- ¹⁷⁷ Welsh Government. 2013. Wales' Tree Health Strategy. Available from <http://gov.wales/docs/drah/publications/140109-tree-health-strategy-for-wales-october-2013-en.pdf>. [Accessed 19th August 2016].
- ¹⁷⁸ Morison J, Matthews R, Miller G, Perks M, Randle T, Vanguelova E, White M & Yamulki S. 2012. *Understanding the carbon and greenhouse gas balance of forests in Britain*. Forestry Commission Research Report. Forestry Commission, Edinburgh. i-vi + 1-149 pp. Available from: [http://www.forestry.gov.uk/pdf/FCRP018.pdf/\\$FILE/FCRP018.pdf](http://www.forestry.gov.uk/pdf/FCRP018.pdf/$FILE/FCRP018.pdf). [Accessed 19th August 2016].
- ¹⁷⁹ Quine C, Bailey SA & Watts K. 2013. Sustainable forest management in a time of ecosystem services frameworks: common ground and consequences. *Journal of Applied Ecology* 50 (4), 863–867

¹⁸⁰ Woodland Trust 2011. The State of the UK's Forests, Woods and Trees. Perspectives from the sector. Policy Paper. November 2011. Available from: <http://www.woodlandtrust.org.uk/publications/2011/11/state-of-the-uk-forests-woods-and-trees/>. [Accessed 26th July 2016].

¹⁸¹ Woodland Trust. 2016. Woodland Indicators by Local Authority. Unitary and county councils. Research Report. Available from: <http://www.woodlandtrust.org.uk/publications/2016/07/woodland-indicators-unitary/>. [Accessed 26th July 2016].

3.10 Freshwater

¹⁸² May J. 1994. *Reference Wales*. Cardiff: University of Wales Press.

¹⁸³ Hatton-Ellis TW. 2014. *Lake BAP Priority Areas in Wales: A Strategic Review*. Cardiff: Wales Biodiversity Partnership

¹⁸⁴ NRW. 2015. *Analysis of data collated for 2012 Article 17 Reporting Round*. Natural Resources Wales.

¹⁸⁵ Jones PS, Stevens DP, Latham J & Duigan CA. 2009 Habitats of Welsh River Floodplains. In: *Welsh Rivers*, Eds Duigan CA and Williams D. Leiden: Backhuys Publishing. Pp. 35-58.

¹⁸⁶ NRW. 2015. Water Watch Wales. Water Framework Directive reporting. Natural Resources Wales. Available: <http://waterwatchwales.naturalresourceswales.gov.uk/en/> [Accessed 15 July 2016].

¹⁸⁷ NRW. 2015. River Basin Management Plans, Published 2015-2021 [online]. Available from: <https://naturalresources.wales/water/quality/river-basin-management-plans-published/?lang=en>. [Accessed 29th July 2016].

¹⁸⁸ JNCC. 2013. *3rd UK Habitats Directive Reports* [online]. Peterborough: Joint Nature Conservation Committee. Available from: <http://jncc.defra.gov.uk/page-6387> [Accessed 14th July 2016]

¹⁸⁹ NRW. 2016. Nitrate Vulnerable Zone (NVZ) GIS datasets. Natural Resources Wales internal datasets.

¹⁹⁰ NRW. 2015. Protected Area Register, River Basin Management Plans, Published 2015-2021 [online]. Available from: <https://naturalresources.wales/water/quality/river-basin-management-plans-published/?lang=en>. [Accessed 29th July 2016].

¹⁹¹ NRW. 2015. The salmon for tomorrow programme. A national programme across Wales 2010-2015. Summary. Natural Resources Wales. Available from: http://www.therrc.co.uk/sites/default/files/files/Conference/2015/Outputs/posters/salmon_for_tomorrow.pdf. [Accessed 25th August 2016].

¹⁹² NRW. 2016. Information submitted to Welsh Government in relation to Nitrate Vulnerable Zone review. Internal data source.

¹⁹³ Shilland EM, Monteith DT, Millidine K & Malcolm IA. 2016. *United Kingdom Upland Waters Monitoring Network: Data report for 2014-2015* [online]. Report to Defra. Available from: <http://awmn.defra.gov.uk/resources/annualreports/year27annRpt.pdf> [Accessed 14th July 2016].

¹⁹⁴ NRW. 2013. *European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC). Supporting documentation for the Third Report by the United Kingdom under Article 17*. Habitats accounts (various). Natural Resources Wales.

¹⁹⁵ NRW. 2015. *LIFE Natura 2000 Programme for Wales* [online]. Cardiff: Natural Resources Wales. Available from: <https://naturalresources.wales/about-us/our-projects/life-n2k-wales/life-n2k-wales/?lang=en> [Accessed 14th July 2016].

¹⁹⁶ 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]

¹⁹⁷ NRW. 2016. Freshwater SSSI data. Internal database. Natural Resources Wales.

¹⁹⁸ Allen D. 2004. *A Rapid Review of SSSI Feature Condition in Wales*. Bangor: Countryside Council for Wales.

¹⁹⁹ Environment Agency and Natural Resources Wales. 2013. Current and future water availability – addendum: A refresh of the Case for Change analysis.

²⁰⁰ Welsh Government. 2015. *Water strategy for Wales* [online]. Available from: <http://gov.wales/topics/environmentcountryside/epq/waterflooding/publications/water-strategy/?lang=en> [Accessed 14th July 2016].

²⁰¹ Environment Agency. 2009. *Water for people and the environment – water resources strategy for Wales* [online]. Available from: <http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/research/library/publications/40731.aspx>. [Accessed 11th August 2016].

²⁰² UK Climate Projections. 2014. UK Climate Projections 2009 (UKCP09) [online]. Available from: <http://ukclimateprojections.metoffice.gov.uk/22530>. [Accessed 19th August 2016].

3.11 Urban Environments

²⁰³ Statistics for Wales, Local Authority Population Projections for Wales, Statistics for Wales, July 2013. Available from: <http://gov.wales/statistics-and-research/local-authority-population-projections/?lang=en>. [Accessed 15 July 2016]

²⁰⁴ Welsh Government, Statistics for Wales. 2008. A statistical focus on rural Wales. 2008 edition.

²⁰⁵ Cecil C. Konijnendijk et al. 2013. *Benefits of Urban Parks A systematic review - report for IFPRA*. Copenhagen & Alnarp. Available from: <http://worldurbanparks.org/images/Newsletters/IfpraBenefitsOfUrbanParks.pdf> [Accessed 15 July 2016]

²⁰⁶ Keep Wales Tidy. 2016. *Green Flag Awards*.

²⁰⁷ NRW. 2014. *Tree Cover in Wales' Towns and Cities*. Available from: <https://naturalresources.wales/media/4123/tree-cover-in-wales-towns-and-cities-2014-study.pdf> [Accessed 15 July 2016]

²⁰⁸ Welsh Government. 2013. A Noise Action Plan for Wales 2013-18. Available from: <http://gov.wales/docs/desh/publications/131217noise-action-plan-for-wales-en.pdf> [Accessed 15 July 2016]

²⁰⁹ Welsh Government, Statistics for Wales. 2013. *Local Authority Population Projections for Wales (2011-based)*. Issued July 2013. Available from: <http://gov.wales/statistics-and-research/local-authority-population-projections/?lang=en> [Accessed 15 July 2016]

²¹⁰ London Assembly Environment Committee. 2005. Crazy Paving: the environmental importance of London's front gardens. September 2005. Greater London Authority, London.

²¹¹ Gill SE, Handley JF, Ennos AR and Pauleit S. 2007. *Adapting cities for climate change: the role of green infrastructure*. In: *Built Environment* 33 (1), 115–133. Available from: http://urbanspace.rec.org/files/Article_Gill_Adapting_Cities_for_CC.pdf [Accessed 15 July 2016]

²¹² Richards IG, Palmer JP, Barratt PA. 1993. *The reclamation of former coal mines and steelworks - Studies in Environmental Science* 56. Elsevier. 717pp. Available from: <https://www.elsevier.com/books/the-reclamation-of-former-coal-mines-and-steelworks/richards/978-0-444-81703-7> [Accessed 15 July 2016].

²¹³ Statistics Wales 2012. Accessible natural greenspace standards by local authority, 2007-2010. Measure 072. Data collated by CCW from local authorities for Wales Environment Strategy Indicator 27b.

²¹⁴ Environmental Noise Mapping. 2012. Welsh Government. Available from <http://lle.gov.wales/catalogue/item/EnvironmentalNoiseMapping/?lang=en>. [Accessed 29th July 2016].

²¹⁵ NRW. 2014. *Tree Cover in Wales' Towns and Cities Study Summary*. Available from: <https://naturalresources.wales/media/3705/tree-cover-in-wales-towns-and-cities-2014-summary.pdf>. [Accessed 22nd August 2016]

²¹⁶ Wildlife Trusts Wales. 2016. *Green Infrastructure: A catalyst for the Well-being of Future Generations Act*. Wildlife Trusts Wales. 32pp.

²¹⁷ Sheffield Hallam University. *Green Infrastructure's contribution to economic growth. A review for Defra and Natural England*. Sheffield Hallam University: Centre for Regional Economic & Social Research.

3.12 Coastal Margins

²¹⁸ JNCC. 2013. *3rd UK Habitats Directive Reports* [online]. Peterborough: Joint Nature Conservation Committee. Available from: <http://jncc.defra.gov.uk/page-6387> [Accessed 14th July 2016]

²¹⁹ Allen D. 2004. *A Rapid Review of SSSI Feature Condition in Wales*. Bangor: Countryside Council for Wales.

²²⁰ UK NEA. 2011. *The UK National Ecosystem Assessment - Technical Report. Chapter 11: Coastal Margins*. Cambridge: UNEP-WCMC.

²²¹ 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]

²²² Halcrow Group. 2002. *Futurecoast: Future coastal evolution around England and Wales*. Report to DEFRA, London (available on CD).

-
- ²²³ Halcrow.Group. 2012. *SMP 22 Great Ormes Head to Scotland (North West England and North Wales) Shoreline Management Plan SMP2*. Available from: http://www.allerdale.gov.uk/downloads/nw_shoreline_management_plan_2.pdf [Accessed 15 July 2016]
- ²²⁴ Atkins. 2010. *SMP 19 Anchor Head to Lavernock Point (Severn Estuary) Shoreline Management Plan (SMP) Review*.
- ²²⁵ Halcrow. Group. 2012. *SMP 20 Lavernock Point to St Ann's Head (South Wales) Shoreline Management Plan SMP2*. Available from: [http://www.npt.gov.uk/ldpexamination/SWW03%20Shoreline%20Management%20Plan%202%20Main%20Document%20\(2012\).pdf](http://www.npt.gov.uk/ldpexamination/SWW03%20Shoreline%20Management%20Plan%202%20Main%20Document%20(2012).pdf). [Accessed 15 July 2016]
- ²²⁶ Royal Haskoning. 2012. *SMP 21 St Ann's Head to Great Ormes Head (West of Wales) Shoreline Management Plan 2*. Available from: <http://www.westofwalesmp.org/>. [Accessed 15 July 2016]

3.13 Marine

- ²²⁷ Welsh Government. 2015. *Wales' Marine Evidence Report* [online]. Available from: <http://gov.wales/topics/environmentcountryside/marineandfisheries/marine-planning/other-supporting-evidence/wales-marine-evidence-report/?lang=en> [Accessed 12th July 2016].
- ²²⁸ NRW. 2015. *Water Watch Wales. Water Framework Directive reporting*. Natural Resources Wales. Available: <http://waterwatchwales.naturalresourceswales.gov.uk/en/> [Accessed 15 July 2016].
- ²²⁹ Acornley RM, Morgan OC, Campos CJA, Kershaw S. 2010. *Temporal trends in the microbial quality of shellfish from UK production areas*. Project WT1001 – Factors affecting the microbial quality of shellfish. Cefas contract report to Defra. Available from: <https://www.cefas.co.uk/media/41388/20110601-c3608-wt1001-temporal-trends-microbial-quality-shellfish-final-report.pdf>. [Accessed 15 July 2016]
- ²³⁰ Welsh Government. 2015. *Bathing water quality and beaches in Wales*. Available from: <http://gov.wales/topics/environmentcountryside/epq/waterflooding/bathing-water-quality-and-beaches/?lang=en> [Accessed 15 July 2016].
- ²³¹ JNCC. 2013. *3rd UK Habitats Directive Reports* [online]. Peterborough: Joint Nature Conservation Committee. Available from: <http://jncc.defra.gov.uk/page-6387> [Accessed 14th July 2016]
- ²³² Biodiversity Action Reporting System. 2010. *UK Habitat and Species Action Plans*. Available from: <http://jncc.defra.gov.uk/page-5155> [Accessed 15 July 2016]
- ²³³ JNCC. 2015. *Seabird Population Trends and Causes of Change: 1986-2014 Report*. Joint Nature Conservation Committee. Updated October 2015.
- ²³⁴ JNCC. 2015. *Seabird Monitoring Programme Online Database [online]*. Joint Nature Conservation Committee. Available from: <http://jncc.defra.gov.uk/smp/>. [Accessed 25th August 2016].
- ²³⁵ HM Government. 2012. *Marine Strategy Part One: UK Initial Assessment and Good Environmental Status*.
- ²³⁶ Defra. 2015. *Marine Strategy Part Three: UK programme of measures*.
- ²³⁷ NRW. 2016. *Proposed new marine Special Areas of Conservation and Special Protection Areas [online]*. Natural Resources Wales. Available from: <https://naturalresources.wales/about-us/consultations/our-own-consultations-closed/proposed-new-marine-special-areas-of-conservation-and-special-protection-areas/?lang=en>. [Accessed 25th August 2016].
- ²³⁸ Airoldi L, Beck MW (2007) Loss, status and trends for coastal marine habitats of Europe. In: Gibson RN, Atkinson RJA, Gordon JDM (eds) *Oceanography and Marine Biology: An Annual Review*. pp 345–405
- ²³⁹ Mossman H, Grant A, Davy A (2013) *Terrestrial biodiversity climate change impacts report card technical paper 10. Implications of climate change for coastal and inter-tidal habitats in the UK*.
- ²⁴⁰ 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]
- ²⁴¹ NRW. 2015. *Western Wales River Basin Management Plan 2015-2021*. Natural Resources Wales. Available from: <https://naturalresources.wales/media/676165/wwrbdsummary.pdf>. [Accessed 15 July 2016]
- ²⁴² NRW. 2015. *River Basin Management Plans, Published 2015-2021 [online]*. Available from: <https://naturalresources.wales/water/quality/river-basin-management-plans-published/?lang=en>. [Accessed 29th July 2016].
- ²⁴³ Welsh Government. 2013. *Wales Marine Planning Portal [online]*. Available from: <http://lle.gov.wales/apps/marineportal/#lat=52.5145&lon=-3.9111&z=8>. [Accessed 12th August 2016].

- ²⁴⁴ NRW. 2016. Bathing Water Data Explorer [online]. Bathing Water Quality. Open data from Natural Resources Wales. Available from: <http://environment.data.gov.uk/wales/bathing-waters/profiles/>. [Accessed 22nd August 2016].
- ²⁴⁵ UK NEA. 2011. *The UK National Ecosystem Assessment - Technical Report. Chapter 20: Status and changes in ecosystems and their services to society: Wales*. Cambridge: UNEP-WCMC.
- ²⁴⁶ Brazier P, Birch K, Brunstrom A, Bunker A, Jones M, Lough N, Salmon L and Wyn G. 2007. When the tide goes out. The biodiversity and conservation of the shores of Wales - results from a 10 year intertidal survey of Wales. Bangor: Countryside Council for Wales.
- ²⁴⁷ Cunningham PN, Hawkins SJ, Jones HD & Burrows MT, 1984. The geographical distribution of *Sabellaria alveolata* (L.) in England, Wales and Scotland, with investigations into the community structure of and the effects of trampling on *Sabellaria alveolata* colonies. Nature Conservancy Council, Peterborough, Contract Report no. HF3/11/22., Manchester: University of Manchester, Department of Zoology. NCC report No. HF3/11/22.
- ²⁴⁸ Bush LE, Balestrini SJ, Robins PE, Davies AJ. 2015. NRW Evidence Report No 049 - The reproduction and connectivity of *Sabellaria alveolata* reefs in Wales – MAR4REF Bangor University. NRW Evidence Report No: 49. 119pp. Bangor: Bangor University. Available from: <http://ukbars.defra.gov.uk/project/show/37531> [Accessed 15 July 2016]
- ²⁴⁹ Boyes S, Hemingway K and Allen JH. 2008. *Intertidal Monitoring of Zostera marina in Pen Llŷn a'r Sarnau SAC in 2004/2005*. CCW Marine Monitoring Report No. 28. Bangor: Countryside Council for Wales
- ²⁵⁰ Boyes, S, Brazier, DP, Burlinson, F, Mazik, K, Mitchell, E and Proctor, N (2009) Intertidal monitoring of *Zostera noltii* in the Menai Strait & Conwy Bay SAC in 2004/05. CCW Marine Monitoring report No 31. Bangor: Countryside Council for Wales.
- ²⁵¹ Howson C. 2009. Intertidal SAC monitoring, Carmarthen Bay and Estuaries SAC (September 2009). CCW Marine Monitoring Report No: 79. Bangor: Countryside Council for Wales
- ²⁵² Jolley E, Guthrie G, Clipsham V, Dawks S, Elmore S, Lavender J. 2012. *Marine Habitat Vulnerability Assessment of the Welsh Coast*. CCW Science Report No: 1010, 153pp, Bangor: Countryside Council for Wales .
- ²⁵³ Elliot P. 2006. *Impacts of Climate Change on Non-Native Species in Marine Climate*. Change Impacts Annual Report Card. (Eds. Buckley, PJ, Dye, SR and Baxter, JM). Online Summary Reports. Lowestoft: MCCIP . Available from: <http://www.mccip.org.uk/media/1391/non-natives-report-from-cambridge-university.pdf> [Accessed 15 July 2016]
- ²⁵⁴ Reid PC, Cook EJ, Edwards M, McQuatters-Gollop A, Minchin D and McCollin T. 2009. *Marine non-native species in Marine Climate Change Ecosystem Linkages Report Card 2009*. (Eds. Baxter JM, Buckley PJ and Frost MT), Online science reviews. Lowestoft: MCCIP. Available from: http://www.mccip.org.uk/media/1626/mccip-elr2009-reid_etal.pdf. [Accessed 15 July 2016]
- ²⁵⁵ Hulme PE. 2015. *Biodiversity Climate change impacts report card Technical paper 9. Non-native Species*. Swindon: Natural Environment Research Council. Available from: <http://www.nerc.ac.uk/research/partnerships/lwec/products/report-cards/biodiversity/papers/source09/>. [Accessed 15 July 2016]
- ²⁵⁶ Defra. 2014. Charting Progress 2: The State of the UK's Seas [online]. Archived content, Department for Environment, Food and Rural Affairs (DEFRA). Available from: <http://webarchive.nationalarchives.gov.uk/20141203181034/http://chartingprogress.defra.gov.uk/>. [Accessed 17th August 2016].
- ²⁵⁷ NRW. 2016. Marine broadscale habitats GIS layers. Natural Resources Wales internal dataset.
- ²⁵⁸ Smale DA, Burrows MT, Moore P, O'Connor N & Hawkins SJ. 2013. Threats and knowledge gaps for ecosystem services provided by kelp forests: a northeast Atlantic perspective. *Ecology and Evolution*, 3, 4016–4038. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3810891/> [Accessed 15 July 2016]
- ²⁵⁹ Bertelli, CM & Unsworth, RKF. 2014. Protecting the hand that feeds us: Seagrass (*Zostera marina*) serves as commercial juvenile fish habitat. *Marine Pollution Bulletin*, 83(2), 425-429.
- ²⁶⁰ Peters, JR, McCloskey, RM, Hinder, SL & Unsworth, RKF. 2015. Motile fauna of sub-tidal *Zostera marina* meadows in England and Wales. *Marine Biodiversity*, 45(4), 647-654. Available At <http://link.springer.com/article/10.1007/s12526-014-0264-x#/page-1> [Accessed 15 July 2016]
- ²⁶¹ Welsh Government, Statistics for Wales. 2012. *Biodiversity conservation - Status of priority habitats and species (HI)* [online]. Available from: <https://statswales.wales.gov.uk/Catalogue/Sustainable-Development/Sustainable-Development-Indicators/TrendsInBiodiversityActionPlan-by-PrioritySpeciesAndHabitats>. [Accessed 15 July 2016].
- ²⁶² Lock K, Burton M, Newman P & Jones J. 2015. Skomer Marine Conservation Zone Project Status Report 2014. NRW Evidence Report No. 66. Available from:

https://naturalresources.wales/media/675105/skomer-mcz-project-status-report-2014_15-sm.pdf. [Accessed 15 July 2016].

²⁶³ NRW. 2016. Welsh marine habitats GIS layers. Internal data source.

Part C

3.14 Landscape information in Wales

²⁶⁴ NRW. 2016. *LANDMAP – the Welsh Landscape baseline* [online]. Aberystwyth: Natural Resources Wales <http://naturalresources.wales/planning-and-development/landmap/?lang=en> [Accessed 19th August 2016]

²⁶⁵ LUC. 2015. *National Seascape Assessment for Wales* [online]. NRW Evidence Report 80. Bangor: Natural Resources Wales. Available from: <http://naturalresources.wales/our-evidence-and-reports/marine-character-areas/?lang=en> [Accessed 19th August 2016]

²⁶⁶ Briggs JHW, White S. 2009. *Welsh seascapes and their sensitivity to offshore developments*. CCW Policy Research Report 08/5. Bangor: Countryside Council for Wales.

²⁶⁷ White S. 2013. *Pembrokeshire Seascape Character Assessment. Supplementary Planning Guidance to the Local Development Plan for the Pembrokeshire Coast National Park*. Pembrokeshire Coast National Park Authority. [online]. Available from: <http://www.pembrokeshirecoast.org.uk/?PID=614> [Accessed 19th August 2016].

²⁶⁸ Snowdonia National Park Authority. 2014. *Supplementary Planning Guidance: Landscapes and Seascapes of Eryri*. [online]. Available from: <http://www.eryri-npa.gov.uk/planning/planning-policy/Supp-Planning-Guidance> [Accessed 19th August 2016].

²⁶⁹ Fyfe F, Countryside, Bangor University (SEACAMS). 2013. *Anglesey Seascape Character Assessment*. Isle of Anglesey Council. [online]. Available from: <http://www.anglesey.gov.uk/planning-and-waste/countryside/areas-of-outstanding-natural-beauty-aonbs/anglesey-aonb-management-plan/anglesey-seascape-character-assessment/126881.article> [Accessed 19th August 2016]

²⁷⁰ Thomas B. 2015. *LANDMAP Change Detection: Visual & Sensory Aspect Monitoring Reports*. Aberystwyth: Natural Resources Wales.

²⁷¹ White S. 2015. *LANDMAP Visual & Sensory Data Monitoring Tables*. Aberystwyth: Natural Resources Wales.

²⁷² Turton N, Naumann EK, Kelly M, Medcalf K. 2015. *LANDMAP Change Evaluation*. Aberystwyth: Natural Resources Wales.

²⁷³ 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]

²⁷⁴ Historic Environment Group. 2013: *Climate change and the historic environment of Wales: A summary of potential impacts*

²⁷⁵ NRW. 2014. *The Review of Designated Landscapes in Wales – The Written Evidence of Natural Resources Wales* [online]. Cardiff: Natural resources Wales. Available from: <https://naturalresources.wales/media/1776/the-review-of-designated-landscapes-in-wales.pdf?lang=en> [Accessed 19th August 2016]

²⁷⁶ Land Use Consultants. 2013. *LANDMAP Statistics Visual and Sensory Aspect*. Aberystwyth: Countryside Council for Wales.

²⁷⁷ Land Use Consultants. 2009. *Wales Tranquil Areas Map*. Bangor: Countryside Council for Wales.