

# Stoneworts

Naturally Scottish



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## Scottish Natural Heritage Dualchas Nàdair na h-Alba

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Nàdair air fad airson Alba air fad

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Front cover image:  
Foxtail stonewort.  
Frontispiece:  
Bird's nest stonewort.  
Back cover image:  
Chara stonewort.

**Stoneworts**  
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1

1  
Stonewort.

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## What are stoneworts?

Stoneworts, or charophytes as they are sometimes known, are a unique form of algae. They have a very complex structure that bears more resemblance to many underwater higher plants than it does to the filamentous blanketweeds and other simpler algae. They are often treated as honorary higher plants and, as a result, much more is known about their ecology and distribution than most other freshwater algae.

There are five main stoneworts in Scotland – *Chara*, *Tolypella*, *Nitella*, *Lamprothamnium* and *Nitellopsis*. They vary in size from a few centimetres to over a metre tall and they have a characteristic appearance with whorls of linear 'leaves' along the stem – rather like underwater horsetails. Indeed, with the horsetails, the earliest botanists classified them in the genus *Equisetum*.

Many species produce a crust of calcium carbonate over the surface of the plant. This is a by-product of photosynthesis and gives the plant a crunchy feel to the touch. It is also the origin of the name 'stonewort'.

The reproductive structures show their relationship to the algae, but these too are remarkably complex. The male structures (antheridia) are small (0.5 mm) balls made up of eight orange shield-like plates. The female structure is called an oogonium and grows out from where the branches join the stem. The spores are surrounded by a protective coat of spiral cells. Protected spores are unusual among the algae and this is one of the characters which suggests that stoneworts are on an evolutionary line between the algae and the vascular plants. These spores are extremely durable and can be found as fossils from a considerable geological period, with the earliest stonewort-like plants occurring in the Silurian period, around 400 million years ago.

There are about 400 species of stoneworts worldwide, 30 of which are native to Britain. Scotland has 22 species of these and seven have their main British strongholds in Scotland.

1  
*Chara hispida* var *major* and pondweed,  
Loch Ollay, South Uist.

## Why are they important?

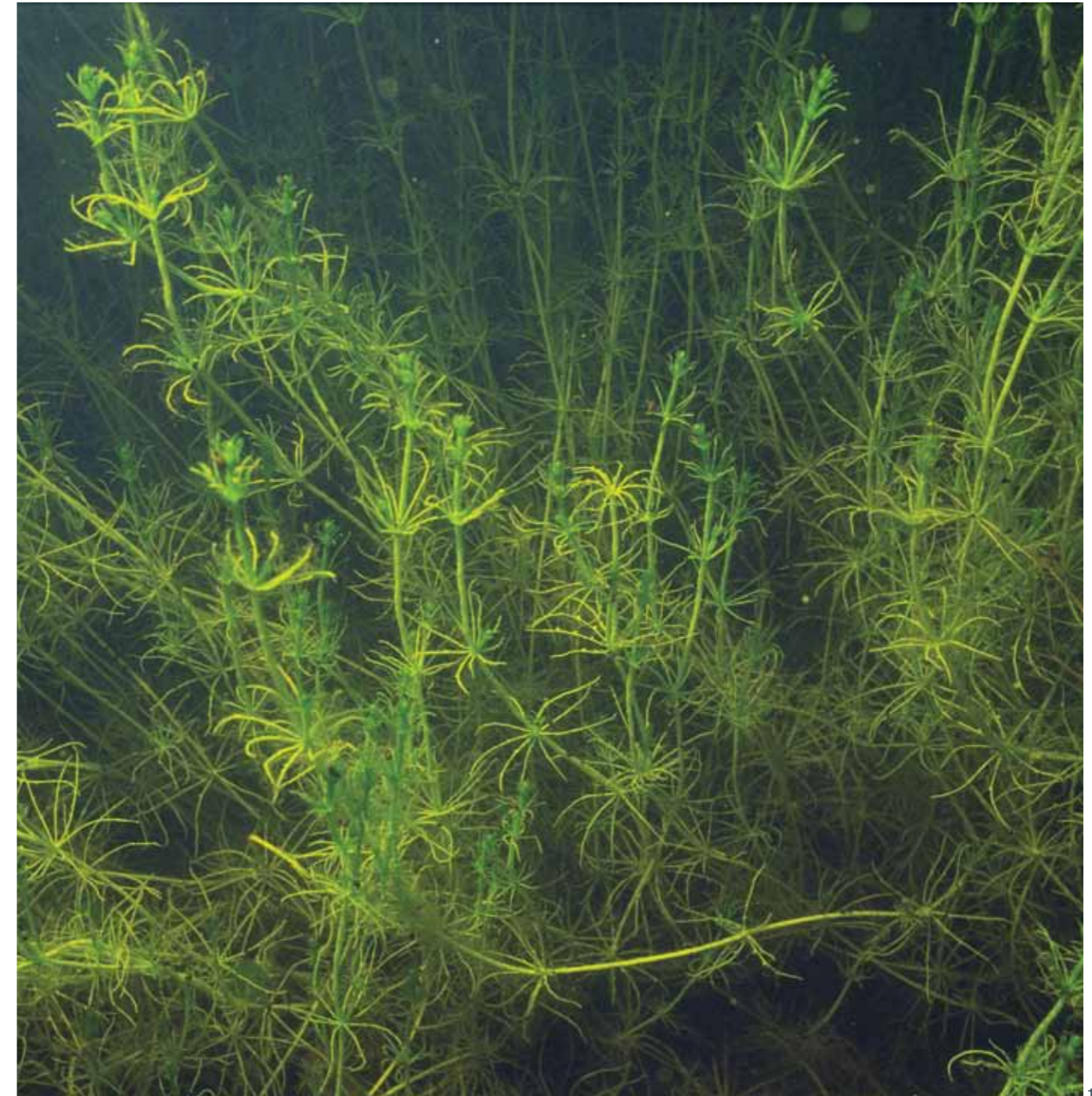
Stoneworts absorb most of their nutrients through the surface of the plants rather than through a root system. This makes them particularly vulnerable to the quality of the water around them. They are therefore good indicators of water quality, particularly in connection with nutrient pollution from nitrates and phosphates.

They can also help to provide clear water. Stonewort beds are extremely dense, and sometimes the biomass per unit area can be 10 times that of an equivalent flowering plant bed. This helps to stabilise the loch bed but also absorbs nutrients from the water that could be used by algal blooms. Stoneworts are also thought to produce compounds that inhibit small algae.

Where they occur, stoneworts are often an important part of the aquatic ecosystem. Their dense structure provides shelter from predators for small invertebrates and fish, and the lime encrustation is a source of calcium carbonate for molluscs and other shell-bearing animals. The plants themselves are also an important food source for wildfowl such as pochard, as well as for coots and swans.

In strongly calcareous sites the encrusting lime contributes to the build-up of marl at the bottoms of lakes. In some places this has been used for agricultural fertiliser.

In the past, stoneworts had another scientific use. Many species have very large cells and the largest closed plant cells known occur among the stoneworts. Some cells of translucent stonewort *Nitella translucens*, for example, frequently reach 20cm in length and 3mm in diameter. These cells are useful for observing how plant cells work, and cyclosis, the rotation of cell contents within the cell, was first observed in a stonewort in 1774.



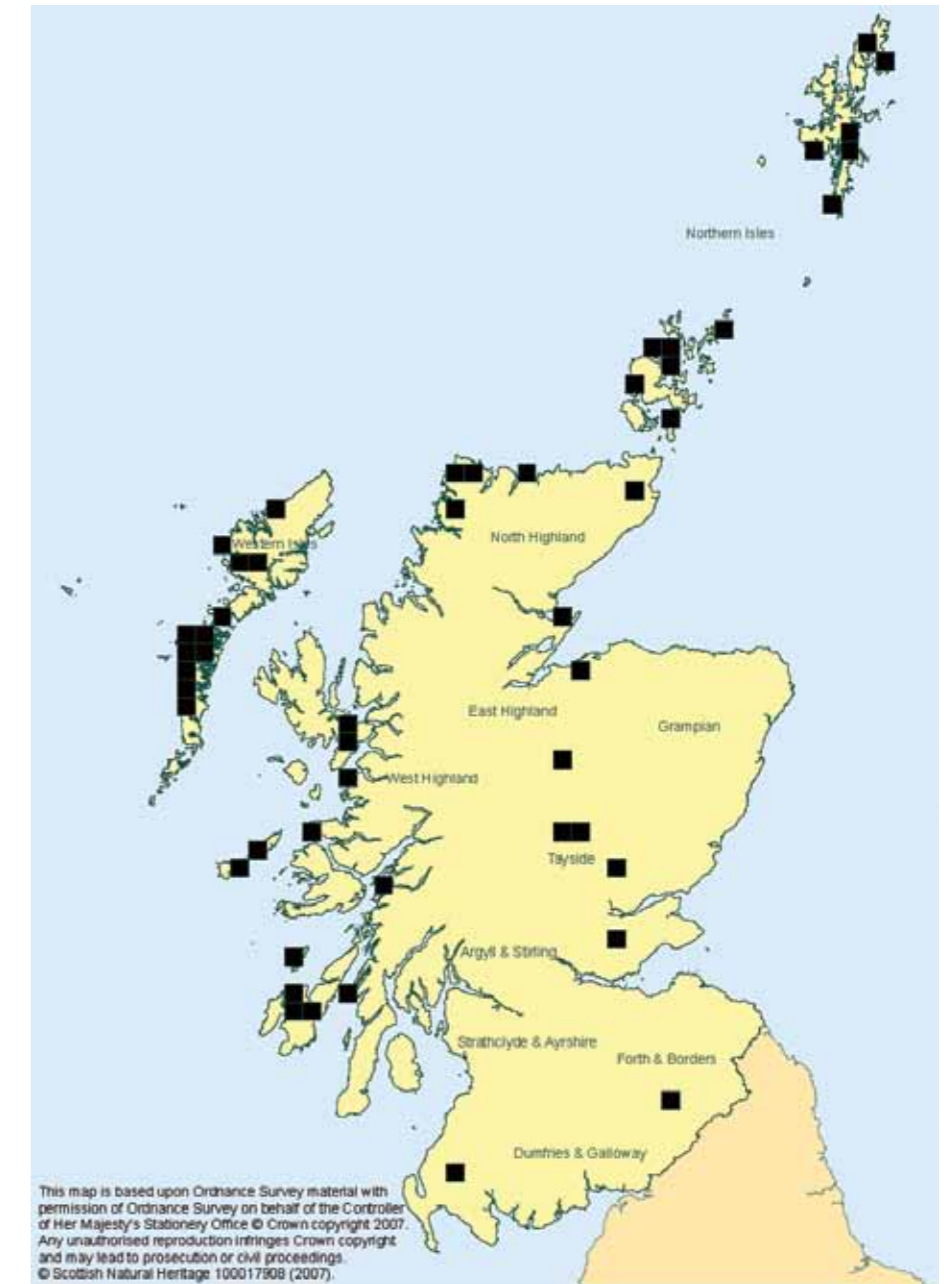
1  
Chara stonewort.

## Where do they live?

Stoneworts grow under-water in a variety of fresh or brackish water habitats. They do not grow in fully saline sea water, but, for example, in the reduced salinities of the Baltic Sea they extend to the inner entrance of the Kattegat. Most of the time they grow in standing water such as lochs and ponds, but occasionally they are found in rivers and streams. A few species, mostly in the genus *Nitella*, can grow in acidic water and some, such as translucent stonewort are more or less restricted to acidic peaty pools and lakes. However, a much greater number are restricted to calcareous or brackish water.

Some species can form dense perennial beds to the exclusion of all other plants, but more often they occur mixed with other aquatic plants. Several species are not good competitors and prefer open conditions, such as where wave-wash reduces the density of vegetation along the shallow edges of lochs. Their ability to colonise at a fast rate can also mean that they appear quickly.

## Important stonewort areas in Scotland



■ Each block represents an area of 10km<sup>2</sup>

# Key habitats in Scotland

## Brackish lochs in the Western Isles

Several species are restricted to brackish water, including foxtail stonewort *Lamprothamnium papulosum*, bearded stonewort *Chara canescens*, Baltic stonewort *Chara baltica* and bird's nest stonewort *Tolypella nidifica*. All of these are extremely threatened in Britain because elsewhere the habitat is rare and particularly vulnerable to habitat change or loss because of the pressures of coastal development. The first two of these species are specially protected on Schedule 8 of the Countryside and Rights of Way Act. In the Western Isles, the number of lochs and inlets along the complex coastline means that some are partially connected to the sea and have some salinity but are not fully saline. These are ideal conditions for these stoneworts and provide probably the best stronghold for them outside of the Baltic Sea.

At one time some of these species also occurred in the Loch of Stenness, Orkney, but there seems to have been a change in salinity here, possibly in connection with the building of the Churchill Barriers during the Second World War. These causeways connect several of the islands and close off the east side of Scapa Flow. As a result, it appears that during south-westerly winds more salt water is pushed into the loch, which is now too saline. But bird's nest stonewort *Tolypella nidifica* is still thought to grow here – its most northerly site in the UK.



1  
Foxtail stonewort.  
2  
Tong Saltings, Isle of Lewis – a shallow, brackish lagoon.





## Machair lochs in the Inner and Outer Hebrides

The calcareous sand deposits that have built up around several of the Hebridean islands has trapped a number of freshwater lochs which are often strongly calcareous in the parts on the sand but quite acidic in the parts on the older rocks. This combination provides a range of conditions and often results in an extremely diverse stonewort flora. The Rough stonewort *Chara aspera* is particularly characteristic of the shallowly shelving sands and is often the dominant plant over acres of the bottom of the loch.



## Marl lochs

Many stoneworts, particularly in the genus *Chara*, require strongly calcareous water. Such lochs are called marl lochs and are often associated with limestone. There are some particularly good examples on the Durness Limestone in Sutherland, where eight species of stonewort have been recorded; on the small island of Lismore near Oban, Argyll, where lesser bearded stonewort *Chara curta* and rugged stonewort *Chara rudis* are found, and near Ballygrant on Islay, one of only two extant sites in Scotland for hedgehog stonewort *Chara aculeolata*. Small outcrops of limestone in northern Perthshire and Shetland also provide sufficiently lime-rich conditions.

Some sandstones also contain a high degree of lime. For example, the Old Red Sandstone of Caithness and Orkney contains some lime-rich bands and account for the rich stonewort flora of these areas. In the Borders there is a group of lochs and fens around Hawick and Selkirk where the source of lime comes from calcareous boulder clay.

1  
Aerial view of the machair lochs of South Uist.

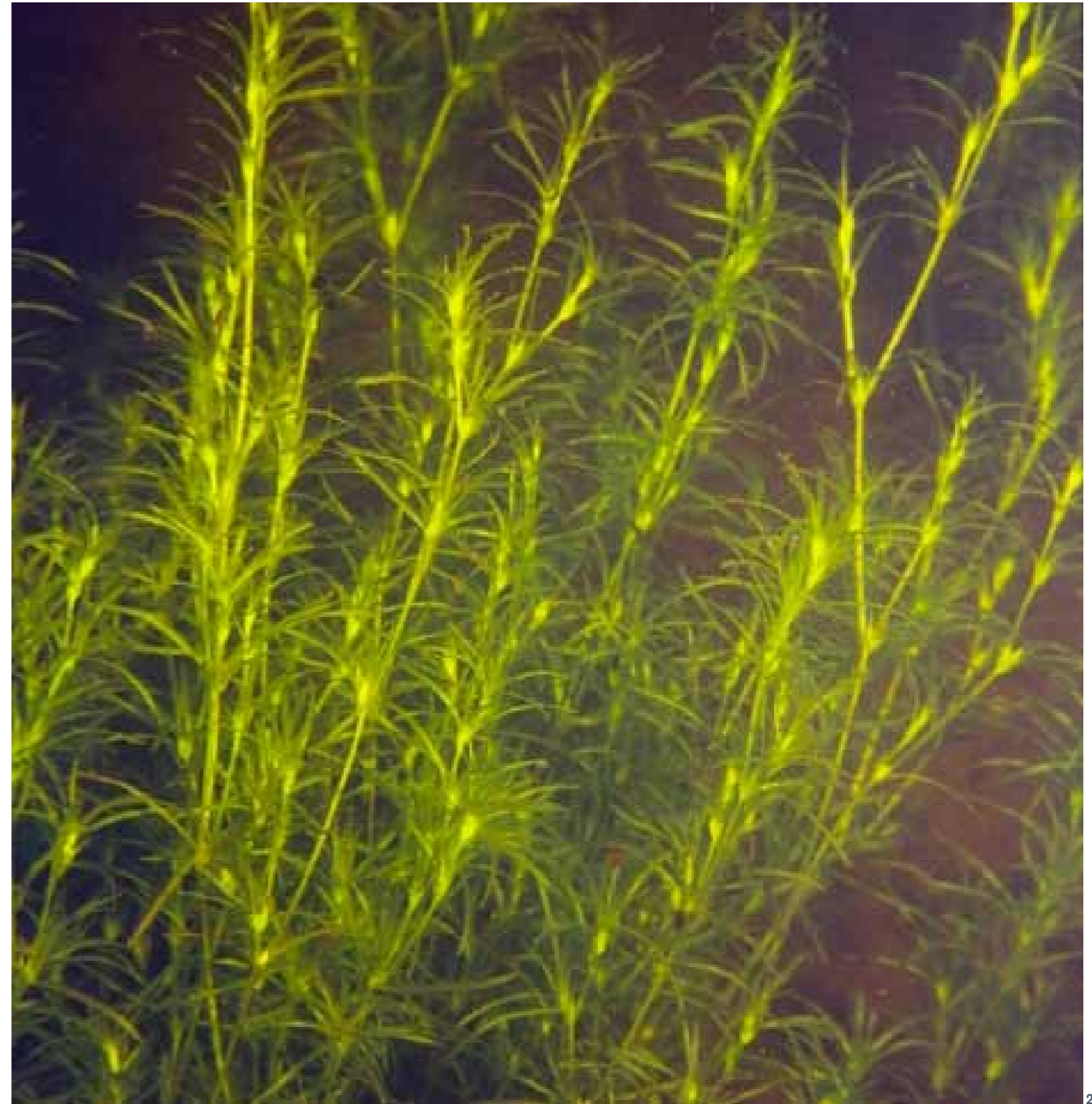
2  
Aerial view of Lunan Lochs, Perthshire, where seven species of stonewort and the slender naiad can be found.

## Acidic lochs

Although there are fewer species that can grow in acidic conditions, these can be an important part of the loch flora. Because acidic lochs are not a common habitat in Europe, Scotland provides an important stronghold for these species. There are several that are very uncommon, including the slender stonewort *Nitella gracilis*, which is restricted to a few lochs in Ayrshire and Sutherland, and the least stonewort *Nitella confervacea*, which is sparsely scattered in northern and western Scotland. The latter is often associated with the slender naiad *Najas flexilis*, a higher plant which has been identified as a threatened species in Europe.



1  
Chapel Mires  
2  
Slender naiad.





## Dune slack pools

Pools in the wet hollows between sand dunes are another important habitat for stoneworts, particularly where the sand is calcareous. Sometimes these pools can be the result of winter flooding and then dry out as the summer progresses, but the stoneworts are able to complete their life cycle while the water remains. Notable sand dune sites include Morrich More in Easter Ross and Killinallan Dunes on Islay.

## Pools in calcareous fens

Small pools and peat cuttings in calcareous fens are often a good habitat for stoneworts because of the combination of calcareous water and peat, which buffers the nutrient levels in the water. Examples of this habitat occur in the Border Mires near Hawick and Selkirk. There are about 15 separate sites in this area that together make an outstanding stonewort complex compared with the rest of southern Scotland. Eight species of stonewort have been recorded, including the nationally scarce clustered stonewort *Tolypella glomerata*.

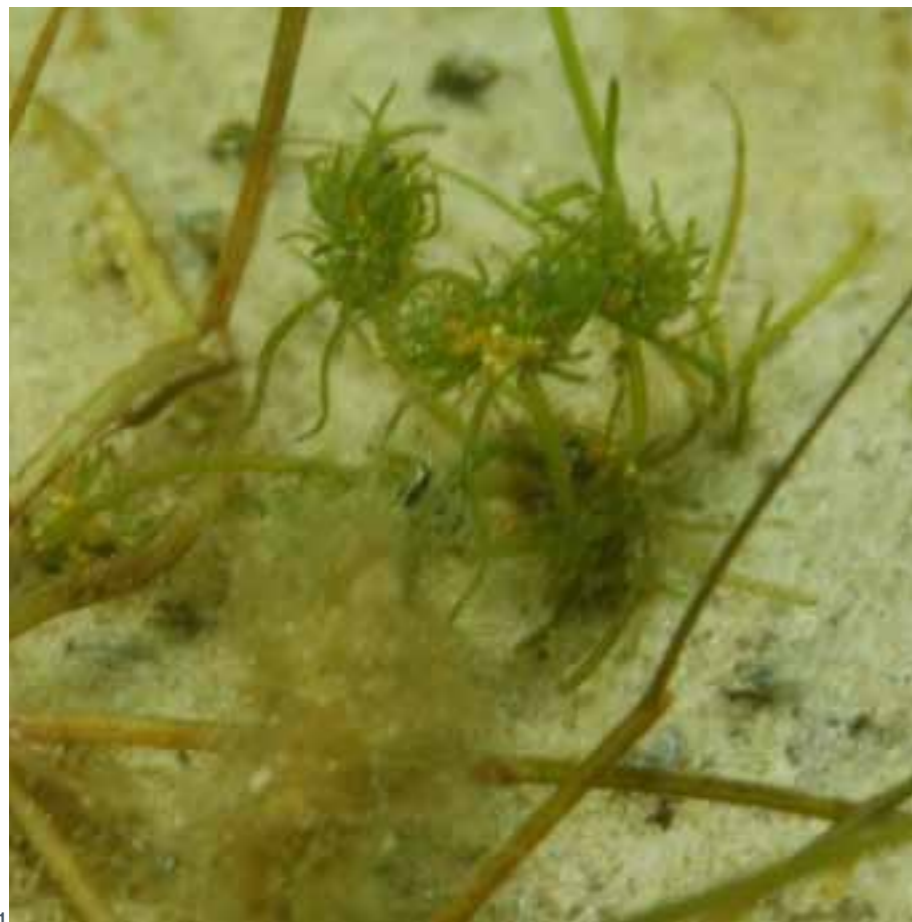


1  
Calcerous fens at Murder Moss, Whitlaw  
Moss NNR.  
2  
Morrich More – a dune slack pool.

# Threats

Forty-five per cent of British stonewort species are considered to be under threat and more than half are very uncommon. This is considerably higher than most other groups of organisms and is a reflection of the threats to their main habitats and, more generally, to a decline in water quality throughout most of Britain. Most species have declined to a greater or lesser degree and this trend seems to be continuing.

A Red Data Book for stoneworts was published by the Joint Nature Conservation Committee in 1992 and was the first to cover a group of lower plants. Twelve species have been identified as Priority Species on the UK government's Biodiversity Action Plan, eight of which occur in Scotland.



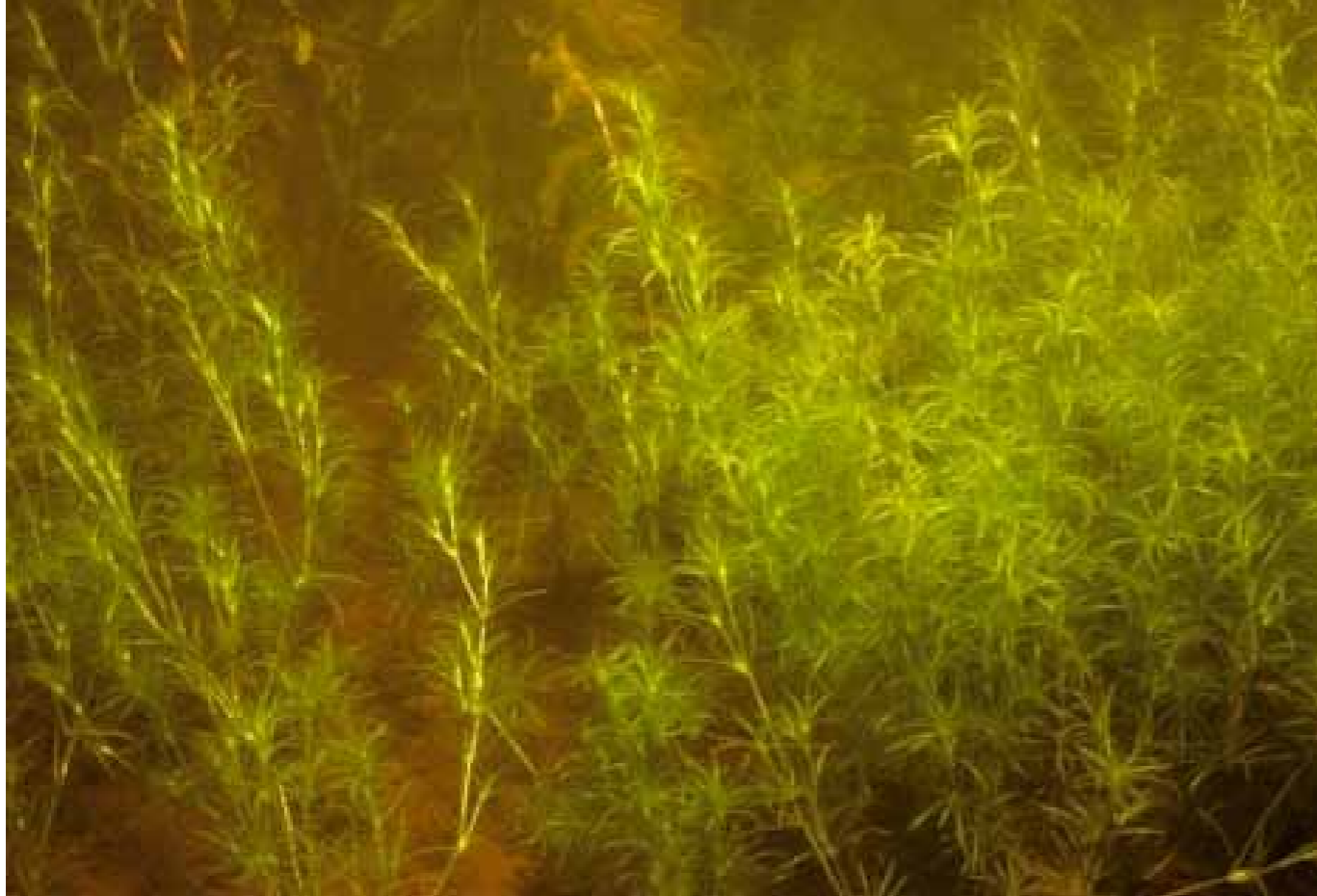
# Stoneworts in Scotland

Latin name	Common name	British rarity and threat status	UK Biodiversity Priority Species
<i>Chara aculeolata</i>	Hedgehog stonewort	Nationally scarce	
<i>Chara aspera</i>	Rough stonewort	Occasional	
<i>Chara baltica</i>	Baltic stonewort	Vulnerable	Yes
<i>Chara canescens</i>	Bearded stonewort	Endangered, Schedule 8	Yes
<i>Chara contraria</i>	Opposite stonewort	Occasional	
<i>Chara curta</i>	Lesser bearded stonewort	Nationally scarce	Yes
<i>Chara globularis</i>	Fragile stonewort	Occasional	
<i>Chara hispida</i>	Bristly stonewort	Occasional	
<i>Chara muscosa</i>	Mossy stonewort	Data deficient and near endemic. Taxonomic status uncertain	Yes
<i>Chara rudis</i>	Rugged stonewort	Near threatened	
<i>Chara virgata</i>	Delicate stonewort	Frequent	
<i>Chara vulgaris</i>	Common stonewort	Frequent	
<i>Lamprothamnium papulosum</i>	Foxtail stonewort	Near threatened, Schedule 8	Yes
<i>Nitella confervacea</i>	Least stonewort	Near threatened	
<i>Nitella flexilis</i>	Smooth stonewort	Nationally scarce	
<i>Nitella gracilis</i>	Slender stonewort	Vulnerable	Yes
<i>Nitella mucronata</i>	Pointed stonewort	Nationally scarce. Scottish record may be incorrect.	
<i>Nitella opaca</i>	Dark stonewort	Frequent	
<i>Nitella translucens</i>	Translucent stonewort	Occasional	
<i>Nitellopsis obtusa</i>	Starry stonewort	Vulnerable. Scottish record may be incorrect	Yes
<i>Tolypella glomerata</i>	Clustered stonewort	Nationally Scarce	
<i>Tolypella nidifica</i>	Bird's nest stonewort	Endangered	Yes

1  
Bird's nest stonewort.

# Stoneworts and water pollution

Stoneworts are extremely sensitive to enrichment from nitrates and phosphates. Phosphate levels are particularly damaging and levels as low as 10 micrograms per litre are thought to affect reproductive success. The main causes of enrichment pollution are run-off from intensively farmed catchments and sewage effluent. When nutrient levels build up in the water, this encourages blooms of planktonic algae, which smother the vegetation beneath and deoxygenate the water when they decay. Stoneworts are particularly vulnerable because they lack a well-developed root system and rely on absorbing nutrients from the water. When algae attached to the plants become abundant the light available to the stoneworts is reduced.



In the Highlands and many of the islands, the levels of excess nutrients entering the water system are often low and stoneworts are thriving where conditions are suitable. However, the situation in the lowlands, and particularly in south and east Scotland, is very different. Many of the lochs in these areas are affected by nutrient pollution and stoneworts have consequently declined. The hedgehog stonewort, for example, has been lost from nearly all of its Scottish sites, with only one population remaining on Islay. The Lunan Lochs, Perthshire, are important for seven species of stoneworts and also the slender naiad, which is a vascular plant and visually resembles some of the more delicate stoneworts. The slender naiad and the stoneworts have been declining in these lochs, but there is now a scheme to help reduce the nutrient run-off from the surrounding land.

Even on the islands there is cause for concern in some areas. On Orkney, for example, the intensification of dairy farming is resulting in an increase in enrichment pollution entering the lochs with a consequent increase in water turbidity and algal blooms. In Shetland, also, the Loch of Spiggie has suffered badly from enrichment pollution, with only three species of stonewort being found in 2003 where formerly there were six species.

Fish-farming is another source of enrichment pollution. This is not contained solely to the vicinity of the fish farm because the nutrients diffuse around the loch, particularly if the loch is small.



1  
Slender naiad.  
2  
Loch of Spiggie, Shetland.



1  
Canadian waterweed, Loch  
Ussie, Easter Ross.

## Other threats

Some stonewort habitats are quite small, such as pools in calcareous fens and sand dunes. These are vulnerable to becoming overgrown and, in some cases, to drainage and site loss. Often, some management is required to keep the habitat open, including cutting back trees and scrub and dredging ponds. Fortunately, stonewort spores remain viable for many years or even decades and there is normally a good supply of spores to germinate after any dredging operations. Grazing can also be important in reducing the accumulation of swamp in shallow water, allowing more open conditions suitable for stoneworts. In brackish water sites there is often a fine balance between the amount of salt water entering the loch and the amount of fresh water coming in from the surrounding land. Disturbance to this balance can occur because of water abstraction in the catchment or the building of causeways at the seaward entrance. Rising sea levels as a result of global warming is likely to become an increasing problem, too.

Invasive species are an increasing problem in some areas. There are several very aggressive aquatic introductions which, once established, are very difficult to remove. Swamp stonecrop *Crassula helmsii* is a particular problem, but other problem species are parrots feather *Myriophyllum aquaticum*, curly water thyme *Lagarosiphon majus* (sometimes sold in garden centres as *Elodea densa*) and Nuttall's waterweed *Elodea nuttallii*. Canadian waterweed *Elodea canadensis* can be an aggressive coloniser when it first appears in an area but seems to become less aggressive once it has been established for a time. All of these species can very quickly form dense beds of vegetation which outcompete the stoneworts and other natural aquatic plants.

# Conservation – how you can help

Stoneworts, along with many other lower plants, have generally received less attention than the more showy flowering plants. Fortunately, many of the conservation measures aimed at other wildlife groups are often of benefit for stoneworts. Even so, the problem of declining water quality in many lochs is a difficult problem to tackle as the pollution sources are often distant from the site and sometimes difficult to pinpoint.

Education has an important role in terms of bringing the problems of water pollution to wider attention. Because it is difficult to see what is happening under water in our lochs, it is all too easy for people to forget that there is a problem.

There are specific things that can be done to help.

## Land managers

- Leave a buffer strip along water courses to catch any chemicals washed off the fields.
- Make sure that silage effluent does not leak into drains and other water courses.
- Avoid manuring fields in winter and early spring, when there is a greater risk of nutrients being washed off the fields rather than being absorbed by the grass or other crops.

## Anglers and wildfowlers

- Avoid excessive use of ground bait to attract fish as this often adds significant nutrients to the water.
- Make sure that any invasive plants are removed from your equipment when leaving a site.
- Avoid dumping grain in ponds and lake edges to attract wildfowl.



1  
Loch survey.  
2  
Clean-up at Brockburn, Glasgow.  
3  
Buffer strip.



## General public

- Use ecologically friendly detergents. Detergents are a principal source of phosphates in our rivers and are not removed in most sewage treatment works.
- Don't waste water. The less you use, the less that has to be treated.
- Don't throw out the plant contents of aquaria into the wild, for example when returning grown-up tadpoles to a wild pond.
- Don't introduce plants from a garden centre into wild situations or ponds connected to water courses. Or, if you do, make sure that any invasive species are removed from among the roots. Remember that aquatic plants are good colonisers as many live in dynamic environments. So, usually, they don't need help to colonise new ponds unless they are particularly isolated.



# Finding out more

Stoneworts, as well as other aquatic plants, have generally been less well studied than terrestrial plants because of the difficulty of seeing and collecting the plants for identification. However, there has been a growing interest in the study of stoneworts in recent years, particularly as people have realised how much they are under threat. With a bit of practice most species can be identified in the field with the aid of a hand lens, although access to a low-power viewing microscope will often help to confirm difficult species.

Stoneworts come under the remit of the Botanical Society of the British Isles, which has a referee which can help with identifications. The Botanical Society of Scotland also has a section devoted to lower plants. These organisations may be able to advise on good places in your area to look for stoneworts.

The Field Studies Council holds an annual course for the identification of aquatic plants, including stoneworts, at their field centre at Kindrogan in Perthshire. Some local records centres in different parts of Scotland have also run day workshops on the group from time to time.

## Further reading

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Stewart, N.F. & Church, J. 1992. *Red Data Books for Britain and Ireland: Stoneworts*. Joint Nature Conservation Committee. (Contains details of ecology and keys for identification as well as the usual Red Data Book information.)

## Useful addresses

Botanical Society of the British Isles, Jim McIntosh, Scottish Officer, c/o Royal Botanic Gardens, 20a Inverleith Row, Edinburgh, EH3 5LR

Botanical Society of Scotland, Royal Botanic Gardens, 20a Inverleith Row, Edinburgh, EH3 5LR

Field Studies Council, Kindrogan Field Centre, Knochdhu, Blairgowrie, Perthshire, PH10 7PG

Scottish Environment Protection Agency, SEPA Corporate Office, Erskine Court, Castle Business Park, Stirling, FK9 4TR

Plantlife Scotland, Balallan House, Allan Park, Stirling, FK8 2QG



# Stoneworts

## Naturally Scottish

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