JOINT NATURE CONSERVATION COMMITTEE

Red Data Books of Britain and Ireland:

Stoneworts

by N.F. Stewart and J.M. Church

1992

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The Joint Nature Conservation Committee
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This Red Data Book
was edited for the
Joint Nature Conservation Committee
by
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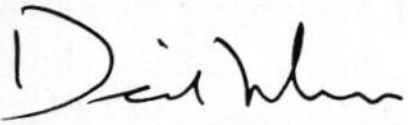
Contents

Foreword

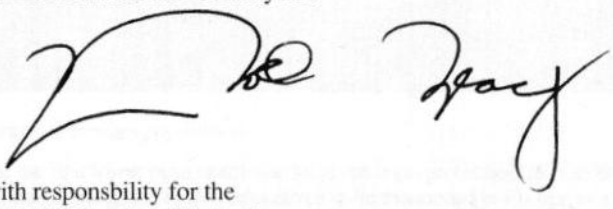
Lower plant conservation has moved forward considerably over the past few years. From a position of obscurity, lower plants are now firmly on the conservation agenda, and it gives us great pleasure to welcome this Red Data Book for stoneworts as a manifestation of the new enlightened attitudes towards the lesser-known biological groups. This book is unusual in two ways. Not only is it the first British and Irish Red Data Book to deal specifically with lower plants, but it also represents a joint venture between the nature conservation agencies of the United Kingdom and Ireland. The distribution of plants and animals is independent of national boundaries, so a book covering all these areas is particularly welcome. It is anticipated that it will be the first in a series of Red Data Books, and that further volumes will deal with lichens, bryophytes (mosses and liverworts) and other groups of plants.

Most of the plants termed 'lower' are unfamiliar to many of us, perhaps because of their predominantly small size. Yet if we take the time to look, there is a wealth of beauty to be discovered in plants without flowers. The algae called stoneworts are fairly large for lower plants, yet are among the least familiar because of their aquatic habitat. Although there are only 33 species in Britain and Ireland, they have great ecological significance, often carpeting vast areas in clear freshwater lakes and forming an important source of food for diving ducks. Furthermore, a worryingly high proportion of the group is regarded as threatened. This reflects the sensitivity of stoneworts to pollution and their value as indicators of pristine water bodies.

This Red Data Book represents an important step in bringing stoneworts to the wider attention of those who manage sites for nature conservation, but of course stoneworts should not be considered in isolation. Many of the sites mentioned in the text are of great importance for other animals and plants. It will be a great step forward if this book can be used to further the conservation of sites which are notable for their stonewort flora, and in doing so can help to protect lakes, ponds and rivers throughout Britain and Ireland.



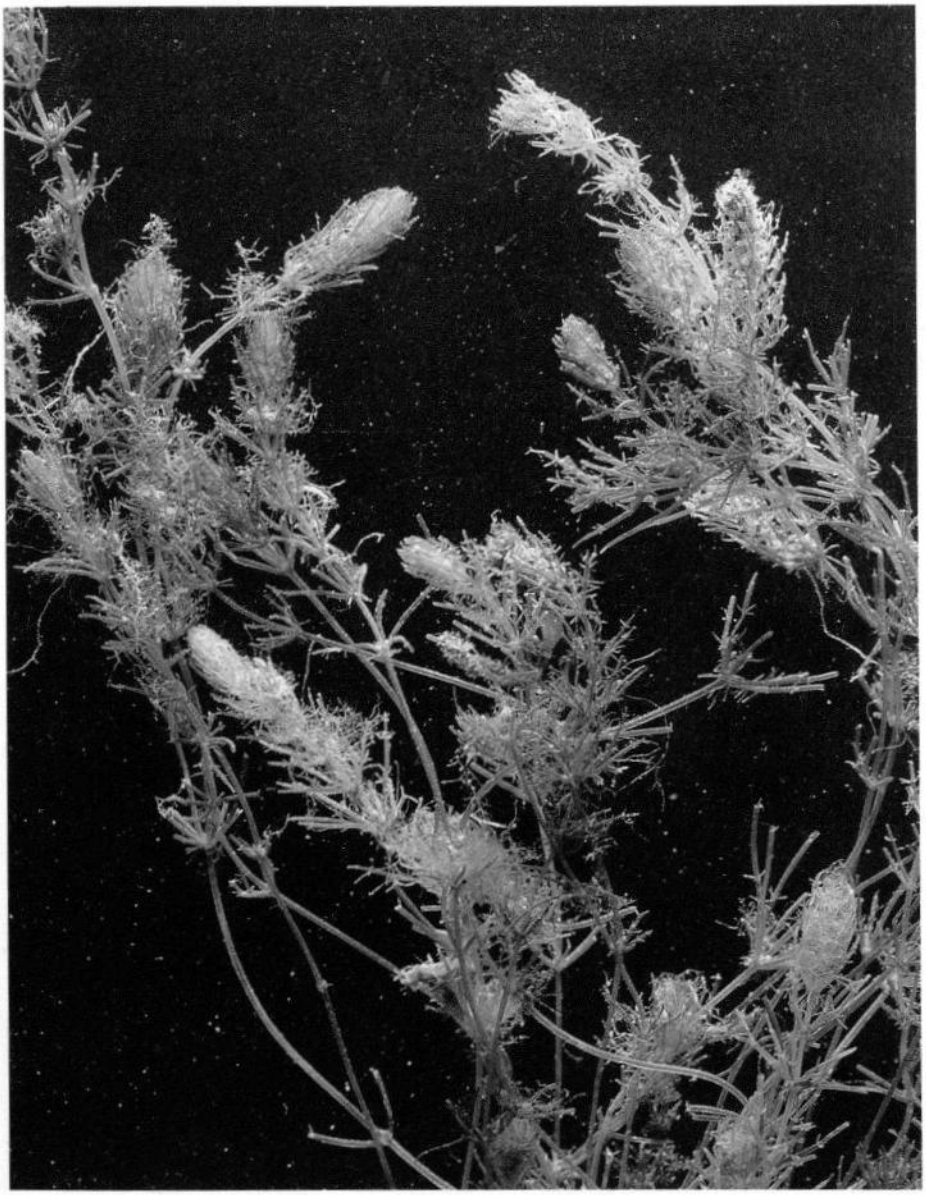
David MacLean MP
UK Minister for the Environment and Countryside



Noel Treacy TD
Minister of State with responsbility for the
National Parks & Wildlife Service of Ireland

Abbreviations

ASI	Area of Scientific Interest
ASSI	Area of Special Scientific Interest
BSBI	Botanical Society of the British Isles
JNCC	Joint Nature Conservation Committee
LNR	Local Nature Reserve
NNR	National Nature Reserve
NT	National Trust
RSPB	Royal Society for the Protection of Birds
SSSI	Site of Special Scientific Interest
E	Endangered
Ex	Extinct
I	Indeterminate
K	Insufficiently known
nt	not threatened
R	Rare
V	Vulnerable



Foxtail stonewort *Lamprothamnium papulosum*.

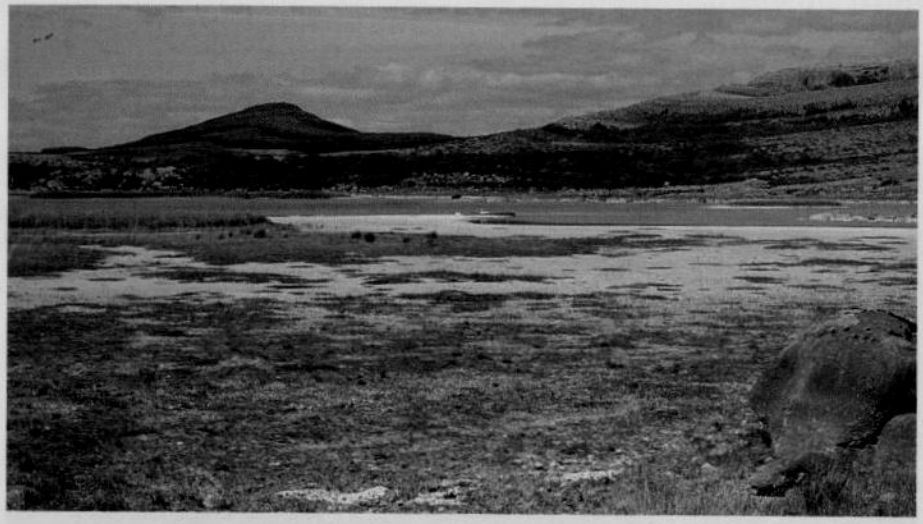
Foxtail stonewort was the first lower plant species to be given legal protection, in both Britain and Ireland. This plant of brackish lagoons is also considered to be threatened in Europe as a whole. (Photo by Natural History Museum Photographic Unit)

Lady's Island Lake, Co. Wexford.

Brackish lagoons are an important habitat for several threatened stoneworts, including foxtail stonewort *Lamprothamnium papulosum* and bearded stonewort *Chara canescens*. These species are vulnerable to change in salinity, which is influenced here by the annual cutting of the sand bar. (Photo by O. Mearne)

Annaghmore Lough, Co. Roscommon.

Several lakes in the Irish Midlands have substantial deposits of marl, causing the white colour of the lake sediments shown here. Marl lakes are rich in calcium carbonate and provide a rich habitat for stoneworts. (Photo by O. Mearne)



Mullaghmore, Co. Clare.

Turloughs are an internationally threatened habitat. They are limestone lakes with dramatically fluctuating water levels. Where permanent pools remain, they are often rich in stoneworts. (Photo by G. Doyle)

Carricknahorna Lough, Co. Galway.

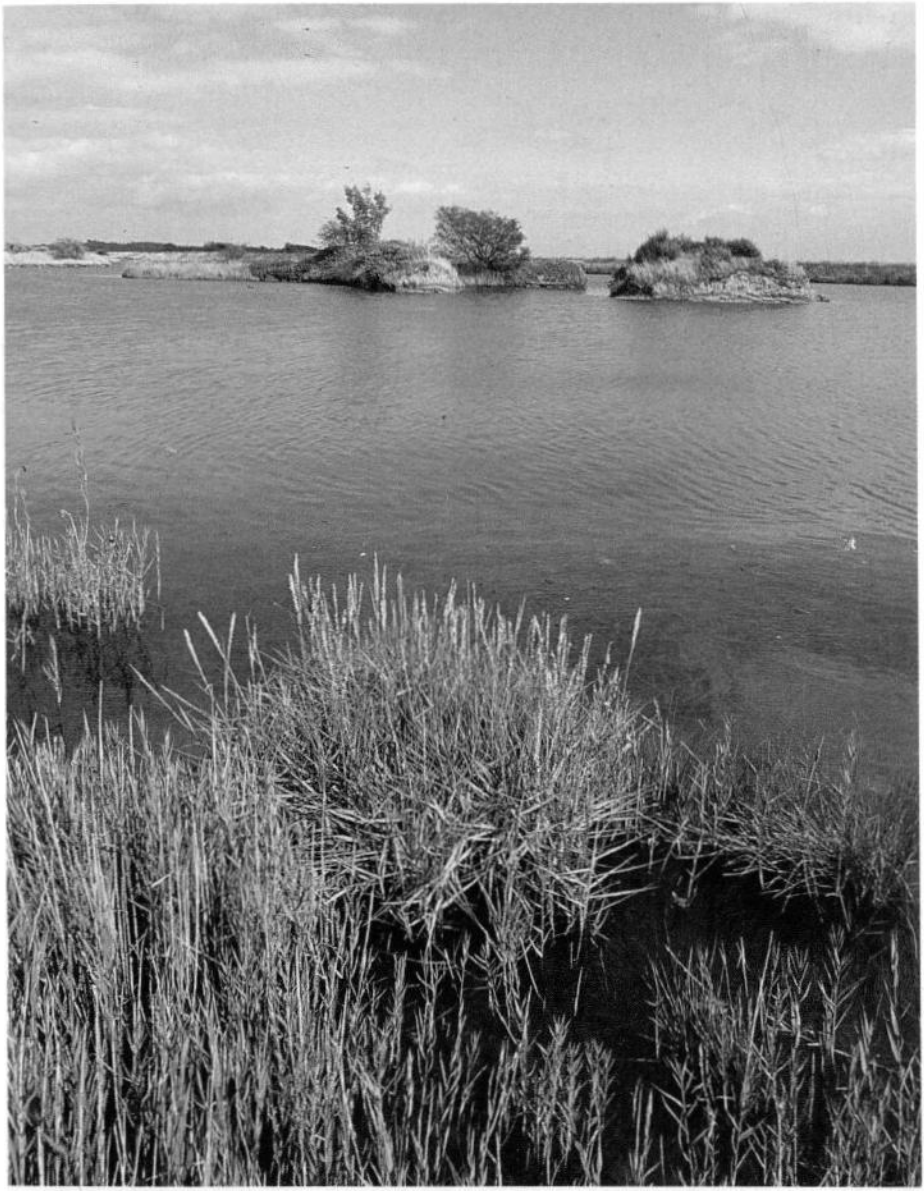
Calcareous fen pools provide a rich habitat for stoneworts that can tolerate periodic drying out. Pools with marl substrates, as illustrated here, are often particularly rich in stoneworts. (Photo by N. Stewart)

Lismore, Argyll.

Some *Chara* species are good opportunists and can colonise artificial habitats. (Photo by N. Stewart)

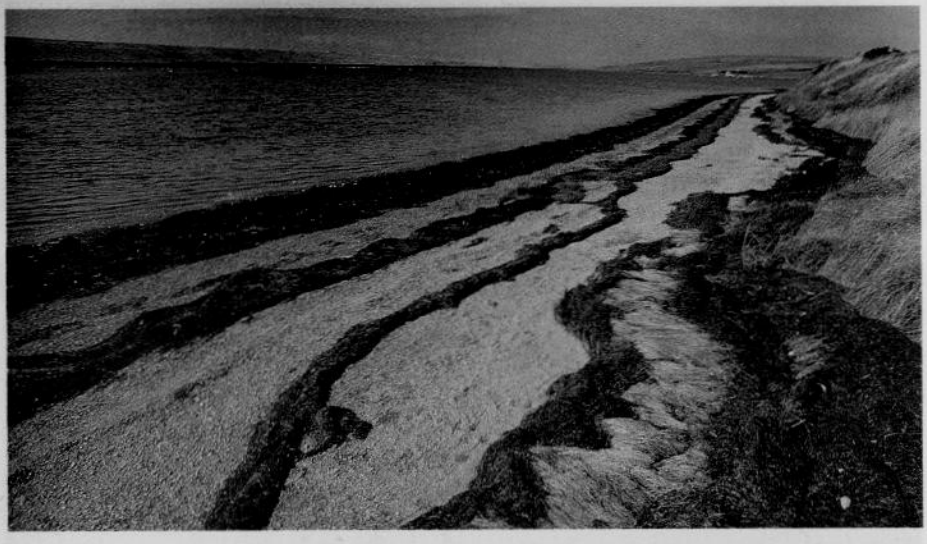
Royal Canal, Co. Dublin.

Canals frequently provide a relatively unpolluted habitat for water plants, including stoneworts. Canal maintenance and heavy boat traffic can be threats to these plants. Tassel stonewort *Tolypella intricata* has recently been rediscovered in the Royal Canal. (Photo by Office of Public Works)



Eight Acre Pond, Lymington, Hampshire.

Stonewort sites are often also important for other organisms. This brackish pond is the only known British site for the lagoon sandworm *Armandia cirrhosa*, as well as being a site for foxtail stonewort *Lamprothamnium papulosum*. (Photo by P. Wakely)



The Fleet, Chesil Beach, Dorset.

This is the most important British site for foxtail stonewort *Lamprothamnium papulosum*. The salinity of the lagoon is maintained by sea water seeping through the shingle bar and coming in through a gap at one end of it. (Photo by P. Wakely)

Chara bed, Countybridge Quarry, Cornwall.

Chara species often form extensive carpets on the beds of shallow calcareous waters. (Photo by J. Moore)

Floating dredger on the Montgomery Canal, Shropshire.

Canal maintenance is essential to the survival of many stoneworts, preserving open water and preventing other vegetation from taking over. However, many species require the sheltered shallows provided by fringing reeds, and excessive maintenance operations or boat traffic can reduce these, to the detriment of the stoneworts. (Photo by C. Walker)

Ditch dredging near Boston, Lincolnshire.

Periodic dredging is necessary to maintain the ditch habitat for stoneworts. This can be important for rarities such as dwarf stonewort *Nitella tenuissima*. (Photo by C. Newbold)

Applying herbicide on the Chesterfield Canal, Nottinghamshire.

Herbicide application during canal maintenance may be a threat to stoneworts. However, some species may benefit from limited applications of herbicide which reduce competing vegetation. (Photo by M. Palmer)

Ludham Marshes NNR, Norfolk.

Ditches, particularly in the East Anglian fens and Broads, provide a relict habitat for many fenland stoneworts, including rare and threatened species. (Photo by P. Wakely)

Introduction

The stoneworts make up a small group of plants which are recognised as a separate class, Characeae, of the green algae (Chlorophyta). Around 400 taxa are known worldwide (Wood & Imahori 1965), although the number of taxa that deserve species rank is likely to be about 250 (Imahori 1954). A total of 33 species have been recorded in Britain and Ireland.

The stoneworts are remarkable for their complexity of structure and they are frequently mistaken at first glance for higher plants. Indeed, at one time they were classified with the horsetails *Equisetum* and given the common names 'creeping water horsetail' and 'stinking water horsetail'. They are also remarkable for the size of some of their cells, which can sometimes exceed fifteen centimetres in length.

Stoneworts grow completely under water and in suitable conditions can dominate communities. They are especially associated with clean water, particularly if this is highly calcareous or brackish, so many species have suffered badly from water pollution. Nevertheless, there remain many areas of considerable importance for stonewort communities, particularly towards the west, where there are many water bodies which are still fairly unpolluted. In Ireland the extent of limestone rocks and high rainfall have contributed to the large number of sites with well developed stonewort communities.

This Red Data Book has been compiled by Plantlife under the direction of the Nature Conservancy Council (NCC) and Joint Nature Conservation Committee (one of the successor bodies of the NCC), the National Parks and Wildlife Service, Office of Public Works (Ireland) and the Environment Service, Department of the Environment (Northern Ireland).

Research and data collation began in 1988 and was initially carried out by the Conservation Association of Botanical Societies (CABS), the voluntary organisation set up by the main botanical societies to deal with conservation issues. The information collected during this time covered only Britain. In 1990, CABS amalgamated with Plantlife, who took over the management of the project. Plantlife succeeded CABS as the major plant conservation organisation in Britain and Ireland.

In 1991, a similar project was set up in Ireland to produce a Red Data list for both the Republic of Ireland and Northern Ireland and the final publication has been a co-operative venture between all the organisations listed above.

Production of this Red Data Book would not have been possible without the help and support of a large number of individuals and organisations, both amateur and professional. In particular we would like to thank:

John Bratton, Joint Nature Conservation Committee (United Kingdom)
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Pat Curry

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Gary Kennison, Broads Authority

Jimmy King, Central Fisheries Board

Jenny Moore, Natural History Museum

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Jim Ryan, National Parks & Wildlife Service, Office of Public Works (Ireland)

Ian Tittley, British Phycological Society & Natural History Museum

Richard Weyl, Environment Service (Northern Ireland)

Shaun Wolfe-Murphy, Northern Ireland Lake Survey

All those people who contributed records.

We would like to thank Margaret Tebbs for the illustrations and we are grateful to the Botanical Society of the British Isles for permission to reproduce parts of these illustrations which were taken from their handbook *Charophytes of Great Britain and Ireland* (Moore, 1986). Thanks are also due to E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, for permission to use the illustration of *Chara rudis*, originally published in *A revision of the Characeae* by R. D. Wood and K. Imahori (1965). The illustration of *Chara intermedia* was first published in the *Journal of Botany* (Groves & Groves 1886).

We would also like to thank the following organisations who assisted with this publication:

Botanical Society of the British Isles

British Phycological Society

Conservation Association of Botanical Societies

Environment Service (Northern Ireland)

South London Botanical Institute

National Parks & Wildlife Service, Office of Public Works (Ireland)

National Botanic Gardens, Glasnevin, Dublin; National Museum of Wales, Cardiff; Natural History Museum, London; Royal Botanic Gardens, Edinburgh; and Ulster Museum, Belfast for access to their herbarium collections.

The Ordnance Survey Offices of Britain and Ireland for permission to use their maps as a basis for the distribution maps.

The Biological Records Centre, Monks Wood, for producing the distribution maps (which were re-drawn for this book).

An Taisce (National Trust for Ireland), Wildlife Trusts, Countryside Council for Wales, English Nature, Nature Conservancy Council for Scotland, Irish Wildbird Conservancy and the National Trust, who provided us with information about sites.

The Natural History Museum and the National Parks & Wildlife Service who have provided us with accommodation and facilities.

Finally, we would like to acknowledge funding for the project from the Nature Conservancy Council, Environment Service (Northern Ireland), National Parks and Wildlife Service, the Nature Conservancy Council for Scotland, English Nature and the Countryside Council for Wales.

The study of stoneworts

Because of the size and complex structure of stoneworts and their important role in aquatic plant communities, these algae have often attracted the attention of botanists primarily interested in flowering plants. The Botanical Society of the British Isles (BSBI), which otherwise deals only with vascular plants, still mentions stoneworts in its rules and continues to encourage their study, even though since 1952 there has been a society specifically devoted to the study of algae, the British Phycological Society. Stoneworts have, therefore, received considerably more attention than most other groups of algae. In both Britain and Ireland they have frequently been mentioned in local and national vascular plant floras and books on plant distribution.

As with the flowering plants, interest in stonewort distribution began to grow in the mid nineteenth century, with Professors Charles Babington and David Moore making a number of interesting discoveries in the Cambridgeshire fens and central Ireland respectively. However, the study of stonewort distribution can be divided into three main phases. The first of these began in the late 1870s, when the Groves brothers became particularly interested in the group. Throughout the rest of the nineteenth century and the early part of the twentieth century they did much to sort out the taxonomy of British and Irish species, through correspondence with botanists in the two countries, and through extensive travels of their own. Henry Groves died in 1912, but his brother James, in collaboration with Canon George Bullock-Webster, published the first standard work on British and Irish stoneworts (Groves & Bullock- Webster 1920, 1924).

Interest in the group then declined. James Groves died in 1933 and George Bullock-Webster in 1934, but meanwhile Guy Allen became interested in stoneworts whilst working in India. He returned to England in 1933 and inherited his mentors' notes and specimens and soon became familiar with the plants in Britain. Again through correspondence and his own travels he encouraged others to study stoneworts and in 1950 produced his own handbook (Allen 1950). He acted as referee for the group for the BSBI until shortly before his death in 1963.

There then followed another lull until the mid-1970s, when Jenny Moore became interested in the group. For many years she and the Natural History Museum have provided an identification service and have built up a considerable body of information on stoneworts in Britain and Ireland. In 1983, together with Dorothy Greene of the Biological Records Centre at Monks Wood, she produced the first stonewort distribution maps (Moore & Greene 1983) and in 1986 produced an identification guide in the BSBI Handbook series (Moore 1986). The renewed interest in the group has coincided with a recent increase in interest in aquatic wildlife in general, linked to a realisation of the damage that has occurred over the last few decades as a result of water pollution. In Britain there have recently been a number of extensive surveys of ditch systems, canals and lakes, funded by organisations such as the former Nature Conservancy Council and its successor bodies, Wildlife Trusts and the Broads Authority. These surveys have looked principally at vascular plants, but many have also included stoneworts. As a result, there is

now a fairly accurate picture of the distribution and frequency of the different species in Britain, and the majority of sites for the rarer species have been checked within the last 15 years. However, the areas where the coverage is least satisfactory are the Outer Hebrides, Orkney and Shetland, where a number of rare species have been recorded in the past, including mossy stonewort *Chara muscosa*, which appears to be extinct in Ireland and is known nowhere else in the world.

Ireland has never had an expert specifically interested in stoneworts. This may be because the small number of botanists there has resulted in less pressure to specialise in any particular group. Nevertheless, a number of people have noted or collected stoneworts in the course of their botanical studies. Notable among those in the latter half of the nineteenth and the early twentieth centuries are Professor David Moore, mentioned above, Robert Praeger, who collected at least one species from every county in Ireland, and Henry Levinge, who investigated the Westmeath lakes. The interest of these and others was encouraged by the Groves brothers with whom they were in correspondence, but the Groves brothers seem only to have made fleeting visits to Ireland. George Bullock-Webster, however, made several visits to Co. Donegal, where he made a number of important discoveries including few-branched stonewort *Nitella spanioclema* and mossy stonewort *Chara muscosa*.

The influence of Guy Allen does not seem to have reached Ireland during the period between the 1930s and 1960s, and there are rather few records for stoneworts, most of which were collected by British botanists on holiday. In the 1970s and 1980s, however, there was a renewed interest in the group in parallel with that occurring in Britain. As in Britain, there have been a number of botanical and general surveys of water bodies which have included stoneworts, in particular those funded by the National Parks and Wildlife Service and Central Fisheries Board in Ireland and the Department of the Environment in Northern Ireland.

The coverage in Ireland is rather less complete than in Britain, both in the past and in recent years. However, the information is more than sufficient to identify the rarest and most threatened species, and many of the known sites for these species have been revisited within the last fifteen years.

Habitats

Stoneworts grow underwater attached to the substrate by a system of root-like rhizoids. They grow in a wide range of water-bodies, but are absent from fully saline conditions, and only rarely occur in more than a slight flow in running water. Stoneworts can grow in oligotrophic to moderately eutrophic conditions, in large lakes, small pools, flushes, temporary water bodies and in fresh to strongly brackish conditions. There are, however, several habitats which are particularly favourable for stoneworts, and such sites can support as many as ten species.

Many species, particularly those in the genus *Chara*, secrete calcium carbonate on the outer surface of the plant, giving a rough and crunchy texture which is the origin of the common name stonewort. This encrustation is produced as a result of the use of the bicarbonate ion as a source of carbon for photosynthesis (Nielsen 1954). The richest variety of species, therefore, tends to occur in sites which are highly calcareous, where there is an influence from limestone, marl, or calcareous sand. It is, however, important to differentiate between calcium-rich and nutrient-rich (eutrophic) waters, since many stoneworts prefer calcium-rich but nutrient-poor situations.

Most stoneworts are unable to tolerate significant levels of phosphates and nitrates, particularly when they are present together. This is partly due to an inhibition of growth – phosphate levels of over 20 µg per litre of water appear to inhibit growth (Forsberg 1965) – and partly due to the proliferation of other aquatic plants. They are, therefore, very sensitive to pollution, particularly from sewage, silage and fertilizers.

Some of the larger stonewort species are capable of forming dense perennial beds, often completely excluding other large aquatic plants. However, stoneworts are not very good at competing with vascular plants and adopt various strategies to obtain an advantage. For example, some stoneworts are able to tolerate low light intensities and can therefore grow at greater depths than most vascular plants. In clear water, stoneworts occasionally occur at depths of up to 8 metres, and there are records of plants occurring at depths of more than 60 metres in the Baltic Sea (Olsen 1944).

A particularly important characteristic of stoneworts is their ability to exploit open spaces more rapidly than higher plants. A high proportion of stoneworts are normally annuals and the durability of the spores is important. They are able to pass through the gut of birds unaffected and can also remain viable for long periods while buried in the substrate (Olsen 1944; Imahori 1954; Krause 1984). The high durability (but not necessarily viability) of the spores is further shown by their frequent occurrence in fossil deposits (Groves & Bullock-Webster 1924).

Several species are good at colonising newly created water bodies such as gravel or clay pits or ponds. Some common species are also able to colonise artificial situations such as concrete drinking troughs.

There is another group of species which benefits from the open conditions resulting from wave disturbance around the edges of calcareous lakes. These include rough stonewort *Chara aspera* and lesser bearded stonewort *Chara curta*, both of which can develop a web of rhizoids to anchor the plants. Several species of *Tolypella* have a winter annual lifestyle which allows them to take advantage of temporary water bodies or shallow water at the edges of lakes. These species germinate in autumn or late winter and complete their life cycle by late spring or early summer, before they become exposed by falling water levels.

Stoneworts can also benefit from other forms of disturbance. Waterfowl can create gaps in the vegetation in their search for food. Semi-permanent open habitats can also result from regular disturbance such as poaching by animals. However, in both cases, where the density of birds or animals is too great, nutrient enrichment usually prevents the growth of stoneworts.

In some smaller water bodies the hand of man is necessary to create open habitats periodically. For example, among the rarer species, dwarf stonewort *Nitella tenuissima* owes its survival at one site to periodic peat cuttings, and both tassel stonewort *Tolypella intricata* and great tassel stonewort *Tolypella prolifera* have benefited from the digging out of ditches and ponds. In certain situations stoneworts can colonise very small water bodies, where the water remains long enough for the plants to complete their life cycle, providing that there is occasional disturbance to maintain an open habitat. A good example of this occurs on the Lizard Peninsula in Cornwall, where ruts in several ancient tracks provide one habitat for strawberry stonewort *Chara fragifera*.

Important stonewort habitats (see Table 1)

Coastal lagoons and lakes

Brackish water is the habitat for a suite of stonewort species, most of which are threatened. Foxtail stonewort *Lamprothamnium papulosum*, for example, lives in salinities of between 1% and 3% (normal sea water is *c.* 3.5% salinity), while bearded stonewort *Chara canescens*, bird's nest stonewort *Tolypella nidifica* and Baltic stonewort *Chara baltica* are largely restricted to brackish sites. All of these species seem to prefer clear water and sandy substrates and therefore tend to avoid sites where there are major inflow streams carrying silt. Typical sites for these species are water bodies cut off from the sea by shingle or sand bars, which allow a certain amount of sea water to percolate through. Sometimes, artificial barriers have created similar sites. Important natural examples include the Fleet (Dorset), Loch of Stenness (Orkney), Lady's Island Lake, Tacumshin Lake and Ballyteige Burrows (all in south-east Co. Wexford) and Loch Murree (Co. Clare).

Another group of species have a marked preference for sites near the sea, perhaps benefiting from a hint of salinity brought in by wind, or from reduced frosts. This group includes convergent stonewort *Chara connivens* and starry stonewort *Nitellopsis obtusa*. Slapton Ley in Devon and the seaward Norfolk Broads are important sites for these species.

Table 1 Summary of habitats of British and Irish stoneworts

	salinity			alkalinity				
	brackish water	fresh water near sea	fresh water inland	low	medium	alkaline	coastal lagoons	sand dune pools
Chara aspera	○	●	●		○	●	○	○
Chara braunii			●		●			
Chara baltica	●	○				●	●	●
Chara canescens	●		○			●	●	
Chara connivens		●	○			●	●	
Chara contraria		●	●			●		●
Chara curta	○	●	●			●		○
Chara denudata			●			●		
Chara fragifera		●	●	●	●			
Chara globularis		●	●		○	●		○
Chara hispida		●	●		○	●		●
Chara intermedia		●	○			●		
Chara muscosa		●			●			
Chara pedunculata		●	●			●		○
Chara rudis		○	●			●		
Chara tomentosa			●			●		
Chara virgata		●	●	●	●	●		○
Chara vulgaris		●	●		○	●		●
Lamprothamnium papulosum	●				?	?	●	
Nitella capillaris			●			●		
Nitella confervacea			●	○	●			
Nitella flexilis		●	●	●	●	○		○
Nitella gracilis			●	●	○	○		
Nitella hyalina		●			●		●	
Nitella mucronata			●		●	●		
Nitella spanioclema		●			●			
Nitella tenuissima			●		○	●		
Nitella translucens			●	●	●			
Nitellopsis obtusa		●				●		
Tolypella glomerata		●	●			●		●
Tolypella intricata			●			●		
Tolypella nidifica	●					●	●	
Tolypella prolifera			●			●		

○ – weak habitat fidelity ● – strong habitat fidelity

machair lakes	W coast splash pools	marl and limestone lakes	clay and gravel pits	acid to neutral lakes	peat cuttings	ditches and rivers	turloughs	canals	small pools	flushes	other ephemeral waters
●	●	●	○		○	○	○				
								●			
			○								
		○			○						
●		●	●		○	○	○	○	●		
●		●	○				○				
		●									
									●		●
○		●	●			●		●	●		
●	●	●	●		●	●	○	○	●	●	
		●									
●											
		●	●		●	○	○		●		
○		●			●	○	○	○	○		
		●									
●	○	●	●	●	●	●	○	●	●	●	●
○	●	○	●		○	●	○	●	●	●	●
						●					
				●							
●	○	○	○	●	●	●	○	●	●	○	○
				●		○					
			○	○				●			
●				●							
					●				●		●
				●	●				●		
		●									
●		●	●			●	○	●	●		●
						○		●	●		
						●		●			

Coastal lagoons are not a common habitat in Britain and Ireland and they are subjected to a number of threats. In natural systems the sand or shingle bar is vulnerable to the effects of storms and other events resulting in changes in salinity. For example, the bearded stonewort *Chara canescens* disappeared from a site in Suffolk after storm damage to the shingle bar resulted in an increase in salinity. Conversely, at the Little Sea in Dorset it disappeared after a build-up of sand cut off the access for saline water.

Artificial lagoons often occur in areas where there is high development pressure. For example, most of the British sites for the foxtail stonewort *Lamprothamnium papulosum* are concentrated on the coasts of Hampshire, Dorset and the Isle of Wight, where there is intense pressure from industrial, urban and recreational development. Other significant threats to coastal lagoons and lakes are from pollution and damage from boats.

Sand dune pools

Pools in calcareous sand dunes often contain a variety of stonewort species. Most frequent are common stonewort *Chara vulgaris*, bristly stonewort *Chara hispida*, opposite stonewort *Chara contraria* and clustered stonewort *Tolypella glomerata*. These species can tolerate periodic drying out in summer, which is often a feature of this habitat.

Sand dune pools, particularly in Britain, are continually being lost to holiday developments and dune erosion from recreational pressure. A more serious threat is the stabilisation of dune systems as a result of coastal protection work. This reduces the drift of sand along the shore, which is an essential part of actively growing dune systems. As dunes age, the wet hollows tend to fill gradually with sand and vegetation. Water extraction and a general lowering of water tables also frequently contribute to the drying out of these hollows. Grazing by livestock, provided this is not at levels that will cause serious erosion, can help to slow the natural succession, but in some cases the digging of pools may be necessary.

Machair lakes

Along the west coasts of Ireland and Scotland there are frequently substantial wind-blown accumulations of calcareous shell sand. Through a combination of its calcareous nature and traditional farming methods this has developed a rich vegetation called machair, which is unique to this area. Some lakes have developed within the machair zone, but others have formed across the boundary between the machair and rocky and peaty areas on the landward side. Such lakes are of considerable interest for aquatic plants because there is often a combination of influences from nutrient-poor, acidic fresh water draining from the rocky or peaty landward edge and calcareous and slightly brackish water, towards the sea, on the machair. These influences are reflected in the plant communities and often typically calcifuge and calcicole species can grow intermixed. Stoneworts tend to be best developed on the machair sand, where there are often extensive open communities with rough stonewort *Chara aspera* and grass-leaved pondweed *Potamogeton filiformis*. These sometimes also contain opposite stonewort *Chara contraria*, lesser bearded stonewort *Chara curta* and, in very shallow water, clustered stonewort *Tolypella glomerata*.

Machair usually occurs in areas where the human population density and intensity of farming are low, so that pollution is often not a major threat. Fish farming can, however, be a cause of pollution where the throughflow of water near the cages is small. Pollution from holiday developments can also be a problem in some sites.

Splash pools

On rocky western coasts exposed to Atlantic storms, a considerable amount of spray is blown on shore and frequently collects in rock pools. These pools can range from fully saline to almost fresh water, depending on the exposure and the height above sea level. Sometimes on stepped shores a range of pools can be found in a single area, and can provide a diversity of communities which is often not available in the usually more acid hinterland. Several stoneworts can occur in these pools, including some that are tolerant of salinity, such as rough stonewort *Chara aspera*. The threats to this habitat are usually small.

Marl and limestone lakes

These lakes provide some of the richest sites for stoneworts, and in many cases stoneworts dominate the plant communities. There is usually a zonation of communities according to depth. In shallow water, annual communities with species such as clustered stonewort *Tolypella glomerata*, rough stonewort *Chara aspera*, lesser bearded stonewort *Chara curta* and opposite stonewort *Chara contraria* occur. As depth increases, more perennial communities are found involving hedgehog stonewort *Chara pedunculata*, lesser bearded stonewort *Chara curta*, bristly stonewort *Chara hispida*, rugged stonewort *Chara rudis* and more rarely coral stonewort *Chara tomentosa* and starry stonewort *Nitellopsis obtusa*. At greater depths, species tolerant of lower light intensities frequently predominate, including fragile stonewort *Chara globularis*, delicate stonewort *Chara virgata*, opposite stonewort *Chara contraria* and more rarely naked stonewort *Chara denudata*.

Some of the richest examples of this habitat occur in central Ireland, particularly in Co. Westmeath and along the River Shannon and the area south-east of the Burren in Cos. Clare and Galway. In Britain the habitat is much rarer, but some good examples occur in the Pennine limestone area and in the Norfolk Broads. A group of marl lakes in the Hawick-Selkirk area in the Scottish Borders also supports some of these communities.

The greatest threat to this habitat is from water pollution. This is a particular problem in the Irish Midlands, where sites have been severely affected by sewage, pig slurry and silage effluent (John *et al.* 1982; King 1988). In Lough Derg for example, perennial stoneworts have now become very local and are mostly restricted to sheltered bays which are relatively well protected from the main throughflow of river water. In the lowland parts of Britain many calcareous and marly sites have suffered from pollution. For example, in lowland Tayside Region several former sites for rugged stonewort *Chara rudis* have become too enriched to support this rare species.

Another problem at some sites is damage by motor-powered boats, both direct physical damage and the indirect effects of pollution and increased turbidity. In the Norfolk Broads some improvement has occurred as a result of restricting boat traffic through the centre of some Broads (George 1992).

Clay, sand and gravel pits and quarries

The ability of stoneworts to colonise new sites is well shown by the frequency with which they colonise pools in abandoned clay and gravel pits and in old quarries. In such sites the stoneworts probably benefit from the unpolluted conditions arising from isolation from other water bodies. This isolation may also impede colonisation by other aquatic plants. Indeed, in some parts of lowland Britain the only areas of standing water are artificial. Significant examples include Cotswold Water Park (Gloucestershire and Wiltshire) and Peterborough Brick Pits (Cambridgeshire).

Common stonewort *Chara vulgaris* is probably the most frequent species in such sites, but other typical species include bristly stonewort *Chara hispida*, fragile stonewort *Chara globularis*, delicate stonewort *Chara virgata* and clustered stonewort *Tolypella glomerata*. In acid sandy deposits smooth stonewort *Nitella flexilis* and translucent stonewort *Nitella translucens* sometimes occur and rough stonewort *Chara aspera* and hedgehog stonewort *Chara pedunculata* can appear in markedly calcareous sites. The only known recent British site for bearded stonewort *Chara canescens* is also in an area of old clay workings.

Stoneworts are often among the earliest colonisers of these newly created sites, taking advantage of the open substrates and the initial burst of chemical salts dissolving into the water. Perennial stonewort communities sometimes develop and these may persist for several decades, but in other sites the stoneworts may be replaced after a few years by more competitive vascular plants.

Pollution, including eutrophication, can sometimes be a threat to these sites. They are also frequently destroyed by reclamation and infilling with rubbish. In the long term, colonisation by reeds and other emergent vegetation, and eventually trees, may result in the displacement of stonewort communities.

Peat cuttings

Several species, such as hedgehog stonewort *Chara pedunculata*, seem to have a marked preference for growing on peaty substrates in calcareous fenland water bodies. This combination of peat and calcareous water is a common feature in Ireland and is one of the reasons why stonewort communities are so well developed in that country. In Britain, the combination occurs more locally, such as in Anglesey and the East Anglian Fens. Where the water is deep enough, perennial stonewort communities similar to those in limestone lakes often develop, but shallower pools often contain communities of annual species. Of particular note in these smaller pools is the rare dwarf stonewort *Nitella tenuissima*.

The main threats to this habitat are pollution, drainage and, in the smaller sites, natural succession.

Acid and neutral lakes

Although the majority of stoneworts prefer calcareous conditions, a few, particularly in the genus *Nitella*, prefer more base-poor conditions. The most frequent of these are smooth stonewort *Nitella flexilis* and delicate stonewort *Chara virgata*. As a result, these are the two most frequent species in Ireland, Scotland and Wales. Translucent stonewort *Nitella translucens* is a more local species which prefers relatively acid conditions, although it tends to grow in more stagnant situations where decaying vegetation is accumulating. Among the rarer species slender stonewort *Nitella gracilis*, few-branched stonewort *Nitella spanioclema* and least stonewort *Nitella confervacea* all prefer relatively base-poor lakes, although the dwarf stonewort *Nitella tenuissima* seems to have quite a wide tolerance of acidity.

Many of the acid and nutrient poor lakes are in upland areas and are not under significant threat, except in some areas from acidification by air pollution and afforestation. Neutral or moderately nutrient-rich sites tend to be more lowland and are vulnerable to water pollution. Many mesotrophic lakes have become enriched with nitrates and phosphates from agriculture and sewage within the last few decades. Even in the less intensively farmed areas some lakes are threatened by enrichment from fish farms.

Ditches and rivers

In areas of fen, some of which were drained centuries ago, ditch systems can support relict fenland floras. Unfortunately, many ditch systems have become polluted in recent decades with run-off from adjacent agricultural land, although the complex arrangements of water flow through these systems can result in isolated ditches escaping the worst effects of pollution and still retaining their interest.

The most interesting ditch systems are usually those where the adjacent ground has escaped intensive cultivation, such as in areas of Washes which become flooded in the winter. Among the more notable ditch systems for stoneworts are those in the Cambridgeshire Fens, the Norfolk and Suffolk Broads and the Somerset Levels.

All ditches, if left undisturbed, will gradually become infilled with emergent vegetation and eventually lose their aquatic plant interest. They therefore depend on periodic clearing out to re-establish the open water habitat. Some stoneworts, including some of the rarer members of the genus *Tolypella*, are quick to make use of these open substrates and large populations can quickly become established, probably from buried spores. In the past, when many ditches were dug by hand, buried spores would readily become exposed and often fragments of aquatic vegetation would be left, providing a source for the recolonisation of the ditch. Nowadays, with modern machinery, ditches are often dredged more thoroughly and probably dug more deeply than the supply of buried spores. Thus, recolonisation is less certain as it depends on propagules spreading from considerably greater distances.

Only rarely do stoneworts occur in more than a slight flow, so rivers are rarely an important habitat. Some species can occur in the more sluggish parts of rivers and streams, but lowland rivers are often too badly polluted.

Canals

Canals can be important for stoneworts in the highly populated and intensively farmed parts of both Britain and Ireland. They are often fed from supply lakes or from the water table outside the main areas of pollution, so they frequently contain clean water where aquatic plants can survive. The canals in the Irish midlands are particularly rich in stoneworts because they are fed by highly calcareous water, including the Curragh Aquifer in the case of the Grand Canal and Lough Owel in the case of the Royal Canal.

Many canals in both countries fell into disrepair when railways and then roads began to provide a faster means of transport for goods. However, there has been a renewed interest in canals in recent years as pleasure boating has gained popularity, and a considerable number of canals have been renovated. This has proved to be of mixed benefit for stoneworts and other aquatic plants. Many sites have benefited from the removal of reeds, which had gradually infilled the derelict canals, and have regained their former diversity during renovation. However, many species, especially brittle plants such as *Chara*, are unable to cope with regular boat traffic, because of the physical damage and increased turbidity. There is therefore a decrease in diversity as boat traffic increases. This is particularly the case where the fringing reeds have become eroded away and it has become necessary to reinforce the banks, since this usually means a reduction in sheltered shallows. The extensive use of herbicides in Irish canals has also reduced the diversity of aquatic plants.

Several species seem able to cope with these activities. Pointed stonewort *Nitella mucronata*, for example, has spread through a number of canals in Britain and is tolerant of a certain amount of turbidity. Several species of *Tolypella* also occur or have occurred in canals. These species may benefit from their ability to complete their life cycle in the spring while the disturbance from boat traffic is at a low level. They may also gain an advantage from the reduction in summer growth of competing vegetation as a result of more intense summer boat traffic and, in some canals, from the application of herbicides.

Small pools, flushes, and other small waterbodies

Stoneworts can colonise even very small water bodies, provided that the water lasts long enough for the plants to complete their life cycle. These habitats include small pools, puddles in tracks, puddles among fen vegetation and flushes. Typical species of these sites are those that can tolerate periodic drying out, such as common stonewort *Chara vulgaris*, opposite stonewort *Chara contraria*, delicate stonewort *Chara virgata* and sometimes bristly stonewort *Chara hispida* and species of *Tolypella*. Of particular note are the marl-rich pans with black bog rush *Schoenus nigricans* that occur at a number of sites on the Irish limestone. These can extend over several hundred square metres and are frequently rich in stoneworts.

The turloughs of Ireland are an internationally important habitat. They are loughs founded on karst limestone which are particularly prone to irregular fluctuations in water level, sometimes up to several metres. They are dominated by marsh or fen vegetation, but where the water persists longest, such as in pools which become stranded when the water level drops, there are often well-developed stonewort communities.

Small acid ponds and puddles in heathland on the Lizard Peninsula are important as they provide the habitat for strawberry stonewort *Chara fragifera*, a mainly Mediterranean species which only just reaches Britain.

Frequently the main threat to these small water bodies is natural succession to fen, carr, or reedswamp. Some disturbance may be required to keep the habitat open, such as periodic cleaning out, occasional vehicle usage, or poaching by grazing animals. The spores can, however, persist for considerable periods of time buried in the substrate ready to recolonise if suitable conditions return (Moore 1986). These small sites are also very vulnerable because of drainage or infilling.

Conservation

Site protection

Many threats have already been discussed in previous sections. Without doubt the most serious threat facing stoneworts is water pollution and unless this is tackled, site or species protection measures will frequently be unsuccessful. The main pollutants that cause damage to stonewort communities are phosphates and nitrates, principally from sewage, farming effluent and agricultural run-off (John *et al.* 1982; King 1988; Moss 1983).

The Norfolk Broads have suffered badly from pollution, but in recent years various attempts have been made to improve the situation. Such measures include the introduction of phosphate strippers in sewage treatment, diverting watercourses to bypass Broads and mud-pumping to clean out the nitrates and phosphates that have accumulated in the mud. This last measure also provides a firm substrate for plant growth. These efforts have met with a certain amount of success and some stoneworts and other aquatics have re-appeared in a few areas. However, these measures are expensive, and their more widespread use will have limited effect unless the sources of pollution are also tackled. The reduction of phosphates in domestic chemicals, reduced use of fertilizers, restrictions on spraying chemicals close to water courses and strict controls on farming effluents would all improve the situation.

In many cases designation of nature reserves and legally protected areas such as SSSIs, ASSIs or ASIs will go a substantial way towards protecting stonewort communities from factors other than pollution coming from outside. However, the ephemeral nature of some species may make it difficult to draw boundaries around such sites. For example, the protection of a single ditch or pool would not necessarily ensure the protection of a species that requires open substrates unless careful management were to be undertaken. Most of the rarer stoneworts seem to be faithful to particular areas while conditions remain suitable, so the protection of a series of ditches or pools will often facilitate suitable management measures.

Some changes are, however, unavoidable. For example, lagoon systems are vulnerable to changes in sand or shingle bars as a result of storms and other events. Climate change may also affect stoneworts. In particular, sea level rises are likely to have a significant effect on the salinity of coastal sites and the survival of certain species may depend on whether suitable new areas develop before existing sites are lost.

Legislation

Britain, Northern Ireland and the Republic of Ireland have separate legislation relating to wildlife protection and nature conservation. In each case there are two aspects to this legislation; species protection and habitat protection. In Britain and Northern Ireland species protection for plants covers only damage to and removal and sale of plants,

although the presence of a specially protected species on a site can be used as justification for giving the site statutory protection. In the Republic of Ireland there is an extra provision covering damage to the habitats of specially protected species.

United Kingdom

Section 13.1 (a) of the Wildlife and Countryside Act, 1981, states that anyone who "intentionally picks, uproots, or destroys any wild plant listed on Schedule 8" is guilty of an offence. This Schedule includes many of the most threatened vascular plants in Britain, and in 1987 the foxtail stonewort *Lamprothamnium papulosum* was added to this list. In 1992 many other species of lower plant were put forward for addition to the list, including the bearded stonewort *Chara canescens*.

Section 13.1 (b) of the Wildlife and Countryside Act stipulates that anyone who "intentionally uproots any wild plant" without the permission of the owner or occupier of the land is committing an offence. The term 'uproot' is clarified to mean "dig up or otherwise remove the plant from the land on which it is growing", which means that all lower plants are covered by this part of the Act, even though they do not have roots.

The Wildlife (Northern Ireland) Order, 1985, follows almost exactly the wording of the British Wildlife and Countryside Act. It too states that anyone who "intentionally picks, uproots, or destroys any wild plant listed on Schedule 8" is guilty of an offence. This Schedule includes many of the most threatened vascular plants in Northern Ireland, but in early 1992 the list did not include any lower plants. A number of lichens and bryophytes are proposed for inclusion in a revised Schedule in 1992, but it is unlikely to include any stoneworts.

Ireland

The equivalent law in the Republic of Ireland is the Wildlife Act, 1976, which empowers the minister to protect wild species of flora anywhere in the State. 52 species of flowering plant were given protection under the Flora Protection Order, 1980, and this figure was raised to 68 species in a revised Flora Protection Order in 1987. These Orders prohibit, except under licence, the picking, uprooting or otherwise taking, purchasing or selling of any species mentioned in the Order, or the wilful alteration, damage, destruction of, or interference with, the habitat of such a species. There are no species of lower plant listed on the Flora Protection Order.

Collecting is not usually a significant threat to stoneworts; they do not have attractive flowers, and the fact that they grow underwater does much to deter most people from collecting these plants. Some exceptions are people with a specific interest in water plants. Even for these, the tendency for stonewort species to be present in abundance means that sampling for the purposes of identification will rarely be a threat to populations. Nevertheless, there are cases where populations are very restricted and collecting should be discouraged.

When lower plants are given legal protection, other benefits accrue. Scheduling highlights the fact that there are lower plants under severe threat and attracts research. Also, the presence of specially protected species is given consideration by nature conservation bodies when assessing the conservation importance of a site. It should be emphasised that the protection of habitat is the most important aspect of the conservation of lower plants. The additional provision in the Republic of Ireland legislation prohibiting wilful damage to the habitats of protected species is highly appropriate for the protection of stoneworts and other lower plants, since the threats to habitats are considerably greater than the threat from collection. The laws in Britain and Northern Ireland could be improved by extending them to cover this aspect, bringing legislation for plants into line with that for Scheduled animals, which provides security for places used for shelter and protection. This legislation has proved particularly beneficial in the conservation of bats.

Introduced species

A number of foreign plants have become widely established in British and Irish fresh waters. The Canadian pondweed *Elodea canadensis* was introduced over a century ago, but more recent arrivals that have become widespread include Nuttall's pondweed *Elodea nuttallii* which is similar to Canadian pondweed, water fern *Azolla filiculoides*, swamp stonecrop *Crassula helmsii* and curly water thyme *Lagarosiphon major*. Often these species become established in considerable abundance in a site, swamping the native flora. It is very difficult to eradicate them since they are able to grow from fragments. No selective chemicals are known and anyway the use of chemical weedkillers in aquatic systems should be discouraged since they can often cause damage without solving the original problem. It is therefore important to discourage the spread of these plants and to prevent other alien plants being introduced in the future.

In Britain, Section 14.2 of the Wildlife and Countryside Act states that anyone who "plants or otherwise causes to grow in the wild any plant which is included in Part II of Schedule 9" is guilty of an offence. There are no freshwater plants on this Schedule, but the addition of some of the above species should be considered. There are no equivalent provisions in the Republic of Ireland.

However, the problem is much more one of education. People should be discouraged from emptying aquaria into wild situations without first removing the plants.

Translocation, cultivation and reintroduction

The use of cultivation and reintroduction as a conservation tool for lower plants is rarely considered. However, an attempt has been made to transplant bearded stonewort *Chara canescens* to new ponds within its only British site, and this has met with some initial success.

Use of these methods for the conservation of lower plants must not be used as an excuse for habitat destruction, but there is good reason for keeping some examples of our most threatened species in cultivation in case any disasters befall the natural populations. Cultivation may also be of use in understanding the ecology of these species.

Survey and monitoring

Our knowledge of the current distribution of and threats to stoneworts has advanced considerably since the mid 1970s, but more work still remains to be done. In particular:

- some of the less well studied species may still persist in some of their former sites and these sites require surveying. These include those species classified as 'Indeterminate' or 'Insufficiently known' in this book;
- several areas require more general surveys of the distribution of stoneworts. In Britain the most important areas requiring survey work are in Orkney, Shetland and the Western Isles. In Ireland there is a more general need for survey because of the large number of lakes. However, the calcareous areas in the midlands, west and south of the country are a particular priority;
- in many cases the size and health of populations are not fully known and monitoring schemes such as those carried out in the Norfolk Broads should be undertaken. This should include investigation of the ecological needs of the species and of the effects of threats such as pollution;
- several taxonomic problems have been noted in the species accounts and these require further investigation.

The international context

As in Britain and Ireland, stoneworts have received a fair amount of attention in the rest of Europe, and quite a lot is known about their distribution. Nevertheless, there has been little work done to draw this information together in one place. Several works give generalised European and worldwide distributions of each species, and Corillion (1957) drew up distribution maps for most European species. These maps were, however, a compilation of all known records irrespective of date, and are now over 30 years old. Given the likely changes to the distribution of stoneworts as a result of water pollution over the last fifty years or so, there is an urgent need to draw together the recent information to gain a picture of the present status of each species.

There are three other published European stonewort Red Lists for Finland, Poland and West Germany. These show a similar picture to that in Britain and Ireland. In each case over 40% of the countries' flora is considered threatened, and a high proportion of the species are in the Endangered and Vulnerable categories. The status of British and Irish species in these lists is given in Table 2.

The following species are endemic to Britain and Ireland:

Chara muscosa	Britain and Ireland only
Nitella spanioclema	Ireland only

In addition, *Chara curta* is restricted to only a few locations outside Britain and Ireland, and Ireland is the main population centre for this plant.

Table 2 List of British and Irish species with threat statuses in other published Red Lists.

This table is based on Rassi & Väisänen (1987) for Finland, Sieminska (1986) for Poland and Krause (1984) for West Germany. The categories used in the Finnish and West German Red Lists do not exactly match those used by the International Union for the Conservation of Nature (IUCN) which have been followed in this book. In this table the nearest appropriate IUCN category to that used in each Red List has been used.

	Poland	Finland	W.Germany
Chara aspera	I	nt	V
Chara braunii	I	V	V
Chara baltica		nt	E
Chara canescens	I	nt	E
Chara connivens	R		E
Chara contraria	nt	R	V
Chara curta			
Chara denudata			
Chara fragifera			
Chara globularis	I	nt	nt
Chara hispida	I		nt
Chara intermedia	I		V
Chara muscosa			
Chara pedunculata	V		V
Chara rudis	V		
Chara tomentosa	I	nt	E
Chara virgata	nt		nt
Chara vulgaris	I	nt	nt
Lamprothamnium papulosum			E
Nitella capillaris	V		
Nitella confervacea	V	R	V
Nitella flexilis	I	nt	nt
Nitella gracilis	V	K	V
Nitella hyalina		R	E
Nitella mucronata	I	nt	nt
Nitella spanioclema			
Nitella tenuissima	E		V
Nitella translucens			V
Nitellopsis obtusa	I	R	V
Tolypella glomerata			V
Tolypella intricata	R		E
Tolypella nidifica		nt	E
Tolypella prolifera	R		E

There are several international conventions and directives which have relevance to the conservation of stoneworts.

- The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention).

This convention places an obligation on countries to protect wetlands of international importance for birds and other species. In 1991 Lopham and Redgrave Fens (Norfolk and Suffolk) were listed under the Convention for the quality of their habitat and wetland species assemblages. This site had some value for stoneworts, although the rare lesser bearded stonewort *Chara curta* and dwarf stonewort *Nitella tenuissima* have not been confirmed there since the 1890s.

- The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention).

This convention is primarily concerned with the protection and conservation of selected threatened species and their habitats. The plant list was substantially revised in January 1991, and now includes 26 species of mosses and liverworts. These were the first lower plants to be listed under any international treaty or law. The foxtail stonewort *Lamprothamnium papulosum* was put forward for consideration when the revised plant list was drawn up, but a decision on this species was delayed pending further information. A panel of experts has been set up to review the list periodically, so this and other stoneworts may be added in due course.

- European Community Directive on the Conservation of Natural and Semi-natural Habitats and Wild Fauna and Flora.

This directive was approved in December 1991 and is intended to ensure the protection of the important wildlife sites and selected threatened species. No stoneworts are identified for special protection measures at present. However, the following habitat types which may contain stoneworts are identified as requiring protection:

- coastal lagoons *
- dune slacks
- machair (* in Ireland)
- hard oligotrophic to mesotrophic waters with benthic vegetation of *Chara* formations
- natural eutrophic lakes with vegetation of the type *Magnopotamion* or *Hydrocharition*
- turloughs (Ireland) *
- alkaline fens (including calcareous fens with *Cladium mariscus* *)
- petrifying springs with tufa formation *

Those marked with an asterisk are identified as special priorities for action.

Taxonomy

The scientific names for stoneworts have become complicated by different concepts of the species unit. A total of 33 species units were identified by Groves and Bullock-Webster (1920, 1924), and these were accepted unchanged by Allen (1950). However, in 1965, R.D. Wood and K. Imahori published a world monograph of the group, in which many of the formerly accepted species were united into much larger aggregate species, with several tiers of subspecies, varieties and forms ranked beneath these. While of interest as a taxonomic exercise to attempt to show the relationship between different taxa, the present authors find this approach unsatisfactory in a number of ways. The treatment of a significant number of the taxonomic units at infraspecific levels belies the distinctness of these units and the constancy of the characters that separate them; the tiers of names at various taxonomic levels makes the scientific names unwieldy, with up to five names being necessary to refer to some taxa that have been previously considered as species; the distinctness of the different taxa at the various taxonomic levels is very variable, for example, some 'forms' show sufficient constancy to deserve specific rank, while some 'varieties' deserve to be varieties or less.

Moore (1986) attempted to resolve some of these problems, but in this book we have decided to revert to the concept of the species unit as perceived before Wood and Imahori. This approach has also been adopted by several other authors elsewhere in Europe, for example Krause (1984), Sieminska (1986) and Rassi & Väisänen (1987). However, since Allen (1950) there have been several changes in nomenclature. The following table lists all the stonewort taxa considered worthy of specific rank, with the nomenclature used by former authors (Table 3).

Table 3 Stonewort species with names used in major publications

	J. A. Moore (1986)	
Chara aspera (rough stonewort)	*C. aspera*	var. *aspera*
Chara braunii (Braun's stonewort)	*C. braunii*	
Chara baltica (Baltic stonewort)	*C. baltica*	
Chara canescens (bearded stonewort)	*C. canescens*	
Chara connivens (convergent stonewort)	*C. connivens*	
Chara contraria (opposite stonewort)	*C. vulgaris*	var. *contraria*
		& var. *hispidula*
Chara curta (lesser bearded stonewort)	*C. aspera*	var. *curta*
Chara denudata (naked stonewort)	*C. vulgaris*	var. *denudata*
Chara fragifera (strawberry stonewort)	*C. fragifera*	
Chara globularis (fragile stonewort)	*C. globularis*	var. *globularis*
Chara hispida (bristly stonewort)	*C. hispida*	var. *hispida*
		& var. *major*
Chara intermedia (intermediate stonewort)	(*C. intermedia*)	
Chara muscosa (mossy stonewort)	*C. muscosa*	
Chara pedunculata (hedgehog stonewort)	*C. pedunculata*	
Chara rudis (rugged stonewort)	*C. hispida*	var. *rudis*
Chara tomentosa (coral stonewort)	*C. tomentosa*	
Chara virgata (delicate stonewort)	*C. globularis*	var. *virgata*
Chara vulgaris (common stonewort)	*C. vulgaris*	var. *vulgaris*
		& var. *crassicaulis*
		& var. *gymnophylla*
		& var. *longibracteata*
		& var. *papillata*
Lamprothamnium papulosum (foxtail stonewort)	*L. papulosum*	
Nitella capillaris (slimy-fruited stonewort)	*N. capillaris*	
Nitella confervacea (least stonewort)	*N. confervacea*	
Nitella flexilis (smooth stonewort) *	*N. flexilis*	var. *flexilis*
Nitella gracilis (slender stonewort)	*N. gracilis*	
Nitella hyalina (many-branched stonewort)	*N. hyalina*	
Nitella mucronata (pointed stonewort)	*N. mucronata*	
Nitella spanioclema (few-branched stonewort)	*N. flexilis*	var. *spanioclema*
Nitella tenuissima (dwarf stonewort)	*N. tenuissima*	
Nitella translucens (translucent stonewort)	*N. translucens*	
Nitellopsis obtusa (starry stonewort)	*N. obtusa*	
Tolypella glomerata (clustered stonewort)	*T. nidifica*	var. *glomerata*
Tolypella intricata (tassel stonewort)	*T. intricata*	
Tolypella nidifica (bird's-nest stonewort)	*T. nidifica*	var. *nidifica*
Tolypella prolifera (great tassel stonewort)	*T. prolifera*	

Notes

Species in brackets () are not given full treatment in the references concerned.

* The case for uniting *Nitella flexilis* and *Nitella opaca* under one species is not universally accepted. Further work may be required before this problem is resolved

R. D. Wood & K. Imahori (1965)		G. O. Allen (1950)	J. Groves & G. R. Bullock – Webster (1920, 1924)
C. globularis	var. *aspera* f. *aspera*	*C. aspera*	*C. aspera*
C. braunii		*C. braunii*	*C. braunii*
C. hispida	var. *baltica*	*C. baltica*	*C. baltica*
C. canescens		*C. canescens*	*C. canescens*
C. globularis	var. *globularis* f. *connivens*	*C. connivens*	*C. connivens*
C. vulgaris	var. *vulgaris* f. *contraria* & f. *hispidula*	*C. contraria*	*C. contraria*
C. globularis	var. *aspera* f. *curta*	*C. desmacantha*	*C. desmacantha*
C. vulgaris	var. *denudata*	*C. denudata*	*C. denudata*
C. globularis	var. *globularis* f. *fragifera*	*C. fragifera*	*C. fragifera*
C. globularis	var. *globularis* f. *globularis*	*C. globularis*	*C. fragilis*
C. hispida	var. *major* f. *major*	*C. hispida*	*C. hispida*
C. hispida	var. *major* f. *intermedia*	(*C. contraria* x *C. hispida*)	(*C. contraria* x *C. hispida*)
C. vulgaris	var. *vulgaris* f. *muscosa*	*C. muscosa*	*C. muscosa*
C. hispida	var. *hispida* f. *polyacantha*	*C. aculeolata*	*C. aculeolata*
C. hispida	var. *major* f. *rudis*	*C. rudis*	*C. rudis*
C. tomentosa		*C. tomentosa*	*C. tomentosa*
C. globularis	var. *virgata* f. *virgata*	*C. delicatula*	*C. delicatula*
C. vulgaris	var. *vulgaris* f. *vulgaris* & f. *crassicaulis* & f. *longibracteata* & f. *sturrockii* & var. *gymnophylla*	*C. vulgaris*	*C. vulgaris*
L. papulosum		*L. papulosum*	*L. papulosum*
N. syncarpa	var. *capitata*	*N. capillaris*	*N. capillaris*
N. gracilis subsp. *gracilis* var. *confervacea*		*N. confervacea*	*N. batrachosperma*
N. flexilis	var. *flexilis*	*N. flexilis* & *N. opaca*	*N. flexilis* & *N. opaca*
N. gracilis subsp. *gracilis* var. *gracilis*		*N. gracilis*	*N. gracilis*
N. hyalina		*N. hyalina*	*N. hyalina*
N. furcata subsp. *mucronata*		*N. mucronata*	*N. mucronata*
N. flexilis	var. *spanioclema*	*N. spanioclema*	*N. spanioclema*
N. tenuissima		*N. tenuissima*	*N. tenuissima*
N. translucens		*N. translucens*	*N. translucens*
N. obtusa		*N. obtusa*	*N. obtusa*
T. nidifica	var. *glomerata*	*T. glomerata*	*T. glomerata*
T. intricata	var. *intricata* f. *intricata*	*T. intricata*	*T. intricata*
T. nidifica	var. *nidifica*	*T. nidifica*	*T. nidifica*
T. intricata	var. *intricata* f. *prolifera*	*T. prolifera*	*T. prolifera*

Selection of species

Initial selection

Although this Red Data Book covers both Britain and Ireland, the lists of threatened species have been compiled separately for the two areas.

Records for all species of British and Irish stoneworts are currently held at the Biological Records Centre at the Institute of Terrestrial Ecology at Monks Wood Experimental Station. These records were used as the basis for the initial selection of species considered for the Red Data Book. The final selection was made using criteria drawn up in consultation with various experts.

The species selected fulfil at least one of the following criteria:

- well recorded species found in Britain in fifteen or fewer 10 km squares since 1970.
- well recorded species found in Ireland in ten or fewer 10 km squares since 1970.
- species with slightly more records than this, but whose populations are known to be low at all or nearly all sites.
- species with more records than this, but which have shown a marked decline, so that they are now considered to be under threat.
- species that are probably still under-recorded, but which are known to be sufficiently habitat-confined that they are likely to fit the above criteria, even when better recorded.

The species listed under Appendix A are those which were considered for the Red Data Book but finally excluded. Introduced species were considered individually, on their own merit.

For each of the species selected for the Red Data Book, the following information was collected and compiled on a computer database:

English names
Recently used synonyms
Site records
British distribution
Irish distribution
State of British populations
State of Irish populations
International distribution
Ecology
Threats
Conservation needs
Notes on identification
Existing site protection
Existing legal protection
Experts with knowledge of the species
References

Sources of information

The following sources were used during the compilation of this information:

1 Records

The records for British and Irish stoneworts held at the Biological Records Centre formed the basis for the distribution information. In total, approximately 800 records for Red Data Book species occurring in Britain and Ireland have been compiled. The information includes details such as locality, grid reference, date of record, recorder and the source of the record.

2 Herbaria

Information was collected from the main herbaria for Britain, Northern Ireland and the Republic of Ireland. These included the herbaria of the Royal Botanic Gardens, Edinburgh, National Botanic Gardens, Glasnevin, the National Museum of Wales, Cardiff, the Natural History Museum, London, and the Ulster Museum, Belfast.

Specimens of each of the species under consideration were examined and the details of habitat and locality were extracted. The identity of some dubiously named specimens was checked and a number of re-identifications were made as a result.

3 Literature sources

A number of sources were searched for information on the habitats and requirements of individual species, including European publications such as Olsen (1944) and Corillion (1957).

4 Expert knowledge and field study

Experts with field knowledge of the species were an invaluable source of information and were consulted throughout the project. Approximately 20% of recently recorded sites have been visited by the senior author.

5 Other organisations

Additional information regarding site protection and possible threats to sites was provided where necessary by the Regional Officers of English Nature, the Nature Conservancy Council for Scotland, the Countryside Council for Wales, Wildlife Trusts, the National Trust, National Parks and Wildlife Service, Department of the Environment (Northern Ireland), An Taisce and the Irish Wildbird Conservancy.

Allocation of species to threat categories (Table 4)

The following analysis is similar to those in Curtis & McGough (1988) and Perring & Farrell (1983). Because there is little difference in the relative attractiveness of the different stoneworts this aspect has been excluded from the analysis. On the other hand, the threat from habitat damage is the most important factor affecting stoneworts and in this analysis 'habitat vulnerability' has been expanded to look at the threats from different causes. The 'remoteness' and 'accessibility' factors have been taken into account when assessing these threats, and have therefore not been treated separately. The categories have been scored so that the greater the number of dots, the greater the degree of threat to each species.

Key to Table 4

Column 1 – Rarity

This is based on the number of localities from which the plant has been recorded since 1970, as follows:

For Britain:	For Ireland:
● 9 to 15 localities	● 6 to 9 localities
●● 4 to 8 localities	●● 3 to 5 localities
●●● 0 to 3 localities	●●● 0 to 2 localities

Column 2 – Scale of decrease

This is based on the number of localities confirmed since 1970 compared with the total number of sites from which the plant has been recorded. In some cases sites have not been re-surveyed during this period and the decline may therefore appear exaggerated.

– decline less than 33% since 1970

● decline 33% to 67% since 1970

●● decline more than 67% since 1970

Column 3 – Existing site protection

This is based on the number of localities in which the species has been found since 1970 which are in designated sites such as SSSIs, ASSIs, ASIs, nature reserves, etc.

– over 67% of localities within designated sites

● 33% to 67% of localities within designated sites

●● less than 33% of localities within designated sites

Column 4 – Sensitivity to changes in water quality

This includes particularly the effects of pollution and of changes in salinity. There is little quantitative information about the ability of different species to tolerate pollution from different chemicals, but there is good evidence that combinations of pollutants can do more damage than individual pollutants (Moss 1983). The assessment in this table concerns pollution from nitrates and phosphates and from 'acid rain', and is based on evidence from areas where the effects of pollution are fairly well documented, such as the Norfolk Broads (Moss 1983) and the Irish Midland lakes (John, Champ & Moore 1982) and on knowledge of the habitat requirements of the species.

Several species prefer or require brackish waters. This makes them vulnerable to changes in salinity which may be caused by alterations to freshwater inflows, modifications to sea walls, cutting of shingle bars and removal of shingle, and storm damage (which may be an indirect result of coastal defences).

– tolerant of pollution or changes in salinity

● moderately sensitive to pollution or changes in salinity

●● very sensitive to pollution or changes in salinity

Column 5 – Vulnerability to habitat destruction

This covers threats that cause permanent loss of habitat such as infilling of ponds and ditches. It also includes drainage and lowering of water tables, as well as partial drainage, if this causes loss of habitat, for example for deep water species. Small sites are more vulnerable to destruction than large sites.

– restricted to large water bodies with low risk of destruction

● some sites small or liable to destruction

●● restricted to small water bodies

Column 6 – Physical disturbance

This covers activities which cause disturbance, but not permanent loss of habitat. Included are boating, dredging and changes in water level, except where disturbance is beneficial by creating open habitats. Perennial species are generally more vulnerable to disturbance than annuals.

– not affected by disturbance at any sites, or disturbance not a threat to the species

● threatened by disturbance at less than 50% of localities

●● threatened by disturbance at 50% or more of localities

Table 4 Table of threats to Red Data Book species

Britain	1 Rarity	2 Decrease	3 Site protection
Chara baltica	●●	●●	–
Chara canescens	●●●	●●	●●
Chara connivens	●●	●	–
Chara curta	●	–	–
Chara fragifera	●	●	–
Chara intermedia	●●	–	–
Chara muscosa	Indeterminate		
Chara rudis	●	●	–
Lamprothamnium papulosum	●●	●	–
Nitella capillaris	Extinct		
Nitella gracilis	●●	●	●●
Nitella hyalina	Extinct		
Nitella tenuissima	●●●	●●	–
Nitellopsis obtusa	●●●	●●	–
Tolypella intricata	●●	●●	●
Tolypella nidifica	Indeterminate		
Tolypella prolifera	●●	●●	–

Ireland	1 Rarity	2 Decrease	3 Site protection
Chara canescens	●	●	–
Chara connivens	Indeterminate		
Chara denudata	●●	–	–
Chara muscosa	Extinct		
Chara tomentosa	●	–	–
Lamprothamnium papulosum	●●	–	–
Nitella gracilis	●●●	●	●●
Nitella mucronata	●●	●	●●
Nitella spanioclema	Indeterminate		
Nitella tenuissima	●●●	●	–
Tolypella intricata	●●●	●	●
Tolypella prolifera	Extinct		

4 Water quality sensitivity	5 Vulnerability	6 Disturbance	7 Threat from competition	Status
●●	●	●	●	V
●●	●●	●	●	E
●●	●	●	–	V
●●	●	●	●	K
●	●	–	●●	R
●	–	●●	–	R
●	–	–	–	I
●●	–	●	–	R
●●	●	●	–	V
				Ex
●●	●	–	●	V
				Ex
●●	●	–	●●	E
●●	–	●●	–	V
–	●	–	●●	V
●●	–	–	●	I
●	●	–	●●	V

4 Water quality sensitivity	5 Vulnerability	6 Disturbance	7 Threat from competition	Status
●●	●	●	●	V
●●	●	●	–	I
●	–	●	–	R
				Ex
●●	●	●	–	R
●●	●	●	●	V
●●	–	–	–	V
–	–	–	–	R
●	–	●	–	I
●●	●●	–	●	V
–	–	●	●●	V
				Ex

Column 7 – Competition from other vegetation

This includes encroachment of reeds, and competition from other underwater plants including introduced species such as Canadian pondweed *Elodea canadensis*. Increased growth of competing species as a result of pollution is dealt with under column 4.

– no localities threatened by competition from other vegetation

● competition from other vegetation considered a threat at less than 50% of localities

●● competition from other vegetation considered a threat at 50% or more of localities

Status

The species satisfying the selection requirements for the Red Data Book have each been allocated a threat status using the standard IUCN Red Data Book categories. These are:

Extinct (Ex)

Taxa which are no longer known to exist in the wild after repeated searches of their localities and other known likely places.

Indeterminate (I)

Taxa known to be Extinct, Endangered, Vulnerable or Rare, but where there is not enough information to say which of these categories is appropriate.

Endangered (E)

Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating.

Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

Vulnerable (V)

Taxa believed likely to move into the Endangered category in the near future if the causal factors continue operating.

Included are taxa of which most or all the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are under threat from serious adverse factors throughout their range.

Rare (R)

Taxa with small populations that are not at present Endangered or Vulnerable, but are at risk.

These taxa are usually localised within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Insufficiently known (K)

Taxa that are suspected but not definitely known to belong to any of the above categories, because of the lack of information.

The interpretation of these categories closely follows the criteria set out in the British Red Data Books and the Irish Red Data Book for vascular plants (Curtis & McGough 1988), with a few modifications. Although there are differences in the approach between the two countries, the two systems produce very similar category assessments.

For Britain, the categories are interpreted as follows:

Extinct (Ex)

This category includes species not found in Britain since 1970 and whose former sites have been surveyed within this period. Definite reports of extinctions since 1970 have also been taken into account.

Indeterminate (I)

This category includes species not seen since 1970, but which require further survey before they can be declared extinct.

Endangered (E)

This category includes species which are known only from single populations, at sites which are under some threat, species which are restricted to habitats that are particularly threatened and species that have shown a rapid and continuous decline during the last thirty years and now exist in five or fewer localities.

Vulnerable (V)

This category includes species where there is good evidence of decline throughout most of their British range, but which do not yet fit the criteria outlined under 'Endangered', species restricted to declining habitats and species with small and vulnerable populations.

Rare (R)

This category includes species that are not, or only locally, decreasing but which are recorded in fifteen or fewer 10 km squares, provided that this is not simply due to under-recording.

Insufficiently known (K)

This category includes species which are known to be extremely restricted in distribution, but for which more survey work is required before they can be placed with certainty in one of the preceding categories.

For Ireland, the categories are defined as follows:

The categories Extinct (Ex), Indeterminate (I) and Insufficiently known (K) are defined as for Britain.

Endangered (E) and Vulnerable (V)

These categories are based on the degree of threat to the species, using the threat analysis table (Table 4). By totalling the number of asterisks for each species a 'Threat number', giving an approximate measure of the degree of threat, can be calculated. These are as follows:

Chara canescens	9
Chara connivens	Indeterminate
Chara denudata	3
Chara muscosa	Extinct
Chara tomentosa	5
Lamprothamnium papulosum	9
Nitella gracilis	8
Nitella mucronata	5
Nitella spanioclema	Indeterminate
Nitella tenuissima	9
Tolypella intricata	8

Species with threat numbers of 10 or more would be classified as Endangered, and species with threats numbers of 8 or 9 have been classified as Vulnerable.

Rare (R)

This category includes those species with threat numbers of 6 or less, which occur in 10 or fewer ten kilometre squares, provided that this is not simply due to insufficient recording work.

Table 5 Summary table of Red Data Book statuses

	No. of species	
	Britain	Ireland
Extinct	2	2
Endangered	2	0
Vulnerable	7	5
Rare	3	3
Indeterminate	2	2
Insufficiently known	1	0

57% (17 out of 30) of the British stonewort flora is in the Red Data Book.
48% (12 out of 25) of the Irish stonewort flora is in the Red Data Book.

Explanation of species accounts

Each species account is divided up into nine major headings for ease of reference, as listed below. This information was summarised from the information recorded on the database. With the exception of the section on distribution all information for Britain and Ireland has been dealt with jointly, as many of the threats and conservation requirements are similar.

Identification

This section deals very briefly with the diagnostic characters of each species. These are only intended as a guide and for accurate identification handbooks such as Moore (1986) will need to be consulted. A field key to all stonewort species, using characteristics visible with a hand lens, is provided in Appendix B of this book.

British distribution

This section provides a summary of both the historical and present day distribution of the species throughout Britain. There is a summary list at the end of the distribution section giving the total number of British localities, localities recorded up to 1969 and records since 1970.

A locality refers to a single water body, or to a group of small pools or ditches within 400 metres of each other.

Irish distribution

This section summarises the historical and present day distribution of each species throughout Ireland, in the same way as for Britain. However, in the summary list the number of localities recorded up to 1969 has been excluded. This is because of insufficient historical information on the distribution of stoneworts in Ireland.

In both the British and Irish distribution sections, localities are only mentioned at a county or regional level where the sites may be of a sensitive nature.

International distribution

A short summary of the range of the species outside Britain and Ireland is given in this section.

Ecology

This section is a summary of the ecological characteristics and requirements of each species. Information on physiology has also been included where this may have relevance to the management requirements of the plant.

Threats

This section summarises the main threats to the species that have been identified. Unless referenced, the threats given have been based on observations made by the author, or the regional staff of English Nature, the Nature Conservancy Council for Scotland, the Countryside Council for Wales and the staff of the Broads Authority, Wildlife Trusts, National Trust, National Parks and Wildlife Service and Department of the Environment (Northern Ireland). It is not possible, in the space available, to mention all the potential threats and only the most important have been listed. However, other threats may become more significant in the future.

Protection

Details of existing site and legal protection are listed in this section. Both statutory designations and protection by voluntary organisations are listed, as well as the number of sites without designation.

Conservation

This section highlights the priorities for action to conserve the species, including management, pollution control, survey and monitoring work and recommendations for site protection and legislative measures. It is important that site protection requirements for all species are addressed through the appropriate legislative and/or administrative procedures.

Sources

This paragraph is only included where there are sources of information that are of particular relevance to the species concerned. For general sources see Sources and references.

Species accounts

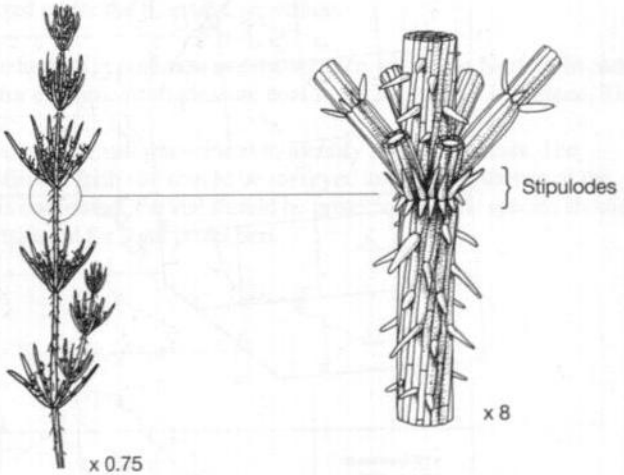
Chara baltica — Baltic stonewort

British status VULNERABLE — Irish status —

Chara baltica Bruz.

Identification

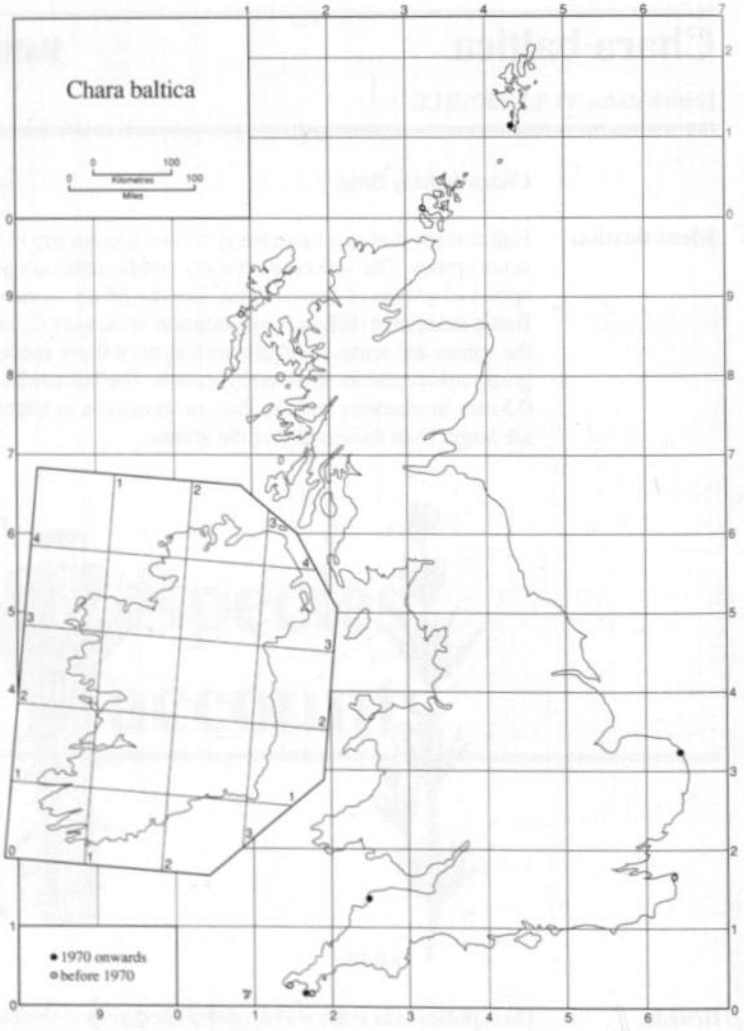
Baltic stonewort is a moderately robust species (up to 90 cm long) with acute spines. The spines are usually single, although a rare variety has spines in groups of two or three, like the bristly stonewort *C. hispida*. Baltic stonewort differs from common stonewort *C. vulgaris* because the spines are acute. It differs from both of these species by its dark green colour and its scant encrustation. The antheridia are larger than 0.5 mm in diameter and the lines of stem cells in which the spines occur are larger than those without the spines.



British distribution

This species was once widely distributed around the coast of Britain. It has been recorded from sixteen sites in Cornwall, Devon, Kent, Norfolk and the Western and Northern Isles of Scotland. It still occurs in western Cornwall, Devon, Norfolk and Shetland, and it may still occur in some of its other sites even though it has not been confirmed at these recently.

Total no. of localities	16
Up to 1969	12
1970 onwards	4



Irish distribution

There is an unconfirmed record from a site in Co. Sligo but further survey work is required before this species is accepted as a member of the Irish flora.

International distribution

This species has been recorded from all the northern coastal countries of Europe and is most frequent in the reduced salinities of the Baltic Sea. In France and Holland, as in Britain, it is confined to lagoons, coastal lakes and pools. Outside Europe the plant is only known from Greenland and Bolivia.

Ecology Baltic stonewort is a plant of ditches, pools, streams, pits and lakes, where it grows on sandy substrates in depths of up to 7 metres. It is restricted to sites close to the sea and probably requires at least a hint of salinity. It can tolerate salinities up to 1.8%. It is often perennial, and may remain green throughout the winter, but it can also be a summer annual, particularly in shallow water. It produces spores from June to October, but is not an abundant fruiter. It more usually spreads from multi-celled whitish bulbils produced on the rhizoids and on swellings at the lower stem nodes.

Threats Sedimentation is a major threat to this species at one site in the Norfolk Broads. It is threatened by pollution, eutrophication and pleasure boating at its other sites.

Protection All four current sites for this species are SSSIs and two are also NNRs. The Shetland site is an RSPB reserve. The Norfolk Broads site is within the Broads Authority area, is owned by the National Trust and is also protected under the Ramsar Convention.

Conservation Any reduction in pollution and disturbance within the Norfolk Broads sites, for example from pleasure boating, is likely to be beneficial. The old sites for this species need to be surveyed to assess whether the populations are still present and to identify potential threats. The unconfirmed Irish site should be surveyed and if the presence of the plant is confirmed, the site should be protected and the species should be considered for legal protection.

Chara canescens

Bearded stonewort

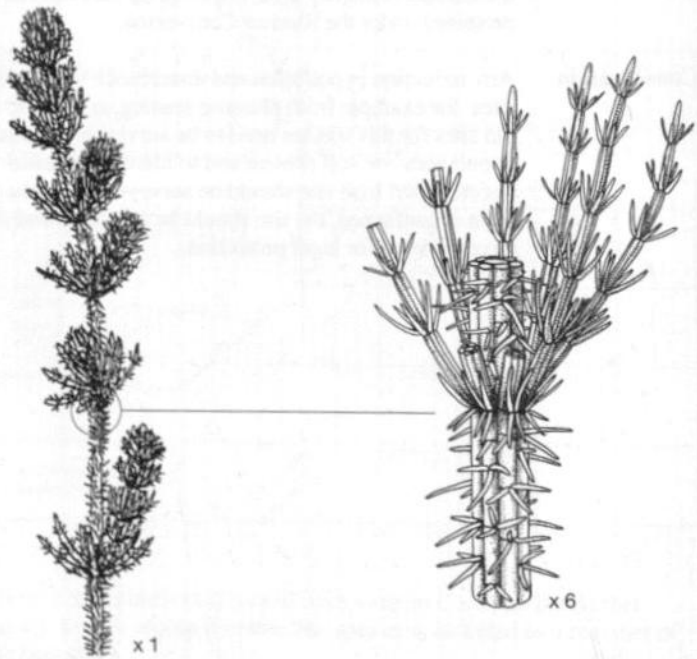
British status ENDANGERED

Irish status VULNERABLE

Chara canescens Desv. & Lois.

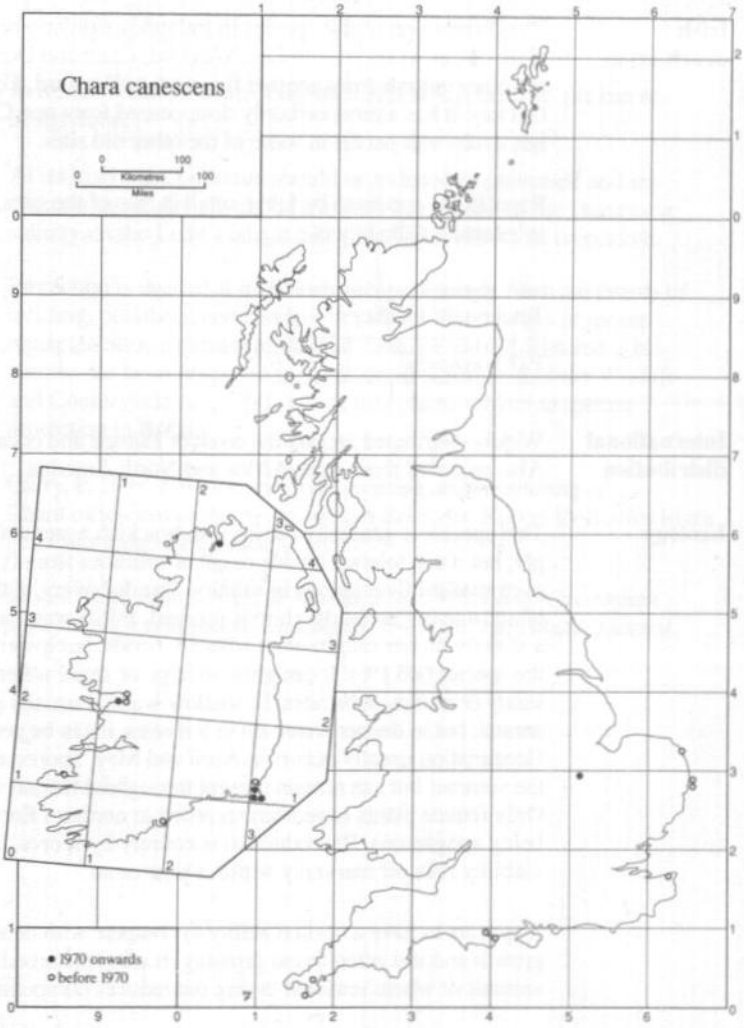
Identification

Bearded stonewort is a densely spiny species which is usually little encrusted. It is most similar in appearance to hedgehog stonewort *C. pedunculata* and lesser bearded stonewort *C. curta* (q.v.) from which it usually differs by the gradual decrease in internode length throughout the stem and by all the bracts in each whorl being equal in length. Lesser bearded stonewort *C. curta* is also usually more slender. It is easily distinguished under a microscope by the number of lines of cortical stem cells which equal the number of branchlets.



British distribution

This plant has had a scattered distribution around the coast of Britain. It has been recorded from Cornwall, Dorset, Suffolk, Norfolk and Orkney, but was last seen in Suffolk in 1956. It was thought to be extinct until it was discovered in a new inland site in Cambridgeshire in 1989, in clay pits that have been excavated since 1975.



It was originally found in three ponds at the Cambridgeshire site. In 1990, material was transferred to two other ponds near the original site. The plant has taken in one of these ponds and was growing quite vigorously in 1991.

Total no. of localities	12
Up to 1969	11
1970 onwards	1

Irish distribution

The distribution of this species in Ireland is similarly widespread; the plant occurs in six sites in Cos. Wexford, Clare and Donegal and there are older records from another five sites in Wexford, Cork, Kerry and Galway. It has almost certainly disappeared from one Co. Wexford site, but it may still persist in some of the other old sites.

Populations appear to be fairly small in two of the sites, but more substantial in the others.

Total no. of localities	11
1970 onwards	6

International distribution

Widely distributed around the coast of Europe and occasionally inland. Also recorded from Asia, Africa and North America.

Ecology

This species is generally confined to brackish water situations of high pH, but it can tolerate a wide range of salinities from 0.1—3.2%, and even marked fluctuations in salinity. The discovery of this plant at an inland site in Cambridgeshire is unusual. Initial water analyses indicate a slightly higher salinity than adjacent ponds, but lower than usual for the species (<0.1%). It can grow in large or small water-bodies and on sandy or muddy substrates. In shallow water it usually grows as an annual, but in deeper water, up to 5 metres, it can be perennial. Germination usually occurs in April and May. Spores are produced in the summer but can remain present throughout the autumn and winter. Only female plants have been recorded in northern Europe, the plant being apogamous. Reproduction is entirely by spores, but the spore viability falls off markedly within a year or so.

It appears to have a limited ability to compete with dense vascular plant growth and it is often found growing in areas disturbed by birds or animals or where seasonal drying out reduces competing vegetation.

Threats

At least one British site has been lost through infilling, and several others have been lost through water pollution and changes in salinity. The recently discovered Cambridgeshire site is under threat from infilling and reclamation.

Pollution is probably the main threat to the Irish sites. However, at Lady's Island Lake, in Co. Wexford, regular cutting of the sand bar which separates the lake from the sea is carried out, to prevent flooding of the causeway to a nearby island, and this may cause fluctuations in salinity.

Protection

The only site for this species in Britain has no designation.

In Ireland, four sites are designated ASI whilst the fifth site has no designation.

Conservation

At its Irish sites, pollution should be reduced or prevented and any changes in salinity should be avoided. The effects of the changes in salinity on the Lady's Island lake population should be monitored.

Protection is needed at its British site, particularly from the threats of infilling, pollution, and changes in salinity. The success of recent transplantation experiments should continue to be monitored. This species has been proposed for addition to Schedule 8 of the Wildlife and Countryside Act, 1981, which lists plants subject to special protection in Britain.

Sources

Curry, P. 1991. *Distribution, translocation and monitoring of* Chara canescens *at the Peterborough Brickpits*. Report by Bedfordshire and Cambridgeshire Wildlife Trust.

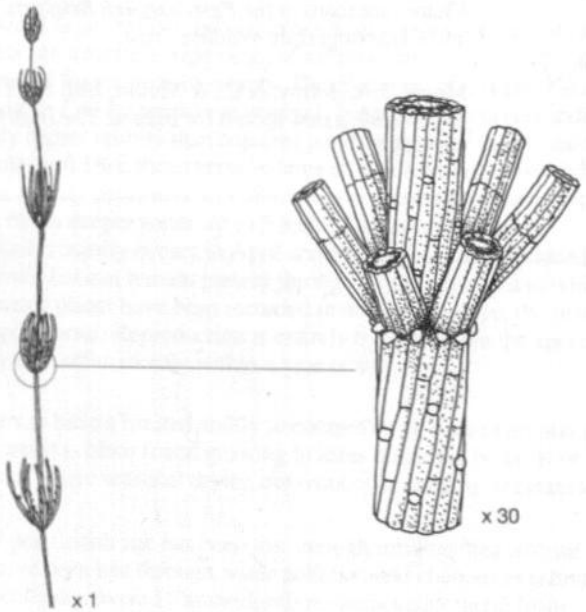
Moore, J.A., Jermy, A.C., & Mullin, J.M. 1975. *Lamprothamnium papulosum*, a new record for Ireland. *The Irish Naturalists' Journal, 18*: 233-237.

Chara connivens — Convergent stonewort

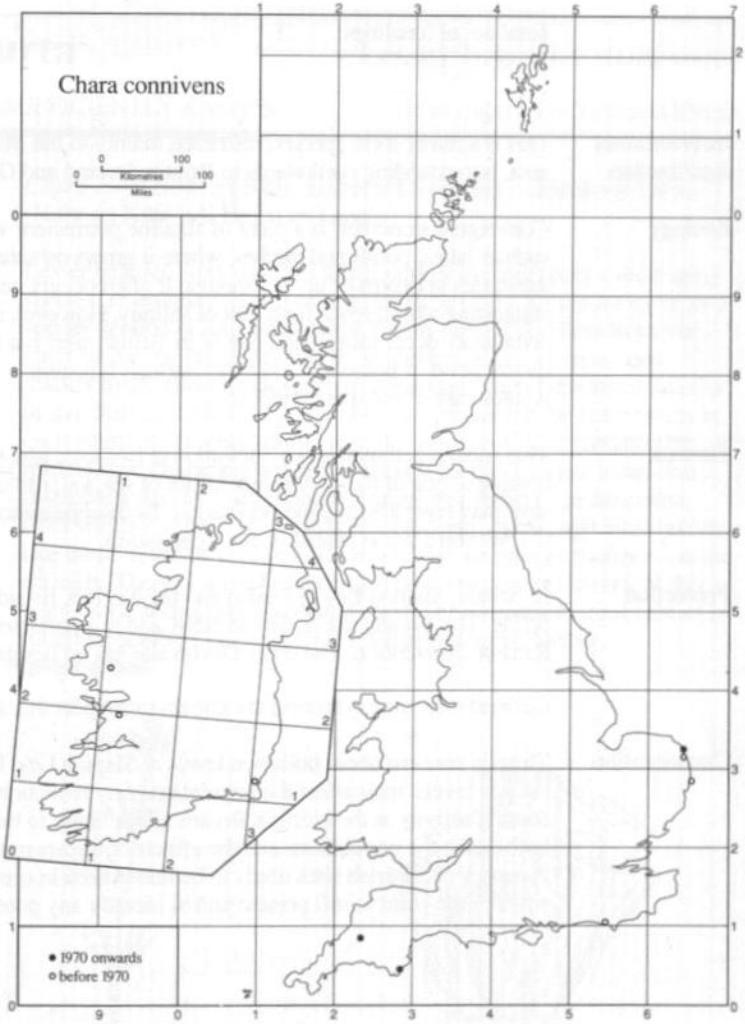
British status VULNERABLE — Irish status INDETERMINATE

Chara connivens Salzm. ex A. Braun

Identification This is a slender species with undeveloped spine cells, similar to fragile stonewort *C. globularis*. It is often difficult to separate the two when reproductive structures are absent. Convergent stonewort differs in being dioecious, usually light green and little encrusted, with the internodes often longer in relation to the branchlets. The younger branchlets, particularly in the male plant, are sometimes strongly incurved, but this feature is not very marked in British material. It sometimes has a more acrid smell than fragile stonewort *C. globularis*.



British distribution This plant is a southern species, recorded recently from two sites in Devon, and one site in the Norfolk Broads. In the past it has also occurred at three or four other sites in the Norfolk and Suffolk Broads and in one site in East Sussex. The species has been rather intermittently recorded, perhaps because of population fluctuations from year to year, or incomplete study.



Total no. of localities	8
Up to 1969	8
1970 onwards	3

Irish distribution

This species has been recorded from three sites in Cos. Wexford, Clare and on the Mayo/Galway border. It was last seen in 1959 at the Co. Clare site, but may still persist there. It has probably disappeared from the Co. Wexford site.

Total no. of localities	3
1970 onwards	0

International distribution

This is a rather local species, restricted mainly to the Mediterranean area, but extending northwards to Britain, Ireland and Germany.

Ecology

Convergent stonewort is a plant of alkaline permanent water bodies such as lakes, ponds and ditches, where it grows on sandy or marly substrates in depths of up to 3 metres. It often occurs near the sea, suggesting a preference for a hint of salinity. However, it can sometimes occur inland, and one of its British sites is a limestone quarry pond. It is usually a summer annual. It is quite a brittle plant and is intolerant of turbulent conditions.

Threats

This species is threatened by pollution at two sites and also by pleasure boating at one of these. A recent influx of sea water to one of its present sites may have affected the population. Its disappearance from the Co. Wexford site is probably due to pollution.

Protection

In Britain, Slapton Ley in Devon and the Norfolk Broads are both SSSIs. The Broads site is also an NNR and is a protected site under the Ramsar Convention. The other Devon site has no designation.

Currently, no sites in Ireland are known to support this species.

Conservation

There is concern about pollution levels at Slapton Ley, Devon, and salinity levels may affect the population. Any reduction of pollution or boating activity at the Norfolk Broads site is likely to be beneficial. In both cases, the populations and the effects of threats require monitoring. A survey of the Irish sites needs to be undertaken in order to discover whether the plant is still present and to identify any potential threats.

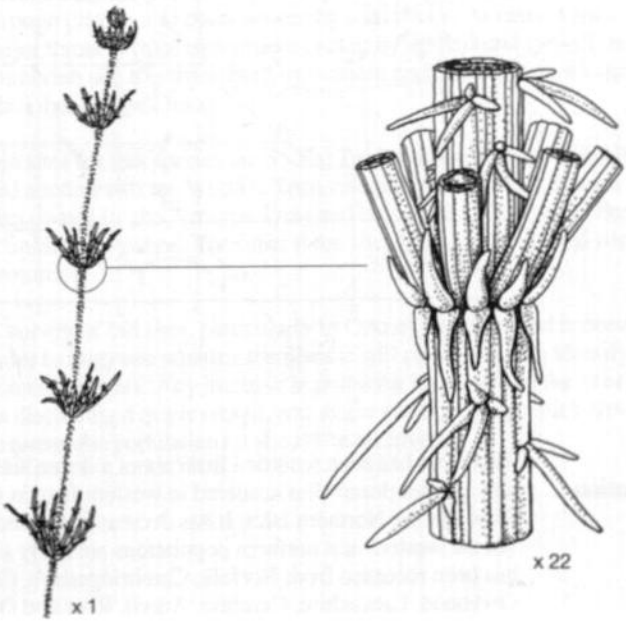
Chara curta — Lesser bearded stonewort

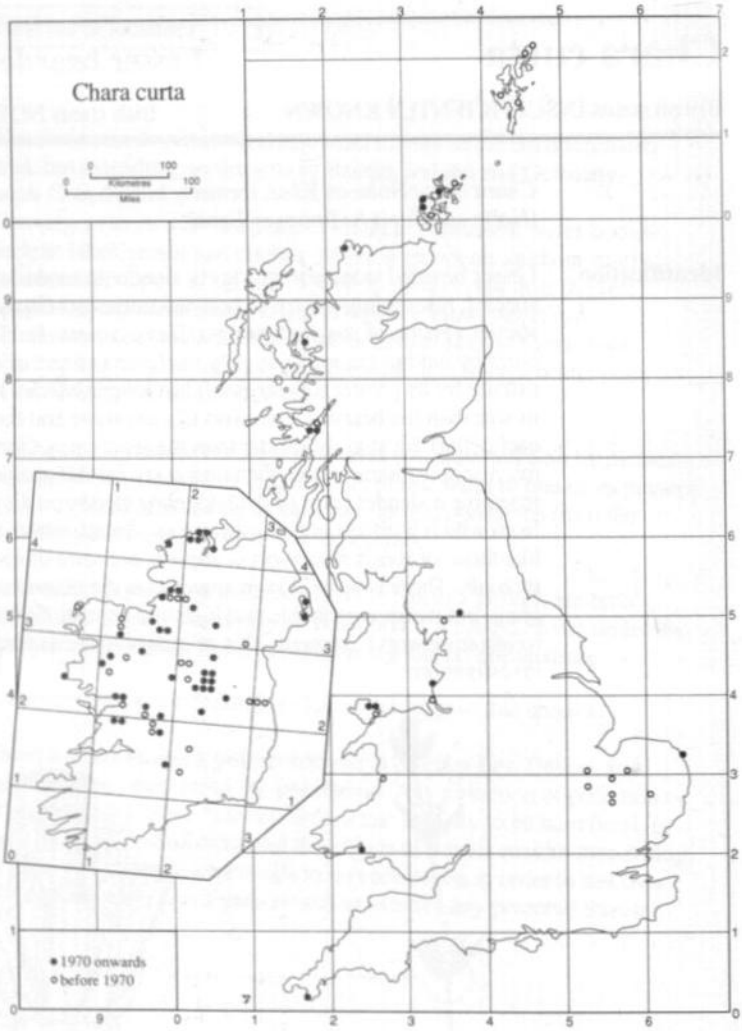
British status INSUFFICIENTLY KNOWN — Irish status NOT THREATENED

Chara curta Nolte ex Kütz. formerly known as *C. aspera* var. *curta* (Nolte ex Kütz.) A. Braun ex Leonh.

Identification

Lesser bearded stonewort is a fairly slender to moderately robust spiny species, resembling a form of bearded stonewort *Chara canescens*, or a spinier version of rough stonewort *Chara aspera*. It differs from the latter by having the spines mostly in clusters of two or more, and usually by its greater robustness. It has longer internodes and is smaller in size than the bearded stonewort *C. canescens* and the outer bracts in each whorl are slightly shorter than the inner ones. Confirmation by microscopic characters is often necessary for this species. It can also resemble a slender form of the hedgehog stonewort *C. pedunculata*, from which it differs in being dioecious. Small, white, spherical bulbils, like those of rough stonewort *C. aspera*, are sometimes produced on the rhizoids. There is some disagreement over the taxonomic rank of this plant, but it seems probable that it should be regarded as a subspecies of rough stonewort *C. aspera*. This relationship needs further investigation.





British distribution

This plant has been recorded from about a dozen sites in East Anglia, and another dozen sites scattered in western Britain from Cornwall to Ross and the Northern Isles. It has decreased markedly in East Anglia, but the western and northern populations are fairly secure. Since 1970 it has been recorded from Norfolk, Cambridgeshire, Cornwall, Dyfed, Gwynedd, Lancashire, Cumbria, Argyll, Ross and Orkney.

Total no. of localities	42
Up to 1969	35
1970 onwards	13

Irish distribution

In Ireland it is widely distributed throughout most of the country except the south west, and it is fairly frequent in the limestone areas. However, some of the older records may be erroneous.

International distribution

Outside Britain and Ireland there are only a few records from Germany, Sweden and Morocco.

Ecology

This is a plant of calcareous water on peaty or sandy substrates, occupying a similar range of habitats to rough stonewort *C. aspera*. In calcareous sandy areas on the west coast it inhabits dune slack ponds and the exposed shores of machair lochs. Elsewhere it is found in limestone lochs, occasionally in clay pits and in fen pits 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 mainly by bulbils, since it does not fruit freely. In limestone lochs it occurs in depths of up to 4.5 metres and frequently forms dense beds which are probably perennial.

Threats

In East Anglia it has probably declined as a result of pollution and through ditches and pools becoming overgrown. At current sites the major threat is from enrichment caused by agricultural run-off. In its Cumbrian site it is threatened by nutrient enrichment from a large black-headed gull roost.

Protection

Ten sites for this species are SSSIs. Two of these sites are also NNR and another two are Wildlife Trust reserves. The Norfolk Broads site is also owned by the National Trust and is specially protected under the Ramsar Convention. The other three sites have no designated site protection.

Conservation

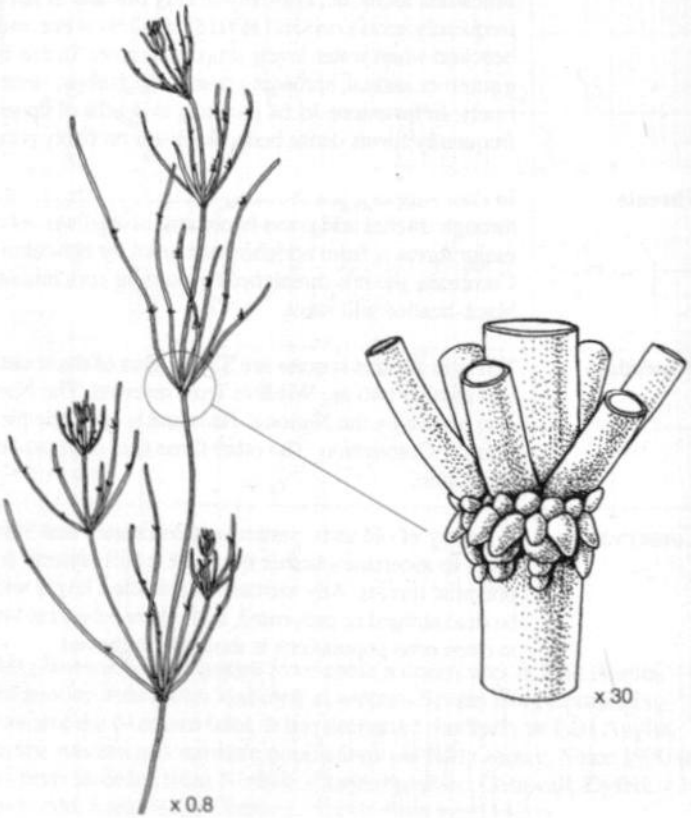
A survey of old sites, particularly in Orkney and Shetland is needed in order to ascertain whether the plant is still present, and to identify any potential threats. Any increase in pollution levels within the sites should be discouraged or prevented, and where emergent vegetation threatens to overcome populations it should be removed.

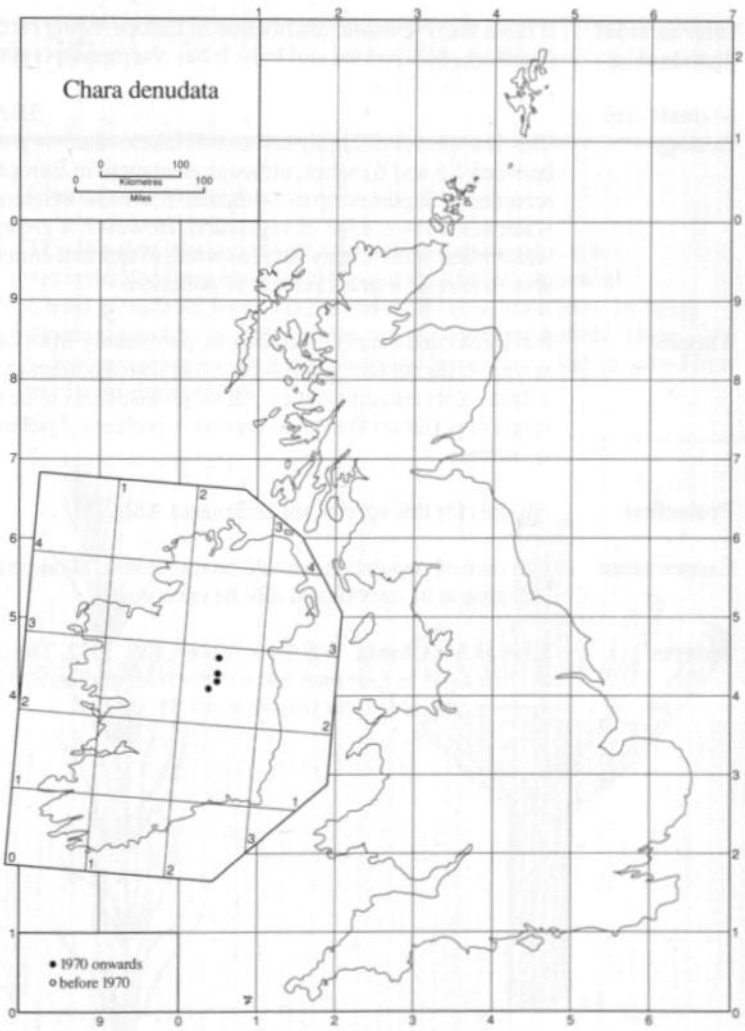
Chara denudata — Naked stonewort

British status — Irish status RARE

Chara denudata (A. Braun) R.D. Wood

Identification This is a fairly slender species with the regular whorls of branches typical of the genus *Chara*, but with the cortex reduced to a few residual cells at the nodes. It is otherwise similar in appearance to a tall form of opposite stonewort *C. contraria*. The relationship to the latter may require further investigation, although intermediate forms have not been observed in sites where they grow together. Braun's stonewort *C. braunii* also lacks the cortex, but differs in having a well developed ring of cells below each whorl of branchlets.





British distribution

This species has not been recorded in Britain.

Irish distribution

It has been recorded from five sites in Co. Westmeath. However, one of these was drained in 1976 (John *et al.* 1981).

Total no. of localities	5
1970 onwards	4

International distribution

It has a fairly sporadic distribution in Europe, being recorded in Denmark, Switzerland and Italy. It has also been recorded occasionally from South Africa.

Ecology

This is a species of highly calcareous lakes, where it grows at depths of between 1.5 and 6 metres, although elsewhere in Europe it has been recorded in depths of up to 14 metres. It is most frequent in deeper water at the lower edge of vegetation. However, it grows in shallower water when water clarity decreases due to nutrient enrichment. It seems able to tolerate a small amount of pollution.

Threats

It is threatened mainly by pollution, particularly from farming and sewage effluent. One site has been lost through drainage, but this is not a threat at its remaining sites. Although it appears to be tolerant of low levels of pollution this could become a problem if pollution continues to increase.

Protection

All sites for this species are designated ASIs.

Conservation

The state of populations should be monitored. Measures to reduce pollution at its sites should also be encouraged.

Sources

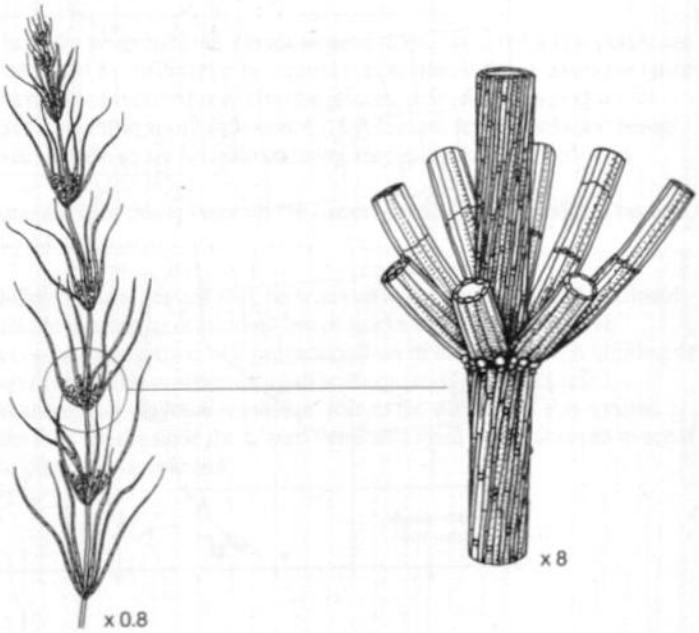
John, D.M., Champ, W.S.T., & Moore, J.A. 1982. The changing status of Characeae in four marl lakes in the Irish midlands. *Journal of Life Sciences Royal Dublin Society, 4*: 47-71.

Chara fragifera — Strawberry stonewort

British status RARE — Irish status —

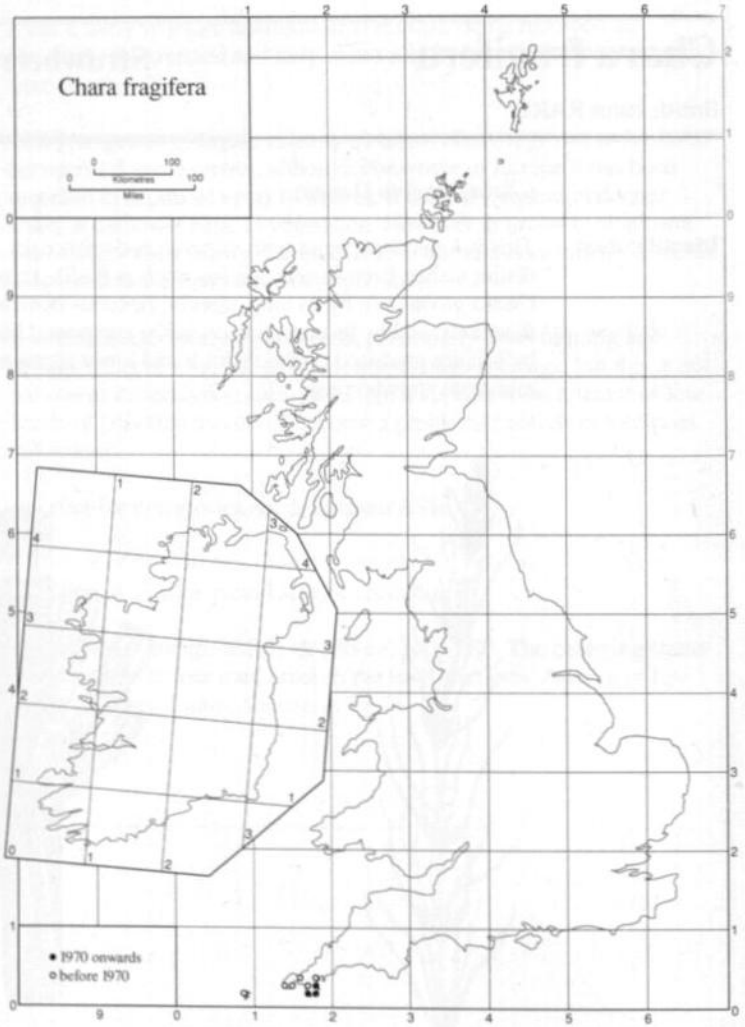
Chara fragifera Durieu

Identification This is a slender species with undeveloped spine cells. It is distinguished from similar species, such as fragile stonewort *Chara globularis*, by its long, slender, flexuous branchlets, by being dioecious, and by its conspicuous, white compound bulbils. These bulbils are produced on the rhizoids and lower stems and are pitted like miniature strawberries.



British distribution The distribution is strongly south-western, being confined to western Cornwall and the Isles of Scilly. It has been recorded from about twenty sites, but has not been seen recently outside the Lizard Peninsula.

Many of its sites are small pools and ponds, but it is often abundant where it occurs.



Total no. of localities	20
Up to 1969	18
1970 onwards	10

Irish distribution

This species has not been recorded from Ireland.

International distribution In Europe this species has a southern Atlantic distribution, reaching its northern limit in Britain. It is also known from the Mediterranean coast of north Africa and the Cape Coast of South Africa.

Ecology This is a plant of clear, shallow, oligotrophic water in moorland situations where it grows on very soft organic clays and muds, to which the plant contributes when it dies back and decays. Most sites are small water bodies such as pools, ditches, vehicle ruts and other sites which may completely dry out in hot summers. Thus, it generally has a winter annual life cycle. It occurs most frequently in pools in small quarry workings and can grow in up to 2 or 3 metres of water. However, in shallow water it is unable to compete with grasses and other terrestrial species which colonise the pools when they dry out for extended periods in the summer. In these situations, it relies on disturbance such as from cattle poaching or vehicles to limit competing vegetation.

Threats There are no immediate threats to most of the sites, but a few ponds are threatened by infilling or by natural succession. In some cases the latter is a result of reduced poaching by grazing animals. Changing use of tracks may also result in losses. On the Lizard, fewer tracks are being used, and these are sometimes being strengthened with hard-core.

Protection Nine sites for this species on the Lizard are SSSIs and NNRs. One site has no designated site protection.

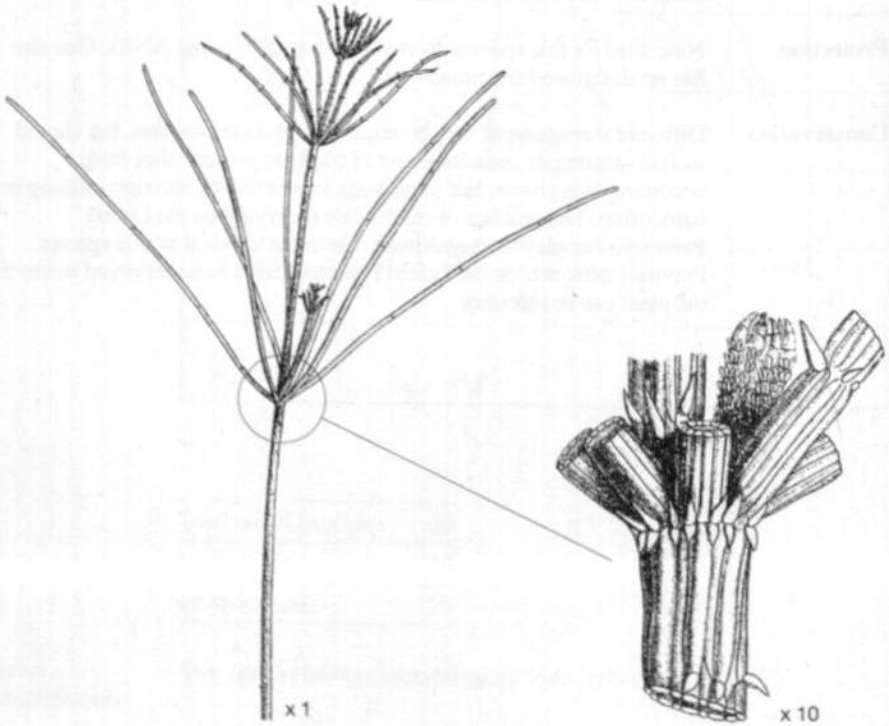
Conservation Different management may be required at the various sites, but should include grazing or occasional use of tracks to prevent sites from becoming overgrown, and preventing loss of habitat through infilling or hardcoring. The practice of small scale quarrying on the Lizard Peninsula has played a significant role in the survival of this species. Previous sites outside the Lizard Peninsula need to be surveyed to see if the plant can be refound.

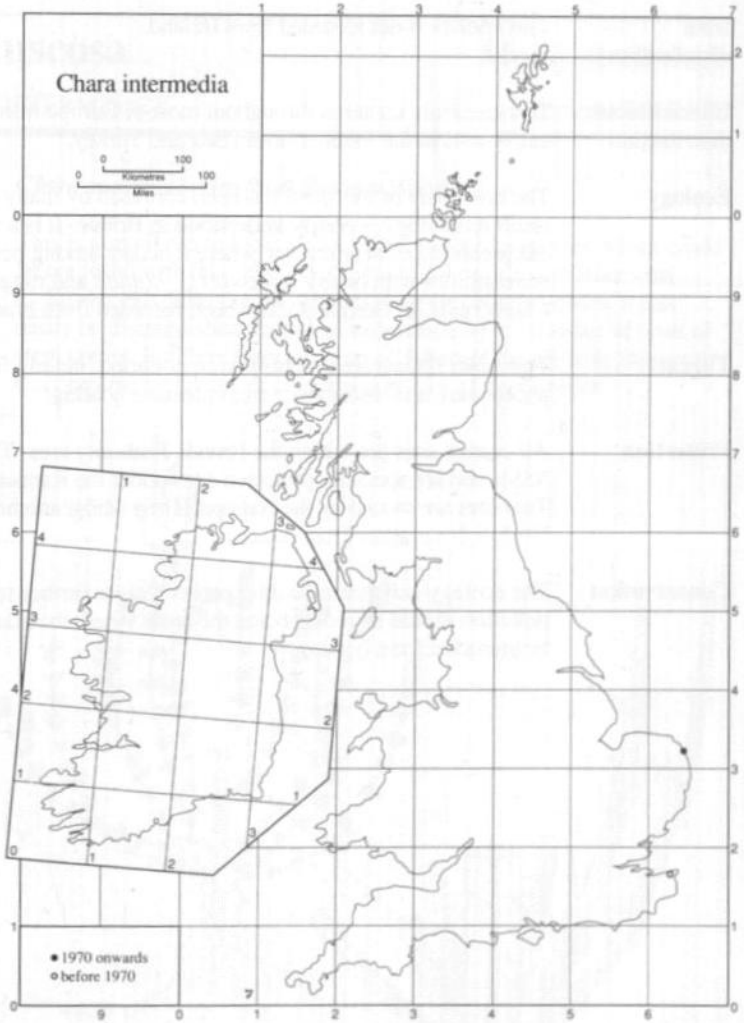
Chara intermedia — Intermediate stonewort

British status RARE — Irish status —

Chara intermedia Braun formerly known as *C. papillosa* Kütz. and *C. contraria x hispida*.

Identification This is a fairly robust species, reaching 30 cm in height and similar in appearance to bristly stonewort *C. hispida*. It differs in having fewer spines, which are usually solitary, and by having a pinkish or brownish tinge when fresh. It also differs under the microscope in the relative size of the cortical cells running along the stem. It is also similar to Baltic stonewort *C. baltica* (*q.v.*), but differs in the colour and by usually being much encrusted. Because of the overlap of characters with several other species, this plant has had a confused taxonomic history. The British populations have been referred to as *C. papillosa* or as a hybrid between *C. contraria* and *C. hispida*, but the treatment of Wood & Imahori (1965) is adopted here.





British distribution

Intermediate stonewort has been recorded from one site in Kent and five sites in the Norfolk Broads. Recent surveys have confirmed it is still present in all five of the Norfolk Broads sites, but it has not been seen in Kent since its discovery in 1923.

Total no. of localities	6
Up to 1969	4
1970 onwards	5

Irish distribution This species is not recorded from Ireland.

International distribution The species is scattered throughout most of Europe from Scandinavia and Russia to the Mediterranean Sea and Turkey.

Ecology The taxonomy of this plant has been confused by many authors and as a result its ecology is poorly understood in Britain. It is a species of calcareous lakes near the sea, where it occurs among perennial *Chara* communities with bristly stonewort *C. hispida* and rugged stonewort *Chara rudis*. In Germany it has been recorded from brackish water.

Threats The major threats are probably from pollution, mainly from nitrates and phosphates, and disturbance from pleasure boating.

Protection All current sites are within the Broads Authority area. They are all SSSIs and are specially protected sites under the Ramsar Convention. Two sites are owned by the National Trust whilst another two are Norfolk Naturalists Trust reserves.

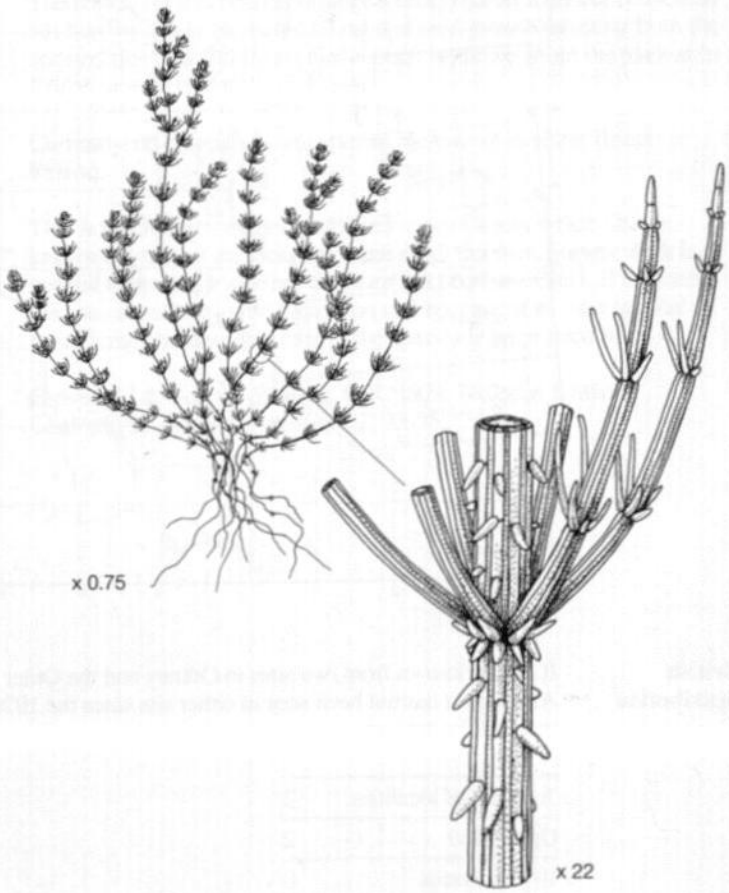
Conservation The ecology and threats to this species require further study. If possible, pollution should be reduced and the areas where the plant grows should be protected from boating.

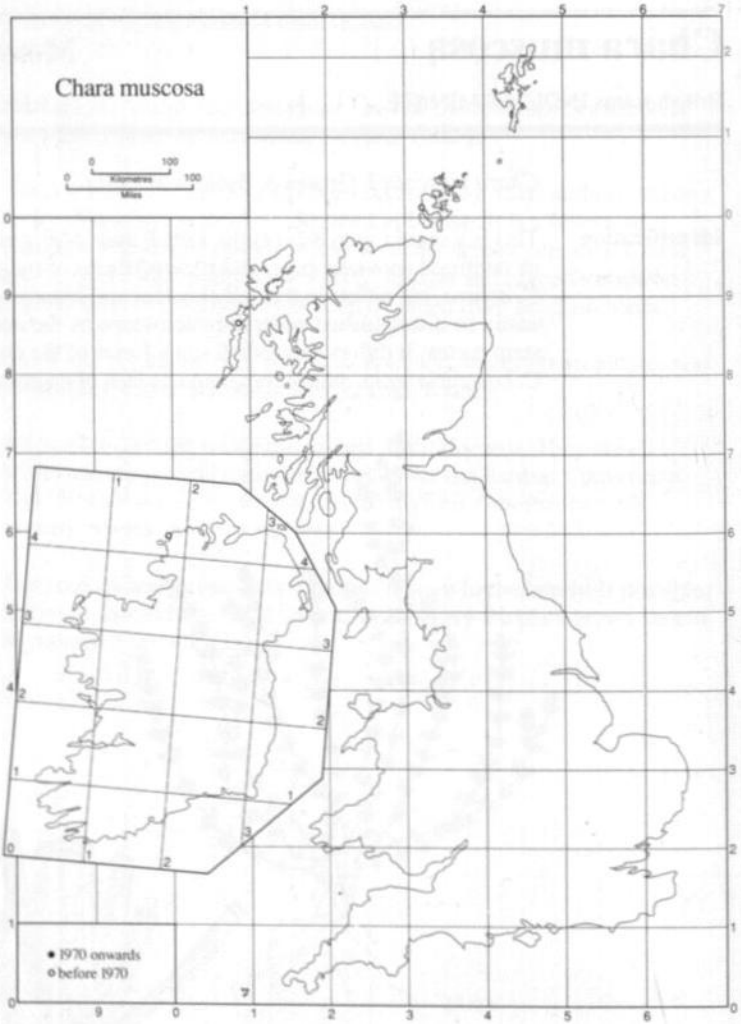
Chara muscosa — Mossy stonewort

British status INDETERMINATE — Irish status EXTINCT

Chara muscosa J. Groves & Bullock-Webster

Identification This is a small (up to 8 cm high), tufted, moss-like species, which could be confused with lake edge, short-spined forms of rough stonewort *C. aspera*, but differs in the darker colour and blunter spines. It can easily be distinguished under the microscope by the number of rows of stem cortex. It differs from small spiny forms of the opposite stonewort *C. contraria* by its darker colour and its lack of encrustation.





British distribution

It is only known from two sites in Orkney and the Outer Hebrides. Although it has not been seen in either site since the 1920s or 1930s, it may still be present.

Total no. of localities	2
Up to 1969	2
1970 onwards	0

Irish distribution

This species was originally described from Lough Mullaghderg, Co. Donegal, where it was discovered in 1917. It was refound in 1919 and 1939 but has not been found subsequently, despite several searches by experts.

Total no. of localities	1
1970 onwards	0

International distribution

It is endemic to Britain and Ireland.

Ecology

This plant grows on sand at the shallow margins of lakes.

Threats

The reason for its apparent disappearance from its Irish site is unclear, but may be due to increased silting and reed growth resulting from the construction of a causeway. Not enough is known about the plant at its British sites to identify any threats.

Protection

Currently, no colonies of this species are known in either Britain or Ireland.

Conservation

This is an internationally endangered species about which little is known because of the isolated nature of all the sites. Survey work is needed to establish whether the plant has become extinct. If refound, the sites should be given protection and because of its international rarity it may be desirable to give the species legal protection.

Sources

Groves, J., & Bullock-Webster, G.R. 1924. Notes on British Charophyta. *Journal of Botany, 62*: 33-35.

Chara rudis

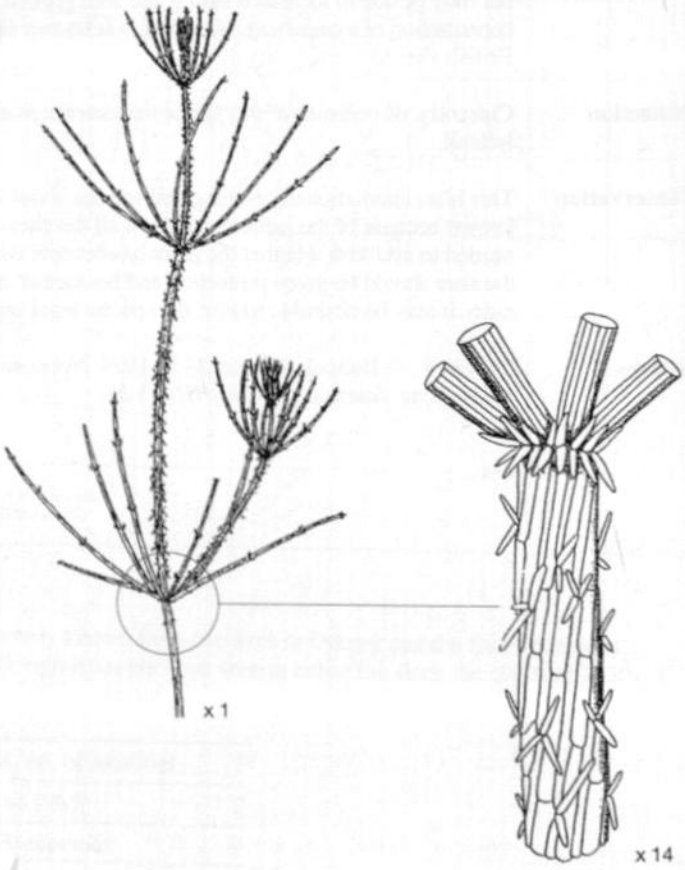
Rugged stonewort

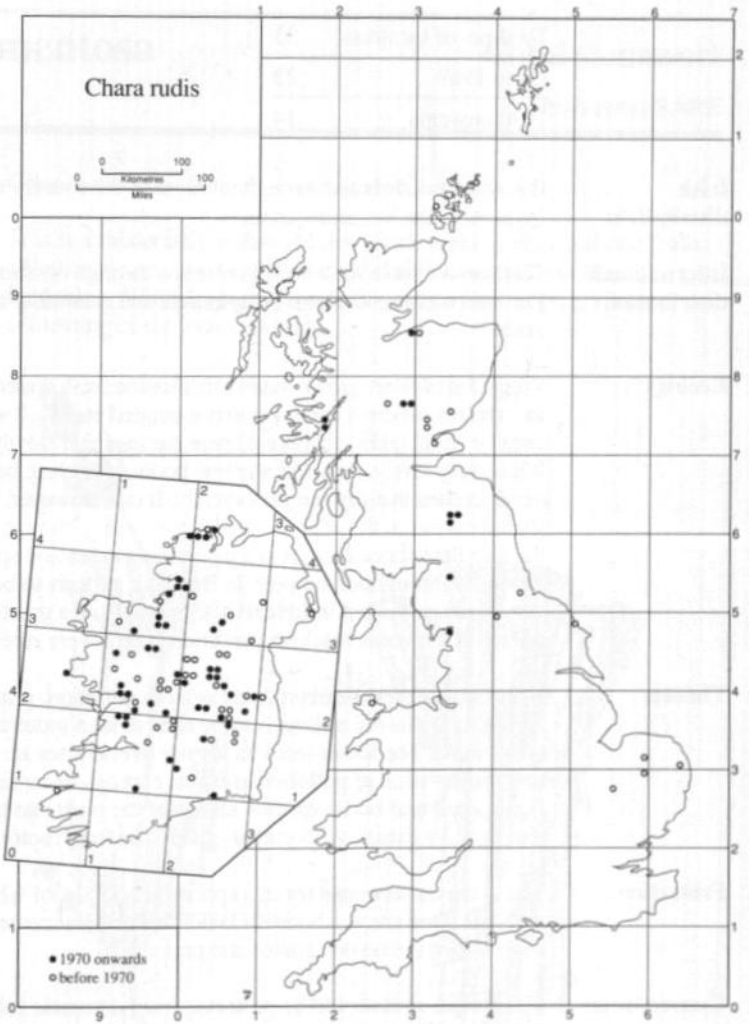
British status RARE

Irish status NOT THREATENED

Chara rudis (A. Braun) Leonh.

Identification This is a robust to very robust, spiny species similar to bristly stonewort *C. hispida*. However, it is fairly easily distinguished by the stem spines being in pairs or triplets, flattened against the stem, with two of the spines in each group more or less pointing in opposite directions and usually aligned along the stem. When seen together with the bristly stonewort *C. hispida* it is slightly smaller, more slender and rather more grey in appearance.





British distribution

Rugged stonewort is a widely distributed but predominantly northern species, occurring in ten sites in Cumbria, Northumberland, Roxborough, Ettrick and Lauderdale, Perth and Kinross, Argyll and Nairn. It has decreased markedly in England and Wales and has disappeared from sites in Norfolk, Cambridgeshire, Anglesey and North Yorkshire. Most of the Scottish sites are probably fairly secure. Although it has been lost from several sites in Perth and Kinross and Angus, it can still be found in considerable abundance at some sites.

Total no. of localities	35
Up to 1969	23
1970 onwards	14

Irish distribution

It is widely distributed throughout most of the country and it is fairly frequent in the limestone areas.

International distribution

This species has a scattered distribution through northern and central Europe, reaching southern Scandinavia and extending into western Asia.

Ecology

Rugged stonewort grows mainly in alkaline fresh waters in depths of up to 7 metres, where it can form 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. It 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 it seems to have a greater tolerance of pollution. It avoids brackish conditions and is very rare near the coast.

Threats

In its British sites the main threat is from pollution, principally from agricultural run-off, although some sites remain protected by their remoteness. The losses from its former British sites are likely to be due to a combination of pollution and peat cuttings becoming overgrown. Being a tall and brittle species, stands of the plant can be seriously damaged by excessive disturbance, such as from motor-powered boats.

Protection

Ten of the current sites for this species are SSSIs, of which one is also an NNR. One site is a Scottish Wildlife Trust reserve and the other three sites have no designated site protection.

Conservation

The British sites should be protected from domestic and agricultural pollution. Where possible intensive cultivation of catchments should be discouraged.

Sources

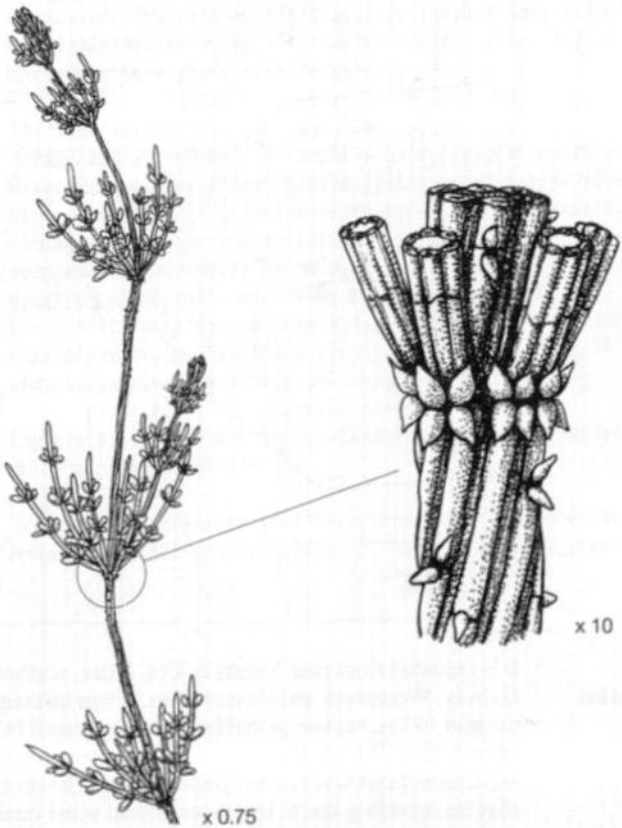
Pereyra-Ramos, E. 1982. The ecological role of Characae in the lake littoral. *Ekologia Polska, 29*: 167-209.

Chara tomentosa — Coral stonewort

British status — Irish status RARE

Chara tomentosa L.

Identification This is a moderately robust species which is easily distinguished from all other species of *Chara* by the inflated final segment of the branchlets. When fresh, it has a distinctive pinkish tinge, giving it something of the look of a coral.



British distribution This species has not been correctly recorded from Britain.

Irish distribution

It is recorded from nine loughs in Cos. Clare, northern Tipperary, Galway, Westmeath and Roscommon. It was last seen in Lough Derg in the mid 1970s, but has probably now disappeared from there as a result of pollution. The populations at Lough Ennell also became much reduced and restricted to less polluted bays. However, some recovery may be occurring due to improvements in water quality.

Total no. of localities	10
1970 onwards	9

International distribution

Coral stonewort is relatively widespread throughout Europe, but most frequent in central Europe. It is also recorded from Asia, North Africa and the Americas from Florida to Brazil.

Ecology

This is a species of medium to large lakes with highly calcareous water. It is intolerant of water pollution from nitrates and phosphates (John *et al.* 1982). It usually grows in depths of up to 8 metres but has been recorded in up to 20 metres of water elsewhere in Europe. It occurs either in open communities, with isolated plants anchored by stones, or mixed among perennial stonewort beds, with rugged stonewort *Chara rudis*, bristly stonewort *C. hispida* and lesser bearded stonewort *C. curta*. It can grow in shallow water but is probably unable to tolerate being stranded by falling water levels. Elsewhere in Europe it has occasionally been reported from pools and ditches, also in slightly brackish situations in sheltered inlets of the Baltic Sea. Ripe spores have never been recorded in Ireland.

Threats

The main threat to this species is from pollution, particularly from nitrates and phosphates. The recent records from the loughs on the River Shannon are all from bays and inlets somewhat cut off from the main river flow. At Lough Ennell the population has been severely damaged by sewage pollution from Mullingar, although there may have been some improvement following the installation of new sewage treatment works in the late 1970s. The population at Lough Derravaragh may have suffered some damage as a result of effluent from pig farms. Being a brittle species it is also vulnerable to disturbance from motor boats and any consequent turbidity.

Protection

Eight of the current sites for this species are ASIs. One site has no designated site protection.

Conservation

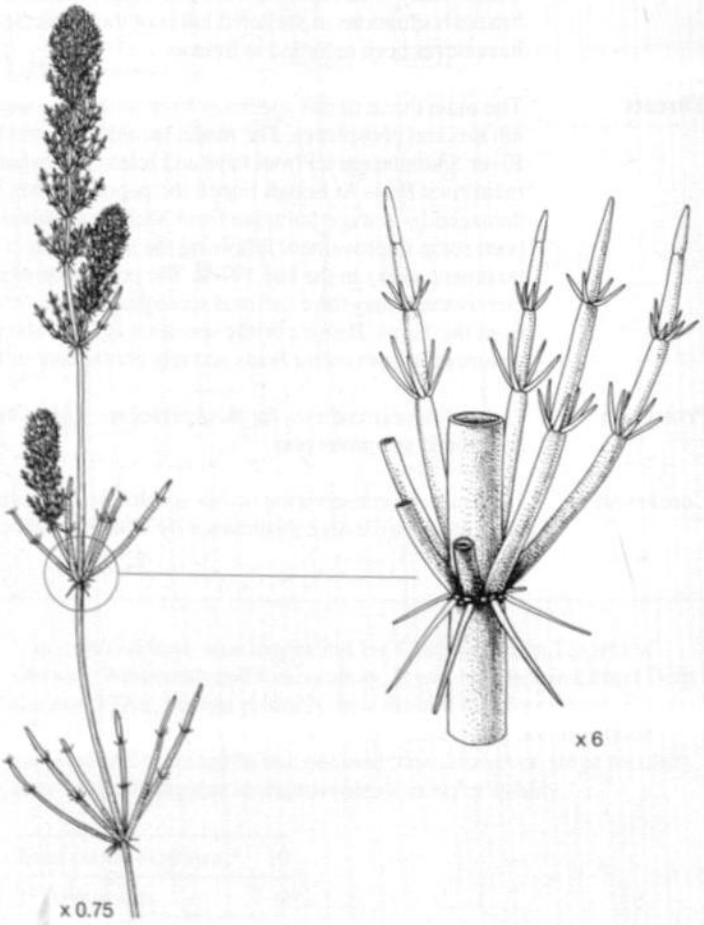
To ensure the conservation of this species, water pollution should be reduced and excessive disturbance by boats should be discouraged.

Lamprothamnium papulosum — Foxtail stonewort

British status VULNERABLE — Irish status VULNERABLE

Lamprothamnium papulosum (Wallr.) J. Groves

Identification Foxtail stonewort is a medium sized plant which can grow up to 40 cm in height. It has *Chara*-like branching, with whorls of equal, simple branchlets, but lacks any stem cortex. It is particularly distinctive because the upper whorls are contracted to form dense heads, resembling bushy fox-tails.



British distribution

It is confined to four sites on the south coast of England in Dorset, Hampshire and the Isle of Wight and one site in Scotland, on North Uist. It has long since disappeared from another site in Dorset and from two more on the Isle of Wight.

A substantial population occurs in the Fleet in Dorset, but populations are small at the other sites.

Total no. of localities	8
Up to 1969	4
1970 onwards	5

Irish distribution

It is restricted to three sites in Cos. Wexford and Clare. One of the Co. Wexford populations is very small and restricted to about 50 square metres. However, the other populations are more substantial. The population at Lady's Island Lake may fluctuate as a result of changes in salinity.

Total no. of localities	3
1970 onwards	3

International distribution

It 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 Cyprus and the Black Sea. There are also a few records from brackish sites inland. The plant also occurs in southern Africa.

Ecology

This species grows in natural and artificial brackish lagoons with salinities in the range of 1—3%. It is most often found growing on sand, gravel or pebbles in less than 2 metres of water, but it is intolerant of strong flow or wave action. Foxtail stonewort usually occurs with tassel pondweeds (*Ruppia* spp.), but it does not compete well with dense vascular plant growth. It is often to be found in areas where there is some disturbance from birds or animals, or in shallow water where fluctuations in the water level result in more open vegetation. It grows as a summer annual, germinating in spring or early summer and producing spores from July to September. It spreads partly by spores and partly by bulbils.

In the reduced salinities of the Baltic Sea it occurs in sheltered places on open coasts. It has occasionally been reported in Europe from saline situations away from the coast.

Threats

The saline lagoon habitat is threatened by reclamation for agriculture, industry, recreation and also by sea defence works, water pollution and changes in salinity caused by modifications to water courses or connections to the sea. For example, at Lady's Island Lake, Co. Wexford, the population may fluctuate as a result of increased salinity caused by regular cutting of the sand bar which separates the lake from the sea. Several former sites in Hampshire and Dorset have been lost through infilling.

Protection

Foxtail stonewort is a specially protected species in Britain, being listed on Schedule 8 of the Wildlife and Countryside Act, 1981. Four of the recent sites for this species in Britain are SSSIs. One site is also an NNR.

In Ireland, all three sites are ASIs.

Conservation

This plant should be protected from habitat destruction, changes in water quality or salinity, or from recreational and other activities which increase wave action and stir up the sediment. The species should be considered for legal protection in Ireland.

Sources

Daniel, G.F. 1975. *The ecology of the charophyte* Lamprothamnium papulosum *J. Groves*. Undergraduate thesis, University of London.

Moore, J.A., Jermy, A.C., & Mullin, J.M. 1975. *Lamprothamnium papulosum*, a new record for Ireland. *The Irish Naturalists' Journal, 18*: 8.

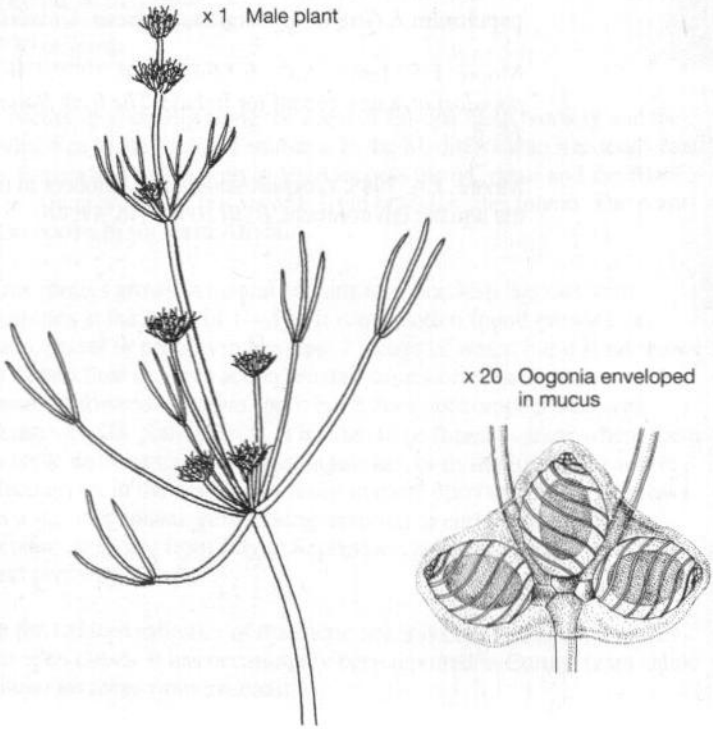
Moore, J.A. 1988. *Lamprothamnium* – a pioneer in the conservation of the aquatic environment. *BSBI News*, No. 49: 48.

Nitella capillaris — Slimy-fruited stonewort

British status EXTINCT — Irish status —

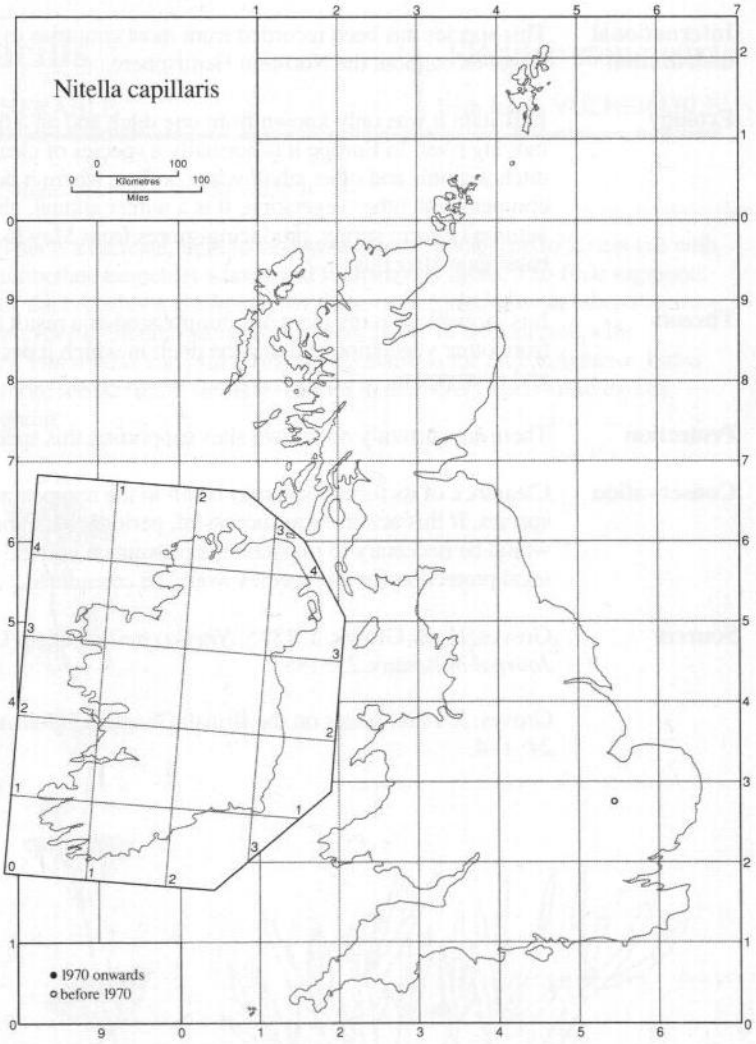
Nitella capillaris (Krocker) J.Groves & Bullock-Webster

Identification This species is similar to a slender form of the common smooth stonewort *Nitella flexilis* and likewise has single-celled final segments to the branches. It differs by the clustered fruits which are enclosed in a globule of jelly.



British distribution The only confirmed record of this plant is from one site near Sutton Gault in Cambridgeshire. Other records from North Wales, North Yorkshire and Scotland are probably errors.

Although the plant has occurred in some quantity at its only site, it has not been seen there since 1959. The ditch where it occurred has almost certainly become overgrown.



Total no. of localities	1
Up to 1969	1
1970 onwards	0

Irish distribution

It is not recorded from Ireland.

International distribution This species has been recorded from most countries in Europe and is found throughout the Northern Hemisphere.

Ecology In Britain it was only known from one ditch and an adjacent slow-moving river. In Europe it is normally a species of clear water in ditches, pools and other small water bodies, where it does not readily compete with other vegetation. It is a winter annual, germinating in autumn or early spring, producing spores from May to July and dying back soon after this.

Threats It is probable that the plant has disappeared as a result of competition from other vegetation and that the ditch in which it occurred is now dry and overgrown.

Protection There are currently no known sites supporting this species.

Conservation Clearance of its former site may result in the reappearance of this species. If this action were successful, periodic clearance of the ditch would be necessary to maintain the population and the possibility of legal protection for this species would be considered.

Sources

Groves, H., & Groves, J. 1885. *Nitella capitata* ag. in Cambridgeshire. *Journal of Botany, 23*: 185.

Groves, J. 1886. Notes on the British Characeae. *Journal of Botany, 24*: 1-4.

Nitella gracilis

Slender stonewort

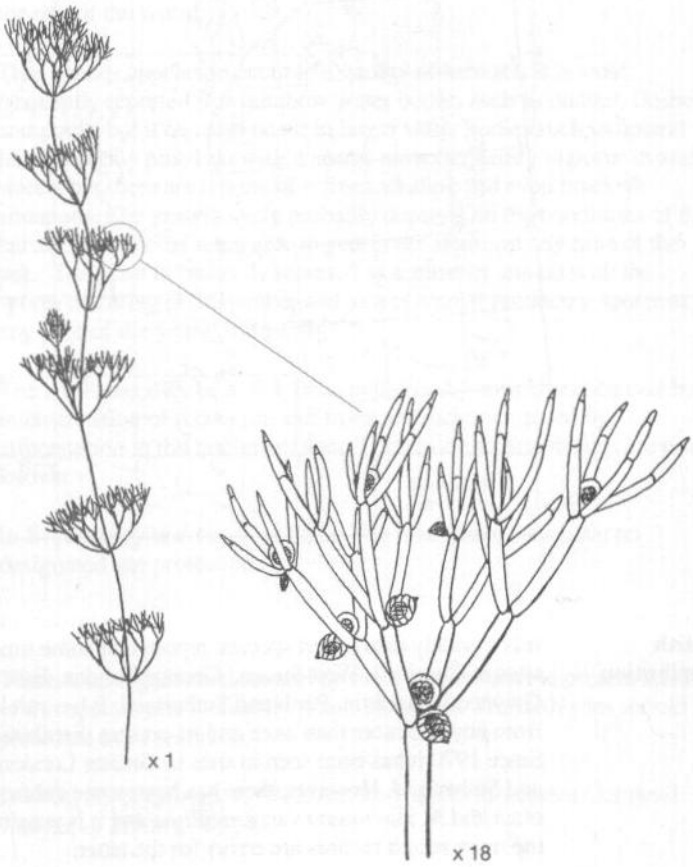
British status VULNERABLE

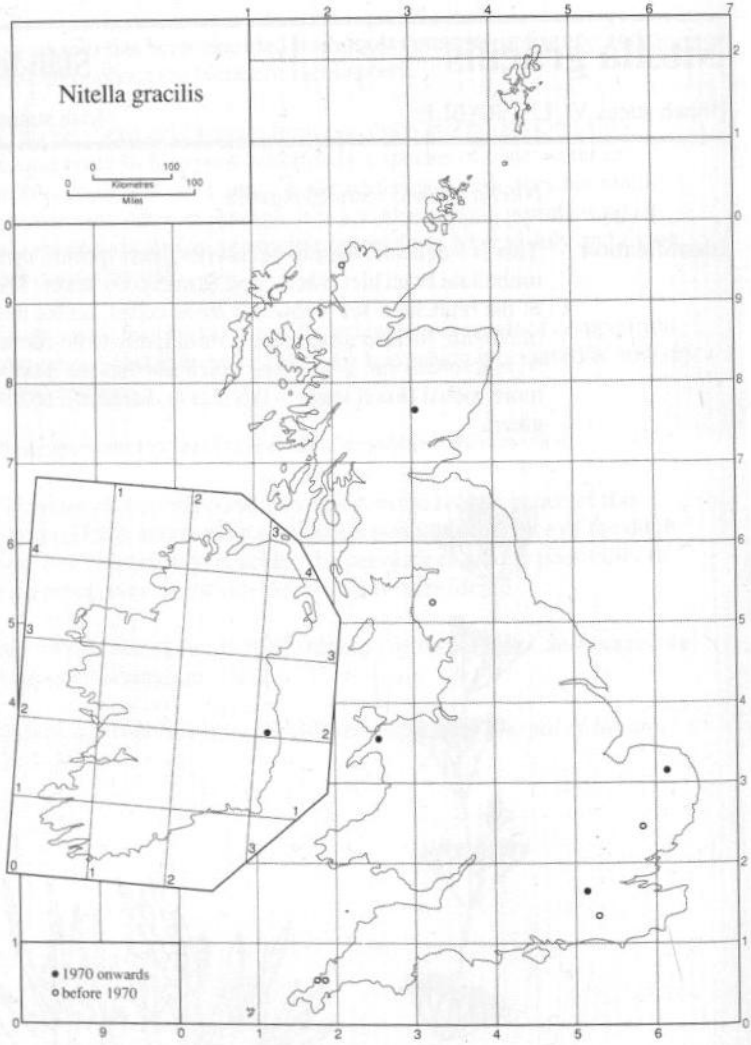
Irish status VULNERABLE

Nitella gracilis (Smith) Agardh

Identification

This is a delicate, light to yellowish-green species, up to 20 cm tall with umbellate branchlet whorls and filamentous stems. The final segments of the branchlets are frequently three-celled, unlike most other species of *Nitella*. Slender stonewort is most likely to be confused with *N. mucronata* var. *gracillima* which also has the latter character, but is more robust (main stems > 0.5 mm in diameter), and is mid to dark green.





British distribution

It is a widely distributed species, reported at some time from scattered sites in Cornwall, West Sussex, Greater London, Essex, Shropshire, Gwynedd, Cumbria, Perth and Sutherland. It has rarely been reported from any site more than once and its present distribution is not known. Since 1970 it has been seen in sites in Greater London, Gwynedd, Perth and Sutherland. However, there has been some confusion between this plant and *N. mucronata* var. *gracillima* and it is possible that some of the more recent records are errors for the latter.

Total no. of localities	11
Up to 1969	7
1970 onwards	4

Irish distribution

The plant has recently been rediscovered in Lough Tay, Co. Wicklow, where it was first recorded nearly 100 years ago. It has not been seen since the 1890s in the nearby Lough Dan, but it may still be present. Other records from Co. Dublin have proved to be errors.

Total no. of localities	2
1970 onwards	1

International distribution

This species is widely distributed, both within Europe and throughout the rest of the world.

Ecology

This species appears to occur in a variety of habitats. It is most frequently reported from shallow water bodies such as ditches, flushes and pools, but it can also occur in larger water bodies such as upland lakes and clay pits. Likewise it seems most frequently to occur in acid waters but there are reports of it from alkaline and even brackish situations. The growth cycle probably depends on the conditions of the habitat. The spores seem able to germinate at almost any time of the year. The plant is variously reported as a summer annual with the spores maturing in September and as a perennial producing spores at any time of the year (Olsen 1944).

Threats

The Irish sites may be at risk from pollution by enrichment caused by intensification of recreation and from acidification caused by afforestation in the catchment area. Threats to the British sites are not known.

Protection

In Britain only one site is an SSSI. The other three sites have no designated site protection.

In Ireland none of the current sites have any designated site protection.

Conservation

There is an urgent need for survey work to ascertain the present status of this species and to identify potential threats. The Irish sites should be protected from pollution.

Sources

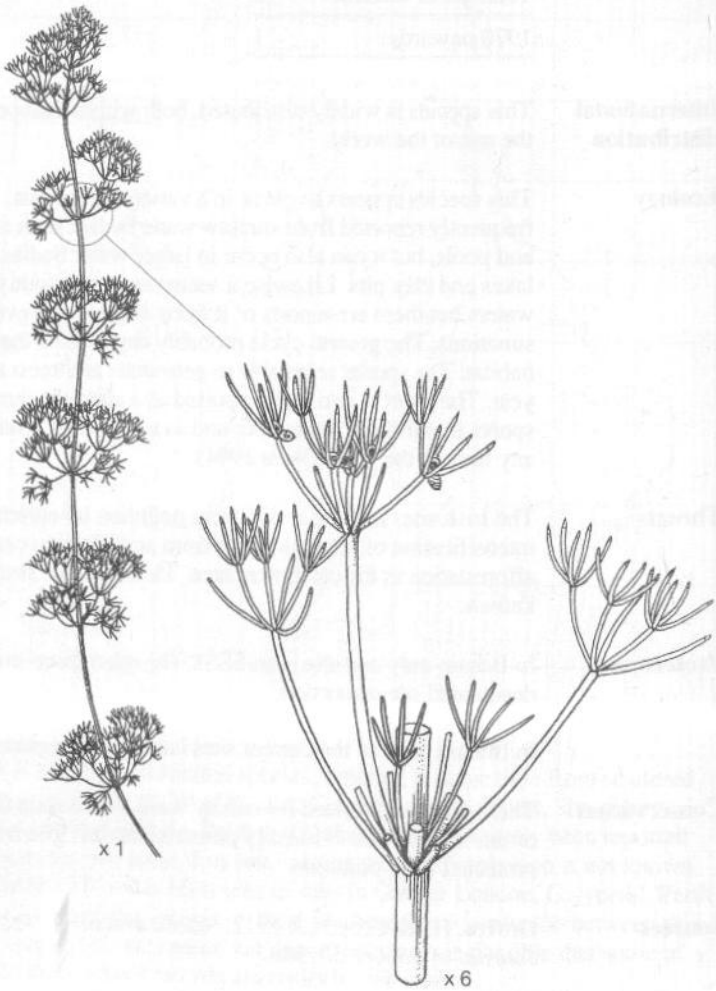
Groves, H., & Groves, J. 1912. *Nitella gracilis* in western Cornwall. *Journal of Botany, 50*: 348.

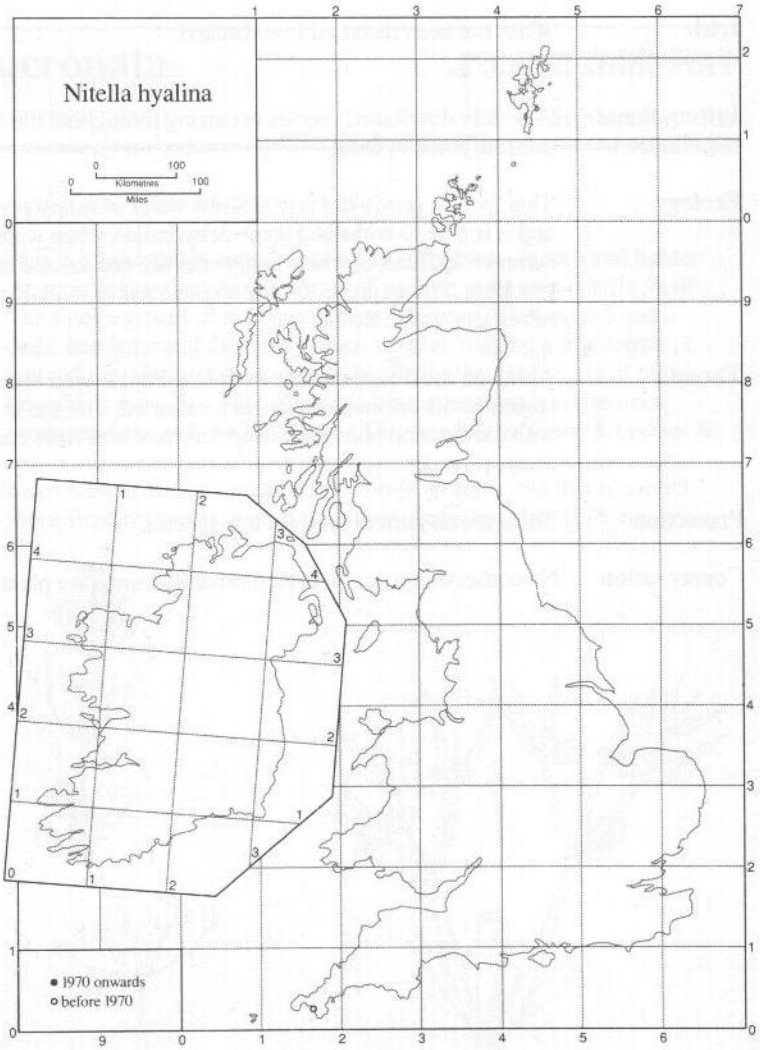
Nitella hyalina — Many-branched stonewort

British status EXTINCT — Irish status —

Nitella hyalina (DC.) Agardh

Identification Although one of the smaller and more delicate stoneworts, it is easily distinguished from other species of *Nitella* by the three rings of branchlets at each node, making about 24 branchlets in each whorl compared with the usual seven to nine.





British distribution

This plant has only ever been found at Loe Pool in Cornwall, but it disappeared from this site around 1915. A record for Llyn Idwal in Gwynedd is an error.

Total no. of localities	1
Up to 1969	1
1970 onwards	0

Irish distribution	It has not been recorded from Ireland.
International distribution	A widely distributed species occurring throughout the world, but generally rare or local.
Ecology	This species grows in fairly shallow water in sunny positions in lakes, and it is able to withstand some dehydration when water levels drop in summer. In Europe, where many sites are coastal and may be mildly brackish, it often grows on calcareous sand or mud. Ripe spores were never seen in the British site.
Threats	Although the disappearance from Loe Pool is well documented, the reason for its decline has not been recorded. The site is now polluted with nitrates and phosphates and this may well have contributed to its disappearance.
Protection	There are no current sites for this species.
Conservation	No conservation action is recommended since the plant is extinct.

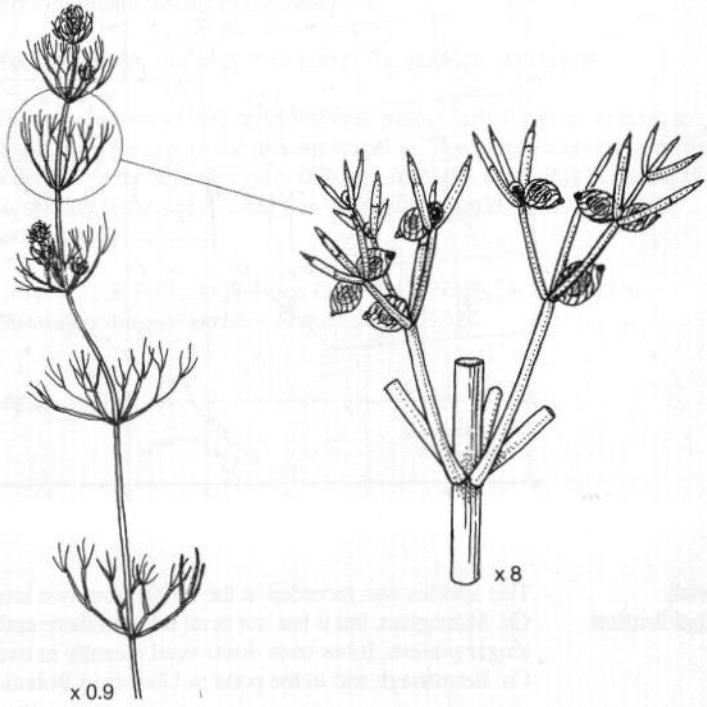
Nitella mucronata — Pointed stonewort

British status NOT THREATENED — Irish status RARE

Nitella mucronata (A.Braun) Miquel

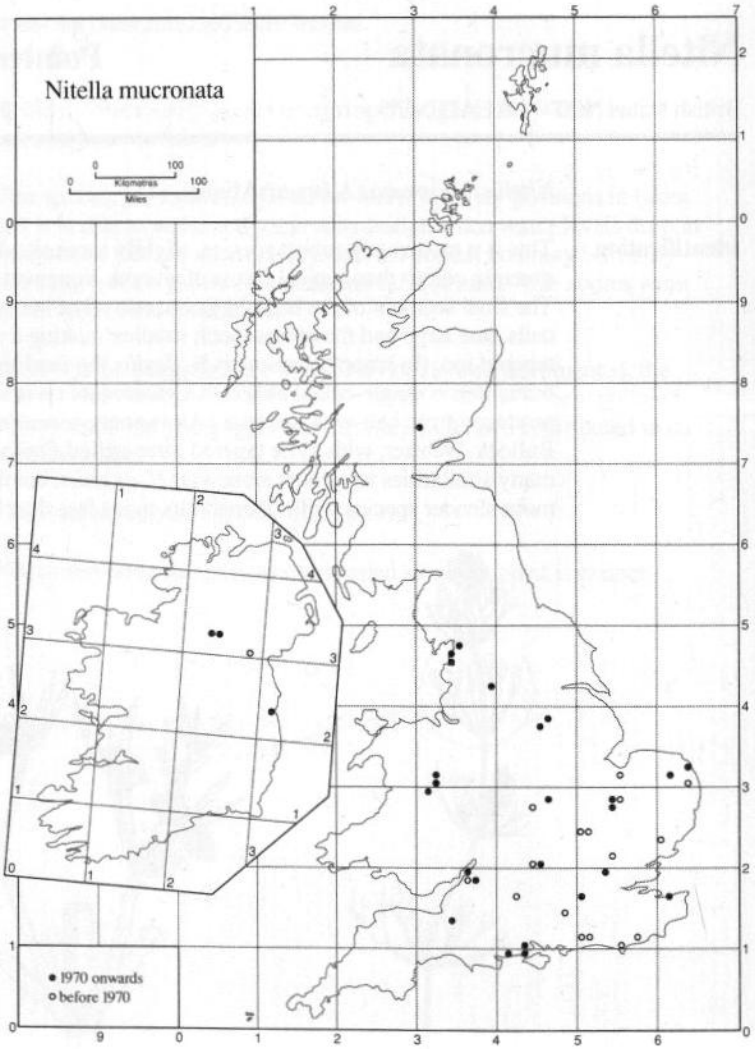
Identification

This is a moderately robust species, slightly more slender and lighter green in colour than typical forms of smooth stonewort *Nitella flexilis*. The final segment of the branchlets is made up of between 2 and 3 cells, one large and the others much smaller, making a mucronate or tapered top. (In smooth stonewort *N. flexilis* the final segment of the branchlets is single-celled although a mucronate tip is sometimes produced from cell-wall material.) The variety *gracillima* J. Groves & Bullock-Webster, with more tapered three-celled final segments, has many similarities to slender stonewort *N. gracilis*, but this is a much more slender species, with filamentous stems less than 0.75 mm wide.



British distribution

The plant has a scattered distribution through England as far north as Lancaster and Sheffield. It has not been refound at some of its older sites, but it is apparently spreading.



Irish distribution

This species was recorded in the 1890s from two loughs in Co. Monaghan, but it has not been refound there and probably is no longer present. It has been discovered recently in two loughs in Co. Fermanagh and in the pond in Glasnevin Botanic Gardens, Dublin.

Total no. of localities	6
1970 onwards	3

International distribution The species is widely distributed throughout most of Europe, except the extreme north, and is recorded from Africa, Asia and the Americas.

Ecology This is a plant of mesotrophic to somewhat eutrophic water and is more tolerant of pollution than most species of stoneworts. It has been recorded from a number of situations including lakes, ponds and canals. Many recent records in Britain are from canals and the plant seems to have benefited from the interest in restoring the canal system. It seems able to tolerate at least some boat movement and the consequent water turbidity. However, there are also a number of recent records from ponds in garden centres and botanic gardens, and it seems likely that some of the apparent spread in recent years is due to accidental introduction. There may also be a connection between the spread and the fact that a significant number of modern records are the variety *gracillima*, which was first noted in Britain in 1917, but this requires further investigation.

Threats Since the plant seems to be spreading it is not clear whether there are any significant threats to the species.

Protection None of the current sites have any designated site protection.

Conservation The populations should be monitored, particularly those in Ireland, to detect any changes in the present situation. The plant recorded from the older sites may be genetically different from the taxon that is currently increasing in frequency, and this possibility should be investigated further.

Sources

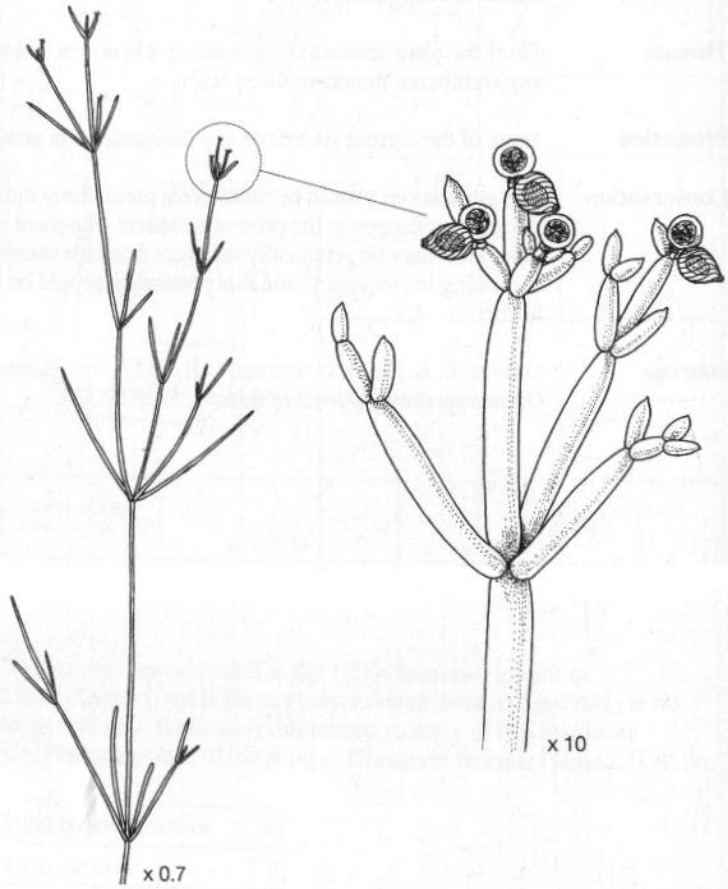
Groves, J., & Bullock-Webster, G.R. 1917. *Nitella mucronata* in Gloucestershire. *Journal of Botany, 55*: 323-324.

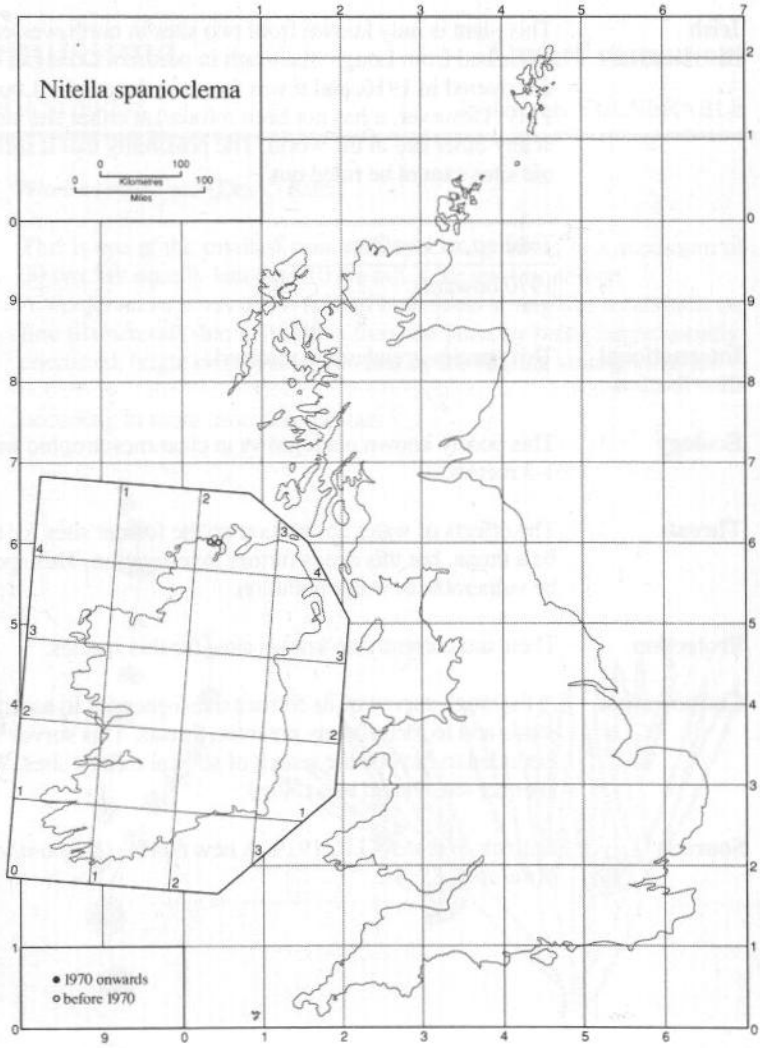
Nitella spanioclema — Few-branched stonewort

British status — Irish status INDETERMINATE

Nitella spanioclema J. Groves & Bullock-Webster, formerly known as *Nitella flexilis* var. *spanioclema* (J. Groves & Bullock-Webster) R.D. Wood

Identification This is a fragile species, about 30 cm tall, which appears somewhat etiolated because of the sparse, irregular branching. Like smooth stonewort *N. flexilis* the final segments of the branchlets are single-celled, but few-branched stonewort differs in the reduced branching and the very short branchlets, which occur in whorls of two to four.





British distribution

This stonewort has been recorded from two sites in Perth & Kinross and Stirling Districts. The latter site is certainly an error and in the absence of voucher material the former must be considered doubtful, pending confirmation.

Irish distribution

This plant is only known from two sites in north-western Ireland. It was described from Lough Shannagh in northern Donegal, where it was discovered in 1916, and it was found in the nearby Lough Kindrum in 1919. However, it has not been refound at either site since that date, nor at any other site in the world. The possibility that it still persists at its old sites cannot be ruled out.

Total no. of localities	2
1970 onwards	0

International distribution

This species is endemic to Ireland.

Ecology

This poorly known plant grows in clear mesotrophic water in depths of 1-3 metres.

Threats

The effects of water abstraction on the former sites for this species may be a threat, but this needs further investigation. This species may also be vulnerable to water pollution.

Protection

There are currently no known sites for this species.

Conservation

A thorough survey of its former sites is needed to ascertain its present status and to identify any potential threats. This survey should be extended to include the search of several nearby sites. Water pollution at either site should be avoided.

Sources

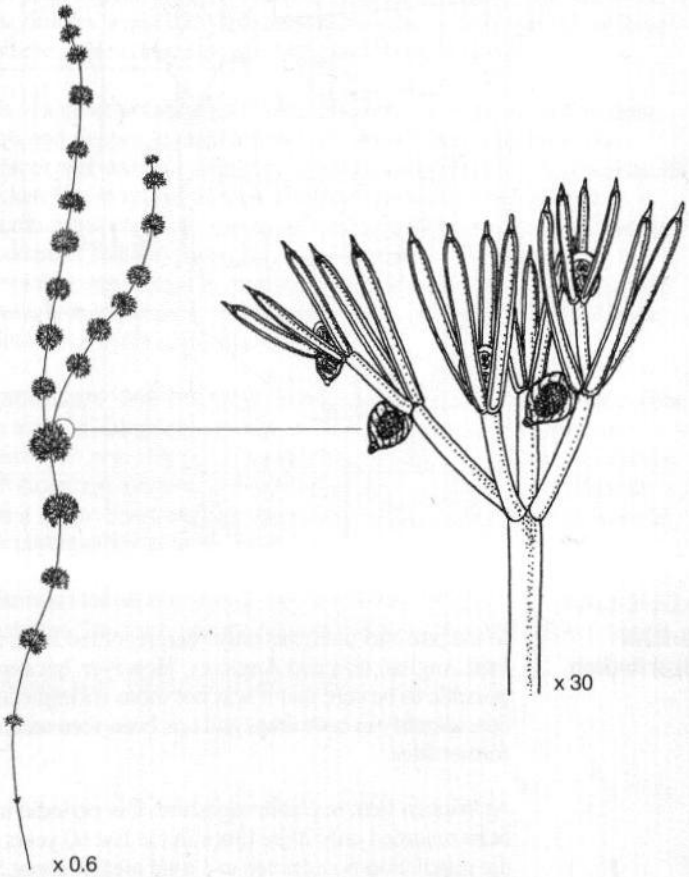
Bullock-Webster, G.R. 1919. A new *Nitella* (*N. spanioclema*). *Irish Naturalist, 28*: 1-3.

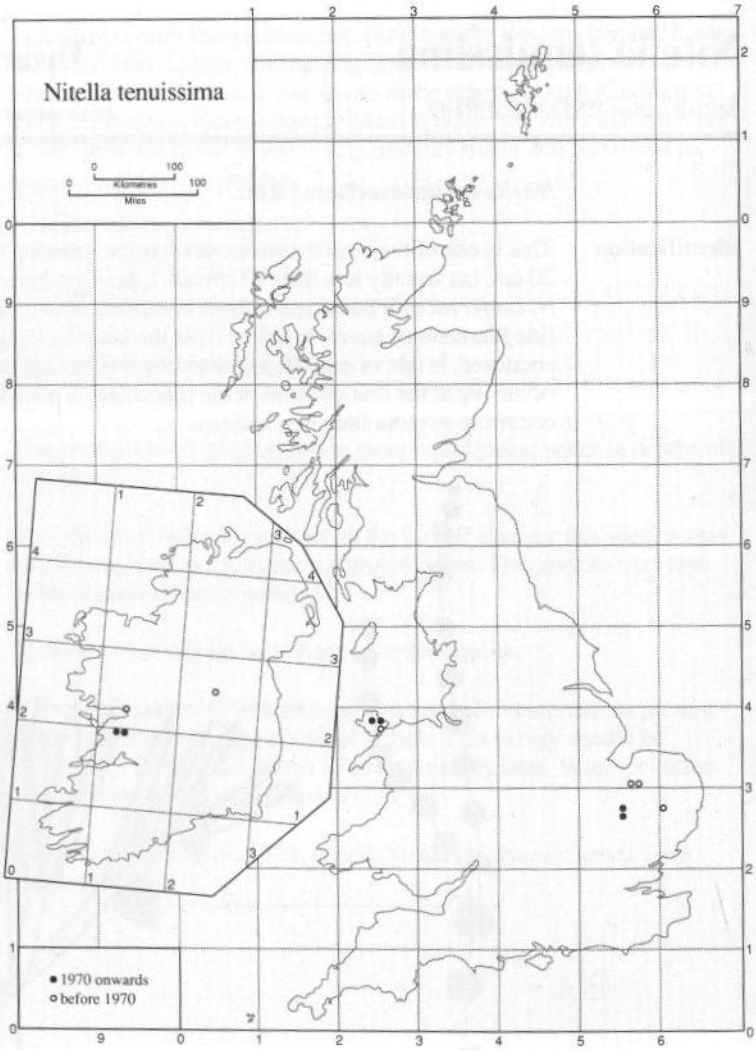
Nitella tenuissima — Dwarf stonewort

British status ENDANGERED — Irish status VULNERABLE

Nitella tenuissima (Desv.) Kütz.

Identification This is one of the smallest stonewort species, growing to a maximum of 20 cm, but usually less than 10 cm tall. Like least stonewort *N. confervacea* it has dense tufts of branchlets strung like small balls on fine filamentous stems. It differs from the latter by being larger, usually encrusted, bright or greyish green and by the fruiting structures never occurring at the first division of the branchlets. It also differs by occurring in more lime rich habitats.





British distribution

In the past this plant has only been recorded from twelve sites in the East Anglian fens and Anglesey. However, because of its size it is not possible to be sure that it was not more widespread. It has decreased considerably in both areas and has been seen recently at only two of its former sites.

At Wicken Fen, in Cambridgeshire, it is periodic in appearance and has been recorded only three times in the last 60 years. In its Anglesey site the population is restricted to a total area of about 500 square metres.

Total no. of localities	12
Up to 1969	12
1970 onwards	2

Irish distribution

This species has been recorded from several places in the south eastern fringe of the Burren, Co. Clare, and may be locally frequent there. It has not been seen for over 50 years in three sites elsewhere in Cos. Galway and Westmeath.

Total no. of localities	6
1970 onwards	2

International distribution

This plant is occasional throughout most of central Europe, but is rare in Scandinavia and the Mediterranean region. It is also recorded from southern Africa, Madagascar, India and North America.

Ecology

This is a plant of calcareous fenland where it occurs in shallow peaty pools and ditches in depths of up to 1 metre. It requires bare peat surfaces and does not compete well with other algae and vegetation. At Wicken Fen in recent years it has only appeared in the summer or autumn following peat-cutting activities, presumably as a result of the exposure of buried spores, but it has soon died out because of competing vegetation. In Anglesey some poaching by cattle may help to maintain openings in the vegetation. It is an annual and clearly the spores can remain viable for decades.

Threats

It has become very restricted, owing to a combination of loss of habitat as a result of drainage, agricultural pollution and the cessation of subsistence peat cutting. The main present day threat is from pollution, both from agriculture and from tourist developments. At the British sites it is also threatened by natural succession. Drainage continues to be a potential threat in the Irish sites.

Protection

In Britain both of the current sites are SSSIs. In addition, Wicken Fen is a National Trust site and the Anglesey site is a Wildlife Trust reserve.

In Ireland both current sites are ASIs.

Conservation All sites for this species should be protected from habitat loss, drainage and pollution wherever possible. At Wicken Fen the plant is dependent on the occasional cutting out of new pools, or clearing out of existing pools. At the Anglesey site, some grazing may be beneficial in keeping the habitat open, but heavier grazing would cause increased pollution and growth of other algae. Where fens still remain at its former sites it is possible that cutting out of pools would re-expose buried spores. This would also probably be beneficial to other stonewort species.

Sources

Walters, S.M. 1958. *Nitella tenuissima*, a rare British charophyte. *Proceedings of the Botanical Society of the British Isles, 3*: 104.

Nitellopsis obtusa

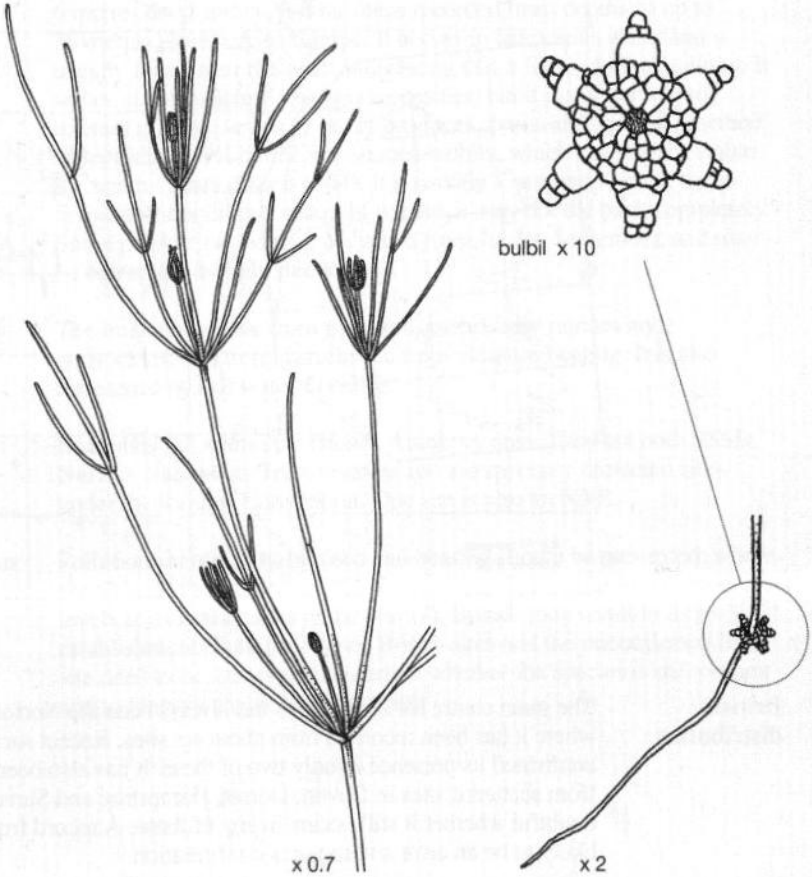
Starry stonewort

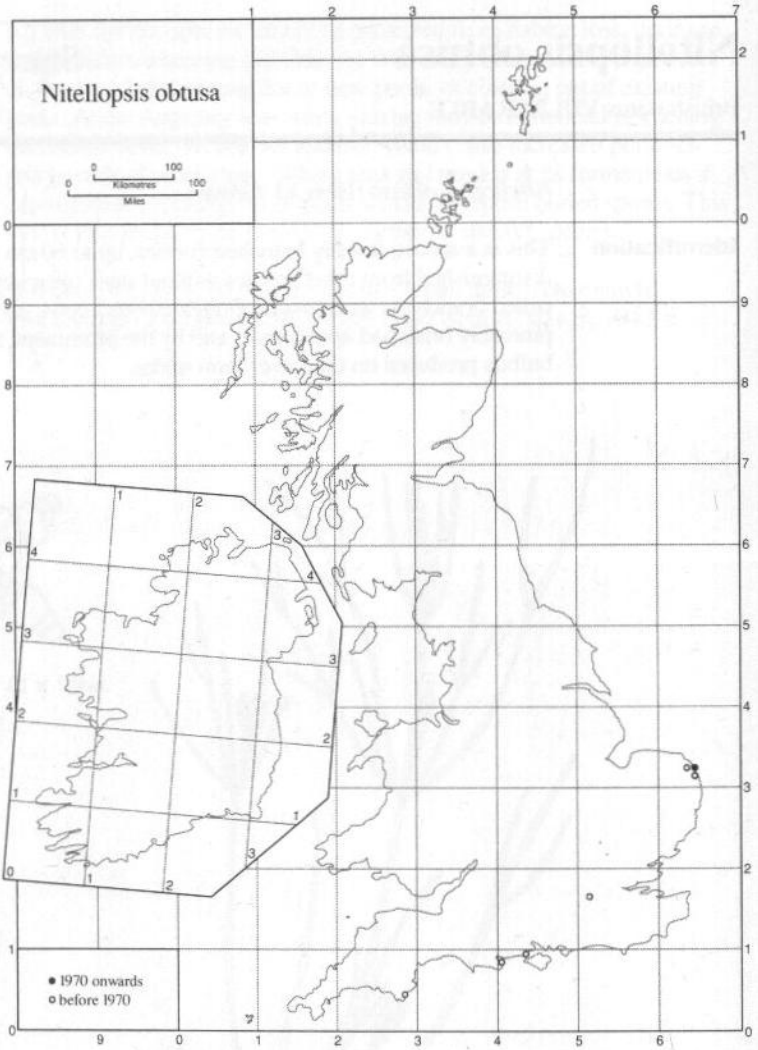
British status VULNERABLE

Irish status —

Nitellopsis obtusa (Desv.) J. Groves

Identification This is a robust, loosely branched species, up to 60 cm tall. It is distinguished from other species without stem cortex by the multi-celled branchlets with several elongated bract cells, giving them a pinnately branched appearance, and by the prominent, star-shaped bulbils produced on the lower stem nodes.





British distribution

The main centre for this species has always been the Norfolk Broads, where it has been recorded from about six sites. Recent surveys have confirmed its presence in only two of these. It has also been recorded from scattered sites in Devon, Dorset, Hampshire and Surrey, but it is doubtful whether it still occurs in any of these. A record from Perth is likely to be an error and requires confirmation.

It is fairly restricted at its only known remaining sites.

Total no. of localities	11
Up to 1969	9
1970 onwards	2

Irish distribution

There is an unconfirmed record from a machair lake at Dooaghtry in Co. Mayo. However, further survey work is required before this species can be accepted as a member of the Irish flora.

International distribution

It is mainly known from Europe where the plant has a scattered distribution, but it is also known from southern Asia and the West Indies.

Ecology

This is a lake species occurring in deep water, generally between 1 and 6 metres deep, although it has been recorded from depths of up to 30 metres elsewhere in Europe. It occurs in calcareous water and is usually found near the coast, suggesting that it likes a hint of salinity. It seems able to tolerate low light intensities, but it is not particularly tolerant of wave action. It rarely produces spores and the main method of reproduction is by the star-shaped bulbils, which can remain viable for several years (Olsen 1944). It is usually a summer annual, but in favourable conditions and mild winters it may not die back completely. Spore production, when it occurs, is from July to September, and may be controlled by light intensity.

Threats

The main threats are from pollution, particularly nitrates and phosphates, and from disturbance from pleasure boating. It is also threatened by salt water flooding.

Protection

Both sites fall within the Broads Authority area. They are both SSSIs, Norfolk Naturalists Trust reserves and are specially protected sites under the Ramsar Convention. One site is also an NNR.

Conservation

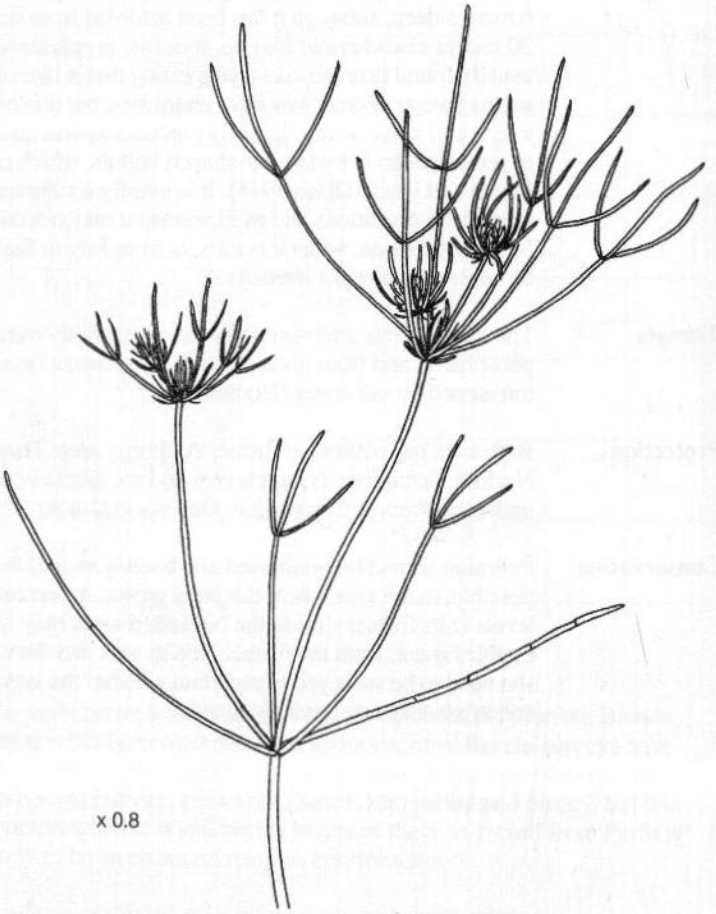
Pollution should be minimised and boating should be prevented, where possible, in the area where the plant grows. A decrease in pollution levels at its former sites in the Norfolk Broads may result in its re-establishment. Both the former British sites and the unconfirmed Irish site need to be surveyed to ascertain whether the species is still present and to identify any potential threats.

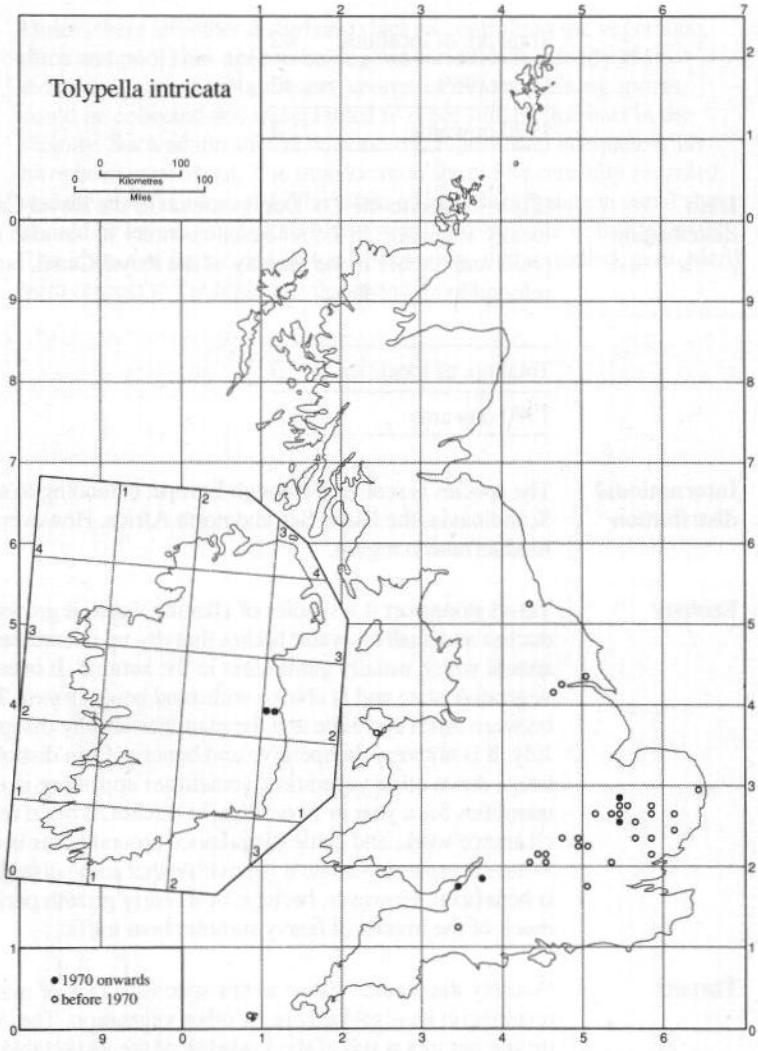
Tolypella intricata — Tassel stonewort

British status VULNERABLE — Irish status VULNERABLE

Tolypella intricata (Trent. ex Roth) Leonh.

Identification This is a delicate, much-branched species up to 40 cm tall, somewhat resembling tangled fishing line. It differs from other species of *Tolypella* by having acute tips to the branchlets and each sterile branchlet having two or three side branches per node. Great tassel stonewort *T. prolifera*, which also has acute-tipped branchlets, is a much larger species with stems up to 2 mm wide.





British distribution

This plant has occurred in widely scattered sites in southern and eastern England, as far west as Somerset and north to Durham. Although it may have been under-recorded in recent years because its presence is obvious only to mid summer, it has certainly declined. It has only been confirmed since 1970 from sites in Avon, Cambridgeshire and Gloucestershire.

It was very restricted in 1989 at the Avon site, where it seemed to be confined to a short stretch of ditch. The state of populations elsewhere is not known.

Total no. of localities	42
Up to 1969	42
1970 onwards	4

Irish distribution

It is restricted to the Co. Dublin stretch of the Royal Canal, where it is locally abundant. In the nineteenth century it was also recorded from pools and ditches in the vicinity of the Royal Canal, but it has not been refound in any of these.

Total no. of localities	3
1970 onwards	1

International distribution

The species is scattered through Europe, extending to southern Scandinavia, the Black Sea and north Africa. However, it is rare in the Mediterranean region.

Ecology

Tassel stonewort is a species of alkaline water. It grows in pools, canals, ditches and shallow water bodies that dry up in summer. It is a winter annual which usually germinates in the autumn. It overwinters in a vegetative state and is able to withstand being frozen. The spores ripen between April and June and the plant has usually disappeared by early July. It is not very competitive and benefits from disturbance which keeps down other vegetation, sometimes appearing in considerable quantities for a year or two. Thus, in ditches, it often reappears after clearance work, and cattle disturbance around pools is often beneficial. Where it grows in canals it is possible that some disturbance from boats is beneficial. However, because of its early growth period, it avoids much of the impact of heavy summer boat traffic.

Threats

Possibly the greatest threat to this species is lack of management, resulting in its displacement by other vegetation. The Avon site is drying out as a result of the lowering of the water table. The Royal Canal site in Co. Dublin is currently undergoing extensive renovation work and this has been of considerable benefit to the plant, but the canal is subjected annually to spraying with herbicide. This may not harm the plants providing that spore production is completed before the sprays are applied, but further research is required.

Protection

In Britain two sites are designated as SSSIs, one of which is also an NNR. The remaining two sites have no designated site protection.

In Ireland the Royal Canal is partially protected as an ASI.

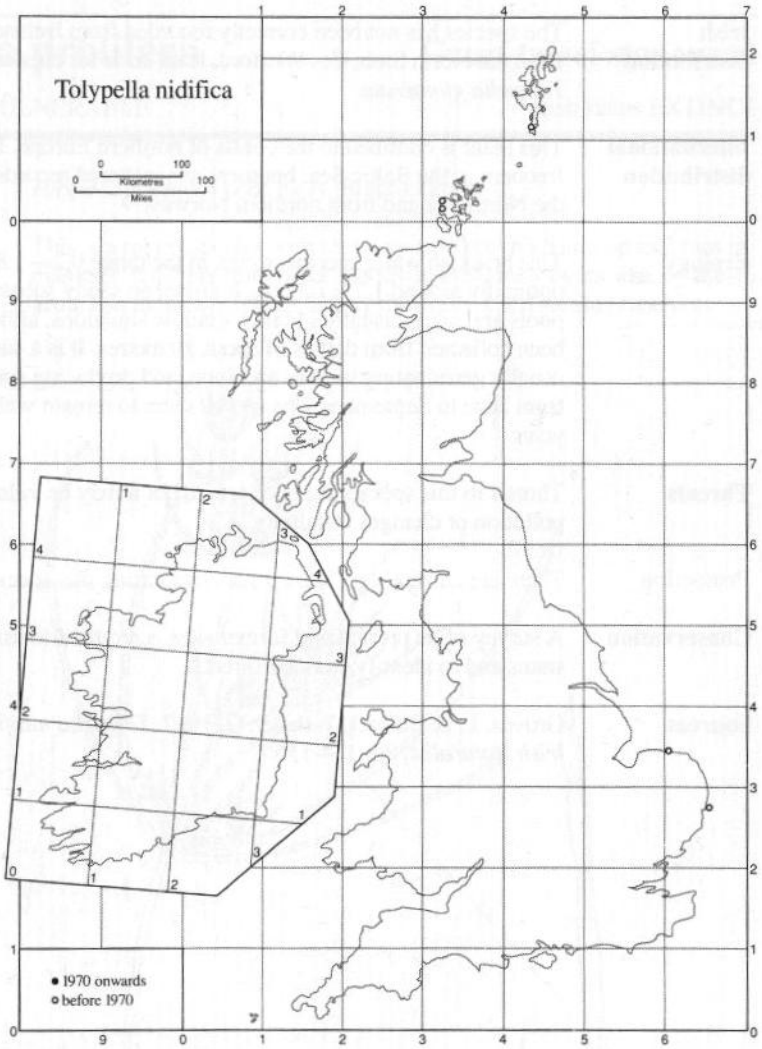
Conservation Unless there are other disturbance factors controlling the vegetation, ditch and pool sites need to be dug out periodically, ideally at least every ten years. As a last resort, spores, or mud containing spores, could be collected and transplanted to other suitable habitats in the vicinity. Such action should be undertaken only after adequate trials have been carried out. The translocation should be carefully recorded and the results monitored. The effect of boat disturbance in canal sites should be investigated to ascertain whether there is an optimum level. The impact of herbicides on the Irish site should be studied, particularly with respect to the timing of the applications.

Tolypella nidifica — Bird's Nest stonewort

British status INDETERMINATE — Irish status —

Tolypella nidifica (O. Müll.) Leonh. formerly known as *Tolypella nidifica* var. *nidifica*.

Identification This is a delicate much-branched species up to 20 cm tall. It differs from other species of *Tolypella* by being little encrusted, dark brownish green in colour, and by having blunt tips to the branchlets. The sexual structures are larger (more than 0.5 mm diameter) than in the closely related clustered stonewort *T. glomerata*, and the spore is reddish, which is rarely the case in the latter species.



British distribution

This plant has been recorded from five coastal sites in Norfolk, Suffolk, Orkney and Shetland. It has not been recorded in any of these sites since the 1920s, but it may still be present in some of the Scottish sites.

Total no. of localities	5
Up to 1969	5
1970 onwards	0

Irish distribution The species has not been correctly recorded from Ireland. The record from the North Slob, Co. Wexford, is an error for clustered stonewort *Tolypella glomerata*.

International distribution This plant is confined to the coasts of northern Europe. It is most frequent in the Baltic Sea, but there are scattered records from around the North Sea and from northern Norway.

Ecology This brackish water species occurs in the range 0.2—1.8% salinity and optimally around 1.5% salinity. It grows on sandy substrates in ditches, pools and lakes, usually in fairly shallow situations, although it has been collected from depths of about 10 metres. It is a summer annual, usually germinating in May and June, and producing spores at any time from June to September. The spores seem to remain viable for many years.

Threats Threats to this species are not known, but it may be vulnerable to pollution or changes in salinity.

Protection There are currently no known sites supporting this species.

Conservation A survey of its present and former sites is required to assess its present status and to identify possible threats.

Sources Groves, J., & Bullock-Webster, G. 1917. *Tolypella nidifica* Leonh. *Irish Naturalist, 26*: 134-135.

Tolypella prolifera

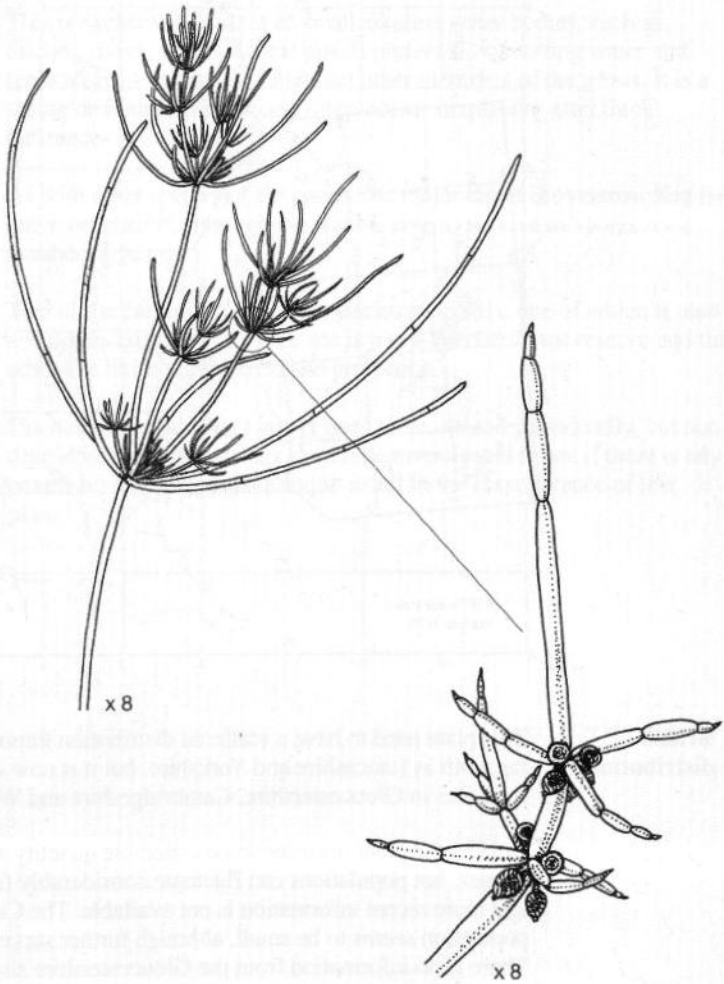
Great tassel stonewort

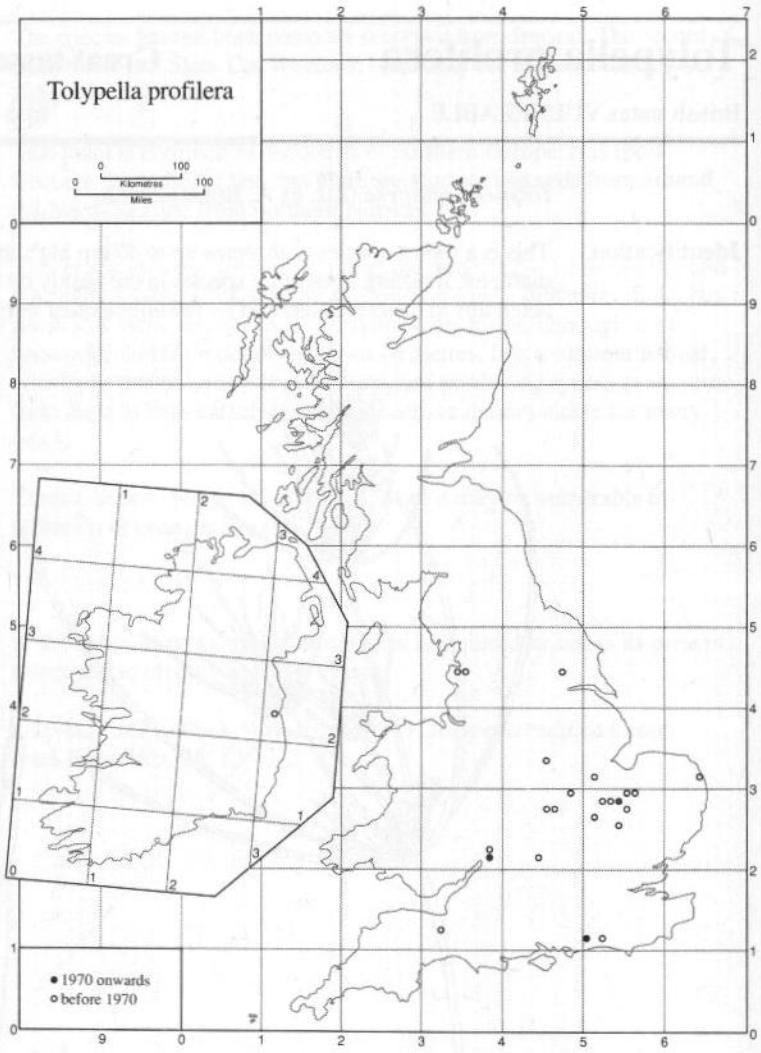
British status VULNERABLE

Irish status EXTINCT

Tolypella prolifera (Ziz. ex A. Braun) Leonh.

Identification This is a robust species with stems up to 40 cm high and up to 2 mm in diameter. It differs from other species in the family by its size, by the acute tips to the branchlets and by the unbranched sterile branchlets.





British distribution

This plant used to have a scattered distribution throughout England, as far north as Lancashire and Yorkshire, but it is now only known from four sites in Gloucestershire, Cambridgeshire and West Sussex.

In 1985 the plant occurred in considerable quantity at the site in West Sussex, but populations can fluctuate considerably from year to year and more recent information is not available. The Cambridgeshire population seems to be small, although further survey work is required. There is no information from the Gloucestershire site.

Total no. of localities	23
Up to 1969	22
1970 onwards	4

Irish distribution This species was recorded from Ireland in the nineteenth century from the Royal Canal, Co. Dublin.

International distribution This plant is scattered throughout central western Europe, reaching its northern limit in England and extending to Poland and northern Italy. It is also recorded from North and South America.

Ecology This is exclusively a plant of small alkaline water bodies, such as ditches, rivers, canals or peat pits. It prefers slow-moving water and tends to grow in deeper water than other members of the genus. It is a spring or summer annual and often occurs in quantity after ditch clearances.

Threats As with other species of the genus, the major threat is overcrowding by other vegetation, although the plant is able to survive as spores for a number of years.

Protection Two of the current sites for this species are SSSIs, one of which is also a Wildlife Trust reserve. One site is just a Wildlife Trust reserve and the other site has no designated site protection.

Conservation Ditches where this plant grows need to be cleared periodically, but not deep-dredged. Former sites should be investigated to see if there is any possibility that digging out might result in the reappearance of this plant.

Appendix A
Species considered for inclusion in the Red Data Book but rejected

There are several species which appear to qualify for Red Data Book status because of the low number of records or apparent decrease, but which have been excluded.

Chara aspera Deth. ex Willd. Rough stonewort

This species seems to have declined considerably in Britain, particularly in the east, but there are still very good populations in the machair lochs of the Hebrides and Orkney, and in several places elsewhere. It is not, therefore, considered to be under immediate threat. It is frequent in Ireland.

Chara braunii Gmelin Braun's stonewort

It is generally agreed that this plant occurred as an introduction, having been accidentally brought into Britain with Egyptian cotton. This species once occurred in the Reddish Canal in Greater Manchester, where it grew in places where the water was maintained at a high temperature (*c.* 17 to 28°C) by discharges from adjacent cotton mills. However, the occurrence of the plant in Scandinavia suggests that high temperature is not directly necessary for the plant. All the original locations for this species have now been infilled and there is little doubt that the plant is extinct in Britain.

Chara pedunculata Kutz. Hedgehog stonewort

This plant is scarce and declining in Britain, and it was initially considered to be a threatened species. Several good populations have, however, been rediscovered in the last few years and it is known from around 20 sites. A significant proportion of these sites are nature reserves or have other nature conservation designations and it may still persist in a few other sites. However, it is certainly a scarce species which is vulnerable to pollution and the state of its populations should be monitored. It is fairly widespread in Ireland, particularly in the limestone areas.

Nitella confervacea (Bréb.) A. Braun ex Leonh. Least stonewort

This is the smallest species of stonewort that occurs in Britain and Ireland. It grows in clear acid to neutral lakes, in depths of up to 5 metres. It is often associated with the slender naiad *Najas flexilis* and like that species it has a predominantly western distribution in both Britain and Ireland. It has been recorded from a total of eleven sites in Ireland and seven in Britain, but because of its size it is likely that it has been overlooked elsewhere. Nevertheless, it is probably a scarce species in both countries.

Tolypella glomerata (Desv.) Leonh. Clustered stonewort

Records for this species have significantly decreased in Britain. Although its status may have changed, the plant is probably under-recorded because it is obvious only for a short time in early summer. In Ireland it is probably frequent, but it is badly under-recorded.

Appendix B
Key to the identification of stoneworts

Introduction

Many stoneworts are extremely variable in their characters, and it is foolhardy to believe that determinations can reliably be made without microscopic examination – some specimens are not easy to identify even with a microscope. Nevertheless, in the majority of cases it is possible to make some headway using field characters alone, and it is hoped that this key will help beginners to get to know the appearance of the different taxa in the field. However, it is only intended as a rough guide and determinations need to be confirmed by microscopic examination and the use of handbooks such as Moore (1986). This is particularly the case when attempting to separate the different varieties.

Glossary

Antheridium	Globular, usually orange, male sexual organ, produced at the branchlet-nodes.
Bracts	Single cells arising in whorls at the branchlet-nodes. NB For the purpose of this key the bracteoles, which are the cells arising immediately below the oogonium, are not differentiated.
Branchlet	One of the branches arising in whorls around the stem, on which the fruiting structures are produced.
Cortex	The rows of thin cells running up and down the stem and branchlets of *Chara* giving the plant a superficial resemblance to a horsetail (*Equisetum*) stem. These rows are divided into primary and secondary rows as discussed below.
Gametangia	The male and female organs.
Mucronate	Terminating abruptly in a small sharp point.
Node	On the stems, the point from which the whorls of branches arise; on the branchlets, the point from which the whorls of bracts and the gametangia arise.
Oogonium	The ovoid female sexual organ, comprising an opaque, usually green (when immature), brown or black oospore, covered with ± clear spirally arranged cells.
Oospore	The 'fruit' within the oogonium.

Patent	Standing out at right angles.
Rhizoid	Pale root-like structure buried in the substrate and anchoring the plant to it. Normally thinner than the stem and lacking any cortical cells.
Spine	A single-celled protuberance on the stem.
Stipulode	One of the cells arising from the lower side of each stem node below the branchlets, arranged in one or two rings.

Characters of stonewort genera

Stoneworts have characteristic and peculiar sex organs. The male sex organ (antheridium) is spherical and made up of eight nearly triangular plates, which are often orange in colour. The female organ (oogonium) consists of a single-celled egg-cell surrounded and enclosed by five spirally arranged elongated cells.

Primary and secondary cortex

An important microscopic character in the genus *Chara* is the number of vertical rows of cortical cells on the stem, which are a multiple (between one and three) of the number of branchlets. Rather than counting all the way round the stem, it is easier to identify the number of secondary rows of cells between each primary line, since the latter are always equal in number to the branches. The primary rows can usually be identified by (a) the spine cells which are restricted to the primary rows and (b) the frequently different thickness relative to the secondary rows. These characters are most easily observed on the stretch of stem below a node on the younger and less encrusted parts of the plant. However, several bits of stem should be examined because in some species the secondary cells meet obliquely so that there is partial overlap to give the impression of an extra line of cortical cells.

Differentiating between monoecious and dioecious species of *Chara*

Dioecious species can be distinguished from monoecious plants that are at a stage when only one type of sexual organ is present by: (a) in male dioecious plants the antheridia are placed centrally on the branchlet node and nestling among the bracts and bracteoles, whereas in monoecious plants they are set below the branchlet node as though in anticipation of the development of the oogonia; (b) in female dioecious plants there is an additional bract-like cell (called a bractlet) set centrally below the oogonia, in place of the antheridia on monoecious species.

In Britain and Ireland there are five genera:

Chara

Nearly all the species in this genus are characterised by the presence of stem cortex, often with spines. The branchlets are unbranched in all species and are arranged in regular whorls around the stem. The bracts occur in whorls on each branchlet and below each whorl of branchlets there are one or two rings of stipulodes (see *Chara baltica*, p. 53).

Lamprothamnium

This genus has branching similar to that of *Chara* but the stem cortex is absent and there is only one ring of stipulodes below each whorl of branchlets. In the single British and Irish species, the ends of the stem are contracted like bushy fox-tails.

Nitella

The stem cortex, spines, stipulodes and bracts are all absent in this genus. The branchlets are furcately (like tuning-forks) branched, although in *N. translucens* the branches are very short, so that they appear unbranched at first glance.

Nitellopsis

In this genus, the stem cortex, spines and stipulodes are absent but there are several elongated bracts on most branchlets. In the only British and Irish species, characteristic whitish, star-shaped bulbils are produced on the lower stem nodes.

Tolypella

Stem cortex, spines, stipulodes and bracts are absent in this genus. The branchlets in each whorl are of two types: short fertile branchlets, which are strongly incurved to form balls like birds' nests, and multi-celled sterile branchlets. The fertile branchlets, and sometimes the sterile branchlets, have simple lateral branches (see *Tolypella prolifera*, p. 117).

Short-cut key for common species

This key probably covers approximately 95% of plants encountered.

A Stem corticate, often spiny — B
Stem without cortex — G
(See note under dichotomy 1 of the main key on p.128)

B Spines and stipulodes well developed and acute or, if obtuse, in groups of two or more (though spines often deciduous on older parts of the stem) — C
Spines, and usually stipulodes, either rudimentary or obtuse and single — E

C Stem slender, less than 0.75 mm wide and usually less than 0.5 mm wide, up to 30 cm tall; small whitish spherical bulbils often present among rhizoids; dioecious

Chara aspera* and *C. curta (see 10)

Stem moderate to robust 0.75-3 mm wide and up to 90 cm tall; whitish bulbils absent; monoecious — D

D Stem moderately spiny, appearing rough; spine clusters wider apart than half the spine length, except on the youngest parts of the stem; spines deciduous and often absent from older parts of the stem; branchlets usually long, up to 8 cm; outer bracts less than half the length of the inner ones

Chara hispida* and *Chara rudis (see 12)

Stem densely spiny, appearing prickly or furry; spine clusters closer together than half the spine length throughout the stem, and often obscuring the stem branchlets; branchlets short, usually less than 3 cm; outer bracts more than half the length of the inner ones

Chara pedunculata (see 13)

E Stem slender, usually less than 0.5 mm wide; spines present as minute raised bumps; only the upper set of stipulodes developed, shortly conical; plant mid to dark green, often little encrusted

Chara virgata (see 3)

Not as above — F

F Stipulodes rudimentary, or minutely globular; spines rudimentary; bracts short, less than 3 mm; plant often fairly slender

Chara globularis **(see 6)**

Both sets of stipulodes developed, blunt, longer than broad; spines rudimentary or variously developed (often best developed on the youngest internodes); bracts short or long; plant often of moderate stature

Chara vulgaris **and** ***Chara contraria*** (see 19)

(NB This can be difficult in the field if spines are absent; even in *C. vulgaris* the stipulodes are small and not very easy to see unless the plant is relatively unencrusted)

G Plant moderately to very encrusted and brittle, brownish or greyish green; branchlets of two types – short fertile branchlets contracted into tight untidy balls, and long simple multi-celled sterile branchlets

Tolypella glomerata (see 25)

Not as above; if fertile branchlets somewhat contracted, then sterile branchlets either simple and single-celled or furcately branched; usually unencrusted or with alternating encrusted and unencrusted rings H

H Branchlets apparently simple, but many with a minute tuft of 1-3 celled branches at the ends, visible under a hand-lens; plant translucent, ± yellowish-green

Nitella translucens (see 28)

Many branchlets conspicuously forked; plant mid to dark green or black I

I Ultimate segments of branchlets single-celled

Nitella flexilis (see 31)

Ultimate segments of branchlets 2-3 celled, at least one cell well-developed, but the apical 1-2 cells often minute

Nitella mucronata (see 34)

(See note under dichotomy 29 of the main key)

Main Key

1 Stem corticate, often spiny — 2 (***Chara***)

Stem without cortex, or with only some residual cortical cells at the nodes, never spiny — 20

(NB Even when the cortical cells are so fine that they are difficult to see, the extra layer of cells makes the stem more or less opaque, whereas the stems of non-corticate species have a translucent green bottle-glass appearance even when moderately encrusted.)

2 Spines rudimentary or present as minute raised bumps — 3

Spines well developed, at least on the youngest parts of the plant, longer than broad — 7

(NB Spines are often easily broken off, and it is best to look at the younger sections of stem. Do not be confused by bits of filamentous algae which are normally much finer than spines.)

3 Stem slender, usually less than 0.5 mm wide; spines present as minute raised bumps; only the upper set of stipulodes developed, shortly conical (very rarely almost as long as the stem width); plant mid to dark green, often little encrusted

Chara virgata

Not as above — 4

(NB Small tufted bushy plants of *C. virgata* growing on wind-exposed lake margins are often referred to as var. *annulata*. This taxon is up to 12 cm tall, has short internodes and stiff upwardly curved branchlets. Intermediates often occur in less exposed situations.)

4 Stipulodes rudimentary, or minutely globular; spines rudimentary; bracts short, less than 3 mm; plant often fairly slender — 5

Both sets of stipulodes developed, blunt, longer than broad; spines rudimentary or slightly developed (often best developed on the youngest internodes); bracts short or long; plant often of moderate stature

19 (***Chara vulgaris* group**)

(NB This can be a difficult split in the field; even in *C. vulgaris* group the stipulodes are small and not very easy to see unless the plant is relatively unencrusted)

5 Conspicuous whitish bulbils up to 4 mm in diameter produced on the rhizoids and lower stems; bulbils multicellular and irregularly spherical (considered by some to resemble miniature strawberries); plant dioecious, usually unencrusted; branchlets relatively long (rarely less than half the internode length and often exceeding it), slender, flexuous, with 9-15 segments (rare, Cornwall)

Chara fragifera (p. 69)

Whitish bulbils absent; plant monoecious or dioecious, often encrusted; branchlets usually stouter and more rigid, with 8-11 segments 6

6 Plant dioecious, slender (stem < 0.5 mm wide), light or yellowish green, usually lightly encrusted, but brittle; internodes, except the youngest, long, mostly 2-5 times the branchlet length; branchlets, especially of the male plant, upswept or incurved, straightening on the older parts of the plant (rare)

Chara connivens (p. 60)

Plant monoecious, slender to moderately sized, green (rarely light green), often encrusted; internodes short, mostly 1-3 times the branchlet length; branchlets incurved, straight or recurved (very common)

Chara globularis

(NB Because of the great variation in *C. globularis*, it is only really possible to identify *C. connivens* with certainty when sexual structures are present. However, the vegetative characters given above for the latter species will rule out many common forms of the former. *C. connivens* also seems to have a more acrid smell.)

7 Bracts and ends of branchlets inflated; plant usually salmon- pinkish, very heavily encrusted and brittle, somewhat cord-like in appearance

Chara tomentosa (p. 81)

Bracts and ends of branchlets slender 8

8 Spines in clusters of 2 or more 9

Spines single, or occasionally with some in pairs 14

(NB Single spines are usually patent or inclined parallel to the stem and pointing towards the centre of each internode; when in clusters, some of the spines are normally at an angle to the line of the stem, except in *Chara rudis* where the two spines in each pair point in opposite directions along the line of the stem – see 12)

9 Plant fairly slender; main stem less than 0.75 mm wide (and usually less than 0.50 mm wide); lines of cortical cells thin and usually difficult to see with a hand-lens; unencrusted young shoots pale or yellowish green; plant dioecious; small spherical whitish bulbils often present among the rhizoids

10 (***Chara aspera* group**)

Plant fairly to very robust; main stem more than 0.75 mm wide (and usually more than 1 mm wide); lines of cortical cells usually easily visible with a hand-lens, though sometimes hidden by dense spines; unencrusted young shoots green; plant monoecious or (*C. canescens* only) dioecious 11

10 Spines mostly solitary (occasionally up to 3 in a cluster), though this is often difficult to determine under a hand lens; stem slender, rather prickly, often reminiscent of fraying thread; spines all ± similar in length, often deciduous on the older parts of the stem

Chara aspera

Spines mostly 3-4 (but varying between 1 and 6) in each cluster; stem stout and stiff, densely spiny, often ± tufted and furry or bristly in appearance; spines usually fairly persistent, some in each cluster often very short

Chara curta (p. 63)

(NB There can be some overlap in the appearance of these two species, and the number of spines should be checked under a microscope; in *C. curta* some spines are often so poorly developed that they are difficult to discern even with a microscope.)

11 Stem moderately spiny, appearing rough-hispid; spine clusters wider apart than half the spine length, except on the youngest parts of the stem; spines deciduous and often absent from older parts of the stem; branchlets usually long, up to 8 cm, often rather stiff and brittle; internodes usually less than 2.5 times the length of the branchlet length; bracts ± tapered, the outer less than half the length of the inner; stem cortex often with a marked spiral twist

12 (***Chara hispida* group**)

Stem densely spiny, appearing prickly or furry; spine clusters closer together than half the spine length throughout stem, and often completely obscuring the stem; spines fairly persistent; branchlets short, usually less than 3 cm; internodes up to 5 times the branchlet length; bracts parallel-sided, the outer more than half the length of the inner; stem cortex usually ± straight 13

(NB Difficulties may be encountered with young plants of *C. hispida* and *C. pedunculata*. In these situations spine persistence, relative length of the outer bracts, and the spiral twist of the cortex may be most helpful, but it may be difficult to reach a conclusion without microscopic examination.)

12 Spines mostly in pairs or threes, appressed to the stem and pointing in opposite directions along the stem (though the density of spines on the youngest internodes frequently distorts this arrangement), rather blunt, obtuse to broadly acute; spines usually emerging from furrows between the much larger secondary cortical cells; often rather grey in appearance

Chara rudis (p. 78)

Spines in clusters of 2-4, patent or inclined, if in pairs then usually side by side, ± acute to subacute; secondary cortical cells only slightly larger than the primary ones

Chara hispida

(NB *Chara hispida* is divided primarily by size into var. *hispida* and var. *major*; var. *hispida* is moderate in size with the main stem up to 30 cm tall by 1.5 mm wide and has slender spines in clusters of 2 or 3. It is typically a plant of shallow pools and ditches. Var. *major* is robust with the main stem up to 90 cm tall by 3 mm wide and has coarser spines in clusters of 2 to 4. It is usually found in deeper water. Rare forms of *Chara baltica* and *C. intermedia* with spines in clusters may also key out here. The characters given in 18 will help to differentiate them from *C. hispida*.)

13 Internodes ± equal for most of stem but decreasing above about the fourth from last internode; outer bracts slightly shorter than the inner; monoecious; unencrusted young shoots dark green but plant frequently heavily encrusted and greenish or brownish grey; brackish or fresh water

Chara pedunculata

Internodes gradually decreasing throughout stem; all bracts at each node equal; dioecious; plant often unencrusted to moderately so, light yellow green when unencrusted, sometimes with orange tints; usually in brackish water

Chara canescens (p. 56)

(NB *Chara curta* may sometimes key out here. It has ± equal internodes, is dioecious, and is normally more slender than either of the above.)

14 Plant tufted, up to 8 cm, moss-like; spines and stipulodes stout, obtuse to subacute 15

Plant larger, or if small and tufted then spines and stipulodes slender, very acute 16

15 Plant light green, dioecious; small whitish bulbils usually present among the rhizoids

Chara aspera

Plant dark green, monoecious; small whitish bulbils absent; (very rare)

Chara muscosa (p. 75)

16 Spines acute; outer bracts well developed, acute 17

Spines obtuse; outer bracts rudimentary, globular, or rarely slightly more developed and obtuse

19 (***Chara vulgaris* group**)

17 Plant slender; main stems less than 0.75 mm in diameter (and usually less than 0.50 mm); dioecious; simple single-celled spherical whitish bulbils often produced on the rhizoids

Chara aspera

Plant moderately to very robust; main stems more than 0.75 mm in diameter (and usually more than 1 mm); monoecious; bulbils, if present, made up of many cells 18

18 Plant dark green, little encrusted; spine length more than 0.75 stem width; compound bulbils made up of numerous spherical cells, frequently produced on the rhizoids and underground stems; (rare)

Chara baltica (p. 53)

Plant mid green, usually with a pinkish or brownish tinge, much encrusted; spine length less than half stem width; bulbils absent; (rare)

Chara intermedia (p. 72)

(NB *Chara hispida* can rarely appear to have single spines. Under a microscope, such plants will normally be found to have undeveloped cells at the base of the developed spines. It also differs under a microscope, by having the secondary cortical cells larger than the primary ones.)

19 Spines, if developed, spreading, patent or inclined; plant usually fairly slender; ripe oospores black; upper and lower sets of stipulodes often of unequal size and rather untidy, the upper set larger and somewhat pointed

Chara contraria

Spines, if developed, ± appressed to stem; plant variable in size; ripe oospore brown; both sets of stipulodes usually ± equal, obtuse and forming ± regular rows

Chara vulgaris

(NB This is a difficult split and, although some characters are given above, in many cases it is probably not possible to separate these two species in the field.

Plants of *C. contraria* with spines longer than the width of the stem are often separated as var. *hispidula*. This variety also has longer stipulodes and bracts.

C. vulgaris has been divided into numerous varieties, but there is more or less continuous variation between them. The more widely recognised varieties are; var. *longibracteata*, with very long bract cells (3-7 mm long), short or rudimentary spines, and elongated branchlet segments, of which the last two or three are non-corticate and often form whip-like ends; var. *papillata*, which has long spines (longer than stem width), rather long bracts, and an irregular cortex of which the secondary rows are much more prominent than the primary rows; var. *refracta*, a neat plant with short, patent or somewhat downwardly curved branchlets, and short spines and bracts; var. *crassicaulis*, which has long internodes and short, stout, often incurved branchlets, with short, thick, rounded spines and very obtuse stipulodes; var. *gymnophylla* with branchlets without any cortical cells, or sometimes with cortex only on the bottom one or two branchlet segments.)

20 Stipulodes well-developed; branchlets ± equal (*Chara*-like) 21

Stipulodes absent; branchlets variable 23

21 Ends of stems contracted, like bushy fox-tails; all bracts in each whorl ± equal

Lamprothamnium papulosum (p. 84)

Ends of stems not contracted; outer bracts markedly smaller than inner ones

22 (***Chara***)

22 Stipulodes slender or inflated, in one series only

Chara braunii

Stipulodes globular, both series developed

Chara denudata (p. 66)

23 Robust (main stem >0.75 mm wide), straggling, laxly branched; branchlets ± straight, to 15 cm long, comprising 2-3 long cells, simple or with 1 or 2 long bracts; characteristic large star-shaped bulbils produced on the lower stem nodes

Nitellopsis obtusa (p. 107)

Not as above; large star-shaped bulbils absent 24

24 Branchlets of two types; fertile branchlets short, forming dense, untidy, ± spherical heads; sterile branchlets much longer, multi- celled, simple or with a few lateral branches; plants often appearing rather untidy and tangled

25 (***Tolypella***)

Not as above; if fertile branches ± contracted, then sterile branchlets simple or furcately branched; segments of branchlets between each fork single-celled, ultimate segments 1-3 celled

28 (***Nitella***)

25 Ultimate segments of branchlets obtuse 26

Ultimate segments of branchlets acute 27

26 Plants usually lightly encrusted, brownish-green, not brittle; end cells of fertile branchlets often short, and narrower than the rest of the branchlet; gametangia more than 0.50 mm diameter; oogonium subspherical; oospore wine-red when mature; brackish water

Tolypella nidifica (p. 114)

Plants usually heavily encrusted, greyish- or brownish-green, often brittle; end cells of fertile branchlets usually longer, and ± the same width as the rest of the branchlet; gametangia less than 0.50 mm diameter; oogonium ovoid; oospore orange, dull brown, or rarely reddish-brown; brackish or fresh water

Tolypella glomerata

27 Branchlets of sterile whorls with one or two lateral branches; stems up to 1 mm in diameter

Tolypella intricata (p. 110)

Branchlets of sterile whorls not branched; main stems 1-3 mm in diameter

Tolypella prolifera (p. 117)

28 Branchlets apparently simple, but many with a minute tuft of 1-3 celled branches at the end, visible under a hand-lens, rarely with the occasional branchlet conspicuously forked; plant fairly robust, clear ± yellowish-green, typically stiff and fairly untidy with the main stem often bent at the nodes, and the branchlets often very unequal

Nitella translucens

Many branchlets conspicuously forked 29

29 Ultimate segments of branchlets one celled 30

Ultimate segments of branchlets 2-3 celled, at least one cell well-developed, but the apical 1-2 cells often minute 32

(NB In typical *Nitella mucronata* the minute apical cell itself forms a mucronate apex to the ends of the branchlets; in *Nitella flexilis* the mucronate branchlet apex is composed of solid cell-wall tissue. It can be difficult to differentiate between these two features under a hand-lens, though frequently in *Nitella mucronata* some apical cells are broken off leaving a small truncate area where they were attached.)

30 Plant light green; gametangia in small dense heads enveloped in mucus; dioecious; spores produced May-July, the plant dying back soon after; (extinct)

Nitella capillaris

Plant olive-, brownish-, mid or dark green to black; gametangia without mucus; monoecious or dioecious; spores produced May-August, the plant being annual or perennial 31

31 Branching reduced, the branchlets very short, 2-3 in each whorl; (rare)

Nitella spanioclema (p. 100)

Branching and branchlets well-developed, or if reduced then infertile, often rather blackened (deep water forms); branchlets 6-8 in each whorl

Nitella flexilis

32 Branchlets numerous (often *c.* 24 at each node), differentiated into a primary whorl, and two shorter accessory whorls, giving the appearance of double-layered umbels; a medium-sized plant, about 15-30 cm high

Nitella hyalina (p. 94)

Not as above; branchlets 5-9 at each node, all of similar length 33

33 Stem very slender, hair-thin; plant up to 20 cm tall, delicate and finely branched 34

Stem more robust, up to 0.75 mm wide; plant up to 30 cm tall, fairly robust and bushy

Nitella mucronata (p. 97)

(NB *Nitella mucronata* is often divided into two varieties: in var. *mucronata* the ultimate segments of branchlets are mostly 2-celled, the end cell being very small and forming a mucronate tip to the branchlet; in var. *gracillima* the ultimate segments of branchlets are frequently 3-celled and are tapered to an acute tip.)

34 Many ultimate segments of branchlets 3-celled; branchlets forming feathery umbels; internodes 1-3 times branchlet length

Nitella gracilis (p. 91)

All ultimate segments of branchlets 2-celled; branchlets in loose or compact ± spherical balls separated by long internodes 2-5 times the branchlet length 35

35 Plants very small, usually not more than 5 cm; very delicate, mid to dark green; rarely encrusted

Nitella confervacea

Plants up to 20 cm, bright or greyish-green; often encrusted

Nitella tenuissima (p. 103)

(NB *N. confervacea* is very likely to be overlooked unless it is being deliberately searched for. It has the appearance of little furry balls about 2 mm in diameter strung together on a filamentous stem, rather like the little balls of fluff that appear on a sweater. It should be looked for in clear mesotrophic or slightly oligotrophic lakes where it occurs at depths of about a metre or more (often with *Najas flexilis*).

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Species index

Note: numbers in **bold** indicate a data sheet for that species.

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