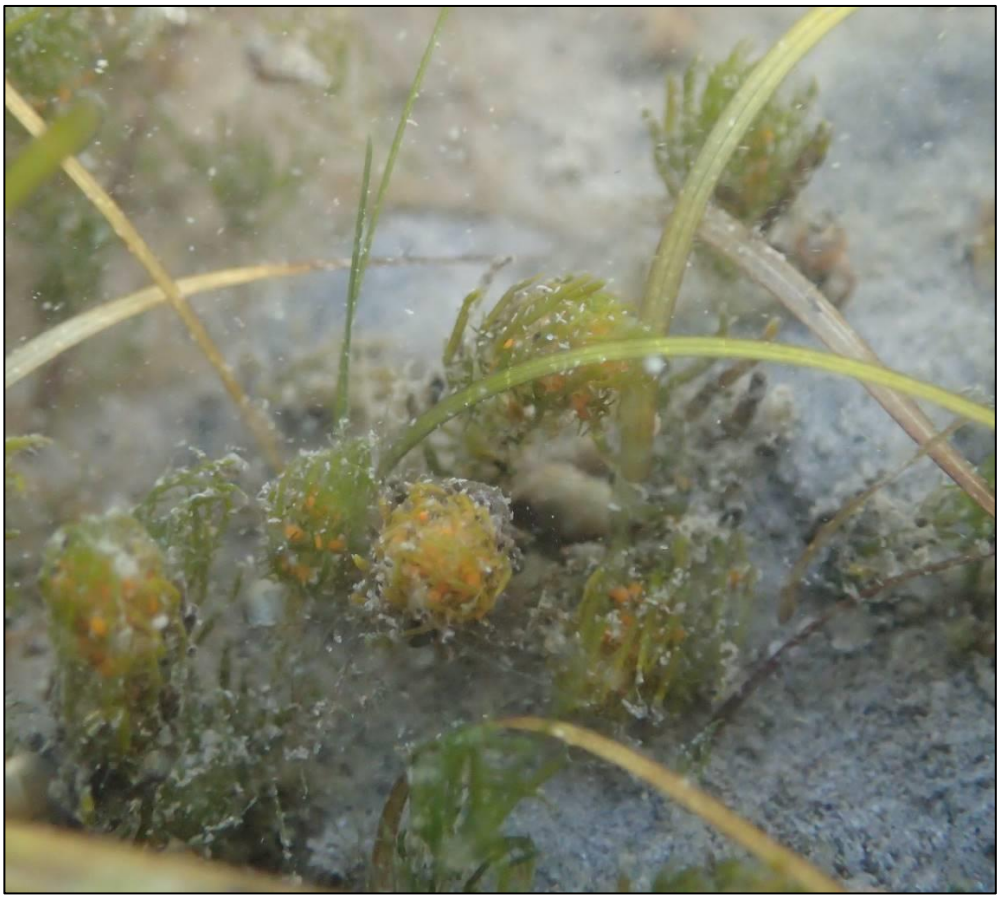
Cyfoeth Naturiol Cymru
Natural Resources Wales

A Red List of Stoneworts in Wales



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NRW Evidence Report No 406.

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Cover image: Foxtail Stonewort *Lamprothamnium papulosum,* newly discovered in Wales in 2017. Photographed by T.Hatton-Ellis.

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1. Crynodeb Gweithredol

Mae'r adroddiad hwn yn cyflwyno canfyddiadau ymarfer i asesu'r perygl difodiant i holl rywogaethau rhawn yr ebol (Charophyta) yng Nghymru. Cafodd yr asesiad o berygl difodiant ei gynnal yn dilyn meini prawf yr Undeb Rhyngwladol dros Gadwraeth Natur (IUCN), gan ddefnyddio'r dull safonol. Yn ogystal â'r asesiad o berygl difodiant, mae arwydd o helaethrwydd bob rhywogaeth wedi'i gyfrifo ar gyfer rhywogaethau nad oeddent wedi'u dosbarthu fel rhai o dan fygythiad, gan ddefnyddio data ers 2000.

Mae'r gwaith hwn wedi'i gynnal ar y cyd â diweddariad o'r gronfa ddata cofnodion ar gyfer rhawn yr ebol yng Nghymru, nad oedd wedi'i diweddaru ers dros degawd. Mae 500 cofnod ychwanegol wedi'u hychwanegu bellach at y 1,500 cofnod yn niweddariad 2007. Mae'r gronfa ddata hon yn cael ei chadw ar hyn o bryd mewn taenlen Excel a gyflenwyd ar wahân i Cyfoeth Naturiol Cymru. Er bod y data diweddar yn dda ar gyfer llynnoedd, ac i raddau llai, ar gyfer ffeniau, prin iawn yw'r wybodaeth o'r arolwg diweddar am systemau twyni a phyllau dŵr ar gyfer cefn gwlad yn ehangach.

Cofnodwyd cyfanswm o 19 o rywogaethau, cynnydd o ddwy rywogaeth ers i'r data gael ei adolygu ddiwethaf. Dosberthir un rhywogaeth fel un sydd heb ei gwerthuso gan nad yw'n hysbys fel un sy'n gynhenid i Gymru. O'r 18 o dacsonau sy'n weddill, mae dau (*Chara baltica* a *C. rudis*) yn cael eu dosbarthu fel rhai sydd mewn perygl difrifol, mae pedwar (*Chara aculeolata*, *C. aspera*, *C. curta* a *Nitella tenuissima*) mewn perygl ac mae dau (*Chara hispida* a *Lamprothamnium papulosum*) yn fregus. O ganlyniad, ystyrir bod 44% o'r rhywogaethau dan fygythiad. Dosberthir un rhywogaeth fel un sydd â data diffygiol.

Mae bylchau amrywiol mewn tystiolaeth wedi'u nodi. Mae cynefinoedd sydd angen arolygon pellach yn cynnwys;

- Twyni tywod: cafodd y safleoedd allweddol eu harolygu yn y 1990au ond, ac eithrio Cwningar Niwbwrch, nid ydynt wedi derbyn sylw systematig ers hynny. Yn yr olaf ceir angen parhaus ar gyfer adleoli *Chara baltica*
- Mae chwareli, pyllau graean a safleoedd "tir llwyd" eraill yn adnodd pwysig yn y rhannau mwy diwydiannol o Gymru. Mae safleoedd lle mae'r ddaeareg yn fwy calchaidd yn flaenoriaeth benodol.
- Rhostiroedd Sir Benfro; unwaith yn rhagor, cafodd rhai safleoedd eu harolygu ar gyfer rhawn yr ebol yn y 1990au ond prin iawn yw'r wybodaeth gyfredol sydd ar gael.
- Ceir monitro parhaus yn ffeniau Ynys Môn, o leiaf tra bod poblogaethau o e.e. *Nitella tenuissima* a *Chara curta* yn parhau i fod yn fregus. Mae rhywfaint o waith rheoli a chreu cynefinoedd yn mynd rhagddo ac mae angen monitro'r mesurau hyn. Mae gwybodaeth o Gors Goch yn llai cyflawn o gymharu â safleoedd eraill.
- Gwastadeddau Gwent; mae rhawn yr ebol yn ymddangos fel petai'n tyfu'n lleol iawn o fewn y gwastadeddau ond mae angen gwaith arolygu pellach, e.e. er mwyn asesu presenoldeb parhaus *Tolypella glomerata.*

Yn ychwanegol i’r anghenion arolygu mwy cyffredinol hyn, mae angen rhai archwiliadau penodol ar gyfer rhywogaethau unigol sydd dan fygythiad, a amlinellir o dan bob rhywogaeth a'u crynhoi yn adran 3.

Mae pump o'r tacsonau a nodir wedi'u darganfod yn gymharol ddiweddar. Er y gallai hyn adlewyrchu'r diffyg gwybodaeth gan arolygon mewn un achos (*Nitella gracilis*) a bod rhywogaeth yn cael ei hanwybyddu oherwydd ei bod yn debyg i rywogaeth arall mewn achos arall (*Chara baltica*), mae'n debygol bod *Lamprothamnium papulosum* a *Nitellopsis obtusa* wedi cytrefu yng Nghymru yn ddiweddar. Ailddarganfyddwyd *Chara rudis* yn ddiweddar hefyd yn dilyn absenoldeb o fwy na 70 mlynedd. Mae rhywogaethau allai gytrefu yng Nghymru o ganlyniad i newid yn yr hinsawdd wedi'u hadolygu’n gryno hefyd.

Y prif fygythiadau i rawn yr ebol yw (i) effeithiau eilaidd gorfaethu'r dŵr lle maent yn tyfu, yn arbennig o ran afloywder a gordyfiant algâu eraill a (ii) lleihau neu roi’r gorau i ddulliau rheoli tirwedd traddodiadol, yn arbennig mewn amgylcheddau ffeniau. Roedd bygythiadau eraill a nodwyd yn cynnwys dinistrio cynefinoedd a chystadleuaeth gan blanhigion goresgynnol dyfrol, yn arbennig *Elodea nuttallii*.

Mae nifer o ffactorau wedi cael effeithiau cadarnhaol ar statws rhawn yr ebol. Mae llai o asideiddio mewn llynnoedd ucheldir â sylfaen wael wedi cyd-fynd â chynnydd mawr yn nosbarthiad a helaethrwydd nifer o rywogaethau *Nitella*, yn benodol *N. gracilis* ac *N. translucens*. Gallai rhywogaethau mwy cyffredin megis *N. opaca* a *Chara virgata* fod wedi elwa hefyd ar lefelau uwch o alcalin yn y dyfroedd hyn.

Mae Safleoedd Gwarchodedig yn chwarae rôl hanfodol wrth warchod bioamrywiaeth rhawn yr ebol yng Nghymru. Mae'r holl rywogaethau sy'n ymddangos ar Restr Goch Cymru bellach wedi'u lleoli yn bennaf neu yn llwyr o fewn y safleoedd gwarchodedig hyn. Mae hyn yn adlewyrchu pwysigrwydd ecosystemau llynnoedd, ffeniau a thwyni o ansawdd uchel naturiol fel hafanau bywyd gwyllt yn ystod yr Argyfwng Difodiant cyfredol. Mae *Tolypella glomerata* hefyd yn ddibynnol iawn ar safleoedd gwarchodedig. Bydd rheolaeth briodol gan gynnwys rheoli maetholion a chreu cynefinoedd olyniaeth gynnar yn rheolaidd drwy lanhau pyllau, torri cyrs, neu bori yn helpu i gynnal amodau sy'n addas ar gyfer y rhywogaethau hyn sydd o dan fygythiad.

Yn y cefn gwlad ehangach, mae colli cynefinoedd, diffyg rheolaeth a newidiadau o ran olyniaeth yn bryder eang ar gyfer rhywogaethau sy'n tyfu mewn pyllau, ffosydd a sgydiau dŵr. Yn y rhannau mwy diwydiannol o Gymru, mae chwareli segur, pyllau graean a gwastraff o byllau glo yn gynefinoedd da ar gyfer rhawn yr ebol a phlanhigion dyfrol eraill oherwydd eu bod ar wahân i'r system draenio naturiol, sydd yn gyffredinol yn llawn maetholion. Ond mae newidiadau olyniaeth yn fater o bwys yn y mannau hyn hefyd wrth i'r cyrff dŵr aeddfedu.

2. Executive Summary

This report presents the results of an exercise to assess the extinction risk to all species of stonewort (Charophyta) in Wales. Assessment of extinction risk was carried out following the IUCN Criteria, employing the standard method. In addition to the assessment of extinction risk, an indication of the abundance of each species has been calculated for species which were not classed as threatened, using data available since 2000.

This work has been undertaken in tandem with an update of the records database for stoneworts in Wales, which has not been updated for over a decade. An additional 500 records have now been added to the 1500 records in the 2007 update. This database is currently held in an Excel spreadsheet supplied separately to Natural Resources Wales. Whilst the recent data for lakes and to a lesser extent fens is good, there is very little recent survey information from dune systems and ponds in the wider countryside.

A total of nineteen species were recorded, an increase of two species since the data were last reviewed. One species is classed as Not Evaluated as it is thought not to be native in Wales. Of the remaining 18 taxa, two (*Chara baltica* and *C. rudis*) are classed as Critically Endangered, four (*Chara aculeolata*, *C. aspera*, *C. curta* and *Nitella tenuissima*) Endangered and two (*Chara hispida* and *Lamprothamnium papulosum*) Vulnerable. Thus, 44% of species are considered threatened. One species is classed as Data Deficient.

Various evidence gaps have been identified. Habitats that need further survey include;

- Sand dunes: the key sites were surveyed in the 1990s but, with the exception of Newborough Warren have received no systematic attention since. In the latter there is still a continuing need to relocate *Chara baltica*
- Quarries, gravel pits and other “brown field” sites are an important resource in the more industrial parts of Wales. Sites where the geology is calcareous are a particular priority.
- Pembrokeshire heaths; again some sites were surveyed for stoneworts in the 1990s but there is little up-to-date information.
- Continued monitoring in the Anglesey fens, at least while the populations of e.g. *Nitella tenuissima* and *Chara curta* remain precarious. Some habitat management and creation is ongoing and these measures need to be monitored. Information from Cors Goch is less complete than other sites.
- Gwent Levels; stoneworts appear to be very localised within the Levels but further survey is needed, e.g. to assess the continued presence of *Tolypella glomerata.*

In addition to these more general survey needs there are some specific investigations needed for individual threatened species, which are outlined under each species and summarised in section 3.

Five of the taxa identified have been discovered relatively recently. Whilst this may reflect lack of survey information in one case (*Nitella gracilis*) and being overlooked due to similarity to other species in an another (*Chara baltica*), it is likely that

Lamprothamnium papulosum and *Nitellopsis obtusa* have colonised Wales recently. *Chara rudis* was also recently rediscovered after an absence of more than 70 years. Species that may colonise Wales due to climate change have also been briefly reviewed.

The key threats to stoneworts are (i) the secondary effects of nutrient enrichment of the water in which they grow, in particular to turbidity and excessive growth of other algae and (ii) reduction in or abandonment of traditional landscape management, especially in fen environments. Other threats identified included habitat destruction and competition from invasive aquatic plants, especially *Elodea nuttallii*.

Several factors have had positive effects on the status of stoneworts. Reduction from acidification in base-poor upland lakes has coincided with a marked increase in the distribution and abundance of several *Nitella* species, notably *N. gracilis* and *N. translucens*. Commoner species such as *N. opaca* and *Chara virgata* may also have benefited from increased alkalinity in these waters.

Protected Sites play a critical role in the conservation of stonewort biodiversity in Wales. All of the species on the Welsh Red List now occur mainly or entirely within protected sites. This reflects the importance of natural high-quality lake, fen and dune ecosystems as wildlife havens in the current Extinction Crisis. *Tolypella glomerata* is also heavily dependent on protected sites. Appropriate management including control of nutrients and regular creation of early succession habitats by pond clearance, reed cutting, or grazing will help to maintain conditions suitable for these threatened species.

In the wider countryside, habitat loss, lack of management and successional changes are a widespread concern for species growing in ponds, ditches and flushes. In the more industrial parts of Wales, abandoned quarries, gravel pits and colliery waste are a good habitat for stoneworts and other aquatic plants because of their isolation from the natural, generally nutrient enriched, drainage system. But here too successional changes as the water bodies age are often a significant issue.

3. Introduction

This report presents the results of an exercise to assess the extinction risk to all species of stonewort (Charophyta) in Wales, using the IUCN criteria (IUCN 2012 and 2012a). This work has been undertaken in tandem with an update of the records database for stoneworts in Wales. This database was initially compiled in 2002 from data from the Biological Records Centre, survey reports, personal data held by interested botanists and an extensive herbarium and literature search. This was subsequently updated in 2004 and 2007.

An additional 500 records have now been added to the 1500 records in the 2007 version. 125 of these were collected by independent members of the Botanical Society of Britain and Ireland and / or have been extracted from BSBI's Distribution Database (DDb). This dataset is currently held in an Excel spreadsheet supplied separately to Natural Resources Wales.

In this report, this introduction is followed by:

- A description of the methods used to assess the extinction risk for stoneworts in Wales, including thresholds and specific considerations.
- The Red List category assigned to each taxon.
- A review of the necessary conservation work identified through the Red list assessment process.
- A list of references cited in the text (each Red List assessment includes a list of references cited).
- The text of each Red List assessment for stoneworts recorded in Wales.

Historic data show that most stonewort species have declined in Wales, as is the case with other wetland-dependent plants, however the most significant declines occurred before the end of the 20th Century. Subsequently the populations of many species such as *Chara vulgaris* and *C. virgata* have been stable, while a small number such as *Nitella mucronata* var. *gracillima* and *Nitellopsis obtusa* are increasing. One major problem with the assessments carried out for this project is the recording history of stoneworts over the last 25 years. During the 1990s, extensive surveys were carried out to assess the condition of populations of many species of stonewort (e.g. Stewart 1996 and 1999). Since 2000, work has focussed on two main areas, the Anglesey fens (which are the richest stonewort sites in Wales) and lakes for Water Framework Directive, SAC and SSSI condition monitoring.

An important dataset over the last three decades has been lake survey and monitoring work carried out by the Countryside Council for Wales, the Environment Agency and Natural Resources Wales, mainly in partnership with ENSIS Ltd. Many early surveys were hampered by inadequate taxonomic resolution, with stoneworts generally being recorded only to genus level (e.g. Allott *et al*. 1993). However, this situation improved through the 1990s (e.g. Monteith (ed.) 1995, 1996). Coupled with the development and subsequent introduction of more structured survey designs in the early 2000s for statutory monitoring purposes (JNCC 2005; Willby *et al*. 2009; Gunn *et al*. 2010; IAFG 2015), this resulted in a greatly improved understanding of the distribution and abundance of stoneworts in Welsh standing waters. Since around 1997, a large body of survey data contributing to our knowledge of the distribution of stoneworts in Welsh lakes has been accumulated (Shilland and Monteith 2001;

Carvalho *et al*. 2003; Goldsmith *et al*. 2006; Burgess *et al*. 2006, 2009, 2013; Hatton-Ellis 2011, 2012; Hatton-Ellis and Culyer 2011; Goldsmith *et al*. 2014a,b,c, 2016, 2017; Baxter and Stewart 2015; Shilland *et al*. 2018).

The lakes dataset is particularly useful because although biased towards protected sites, some lakes outside the protected site series have also been surveyed. Since the survey is targeted at assessing general lake ecology rather than the distribution of stoneworts, it also shows that stoneworts are absent from some lakes. This data is linked to wider information on the ecology of these lakes, which now makes it possible to more specifically describe the ecological requirements of many taxa including water chemistry, transparency, substrate, and the abundance of competitor taxa such as vascular plants and filamentous algae. Whilst it is not possible to exhaustively describe these here, there is scope to further interrogate this dataset.

Other habitats have been neglected, for example sand dunes which are another habitat of high importance for Welsh stoneworts. A few BSBI members have done some recording but this is patchy, the main contributors being Richard Pryce in Carmarthenshire and in the 1990s Arthur Chater in Ceredigion. These gaps in information have hampered the assessments, particularly in the quantification of declines and the assessment of how many sites are still extant. However, there is sufficient information to produce a good quality initial Red List and, in the process, to highlight where further information is needed.

4. Methods

Assessment of extinction risk was carried out following the IUCN Criteria (IUCN 2012 and 2012a), employing the standard method. This process assigns each species to one of ten categories of extinction risk:

EX - Extinct
EW - Extinct in the Wild
CR - Critically Endangered
CR (PE) - Critically Endangered (Possibly Extinct)
EN - Endangered
VU - Vulnerable
NT - Near Threatened
LC - Least Concern
DD - Data Deficient
NE - Not Evaluated

Species assigned to CR, EN or VU are referred to as threatened.

The specific criteria for assessing IUCN threat categories are summarised in Table 4.1: further details of the approach and definitions of specific terms are provided in IUCN (2012, 2019). As this is a regional rather than a global assessment, the absolute range values used in the Criterion B2 are not applicable. The approach has therefore been modified following the approach of Dines (2008) for the Welsh Vascular Plants Red List (Table 4.2).

A. Population size reduction. Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

	Critically Endangered	Endangered	Vulnerable
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased.

A2 Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years) *[(a) cannot be used for A3]*.

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

based on any of the following:

(a) direct observation *[except A3]*

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality

(d) actual or potential levels of exploitation

(e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)

	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented **OR** Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals			
(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals			

C. Small population size and decline

	Critically Endangered	Endangered	Vulnerable
Number of mature individuals	< 250	< 2,500	< 10,000
AND at least one of C1 or C2			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(ii) % of mature individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals			

D. Very small or restricted population

	Critically Endangered	Endangered	Vulnerable
D. Number of mature individuals	< 50	< 250	**D1.** < 1,000
D2. *Only applies to the VU category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	-	-	**D2.** typically: AOO < 20 km² or number of locations ≤ 5

E. Quantitative Analysis

	Critically Endangered	Endangered	Vulnerable
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

1 Use of this summary sheet requires full understanding of the *IUCN Red List Categories and Criteria* and *Guidelines for Using the IUCN Red List Categories and Criteria*. Please refer to both documents for explanations of terms and concepts used here.

Table 4.1. Summary of IUCN Threat Criteria (from IUCN 2019).

Threat Category	Criterion	Thresholds
EX Extinct		Extinct in Great Britain (but was present in Wales)
RE Regionally extinct		Extinct in Wales but still present elsewhere in Great Britain
EW Extinct in the wild		Extinct in Great Britain (was present in Wales) but still present in cultivation
CR Critically Endangered	**A**	AOO trend or Hectad trend > 80% decline
	B	1 location + continuing decline
	C	<250 individuals + continuing decline
	D	< 50 individuals
EN Endangered	**A**	AOO trend or Hectad trend > 50% decline
	B	5 locations + continuing decline
	C	< 2,500 individuals + continuing decline
	D	< 250 individuals
VU Vulnerable	**A**	AOO trend or Hectad trend > 30% decline
	B	10 locations + continuing decline
	C	< 10,000 individuals + continuing decline
	D1	< 1,000 individuals
	D2	< 5 locations
NT Near Threatened	**A**	AOO trend or Hectad trend > 20% decline
	B	30 locations + continuing decline
	D	< 10,000 individuals
LC Least concern		No threat to taxon
DD Data deficient		Threat suspected but there is insufficient data for analysis
WL Waiting list		Inadequate data, taxonomic uncertainties or uncertainties over native or archaeophyte status means no assessment can be made.

Table 4.2. Regional IUCN Threat Criteria used by the Welsh Vascular Plants Red List (Dines 2008).

In these criteria, quantitative declines are calculated based on a reduction in the population over a period of “ten years or three generations, whichever is shorter”. There is generally no information on generation length in stoneworts (excluding the implications of a long-term persistent spore-bank, which see below) and therefore the period over which declines have been measured is ten years. Where possible, declines have been based on data since 2007. However, in many cases there are sites which have not been visited for stoneworts within that period and it is thought that there is a good likelihood of the species still being present based on other knowledge of the site. Allowances for this have been made when assessing declines.

Assessment of “individuals” for criteria relating to population numbers is difficult with stoneworts which often form continuous patches. These criteria have not therefore been used except in rare cases discussed under those species. Assessments of declines have been based variously on Extent of Occurrence, Area of Occupancy, numbers of sites, numbers of sub-populations and area of cover.

In addition to the assessment of extinction risk, an indication of the abundance of each species has been calculated for species which were not classed as threatened, using data available since 2000.

Many stonewort species are known to be able to persist as dormant spores in a long-term spore-bank. It is reasonably certain that the spores of some species (such as *Nitella tenuissima*) can remain viable in a spore-bank for many tens of years and there is evidence that stonewort spores may be able to remain viable for hundreds of years in certain circumstances (Goldsmith *et al*. 2013). Clearly if a persistent spore-bank exists, then the species cannot be considered extinct, even if no growing plants have been recorded for decades. However, as no method for assessing the size of a spore-bank exists, they have not been taken into account in these assessments.

Analysis of Trends

Hectad (10km^2) data has been used as the most practical and consistent means of evaluating trends over time. Records have been divided into standard time periods reflecting BSBI Atlas epochs: these are up to 1969; 1970-1986; 1987-1999; 2000-2009 and 2010-present.

Recording effort appears to be roughly similar with the exception of 1971-86 when there were disproportionately few records. The reduction in the number of records recently most likely reflects a combination of reduced monitoring and a shorter period. Some records also may not have reached the relevant data sources yet. Records with insufficient taxonomic detail (e.g. *Chara* sp.) were excluded.

Epoch	Number of Hectad Records	Number of Hectads with one or more species	Total Taxa Recorded
Pre 1970	155	78	14
1971-1986	70	49	12
1987-1999	185	86	16
2000-2009	165	79	17
2010 on	106	53	18

Table 4.1. Data summary for each of the different epochs in the dataset.

To allow for differences in recording effort, a percentage occupancy was calculated for each species in each epoch by dividing the number of occupied hectads for that species by the total number of hectads in which one or more stonewort species was recorded for the relevant epoch.

Taxon richness per hectad for each epoch was calculated and plotted on a GIS to allow the creation of heat maps of total charophyte richness (see section 5).

5. Overview of Results

There has been a gradual increase in the number of species recorded in Wales over time. Fourteen species are evident in the pre 1970 records. Species that had not been recorded from Wales at that time were *Chara baltica*, *Lamprothamnium papulosum*, *Nitella gracilis*, *N. mucronata* and *Nitellopsis obtusa*. While it is conceivable that *Nitella gracilis* and *Chara baltica* may have been overlooked, it is likely that the other three species are recent colonists. No species have been lost during this period. A total of nineteen species are currently known from Wales.

Figure 5.1 shows changes in taxon richness per hectad over time. In general the greatest taxon richness for stoneworts is in lowland and coastal areas, reflecting the general distribution of base-rich geology in Wales. There are some notable biodiversity hotspots in Wales for stoneworts, especially Anglesey where a small cluster of grid squares support up to half of the Welsh stonewort flora. Five species (*Chara aculeolata*, *C. baltica*, *C. rudis*, *Lamprothamnium papulosum* and *Nitella tenuissima*) occur only on Anglesey.

Other important locations are sand dune systems along the south and west coasts. Much of the rest of Wales has low stonewort species richness (although there are still sites of importance for uncommon species). There is also some evidence that Welsh uplands have been increasing somewhat in taxon richness in the last two decades.

These general distribution patterns have shown little change over time, although there are differences in the detail, especially around some of the hotspots. The potential reasons for some of these are explored in the species accounts.

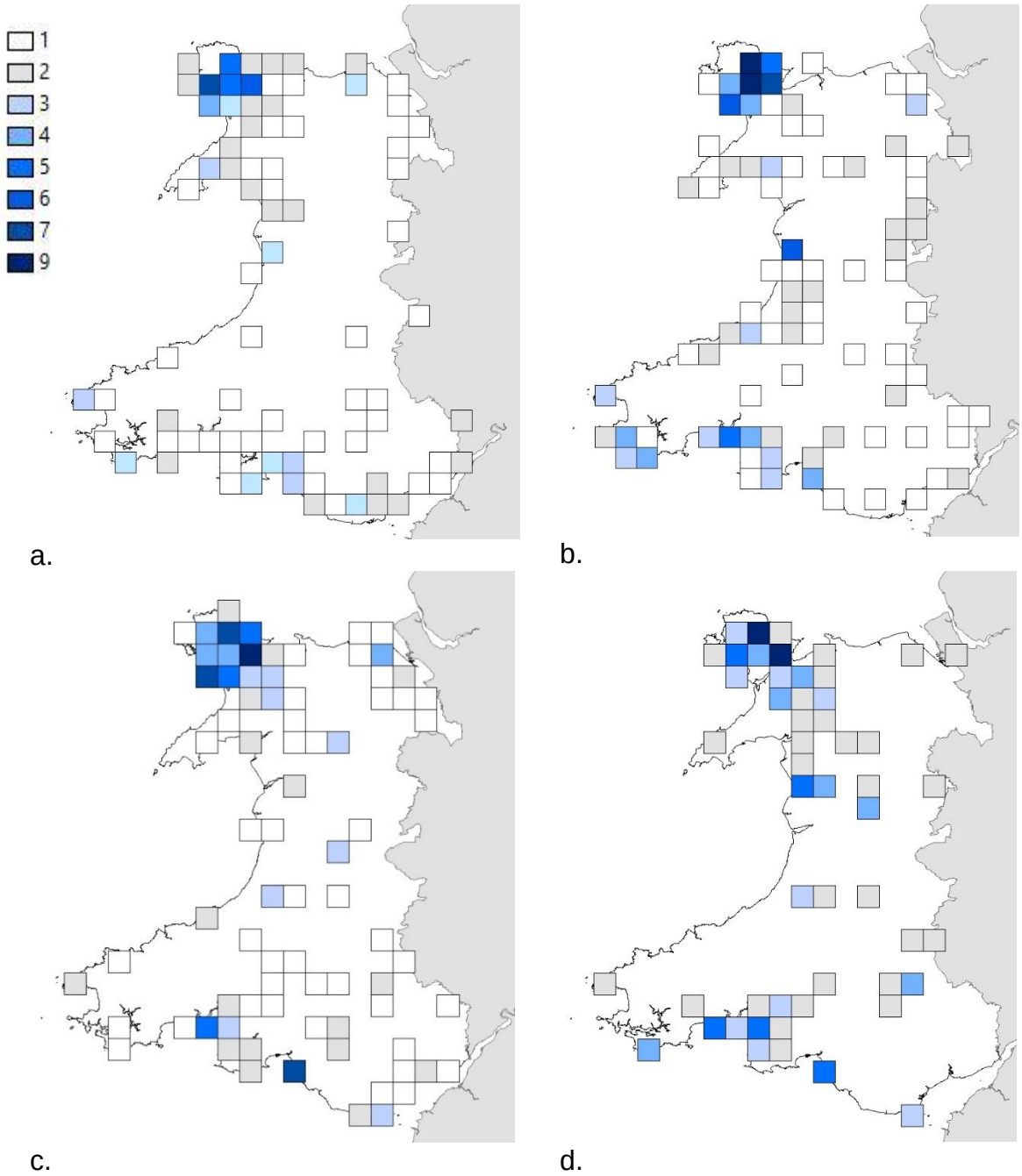

Figure 5.1. Stonewort taxon richness per 10km square in Wales. a. pre 1970; b. 1987-99; c. 2000-09; d. 2010 on. The data between 1970 and 1986 are poor and have not been mapped.

The results of the assessment of extinction risk of stoneworts in Wales are presented in table 5.1. One species is classed as Not Evaluated as it is probably not native to Wales. Of the remaining 18 taxa, two (11%) are classed as Critically Endangered , three (17%) Endangered and four (22%) Vulnerable, thus 50% of species are considered threatened. In addition, one species is classed as Data Deficient.

Taxon	Wales status	GB status
Chara baltica	CR (PE)	VU
Chara rudis	CR	NT
Chara aculeolata	EN	NS
Chara aspera	EN	
Chara curta	EN	NS
Nitella tenuissima	EN	EN
Chara hispida	VU	
Lamprothamnium papulosum	VU	NT
Nitella flexilis	DD	NS
Tolypella glomerata	LC	NS
Chara contraria	LC	
Chara globularis	LC	
Chara virgata	LC	
Chara vulgaris	LC	
Nitella opaca	LC	
Nitella gracilis	LC	VU
Nitella translucens	LC	NS
Nitellopsis obtusa	LC	VU
Nitella mucronata var. *gracillima*	NE	

Table 5.1 The threat status of stoneworts in Wales compared to their GB Status (Stewart & Church 1992, revised 2001).

The proportion of stoneworts classed as threatened is relatively high compared to the proportion of wetland-dependent vascular plants assessed as threatened through regional projects carried out by IUCN which range from 2.5% in the Eastern Mediterranean (Lansdown *et al*. 2014) and Indo-Burma (Lansdown 2012) regions, through 6.6% in Europe (Bilz *et al*. 2011) to 12.6 % in the Arabian Peninsula (Patzelt, Lansdown and Knees 2015). However, it is very much in line with other stonewort Red Lists assessments in Britain and elsewhere in Europe (e.g. Stewart and Church 1992). The reason for this is their more or less universal sensitivity to the pervasive problem of nutrient enrichment on top of other habitat damage and losses.

6. Species Accounts

The following accounts provide maps, trend information and where relevant, location details for all species recorded from Wales. Tables have been used to summarise locations. For reasons of space the following abbreviations have been used throughout: Designations: SI = Site of Special Scientific Interest (SSSI); N2K = Natura 2000 Site (Special Area of Conservation / SAC); NN = National Nature Reserve (NNR); Management: NRW = Natural Resources Wales; NT = National Trust; RSPB = Royal Society for the Protection of Birds; WT = Wildlife Trust; LA = Local Authority; MoD = Ministry of Defence; CC = Crown Estate; WR = Water Company.

Designations and Managers shown are the current status of the site and manager; they do not necessaruily reflect the designation status or management at the time of the record.

6.1. Hedgehog Stonewort (*Chara aculeolata* Kütz.)

Synonyms: *Chara pedunculata* Kütz.

Distribution:
C. aculeolata is endemic to Europe including fairly healthy populations in central Ireland (Bryant and Stewart 2011). In Britain it is Nationally Scarce.

In Wales it is now restricted to the Anglesey fens but there are also isolated historic records from Newborough Warren (Anglesey) the Llŷn Peninsula and Bosherston Lakes (Pembrokeshire). Modern records from Newborough Warren and Bosherston Lakes are unconfirmed.

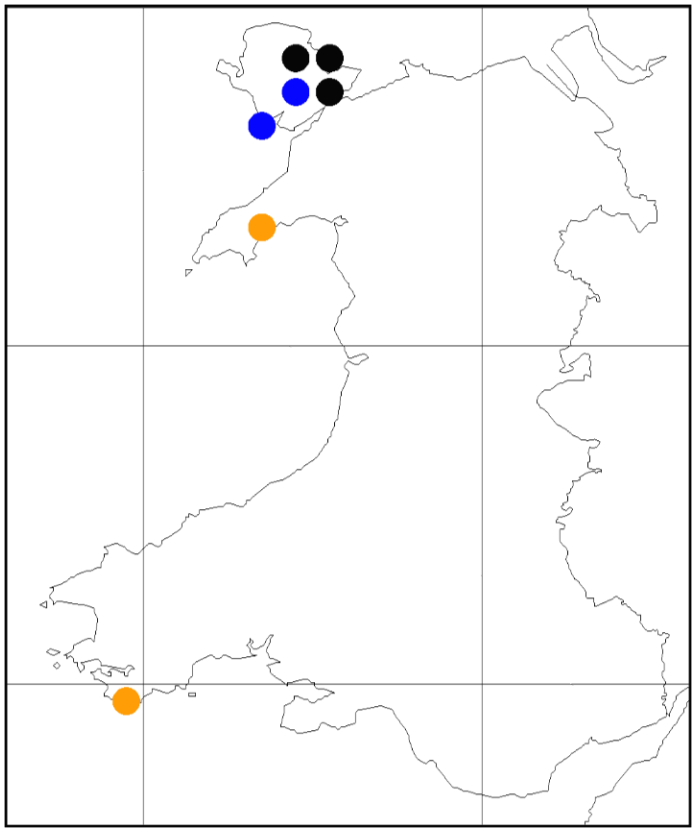

Figure 6.1.1. Welsh Distribution of *Chara aculeolata*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Yellow: last recorded pre 1969.

Occurrence:

Table 6.1 presents details of sites or populations from which this species has been confirmed in Wales: the date given is the year of the most recent record. Pink shading indicates probable losses based on surveys since the most recent record, grey shading indicates other sites with no records since 2007.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protected	Manager
Bosherston Lakes	45	Pembs.	SR99	1937	Marl lake	SI, N2K, NN	NRW, NT
Pwllheli	49	Caerns	SH33	1948	Unknown	No	Unknown
Newborough Warren	52	Anglesey	SH36	1996	Requires confirmation	Uncertain	Uncertain
Cors Bodeilio	52	Anglesey	SH500776	2014	Calcareous flushes	SI, N2K, NN	NRW
Near Plas Llanddyfnan	52	Anglesey	SH47	1962		Uncertain	Uncertain
Cors Erddreiniog	52	Anglesey	SH474822	2016	Calcareous flushes	SI, N2K, NN	NRW
Cors Goch	52	Anglesey	SH499814	2016	Calcareous flushes	SI, N2K, NN	WT
Upper Afon Braint	52	Anglesey	SH57	1798		No	Unknown

Table 6.1. Location details for *Chara aculeolata* in Wales.

Hectad Trend: This has always been a relatively rare species in Wales, occurring in fewer than 10% of hectads containing stoneworts. There appears to have been quite a marked decline during the 20th Century, with current occupancy being low but stable.

Figure 6.1.2. Long-term trend in the occurrence of *Chara aculeolata* in Wales.

Population Size:

C. aculeolata has been recorded from 3 sites in Wales within the last 10 years, with old records from 5 other sites (Table 6.1). In all the remaining sites, the populations are small, being restricted to a few flush systems and small pools and only a few

square metres in extent. Within these sites there have been some losses of sub-populations due to successional changes but other populations have been discovered and currently the populations seem to be stable.

Habitats and Ecology:

C. aculeolata occurs in shallow water up to 1m depth in alkaline, low nutrient pools and lakes, often associated with fen peat (Bryant and Stewart 2011). It usually occurs with other stonewort species and fen pondweed *Potamogeton coloratus.* In the Anglesey Fens it is more usually associated with calcareous flushes but it can also occur in pools and sheltered areas in lakes.

Threats:

Most present and historic sites are small water bodies in lowland wetlands which are vulnerable to succession and drainage. This has resulted in the loss of sub-populations at its extant sites and may well be the cause of loss from some of the historic sites.

C. aculeolata is also very sensitive to the secondary effects of nutrient pollution. This could be the cause of its loss from Bosherston Lakes and recent restoration measures have not resulted in its reappearance, although careful searching in the good quality, groundwater fed Central Arm may be worthwhile. Nutrient enrichment continues to be an issue at its remaining sites although there are ongoing attempts to isolate and redirect nutrient rich water coming from the surrounding land.

Conservation:

All three of the remaining sites are SSSIs, SACs and National Nature Reserves. Although populations appear to be stable, they are small and need ongoing monitoring and management. This includes:

- Continued grazing and/or mowing. Grazing is preferred as it breaks up any accumulated litter layer although this species can cope with litter better than some other species because of its size.
- Continued pond clearance and creation
- Isolation of raised nutrient inputs

The Anglesey Fens LIFE project has recently carried out management including pond and scrape creation and vegetation management which is likely to have benefited this and other stoneworts.

Of the historic sites;

- the “near Plas Llandyfnan” is most likely to be Cors y Farl and there is scope for pond clearance and grazing to improve the habitat for this species. Given the durability of stonewort spores there is a reasonable chance of recolonisation from the spore bank.
- the location at Newborough Warren is unknown and due to the large area it is only viable to keep an eye out for it during monitoring of the various ponds and other habitat creation work

- At Bosherston Lakes, steps were taken in the 1990s to isolate half of the lake system from nutrient enrichment. However, the vegetation has not yet fully recovered in the restored parts and its reappearance is still possible. It is possible that the species still grows among the dense beds of *C. hispida* in the Central Arm.
- At Pwllheli and upper Afon Braint, the details of the historic sites are too vaguely localised to recommend any action. However, the former could refer to Cors Geirch and there is scope for further survey in that area.

Red List Assessment:	**EN (B2a)**

Assessment Rationale:

C. aculeolata has certainly declined in Wales but much of this is historical (pre-1970s). It now has a very restricted distribution on only three sites and therefore qualifies as Endangered.

The remaining sites are nature reserves where active management is ongoing. Although, there have been some losses of sub-populations, there have also been some new sub-populations discovered and overall the situation seems to be stable at the moment. Nevertheless, the remaining populations are small and dependant on continued management. Active measures are needed to re-establish extinct populations to increase the resilience of the species in Wales.

6.2. Rough Stonewort (*Chara aspera* Deth. ex Willd.)

Distribution:

C. aspera occurs in Europe, Turkey, Bangladesh, North Africa and North America (Guiry 2017); in the British Isles it is most frequent in central and western Ireland, and the Hebrides, Orkney and Shetland in Scotland (Bryant and Stewart 2011) but it is widely scattered and declining elsewhere. In Wales it is/was most frequent on Anglesey and near the coast elsewhere. There are six recent sites in Anglesey, Ceredigion and Glamorgan. There are three further sites in Anglesey and Glamorgan recorded in the 1990s, at least two of which have been surveyed since without success. There are a further seven historic sites in Anglesey, Gwynnedd, Flintshire, Carmarthenshire and Glamorgan but it has not been seen in any of these for over 80 years.

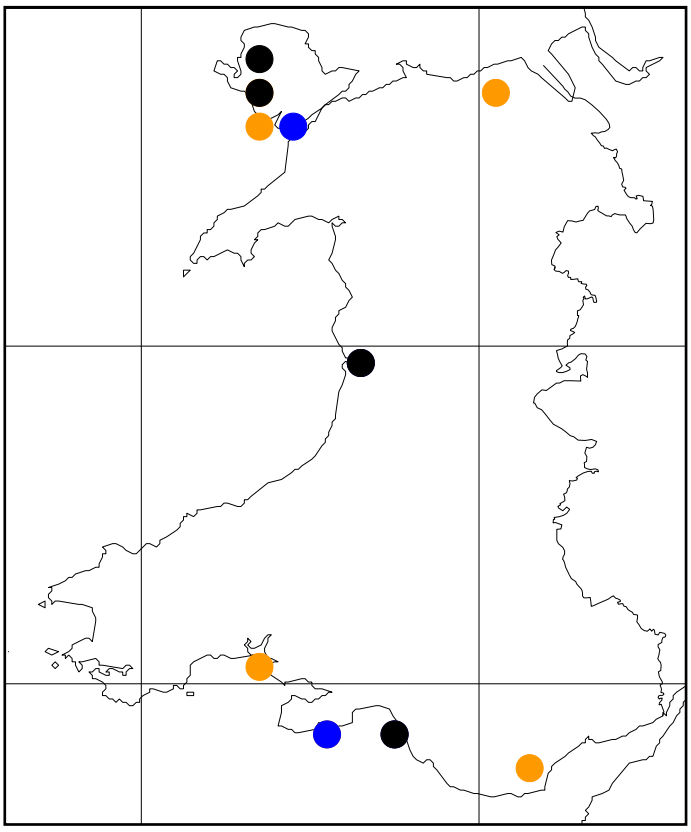

Figure 6.2.1. Welsh Distribution of *Chara aspera*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Yellow: last recorded pre 1969.

Occurrence:

The table below presents details of sites or populations from which this species has been confirmed in Wales, the date given is the year of the most recent record. Pink shading indicates probable losses based on surveys since the most recent record, grey shading indicates other sites with no records since 2007.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protected	Manager
Oxwich Burrows	41	Glam.	SS503872	1996	Pool in bog	SI, NN	NRW
Kenfig Pool	41	Glam.	SS797817	2016	Lake	SI, N2K, NN	LA
Kenfig Burrows	41	Glam.	SS789811	2016	Dune pools	SI, N2K, NN	LA
Margam Burrows	41	Glam.	SS779842	1996	4 dune pools	No	
Eglwys Nunnydd Reservoir	41	Glam.	SS794854	2016	Reservoir	Yes	Private
Penarth Head	41	Glam.	ST17	1870	Brackish pool	No	Unknown
Gwendraeth Canal	41	Glam.	SN30	1846	Canal	No	Unknown
Ynyslas Dunes	46	Ceredigion	SN610939	2007	Dune slack pool	SI, N2K, NN	NRW
Caernarfon-shire	49	Gwynedd		<1880		No	Unknown
Cwm	51	Flintshire	SJ07	1901		No	Unknown
Llyn Coron	52	Anglesey	c.SH36	1937	Lake	SI, N2K	Private
Cleifiog Farm	52	Anglesey	SH37	1834	Peat pits	No	Unknown
Llyn Hendref	52	Anglesey	SH37	<1895	Lake	No	Unknown
Llyn Dinam	52	Anglesey	SH310775	2009	Lake	SI, N2K	RSPB
Llyn Traffwll	52	Anglesey	SH325769	2011	Lake	SI	RSPB
Llyn Llygeirian	52	Anglesey	SH346897	2014	Lake	SI	Private
Llyn Rhos-ddu	52	Anglesey	SH426649	1996	Small lake	SI, N2K, NN	NRW

Table 6.2. Location details for *Chara aspera* in Wales.

Hectad Trend: There has been a marked decline in the occurrence of this species over the 20th Century with some evidence of an ongoing decline more recently.

Population Size:

There is a large population at Kenfig Pool with small outlying populations in dunes in Kenfig Burrows and Margam Burrows nearby. LEAFPACS data shows a marked decline in population size at Kenfig Pool, equivalent to a decline of about 40% in the last decade (Figure 6.2.3). If the population continues on its current trajectory, it will have declined by a further 69% in the next decade and be extinct by around 2032.

Several of the recent sites are lakes which have only been sample-surveyed but the current information suggests that the populations are/were very localised in these

sites. At Ynyslas it is only known from a single dune slack pool. Only isolated specimens or tiny populations have been found on the Anglesey lakes.

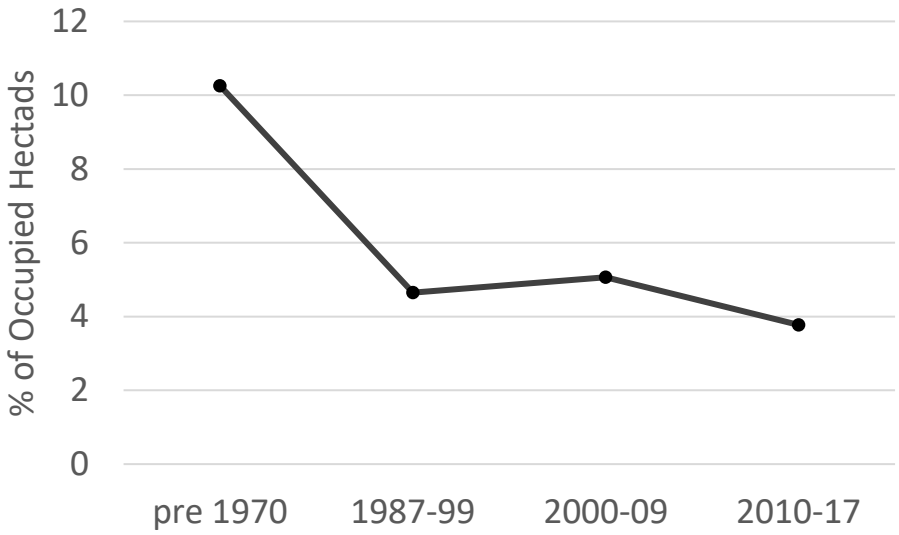

Figure 6.2.2. Distribution Trend of *Chara aspera*.

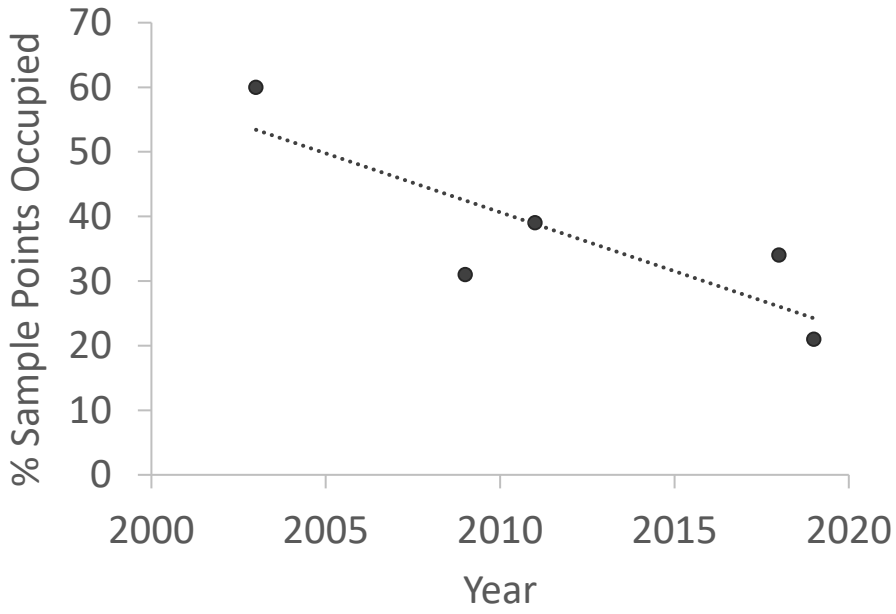

Figure 6.2.3. Population Trend of *Chara aspera* at Kenfig Pool.

Habitats and Ecology:

C. aspera typically occurs in calcareous lakes, pools and ditches, often on marl or sand. It is tolerant of mildly brackish water, sometimes forming extensive beds in dune pools and sandy lakes (Bryant and Stewart 2011). It most often occurs in shallow water up to 1 metre depth but can sometimes form beds in deeper water

Threats:

The primary concern for this species is the secondary effects of nutrient enrichment, through increased turbidity and increased competition from larger vegetation and algae. It has a preference for sand and clay substrates and can also be affected by the increase in organic deposition in more enriched systems. However, its ability to withstand wave-wash means that it can persist in the shallows where turbulence disperses the organic sediment while these remain unshaded by trees or uncolonised by swamp communities.

Nutrient issues are likely to have been the cause of loss from Llyn Coron, Llyn Hendref, Oxwich Burrows, Llyn Rhos-ddu and possibly other historic sites. In the case of Llyn Rhos-ddu the arrival of the invasive *Elodea nuttallii* may also have been a contributing factor.

Several Welsh sites are in dune pools where the main threat is natural succession to swamp and carr, particularly because of the small size of populations.

Conservation:

Four of the five recent sites have SSSI status and some have other legal designations. *Chara aspera* is a key species for the Habitats Directive lake habitat H3140 'Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.' and therefore is one of several species which receives conservation management focus in this water body type. Kenfig Pool is a particularly important example and is overwhelmingly the largest population of *C. aspera* in Wales.

However, there are concerns at several of these sites, particularly from nutrient enrichment.

Lake sites;

- Measures to reduce nutrient inputs are needed, particularly at Llyn Llygerian, Llyn Dinam, Llyn Traffwll and Llyn Rhos-ddu. Although it has not been seen at the last of these for 20 years, improved nutrient levels could result in its reappearance
- Some survey is needed at Llyn Llygerian, Llyn Dinam, Llyn Traffwll, and Eglwys Nunnydd Reservoir to assess the extent of the populations. Llyn Rhos-ddu also needs revisiting to attempt to relocate the population there.

Dune slack sites:

- Periodic clearance may be needed to maintain the population at Ynyslas and Kenfig Burrows. Extensive mobilisation works have been carried out at Kenfig as part of the Sands of Life LIFE+ project and this is likely to benefit this and other stoneworts.
- The Margam Burrows needs revisiting to assess whether the species is still present and whether any pond clearance is needed. This site is surrounded by land reclamation associated with Port Talbot steelworks but examination of aerial photographs suggests that this has not encroached further in the area where the species occurred since it was last recorded in the 1990s.

Red List Assessment:	**EN (A3b,c, B2a, b(iii,iv))**

Assessment Rationale: This species is currently known from 5 localities with an additional 3 losses or apparent losses in the last 20 years, and a general trend towards a longer-term decline. Ongoing concerns of nutrient enrichment remain an issue at some of the remaining sites. Probably more than 90% of the Welsh population is at Kenfig Pool where it is on a steep downward trajectory and threatened by invasive *Elodea* spp. and illegal carp introduction.

6.3. Baltic Stonewort (*Chara baltica* Bruz.)

Synonyms: *Chara hispida* L. var. *baltica* (Bruz.) R.D. Wood

Taxonomic Note:

Records of *C. baltica* from Anglesey may involve a species not previously recorded in the British Isles and need further investigation (Bryant and Stewart 2011).

Distribution:

C. baltica occurs in the Baltic Sea and northern Atlantic Europe, in the British Isles it is local in the Outer Hebrides in Scotland, Norfolk, Anglesey and Co. Galway in Ireland.

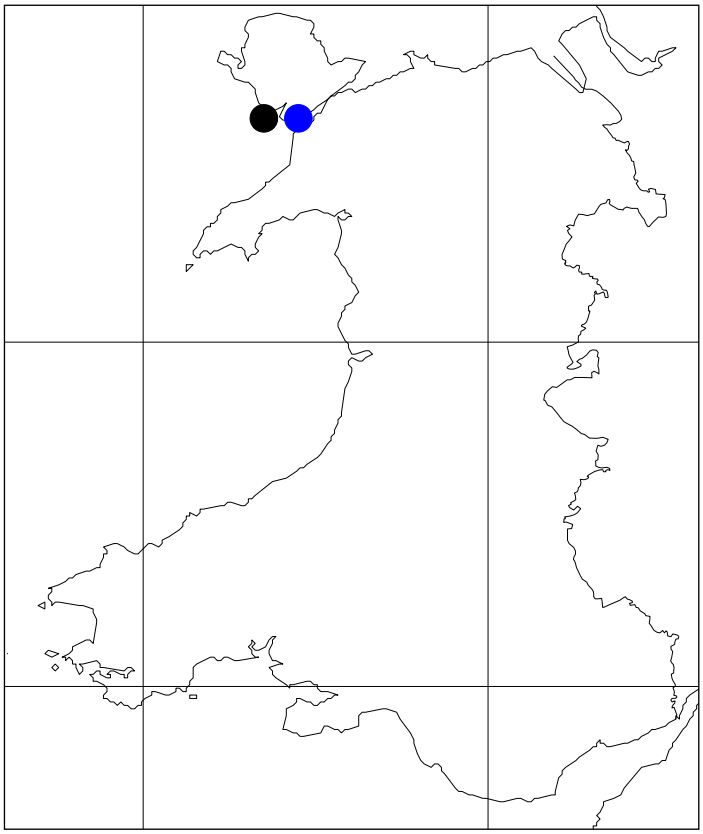

Figure 6.3. Welsh Distribution of *Chara baltica*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999.

Occurrence:

Table 6.3 presents details of sites from which this species has been confirmed in Wales, the date given is the year of the most recent record. Pink shading indicates probable losses based on surveys since the most recent record, grey shading indicates other sites with no records since 2007.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protection	Manager
Newborough Forest, northern Canada Pool	52	Anglesey	SH392648	2004	Pond	SI, N2K, NN	NRW
Newborough Forest, Dune Slack Pool	52	Anglesey	SH397651	2011	Pond	SI, N2K, NN	NRW
Newborough Warren, 110 Acre Pond	52	Anglesey	SH428643	1996	Pond	SI, N2K, NN	NRW

Table 6.3. Location details for *Chara baltica* in Wales.

This species is only known from a single site, Newborough Warren.

Population Size:

Chara baltica occurs in only a single locality with three subpopulations, all of which are very small. This species has been recorded from 3 ponds but has not been seen in any of these since 2011. The ponds were surveyed in April 2016 without success but the survey was hampered by very high water levels. It is therefore not possible to assess whether it is still present, particularly as two of the ponds still retain a rich charophyte flora, including the similar *Chara hispida*.

Habitats and Ecology:

C. baltica occurs in lakes and pools near the sea, usually in mildly brackish water (Bryant and Stewart 2011). The Anglesey populations (which may not be true *Chara baltica*) are/were in ponds in a calcareous sand dune system. All three have fluctuating water that probably dry out for a period in late summer in most years.

Threats:

The main threat to this species is successional changes to swamp and carr but the fluctuating water level limits the swamp colonisation. The habitat appears to be still suitable and the reasons for the apparent loss of this species need further study.

Conservation:

The Anglesey sites are within a National Nature Reserve and Special Area for Conservation. The 110 Acre Pond was extended around 2000 but it was not refound there in a survey in 2004. However, further survey is needed in late spring when the ponds are shallow but still with water to assess whether the species is still present .

Red List Assessment:	**CR (PE) (B1a, b, c, B2a, b)**

Assessment Rationale: This species is restricted to a single site where three small populations have been recorded. However it has not been seen in one pond since

2004 and another since 1996. Although further survey is needed there are concerns as to whether it is still present.

6.4. Opposite Stonewort (*Chara contraria* A.Braun ex Kütz.)

Synonyms: *Chara vulgaris* L. var. *contraria* (A.Braun ex Kütz.) J.A. Moore

Distribution:

Chara contraria has a more or less cosmopolitan distribution. In Britain it is occasional to locally-frequent in south-eastern England, particularly in the Thames Valley and East Anglia and it becomes rarer westwards and northwards (Bryant and Stewart 2011). In Wales it is particularly associated with areas with limestone geology and calcareous sand dunes. It is therefore most frequent in the Anglesey fens and the dunes along the south Welsh coast but there are scattered records elsewhere.

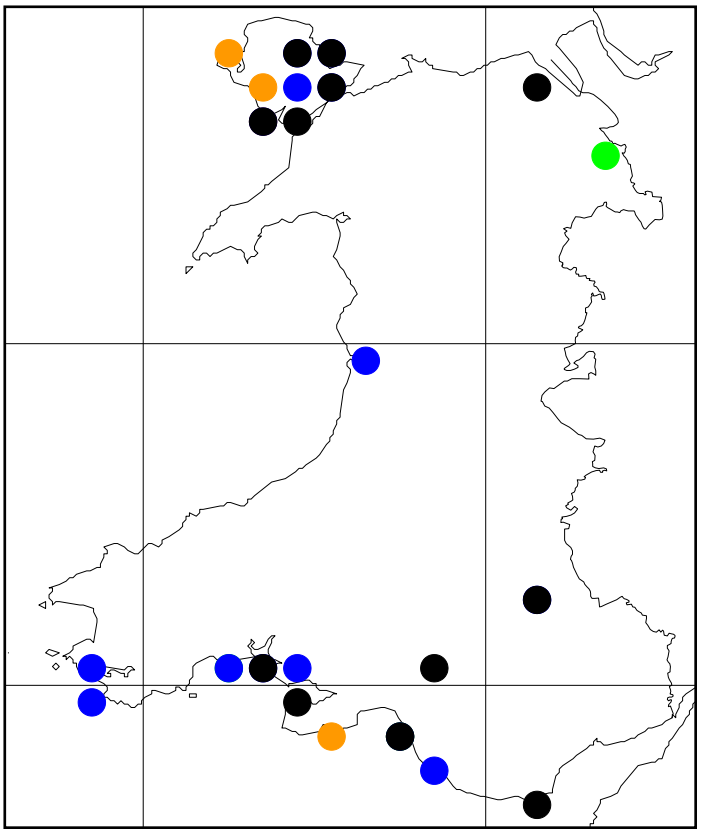

Figure 6.4. Welsh Distribution of *Chara contraria*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Green: 1970-1986; Yellow: last recorded pre 1969.

Occurrence:

Table 6.4 below summarises the hectads from which this species has been confirmed in Wales. This species appears to have increased markedly over the course of the 20th Century, though this trend seems to have ceased and may be reversing.

Hectads confirmed since 2000	12
Post 1986 hectads not confirmed since 2000	7
Post 1970 hectads not confirmed since 1986	1

Older hectads not confirmed since 1970	3

Table 6.4. Summary of the status of *Chara contraria* in Wales.

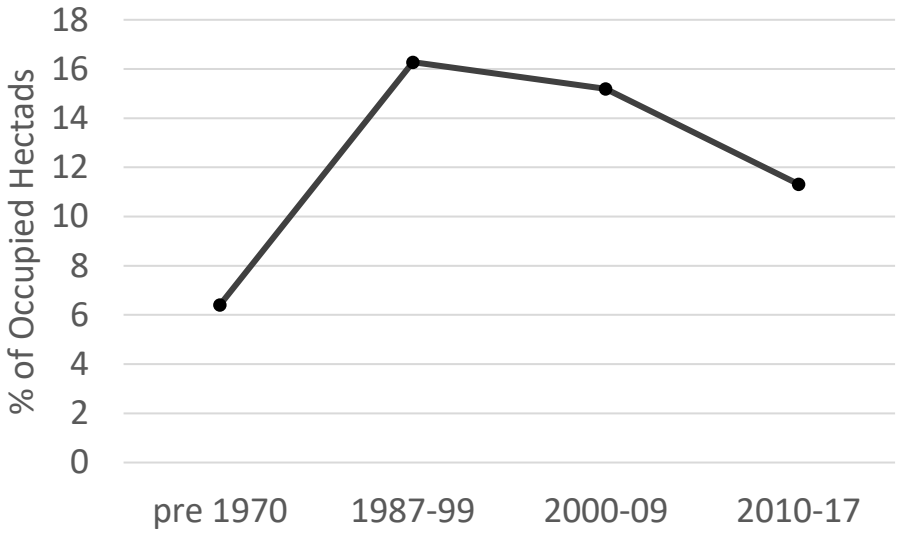

Figure 6.4.2. Trend in the distribution of *Chara contraria*.

Many of the records in the 1987-2000 category are from sand dunes which have received rather less survey attention in recent years. Most are thought likely to be still present.

Habitats and Ecology:

C. contraria occurs in a wide range of calcareous water bodies, with a greater preference towards lakes compared to its more common relative *C. vulgaris*. It prefers marly or sandy substrates and will occur in some clay-pit systems. It is particularly prominent as an early pioneer in new water bodies but gradually declines with increasing vegetation and higher organic accumulation in the sediment. However, it often persists in the shallow edges where wave-wash keeps the habitat more open. In alkaline lakes it can form extensive beds in deep water but often in this situation it can become replaced by *Elodea* species, as at Llangorse Lake. It also frequently occurs in small water bodies where it often grows in the shallower edges which dry out for for part of the year. For example in dune slacks it can occur with *Tolypella glomerata* in areas where there is less vegetation in winter flooded slacks as well as in more permanent pools.

Threats:

C. contraria is less sensitive to nutrient pollution than many stoneworts, and the records suggest only a relatively small decline. In sand dunes and calcareous fen pools it is also vulnerable to natural successional changes to swamp and carr.

Conservation:

There is no conservation in place specifically for this species and none needed.

Red List Assessment:	LC

Assessment Rationale:

Although there may have been some decline, this species is still widespread and sometimes frequent in suitable habitats. It is therefore classed as Least Concern.

6.5. Lesser Bearded Stonewort (*Chara curta* Nolte ex Kütz.)

Synonyms: *Chara aspera* Kütz. var. *curta* (Nolte ex Kütz.) A.Braun ex Leonh.

Distribution:

This species has its main world stronghold in Britain and Ireland, but it also occurs in Germany and Sweden and possibly elsewhere in Europe where it may have been overlooked or not differentiated from *C. aspera*. It is occasional in central and western Ireland, and is Nationally Scarce but widely scattered in Britain. In Wales it occurs in the Anglesey fens and in the dunes around Carmarthen Bay but there is also an old record from Pembrokeshire.

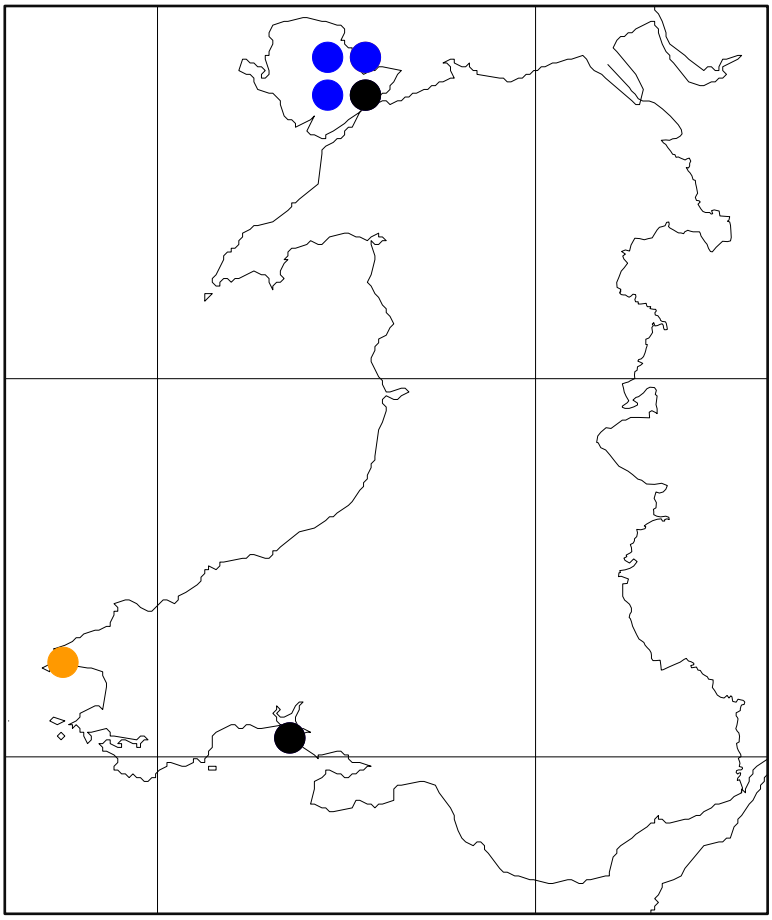

Figure 6.5.1. Welsh Distribution of *Chara curta*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Yellow: last recorded pre 1969.

Occurrence:

Table 6.5 presents details of sites from which this species has been confirmed in Wales, the date given is the year of the most recent record. Pink shading indicates probable losses based on surveys since the most recent record, grey shading indicates other sites with no records since 2007.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protection	Manager
Laugharne Burrows	44	Carms	SN305073	1986	Sand dune ditch	Yes	MoD
Pembrey Coast A	44	Carms	SN397007	1996	Sand dune pond	No	NRW
Pembrey Coast B	44	Carms	SN373038	2003	Sand dune pond	No	MoD
Pembrey Coast C	44	Carms	SN390015	2003	Sand dune pond	No	NRW
Pembrey Coast D	44	Carms	SN376037	2005	Sand dune pond	No	MoD
Trefeiden Moor	45	Pembs	SM72	1914	Pond	SI, N2K	Unknown
Malltraeth Marsh	52	Anglesey	SH451713	1998	Fen scrape	SI	RSPB
Cors Goch A	52	Anglesey	SH496813	1991	Fen pools	SI, N2K, NN	WT
Cors Goch B	52	Anglesey	SH500815	1991	Fen pools	SI, N2K, NN	WT
Cors Bodeilio A	52	Anglesey	SH502775	2016	Fen pond	SI, N2K, NN	NRW
Cors Bodeilio B	52	Anglesey	SH502774	2012	Fen pond	SI, N2K, NN	NRW
Llyn Bodgylched	52	Anglesey	SH5877	1885	Small lake	SI	Private

Table 6.5. Location details for *Chara curta* in Wales.

Figure 6.5.2. Trend in the distribution of *Chara curta*.

Population:

C. curta occurs in two main areas in Wales: in the Anglesey Fens (especially Cors Bodeilio) and Pembrey Dunes. At Cors Bodeilio it occurs in several interconnected ponds: in one it has persisted for over 20 years but is beginning to be encroached by swamp. The other is a new pond where only a few plants were seen among other stoneworts in 2012 but it was not refound in 2014. It has also been recorded from 4 ponds and a ditch in the Pembrey area. Attempts to refind it at Cors Goch and Malltraeth Marsh since the 1990s have been unsuccessful.

Habitats and Ecology:

This is a plant of calcareous mesotrophic water on peaty, sandy or marly substrates. It occupies a similar range of habitats to *C. aspera* but requires harder water and it is intolerant of salinity. It is often associated with a rich diversity of other aquatic species including other stonewort species. It is found in limestone lochs, calcareous clay and gravel pits and fen pools, sand dune pools and ditches. It frequently grows on sand in fairly shallow water and may become beached when water levels drop in summer. In this habitat it is probably a summer annual, spreading by bulbils or spores. In limestone lakes it occurs in depths up to 4.5 m and forms dense beds which are probably perennial (Stewart and Church 1992).

In Wales *C. curta* is only known from small ponds in fens and sand dunes and has only once been recorded from lakes in the 19th century. Two historic sites (Malltraeth Marsh and Trefeiddan Moor) seem more acidic than typical for this species but the populations seem to have occurred where there was a local more calcareous influence.

Threats:

The main threat is from succession to swamp and carr. This is thought to have been the cause of losses from Laugharne Burrows, Trefeiddan Moor and Cors Goch. In the latter, nutrient enrichment is thought to be a contributing factor as the colonies were close to the main arterial ditch. The historic site at Llyn Bodgylched has also been impacted by nutrient enrichment.

Conservation:

All current and historic sites are SSSIs and many have other conservation designations. Pond clearance has recently (2017) been undertaken in connection with the Freshwater Habitats Trust's Million Pond Project at Cors Bodeilio and Malltraeth Marsh but the results of this are not yet known.

Chara curta is a key species for the Habitats Directive lake habitat H3140 'Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.' and therefore is one of several species which could receive conservation management focus in this water body type. However, most of the locations in which it occurs in Wales do not match this habitat type.

There is a need for further survey at Cors Goch to assess possible locations for pond clearance/creation in the vicinity of the former locations.

Red List Assessment:	**EN (B2a, b)**

Assessment Rationale:

Assuming that it is still present at Pembrey Coast, *Chara curta* is now restricted to two sites and there is evidence of a continuing decline. Although both locations are protected, populations at both sites are small and vulnerable to succession.

6.6. Fragile Stonewort (*Chara globularis* Thuill.)

Synonyms: *C. fragilis* Desv., *C. globularis* Thuill. var. *globularis* sensu Moore (1986).

Taxonomic Note:

Records for this species (as *C. fragilis*) before 1924 should be treated with considerable caution as *C. virgata* was included as a variety of this species until that time. There is a need for a complete revision of available historic voucher specimens. In more recent times a similar problem has occurred due to *Chara globularis* sensu Moore again including *C. virgata* as a variety.

Distribution:

C. globularis is probably cosmopolitan. In Britain it is fairly frequent in southern and eastern England but becomes rarer westwards and northwards. In Wales it is occasional and most frequent in Anglesey and along the eastern side of the country but there are a few records elsewhere.

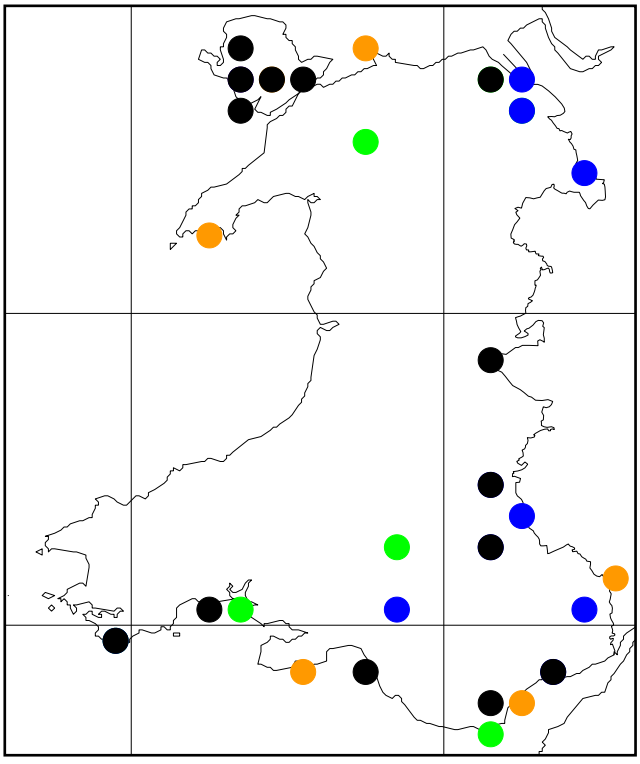

Figure 6.6.1. Welsh Distribution of *Chara globularis*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Green: 1970-1986; Yellow: last recorded pre 1969.

Occurrence:

Table 6.6 presents a summary of the hectads from which this species has been confirmed in Wales.

Hectads confirmed since 2000	14

Post 1986 hectads not confirmed since 2000	6
Post 1970 hectads not confirmed since 1986	4
Older hectads not confirmed since 1970	5

Table 6.6. Summary of the status of *Chara globularis* in Wales.

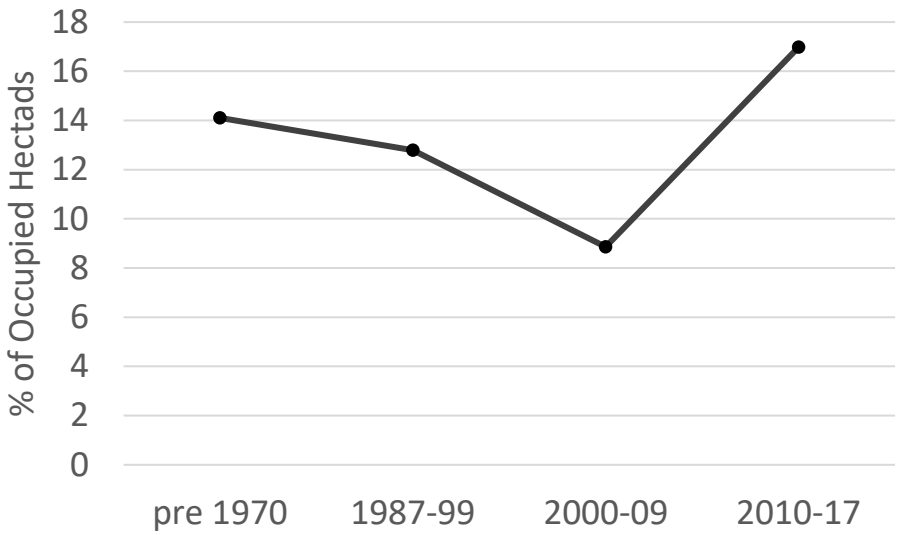

Figure 6.6.2. Trend in the distribution of *Chara globularis*.

Many historic records probably belong to *C. virgata,* so there may be an even more marked increasing trend. The populations vary considerably in size and density but there are some strong populations e.g. at Llangorse Lake (Powys) and in the Valley Lakes (Anglesey).

Habitats and Ecology:

C. globularis is recorded from permanent pools and lakes, often in water greater than 1m depth. It sometimes occurs in sand dunes but only the more permanent pools. In certain conditions, particularly in alkaline water, it can form dominant stands but it more frequently occurs mixed with other stoneworts or vascular plants. It is apparently restricted to calcareous and moderately nutrient-rich habitats.

Threats:

This species seems to be less sensitive to nutrient enrichment compared to most stoneworts and there are several examples where it has managed to persist in lakes with unstable vegetation due to elevated nutrient levels (e.g. Llyn Penrhyn , Anglesey; Llangorse Lake, Powys). It is also one of the few stonewort species to occur in the Gwent Levels ditch system. Nevertheless, it is still sensitive to the secondary effects of higher levels of nutrient enrichment. Its preference for deeper water also means that it is outcompeted by dense growths of *Elodea* species.

Conservation:

There is no conservation in place specifically for this species and none needed. *C. globularis* is a common species in lowland lake SSSIs and probably has benefited from general habitat conservation measures.

Red List Assessment:	**LC**

Assessment Rationale: This species is still quite common in suitable habitats and is frequent in some sites; it is therefore classed as Least Concern. Although there have been some losses, the overall trend appears to be stable.

6.7. Bristly Stonewort (*Chara hispida* L.)

Distribution:

C. hispida occurs in Europe, Siberia and North Africa. In Britain it is occasional to locally frequent in the south-east and midlands but rare elsewhere (Bryant and Stewart 2011). In Wales it is restricted to areas with calcareous geology and coastal sand dunes, particularly in Anglesey and the south coast dunes.

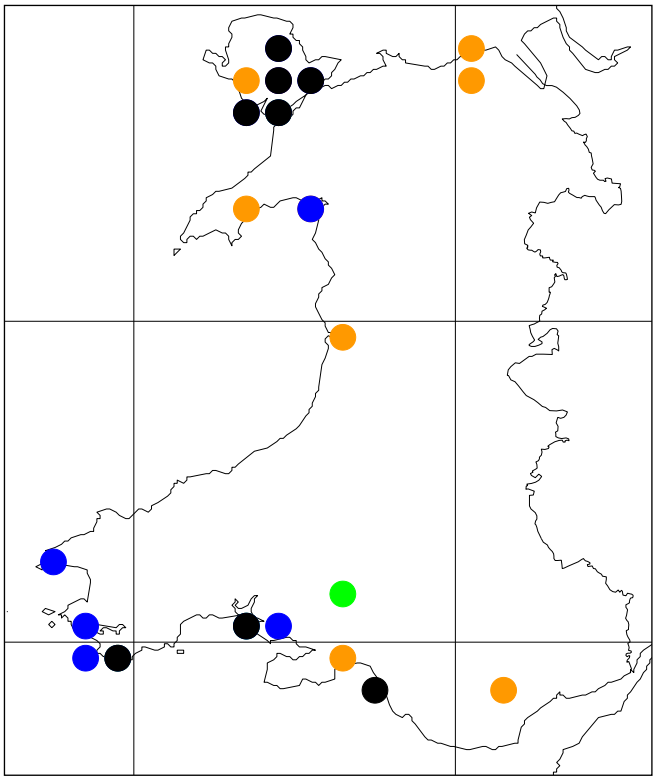

Figure 6.7.1. Welsh Distribution of *Chara hispida*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Green: 1970-1986; Yellow: last recorded pre 1969.

Population Size:

Table 6.7 below presents a summary of the locations from which this species has been confirmed in Wales. There are at least four strong populations: at Bosherston Lakes, Pembrokeshire, and three sites on Anglesey: Cors Bodeilio, Cors Erddreiniog and Newborough where it occurs in multiple ponds. There is also a recent record for a dune slack pool at Traeth Llydan near Rhosneigr.

There is considerable uncertainty regarding the status of many populations as a number have not been surveyed since the 1990s, especially in dune systems. Most of these populations were recorded in dune slacks or ponds; many are likely to have been small.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protection	Managed
Glamorgan Canal	41	Glamorgan	ST18	1943	Canal	SI	LA
Kenfig Burrows	41	Glamorgan	SS7980	2004	Dune pool	SI, N2K, NN	LA
Pembrey Coast A	44	Carmarthen-shire	SN4101	1998	Sand dune pond	No	NRW
Pembrey Coast	44	Carmarthen-shire	SN3704	2003	Sand dune pond	No	MoD
Pistyll Pond	44	Carmarthen-shire	SN6216	1979	Calcareous Pond	No	Private
Bosherston Lakes	45	Pembroke-shire	SR9794	2017	Shallow alkaline lakes	SI, N2K, NN	NRW / NT
Brownslade Burrows	45	Pembroke-shire	SR8998	1998	Dune pool	SI, N2K	MoD
Broomhill Burrows	45	Pembroke-shire	SM8900	1996	Dune pool	SI, N2K	NT
Pwll Trefeiddan	45	Pembroke-shire	SM7325	1998	*Menyanthes* swamp	SI, N2K	Private
Ynyslas Dunes	46	Cardigan-shire	SN69	1938	Pond	SI, N2K, NN	NRW
Morfa Harlech	48	Merioneth-shire	SH5634	1998	Dune slack	SI, N2K, NN	NRW
Pwllheli	49	Carnarvon-shire	SH33	1949	Unknown	No	Unknown
Brickfields Pond	51	Flintshire	SJ07	1910	Clay pits	No	Unknown
Cors Bodeilio	52	Anglesey	SH5077	2016	Fen ponds	SI, N2K, NN	NRW
Cors Erddreiniog	52	Anglesey	SH4782	2016	Fen ponds	SI, N2K, NN	NRW
Cors y Farl	52	Anglesey	SH4978	2003	Fen pool	SI, N2K, NN	NRW
Llyn Dinam	52	Anglesey	SH37	1895	Shallow alkaline lake	SI, N2K	RSPB
Newborough	52	Anglesey	SH4065	2016	Dune slack / forest ponds	SI, N2K, NN	NRW
Rhos y Gad	52	Anglesey	SH5178	2003	Swamp in fen	SI, N2K, NN	NRW
Traeth Llydan	52	Anglesey	SH3272	2009	Dune slack	No	Private

Table 6.7. Summary of the status of *Chara hispida* in Wales.

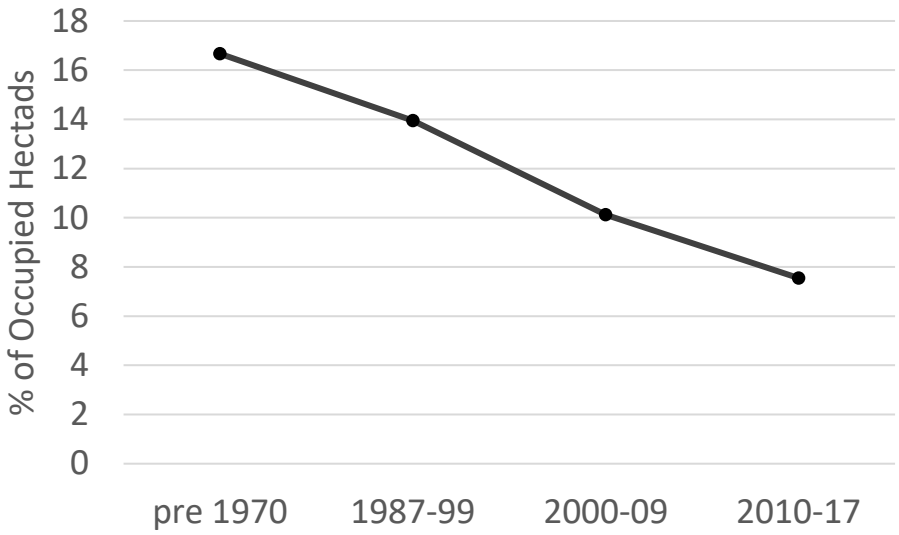

Figure 6.7.2. Trend in the distribution of *Chara hispida*.

Chara hispida has approximately halved in distribution since the 1970s and continues to show a declining trend. The largest population, at Bosherston Lake, is also declining due to nutrient increases, competition with invasive *Elodea* spp, and climate change (Davidson *et al*. 2002; Haycock and Hinton 2010; Hatton-Ellis and Culyer 2012; Hatton-Ellis 2016), and since 2007 survey data indicates that cover in the Central and Western Arms, the main remaining population, has dropped by 59%. This site is also threatened by sea level rise (Holman *et al*. 2009).

Most of the records in the 1987-2000 category are small populations in coastal sand dunes which have received less survey attention in recent years. It is likely that some are still present.

Habitats and Ecology:

C. hispida occurs in calcareous pools, lakes and ditches and often occurs in sites with a good diversity of other aquatic plants. There is an especially large population at Bosherston Lakes which may well exceed the total at all other Welsh sites combined. It often forms dense perennial beds which can out-compete other aquatic vegetation but also occurs as scattered plants in mixed vegetation, including seasonally inundated fenland. It is most frequent in deeper water beyond 75 cm but also often occurs in shallower water and can tolerate habitats which dry out for short periods.

Figure 6.4.3. *Chara hispida*, Bosherston Lakes Central Arm, Pembrokeshire, 2017. Photo: ENSIS Ltd for NRW.

Threats:

C. hispida is sensitive to nutrient pollution and this is probably the main cause of loss from historic sites and ongoing population reduction. In sand dune sites it often occurs in small ponds which are subject to successional changes to swamp and carr.

Conservation:

Chara hispida is a key species for the Habitats Directive lake habitat H3140 'Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.' and therefore is one of several species which receives conservation management focus in this lake type (e.g. Bosherston Lakes).

In fen and dune sites it does not receive specific management focus but nevertheless benefits from SSSI and / or SAC protection and management (for example, dune remobilisation work in the Sands of Life project, or pond construction in the Anglesey Fens LIFE project). Measures to control and reduce nutrient enrichment pollution, manage invasive species and generally improve the quality and resilience of these important conservation sites should be encouraged.

Red List Assessment:	**VU (A2a, B2ab)**

Assessment Rationale:

Chara hispida is probably the most widespread and tolerant of the more specialist *Chara* species in Wales, and many sites that support this species also support one or more of the rarer taxa. Monitoring at Bosherston Lakes, the largest population, indicates that the stonewort population has recently declined by almost 60%, in addition to longer-term declines.

The uncertainty around the data makes it more difficult to assess this species. It is certainly present in at least five sites, but the status of a further ten is uncertain. On balance it is considered likely that at least some of the sites that have not recently been surveyed are no longer extant and therefore that the species also qualifies under criterion B2a.

6.8. Rugged Stonewort (*Chara rudis* (A.Braun) Leonh.)

Synonyms: *Chara hispida* L. var. *rudis* A.Braun

Taxonomic Note: The correct name for this species should be *Chara subspinosa* Ruprecht, but this name is not yet widely used in western Europe and was not adopted by Bryant & Stewart (2011). We have therefore used *C. rudis* in this publication.

Distribution: *C. rudis* occurs in Europe and Western Asia; it is occasional in central and western Ireland but rare in Britain and is considered Near Threatened. In Wales it has been recorded from 2 sites on Anglesey but was thought to be extinct until it reappeared in Llyn Cadarn in 2013 where it had been last seen in 1937, despite several surveys in 1990s and 2000s.

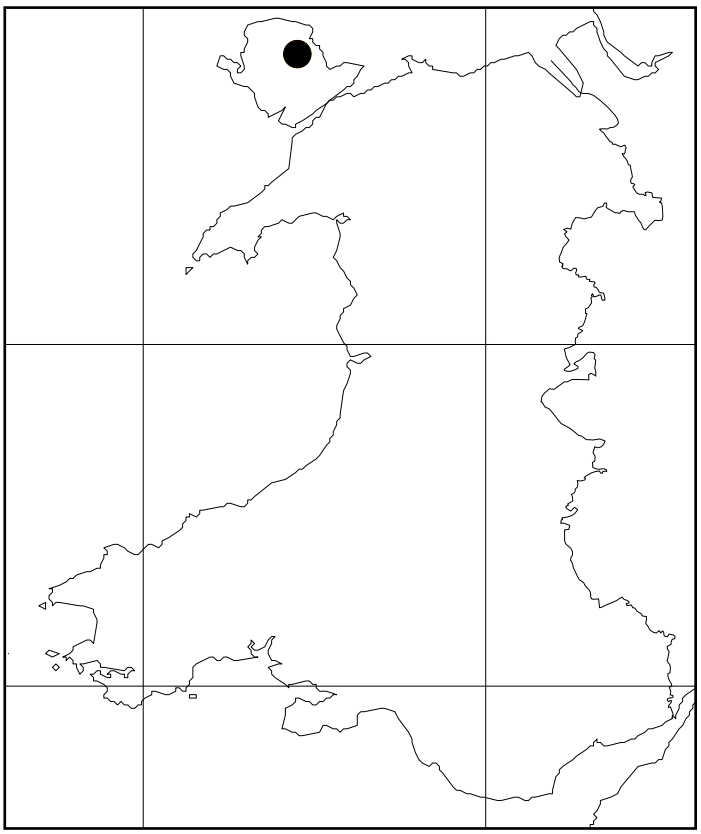

Figure 6.8. Welsh Distribution of *Chara rudis*.

Occurrence: The table below presents details of sites from which this species has been confirmed in Wales, the date given is the year of the most recent record. Pink shading indicates probable losses based on surveys since the most recent record, grey shading indicates other sites with no records since 2007.

Site Name	Vice County		Grid Ref.	Year	Habitat	Protected	Manager
Llyn yr Wyth Eidion	52	Anglesey	SH48	1885	Marl Lake	SI, N2K, NN	NRW
Llyn Cadarn	52	Anglesey	SH491811	2016	Marl Lake	SI, N2K, NN	WT

Table 6.3. Location details for *Chara rudis* in Wales.

Population:

This species was only noted at a single transect during monitoring of Llyn Cadarn in 2014 and 2016 (LEAFPACS cover score 0.06) (Goldsmith *et al*. 2015; Shilland *et al*. 2017). Given the small size of the lake, the population is evidently very small, consisting of only a few plants. In the latest survey (2018) it was not refound but it is likely that a viable spore bank still exists.

Habitats and Ecology:

This species grows mainly in alkaline fresh waters at depths of up to 7 metres, where it can forms dense tangled stands. It will grow in large or small lakes, abandoned peat cuttings and slowly running water. It also very rarely occurs in shallow pools or ditches but probably never in sites that dry out periodically. It can, however, grow in fairly shallow water at the edge of large water bodies, though normally below the turbulent shore zone.

Chara rudis is a perennial species and spores can be produced throughout the year. In Britain it appears to be restricted to very clean water but in Ireland seems to have a greater tolerance of pollution. It avoids brackish conditions and is very rare near the coast (Stewart and Church 1992).

Threats:

At both Welsh lakes, a dramatic change occurred in the 1850s that caused an ecological switch from stonewort-dominated to more nutrient-rich, fine-leaved pondweed and then *Fontinalis* dominated habitats as today (Davidson *et al*. 2009; Goldsmith *et al*. 2013). This is thought to be due to attempts to drain the fens resulting in changes to the hydrological regime and in particular switching the water source from mineral rich groundwater to circumneutral surface water richer in nutrients and silt.

Both the current and historic Welsh sites have been significantly affected by nutrient enrichment, despite the fact that both are highly protected (SAC, SSSIs and NNR). However, its reappearance at Llyn Cadarn may be due to improved water quality. This lake also receives surface water from a nearby quarry that is likely to reduce its suitability for *C. rudis*.

Conservation:

The main priority at both its sites is reinstating suitable water quality. It is likely that the current water supply is both too base-poor and too nutrient-rich (Davidson *et al*.

2009; Goldsmith *et al*. 2013). As a result, both lakes are currently dominated by *Fontinalis antipyretica*. Cutting back of marginal floating fen vegetation could also provide shallow water refugia for *C. rudis* where cleaner water seepage from the adjacent fen can buffer the higher nutrient levels in the open water, and where low light levels due to phytoplankton and peat discolouration will not be a problem.

Although it has not been seen in Llyn yr Wyth Eidion for over 130 years, it is still possible that it could reappear from the spore bank if restoration works are carried out. A LIFE project in 2012-2014 has reduced one of the main nutrient sources feeding the lake. A key action will be the diversion of the main surface water inflow (Goldsmith *et al*. 2013). Potentially, pumping of nutrient-rich peaty sediment and liming could also be needed to restore water transparency and reinstate marl deposition.

Red List Assessment:	**CR (PE) (B1a, c, B2a, c, D)**

Assessment Rationale:

C. rudis is known from a single Welsh site where the population is extremely small. Until the population has stabilised it seems best consider this as a fluctuating population. Although no formal count has been carried out it seems very unlikely that the number of fertile plants exceeds 250.

6.9. Delicate Stonewort (*Chara virgata* Kütz.)

Synonyms:

C. fragilis Desv., *Chara globularis* Thuill. var. *virgata* (Kütz.) R.D. Wood

Taxonomic Note:

C. virgata was not fully differentiated from *C. globularis* until 1924 and a significant number of earlier records for the latter (under *C. fragilis*) probably belong here.

Distribution:

C. virgata occurs in Europe, India, Japan and North America (Guiry 2017). It is widespread in Britain particularly in the north and west where it is locally frequent. In Wales it is one of the most frequent and widespread charophytes.

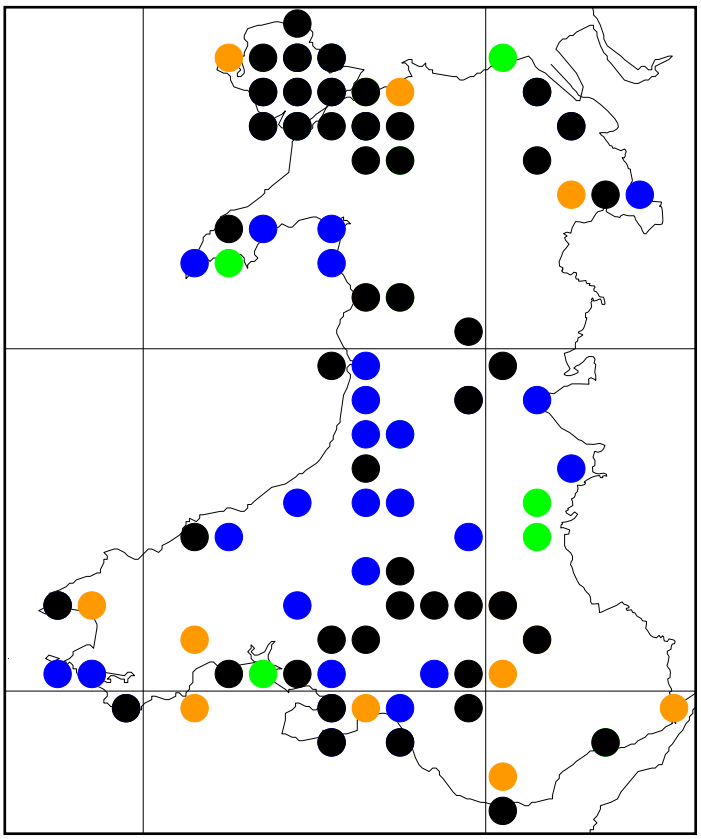

Figure 6.9. Welsh Distribution of *Chara virgata*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Green: 1970-1986; Yellow: last recorded pre 1969.

Occurrence:

Table 6.9 presents a summary of the hectads from which this species has been confirmed in Wales.

Hectads confirmed since 2000	47
Post 1986 hectads not confirmed since 2000	23
Post 1970 hectads not confirmed since 1986	5
Older hectads not confirmed since 1970	10

Table 6.9. Summary of the status of *Chara virgata* in Wales.

It may have been lost from some sites and the decline may be greater than it appears from this data because some historic records (pre-1920s) would have been recorded under *C. globularis*. Pre-1920s *C. globularis* records that may fall into this category records are mainly in South Wales. However, the general trend appears broadly stable (Figure 6.7.2).

Figure 6.7.2. Trend in the distribution of *Chara virgata*.

Habitats and Ecology:

Recorded from a wide range of aquatic habitats, from seasonal pools and flushes to large lakes, including in upland areas. In lakes it can occur as tufts in the shallows or as extensive beds in deep water. It is more frequent in base-poor water than any other species of *Chara* but it can also occur in alkaline water providing nutrient levels are low.

Threats:

This species is sensitive to the secondary effects of nutrient pollution and this is probably the main cause of its loss from sites.

Conservation:

There is no conservation in place specifically for this species and none needed. Although some sites have been lost, the species is still widely distributed with some large populations, and many sites are in areas where the threat from nutrient enrichment is low.

Red List Assessment:	**LC**

Assessment Rationale:

This species is still widespread and frequent in suitable habitats and is therefore classed as Least Concern.

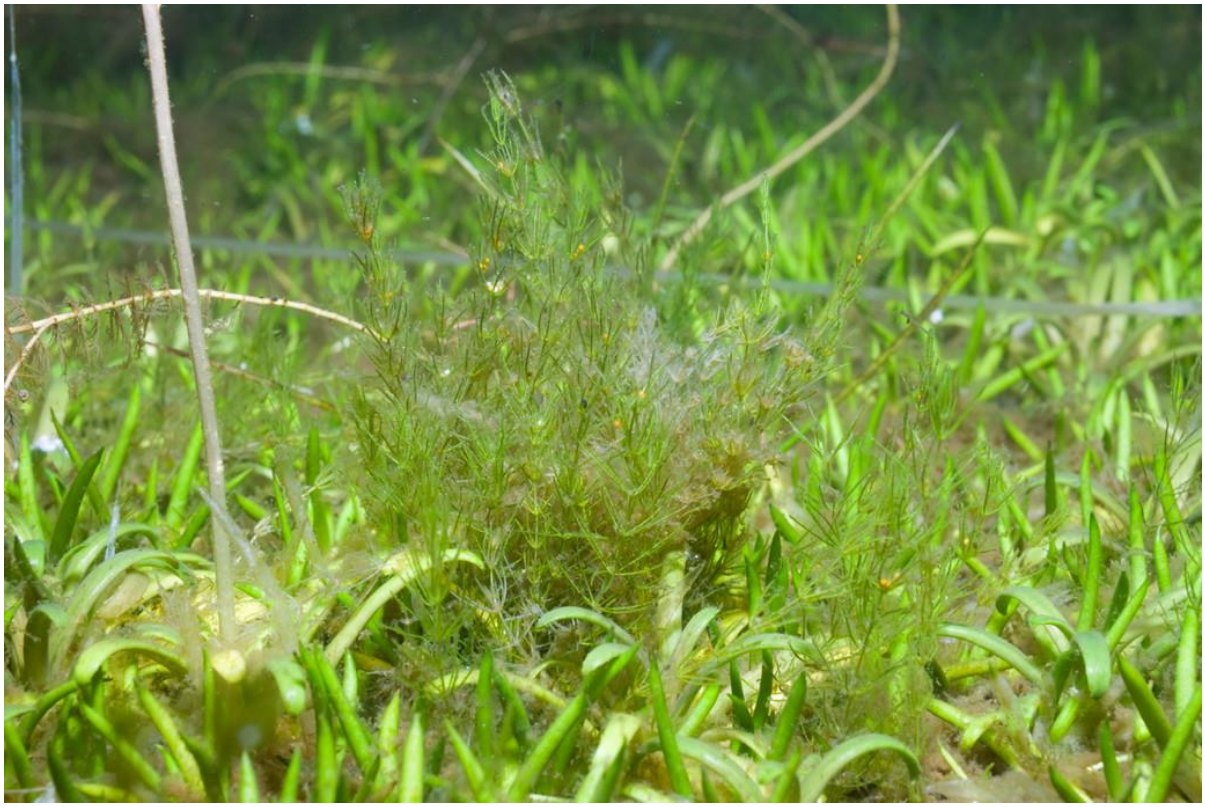

Figure 6.7.3. *Chara virgata* growing among *Littorella uniflora* and *Lobelia dortmanna*, Llyn Cregennen Isaf.

Figure 6.7.4. A dense bed of *Chara virgata*.

6.10. Common Stonewort (*Chara vulgaris* L.)

Distribution: *C. vulgaris* has a cosmopolitan distribution. It occurs throughout Britain but is more frequent in the south and east. In Wales it is restricted to lowlands and is mainly concentrated in areas with limestone geology or calcareous sand dunes. However, there are also a scattering of sites elsewhere.

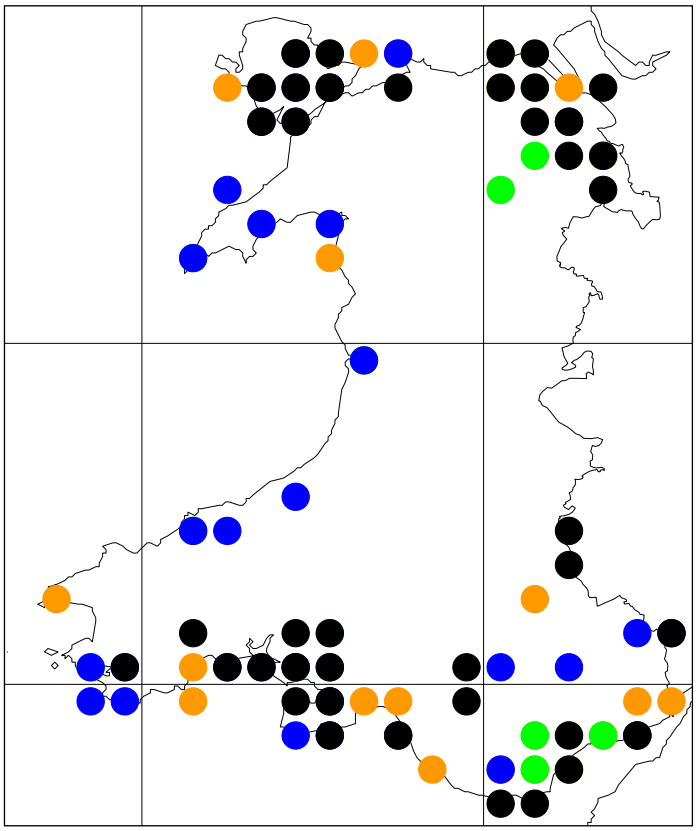

Figure 6.10. Welsh Distribution of *Chara vulgaris*. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Green: 1970-1986; Yellow: last recorded pre 1969.

Occurrence: The table below presents a summary of the hectads from which this species has been confirmed in Wales

Hectads confirmed since 2000	40
Post 1986 hectads not confirmed since 2000	17
Post 1970 hectads not confirmed since 1986	5
Older hectads not confirmed since 1970	13

Table 6.9. Summary of the status of *Chara vulgaris* in Wales.

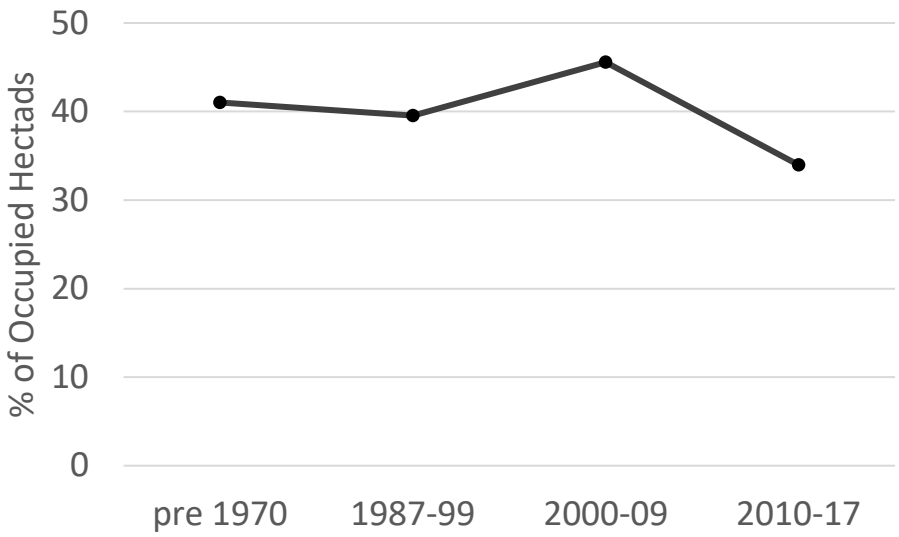

Figure 6.7.2. Trend in the distribution of *Chara vulgaris*.

Some of the apparent decline is due to the ability of the species to move between sites as habitat suitability varies, but it is thought that there has been some decline.

Habitats and Ecology: *C. vulgaris* occurs in all kinds of wetland habitats from puddles and ditches to lakes but it is most typically a species of small water bodies. Often the first colonist of new habitats such as gravel workings or limestone quarries but it may be out-competed over time by vascular plants. It is able to withstand drying out for periods in the summer. It appears to be tolerant of some nutrient enrichment but it is more usually an indicator of clean water conditions.

In Wales there is a strong association with limestone geology and with calcareous sand dunes. However some sites appear to quite acidic, for example in pools on colliery waste.

Threats: This species is sensitive to the secondary effects of nutrient pollution and it is probable that this has caused some decline in abundance and range.

Conservation: There is no conservation in place specifically for this species and none needed.

Red List Assessment:	**LC**

Assessment Rationale: Although there has probably been some decline, this species is still widespread in suitable habitats and is therefore classed as Least Concern.

6.11. Foxtail Stonewort (*Lamprothamnium papulosum* (Wallr.) J. Groves)

Distribution:

Lamprothamnium papulosum occurs sporadically along the coast of Europe from Norway and the Baltic Sea to the Iberian Peninsula. In the Mediterranean it extends east to Tunisia and Sicily, with isolated records from Greece, Cyprus and the Black Sea. There are also a few records from brackish sites inland (Stewart and Church 1992). In Britain it is restricted to a few sites along the south coast of England from Sussex to Dorset and the Western Isles of Scotland (Bryant and Stewart 2011).

The species had never been recorded from Wales until 2017 when a small population was discovered in the Inland Sea, Anglesey.

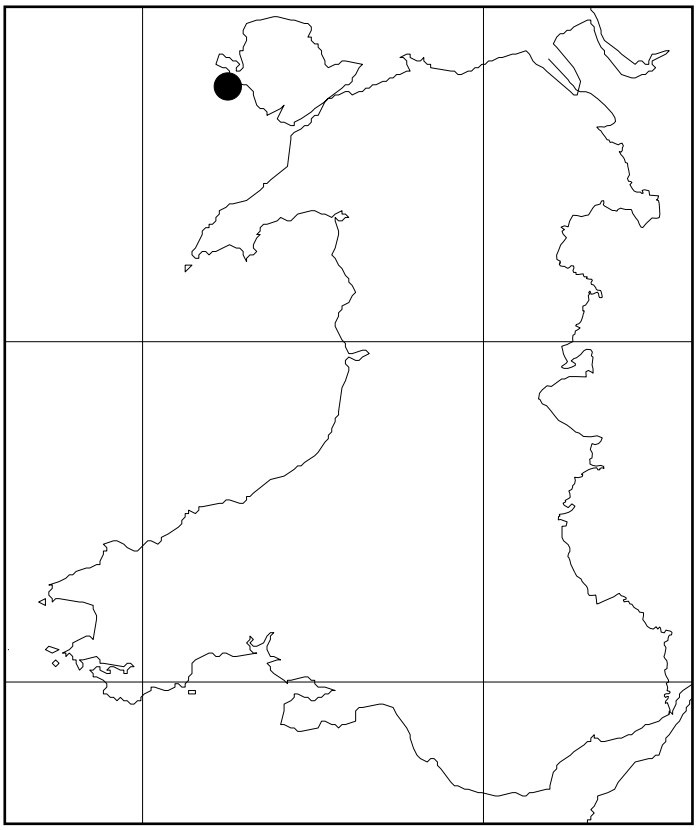

Figure 6.11.1. Welsh Distribution of *Lamprothamnium papulosum*.

Occurrence:

There is only one record of foxtail stonewort in Wales (Table 6.11).

Site Name	Vice County		Grid Ref.	Date	Habitat	SSSI	Status
Inland Sea	52	Anglesey	SH277787	2017	Brackish lagoon	Yes	

Table 6.11. Location details for *Lamprothamnium papulosum* in Wales.

Population:

The known population occupies patches totalling around 10-20 square metres in one area (T. Hatton-Ellis pers. obs.). However, a more extensive survey is needed in other suitable locations around this large site, and elsewhere around the coast of Anglesey. There is also the potential for populations to exist elsewhere in Wales, especially in sheltered sandy locations with a freshwater influence.

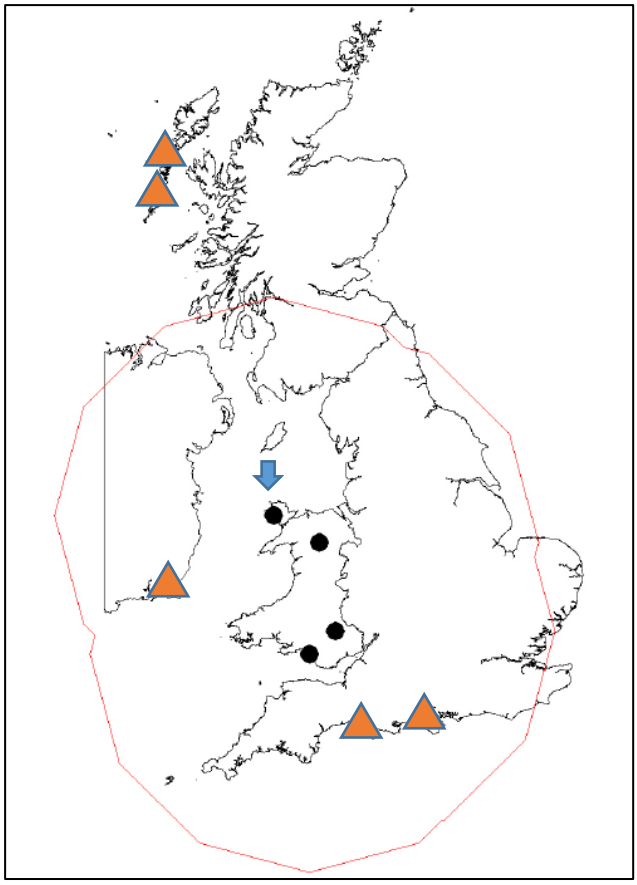

Figure 6.11.3. Theoretical range of waterfowl oospore dispersal via endozoochory from four Welsh lakes, illustrated by black dots (from Ormerod *et al.* 2011).

It seems likely that *L. papulosum* is a recent colonist, potentially via dispersal of spores in the faeces of waterfowl (endozoochory). Ormerod et al. (2011) used the calculations of Clausen et al. (2002) to estimate the effective range of endozoochory

via waterfowl to show that for species that could be dispersed in this way, waterfowl could potentially connect Wales to sites as far as southern Scotland, most of England and eastern Ireland (Figure 6.11.3). This means that the Anglesey population (arrowed in Fig. 6.11.3) is most likely to have originated from those in Hampshire and Dorset, or County Wexford (orange triangles).

Although *L. papulosum* is likely to be a recent colonist, GIS analysis of the small number and relatively distant location of potential source populations suggests that colonization events are unlikely (Figure 6.11.3; Hatton-Ellis et al. in prep).

Habitats and Ecology:

L. papulosum grows in natural and artificial brackish lagoons with salinities in the range of 8-25 psu (Schubert and Blindow 2003). It is most often found growing on sand, gravel or pebbles in less than 2 m of water, but it is intolerant of strong flow or wave action. It usually occurs with *Ruppia* spp. but it does not compete well with dense vascular plant growth or abundant filamentous algae. It is often to be found in areas where there is some disturbance from birds or other animals or in shallow water where fluctuations in the water level result in more open vegetation. It spreads partly by spores and partly by bulbils (Stewart and Church 1992).

In its Welsh site foxtail stonewort grows in shallow water (c.30 cm deep) in the Inland Sea, an area between mainland Anglesey and Holy Island with very restricted connections to the open sea due to artificial causeways. Salinity levels are not known but much of the water offshore has frequent *Zostera marina*, suggesting near sea-water salinities. However in the shallows there is open *Zostera noltei* and *Ruppia* suggesting more brackish water perhaps freshened by freshwater seepages and creeks. Here the *Lamprothamnium* grows in an open community on cobbles and sand (T. Hatton-Ellis pers. obs.).

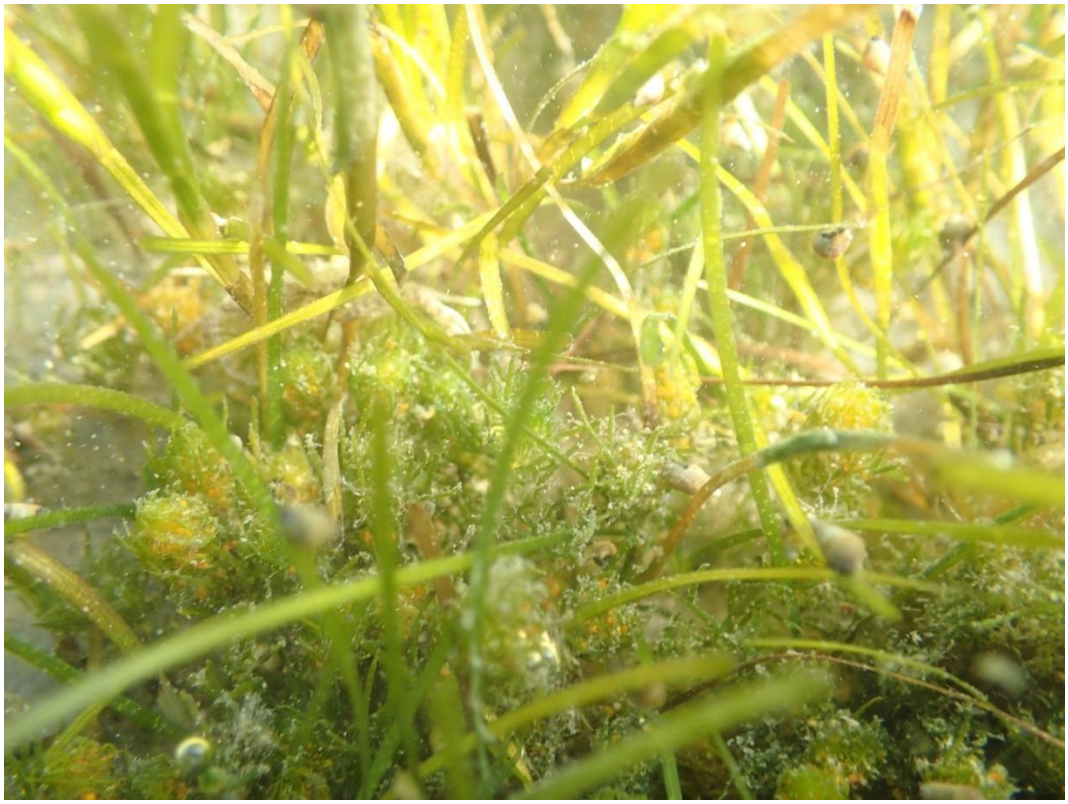

Figure 6.11.2. *Lamprothamnium papulosum* growing among *Zostera noltei*, Inland Sea, Anglesey.

Threats:

L. papulosum is sensitive to the secondary effects of nutrient enrichment (Martin 2001), particularly through increases in turbidity and being overwhelmed by filamentous algae. Salinity changes are also a major concern, particularly since the site has artificial connections to the sea which are vulnerable to modification. Further investigation is needed regarding the salinity range at this site as it may be at the higher end of the spectrum for this species. If so, rising sea levels as a result of global climate change could also be a concern in the longer term.

Conservation:

L. papulosum is specially protected on Schedule 8 of the Wildlife and Countryside Act 1981. Its only Welsh location is an SSSI. The main initial priority is to survey other suitable locations around the site focussing on areas close to freshwater seepages to establish whether other sub-populations occur and to investigate likely threats. This should include investigation of salinity variation at different locations and in relation to depth.

In addition, measures to reduce nutrient enrichment inputs should be encouraged and changes to the salinity levels should be avoided.

Red List Assessment (preliminary):	**VU (D2)**

Assessment Rationale:

This species qualifies as Vulnerable because of the small size of the single population, and because further colonization events are considered relatively unlikely in the event of population extinction. Due to the dearth of data this is a preliminary assessment, and intuitively this threat category feels inadequate to describe the status of this species in Wales. However, there are at present no data - especially with regard to trends - which could be used to support a higher threat category.

6.12. *Nitella flexilis* agg. [Smooth Stonewort (*Nitella flexilis* (L.) Agardh.) and Dark Stonewort (*Nitella opaca* C.Agardh ex Bruzelius) C.Agardh)]

Taxonomic note:

The two taxa *N. flexilis* and *N. opaca* can only be separated when fertile and are otherwise recorded as *N. flexilis* agg. Also, although they were well recognised as separate species over 130 years ago, for a period in the 1980s and 1990s they were united under one taxon (*N. flexilis* var. *flexilis* sensu Moore 1986). Since then a further complication has arisen due to nomenclatural confusion in the dictionaries of the main recording databases (Mapmate, BSBI DDb, NBN) which has resulted in records for the aggregate being translated as *N. flexilis* s.s. As a result there is a need for a complete review of all records, including historical records where vouchers exist.

The two species are discussed together here, with species-specific information where possible.

Distribution:

Smooth stonewort is widely distributed in Europe, Asia, Africa and North and South America. Based on historical records and a few modern confirmed records, it seems to be very sparsely scattered in Wales. Most records for *N. flexilis* agg. are likely to be *N. opaca* but it is likely this segregate species is significantly under-recorded. The two species sometimes grow together, for example at Llynnau Cregennen and Llyn Gwyddior.

N. opaca occurs in Europe, Asia, North Africa and the Americas. Despite the confusion discussed above, it is clear that this species is widespread and fairly frequent throughout the British Isles, particularly in the north and west. It is much more common than *N. flexilis* s.s. and most records for *N. flexilis* agg. will be *N. opaca*.

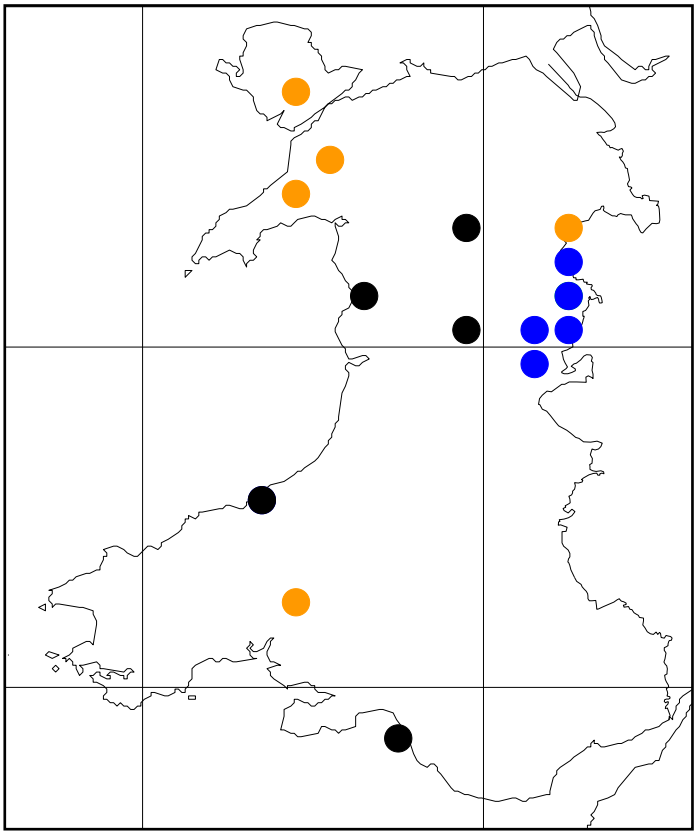

Figure 6.12.1. Welsh Distribution of *Nitella flexilis* s.s. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Green: 1970-1986; Yellow: last recorded pre 1969.

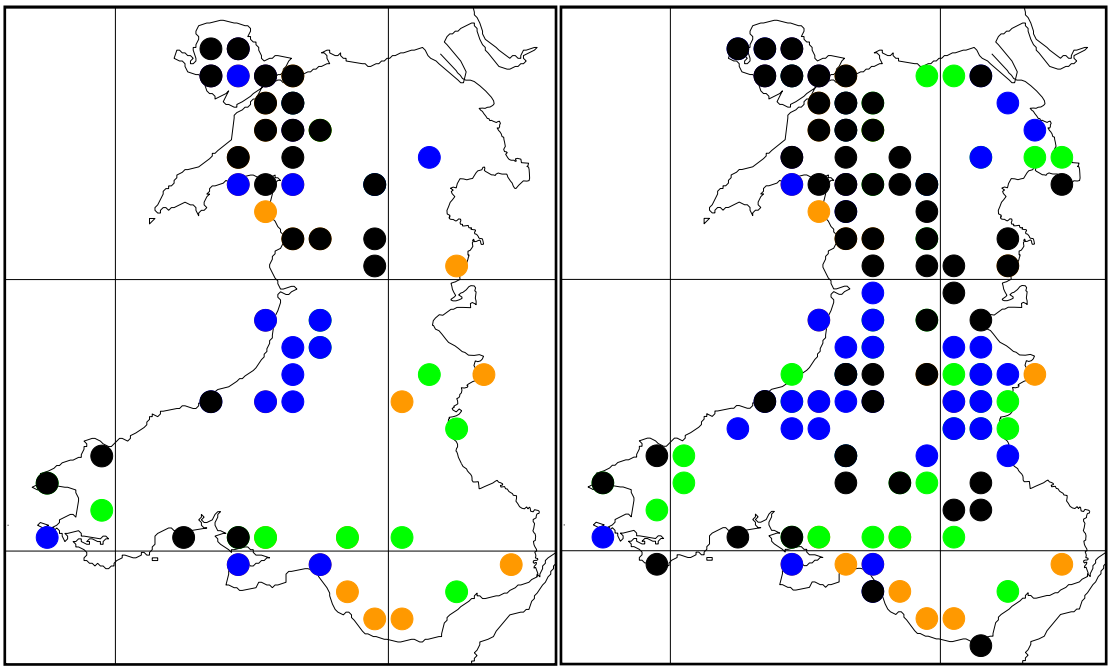

Figure 6.12.2. Welsh Distribution of (a) *Nitella opaca* and (b) *N. opaca* plus *N. flexilis* agg.

Occurrence:

Table 6.12.1 presents details of the sites or populations from which *N. flexilis* s.s. has been confirmed in Wales, the date given is the year of the most recent record. For some sites more recent records of *N. flexilis* agg. are available but positive confirmation of *N. flexilis* s.s. has not been possible due to a lack of fertile material. There is little doubt that these represent only a proportion of the recent sites for this species.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protected	Manager
Kenfig Pool	41	Glam.	SS798815	2005 (2015)	Shallow alkaline lake	SI, N2K, NN	LA
Carmar-then	44	Carms	SN42	1922	Unknown	No	Unknown
Rhos Pil-bach	46	Ceredigion	SN368530	1998	Pond	SI	WT
Llyn Gwyddior	47	Powys	SH934073	2013	Lake	No	Private
Montgom-ery Canal	47	Powys	SO143935-SJ294156	1987 (2013)	Canal	SI, N2K	CRT
Llyn Cregennen Uchaf	48	Gwynedd	SH664141	2013	Lake	No	NT
Llyn Tegid	48	Gwynedd	SH909334	2008	Lake	SI, N2K	SNP
Llyn Glasfryn	49	Gwynedd	SH44	1895	Lake	SI	Private
Llyn y Gader	49	Gwynedd	SH55	1886	Lake	SI	CE
Chirk	50	Clwyd	SJ23	1950	Trout ponds	No	Private
NW of Llangefni	52	Anglesey	SH47	1887	Unknown	No	Unknown
Llyn Frogwy	52	Anglesey	SH47	1895	Pond	No	Private

Table 6.12.1. Location details for *Nitella flexilis* s.s. in Wales. Dates in brackets indicate that there is a more recent record for *Nitella flexilis* agg. from that date.

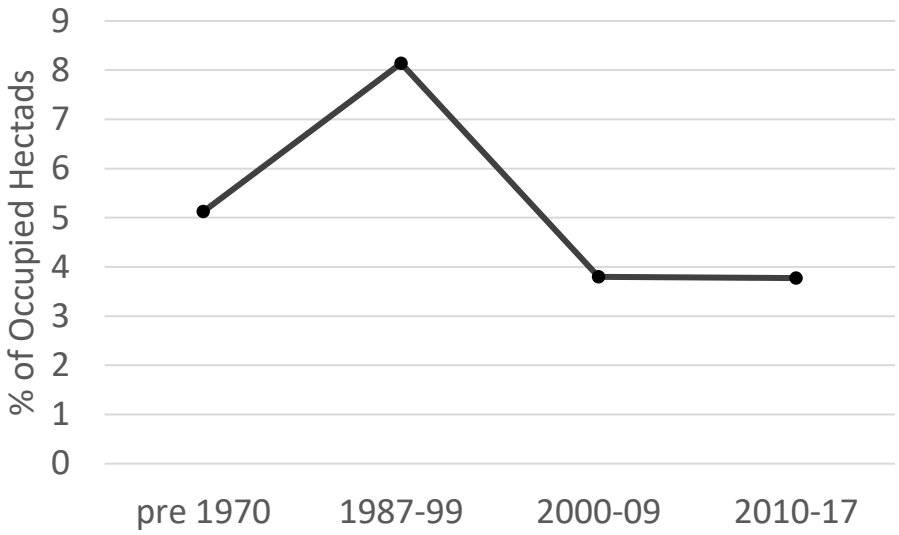

Figure 6.12.2. Trend in the distribution of *Nitella flexilis*.

The table below presents a summary of the Welsh hectad records for *Nitella flexilis* agg. It is probable that over 90% of these would belong under *N. opaca.*

Hectads confirmed since 2000	54
Post 1986 hectads not confirmed since 2000	28
Post 1970 hectads not confirmed since 1986	17
Older hectads not confirmed since 1970	7

Table 6.12.3. Summary of the hectad distribution of *Nitella opaca*.

Figure 6.12.3. Trend in the distribution of *Nitella opaca*.

N. opaca is widespread and fairly abundant throughout Wales. It may have declined slightly during the 20th Century but confusion with *N. flexilis* makes trends difficult to discern.

Population:

N. flexilis is known from a total of 12 named sites (see table) of which there are records from only five since 2006, however its true distribution is obscured by limited distinction by recorders from *N. opaca*. *Nitella flexilis* agg. is known from scattered locations on the Montgomery Canal but it has not been confirmed as *Nitella flexilis* since 1987. There are also recent records of the aggregate in Kenfig Pool but *N. opaca* is also present there and there has been no confirmation of *Nitella flexilis* since 2005.

Nitella opaca is widespread and common in a range of lake types including relatively base-poor waters where few other stoneworts occur. There is no clear evidence of a decline in population.

Habitats and Ecology:

N. flexilis is primarily a species of lakes, pools, ditches and canals where it grows in permanent water, generally in 1-3 metres depth. It does not seem to have a strong preference for base status though it is apparently absent from many of the base-poor upland lakes that are common in Wales, where it is often replaced by *N. opaca*. It occurs over a wide range of nutrient conditions but has not been recorded from very eutrophic waters in Wales.

N. opaca occurs in a wide range of habitats including lakes, clay and gravel pits, ponds, ditches, canals and seasonal pools. It is also one of the few stoneworts that is capable of growing in moderately fast-flowing water. It is most frequent in base-poor habitats, where it may be dominant in deeper water over one metre depth but also as scattered tufts in the shallows. It can also grow in alkaline waters, providing that nutrient levels are low.

Threats:

Threats to *Nitella flexilis* are poorly known but the main threat is likely to be from the secondary effects of nutrient enrichment. The species is also acid sensitive (Arts *et al*. 2011) and may therefore benefit from the recovery of Welsh upland waters from acidification.

N. opaca is sensitive to the secondary effects of nutrient pollution, particularly through increased turbidity and competition from other plants and algae. In deeper water it is often out-competed by dense growths of *Elodea* spp. and these can severely reduce the available habitat. In smaller water bodies there have been losses due to succession, drainage and infill.

Conservation:

There is a need to review all records for *Nitella flexilis*, *N. flexilis* agg. and *N. opaca*.

There is no conservation in place specifically for either species and none needed.

Red List Assessment	
Nitella flexilis	**DD**
Nitella opaca	**LC**

Assessment Rationale:

There is considerable uncertainty over the current status of *Nitella flexilis* but based on the historical distribution and a limited number of confirmed recent records, it appears to be uncommon but widespread. Based on its habitat requirements, some decline is likely to have occurred but it is impossible to estimate how much. It has therefore been classed as Data Deficient.

Nitella opaca is the most frequently encountered of the genus in Wales, and is widespread in suitable habitats. Although there may have been some decline during the twentieth century, it is still widespread and it is therefore classed as Least Concern.

6.13. Slender Stonewort (*Nitella gracilis* (Smith) Agardh.)

Taxonomic Note:

In the mid-nineteenth century, the name *Chara gracilis* was sometimes used indiscriminately for small or slender *Nitella* species. In some cases these may refer to *N. tenuissima* but in other cases the identity is unclear. More recently there has been confusion with a strain of *Nitella mucronata* (var. *gracillima*) which seems to be increasing but this confusion has not been issue in Wales.

Distribution:

N. gracilis probably has a cosmopolitan distribution and is widely but sparsely distributed across much of Europe. It is regarded as threatened in most European countries that have Red Lists. Known in the British Isles from Sutherland and Ayrshire in Scotland, northern and central Wales and Cos. Kerry and Wicklow in Ireland.

In Wales it is known only from a few scattered sites in Snowdonia and the Cambrian Mountains. It is not clear whether the species is spreading or if this reflects improved recording.

Figure 6.13.1. Welsh Distribution of *Nitella gracilis*.

Occurrence:

The table below presents details of sites from which this species has been confirmed in Wales, the date given is the year of the most recent record. Pink shading indicates probable losses based on surveys since the most recent record, grey shading indicates other sites with no records since 2007 where the locations have not been searched exhaustively.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protected	Manager
Gwynllyn	43	Powys	SN947689	2014	Lake	SI	Private
Llyn Berwyn	46	Ceredigion	SN743569	2004	Lake	No	Private
Llyn Gynon	46	Ceredigion	SN798645	2011	Lake	SI, N2K	Private
Pond-y-Gwaith	46	Ceredigion	SN7767	2014	Lake	SI, N2K	CC
Llyn Ebyr	47	Powys	SH648239	2007	Lake	No	Private
Llyn Bodlyn	48	Gwynedd	SH648239	2011	Lake	No	WR
Llyn Conglog-Mawr	48	Gwynedd	SH759387	2009	Lake	SI, N2K	CC
Llyn Morwynion	48	Gwynedd	SH737423	2016	Lake	Yes	WR
Llyn Dwythwch	49	Gwynedd	SH568780	2016	Lake	SI	Private
Llyn Cwellyn	49	Gwynedd	SH559549	2009	Lake	SI, N2K	WR
Llyn y Gader	49	Gwynedd	SH568520	2015	Lake	SI	Private
Llynnau Mymbyr	49	Gwynedd	SH711575	2017	Lake	SI	Private

Table 6.13. Location details for *Nitella gracilis* in Wales.

This species was first recorded in Wales by Max Wade in 1979, in Llyn Dwythwch. There has been an increasing number of records from predominantly upland sites since the late 1990s.

There are records since 2000 from 12 sites in Powys, Ceredigion and Gwynedd, most of which are recent. The habitat for this species is not uncommon in the uplands of Wales and recent surveys, particularly by University College London (ENSIS) have resulted in a number of new sites being discovered.

Two more locations, Llyn Cwmorthin (VC 49 Gwynedd: SH6746) and Llyn Rhosgoch (VC 46 Ceredigion: SN7183) were discovered in 2018 but could not be incorporated into the maps and analysis. It is likely that other sites will be discovered but the evidence suggests that it is an uncommon species that is rarely found at high cover.

Nitella gracilis shows a strongly increasing trend in distribution in Wales (Figure 6.13.2). It is unclear if this reflects lack of survey or whether it is a genuine increase in occupancy reflecting recovery of upland lakes from acidification.

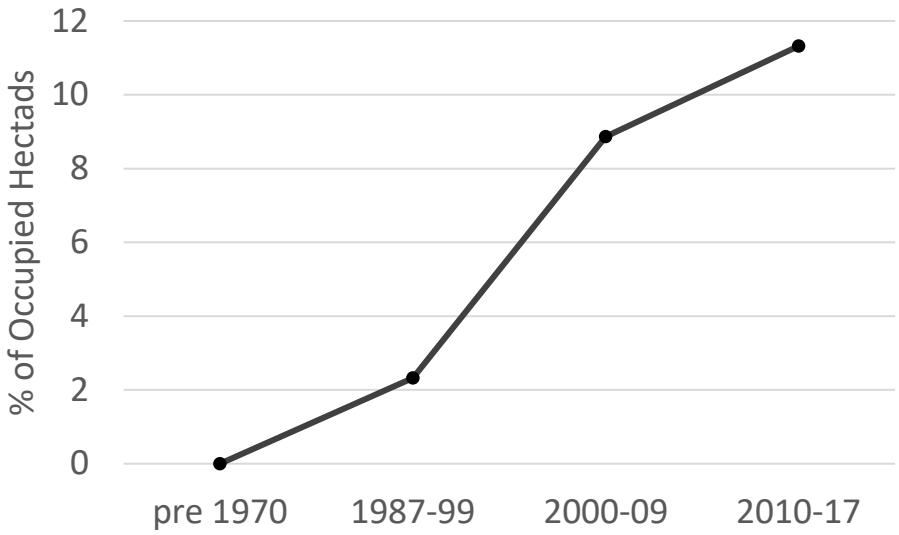

Figure 6.13.2. Trend in the distribution of *Nitella gracilis*.

Population:

Slender stonewort has been recorded from rather few locations and generally at low cover in most of its sites. However this may be because it is a deep water species not particularly easily detected by grapnel sampling. A diving survey in Llyn Gynon found it to be sparsely scattered in the lower photic zone (Jones and Stewart 2001) and it is quite likely that it grows similarly at other sites.

Habitats and Ecology:

In Wales *N. gracilis* occurs in upland base and nutrient poor lakes, often with peat staining. It appears to require locations where there is some shelter from wave action and where competition from other plants is not too intense. Like many *Nitella* it is tolerant of low light levels and this allows it to occur at the bottom of the photic zone where other plants grow less vigorously (Jones and Stewart 2001). Common associates include *Luronium natans*, *Utricularia minor*, *Lobelia dortmanna*, *Nitella translucens*, *N. flexilis* agg. and water lilies (*Nuphar lutea* and *Nymphaea alba*).

Threats:

This species is very sensitive to nutrient enrichment, being easily overwhelmed by other vegetation and filamentous algae. In deeper water locations, increases in turbidity affect this species more than vascular plants; the latter have larger propagules and flotation, allowing plants to reach higher in the water column before needing light. However, most of the Welsh sites are upland lakes where nutrient pressures are low and unlikely to increase significantly.

The sensitivity of *N. gracilis* to acidification is unclear, but it is possible that increases in detection recently reflect recovery of its habitats from acid rain. A study in Holland showed that *N. flexilis* is acid sensitive (Arts *et al*. 1990). Pleijel *et al*. (1999)

considered *N. gracilis* as an acid sensitive species in their analysis of the impact of acidification on Swedish ecosystems.

Invasive species may be a threat to slender stonewort, as it is a poor competitor. Australian swamp stonecrop *Crassula helmsii* is spreading in the Snowdonia area and is likely to cause a decline or loss of populations if it establishes in lakes supporting *N. gracilis*.

Conservation:

The majority of localities for this species are upland and within protected sites designated for one or more of H3130 ‘Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoëto-Nanojuncetea’, H3160 Natural Dystrophic lakes and ponds, and floating water-plantain *Luronium natans*. Most sites do not need any specific conservation action but should be monitored for any decrease in water quality.

Red List Assessment:	**LC**

Assessment Rationale:

This species has been recorded from 14 sites in the last 15 years and is probably increasing. The sites where it occurs are generally well protected and at present are probably improving in quality.

6.14. Pointed Stonewort (*Nitella mucronata* (A.Braun) Miquel)

Taxonomic Note:

Two varieties of *N. mucronata* are recognised in Britain; var. *mucronata* is native, while var. *gracillima* is likely to be introduced. The Welsh populations are all thought to belong to the latter.

Distribution:

N. mucronata is widely distributed in Europe, Asia, Africa and the Americas. In Britain, var. *mucronata* is rare and decreasing and may be restricted to West Sussex and Humberside, although there is also a possible recent record from County Louth in Ireland; var. *gracillima* is scarce; it was first described from Gloucestershire in the 1930s, and has since gradually spread, particularly in anthropogenic sites such as canal systems, clay pits and ornamental ponds where it may be accidentally introduced among the roots of water lilies and other plants.

In Wales this species is rare but spreading.

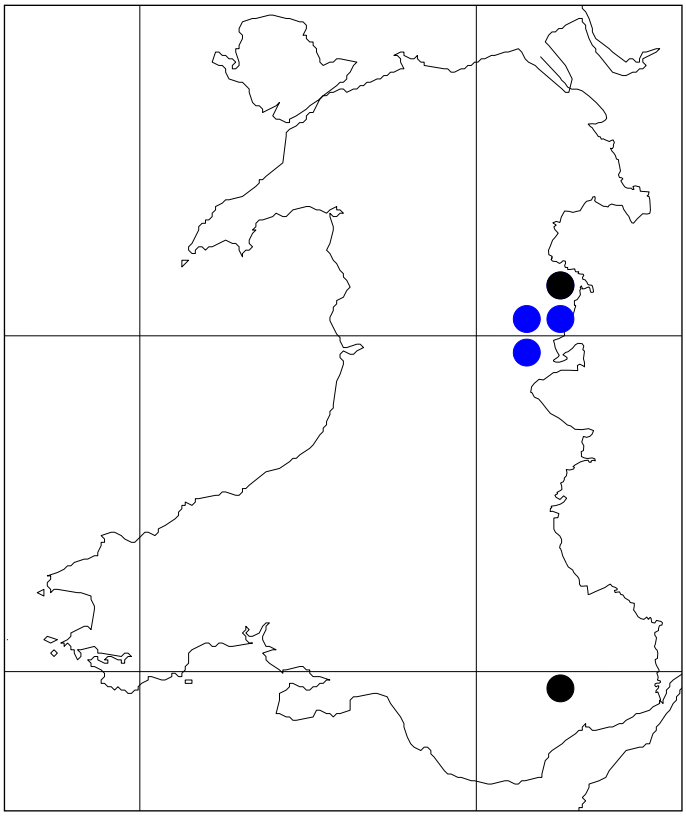

Figure 6.14.1. Location details for *Nitella mucronata* in Wales. The Kenfig record is not shown. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999.

Occurrence:

Table 6.14 presents details of sites from which this species has been confirmed in Wales, the date given is the year of the most recent record. Pink shading indicates

probable losses based on surveys since the most recent record, grey shading indicates other sites with no records since 2007 where the locations have not been searched exhaustively.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protected	Manager
Cwmbran, Monmouth and Brecon Canal	35	Gwent	ST29	2003	Canal	No	CRT
Montgomery Canal	47	Powys	SJ1902 – SJ2512	2014	Canal	SI, N2K	CRT
Wern Clay Pits	47	Powys	SJ251141	1988	Constructed wildlife ponds	SI, N2K	CRT
Kenfig Pool	41	Glamorgan	SS7981	2019	Shallow alkaline lake	SI, N2K, NN	LA

Table 6.14. Location details for *Nitella mucronata* in Wales.

Population:

On the Montgomery Canal this species is sparsely scattered and has been recorded on different surveys from around 14 locations along about 10 km of the canal. No information is available about the population in the Cwmbran, Monmouth and Brecon Canal. The species has recently colonised Kenfig Pool (Goldsmith *et al*. 2019).

Habitats and Ecology:

This is a species of lakes, canals and ponds, typically growing in 1-3 metres depth. It is often associated with a diverse aquatic flora but usually occurs in the gaps among denser vegetation or where the vegetation becomes sparser at the lower edge of the photic zone. It can occur in mesotrophic to eutrophic water and appears to tolerate higher levels of nutrients than most stoneworts. In such situations it may grow

amongst filamentous algae such as *Cladophora glomerata* where it may have an advantage over other algae by developing in the early part of the season before the filamentous algae proliferates. In Wales it is mainly known from canals although it previous occurred in some abandoned clay pits and has recently appeared in Kenfig Pool, a shallow alkaline lake.

Threats:

Although the species has some tolerance to nutrient enrichment it is probably unable to cope with higher levels of enrichment. It has been lost from Wern Clay Pits due to the water bodies becoming overgrown and shaded.

It can probably tolerate some canal boat traffic due to its ability to grow over the winter when boat traffic is low. However, it is fragile and unlikely to tolerate heavy boat traffic. On the other hand, abandonment of the canal would result in its eventual loss by swamp colonisation.

Conservation:

The Montgomery Canal is a SSSI and SAC. There is a need to survey the Cwmbran, Monmouth and Brecon Canal to assess the population there. However, its status as a probable introduction mean that conservation measures are a low priority.

Red List Assessment:	**Not Evaluated**

Assessment Rationale: The var. *gracillima* form which is the one present in Wales is thought likely to be an introduction and is therefore not evaluated.

6.15. Dwarf Stonewort (*Nitella tenuissima* (Desv.) Kütz.)

Distribution:

N. tenuissima occurs in Europe, Southern Africa, India, North America and Madagascar. It is rare in the British Isles where it is known from Cambridgeshire and Anglesey in Britain and several sites in central and western Ireland. Historically it was also recorded from Norfolk but there have been no recent records (Bryant and Stewart 2011).

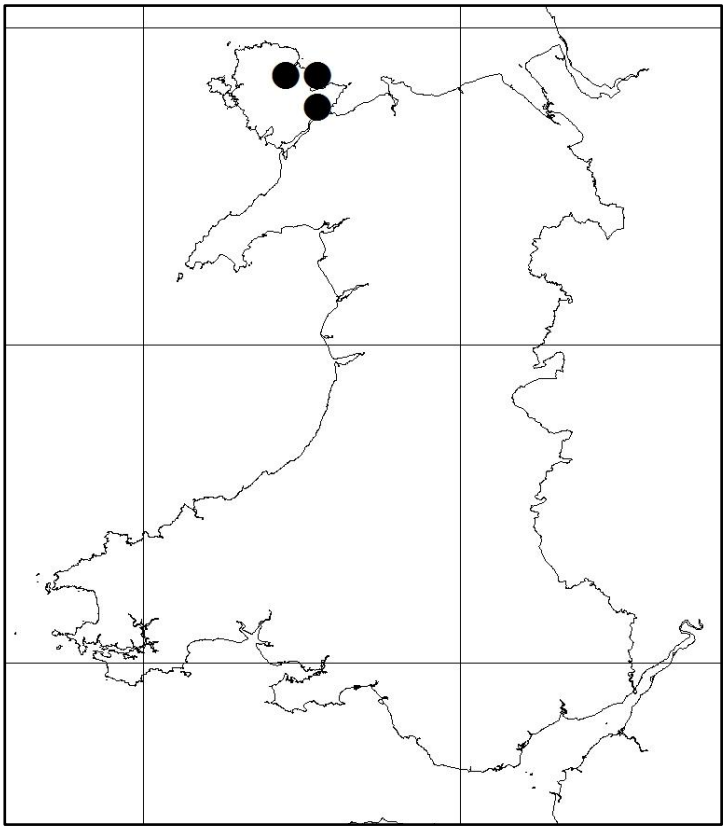

Figure 6.15.1. Distribution of *Nitella tenuissima* in Wales.

Occurrence:

Table 6.15 presents details of sites from which this species has been confirmed in Wales, the date given is the year of the most recent record. Pink shading indicates probable losses based on surveys since the most recent record, grey shading indicates other sites with no records since 2005.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protected	Manager
Cors Erddreiniog A	52	Anglesey	SH468832	2016	Fen seepages	SI, N2K, NN	NRW
Cors Erddreiniog B	52	Anglesey	SH475819	2014	Fen pools	SI, N2K, NN	NRW
Cors Erddreiniog C	52	Anglesey	SH474810	2003	Fen pools	SI, N2K, NN	NRW
Cors Bodeilio	52	Anglesey	SH502775	2003	Fen pool	SI, N2K, NN	NRW
Cors Goch A	52	Anglesey	SH494811	2003	Fen seepages	SI, N2K, NN	WT
Cors Goch B	52	Anglesey	SH500815	2003	Fen pool	SI, N2K, NN	WT
Cors Goch C	52	Anglesey	SH501815	2003	Fen seepages	SI, N2K, NN	WT
Cors Goch D	52	Anglesey	SH501816	1991	Drain, peat cuttings	SI, N2K, NN	WT

Key 1 - Local Nature Reserve, 2 - National Nature Reserve, 3 - National Trust, 4 - Ramsar sites, 5 - Special Area of Conservation, 6 - Wildlife Trust Reserve

Table 6.15. Location details for *Nitella tenuissima* in Wales.

In Wales *N. tenuissima* has only been recorded recently from three Anglesey fens: Cors Erddreiniog, Cors Goch, and Cors Bodeilio.

Population:

All of the populations are small and very vulnerable to competition and succession. In a survey in 2003 the summed total area between the 3 sites was assessed as 20 square metres, mostly in Cors Erddreiniog sub-population C. Since then it has not been refound in Cors Bodeilio and Cors Erddreiniog C, despite recent surveys (in 2016). A superficial survey of Cors Goch in 2016 also failed to locate it and the habitat only seemed suitable in one of the four sub-population locations. Of the colonies seen between 2014 and 2016, the summed total area was around 4 square metres in Cors Erddreiniog and nil in Cors Bodeilio. This represents an 80% population decline in 14 years, equivalent to a 57% population decline since 2007 assuming a steady rate of decline.

Habitats and Ecology:

This is a plant of calcareous fenland where it occurs in open areas in *Schoenus nigricans* flushes and *Cladium* fen, and in shallow peaty pools and ditches in depths of up to 1 m. It requires bare peat surfaces and does not compete well with other

algae or vascular plants (Stewart 2004). It is therefore an early colonist in new pools but usually disappears within a few years as other vegetation takes over. Nevertheless there are some pools where it has survived for over 10 years. In flush systems it can probably persist for longer periods providing grazing is sufficient to keep the habitat open.

Threats:

In the past when there was subsistence peat-cutting, *N. tenuissima* may have been much more widespread but it has declined due to natural successional changes to swamp, fen and carr. In recent years there has been a programme of grazing and pond clearance/creation which has maintained some of the sub-populations but others have become overgrown. Fortunately, the spores of this species are known to remain viable for decades and its appearance in some new scrapes and pools in Cors Erddreiniog suggests that there may be a good spore bank in some parts of the site.

On the other hand, the creation of new pools close to the last known location in Cors Bodeilio has not been successful. Grazing by heavy livestock such as cattle or ponies is also a mechanism for maintaining the open habitats suitable for the species. However, mowing and reed-cutting are not sufficient because of the leaf litter that remains over the peat surface. Fire is an option for breaking up this litter but is not usually compatible with other nature conservation interests.

Dwarf stonewort is also very vulnerable to nutrient pollution, particularly through consequent competition from filamentous algae and greater deposition of soft organic sediments which are difficult for this species to anchor into. At Cors Erddreiniog and Cors Goch, all of the locations are away from the main through-ditches which are more enriched.

Conservation:

All three sites are SSSIs, Nature Reserves, Ramsar sites and Special Area of Conservation and have ongoing management programmes which give consideration to this species. These need to be continued, including;

- Continued grazing by heavy livestock, particularly where there are Dwarf Stonewort colonies. Grazing levels are lowest at Cors Goch and there is scope for increasing grazing levels here.
- Continue the programme of pool creation/clearance, particularly in the vicinity of Dwarf Stonewort colonies. Particular priorities are Cors Bodeilio and Cors Erddreiniog sub-population C
- Monitor the water quality within sites and encourage measures to reduce enrichment pollution, including the diversion of more polluted sources.
- Investigate the use of fire as a management tool, in areas where grazing is not feasible.

A resurvey at Cors Goch is needed as it has not been seen here for over 15 years. A superficial survey in 2016 suggests that some pool clearance is needed here.

Red List Assessment:	**EN (A2a, B1a, b(iv), B2a, b(iv), C1)**

Assessment Rationale:

Of the seven sub-populations known in 2003, two (29%) have not been refound since despite survey and in a further two the habitat appears no longer suitable but further survey is needed. Population size measured by plant area in Cors Bodeilio and Cors Erddreiniog was assessed as 20 square metres in 2003 but only 4 square metres in 2016. In Cors Goch the area was assessed as 2 square metres in 2003 and although there is no recent data it is thought to have declined here too. Although it is difficult to translate this into numbers of individual plants for the IUCN criteria, plants tend to form clumps of about 10 cm diameter translating to around 2000 “plants” in 2003.

6.16. Translucent Stonewort (*Nitella translucens* (Persoon) Agardh.)

Distribution:

Translucent stonewort occurs in Europe and North Africa; In Britain it is occasional to locally frequent in more northerly and westerly parts but is rare and declining elsewhere (Bryant and Stewart 2011). It is widely scattered but uncommon in Wales.

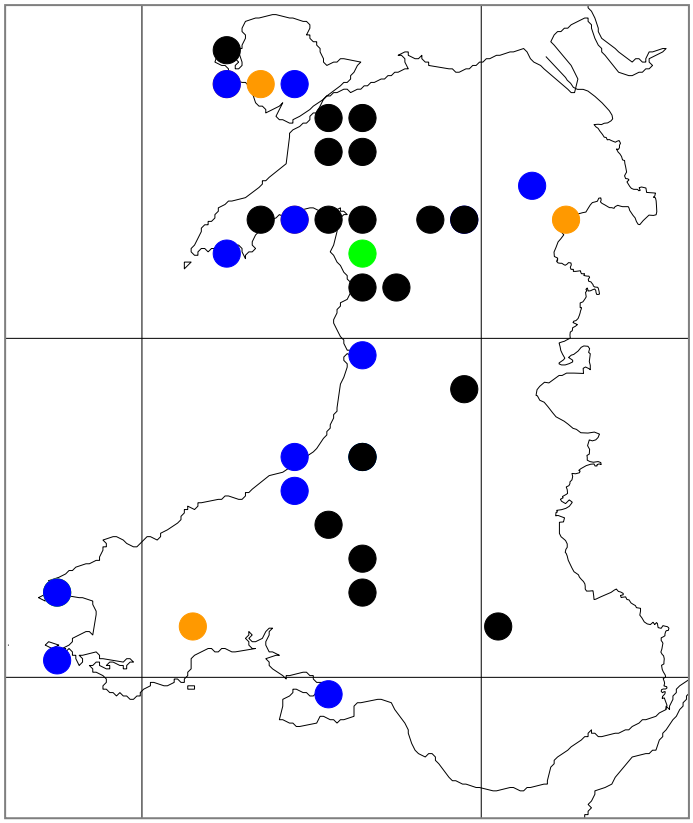

Figure 6.16.1. Distribution of *Nitella translucens* in Wales. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Green: 1970-1986; Yellow: last recorded pre 1969.

Occurrence:

Table 6.16.1 presents a summary of the sites from which this species has been confirmed in Wales

Hectads confirmed since 2000	18
Post 1986 hectads not confirmed since 2000	11
Post 1970 hectads not confirmed since 1986	1
Older hectads not confirmed since 1970	3

Table 6.16.1. Summary of the hectad distribution of *Nitella translucens*.

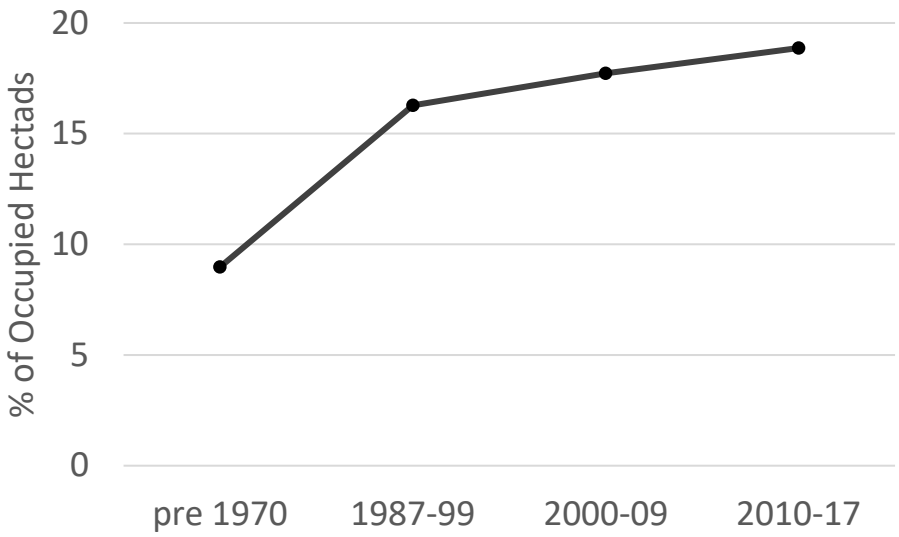

Figure 6.16.2. Trends in occupancy of *Nitella translucens* in Wales.

In Wales *Nitella translucens* is widely scattered in areas with base-poor water chemistry and there are good populations in some sites. Many of the sites where the plant was last seen between 1987 and 2000 have not been re-surveyed and it is likely to be still present in many of these. Although a few sites have been lost, this species may be increasing overall, perhaps as a result of recovery from acidification in upland lakes.

Population:

Sites vary considerably in size from small pools to large lakes, and population density is similarly variable.

Habitats and Ecology:

N. translucens is sometimes found in considerable abundance in low pH, nutrient-poor pools and lakes on peat or peaty silt and in open swamp communities such as *Menyanthes trifoliata* (Bryant and Stewart 2011). In lakes it may grow as dominant stands, where turbulence is low. Like several other *Nitella* it tolerates low light levels and in Llynnau Cregennen grows at depths of up to 8m. It also grows among other plants such as *Myriophyllum alterniflorum*, *Potamogeton* spp., *Nitella opaca* and *Chara virgata*. In smaller more sheltered pools it can form dense stands with few associates.

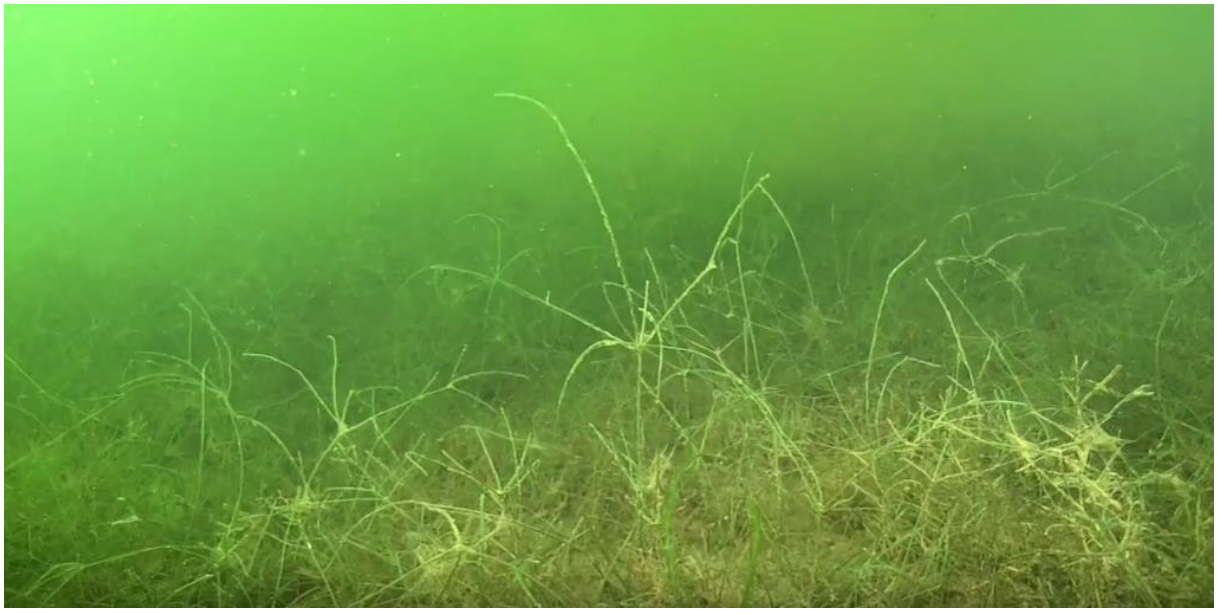

Figure 6.16.3. A thin bed of *Nitella translucens* growing at 8m depth, Llyn Cregennen Isaf, Gwynedd.

Threats:

The main threats are from nutrient enrichment although some small water bodies are being lost to succession, infill and drainage. Acidification may have restricted the occurrence of this species in upland areas during the 20th century.

Conservation:

Populations in lowland situations need protection from nutrient enrichment, and some sites are being affected by succession and habitat loss.

Red List Assessment:	**LC**

Assessment Rationale:

Translucent stonewort is widely distributed but local across Wales and appears to be spreading.

6.17. Starry Stonewort (*Nitellopsis obtusa* (Desv.) J. Groves)

Distribution:

Nitellopsis obtusa is widely distributed across Europe and Asia, east to Japan. It has also recently appeared as a non-native in the central United States where it is regarded as a pest. In north-west Europe it seems to be increasing, including recently being discovered in two sites in central Ireland (C. Roden pers. comm.) and this is also the case in southern Britain. Although there have been a scattering of historic records across southern England, for many years starry stonewort was thought to be confined to the Norfolk Broads.

In 1995 *N. obtusa* was discovered in a gravel pit in Gloucestershire and since then it has been recorded in scattered sites in Wales and in England north to Lincolnshire. Some of its sites have had a history of survey by botanists and a significant number of sites are gravel pits that are less than 50 years old. This indicates that there has probably been a real spread rather than the species being overlooked.

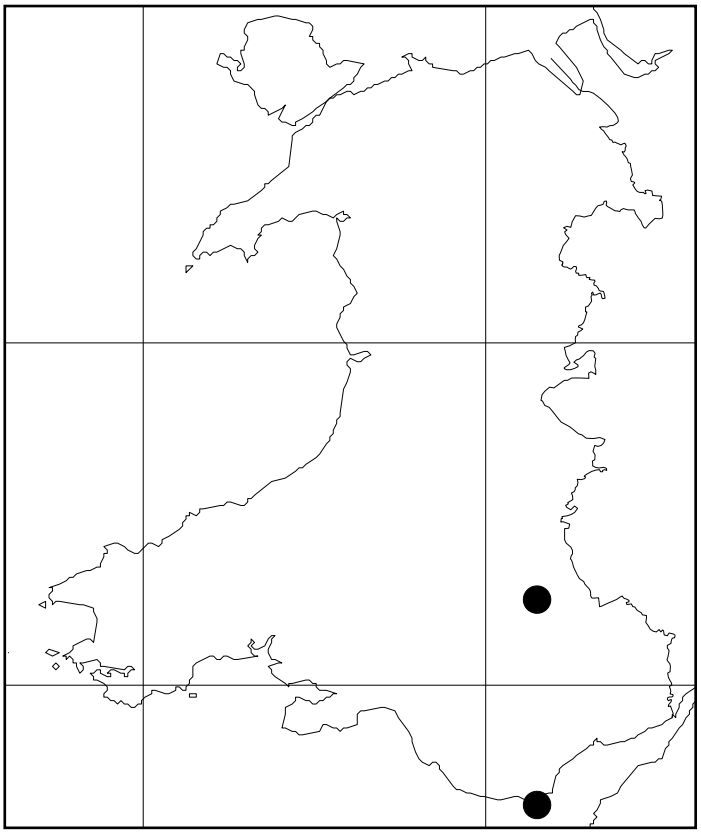

Figure 6.17.1. Distribution of *Nitellopsis obtusa* in Wales.

Occurrence:

Table 6.17.1 presents details of sites from which this species has been confirmed in Wales, the date given is the year of the most recent record.

Site Name	Vice County		Grid Ref.	Date	Habitat	Protected	Manager
Cosmeston Lake	41	Glam.	ST176692	2013	Alkaline Quarry Lake	SI	LA
Llangorse Lake	42	Powys	SO124268	2016	Eutrophic Lake	SI, N2K	3

Table 6.17.1. Location details for *Nitellopsis obtusa* in Wales.

Starry stonewort appears to be a recent arrival in Wales. It was first definitively recorded from Cosmeston Lake in 2007 and Llangorse Lake in 2014. A 2006 record of *N. flexilis* agg. from from North Pond, Oxwich (T. Hatton-Ellis pers. obs.) may also have been this species, and a resurvey of the site may be worthwhile. In 2018 it was also discovered at Kenfig Pool (Goldsmith *et al*. 2019 – not shown on map or table).

Population:

The population appears to be locally frequent and increasing at both sites. LEAFPACS cover scores (which give a rough approximation of percentage cover in sample points) from different monitoring surveys are detailed below.

Site	Year	LEAFPACS cover score
Cosmeston Lake	2007	4
	2013	5.36
	2019	15.96
Llangorse Lake	2003	-
	2008	-
	2011	-
	2013	-
	2014	0.48
	2015	1.82
	2017	2.85

Table 6.17.2. LEAFPACS cover scores for *Nitellopsis obtusa* in Wales.

Figure 6.17.2. *Nitellopsis obtusa* with *Ceratophyllum demersum*, collected during monitoring at Llangorse Lake (Ben Goldsmith).

Habitats and Ecology:

Nitellopsis obtusa is typically a lake species usually occurring in deep water, generally between 1 and 6 metres deep, although it has been recorded from depths of up to 30 m elsewhere in Europe. It normally occurs in base-rich water but one former English site (Little Sea, Dorset) is a soft water lake. Most of its sites also contain a diversity of other stonewort and vascular plant species.

Although primarily a freshwater species it can tolerate low levels of salinity (up to 2.5 psu but sometimes periodically higher in fluctuating salinities (Schubert and Blindow 2003). Traditionally it is said to produce spores rarely, reproducing mainly by the star-shaped bulbils, which can remain viable for several years (e.g. Stewart and Church

1992, Schubert and Blindow 2003), however, there are suggestions that the current spread may be linked with increased fertility. Some of the West London gravel pits have supported abundantly fertile populations.

Starry stonewort is usually a summer annual, but in favourable conditions and mild winters it may not die back completely. Spore production is from July to September and may be controlled by light intensity (Stewart and Church 1992). In West London it occurs in water sufficiently shallow that the tops of shoots may be exposed and dry out during low water.

Threats:

Some of the new British and Irish sites have good water quality but some show signs of enrichment and it may be that, while still sensitive to nutrient enrichment, it is more tolerant than most stonewort species. Both Cosmeston and Llangorse Lakes have high phosphorus concentrations (Burgess *et al*. 2009; Hatton-Ellis 2016). However, further information on the tolerance limits of this species is needed as the main cause of the instability of its populations in the Norfolk Broads is due to secondary effects of raised nutrient levels. This causes increased turbidity through algal blooms and mobile soft sediments and favours vascular plant growth or sometimes an absence of rooted vegetation.

Increasing competition from *Elodea nuttallii* was raised as a concern at one English site, but *N. obtusa* is still present and because of its large size it may have some resilience to competition from vascular plant species. At Llangorse it is still increasing in abundance despite the dominance of *E. nuttallii*.

Conservation:

Both sites for this species are SSSIs; Llangorse is also an SAC designated for the Natural Eutrophic Lakes with Magnopotamion vegetation feature. These are monitored periodically for Water Framework Directive, SAC and SSSI condition monitoring assessments. With the population apparently increasing at both sites, despite in Llangorse Lake being impacted by raised nutrient levels it is likely that no specific action is needed. Nevertheless, measures to reduce nutrient levels at both sites should be encouraged.

Red List Assessment:	**LC**

Assessment Rationale:

This species is known from only two sites, so technically qualifies for VU status under criterion D2. However, the species has apparently recently colonised from England and populations appear to be increasing at both sites. Following IUCN guidance on Regional Assessments (IUCN 2012a), it seems appropriate to downgrade the threat status of *Nitellopsis obtusa* to Least Concern. Current trends also suggest that rather than being at risk of extinction, *N. obtusa* is likely to extend its range within Wales.

6.18. Clustered Stonewort (*Tolypella glomerata* (Desv.) Leonh.)

Synonyms: *Tolypella nidifica* (O.Müll.) Leonh. var. *glomerata* (Desv.) R.D.Wood

Distribution:

Tolypella glomerata probably has a cosmopolitan distribution. In the British Isles it is widespread but scarce and apparently decreasing; in Britain it is occasional in the south and east and rare elsewhere (Bryant and Stewart 2011).

In Wales, clustered stonewort is most frequent in Anglesey and in dunes on the south coast but there are a scattering of records elsewhere.

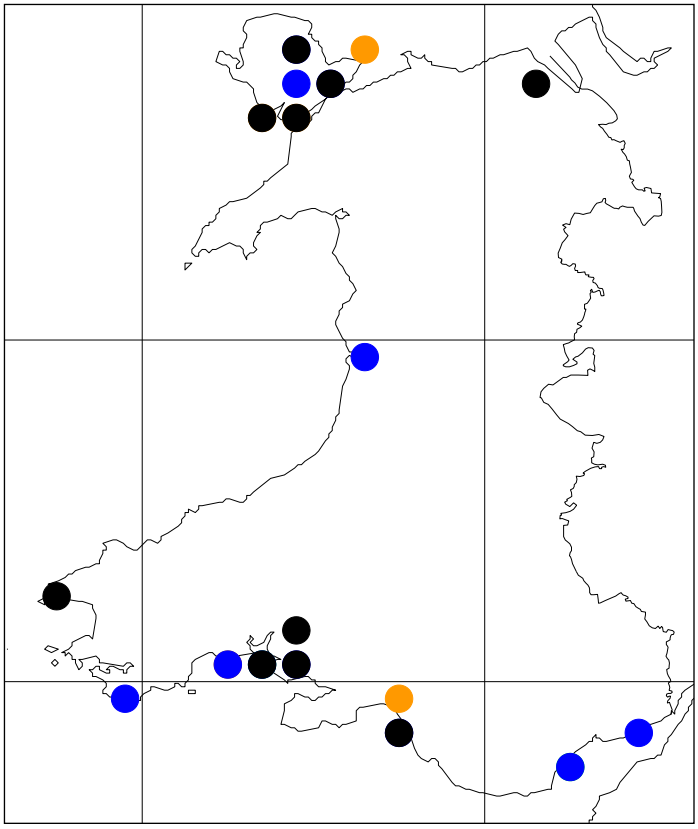

Figure 6.18.1. Distribution of *Tolypella glomerata* in Wales. Black: last recorded 2000 onwards; Blue: last recorded 1987-1999; Yellow: last recorded pre 1969.

Occurrence:

Table 6.18.1 presents a summary of the sites from which this species has been confirmed in Wales

Hectads confirmed since 2000	10
Post 1986 hectads not confirmed since 2000	6
Post 1970 hectads not confirmed since 1986	0
Older hectads not confirmed since 1970	2

Table 6.18.1. Summary of the hectad distribution of *Tolypella glomerata*.

Figure 6.18.2. Trends in the occupancy of *Tolypella glomerata* in Wales.

Determining the trend in the distribution of *T. glomerata* in Wales is not straightforward. A number of records in the 1987-2000 range are from sand dunes which have received less survey attention for stoneworts in recent years. There may also be a degree of under-recording because it is a vernal species that has normally disappeared by the beginning of June, while aquatic surveys are often undertaken later in the year.

On the whole, the available data suggests that this species is stable in Wales (Figure 6.18.2) and may even be increasing – the apparent dip in 2010-17 is likely to represent a relative reduction in recording effort in dunes and fens relative to lakes.

Population:

Populations vary considerably depending on habitat but many populations are small. Substantial populations can occur for a period in newly created gravel pits and on occasionally disturbed quarry floors but are normally transient. Persistent populations can occur where there is regular drying out or disturbance, such as in dune slack pools, ponds where there is periodic livestock disturbance and in the inundation zone at the edges of lakes.

Habitats and Ecology:

Clustered stonewort typically occurs in alkaline pools and the shallow sides of ditches, lakes and canals, often in those parts that dry out in summer. It tolerates mildly brackish water and is sometimes locally frequent in dune pools. It is usually a winter annual, visible from October to May, but persisting throughout the year at a few sites in the deeper water of low nutrient, large alkaline lakes where it occurs with *Chara globularis* and *C. contraria* (Bryant and Stewart 2011).

In Wales it is mainly restricted to pools in calcareous fens and sand dunes but there are few records from abandoned quarries and gravel pits, grazing marsh ditches and clay pools with some calcareous influence on heathland.

Threats:

At individual sites the main threat is usually succession to swamp and wetland vegetation, but it probably has some ability to migrate to new sites where the habitat is suitable. Its sites are also particularly vulnerable to drainage and infilling. It is sensitive to the secondary effects of water pollution and usually occurs in locations where there is some isolation from nutrient enrichment. In ditches it occurs in areas which are remote from the main arterial drains

Conservation:

Management for this species normally requires periodic disturbance such as clearance, low intensity grazing or occasional vehicle rutting, as well as isolation from enrichment.

Red List Assessment:	**LC**

Assessment Rationale:

This species is widespread and occasional in suitable habitats, and there may be some under-recording due to its season of growth. Although there have been some losses, it is still too frequent to qualify as threatened. It is therefore classed as Least Concern.

7. Potential New Additions

Although many species are listed as threatened, the list of Welsh charophytes has been lengthening in recent years. Here we have considered some of the species that could potentially colonise, or which might already be present but overlooked. These are based on former records or on connectivity scores (Appendix 1); all occur in Britain, Ireland or Northern France. Descriptions are based on Stewart & Church (1992) and Urbaniek & Gabka (2014).

7.1. *Chara canescens* Loiseleur

This is a heavily-spined species that usually occurs in brackish, calcareous sites. It can be distinguished easily from other strongly-spined species by the stem being milky-translucent rather than opaque and by the neat, short-branched, furry appearance. It occurs in very few widely scattered locations in Britain and Ireland. Although it seems quite specialist, it is considered reasonably likely to be found in Wales if suitable habitat exists.

7.2. *Chara connivens* P. Salzmann ex. A. Braun

This species resembles *Chara globularis*, from which it differs in being dioecious. It is found in calcareous alkaline lakes and quarry pools, usually near the sea. It is rare but has a scattered distribution including the Lake District, the Wexford area of SE Ireland, Devon and the Norfolk Broads. Some of the Anglesey Lakes such as Llyn Coron and Llyn Traffwll may have suitable habitat, though all of these have high nutrient levels.

7.3. *Chara fragifera* Durieu

This unusual *Chara* is rather similar to *C. virgata* but has longer, flexuous branchlets, is dioecious, and produces whitish bulbils on the lower stem and rhizoids. It is an oceanic Atlantic-Mediterranean species only known in Britain from extreme southwest Cornwall, notably the Lizard Peninsula, where it shows a marked preference for small temporary pools. Here it is currently restricted to areas with serpentinite geology but in the past it was also associated with granite – similar maritime serpentine habitat occurs on Holy Island and western Anglesey, and a search there might be worthwhile. There are also potentially suitable ponds on coastal heaths in Pembrokeshire and the Llŷn Peninsula.

7.4. *Nitella capillaris* (A.J. Krocker) J. Groves & G.R. Bullock-Webster

This *Nitella* resembles *N. flexilis*, from which it can be distinguished by the jelly-coating around the sexual parts. It occurs in northern France and was recently rediscovered in Suffolk after being thought extinct from Britain. Its original site was a ditch and adjacent slow-flowing river but its new sites are in small ponds. Although its habitat requirements are poorly known it seems to be limited to south-eastern England. Nevertheless, there is a possibility that it could turn up in south Wales, with areas such as the Gwent Levels potentially being suitable.

7.5. *Nitella confervacea* (Brébisson) A. Braun ex. Leonhardi

This is a small, delicate species which in Britain and Ireland seems to have an Atlantic distribution but is also scattered through much of Europe. It is scarce in western Ireland and has also been recorded from scattered sites in the Lake District and western Scotland. It grows in clear, soft water, oligotrophic to mesotrophic lakes.

There is good availability of potentially suitable habitat for this stonewort in Wales, and due to its small size there is there is a reasonable possibility that it may have been overlooked. Searches in the lakes of Snowdonia and other upland locations may be worthwhile.

7.6. *Nitella hyalina* (De Candolle) C. Agardh

Another small *Nitella*, *N. hyalina* has three rings of branchlets at each node, giving a bushy appearance. In Britain it has only ever been recorded from Loe Pool, Cornwall, where it is now considered extinct, but it also occurs in northern France (Le Bail *et al*. 2012). Climate change and recovery from acidification may render some of the Welsh base-poor lakes more suitable for this species, thereby potentially allowing northward spread.

7.7. *Nitella syncarpa* (J.L. Thuillier) Kutzing

A slender species similar to *N. capillaris*, of which it has been considered a variety. This species has not been recorded from Britain (apart from once as an introduction) but occurs in Europe including northern France. It is relatively ephemeral occurring in warm locations on calcium-rich organic substrates in ponds, pools, peat cuttings and fenland drains (Urbaniak & Gabka 2014). This habitat is most likely to be available on Anglesey, but the ditches in the Gwent Levels could also be suitable.

7.8. *Tolypella intricata* (Trentepohl ex Roth) Leonhardi

This species was formerly fairly widespread in southern England, but has declined substantially. It forms tufted, tassel-like heads with narrowly pointed branchlet-tips. It is a winter annual that grows in alkaline, ephemeral water bodies, and populations may increase explosively after disturbance but typically disappear as competing vegetation increases. Typical habitats include stock-watering pools in unimproved grassland and ruts in woodland rides.

Although it has never been recorded from Wales, one of its remaining strongholds is in north-west Gloucestershire. It is possible that the species could spread northwestwards although it seems to have limited dispersal ability.

7.9. *Tolypella nidifica* (O.F. Müller) Leonhardi

Tolypella nidifica is a rare brackish water species, growing on sandy substrates in pools, lakes and ditches. It has a larger fruiting structures than other British *Tolypella* and a strongly clustered appearance but can best be picked out from related species by its glossy appearance. Formerly recorded only from East Anglia and Orkney in Britain, there are recent records from North Uist and southeast Ireland. Searches for

this species in suitable habitat around the coast may reveal its presence in Wales, especially as brackish habitats are often poorly surveyed.

7.10. *Tolypella prolifera* (Ziz ex A. Braun) Leonhardi

This is much the largest of the *Tolypella* species, and like the smaller *T. intricata* has narrowly acute branchlet-tips. It has a scattered distribution in southern England including the Cambridgeshire Fens, several sites near Arundel, and the Somerset Levels as well as a handful of scattered sites elsewhere. It is a summer annual and grows in small alkaline water bodies, particularly recently-cleared ditches but also occasionally in canals and lakes.

In Wales it would be most likely to be found in the less-enriched parts of the Gwent Levels.

8. Review of Conservation Action

The process of assessment of the extinction risk of a species includes review of existing conservation action and generally includes some recommendation for conservation of species which are classed as threatened. This chapter presents a review of the conservation actions proposed under the stonewort assessments appended to this report. Similar types of action are grouped in order to minimise the number of separate actions, whilst maximising the number of species or actions which can be addressed. *Nitella mucronata* is considered to be non-native in Wales and therefore no conservation actions are proposed for it. Due to their frequency, there are no conservation measures in place for the following species and none needed although in many cases conservation measures for rarer species will also be of benefit to these species: *Chara contraria*, *Chara globularis*, *Chara hispida*, *Chara virgata*, *Chara vulgaris* and *Nitella opaca*.

8.1. Control of nutrient levels

Most stonewort populations are vulnerable to the secondary effects of nutrient (nitrates and phosphates) enrichment of the water in which they grow, in particular as a result of increased turbidity and excessive growth of other algae and vascular plants. Enriched conditions also generally result in an increase in the deposition of soft organic substrates which suppress spore germination and are more difficult for stoneworts to anchor into. The following species are considered particularly vulnerable to this: *Chara aculeolata*, *C. aspera*, *C. curta*, *C. hispida, C. rudis*, *Lamprothamnium papulosum*, *Nitella gracilis*, *N. tenuissima*, and *Tolypella glomerata*.

There is a need to review water quality at all sites supporting Threatened stonewort species, and assess potential nutrient control measures, such as establishment of buffer zones between agricultural land and water bodies, treatment of point-source pollution and diversion of polluting inflows. Addressing this issue is one of the most important challenges facing stonewort conservation in Wales.

Some major remedial work has been undertaken at several important sites. For example at Bosherston Lakes, water from the more enriched part of the lake was piped directly to the sea. This has resulted in considerable improvements to the water quality in the remaining part of the lake although the vegetation has still not fully re-estabilised. At Cors Erddreiniog water from a nutrient rich source has been directed through a managed wetland system again resulting in significant improvements in water quality in that part of the fen. However, more usually measures have focussed on identifying and reducing nutrient inputs at their sources.

Stoneworts have also responded to general water quality improvements at other sites. A good example of this is Llangorse Lake in Breconshire. In the 1970s, the lake received water from two sewage treatment works, resulting in phytoplankton blooms that virtually eradicated all macrophytes from the lake (Duigan et al. 1999; Wade 1999). During the 1980s and early 1990s, both sewage works were diverted, resulting in significant improvements to water quality. The lake now supports quite extensive charophyte beds including *Chara contraria*, *C. globularis*, *Nitella translucens* and *Nitellopsis obtusa* (e.g. Shilland *et al*. 2018).

8.2. Site and Habitat Management

A number of species are particularly associated with small water bodies which are vulnerable to successional changes, particularly *Chara aculeolata, Chara baltica, Chara curta, Nitella tenuissima* and *Tolypella glomerata*. The abandonment of traditional land-use practices, notably decline in stocking levels and their access to water bodies and the processes which formerly created new water bodies such as peat cutting have ceased. This has allowed seral succession to proceed in and around water bodies supporting threatened stoneworts, with the result that many such sites are now threatened.

In Wales this is particularly an issue in sand dunes and in the Anglesey fens which support some of the richest habitats for stoneworts in the country. Fortunately, many of the key sites with these habitats are in some form of conservation management and it is has been possible to address these issues through appropriate grazing levels and periodic creation or clearance of ponds and dune slack scrapes.

Nevertheless, away from these sites, lack of management and successional changes are a widespread concern for species growing in ponds, ditches and flushes. For example, in Pembrokeshire there has been a gradual loss of heathland habitat to improved farmland on the one hand, combined with increasing neglect of the remaining areas with reversion to scrub and woodland. In the more industrial parts of Wales, abandoned quarries, gravel pits and colliery waste are a good habitat for stoneworts and other aquatic plants because of their isolation from the natural, generally nutrient enriched, drainage system. But here too successional changes as the water bodies age are often a significant issue. In the Gwent Levels regular ditch management are also an integral part of maintaining a diverse ditch flora.

8.3. Data quality and Monitoring Requirements

In recent years the main focus of survey for stoneworts has been the Anglesey fens and as part of NRWs routine monitoring of aquatic vegetation condition of lakes (Burgess et al. 2006, 2009; Goldsmith et al. 2006; 2013; 2014a, b, c; 2016; Shilland et al. 2018). Lakes in particular have a good quality dataset combining a standardised protocol, regular visits, good taxonomic resolution, information on other plant species, and water chemistry data. This has allowed a much more accurate assessment of the status of species such as *Chara rudis, Nitellopsis obtusa* and *Nitella gracilis*.

Other habitats have received less attention and this has hampered assessments of status, especially in relation to trends.

Habitats that need further survey include;

- Sand dunes; a number of the key sites were surveyed in the 1990s but, with the exception of Newborough Warren have received little attention since. In the latter there is still a continuing need to relocate *Chara baltica*.
- Quarries, gravel pits and other “brown field” sites are potentially an important resource in the more industrial parts of Wales. Sites where the geology is calcareous, such as disused limestone quarries, are a particular priority.

- Pembrokeshire heaths; again some sites were surveyed for stoneworts in the 1990s but there is little up-to-date information.
- Continued monitoring in the Anglesey fens, at least while the populations of e.g. *Nitella tenuissima* and *Chara curta* remain precarious. Some habitat management and creation is ongoing and these measures need to be monitored. Information from Cors Goch is less complete than other sites.
- Gwent Levels; stoneworts appear to be very localised within the Levels but further survey is needed, e.g. to assess the continued presence of *Tolypella glomerata.*

In addition to these more general survey needs there are some specific investigations needed for individual threatened species, including;

- Further exploration for *Chara aculeolata* at Bosherston Lakes and in the Pwllheli area. In the former case, improving water quality could result in its reappearance.
- Survey is needed for *Chara aspera* at Llyn Llygerian, Llyn Dinam, and Eglws Nunnydd Reservoir to assess the extent of the populations. Although these sites are sample monitored at intervals, the indications are that the species is quite localised. Llyn Rhos-ddu also needs revisiting to attempt to relocate the population there.
- Margam Burrows needs revisiting to assess whether *Chara aspera* and *Tolypella glomerata* are still present and whether any pond clearance is needed. This site is surrounded by land reclamation associated with Port Talbot steelworks and has not been revisited since the 1990s.
- Sand dune surveys, as discussed above, need to include the Pembrey Coast and Laugharne Burrows to assess the current populations of *Chara curta*.
- Continued monitoring of the *Chara rudis* population at Llyn Cadarn.
- *Lamprothamnium papulosum* has only recently been discovered at the Inland Sea. Further survey of suitable locations is needed to assess if other colonies occur. Further information on the salinity variation is also needed.
- Although knowledge of *Nitella flexilis* s.s. is very incomplete, it is difficult to design a targeted survey to address this issue. Further knowledge of this species will probably need to rely on routine lake monitoring surveys. However, in the Montgomery Canal there are a scattering of locations for *Nitella flexilis* agg. which are assumed to be *Nitella flexilis* s.s. based on identification of a few specimens in the 1980s. Confirmation that it is this species throughout the canal would be desirable.
- *Nitellopsis obtusa* populations at Llangorse Lake and Cosmeston Lake should continue to be monitored as part of the ongoing programme of lake condition monitoring. The record of a *Nitella*-like species from Serpentine Lake, Oxwich needs further investigation.

8.4. Important Stonewort Areas

Stewart (2004) carried out a UK wide exercise to identify Important Stonewort Areas in the UK, including Wales. Most of the areas identified in 2004 remain important today and are relevant to NRW's production of Area Statements. A summary of his findings is included in Table 7.4.1.

It is not the purpose of this report to carry out an exhaustive reanalysis of his conclusions. However, a brief update and review of the existing areas is relevant as it could link to existing area-based policy development.

Based on the revised species records and threat categories here, most of Stewart's (2004) recommended Important Stonewort Areas would be retained (Table 7.4.1). The importance of Anglesey in a Welsh context is emphasised and there is also a good case to include the western Anglesey Lakes, as these included some important historic populations. A useful approach would be to include much of Anglesey as an Important Stonewort Area, as this would encourage the development of measures in the wider countryside and also allow the newly discovered *Lamprothamnium papulosum* population to be incorporated.

Site Name	Area	Total Species	RDB Species	Habitat
Anglesey Fens	Anglesey	11	5	Fen
Newborough Warren	Anglesey	8	4	Dune
Western Anglesey Lakes	*Anglesey*	*8*	*2*	*Lakes*
Kenfig Burrows and Pool	Bridgend	8	2*	Fen and Lake
Pembrey Coast	Carmarthenshire	6	2	Dune
Laugharne / Pendine Burrows	Carmarthenshire	5	1	Dune
Llyn Gynon	Ceredigion	2	0	Lake
Ynyslas	Ceredigion	6	2	Dune
Llynnau Mymbyr	Conwy	2	0	Lake
Llyn Dwythwch	Gwynedd	1	0	Lake
Gwent Levels	Monmouth / Newport	5	0	Ditch System
Bosherston Lakes / Stackpole Warren	Pembrokeshire	6	2*	Lakes and Dune

Table 7.4.1. Important Stonewort Areas identified by Stewart (2004). Areas identified in grey should no longer be included. An additional site (italics) is proposed here. * Denotes large population of one or more RDB Species.

Three Important Stonewort Areas, Llyn Gynon, Llynnau Mymbyr and Llyn Dwythwch, were identified based on the presence of a single species, *Nitella gracilis*, which was then considered a very rare plant. Subsequent survey has shown it to be more widespread than previously realised, leading to its current threat status being downgraded to LC. As a result, these three lakes should no longer be included. The

value of the Gwent Levels as an Important Stonewort Area is also dubious, as it does not support any species identified as threatened on this list.

8.5. Protected Sites as a Conservation Mechanism for Stoneworts

In Wales, the more threatened stoneworts are strongly dependant on the protected sites series (SSSIs and SACs) for their persistence. Six species (*Chara baltica*, *C. curta*, *C. rudis*, *Nitella tenuissima*, *Nitellopsis obtusa* and *Lamprothamnium papulosum*) are found only on protected sites. Three additional species, *Chara aculeolata*, *C. aspera* and *C. hispida*, have more than 90% of their population within the protected sites network, whilst significantly more than half of the Welsh populations of *Tolypella glomerata* and *Nitella gracilis* are in protected sites. These species are all either rare or have been lost entirely from the wider countryside. In other words, of the eighteen species of stoneworts native to Wales, more than half might be lost if the protected sites network did not exist. The remaining species (*Chara contraria*, *C. globularis*, *C. virgata*, *C. vulgaris*, *Nitella flexilis*, *N. opaca*, *N. translucens*) are relatively widespread species that are generally stable or increasing.

Within the protected sites network, the picture for stoneworts is mixed. In lake habitats, their importance for ecological function is generally well recognised and they are consequently used as indicators of ecological quality. By contrast, in sites designated for terrestrial habitats, monitoring is scant and there is little specific recognition of the value of the group. However, management activities in both fens and dunes are likely to benefit stoneworts (e.g. the Anglesey Fens LIFE+ Project: https://naturalresources.wales/about-us/our-projects/nature-projects/anglesey-and-llyn-fens-life-project/?lang=en; Sands of LIFE: https://naturalresources.wales/about-us/our-projects/nature-projects/sands-of-life/?lang=en).

The above evidence indicates that the existing protected sites network is extremely effective at conserving stoneworts. Although many of the stonewort populations themselves are not in favourable condition, it is conceivable that without the protected site series safeguarding the existence of high-quality stonewort habitats, as much as half of all Welsh stonewort diversity could have been lost. During the current Biodiversity Crisis, the Welsh protected site series is a haven for our stonewort flora.

9. Concluding Remarks

Although consisting of just nineteen species, the patterns seen in this review of Welsh stonewort flora are likely apply to many other taxonomic groups at present, reflecting wider environmental themes and patterns. These are:

Recovery from Acidification

Following actions to reduce emissions of sulphates from power stations and heavy industry, the Welsh uplands have started to show increasing evidence of recovery from the impacts of acid rain. There has been an increase in the more widespread charophytes using these habitats, notably *Nitella gracilis* but potentially also *N. opaca*, *N. translucens* and *Chara virgata*.

Species Richness and the Extinction Crisis

Eight species – almost half the Welsh flora – are listed on a threat category in this Red List. This is an unusually high proportion. Most of these are habitat specialists, requiring habitat types that have declined markedly or have degraded in quality over the past half century. Calcareous lowland fens and alkaline lakes are particularly important in this regard, and the stonewort hotspot on Anglesey also reflects key loci for these habitats in Wales. These specialist and highly threatened habitats are crucial for the maintenance of many of our most threatened species.

A contrary pattern is apparent with regard to the total species richness of stoneworts in Wales. Although this is a well recorded group, five new species have been found in Wales since 1975: *Chara baltica*, *Lamprothamnium papulosum*, *Nitella gracilis*, *N. mucronata* and *Nitellopsis obtusa*. Whilst the reason for this is uncertain, in the case of *N. obtusa* at least, warmer conditions may be encouraging more frequent fruiting, allowing it to spread more readily between water bodies.

The Importance of Protected Areas

Protected Areas are a crucial and effective mechanism for the conservation of species and their habitats, including stoneworts. It should be noted that a disproportionate amount of monitoring effort takes place in Protected Areas and therefore the true status outside them may be underplayed. Nevertheless, Protected Areas are important because they safeguard a high proportion of the remaining area of lowland alkaline fen, sand dune and lowland lakes from habitat damage and destruction. It is also noteworthy that all of the new stonewort species that have colonised Wales appeared in protected areas.

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Finally we would like to dedicate this publication to the memory of Alan Hale, who contributed so much to the study of Welsh stoneworts.

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Data Archive Appendix

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] A dataset in Microsoft Excel format. This is an update to the existing Metadata resource 100170 Stoneworts in Wales.

[C] An ArcMap Geodatabase dataset named Stoneworts In Wales consisting of GIS layers for all of the species.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue https://libcat.naturalresources.wales (English Version) and https://catllyfr.cyfoethnaturiol.cymru (Welsh Version) by searching 'Dataset Titles'. The metadata is held as record no [NRW to insert this number]

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