Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Report-28B: Welsh Mountain, Moor and Heath (MMH) Condition Account

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Approved by James Skates
Bridget Emmett

Abbreviations Used in this Report

ANC	Acid Neutralising Capacity
DOC	Dissolved Organic Carbon
DOM	Dissolved Organic Matter
ECT	Ecosystem Condition Typology
eftec	Economics for the Environment Consultancy
ERAMMP	Environment and Rural Affairs Monitoring & Modelling Programme
MMH	Mountain, Moor and Heath
NRW	Natural Resources Wales
NUTS	Nomenclature of Territorial Units for Statistics
ONS	Office for National Statistics
SAC	Special Area of Conservation
SEEA	System of Environmental Economic Accounting
SoNaRR	State of Natural Resources Report
SSSI	Site of Special Scientific Interest
UKAWMN	UK Acid Waters Monitoring Network
UKCEH	UK Centre for Ecology & Hydrology
UKNEA	UK National Ecosystem Assessment
UWMN	Uplands Water Monitoring Network

Abbreviations and some of the technical terms used in this report are expanded on in the programme glossaries: https://erammp.wales/en/glossary (English) and https://erammp.cymru/geirfa (Welsh)

Contents

1 Policy Summary

1. Natural Capital Accounts for woodland, farmland and freshwater broad habitats were produced by ERAMMP in collaboration with the Office of National Statistics in 2017. These accounts estimated the combined partial asset value for these habitats to be £30.5 billion for 2014. A new monetary account has now been created for Mountain, Moor and Heath (MMH) habitat. This account estimates the MMH asset value to be £3 billion for 2018.

2. It is noted in all the reports produced that Office for National Statistics produced Natural Capital accounts remain experimental and future publications will be subject to methodological improvements. Also, it should be noted that all accounts only represent partial or a minimum valuation as methods are not available for all services.

3. This partial asset value for MMH is a relatively small asset figure – but it underlines how cheaply the products of the environment are rather than how important they are. The price is an important signal of levels of trade. If we are to decouple economic production and growth from environmental impact then the raw price ought to remain low with most value added upstream in the supply chain. If we were to look at the final consumer value of products from Welsh upland agriculture, it would be significantly higher.

4. For all of these accounts, the condition of the various broad habitats are not included explicitly as these are not typically represented in the reporting of many natural capital accounts by the Office of National Statistics. This means the rich set of condition data from the GMEP and ERAMMP National Field Survey and many other sources have not been exploited. These condition data are particularly important for assessing the underpinning resilience of ecosystems to sudden shocks. In addition, as standalone indicators these condition metrics help us to track the outcomes of policy (and other) interventions in improving the health of our ecosystems.

5. To test out the value of assessing condition data, this report presents a condition account for the Mountain, Moor and Heath (MMH) habitat. This is an important habitat for many cultural, provisioning and regulating services in Wales. The methodology used was informed by, but deviated to some extent, from the internationally accepted standard to increase the relevance for Welsh policy needs.

6. A first step was to agree which data would provide efficient, robust and repeatable information representative of the habitat condition. A participatory approach was taken to achieve this involving a range of actors to select the indicators which had greatest consensus as being appropriate and understandable to a broad audience. It was agreed, the relevance of these indicators to the delivery of a range of services and benefits should be the priority. A decision relating to a reference point was also needed i.e. how does current condition compare to either a theoretical 'intact' ecosystem, a reference year, or a policy target? A pragmatic approach was taken and the final selected reference point was based on the year(s) from which most historic data is available.

7. In summary, the trends reported for the final selected list of indicators in MMH since the 1990s (2010s only for some indicators) reported are:
    a) Water quality – a general improved in quality has been observed since the 1990s
    b) Soil quality - no change has been observed in 2 selected soil indicators since the 1990s

c) Moorland Bird index – a decline has been observed which has stabilised since 2009
d) Habitat Connectivity - status but no trend data is available
e) Protected sites – most are in unfavourable condition with little improvement observed over time
f) Wildfires – increases have been observed since the 2010s
g) Access – no trend data are available
h) Visitor satisfaction – a high satisfaction rating is reported but no trend data is available

8. The monetary accounts for MMH suggest the value has been relatively stable over the time period for which we have enough data (2009-2018). This would seem to concur with these condition accounts where overall there is no ongoing decline but there is also only limited improvement observed.

9. In conclusion, there is a complex mix of drivers and policies interacting on the selected indicators. This is further confounded by different sensitivity of indicators to these drivers and variability in historic data sources. However there are some clear policy messages with respect to policy outcomes:
   a) major policy success (e.g. MMH water quality recovering from acidification)
   b) partial policy success halting decline (e.g. Moorland Bird Index; stability in soil indicators)
   c) outstanding policy needs (e.g. no improvement in status of protected sites; increase in wildfire frequency).

10. Availability of new sources of data will allow improvement going forward in any future condition accounts. For example not all sources of GMEP/ERAMMP data were explored due to lack of availability of ONS staff resources due to their heavy engagement in the covid response.

One recommendation is to increase engagement with the ONS team to ensure more effective use of Welsh data streams going forward even in the creation of UK accounts.

A priority going forward is to develop methods to better embed these condition indicators in the monetary accounts.

2 Understanding Condition Accounts

The condition of an ecosystem asset, in terms of its characteristics, reflects its overall quality in a set of key indicators and assists in determining the quantity and quality of services the asset provides. The System of Environmental Economic Accounting[1] (SEEA) advocates the condition of ecosystems is an important part of natural capital accounts as it shows changes over time and the main areas of improvement and degradation.

The condition account should be the one most familiar to policy makers since it is made up of a range of indicators of ecological health. Many policies or even legal obligations will be linked to a set of quantitative indicators which can be measured over time to judge the success or otherwise of government interventions.

There are many metrics that could be developed to indicate the condition of Welsh Mountain, Moor and Heath (MMH). However, the goal is to choose a small number of robust and repeatable metrics that are representative of the habitat condition. The process of selecting the metrics is discussed below, with reference to the most recent SEEA guidance. A condition workshop was carried out, involving ONS, UKCEH, Welsh Government, NRW and eftec to decide on the condition metrics for Welsh MMH.

2.1 Relating Ecosystem services to Condition

The most recent SEEA guidance on condition accounts[2] discusses the impact that the condition of habitats will have on ecosystem service provision, but it is not the stated purpose of the accounts. The current SEEA position presents a condition account as a separate entity to the monetary accounts. The purpose is to provide a very separate and more traditional view of the underlying health of ecosystem assets.

Functionally – long term – the Natural Capital Accounts will have to incorporate all these ideas. The long-term asset value is derived from the future expected stream of benefits. For example, if the condition of pollinator habitat is in decline, we need to be able to project the impact on pollinators and consequent losses in food productivity.

To meet SEEA guidelines we do not need to provide a holistic set of condition metrics related to all ecosystem services. However, it is also worth noting that countries already have other systems in place for looking at wider ecological health, such as SoNaRR in Wales, and that greater value may be added by having a condition account more oriented towards the outcomes for goods and services.

The ecosystem services calculated for Welsh MMH, that are included in the first part of this report are air pollution removal by vegetation, carbon sequestration, wind power, recreation and agricultural biomass. It was decided by the workshop that for the Welsh MMH condition account, indicators were chosen based on their alignment with the ecosystem services, prioritising policy relevance and slightly diverging from SEEA guidance.

[1] www.seea.un.org/content/natural-capital-and-ecosystem-services-faq
[2] www.seea.un.org/sites/seea.un.org/files/documents/EEA/2_seea_eea_rev._ch5_gc_mar2020_final.pdf

2.2 Habitat condition and ecosystem service example: Peatlands Wales MMH

Peatland carbon flux provides a stark example of the importance of condition to the production of ecosystem services. The condition of peatlands is strongly related to land use and the carbon sequestration ecosystem service. Only 38% of peatlands in Welsh MMH is in a near natural condition. This latest estimation on peatlands condition categories is included in the Implementation of an Emissions Inventory for UK Peatlands project report (Table 2.1).

Only peatlands in a near-natural condition are a sink of carbon and those that have been modified in the UK are emitting greenhouse gases. For the whole of the UK peatlands, it is estimated 640,000 hectares, 22%, are in a near-natural condition with an estimated carbon sink of 1,800 kt CO2e yr-1. Peatlands that are in a near-natural condition in MMH in Wales represents 3.7% of the UK near natural total.

Table 2.1: Peat area (hectares) by condition category for Wales

Wales peatland condition	**hectares**	**%**
Drained Eroded Modified Bog	19	0
Undrained Eroded Modified Bog	206	0
Drained Heather Dominated Modified Bog	1,588	3
Undrained Heather Dominated Modified Bog	6,237	10
Drained Grass Dominated Modified Bog	1,588	3
Undrained Grass Dominated Modified Bog	29,000	47
Near Natural Bog	23,548	38
Total	**62,186**	**100**

Source: UK Centre for Ecology and Hydrology

The habitat data used in Table 2.1 was gathered in 1990 from the Phase 1 Habitat Survey. Without a long-term peatland survey, we cannot replicate this work as a condition metric, but it underlines the impact of condition on ecosystem service provision.

2.3 Types of condition metrics

Table 2.2 is the condition typology from the SEEA guidance document. The taxonomy of metrics identified by SEEA can be helpful when thinking about what kinds of metric to include. Condition metrics are broken up into 3 groups and 6 classes. The groups are relatively self-explanatory with: Abiotic and biotic considering the non-living and living elements of the natural world and the final group covering wider landscape measures.

In addition to the three groups are what SEEA considers, “Ancillary” metrics. These are indicators that are relevant but not considered to directly measure ecosystem health. It is data that can be used as a proxy for missing metrics. SEEA classes data on protected sites and pressure indicators, such as wildfires, as ancillary data. Another group would include man-made elements of the natural world, such as accessibility e.g., paths. Paths are clearly not a measure of ecological health, but they are a significant driver of the recreational value of a landscape. Excluding them makes it clear that the purpose of the condition account from SEEAs perspective is not to support our understanding of the monetary account.

Understanding the interactions between things like path networks and ecosystem services enables us to better interpret changes in the monetary accounts and gain policy insight. Access is amenable to policy intervention and a key driver of a key ecosystem service and so can aid the policy relevance of the accounts.

Table 2.2 The SEEA Ecosystem Condition Typology (ECT)

	ECT groups	ECT classes
Ecosystem condition	Abiotic ecosystem characteristics	1. Physical state characteristics (including soil structure, water availability)
		2. Chemical state characteristics (including soil nutrient levels, water quality, air pollutant concentrations)
	Biotic ecosystem characteristics	3. Compositional state characteristics (including species-based indicators)
		4. Structural state characteristics (including vegetation, biomass, food chains)
		5. Functional state characteristics (including ecosystem processes, disturbance regimes)
	Landscape level characteristics	6. Landscape and seascape characteristics (including landscape diversity, connectivity, fragmentation, embedded semi-natural elements in farmland)

Source: United Nations System of Environmental Economic Accounting (SEEA)

2.4 Reference point

The SEEA guidance spends a considerable amount of time considering reference points[3]. The reference condition represents the condition of an ecosystem to maintain ecological integrity. In many cases it is impossible to include a reference point, however, they are incredibly useful in providing context for changes in condition metrics.

The types of reference point include:

- Ecologically Intact
- Historical
- Globally Agreed
- Target (not advised by SEEA)
- Ecological Boundary (not suggested by SEEA)

In a heavily managed nation like Wales an “ecologically intact” reference point is conceptually difficult, as well as quantitatively. In some cases there may be globally agreed

[3] www.seea.un.org/sites/seea.un.org/files/documents/EEA/ec_discussionpaper21_purpose_6_9_2019.pdf

reference points that are not targets. Most commonly a relatively arbitrary moment in time would need to be chosen and this can happen de-facto as a condition account begins.

Interestingly – since the SEEA goal is to create an account which describes ecological health rather than a specific policy intervention they state that “targets” are not appropriate. Similar to other issues with the SEEA accounts a policy maker may prefer to use a target as the reference point and the choice should largely be driven by the purpose of the accounts for the commissioner.

For Wales, perhaps practically this should start where we have a robust baseline in a specific year. Whilst data goes back to 1970s, perhaps the 1990s is effectively where repeatable data or sufficient quantity is available could be one option to consider.

As both historical and target data are useful, the decision from the workshop was that two condition tables could be produced – one with long term variables using a common reference year and another with varying reference years that includes all the data.

2.5 Selection Criteria

Finally, criteria are useful for reducing the number of metrics chosen. Table 2.3 is again taken directly from the SEEA guidance. It is a simple and intuitive list of the questions we might ask ourselves when choosing between candidates. Some are clear – if a metric is not repeatable (and fails on “Temporal Reference”) then it is of no use to a long-term condition account. Others such as “Quantitativeness” may by harder to interpret since an ecological condition assessment can be relatively subjective but may be the most appropriate measure.

Table 2.3: SEEA selection criteria for condition metrics

Criterion	Short description
Individual criteria for characteristics, variables and indicators	
Relevance	ecosystem characteristics and their metrics should be relevant in terms of the purpose of measuring ecosystem condition
State orientation	ecosystem characteristics and their metrics should describe the state of the studied ecosystem
Framework conformity	ecosystem characteristics and their metrics should be differentiated from other components of the SEEA ecosystem accounting framework
Individual criteria for variables and indicators	
Spatial reference	ecosystem condition metrics should be linked to a specific location (mapped) or spatially referenced
Temporal reference	ecosystem condition metrics should be linked to a specific time period and be sensitive to change
Feasibility	ecosystem condition metrics should (potentially) be covered by data sources over multiple EAs of the same ET
Quantitativeness	ecosystem condition metrics should be measured at a well-defined quantitative scale that allows comparisons in space and time
Reliability	primary (measured) data should be preferred over derived data which, in turn, should be preferred over modelled data.
Normativity	ecosystem condition indicators should have a strong inherent 'normative' interpretation ('good' vs 'bad', this makes it possible to turn them into indicators with the use of appropriate reference levels)
Simplicity	ecosystem condition metrics should be as simple as possible
Ensemble criteria (for the whole set of variables and indicators)	
Comprehensiveness	all relevant characteristics of the ecosystem should be covered
Parsimony (or complementarity)	the final set of ecosystem condition metrics should be free of redundant (correlated) variables

Source: United Nations System of Environmental Economic Accounting (SEEA)

With respect to accounts for Wales, spatial reference is critical as is use of representative national data which is likely to repeated going forward. Considerations need to be made as to whether expert judgement metrics is suitable for inclusion e.g., site condition assessment by managers? To reduce the number of indicators, some work to remove co-correlated indicators is needed but ensuring this does not remove indicators which may diverge in time due to ongoing climate and global change. Ideally, the selection of metrics which are efficient in indicating a range of services are a priority both to collate and ensure ongoing data e.g., presence of bog forming plants – relevant for carbon sequestration and biodiversity.

It was decided that the most important selection criteria are spatial reference, as indicators need to be representative of Welsh MMH, specifically, and temporal reference so that the quality of habitats can be measured overtime.

3 Selecting Condition Metrics for Welsh MMH

The metrics chosen must be responsive and representative of the Welsh MMH habitat. The definitions of MMH for this report can be found in table 3.1 below:

Table 3.1: Definition of Mountain, Moor and Heath (MMH)

SoNaRR MMH definition	Welsh MMH definition
Bog	Bog
Bracken	Bracken
Dwarf Shrub Heath	Dwarf Shrub Heath
Inland Rock	Inland Rock
Montane	Montane
Fen, Marsh and Swamp above NRW upland boundary	Fen, Marsh and Swamp above NRW upland boundary
-	Acid Grassland above NRW upland boundary

Natural Resources Wales' (NRW) State of Natural Resources Report (SoNaRR) currently defines MMH[4] in Wales as "Mountainous habitats are those above the climatic tree-line. Moorlands and heaths are predominantly open, unenclosed and extensive landscapes. This broad habitat includes upland and lowland heathlands (including dwarf shrub heath), moorlands, blanket bog, montane habitats, inland rock habitats and stands of bracken in the lowlands". Currently there is no Fen Marsh and Swamp above the moorland line in Wales. For the purpose of the Welsh MMH report the inclusion of the habitat acid grassland within the NRW upland boundary is also considered, however, acid grassland is not strictly included by SoNaRR. Acid grassland is one of Wales's most extensive upland habitat.

Following the consensus of workshop attendees, the decision was made to include acid grassland above the moorland line within the definition of MMH for ERAMMP Report 28.

3.1 Condition indicators

A full list of the proposed condition indicators for Welsh MMH can be found in Section 8 (Annex A). The condition metrics that were able to be collected for this report are found in this section.

[4] www.cdn.cyfoethnturiol.cymru/media/692847/sonarr2020-glossary.pdf

4 MMH Condition Account Metrics

4.1 Uplands Water Quality

The UK Acid Waters Monitoring Network[5] was set up in 1988 to investigate the chemical and biological responses of acidified streams and lakes to changes in air quality and “acid rain”. It later became the UK Uplands Water Monitoring Network (UWMN) (in 2013) and now has a wider remit to also investigate impacts of climate change and land management on these systems. Amongst a wide range of variables, the UWMN measures the acidity and acid neutralising capacity (ANC) of these waters, together with dissolved organic carbon (DOC), nitrate and non-marine sulphate. Year-on-year changes in these metrics across a wide range of sites provide a strong indication of how the water quality our upland streams and lakes has been evolving over recent decades. Currently the UWMN samples around 26 sites in the UK regularly for water quality assessment, with 4 sites being in Wales. Lakes sites at Llyn Llagi and Llyn Cwm Mynach and stream sites at Afon Hafren and Afon Gwy (monitoring started 1991). In addition GMEP/ERAMMP also has data for headwater streams and ponds some of which sit in MMH which can be better exploited going forward.

4.1.1 Non-marine sulphate

Non-marine sulphate in upland surface waters represents the chief acidifying anion (a negatively charged ion) and is mostly derived from the burning of fossil fuels by power stations and heavy industry. Upland water condition has improved at all four sites in Wales from the reduction in concentrations of non-marine sulphate (Table 4.1).

Table 4.1: Non-marine sulphate, microequivalent per litre, at upland monitoring sites in Wales

Annual mean	**Llyn Llagi**		**Llyn Cwm Mynach**		**Afon Hafren**		**Afon Gwy**	
Year	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation
2016-17	10.79	3.15	24.73	5.86	36.21	4.12	26.82	4.95
2015-16	7.35	6.43	17.60	3.31	31.69	5.66	23.68	6.67
2014-15	14.54	2.17	18.05	2.37	35.27	4.16	29.08	4.84
2013-14	9.92	11.79	22.96	15.24	35.39	9.92	33.00	11.28
2012-13	13.98	4.50	31.80	6.68	40.16	4.75	32.89	6.96
2011-12	15.36	7.78	28.88	5.76	38.95	7.89	28.69	8.61
2010-11	17.56	4.46	47.33	10.42	44.18	7.20	38.44	5.42
2009-10	14.31	5.63	30.96	11.76	40.97	10.24	34.91	9.81
2008-09	18.56	4.52	37.09	6.70	44.70	5.28	36.14	10.00
2007-08	20.87	6.43	32.79	8.61	40.98	8.53	36.01	6.40
5-year mean								
1991-95							48.91	
1988-92	39.91		52.91		59.79			

Source: UK Centre for Ecology and Hydrology

[5] www.uwmn.defra.gov.uk/about/history.php

4.1.2 pH

pH is a measure of the acidity or alkalinity of water. It is measured on a scale of pH units between 0 and 14, with low numbers being acidic, seven being neutral and higher values being classed as alkaline.

Table 4.2 shows acidity has gradually declined in response to a reduction in acid anions like sulphate. The reduction of acidity is considered to be making these waters more favourable to a range of aquatic organisms, including algae, higher plants, macroinvertebrates and fish.

Table 4.2: pH values at upland monitoring sites in Wales

Annual mean	**Llyn Llagi**		**Llyn Cwm Mynach**		**Afon Hafren**		**Afon Gwy**	
Year	Annual mean pH	Annual standard deviation	Annual mean pH	Annual standard deviation	Annual mean pH	Annual standard deviation	Annual mean pH	Annual standard deviation
2016-17	5.69	0.17	5.65	0.51	5.70	0.35	5.93	0.28
2015-16	5.52	0.43	5.43	0.47	5.45	0.71	5.72	0.55
2014-15	5.97	0.26	5.59	0.40	5.81	0.57	5.99	0.50
2013-14	5.44	0.23	5.10	0.69	5.55	0.84	5.67	0.79
2012-13	5.94	0.12	5.51	0.52	5.74	0.41	6.04	0.30
2011-12	5.81	0.20	5.34	0.51	5.58	0.66	5.79	0.65
2010-11	5.83	0.24	5.77	0.24	5.92	0.44	6.10	0.32
2009-10	5.64	0.29	5.25	0.53	5.37	0.52	5.64	0.56
2008-09	5.77	0.21	5.64	0.35	5.37	0.63	5.73	0.42
2007-08	5.52	0.33	5.19	0.57	5.58	0.65	5.69	0.71
5-year mean								
1991-95							5.51	
1998-92	5.23		5.35		5.29			

Source: UK Centre for Ecology and Hydrology

4.1.3 Acid Neutralising Capacity

Acid neutralising capacity (ANC) is a measure of the capacity of water to resist changes in pH levels. Catchments whose drainage waters have higher levels of ANC have a greater ability to neutralise acid deposition[6]. An increase in ANC is favourable for water quality because this represents an increased ability of a system to neutralise acid inputs.

Table 4.3 shows in Wales for all sites there is an increase in the ability of the system to neutralise acid inputs.

[6] www.aquaticrestorationpartnership.org.uk/upland-lakes/

Table 4.3: Acid neutralising capacity at upland monitoring sites in Wales

Annual mean	Llyn Llagi		Llyn Cwm Mynach		Afon Hafren		Afon Gwy	
Year	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation
2015-16	24.12	18.03	14.81	19.25	17.53	27.99	24.15	25.35
2014-15	41.96	19.46	28.20	15.34	31.97	24.35	31.50	19.57
2013-14	18.06	17.19	16.45	39.40	10.01	39.41	15.93	31.66
2012-13	40.95	16.18	24.30	10.54	25.78	13.90	33.34	14.60
2011-12	25.73	9.75	22.19	19.52	24.02	22.63	29.22	22.52
2010-11	28.32	16.40	38.43	20.00	25.46	18.87	35.25	26.11
2009-10	28.46	10.86	12.89	14.75	16.51	14.58	29.58	24.56
2008-09	23.23	9.10	11.80	13.95	16.62	19.18	27.96	8.07
2007-08	33.68		37.90		5.53	25.35	25.18	29.48
5-year mean								
1991-95							14.13	
1998-92	5.71		7.68		-2.40			

Source: UK Centre for Ecology and Hydrology

4.1.4 Dissolved organic carbon

Dissolved organic carbon (DOC) is derived largely from the degradation of plant and soil organic material. It forms a substantial part of dissolved organic matter (DOM) that often causes a brown staining to upland waters. Concentrations of DOC tend to be particularly high in waters draining peatlands. A large proportion of the UK's drinking water comes from the uplands and the water industry must remove most of the DOM at an early stage in the treatment process in order to avoid the creation of potentially toxic disinfection by products. Water that is sourced from degraded peatland has dissolved organic carbon, representing a large cost[7] to water companies to remove it.

As Table 4.4 shows, mean concentrations of Dissolved Organic Carbon (DOC) have increased at all four sites in Wales. The increase in DOC is thought be largely due to an increase in the solubility of soil organic matter as upland soils recover from the effects of acidification.

[7] www.leeds.ac.uk/news/article/4232/peatland_contributions_to_uk_water_security

Table 4.4: Dissolved Organic Carbon at upland monitoring sites in Wales

Annual mean	Llyn Llagi		Llyn Cwm Mynach		Afon Hafren		Afon Gwy	
Year	Annual mean mg/l	Annual standard deviation	Annual mean mg/l	Annual standard deviation	Annual mean mg/l	Annual standard deviation	Annual mean mg/l	Annual standard deviation
2016-17	4.59	1.24	4.33	1.96	3.33	1.01	2.83	0.81
2015-16	3.55	1.88	2.58	1.23	3.79	2.66	2.63	1.31
2014-15	3.64	1.12	4.06	3.14	3.67	2.80	2.75	1.24
2013-14	2.99	1.57	2.72	2.13	2.32	1.24	2.03	1.23
2012-13	3.77	1.97	4.54	2.97	3.62	2.11	2.79	1.30
2011-12	3.13	1.04	3.96	2.49	3.30	1.71	2.69	1.17
2010-11	3.27	1.49	1.94	0.41	2.63	1.14	2.51	1.03
2009-10	3.40	1.20	3.04	1.85	3.29	1.92	2.97	1.55
2008-09	2.91	1.55	1.79	0.44	16.62	19.18	2.85	1.21
5-year mean								
1991-95							1.98	
1988-92	2.13		2.50		1.76			

Source: UK Centre for Ecology and Hydrology

4.1.5 Nitrate

Nitrate concentrations have fluctuated with inter-annual variations (Table 4.5) but also show a long-term decline from the 5-year mean when the time series started. Nitrate concentrations tend to peak during the winter months, when nutrient demands within catchment soils are at a minimum, and analysis by the UKAWMN for data over the period 1998 to 2000 data suggested that much of the interannual variation in concentrations for the UK could be linked to variations in winter temperatures, with the highest concentrations occurring in the coldest years (Monteith et al. (2000)).

There are health and environmental reasons for concern about the level of nitrates in drinking water. However, the concentrations measured in Wales considerably lower than nitrate concentration limit (50 milligrams per litre) specified under the Drinking Water Directives of 1980 and 1998)[8].

[8] www.publications.parliament.uk/pa/cm200708/cmselect/cmenvfru/412/41205.htm

Table 4.5: Nitrate levels at upland monitoring sites in Wales

Annual mean	**Llyn Llagi**		**Llyn Cwm Mynach**		**Afon Hafren**		**Afon Gwy**	
Year	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation	Annual mean ueq/l	Annual standard deviation
2016-17	1.77	2.82	9.37	7.81	9.95	3.57	3.69	4.33
2015-16	4.82	2.69	14.00	7.83	10.82	4.88	6.05	3.93
2014-15	6.43	2.12	15.95	8.83	11.66	6.57	7.62	5.87
2013-14	4.81	1.51	16.10	8.86	10.89	6.11	7.87	7.28
2012-13					10.52	4.51	7.52	6.56
2011-12	4.46	2.58	15.71	13.77	7.67	5.02	5.99	4.92
2010-11	6.48	2.58	12.12	13.39	7.70	5.99	6.07	5.58
2009-10	6.59	4.22	13.50	10.63	9.45	4.98	8.82	5.93
2008-09	13.87	9.60	18.12	19.04	5.37	0.63	10.27	9.17
2007-08	4.05	3.50	10.37	9.12	16.01	9.91	6.22	6.45
5-year mean								
1991-95							8.65	
1998-92	10.44		9.40		20.58			

Source: UK Centre for Ecology and Hydrology

4.2 Soils

Soil is important for providing many essential ecosystem services. Monitoring trends over time of specific soil indicators provides a suitable condition indicator for MMH habitats in Wales.

The Countryside Survey collected soils data for 1978, 1998 and 2007. For the broad habitats in MMH the sample size was only meaningful for analysis of Dwarf Shrub Heath in Wales (Smart et al. (2009)). No significant change was found in pH and soil carbon between 1978 to 2007.

Again GMEP/ERAMMP soil monitoring data and other data sources will be available going forward.

4.3 Bird index

Bird populations are monitored in the UK as they are considered as a good indicator of the broad state of the wildlife. Birds occupy a range of habitats and respond to environmental pressures.

The Moorland Bird Index of Wales, shown in Figure 4.1 is an unsmoothed index calculated by the Office for National Statistics (ONS). The species included are red grouse, curlew, common gull, meadow pipit, whinchat, wheatear, raven and hen harrier.

The index between 2002 and 2018 has decreased by 31%, with the largest decrease being the whinchat (68%). The largest increase over this time has been the hen harrier (49%).

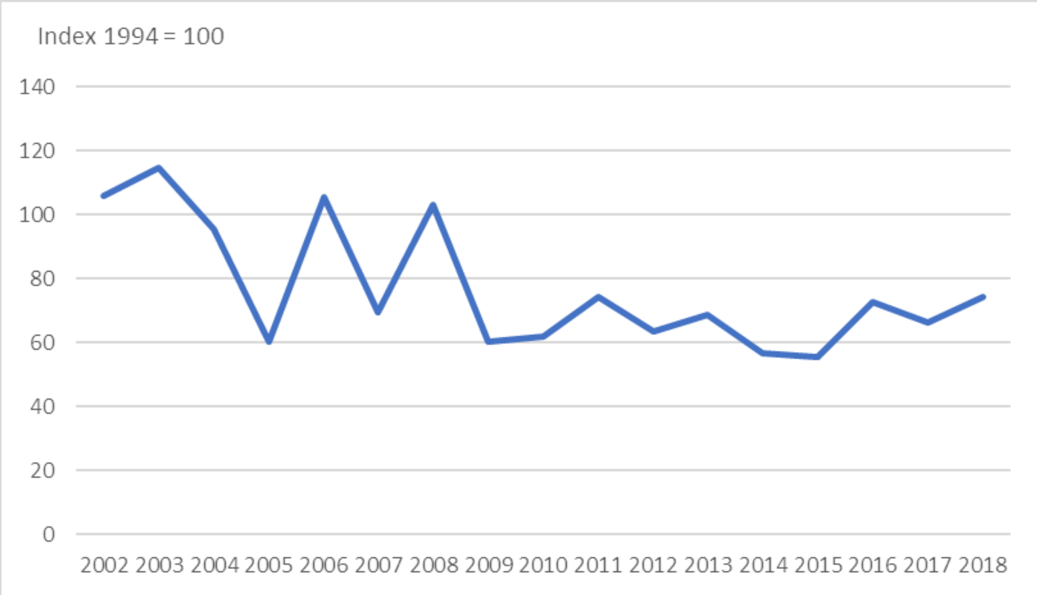

Figure 4.1: Wales Moorland bird index 2002 to 2018

Additional new bird data and critically its association with change in habitat structure and condition is available from GMEP/ERAMMP going forward.

4.4 Habitat connectivity

Initial research has been undertaken to identify habitat connectivity in Wales[9]. Natural Resources Wales have developed CuRVe[10] to investigate ecosystem resilience, an interactive map with many different layers, including connectivity ecological networks and connectivity overall layers. Chapter 3 of the 2016 State of Natural Resources Report[11] identified that the mountain, moorland and heath habitat in Wales extends over 261,824 ha and fragmentation of this habitat has resulted in poor connectivity for lowland examples of mountain, moorland and heath habitats (Natural Resources Wales, (2016))

Many more connectivity metrics are coming on line using new data streams using remote sensing e.g. from, UKCEH Landcover Map and Living Wales. These could be compared and exploited going forward.

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[9] www.biodiversitywales.org.uk/File/118/en-GB
[10] www.nrw.maps.arcgis.com/apps/MapSeries/index.html?appid=c7770d2881394c899123bae210afe370
[11] www.cdn.cyfoethnaturiol.cymru/media/684348/chapter-3-state-and-trends-final-for-publication.pdf

5 Ancillary Condition Indicators

5.1 Protected sites

There are several **formal designations, including Special Areas of Conservation (SAC) or a Site of Special Scientific Interest (SSSI). It is an area of interest to science that has rare fauna or flora present or important geological or physiological features.** In Wales the only protected sites regularly monitored are the SACs (Table 5.1). However, insufficient sites were assessed in the 2013-18 period to show if there has been any change since the 2007-12 period. The majority of sites are classed as unfavourable, with the only improvement in condition being show in inland rock habitats.

Table 5.1: Condition status SACs for Wales for EC reporting, 2001to 2006 and 2007 to 2012

SAC		**1st round 2001-06**		**2nd round 2007-12**	
Habitat	**Condition**	**ha**	**%**	**ha**	**%**
Dwarf shrub	Favourable	2331.9	10.6	2201.2	10.0
	Unfavourable recovering	2753.3	12.5	3118.8	14.1
	Unfavourable	17005.7	77.0	16751.3	75.8
	Not assessed/ no data	2.8	0.0	22.5	0.1
Inland rock	Favourable	372.6	14.2	661.0	25.2
	Unfavourable recovering	40.9	1.6	1229.5	46.8
	Unfavourable	2214.7	84.3	658.0	25.0
	Not assessed/ no data	0.0	0.0	79.7	3.0
Montane habitats	Favourable	31.4	16.7	0.0	0.0
	Unfavourable recovering	0.0	0.0	0.0	0.0
	Unfavourable	156.6	83.3	188.0	100.0
	Not assessed/ no data	0.0	0.0	0.0	0.0
Bogs	Favourable	367.5	1.4	78.6	0.3
	Unfavourable recovering	4667.6	18.0	639.3	2.5
	Unfavourable	20849.6	80.5	25059.5	96.8
	Not assessed/ no data	0.0	0.0	107.3	0.4

Source: Natural Resources Wales

The new ERAMMP biodiversity index which better expls the Local Environment Record Centre (LERC) Data for the wider countryside in addition to protected site data plus the GMEP/ERAMMP High Nature Value Farmland Index could be exploited going forward.

5.2 Pressure indicator: Wildfires

Pressure indicators are defined here as damage inflicted on the landscape by humans. Wildfires can also be considered a pressure indicator. Most wildfires are anthropogenic in origin, with and without intent. Fire can be used as a management tool to control habitat diversity and disease control (Chesterto (2009)), such as the controlled burning undertaken by the Brecon Beacons National Park[12]. Rotational burning is used on heather moorland for higher grouse breeding. However, this is controversial with opponents to burning on

[12] www.beacons-npa.gov.uk/the-authority/press-and-news/archive/2015-2/february-2015/controlled-burning-to-protect-against-wildfires/

peatland noting the impacts on the ecosystem services such as carbon storage and flood protection from burning the moorland (Clay et al. (2010)).

As can be seen in Table 5.2 there is a large increase in the number of fires on heathland and moorland in Wales during period 2018-19. In July 2018 there were almost 9 times as many grassland, woodland and crop fires compared with July 2017 and this month accounted for 46 per cent of the grassland fires in the 2018-19. In July 2018 there was around 40 per cent more hours of sunshine and around half the amount of rainfall compared with July 2017. Wildfires in Wales on heathland and moorland accounted for 4% of all primary and 13% of all secondary wildfires on grasslands, woodland and crops in the period 2019-20.

Table 5.2: Number of wildfires on heathland or moorland in Wales, 2011-12 to 2019-20

Wales		**2011-2012**	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**	**2016-2017**	**2017-2018**	**2018-2019**	**2019-2020 (p)**
Heathland or moorland	Primary fires	18	3	8	3	4	4	3	25	4
Heathland or moorland	Secondary	736	343	470	349	446	225	310	495	276

Note: (p) provisional *Source: Welsh Government*

5.3 Access

One of the primary pressures on the MMH habitat is the proximity of human habitation to it. Too much access to the habitat, by humans, disturbs wildlife and habitat fragmentation increases the vulnerability of populations of rare species (UK National Ecosystem Assessment (2011)). Conversely, recreation is a significant ecosystem service in the UK (please see UK natural capital accounts: 2020[13]) and increased accessibility of outdoor spaces functionally increases the supply of this service.

To determine levels of accessibility in MMH areas a variety of data sources, including Open Street Map (OSM), national public transport access nodes (NaPTAN) and Addressbase, were used. It is important to note that as a result of using open data, the path lengths may not accurately represent the National Park path lengths, as some paths captured may be privately owned and not public paths. The data on Wales in Tables 5.3, 5.4 and 5.5 is based on Nomenclature of Territorial Units for Statistics (NUTS)[14]. This data does not include acid grasslands.

Path length per bus stop indicates the distance visitors would need to travel along paths to find a bus stop. The shorter the length the more accessible the site is considered. Wales has on average a bus stop for every 114 metres nearby a MMH path and on average a train stop for every 12,353 metres nearby a MMH path (Table 5.3). The National Parks are less accessible with no train stops withing the three parks, no bus stops within Pembrokeshire

[13]www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2020
[14]www.ec.europa.eu/eurostat/web/nuts/background

Coastal, two bus stops in Breacon Beacons and seven within Snowdonia National Park (Table 5.3).

Within a kilometre of the MMH habitat in Wales there are 485,733 residential properties (Table 5.3). Of the three national parks Snowdonia being the largest also has the most residential properties within the park, 94, and within a kilometre of the park, 6,480 (Table 5.5).

Table 5.3: Number of Addressbase residential properties and public transport links within 1KM of mountains, moorlands and heath in Wales, 2019

Addressbase	485,733
Train Stops	91
Bus Stops	9,892
Train 1KM Path	48
Bus 1KM Path	4,046
Path length (m)	1,124,107
Path length (m)/number of bus 1KM in MMH	114
Path length (m)/number of train 1KM in MMH	12,353

Source: Open Street Map, National Public Transport Access Nodes and Addressbase

Table 5.4: Number of Addressbase properties and public transport links within mountain, moorland and heath MMH national parks, 2019

National Parks	Pembrokeshire Coast	Brecon Beacons	Snowdonia
Addressbase	19	40	94
Train stops	0	0	0
Bus stops	0	2	7
Path length (m)	40,193	128,860	257,944
Path length (m)/number of bus stops in MMH	0	64,430	36,849
Road length (m)	8,923	20,911	55,608
MMH area km^2	21	95	271
MMH area km^2/number of bus stops in MMH	0	48	39

Source: Open Street Map, National Public Transport Access Nodes and Addressbase

Table 5.5 Number of Addressbase residential properties and public transport links within 1km of mountain, moors and heaths in Wales, 2019

National Parks	Pembrokeshire Coast	Brecon Beacons	Snowdonia
Addressbase	5,258	2,731	6,480
Train Stops	1	0	8
Bus Stops	103	82	354
Train 1KM Path	0	0	4
Bus 1KM Path	46	43	194
Path length (m)	40,193	128,860	257,944
Path length (m)/number of bus stops in MMH	390	1,572	729
Path length (m)/number of bus stops within 1KM path	874	2,997	1,330
Road length (m)	8,923	20,911	55,608

Source: Open Street Map, National Public Transport Access Nodes and Addressbase

Condition of paths is also critical for their effective use and this data is now available from the GMEP and ERAMMP National Field Survey and with additional analysis can be used going forward.

5.4 Visitor satisfaction at MMH sites

The Wales Visitor Survey 2019 identified visitors to selected Natural Resources Wales (NRW) sites were, in general, highly satisfied with their visit. Eight in ten visitors gave a score of 9 or 10 in a scale of 1 to 10, where 10 was ‘very satisfied’, with the average score being 9.3. None of the visitors were dissatisfied with their visit. From a survey sample size of 918 face to face interviews followed by 485 telephone interviews. The sites managed by NRW that had visitor interviews were Newborough, Coed y Brenin, Garwnant, Ynyslas and Bwlch Nant yr Arian. The individual site mean scores for overall satisfaction for the ones located in the Welsh MMH habitat are Coed y Brenin with 9.33, Garwnant with 8.97 and Bwlch Nant yr Arian 9.48.

It was not possible to obtain a time series for this data therefore it is not possible to say whether visitor satisfaction in Welsh MMH has increased overtime, or not.

6 Conclusions

In conclusion, there is a complex mix of drivers and policies interacting on the selected indicators. This is further confounded by different sensitivity of indicators to these drivers and variability in historic data sources.

However there are some clear policy messages with respect to policy outcomes which can be reported including evidence of:

a. major policy success (e.g. MMH water quality recovering from acidification)
b. partial policy success halting decline (e.g. Moorland Bird Index; stability in soil indicators)
c. outstanding policy needs (e.g. no improvement in status of protected sites; increase in wildfire frequency).

The monetary accounts for MMH suggest the value has been relatively stable over the time period for which we have enough data (2009-2018). This would seem to concur with these condition accounts where overall there is no ongoing decline but there is also only limited improvement observed.

7 Next steps

Availability of new sources of data will allow improvement going forward in any future condition accounts. For example not all sources of GMEP/ERAMMP data were explored due to availability of staff resources in ONS due to their heavy engagement in the covid response.

One recommendation is to increase engagement with the ONS team to ensure more effective use of Welsh data streams going forward even in the creation of UK accounts.

A priority going forward is to develop methods to better embed these condition indicators in the monetary accounts.

8 Annex-A: Selection of Condition Indicators for Welsh Ecosystem Services

SERVICES	METRIC	HABITAT
Carbon Sequestration	Organic Matter	Dwarf Shrub and heather
Carbon Sequestration	Organic Matter	Bog
Carbon sequestration	Bog building plants (% cover of Sphagnum species)	Bog
Carbon Sequestration	Organic Matter	Bracken
Biodiversity	protected area condition	Inland Rock
Biodiversity	protected area condition	Dwarf Shrub and heather
Biodiversity	protected area condition	Bog
Biodiversity	protected area condition	Bracken
Biodiversity	Moorland Bird Index	Inland Rock
Biodiversity	Moorland Bird Index	Dwarf Shrub and heather
Biodiversity	Moorland Bird Index	Bog
Biodiversity	Moorland Bird Index	Bracken
Biodiversity	Soil pH	Dwarf Shrub and heather
Biodiversity	Soil pH	Bog
Biodiversity	Soil pH	Bracken
Biodiversity	Vegetation Composition	Dwarf Shrub and heather
Biodiversity	Vegetation Composition	Bog
Biodiversity	Vegetation Composition	Bracken
Biodiversity	Vegetation Composition	Acid grassland
Biodiversity	Appropriate fragmentation/diversity appropriate for HNV II open upland habitat	dwarf shrub heath
Biodiversity	Pollinators	MMH
Biodiversity	Bulk density	Dwarf Shrub and heather
Biodiversity	Bulk density	Bog
Biodiversity	Bulk density	Bracken
Water quality	Headwater Stream Macroinverts (ecological condition)	MMH
Water quality	Pond ecological quality	MMH
Water quality	River Habitat Survey	MMH
Water Quality	Freshwater Non Marine Sulphate	Bog
Water Quality	Freshwater pH	Bog
Water Quality	Freshwater acid neutralising capacity	Bog
Water Quality	Freshwater Dissolved organic Carbon	Bog
Water Quality	Freshwater Nitrates	Bog
Water Quality	Presence of fencing	MMH
Water flow regulation	Modification of headwater streams	MMH
Water Flow regulation	Natural aquifer function recharge & discharge	MMH
Water Flow regulation	Naturalness of flooding regime	MMH
Recreation	Number of Public Transport Access Points	MMH
Recreation	Path Length	MMH
Recreation	Path condition	MMH
Recreation	Domestic Properties within MMH	Dwarf Shrub and heather
Recreation	Domestic Properties within MMH	Bog
Recreation	Domestic Properties within MMH	Bracken
Recreation	Domestic Properties within MMH	Inland Rock
Recreation	Tranquillity	MMH
Cultural services	GMEP/ERAMMP Visual Quality Index (VQI)	MMH
Cultural services	Condition of SAMs and HEFs in MMH	MMH
Air Pollution Removal		
Noise Pollution Removal	missing	
Renewable Energy	missing	
Water Provisioning	missing	
Fossil Fuels	n/a	
Timber	n/a	
Food Biomass	n/a	
Minerals	n/a	

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