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WALES BIODIVERSITY PARTNERSHIP

Lake BAP Priority Areas in Wales – a Strategic Overview

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This report is a joint publication between the Wales Biodiversity Partnership Freshwater Ecosystem Group and Natural Resources Wales.

Front Cover, clockwise from top: Llyn Anafon panorama, Snowdonia; water lobelia *Lobelia dortmanna*; small red dragonfly *Ceriagrion tenellum*; water violet *Hottonia palustris*; white water-lily *Nymphaea alba*.

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Introduction

This document provides the first mapped prioritisation of biodiversity action for Welsh lakes. It is intended to complement existing documents for other habitats on the Wales Biodiversity Partnership website by helping to guide action to those areas where it is most needed, and builds on previous work (Duigan 2003), incorporating the results of more recent surveys (Burgess et al. 2006, 2009, 2013).

The focus here is generally on identifying the locations of individual lakes of particular types where we know action is needed at a fairly strategic level. In many cases there already exist more detailed action plans for individual sites, or else there are individuals on the ground who are able to articulate the issues in greater detail than is possible in a document of this nature. Instead, this document focuses on assisting funders and budget holders to target their resources at locations where the need and / or potential biodiversity gains are greatest.

Lake BAP Types

The UKBAP classification recognises five Priority Habitats under the broad Standing Open Waters and Canals habitat type. These are:

- Oligotrophic and dystrophic lakes.
- Mesotrophic lakes.
- Eutrophic standing waters.
- Ponds.
- Aquifer fed naturally fluctuating water bodies.

Of these, this document only covers the first three types. Ponds have already been addressed in detail by the Wales Important Areas for Ponds report (Nicolet et al 2007). Aquifer fed naturally fluctuating water bodies are represented by only a single site, Pant-y-Llyn turlough in Carmarthenshire, the only turlough in Britain.

The types used here do not exactly match the UK lakes typology. This is because the dataset used was originally used for Habitats Directive reporting, and there are differences between the Habitats Directive and BAP typologies. Rather than amalgamate types as in the UKBAP classification, they have been kept separate. This approach also serves to highlight the level of threat posed to some of the Habitats Directive habitat types which would not be apparent were the data to be lumped.

Species of Conservation Importance

Each of the descriptions of the lake habitat types lists species of conservation importance associated with the habitat type. In practice the link between these species and the respective habitat is often relatively weak: rare species often occur in only a small proportion of the relevant lake type and / or may use other habitats as well, such as ponds, rivers and surrounding terrestrial habitat. Habitat works at particular sites should take into account the needs of any species of conservation importance there, both in order to prevent damage and to ensure that conservation work benefits both habitat and species where possible. For further advice on the distribution and requirements of these species, we recommend that the Species Expert Group is consulted.

Invasive Non-native Species

Lakes are often very vulnerable to invasive non-native species such as zebra mussel, killer shrimp, Australian swamp stonecrop and Nuttall's water-thyme. Many freshwater habitats

are already damaged by existing pressures, creating gaps that can be exploited by fast-growing non-native species. Once established, these species are impossible to eradicate. It is very important that any works close to or in lakes – including restoration work – takes account of the risk of non-native species. Further information on invasive non-native species likely to be encountered in freshwaters camn be found on the GB Non-native Species Secretariat (NNSS) website.

Methods

Data Sources

Two data sources are the primary basis for creating the prioritization maps. These are the UK Lakes Inventory, and the results of survey and monitoring work carried out by the Countryside Council for Wales and the Environment Agency. The UK Lakes Inventory, a detailed list of every lake in the UK greater than 1 hectare in area, was created by the UK Lakes HAP Group (Hughes et al. 2003). This was subsequently refined and updated for Wales by CCW. All water bodies were verified using aerial photography to ensure that they were still present and that names were correct. Artificial water bodies considered unlikely to be of biodiversity importance were also screened out at this stage (see below). In addition, metadata columns especially on alkalinity, depth and nutrient status were updated to reflect recent survey and monitoring work. This has created a strategic dataset that can be used to support mapping and action, here termed the Wales Lakes Inventory (WALI). There are 558 water bodies listed on WALI, totalling 8142.6ha.

Lakes were assigned to BAP categories using a mixture of field data from previous surveys (Allott et al. 1994, Burgess et al. 2006, 2009, 2013; Carvalho et al. 2003; Duigan et al. 1996, 1998, 1999, 2003; Goldsmith et al. 2006, 2009, in prep; Goldsmith 2010; Monteith (ed) 1996, 1997; Shilland & Monteith 2001) and map-based methods. Where field data was available, this was always used. Initially, artificial lakes unlikely to be of biodiversity importance were identified and screened out. Examples of this type of water body included industrial lagoons; quarry lakes; constructed public water supply reservoirs; intensive artificial fishing lakes and recreational boating lakes. A lake of this type could nevertheless be included within BAP targets if there was evidence of potential biodiversity interest, in particular clear water and presence of extensive aquatic or marginal plants.

The remaining lakes were then assigned sequentially to types as follows:

1. Dystrophic lakes were identified as lakes where measured water chemistry complied with the UKTAG definition of a humic lake (i.e. with Colour > 30mgPtl^{-1}).
2. Potential dystrophic lakes were defined as lakes on deep peat as identified by the Cranfield University soils map dataset, but where no field data were available.
3. Oligotrophic lakes were identified as non-dystrophic lakes with a measured annual mean alkalinity < 200µeql^{-1}.
4. Other upland lakes (i.e. lakes with a predominantly upland catchment) were classified as probable oligotrophic lakes.
5. Mesotrophic lakes were identified as non-dystrophic lakes with a measured annual mean alkalinity 200-1000µeql^{-1}, or lakes with high cover of both isoetids and *Chara*, and broad-leaved *Potamogeton* spp. present.

6. Potential mesotrophic lakes could not be identified using map-based data, but one unsurveyed lake with records of characteristic mesotrophic plant species was also included.
7. Lakes with alkalinity >1000 μeql^{-1} and with high cover of *Chara* spp. (i.e. *Chara* present in >60% of vegetated sample points) were classified as hard water lakes.
8. Lakes on Carboniferous limestone were classified as probable hard water lakes.
9. Lakes with an alkalinity >1000 μeql^{-1} with a diverse plant community but lacking extensive *Chara* were classified as eutrophic lakes. A small number of additional lakes were classed as potential eutrophic lakes based on expert judgment.
10. All remaining records were classed as 'Unknown'.

A summary of the dataset is shown in Table 1.

Category	N° of Lakes	Area (ha)
Oligotrophic	157	1392.2
Dystrophic	15	52.4
Mesotrophic	21	618.2
Hard	11	91.1
Eutrophic	33	799.9
Unknown Type	129	811.1
Unlikely to match a BAP Category	185	4391.4
Destroyed	12	31.6

Table 1. Number and combined area of Welsh lakes in different habitat categories.

Mapping

Two extra fields have been added to the WALI spreadsheet, one indicating whether BAP action is required (Yes or No) and one indicating what type of action is needed. Where insufficient information was available to identify whether BAP action was needed, 'No' was entered on the spreadsheet. Types of action were listed as follows:

- *Protect* – lake is a feature of a designated site and is either favourable or recovering (current management should be maintained).
- *Safeguard* – the lake is not currently designated but is of national biodiversity importance and should be designated as a protected site.
- *Restore*[i] *catchment* – actions to control small-scale pollution from sources such as agriculture are needed.
- *Restore point* – actions to control one or more point source inputs are needed.
- *Restore in-lake* – in-lake restoration actions are needed.
- *Survey*[ii] – a survey is recommended to establish the biodiversity importance of the lake.
- *None*

For each primary habitat type, maps have been generated by filtering WALI against relevant criteria. Separate maps have been produced for each habitat type, showing the

[i] Restore categories refer both to designated and non-designated sites
[ii] Survey category refers to both designated and non-designated sites; however most designated sites have pre-existing survey or monitoring data.

locations of individual lakes coded according to their priority category. Colours used throughout are as follows:

- *Red triangle* ▲ – lake is a priority for action (all actions except *Protect*)
- *Blue diamond* ♦ - lake is in the 'protected' category
- *Grey circle* ● – status of the lake is unknown, or no action identified.

Oligotrophic and Dystrophic lakes

(a) Oligotrophic lakes

Habitat Summary
Oligotrophic lakes are here taken to mean low alkalinity (i.e. soft water) lakes with a significant area of hard substrate such as gravels and cobbles. These may be of any depth and size and are characterised by clear, well-oxygenated water that is low in nutrients (usually less than 10 microgrammes per litre total phosphorus). They correspond with the oligotrophic end of the EU Habitat type 'H3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea'.*

Llyn Idwal, Snowdonia. Photograph: Peter Rhind

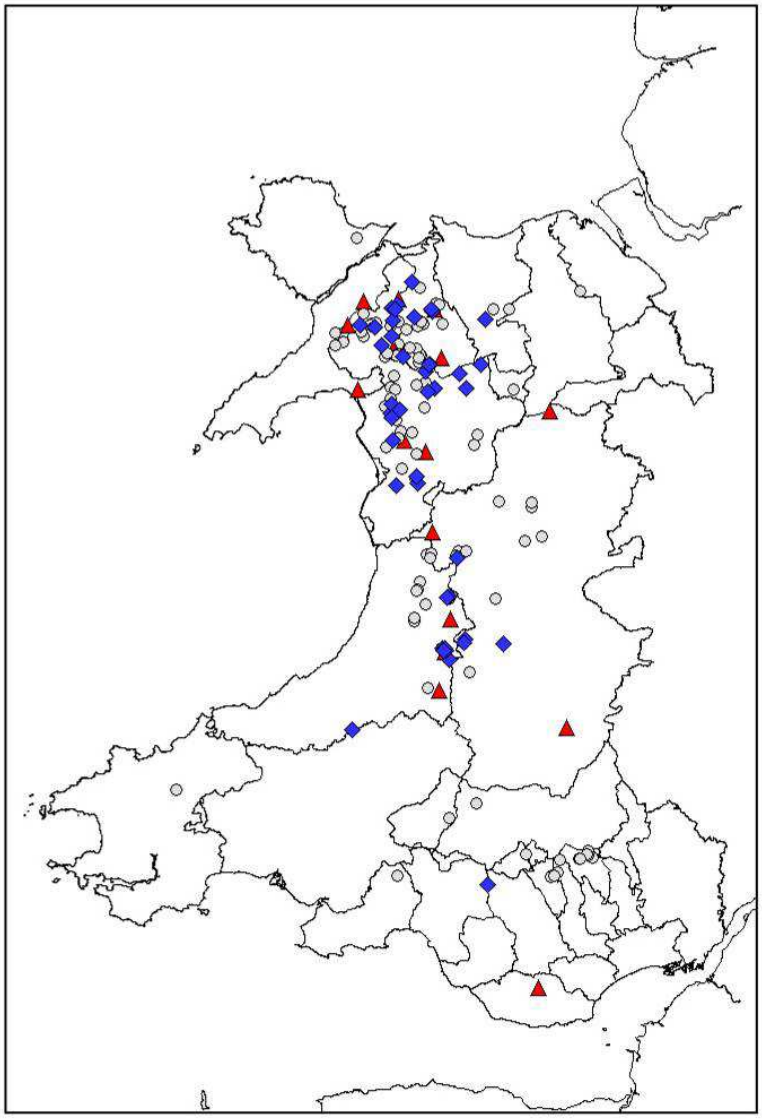
Vegetation is normally relatively species-poor, with around 6-10 species of submerged plant being typical. They are normally dominated by montane species such as quillworts *Isoetes* spp, water lobelia *Lobelia dortmanna* and shoreweed *Littorella uniflora*. Lakeside boulders can support diverse lichen and bryophyte assemblages, including the only Welsh population of tarn lecanora *Lecanora achariana*, and scarce mosses such as *Grimmia anomala*, *Grimmia muehlenbeckii* and *Hedwigia ciliata*. These lakes are normally fishless

or have natural or introduced populations of brown trout. A few examples in Snowdonia contain Arctic charr (*Salvelinus alpinus*).

Active water supply reservoirs have generally been excluded from the definition of this habitat type unless they are known to be of biodiversity importance.

Distribution and Abundance

This is a widespread habitat type in Wales and is common in the upland areas of Snowdonia and the Cambrian mountains (Map 1). Elsewhere it is relatively scarce.



Map 1. Distribution of oligotrophic lakes in Wales. Red triangle: action recommended; blue diamond; Protect; Grey circle: no data. © Crown copyright and database right 2013. Ordnance Survey 100019741.

Species of Conservation Importance supported

Arctic charr *Salvelinus alpinus*; trout *Salmo trutta*; eel *Anguilla anguilla*; floating water-plantain *Luronium natans*; slender stonewort *Nitella gracilis;* marsh clubmoss *Lycopodiella*

inundata; tarn lecanora *Lecanora achariana*; pea mussel *Pisidium conventus*; medicinal Leech *Hirudo medicinalis;* downy emerald dragonfly *Cordulia aenea.*

Arctic charr. Photograph: Tristan Hatton-Ellis

Ecological Status

Acid rain has affected many lakes of this type across Wales by causing acidification, killing many of the characteristic plants and animals that occur in these lakes. However, controls on sulphur emissions from power stations and industry have greatly reduced this type of pollution and there is now a gradual pattern of recovery across Wales.

Historic Industries, especially mining, has affected many oligotrophic lakes. The impacts of mining are either heavy metal pollution, or hydrological changes resulting from the lake being dammed for water supply. This type of lake was often also used for public water supply before the construction of larger reservoirs.

In lowland areas nutrient enrichment and invasive species may also affect some oligotrophic lakes. However, in general these pressures are less significant than for other lake types in Wales and at a strategic level the urgency for actions is markedly less than for the other lake types..

Sites Requiring Action

The breakdown of action types identified in the oligotrophic category is shown in Table 2, and the lakes requiring action with broad indication of the type of action required are listed in Table 3. Most lakes fall into the Protect category; only 7 lakes (5.1% by number / 17.8% by area) require restoration action.

Action Type	No of Lakes	Area (ha)
Protect	44	554.3
Safeguard	1	5.1
Restore catchment	5	162.1
Restore point	1	97.6[iii]
Restore in-lake	2	4.3
Survey	8	25.9
No Action Identified	97	640.5
Total	**158**	**1489.8**

Table 2. Number and area of lakes in different BAP action categories.

Lake Name	Grid Ref.	Local Authority	Lake Area	Action
Llyn Conwy*	SH780461	Eryri NP	41	Restore catchment
Llan Bwch-llyn Lake*	SO119463	Powys	9.7	Restore catchment
Llyn Bodgynydd*	SH760592	Conwy	8.1	Restore catchment
Llyn Cwm-mynach	SH679238	Eryri NP	5.7	Restore catchment
Llyn Padarn*	SH569614	Gwynedd	97.6	Restore catchment and point source
Llyn Gareg-wen	SH554374	Gwynedd	2.2	Restore in-lake
Pysgodlyn Mawr*	ST041761	Vale of Glam.	2.1	Restore in-lake
Llyn Llagi	SH649482	Eryri NP	5.1	Safeguard
Llyn Cynwch	SH737207	Eryri NP	8.6	Survey
Llyn yr Adar	SH655480	Eryri NP	5.5	Survey
Llyn Glanmerin	SN754990	Powys	3	Survey
Llyn Isaf	SN802757	Ceredigion	2.1	Survey
Llyn Lluncaws	SJ071317	Powys	1.9	Survey
Llyn Esgair	SN772565	Ceredigion	1.9	Survey
Llyn Bach	SN788668	Ceredigion	1.9	Survey
Llyn Ffynhonnau	SH524551	Eryri NP	1	Survey

Table 3. List of oligotrophic BAP lakes prioritised for action. * = lake that is a feature of a protected site (SSSI and / or SAC).

Types of Action Required

Oligotrophic lakes will generally benefit from any action that improves the quality of the surrounding terrestrial ecosystems in their catchment. These include actions such as ditch blocking and other forms of wetland restoration; reducing stock grazing along the shoreline and inflow streams; restoring inflows and outflows where these have been straightened; planting broadleafed woodland; nutrient management; diverting polluted minewater inflows where feasible.

Lakes that are naturally fishless should be retained in this way as they can support unique invertebrate communities. Liming as a means of managing acidification impacts is generally inappropriate, because many of the species that occur in these lakes are adapted to soft-water conditions and may be damaged by liming.

[iii] This lake also requires catchment actions, and its area is therefore included in the 'Restore catchment' category.

Dystrophic lakes

Habitat Summary

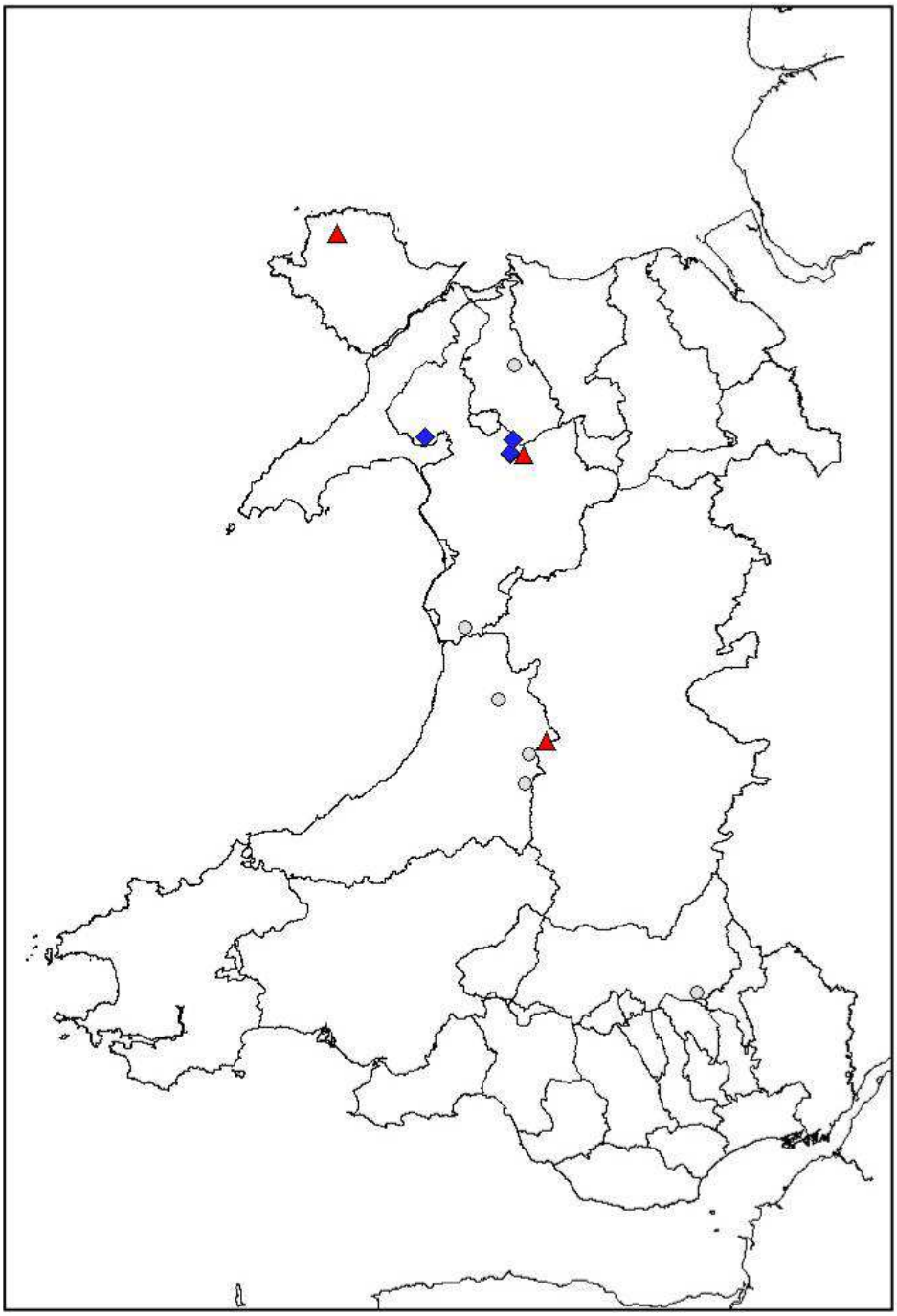
Dystrophic lakes have water that is stained brown due to the presence of high concentrations of dissolved organic carbon from peat. They occur exclusively on or close to deep peat, usually blanket bog. They are usually strongly acidic with a pH of less than 5 being common, and tend to have a naturally low biodiversity of specialist species. They are often fishless and may also lack submerged plants. Despite their natural acidity these lakes are sensitive to acidification, because the weak organic acids that cause the acidity in this environment have quite different chemical properties to the strong acids (such as sulphuric acid) that cause acidification.

In practice there is a continuum between oligotrophic and dystrophic lakes, and many oligotrophic lakes are stained brown to some extent due to the presence of boggy areas in their catchments.

Llyn Gwngu. Photograph: NRW.

Distribution and Abundance

This is a scarce habitat type in Wales, being restricted to areas of deep peat (Map 2). It occurs almost exclusively in upland areas. Less than 40ha are known across Wales, and it is unlikely that much more occurs. Acidification has resulted in a decrease in dissolved organic carbon levels. As lakes recover from acidification, it is possible that the area of dystrophic lakes in Wales may increase.



Map 2. Distribution of dystrophic lakes in Wales. Red triangle: action recommended; blue diamond; Protect; Grey circle: no data. © Crown copyright and database right 2013. Ordnance Survey 100019741.

Species of Conservation Importance supported

No BAP Priority species are recorded from this habitat. However, these habitats are closely associated with the Blanket Bog Priority Habitat.

Ecological Status
Due to the remote locations of most of these lakes, they face relatively few problems. The primary threats to this habitat are acidification and upland drainage. Most sites are recovering naturally from acidification and should be allowed to continue to do so.

Sites Requiring Action
Only three sites (22.3ha / 29%) require restoration action but further survey and safeguarding of this rare habitat is also recommended.

Action Type	N Lakes	Area
Protect	5	14.9
Safeguard	1	1.5
Restore catchment	3	22.3
Restore point	0	0
Restore in-lake	0	0
Survey	6	13.7
Total	**15**	**52.4**

Table 4. Number and area of lakes in different BAP action categories.

Lake Name	Grid Ref.	Local Authority	Area (ha)	Action
Llyn Gwngu*	SN838729	Ceredigion	3.1	Restore catchment
Llyn Fyrddon Fawr*	SN800707	Ceredigion	12.0	Restore catchment
Llyn Tryweryn*	SH788385	Eryri NP	7.2	Restore catchment
Llyn Bwch	SH359892	Ynys Môn	1.5	Safeguard

Table 5. List of dystrophic BAP lakes prioritised for action. * = lake that is a feature of a protected site (SSSI and / or SAC).

Types of Action Required
Projects to restore peatlands such as ditch blocking in the catchment are very likely to benefit this habitat. Reduction of grazing around the margins may also be beneficial. Due to the naturally acidic nature of this habitat type, liming must not be attempted as lime is toxic to many of the characteristic organisms of this habitat.

Mesotrophic Lakes

There are two subcategories of mesotrophic lakes, both of which are scarce and seriously threatened. These are typical mesotrophic lakes, and hard water lakes. The former have a fairly widespread distribution, whereas the latter are closely associated with alkaline rocks such as limestones and have a distinctive biota.

Typical Mesotrophic Lakes

Lower Talley Lake. Photo: Tristan Hatton-Ellis

Habitat Summary

Mesotrophic lakes have a moderate alkalinity[iv] and nutrient[v] levels. Their clear, well-oxygenated waters are more productive and usually warmer than oligotrophic lakes, and they occur at lower altitudes and more sheltered locations. However, nutrient levels are still low enough to restrict plant and algal growth, resulting in well-oxygenated conditions all year round. They often contain a mixture of hard and soft substrates, providing a range of niches, and marginal swamp, fen and wet woodland tend to occur along their margins. Consequently, mesotrophic lakes can support a very wide range of biodiversity, with upland species such as trout or quillwort coexisting with lowland ones such as perfoliate

[iv] Typical range is around 100-1000 microequivalents per litre
[v] Typically in the range 10-20 microgrammes per litre

pondweed, pike, perch and stoneworts. Mesotrophic lakes tend to occur in semi-upland locations where soil nutrient levels are relatively low.

Distribution and Abundance

This habitat type has a scattered distribution throughout Wales, around the upland fringes (Map 3), without any particular concentrations. Although there are estimated to be 595ha of this habitat type in Wales, 415ha (70%) is in a single site, Llyn Tegid. The remaining sites are much smaller but many of them are nonetheless of great importance and habitat area should not be used as a strong indicator of priority for action.

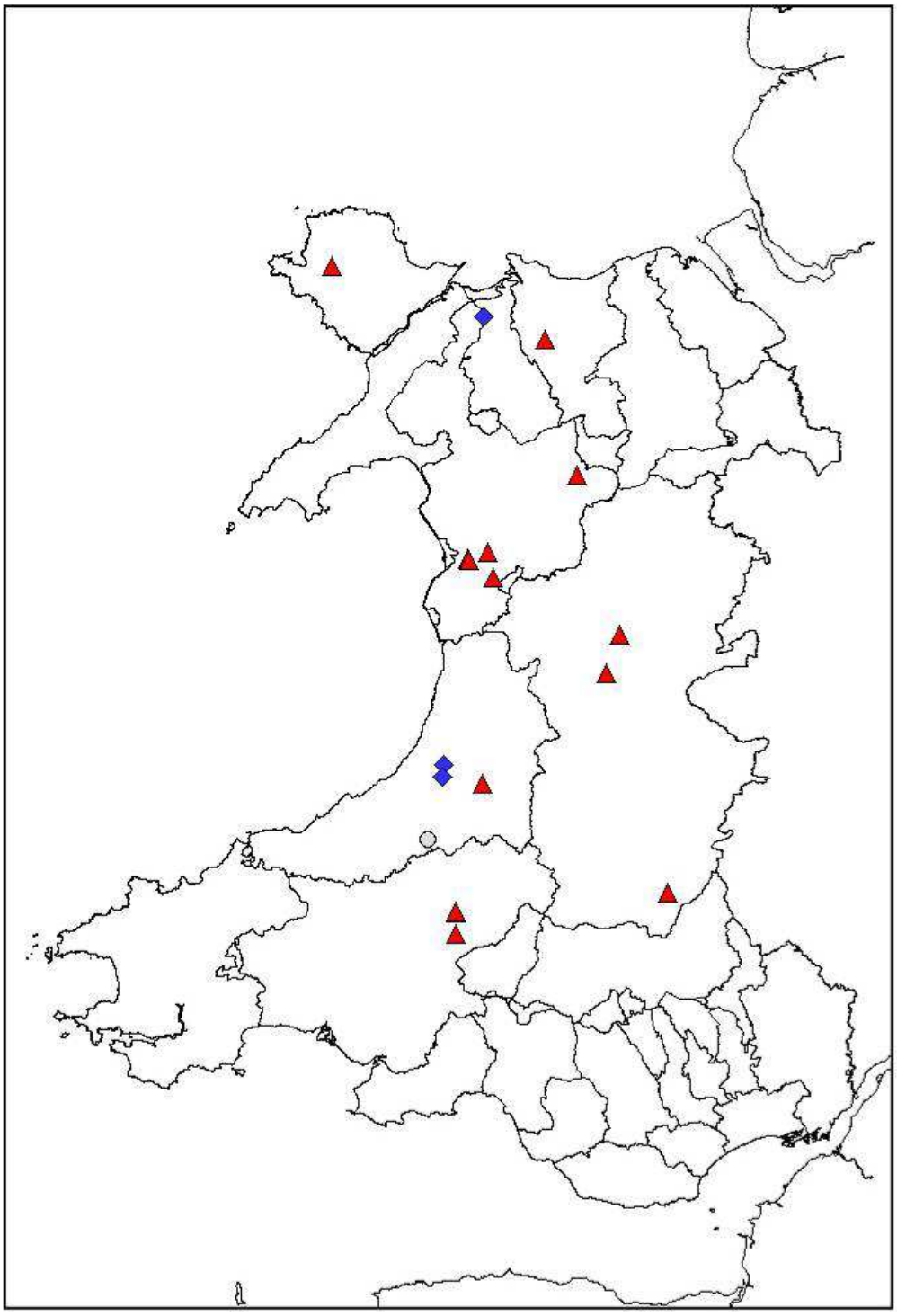
Floating water-plantain. Photograph: Liz Morris

Species of Conservation Importance supported

Floating water-plantain *Luronium natans*; brown trout *Salmo trutta*; common toad B*ufo bufo*; gwyniad *Coregonus lavaretus*; slender stonewort *Nitella gracilis*; long-stalked pondweed *Potamogeton praelongus*; red pondweed *Potamogeton alpinus*; eel *Anguilla anguilla*; glutinous snail *Myxas glutinosa*; noctule *Nyctalus noctula*; otter *Lutra lutra*; pennyroyal *Mentha pulegium*; water vole Arvicola terrestris; pillwort *Pilularia globulifera*; medicinal leech *Hirudo medicinalis*.

Ecological Status

Typical mesotrophic lakes are a threatened habitat throughout the UK. They are particularly vulnerable to agricultural impacts, in particular nutrient enrichment, siltation and overgrazing of marginal vegetation. Some sites have also been affected by introduction of coarse fish and invasive plants such as Canadian pondweed (*Elodea canadensis*), Nuttall's water-thyme (*Elodea nuttallii*) and Australian swamp stonecrop (*Crassula helmsii*). Almost all lakes of this type in Wales require action of some kind to restore them (Map 3).



Map 3. Distribution of typical mesotrophic lakes in Wales. Red triangle: action recommended; blue diamond; Protect; Grey circle: no data. © Crown copyright and database right 2013. Ordnance Survey 100019741.

Sites Requiring Action

Of 21 mesotrophic lakes, 13 (62%) require restoration action (91% by area, but note the comments above under distribution and abundance) (Table 6). In addition, 3 lakes have been identified recently that should be safeguarded by appropriate designation such as SSSI or SAC. Details are shown in Table 7.

Action Type	N° of Lakes	Area (ha)
Protect	3	19.7
Safeguard	3	28.9
Restore catchment	11	543.2
Restore point	0	0
Restore in-lake	2	23.6
Survey	1	2
No Action	1	2.7
Total	**21**	**620.1**

Table 6. Number and area of mesotrophic lakes in different BAP action categories.

Lake Name	Grid Ref.	Local Authority	Area (ha)	Action
Taliaris Lake	SN633282	Carmarthenshire	2.0	Survey
Llyn Eiddwen*	SN606669	Ceredigion	10.1	Protect
Llyn Fanod*	SN602643	Ceredigion	5.3	Protect
Llyn Anafon*	SH697698	Gwynedd	4.3	Protect
Llyn Glasfryn*	SH402421	Gwynedd	5.8	Restore catchment
Llyn Tegid or Bala Lake*	SH909334	Gwynedd	415.2	Restore catchment
Tal-y-llyn Lake*	SH717099	Gwynedd	50.7	Restore catchment
Llyn Mawr*	SO008971	Powys	8.3	Restore catchment
Upper Talley Lake*	SN632330	Carmarthenshire	6.4	Restore catchment
Chwythlyn*	SH835648	Conwy	1.6	Restore catchment
Llyn Llywenan*	SH347816	Isle of Anglesey	39.1	Restore catchment
Lower Talley Lake*	SN631336	Carmarthenshire	10.1	Restore catchment
Maes-Llyn*	SN692628	Ceredigion	1.9	Restore catchment
Llyn Padrig	SH363727	Isle of Anglesey	1.7	Restore catchment
Brechfa Pool*	SO118376	Powys	2.4	Restore catchment and in-lake
Llyn Gwernan	SH704160	Gwynedd	4.6	Restore in-lake
Llyn Helyg	SJ112772	Flintshire	19.0	Restore in-lake
Llyn Ebyr	SN976881	Powys	12.3	Safeguard
Llyn Cregennen Isaf	SH660143	Gwynedd	11.1	Safeguard
Llyn Cregennen Uchaf	SH664141	Gwynedd	5.5	Safeguard

Table 7. List of mesotrophic BAP lakes prioritised for action. * = lake that is a feature of a protected site (SSSI and / or SAC).

Types of Action Required

Restoration of mesotrophic lakes requires working with farmers and other relevant stakeholders to ensure that management in the catchment is sympathetic. In particular, it is necessary to minimise nutrient inputs to the catchment (e.g. fertilizer, slurry spreading, septic tanks, farmyard runoff) and manage livestock access to the lake shore and feeder

streams by fencing them. Nutrient and water pathways should be considered and drains or ditches blocked if possible to trap nutrients and silt. Many of the approaches used in the Pontbren project may provide a way to maintain or even increase farm profits whilst having much less impact on the lake environment. Alternatively or in addition, the opportunities for creating terrestrial BAP habitats such as broadleaved woodland, semi-natural grassland, wetland or heathland in catchments of mesotrophic lakes should be explored.

Where coarse fish have been introduced, agreements should be sought with any angling clubs not to stock further and to encourage appreciation of wild fish native to the lake. Due to their increased productivity, mesotrophic lakes can provide excellent trout fishing, for example.

Catchment management of mesotrophic lakes may be easier than for some other lake types, because they often lie in headwater areas and therefore have small catchments that may be managed by one or a few landowners. Apart from the two largest lakes of this type (Llyn Tegid and Tal-y-Llyn lake), the other lakes requiring restoration or protection have a mean catchment area of just 72ha. This greatly increases the opportunities for effective action, because projects can be smaller scale and lower cost, and because farmers are more likely to have access to land off-catchment.

Hard Water Lakes

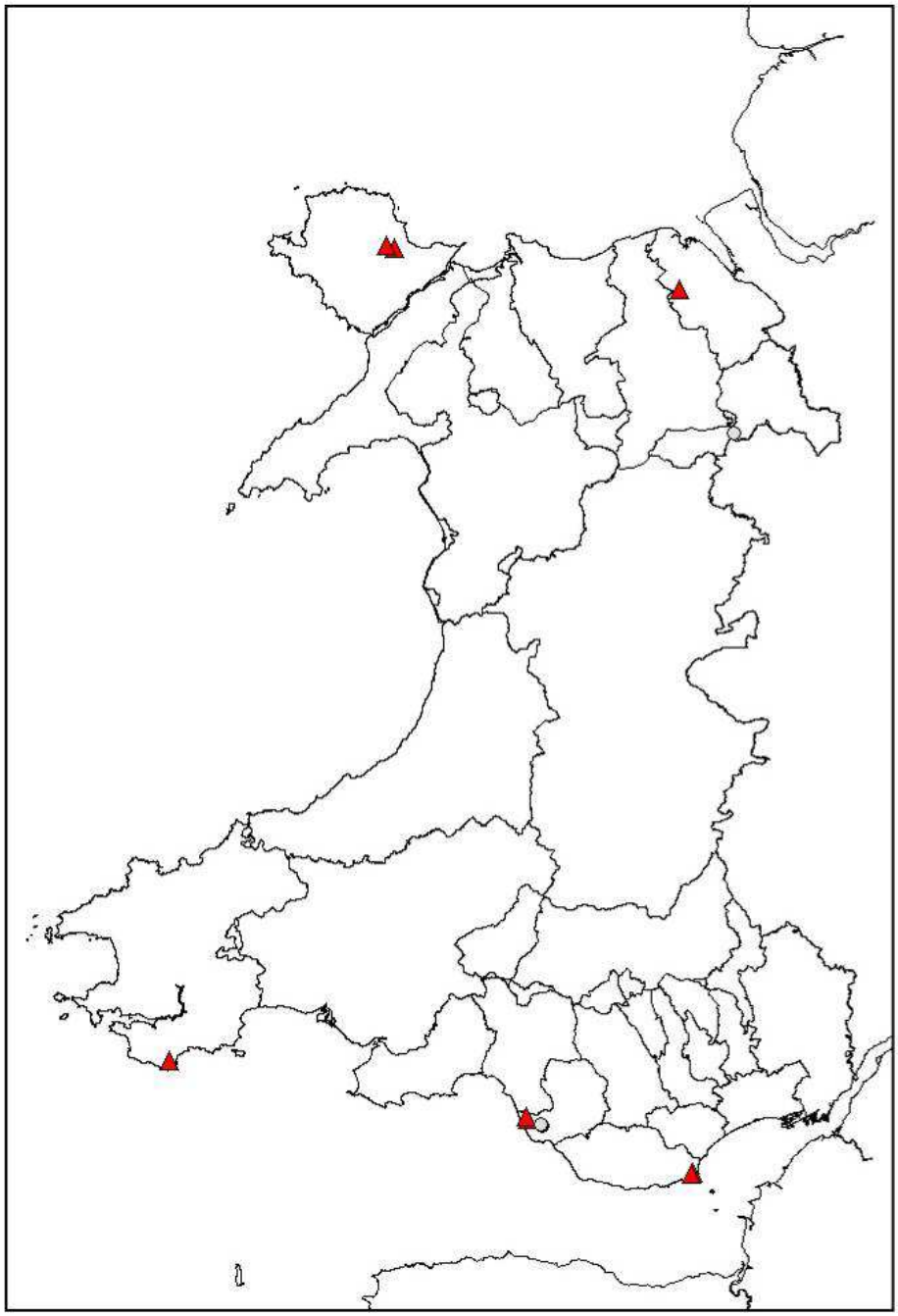
Habitat Summary

These are alkaline, exclusively lowland lakes with high calcium carbonate concentrations. The water chemistry is conducive to dense growths of stoneworts (*Chara* spp.) which are usually the dominant vegetation in healthy lakes of this type. Stoneworts are very effective at removing nutrients from the water column; these are deposited together with calcium carbonate as marl deposits on the lake bed. In this way nutrients are removed from the ecosystem and therefore the water remains very clear.

Llyn yr Wyth Eidion. Photo: Tristan Hatton-Ellis

Distribution and Abundance

This is a rare lake type in Wales with a scattered and mainly coastal distribution, reflecting the location of the limestone rocks which are required to provide the hard water on which this habitat depends. All of the lakes of this type are relatively small and are often artificial.



Map 4. Distribution of hard water mesotrophic lakes in Wales. Red triangle: action recommended; blue diamond; Protect; Grey circle: no data. © Crown copyright and database right 2013. Ordnance Survey 100019741.

Species of Conservation Importance supported

Lesser bearded stonewort *Chara curta*; Baltic stonewort *Chara baltica*; starry stonewort *Nitellopsis obtusa*; rugged stonewort *Chara rudis*; eel *Anguilla anguilla*; otter *Lutra lutra*; bittern *Botaurus stellaris; medicinal leech Hirudo medicinalis*. This lake type is often associated with other important conservation habitats such as fens, limestone woodland and sand dunes.

Stonewort meadow in the central arm of Bosherston Lakes. Photo: Lisa Whitfeld / Celtic Images Ltd.

Ecological Status

This lake type is generally in poor condition in Wales due to the effects of nutrient enrichment, hydrological changes, invasive species and fish introductions. Probably the best quality example is the Central Arm of Bosherston Lakes. Several lakes of this category have lost their stonewort populations and suffer from chronic algal blooms and deoxygenation.

Sites Requiring Action

5/10 (50%) of hard water lakes require at least some action to restore them with a further 2 requiring survey (Tables 8 and 9). This amounts to 91% of the total known resource by area.

Action Type	N^{o} Lakes	Area
Protect	0	0
Safeguard	0	0
Restore catchment and in-lake	5	76.7
Restore point	0	0
Survey	2	6.6
No Action	3	7.8
Total	**10**	**91.1**

Table 8. Number and area of hard water lakes in different BAP action categories.

Lake Name	Grid Ref.	Local Authority	Area (ha)	Action
Cosmeston Lakes*	ST173691	Vale of Glamorgan	11.3	Restore in-lake and catchment
Kenfig Pool*	SS796815	Bridgend	29.2	Restore in-lake and catchment
Lily Ponds*	SR977949	Pembrokeshire	33.7	Restore in-lake and catchment
Llyn Cadarn*	SH492811	Isle of Anglesey	1.2	Restore in-lake and catchment
Llyn yr Wyth-Eidion*	SH474818	Isle of Anglesey	1.3	Restore in-lake and catchment
Ysceifiog Lake	SJ147716	Flintshire	5.6	Survey
Kenfig Burrows pond*	SS796821	Bridgend	1	Survey

Table 9. List of mesotrophic BAP lakes prioritised for action. * = lake that is a feature of a protected site (SSSI and / or SAC).

Types of Action Required

It is relatively difficult to generalise about actions for this type of lake because individual sites contain unique sets of problems and contexts. In each situation it will be important to refer to relevant management plans and discuss possibilities with site managers.

At several sites impacts result from historic damage but corrective action may be required to restore ecosystem function (for example removing nutrient-rich silt to encourage development of stonewort beds). Such actions are both expensive and invasive so any actions need to be carefully scoped before commencing work. In particular, careful consideration needs to be taken of connections to aquifers. Most of the key sites are already designated as SACs or SSSIs.

Although agricultural inputs may still be an influence contributing to the nutrient load of this lake type, in general agriculture is a less direct influence on the water quality of hard water lakes in Wales. This is generally because of the importance of groundwater inputs to these sites. In this context hydrological changes due to groundwater inputs may be particularly important.

Natural Eutrophic Lakes

Habitat Summary
Natural eutrophic lakes are predominantly lowland lakes that occur exclusively on soft rocks or over drift geology. They typically are shallow[vi], have fairly high nutrient levels[vii] and are base-rich.

Healthy eutrophic lakes support a diverse range of water plants including broad-leaved and fine-leaved pondweeds (*Potamogeton* spp.), charophytes, water lilies and often a fringe of shoreweed (*Littorella uniflora*). Their shallow margins often support dense reedbeds and marginal swamp vegetation. Mud banks left dry as water levels drop may support abundant bryophytes, including violet crystalwort *Riccia hubeneriana* and various rarer species. Although there may be short-lived spring and autumn phytoplankton blooms, the water is generally clear in summer because dense growths of aquatic plants removes nutrients from the water column, suppressing algal growth.

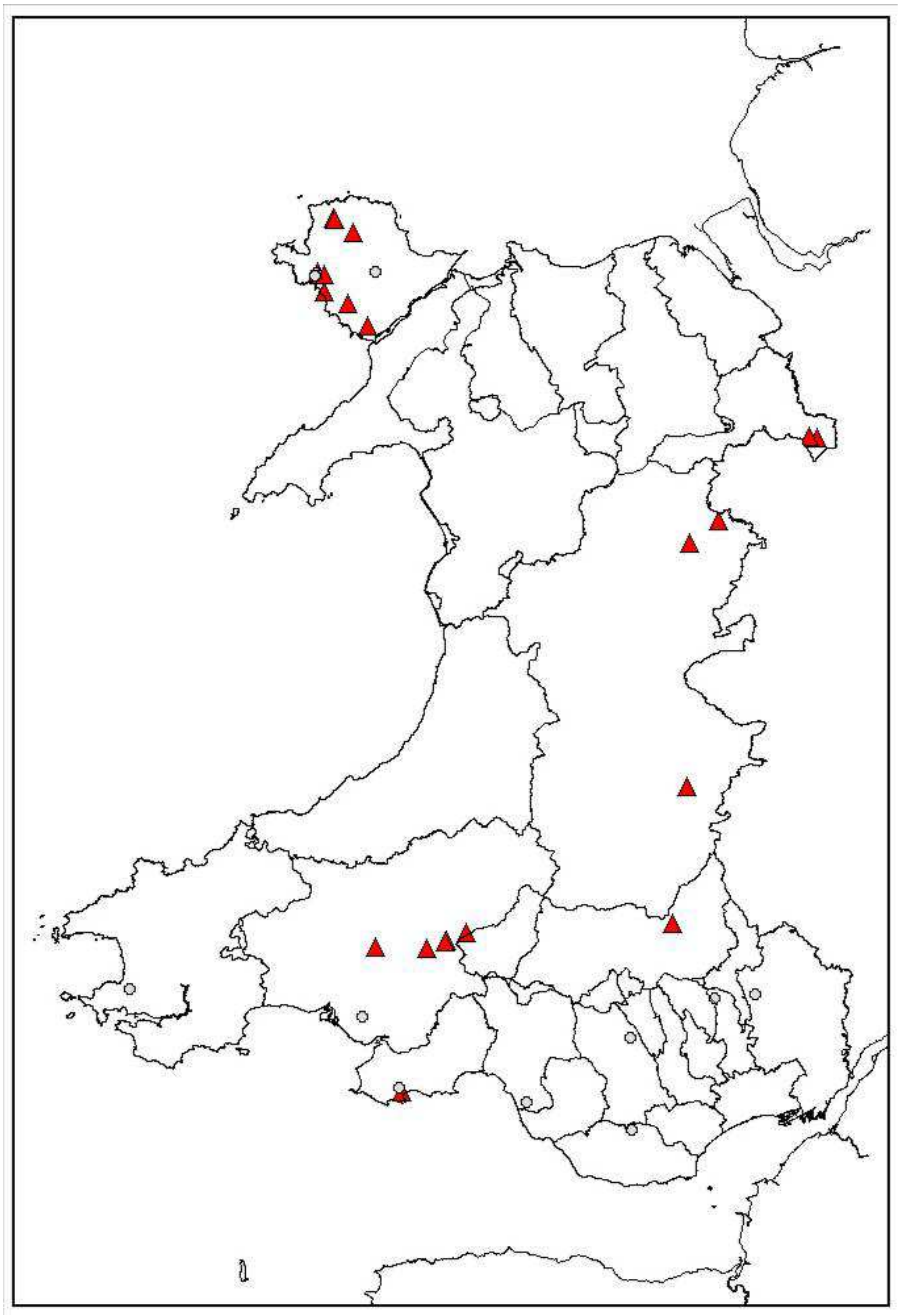
Fish populations in these lakes may be diverse, though in western Wales many coarse fish are introduced. Where coarse fish are present, a balanced community that includes predators such as pike is important to control numbers of herbivorous and planktivorous fish, otherwise aquatic plants may be lost and the lake revert to phytoplankton dominated 'green soup'.Oxbow lakes that are formed naturally by river processes are included in this category.

A mature oxbow lake, Parc Dinefwr. Photo: Catherine Duigan.

[vi] Llangorse Lake, the largest example, has a maximum depth of 7.5m, but most Welsh eutrophic lakes are less than 5m deep.
[vii] Typical range is an annual mean total phosphorus of 20 to 50 microgrammes per litre

Distribution and Abundance

Eutrophic lakes are fairly widespread in Wales with clusters in Anglesey and Powys. The Tywi and Severn Valleys contain a number of important oxbow lakes.



Map 5. Distribution of eutrophic lakes in Wales. Red triangle: action recommended; blue diamond; Protect; Grey circle: no data. © Crown copyright and database right 2013. Ordnance Survey 100019741.

Species of Conservation Importance supported

Reedbed and pondweeds at Llangorse Lake. Photo: NRW.

Bittern *Botaurus stellaris*; reed bunting *Emberiza schoenicus*; common toad *Bufo bufo*; grass snake *Natrix natrix*; the reed beetles *D. bicolora*; diving beetle *Hydroporus rufifrons*; variable damselfly *Coenagrion pulchellum*; medicinal leech *Hirudo medicinalis*; freshwater bryozoan *Lophopus crystallinus*; Lilljeborg's whorl snail *Vertigo lilljeborgi*; tubular water-dropwort *Oenanthe fistulosa*; long-stalked pondweed *Potamogeton praelongus*; shining pondweed *Potamogeton lucens*; hairlike pondweed *Potamogeton trichoides*; millimetre-moss *Micromitrium tenerum*; channelled crystal-wort *Riccia canaliculata*. Closely associated with the Reedbeds priority habitat.

Ecological Status

The most serious threats to eutrophic lakes in Wales are eutrophication (nutrient enrichment) and invasive species. Eutrophication may cause a variety of impacts that destabilise the ecosystem including toxic algal blooms, deoxygenation, loss of plant and invertebrate species and fish kills. Invasive species often prosper in the warm nutrient rich waters of eutrophic lakes, especially where native species are already stressed by other impacts.

Climate change is likely to worsen both of these threats because more extreme weather events are expected to increase nutrient runoff, and increase growth rates of phytoplankton and invasive species, giving them a competitive advantage.

Sites Requiring Action

Over half (52%) of eutrophic lakes (77.7% by area) have an identified need for restoration action with a further four small oxbow lakes identified as a priority for safeguarding (table 9). Details of these are shown in Table 10.

Action Type	N Lakes	Area
Protect	0	0
Safeguard	4	6.0
Restore catchment	8	548.7
Restore point and in-lake	1	22.3
Restore in-lake and catchment	8	43.7
Survey	0	0
No Action	12	175.8
Total	**33**	**790.5**

Table 9. Number and area of eutrophic lakes in different BAP action categories.

Lake Name	Grid Ref.	Local Authority	Area (ha)	Action
Llangorse Lake*	SO132264	Powys	139.6	Restore catchment
Llyn Alaw*	SH392866	Isle of Anglesey	308.4	Restore catchment
Llyn Coron*	SH378700	Isle of Anglesey	28	Restore catchment
Llyn Dinam*	SH310775	Isle of Anglesey	9.7	Restore catchment
Llyn Maelog*	SH326730	Isle of Anglesey	23.8	Restore catchment
Llyn Rhos-ddu*	SH424648	Isle of Anglesey	2.4	Restore catchment
Llyn Traffwll*	SH325769	Isle of Anglesey	36.8	Restore catchment
Llynheilyn	SO167581	Powys	3.4	Restore catchment
Bishop's Pond*	SN443209	Carmarthenshire	1.3	Restore in-lake and catchment
Dinefwr Park Pond 1	SN607223	Carmarthenshire	1.3	Restore in-lake and catchment
Dinefwr Park Pond 2	SN605220	Carmarthenshire	1.6	Restore in-lake and catchment
Hanmer Mere*	SJ452392	Wrexham	18.3	Restore in-lake and catchment
Llyn Bedydd*	SJ470391	Wrexham	1.1	Restore in-lake and catchment
Llyn Llygeirian*	SH346898	Isle of Anglesey	12.3	Restore in-lake and catchment
Serpentine Lake*	SS503872	Swansea	7.8	Restore in-lake and catchment
Llyn Penrhyn*	SH313768	Isle of Anglesey	22.3	Restore point source and in-lake
Tre-derwen Hall oxbow	SJ240196	Powys	1.2	Safeguard
Bron-y-Main oxbow	SJ172145	Powys	1.1	Safeguard
Tywi oxbow 1	SN654243	Carmarthenshire	1.9	Safeguard
Dryslwyn oxbow 1	SN562205	Carmarthenshire	1.8	Safeguard

Table 10. List of eutrophic BAP lakes prioritised for action. * = lake that is a feature of a protected site (SSSI and / or SAC).

Types of Action Required

The most important pressure affecting eutrophic lakes is eutrophication (nutrient enrichment) and actions to control and reverse its impacts are a high priority. Nutrients may come from regulated point sources such as sewage treatment works, from smaller unregulated sources such as farmyards and septic tanks, and from catchment sources such as runoff from agricultural fields. Additionally, the lake itself may contain phosphorus that has been accumulated in the sediments and whose availability is affected by in-lake processes such as the extent of macrophyte beds and the fish community. A wide range of tools and techniques are available to tackle these diverse impacts. Effective action will require consideration and management of these different sources.

Invasive species management should focus on biosecurity measures to reduce the risk of new species becoming established, taking account of the most likely pathways for transmission. Once established the options for control and eradication are often limited.

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