



www.environment-agency.gov.uk

Guidance for the control of invasive weeds in or near fresh water



**ENVIRONMENT
AGENCY**

The Environment Agency is the leading public body protecting and improving the environment in England and Wales.

It's our job to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world.

Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters and contaminated land, and improving wildlife habitats.

Published by:

Environment Agency
Rio House
Waterside Drive, Aztec West
Almondsbury, Bristol BS32 4UD
Tel: 01454 624400
Fax: 01454 624409

ISBN : 1844320839

© Environment Agency August 2003

Acknowledgements:

The text was written by Jonathan Newman (CAPM), with assistance from Trevor Renals and Phil Griffiths (Environment Agency). Distribution maps were provided by the Biological Records Centre at Monks Wood. Photographs were provided by Trevor Renals, Phil Griffiths, Richard Shaw (CABI Bioscience) and Jonathan Newman (CAPM).

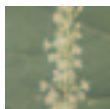
All rights reserved. This document may be reproduced with prior permission of the Environment Agency.

This report is printed on Cyclus Print, a 100% recycled stock, which is 100% post consumer waste and is totally chlorine free. Water used is treated and in most cases returned to source in better condition than removed.

Front cover photograph by Environment Agency

Contents

Foreword	2
What are invasive weeds?	3
Existing legislation	4
Responsibility for invasive weed control	6
General methods of control	6
Health and safety	7
Disposal of non-native weeds	7
Monitoring	7
Japanese knotweed fact file	8
Giant hogweed fact file	10
Himalayan balsam fact file	12
Australian swamp stonecrop fact file	14
Parrot's feather fact file	16
Floating pennywort fact file	18
Glossary	20
Further information	20
Publications	20



Foreword

Our native flora and fauna represent a wealth of diversity within the distinctive character of the wildlife habitats that we all appreciate. Many species have been introduced either deliberately or accidentally since Roman times and some of these have added to the character of the countryside and, more often, our towns and gardens. Victorians were obsessed by the beauty and structure of wild plants and introduced many species from the furthest corners of the British Empire. We live today with the consequences of some of these introductions, which have thrived in our climate and environment.



In more recent times, there has been an unprecedented increase in the rate of new species being brought into the country, many associated with water. Some introductions give considerable cause for concern and action needs to be taken. Environment Agency staff are dealing with more and more requests for advice from members of the public and organisations about how they should deal with such species.

Problems caused by introduced water and waterside plants include blockage of drainage channels, ousting native vegetation, deoxygenation causing fish mortalities, limiting safe access to water and, in some cases, posing significant health risks to the public and livestock.

Important research on how to minimise the impacts of invasive plants is being carried out by the Centre for Aquatic Plant Management. Their experience and technical expertise has been instrumental in compiling this booklet which focuses on those bankside and aquatic species that are causing most concern and generate the most enquiries.

I hope that you will find the information in this booklet useful.

A handwritten signature in black ink that reads "Barbara Young". The script is fluid and cursive.

Barbara Young
Chief Executive of the Environment Agency

What are invasive weeds?

Several types of plant can become invasive weeds. They are either native species that grow well in disturbed or nutrient-enriched conditions, to the detriment of other plant and animal species, or non-native plants that have been introduced to this country by accident or as a consequence of trade or deliberate collection. The latter tend to grow in situations where native plants of similar form do not. Not all non-native species become weeds, but if they do, they become very difficult to control. Native weed species, although troublesome, do not cause as much ecological or physical damage as the non-native variety. This booklet deals with those non-native invasive species that have caused serious problems in the aquatic and riparian environments of Britain.

Invasive non-native species tend to share characteristics that make them successful. These are related to the method of reproduction, growth rate, growth form and persistence, but in particular the absence of pests and diseases and their consequent resistance to control. Species in aquatic plant families are more likely to be both weedy and invaders of natural environments than those of any other plant families. In addition, the frequently disturbed nature of man-made aquatic habitats and artificial nutrient enrichment of aquatic systems makes them more prone to invasion. Successful management of alien invasive species requires an understanding of how they grow and also the ecology of the aquatic systems in which they occur.

The introduction of plant species into new environments carries risks. The danger of species becoming serious weeds in agricultural areas is well controlled, but other potential weeds are not currently recognised and subject to risk assessment and management. The effects of climate change will alter the distribution of weed species in future; already, several aquatic weeds found in Europe originated in sub-tropical areas of the world. The predicted consequences of global warming, including increased temperatures, increased carbon dioxide and stormier weather, make it more likely that additional invasive species will cause problems in future. The huge increase in the distribution of Himalayan balsam since 1962 indicates that conditions are ideally suited for this species. Other species may respond similarly in future if climate change favours their colonisation and rapid growth. Plants that grow in water and on riverbanks can cause flooding if not managed correctly. All the species described in this booklet create serious flood risks.

The consequences and costs of invasive non-native species are huge. The cost for eradicating Japanese knotweed has been estimated at between £1.5 and 2.6 billion, and that for Himalayan balsam as between £150 and 300 million. This booklet tells you how to identify six problem species and how to reduce their threat to aquatic ecosystems.

Existing legislation

When non-native species become invasive they can transform ecosystems, causing a variety of problems including seriously threatening native and endangered species. These problems are acknowledged in several international treaties, European Union Directives and also in domestic legislation. The problems caused by some invasive non-native species occur worldwide, and international obligations to address them are placed on the United Kingdom through regional and global agreements. These include the Convention on Biological Diversity (CBD), International Plant Protection Convention (IPPC), the Bern Convention on the Conservation of European Wildlife and Natural Habitats, and the EC Habitats and Species Directive. The sixth CBD conference adopted a series of Guiding Principles for States to follow as part of their invasive non-native species policies.

The Wildlife and Countryside Act 1981 provides the primary controls on the release of non-native species into the wild in Great Britain. It is an offence under section 14(2) of the Act to “plant or otherwise cause to grow in the wild” any plant listed in Schedule 9, Part II. The only flowering plants currently listed in Schedule 9 are Japanese knotweed and giant hogweed. However, Japanese knotweed in particular has continued to spread and has nearly doubled its distribution in the past 20 years.

Stricter enforcement provisions for wildlife offences were introduced under the Countryside and Rights of Way Act 2000. These include increased penalties available to the courts for offences committed under the Wildlife and Countryside Act 1981.

The Weeds Act 1959 provides for the control of five specified weeds. These are non aquatic species, though ragwort, (*Senecio jacobaea*), can grow in riparian areas. This legislation is directed at clearing weeds that threaten agricultural production.

Other legislation relevant to non-native species control includes:

- *Environmental Protection Act 1990*
- *Environmental Protection (Duty of Care) Regulations 1991*
- *Town and Country Planning Act 1990*
- *Highways Act 1980*
- *Water Resources Act 1991*
- *The Waste Management Licensing Regulations 1994*
- *The Landfill (England and Wales) Regulations 2002*

The Government has acknowledged the problems that can be caused by non-native invasive species. The Department for Environment, Food and Rural Affairs (Defra) has undertaken a review of non-native species policy. The Review working group report to Government published in March 2003 sets out a series of recommendations that took account of the guiding principles established by the Convention on Biological Diversity. The Government response to this report will determine future policies and actions.

Responsibility for invasive weed control

Responsibility for dealing with invasive weeds rests with individual landowners. Strategic, widespread control is currently not the sole responsibility of any statutory organisation. The Environment Agency may seek to control specific invasive weeds on land that it owns or flood defence structures that it maintains.

Control efforts by individuals can help reduce the spread of invasive non-native species and are most successful if carried out as a catchment wide co-ordinated strategy with collaboration of all relevant parties. Control is best achieved by working from the upstream end of a watercourse to reduce the chances of recolonisation.

General methods of control

There are four basic methods of controlling weeds: mechanical, chemical, natural and environmental. Mechanical control includes cultivation, hoeing, pulling, cutting, raking, dredging or other methods to uproot or cut weeds. Chemical control uses specific herbicides. Natural control uses pests and diseases of the target weed to weaken it and prevent it from becoming a nuisance. Environmental control works by altering the environment to make it less suitable for weed growth, for example by increasing or decreasing water velocity.

Users should follow the instructions on the label. In England and Wales the use of herbicides in or near rivers, canals, lakes and drainage channels requires prior agreement from the Environment Agency.

What to do and what not to do

- Do:**
- **take immediate action;**
 - *contact the Centre for Aquatic Plant Management to confirm identification and the location of the plant;*
 - *seek advice on correct management for your specific location;*
 - *obtain approval from the Environment Agency if planning to use herbicides;*
 - *remove all plant debris from the water after cutting operations;*
 - *seek advice from the Environment Agency on the disposal of plant material.*
- Don't:**
- **delay in doing something;**
 - *allow the plant to spread to nearby water bodies;*
 - *dispose of cut material in the nearest water body;*
 - *use invasive non-native species in habitat restoration projects.*

Health and safety

Take care when using machinery or herbicides. Environment Agency staff, contractors and others should undertake Control of Substances Hazardous to Health (COSHH) assessments for the activity, and others should be aware of the risks of working near water. There is often a high risk of slipping on banks and other muddy surfaces when carrying equipment or chemicals.

All mixing and application of herbicides must be carried out in accordance with the manufacturer's instructions, which will be found on the product label. All precautions recommended by the manufacturer must be followed.

Although most species in this booklet are not toxic to humans, great care should be taken to avoid contact with the sap of giant hogweed, as this can cause serious skin blistering.

Disposal of non-native weeds

Plant material is considered a 'controlled waste', requiring a waste management licence, unless one of the exemptions set out in Schedule 3 of the Waste Management Licensing Regulations 1994 applies, although exemptions also require registration with the Agency. The correct disposal of plant material as part of mechanical control is vital. It is best to contact the Environment Agency for advice on disposal because there are Regulations which cover the composting, burning and burial of plant materials on-site and the transfer and disposal of material to licensed landfill sites. Any burning must not produce excess smoke or create a nuisance and must take place on a hot fire consisting of wood or clean timber. Plastic and other rubbish must not be burnt. Tyres and petrol must NEVER be used to start a fire. The Environment Agency can give advice on suitable disposal sites and disposal methods.

Japanese knotweed will survive composting and therefore this method of disposal is NOT advisable. Japanese knotweed must only be buried or burnt in accordance with Environment Agency advice. Failure to ensure safe legal disposal or obtain an appropriate licence or exemption could result in prosecution. Burial on-site may require a licence under the Landfill Regulations 2002, whilst removal of plant material will need to be carried out by a licensed waste carrier and buried at a licensed landfill site.

Monitoring

New records of the plants described in this booklet will be helpful in assessing how fast they are spreading and determining local control options. If you see any of these species, please tell the Centre for Aquatic Plant Management, Broadmoor Lane, Sonning, Reading, Berkshire, RG4 6TH. Information required is the exact location, with a map grid reference if possible, the extent of the infestation and the kind of water body it is affecting.

Japanese knotweed

Fact file

Japanese knotweed was first brought to Britain in the mid-nineteenth century as an ornamental garden plant. Since then it has caused serious problems in a range of habitats - particularly roadsides, riverbanks and derelict land - by displacing native flora and even causing structural damage. There are three species of invasive knotweed in the UK: Japanese knotweed (*Fallopia japonica*); giant knotweed (*Fallopia sachalinensis*); and hybrid knotweed (*Fallopia x bohemica*), which is a cross between Japanese and giant knotweed. Japanese knotweed is the most widespread and troublesome bankside species, followed closely by hybrid knotweed, which has a similarly high regeneration capacity.

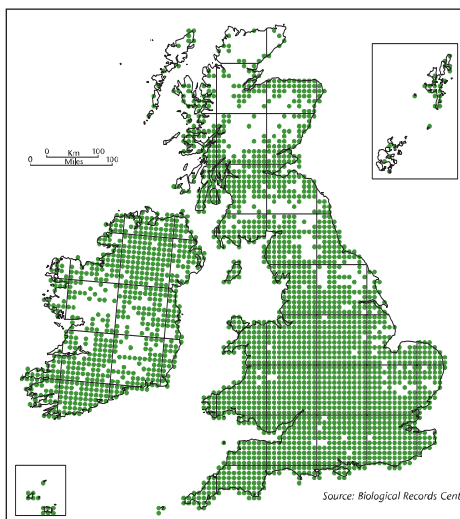


Only female plants are present in the UK. Japanese knotweed forms dense clumps with fleshy, red/green shoots, 2-3m tall, which have hollow green stems with red/purple flecks. Leaves are green, heart or shield-shaped with a flat base, up to 120mm long. Creamy clusters of flowers are borne on the tips of most stems in late summer. The root system consists of rhizomes which are yellow when cut.

The underground rhizome system can extend at least 7m from the parent plant, and reach a depth of 3m or more. A piece of rhizome the size of a little finger nail can grow into a new plant. The crown, located at the base of the stem, will produce new plants. The stems die back in winter and take up to three years to decompose. Japanese knotweed crowns should neither be composted, nor removed from a site without a waste licence.

Control

Near water **chemical** control can be achieved with herbicides containing



glyphosate. Spraying both the top and underside of leaves improves control.

Cutting should be done extremely carefully using a hand sythe to avoid spreading stem fragments. Flail mowing must not be carried out.

Digging out rhizomes and disposing of the spoil is an expensive option and often impracticable. The spoil can be removed from site as special waste, disposed of on-site at least 10m deep, or the material can be sieved through a 20mm mesh and the spoil re-used on site.

Spring *Cut new growth. Dig out rhizomes or spray new growth with glyphosate. Excavate soil and dispose of on site or take to landfill as special waste, under licence.*

Summer *Cut new growth. Dig out rhizomes or spray with glyphosate.*

Autumn *Cut new growth. Dig out rhizomes and spray with glyphosate. This is the most effective time for glyphosate application.*

Non-chemical control

Cutting	Digging	Grazing
<p>Use a simple scythe method of cutting to prevent stem fragmentation. Flail mowing or strimming must not be undertaken.</p> <p>Continue cutting every 2-4 weeks to reduce both above and below-ground biomass.</p> <p>Burn cut stems on site or remove to landfill (licence required).</p>	<p>Dig out soil around clump for up to 7m. Either sieve soil on site through 20mm mesh and re-use soil on site, or remove soil to landfill (licence required). Burn rhizome and stem fragments on site or bury 10m deep or dispose in landfill (licence required).</p> <p>Pulling</p> <p>Uproot stems by pulling from the base - best done from June onwards. Burn rhizome and stem fragments on site or bury 10m deep or dispose in landfill (licence required).</p>	<p>Grazing of shoots by horses, sheep and goats keeps the plant in check, provided previous dead growth is removed.</p>

CONTACT THE ENVIRONMENT AGENCY FOR DISPOSAL ADVICE

Chemical control

Near water		In general
<p>Glyphosate</p> <p>Apply as soon as shoots appear, but best effects are when shoots are more than 1.5m tall, in August or September. Can be applied by stem injection using a 1 in 10 dilution.</p> <p>2,4-D amine</p> <p>Apply in May and then again in August /September for best results.</p>		<p>Plants respond best when actively growing and when previous year's growth has been removed. Herbicides can be applied using tractor-mounted, knapsack long-lance, or CDA applicators. Application in sensitive areas is best achieved by stem injection or weed wiper.</p>

Giant hogweed

Fact file

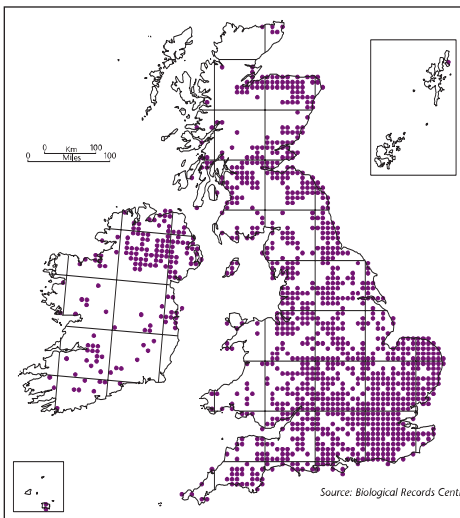
Giant hogweed (*Heracleum mantegazzianum*), is a native of the Caucasus mountains and was introduced to Britain in 1893 as an ornamental plant. It escaped from gardens and now colonises many areas of wasteland and riverbanks. Each flowerhead produces several thousand seeds that are easily dispersed by water, so the plant spreads rapidly along watercourses.



It is a perennial plant, taking up to four years to mature and flower, after which it dies. It forms dense colonies that suppress the growth of native plants and grasses, leaving the banks bare of vegetation in winter and increasing the risk of erosion and recolonisation from seeds washed downstream.

Children have been known to use the hollow stems as “pea shooters” and “telescopes”. However, the stems, edges and undersides of the leaves bear small hairs containing poisonous sap, and the slightest touch causes painful blistering and severe skin irritation. Unshaded habitats with high soil nitrate levels (for example, riverbanks, roadsides and waste ground) tend to produce greater quantities of toxins in the plant. Contact with the cut material in sunlight produces a skin reaction in almost all cases. Blistering symptoms occur 24-48 hours after exposure, and dense pigmentation is visible after three to five days. This may persist for six years or more. Cut material remains active for several hours after cutting. Protective clothing must be worn when treating this plant because the hairs can penetrate light fabrics.

Growth starts in March and the plants reach 5m in height. The leaves are dark green, and form a rosette. The lobes are deeply cut and spiked at the ends. The stems are green with dark red or purple spots or blotches. Stems are ribbed, with sparse spiky hairs on the ridges. The stems are hollow and up to 100mm across. The flowers are



white, forming a large umbel. Each plant produces up to 50,000 seeds, approximately 10mm long by 7mm wide. Seeds may remain viable for up to 15 years.



Control

The aim should be to kill the plant or prevent flowering. Repeated treatment may be necessary during the growing season to prevent flowering.

Chemical control using glyphosate at 6 litres/ha is the most effective method. Spraying can start as soon as the plant is about 1m high, usually in March and continue throughout the summer. More than one application is often necessary and follow-up spraying will be required to kill seedlings in subsequent years.

Cutting down the stems with a sharp scythe or sickle before flowering will help to control this plant. Flail mowing may be carried out, but extreme caution is required to avoid the risk of being sprayed with sap. Strimming is not recommended, unless full protective clothing is worn.

Digging out the crown just below ground prevents regrowth and will provide good control. This can be done with an axe or sharp spade.

Non-chemical control

Cutting	Digging	Grazing
Cut stem below ground using an axe or spade. Wear full protective clothing, especially if strimming. Cut regularly early in the season to prevent flowering. Cutting should be repeated regularly for between 5 and 10 years to eradicate the plant.	Shallow excavation to about 20cm will remove the growing crown. Spoil should be disposed of at landfill or by piling on site and composting. Any regrowth should be treated chemically.	Grazing by cattle, sheep, pigs or goats throughout the growing season will suppress growth, but does not eradicate it.

CONTACT THE ENVIRONMENT AGENCY FOR DISPOSAL ADVICE

Chemical control

Glyphosate	In general
In mixed stands, use a weed wipe when plants are about 1m tall between March and May. When plants are more than 1.5m tall, proceed with extreme caution. Repeat chemical treatment may be required for up to 10 years.	It is essential to establish vegetation quickly after control measures have been applied. Dense grass sward tends to discourage seed germination. Control should be undertaken on a catchment basis, working from the upstream end to prevent seed recolonisation.

Himalayan balsam

Fact file

Himalayan or Indian balsam (*Impatiens glandulifera*) is a native of the western Himalayas. Introduced to Britain in 1839, it escaped from gardens and rapidly colonised river banks and areas of damp ground. It is the tallest annual plant in Britain, growing up to 3m high. The characteristic purplish-pink slipper-shaped flowers appear in June.

When the seed pods mature, they explode when touched, scattering the seed up to 7m away. Seeds are also spread by water and they may remain viable for up to two years.



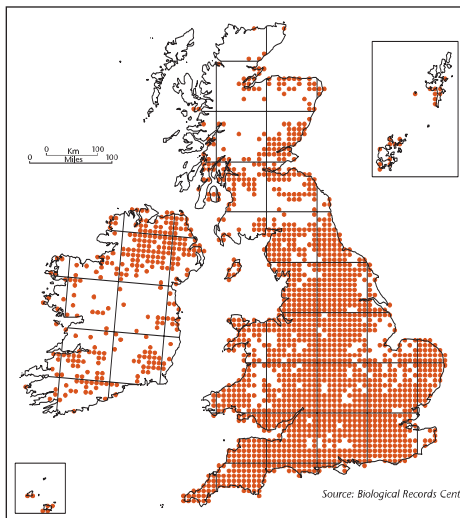
Himalayan balsam plants grow in dense stands that suppress the growth of native grasses and other flora. In autumn the plants die back, leaving the banks bare of vegetation, and therefore liable to erosion.

The stems are pinkish-red, hollow and jointed, often with some branching. Leaves and side branches originate from stem joints. The stem is sappy and brittle. The shiny dark green leaves are lance-shaped, have serrated edges, a dark red midrib and can be up to 150mm long. They grow on the stem in whorls of three. Purplish-pink flowers, held on long stalks, appear from June to October. The white, brown or black seeds are produced from July to October and are 4-7mm in diameter. There are between 4 and 16 seeds per pod.

Control

Control measures should aim to prevent flowering, and are best carried out before June for maximum effectiveness.

Chemical control near water can be carried out with herbicides



containing glyphosate or 2,4-D amine. Glyphosate will kill all plants, but 2,4-D amine will kill only broad-leaved weeds; either should be used when the plant is actively growing in early spring for best effect.

Cutting, mowing or strimming on a regular basis for about three years will be effective and may even eradicate the plant from isolated sites.



Non-chemical control

Cutting	Pulling	Grazing
<p>Cut at ground level using a scythe, machete, flail or strimmer before the flowering stage in June. Cutting earlier than this will promote greater seed production from plants that regrow. Cutting should be repeated annually until no more growth occurs.</p>	<p>Shallow-rooted plants can be pulled up very easily and disposed of by burning or composting, unless seeds are present.</p>	<p>Grazing by cattle and sheep is effective from April throughout the growing season. It should be continued until no new growth occurs.</p>

CONTACT THE ENVIRONMENT AGENCY FOR DISPOSAL ADVICE

Chemical control

Glyphosate	2,4-D amine	In general
<p>Treatment with a weed wipe in mixed stands, or by foliar spray in dense stands, before flowering. If all plants are controlled, then spraying programmes should only be required for two to three years.</p>	<p>Treat during early spring at the rosette stage for effective control.</p>	<p>The plant must not be allowed to flower and set seed. Reproduction is mainly by seed, and if control can be achieved before seeds are set, eradication is possible in two to three years.</p>

Australian swamp stonecrop

Fact file

Australian swamp stonecrop (*Crassula helmsii*) was introduced from Tasmania to Britain in 1911. It was first sold as an “oxygenating plant” in 1927.

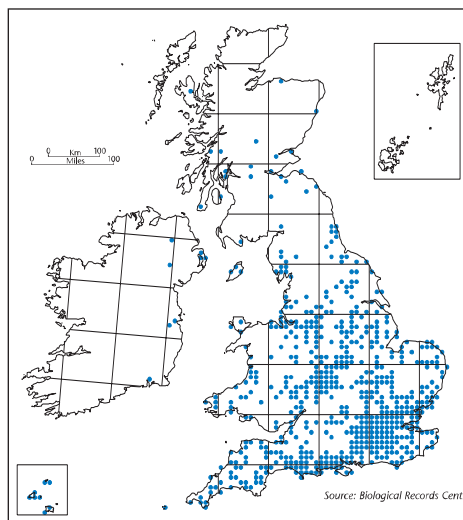
The first occurrence in the wild was reported in Essex in 1956. In recent years, it has spread much more rapidly due to the increased availability of the plant at garden centres and aquatic nurseries. It has been recorded at about 1,500 sites although this is probably an underestimate of the true distribution. It is sometimes referred to as *Tillaea recurva*, *Tillaea helmsii*, or New Zealand pigmy weed.

The plant is easily dispersed and, although not always sold by suppliers, it is often found as a “contaminant” with other water plants. Introductions to new sites are associated with a wide range of human, water-based activities, and awareness and education programmes can dramatically reduce transport of the plant between sites. Local dispersal is aided by the high viability of small fragments, which can be carried on mud to new sites.

The success of *Crassula* lies mainly in its ability to colonise virtually any suitable static-to very-slow-flowing freshwater habitat across a wide range of water chemistry. It has vigorous, year-round growth, and can grow equally well either on damp ground or in water up to 3m deep.

Where *Crassula* invades, it quickly out-competes native vegetation, and maintains its dominance by very rapid growth and uptake of almost all the available nutrients.

There are three typical growth forms: (i) a terrestrial form with creeping stems and aerial, succulent leaves; (ii) an emergent form with



densely packed stems, found in water less than 0.6m deep; (iii) and a submerged form that grows from a basal rosette with long, sparsely-leaved stems reaching the surface. The three forms change according to prevailing conditions. The rigid stems have pairs of fleshy leaves that vary in shape from long and narrow in deeper water to slightly elliptical, with sharp or bluntnish tips in air. The leaf tip is never notched, which distinguishes it from the native water starwort (*Callitriche* spp.). The leaf bases are joined, forming a distinctive 1mm collar around the stem. In summer, white flowers grow in the axils of the leaves on emergent and terrestrial forms.

Control

This plant is best treated at the early stages of infestation. Delay will make the problem several orders of magnitude worse in each successive year.

Chemical control of submerged material with diquat (which is permitted only until June 2004) and emergent material with glyphosate are the best options.

Cutting is not recommended, but dredging out marginal and emergent material can be effective, as the plant is shallow-rooted. The area around any infestation should be fenced to prevent movement of fragments by livestock. Dredged material should be piled in heaps and covered with thick black polythene sheeting or at least 20cm of soil.

Shading of terrestrial or emergent forms with opaque material such as black polythene for about three months may be effective, but is difficult to install and manage, and vandalism can be a problem.

Non-chemical control		
Cutting	Dredging	Shading
Not recommended.	Dredging of marginal and emergent material throughout the year can be effective, although it is necessary to ensure that plant fragments cannot be transported elsewhere.	Covering with black polythene or similar for up to 10 weeks during the growing season.

CONTACT THE ENVIRONMENT AGENCY FOR DISPOSAL ADVICE

Chemical control		
Emergent	Submerged	In general
<p>Glyphosate</p> <p>Application of glyphosate at 6 litres/ha to emergent stands from March to October. Regular treatment is required, and at least two applications may be necessary each year.</p>	<p>Submerged material can be treated with dichlobenil in March, or with diquat throughout the year. Submerged material will also die if connected emergent vegetation has been sprayed with glyphosate.</p>	<p>Regular treatment is necessary. Weed wiping may be appropriate in mixed marginal vegetation. Spot treatment of small patches will prevent complete dominance. Treat early and regularly.</p>

Parrot's feather

Fact file

Parrot's feather (*Myriophyllum aquaticum*) is a native of lowland central South America. It was first found in Britain in 1960 and has now spread to about 150 sites.

It grows in ponds, reservoirs, gravel pits, streams, canals and ditches, particularly where eutrophic water occurs. It can grow as a terrestrial plant when a pond dries out, and

has even been found growing on the dry bank of a rubbish tip in Cornwall. It produces emergent shoots in addition to submerged ones, which give it the characteristic feathery appearance, hence its name.

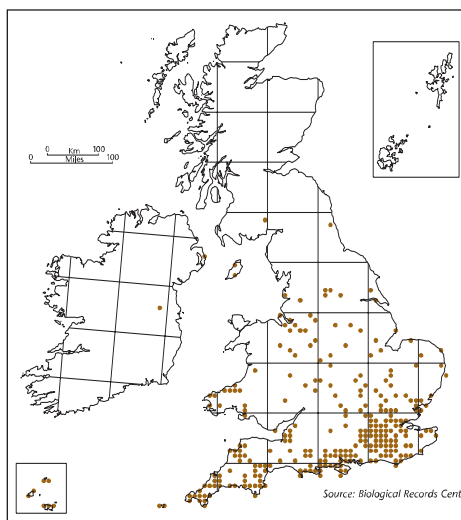


Only female plants are established in the UK and it therefore spreads by vegetative means only. The stems are brittle and the plant propagates by growth from small stem fragments. The species is attractive to look at and is widely grown in garden ponds. Introductions to the wild are usually not deliberate, but fragments can be concealed in the soil of other pot plants sold at aquatic garden centres and nurseries.

Control

Chemical control can be achieved by applying dichlobenil in spring to shallow water and to areas of damp ground. Applying diquat to emergent leaves and stems at 25 l/ha (only permitted until June 2004) during the growing period will also give good control. Glyphosate is less effective on this species, unless used with an approved wetting agent.

Cutting and dredging can be used very effectively in small areas, but all fragments should be removed to prevent regrowth and downstream spread.





Non-chemical control

Cutting	Pulling or dredging	Grazing
<p>Cut material must be removed from the water as soon as possible. Fragmentation must be avoided. Material should be cut as often as necessary and at least every six to nine weeks from March to October to weaken the plant.</p>	<p>Dredging shallow areas will remove this plant very effectively.</p> <p>Carefully pulling out stems by hand after mechanical removal will help to eradicate it.</p>	<p>The plant is not palatable to herbivores; cattle and horses will avoid it. There is virtually no insect damage to plants in the UK, but research into biological control agents is under way.</p>

CONTACT THE ENVIRONMENT AGENCY FOR DISPOSAL ADVICE

Chemical control

Emergent	Submerged	In general
<p>Apply glyphosate at 6 litres/ha to emergent stands from March to October. Regular annual treatment is required, and at least two applications will be necessary each year.</p>	<p>Treat submerged material with Reglone throughout the year. Submerged parts will die if the emergent portion has been regularly sprayed with glyphosate. Treatment usually lasts for three to five years.</p>	<p>Regular treatment is necessary. Weed wiping may be appropriate in mixed marginal vegetation. Spot treatment of small patches will prevent complete dominance. Treat early and regularly.</p>

Floating pennywort

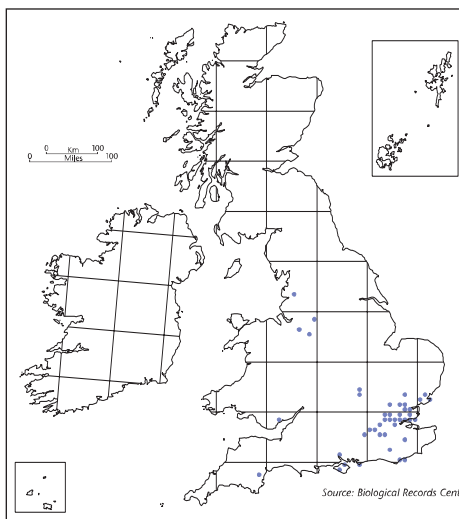
Fact file

Floating pennywort (*Hydrocotyle ranunculoides*) is a native of North America. It was first brought to Britain in the 1980s as a plant for tropical aquaria and garden ponds, and was first noted in the wild in Essex in 1991.

H. ranunculoides grows in the shallow margins of slow-flowing eutrophic water bodies (particularly ditches, slow flowing dykes and lakes), and forms dense interwoven mats of vegetation. These quickly cover the water surface interfering with both the ecology and amenity uses of the water body. These mats grow up to 15m from the bank in a single season, with stem growth rates of up to 20cm per day.

H. ranunculoides roots freely from nodes at approximately 40-60mm intervals. The roots are profuse and hair-like. The leaves are emergent, rising on stalks from horizontally growing stems. Both the stem and the petioles are fleshy. The leaf form ranges from circular to kidney-shaped; they are deeply lobed, and up to 180mm across. Leaves are held above the water surface whilst the interwoven mat of roots and stems sink up to 50cm into the water.

Reproduction in Britain is thought to be principally vegetative, and the plant is capable of forming extensive mats from the smallest shoot fragment. Introduction by seed, however, may also have



occurred. Floating pennywort can double its wet weight in as little as three days. The plant exhibits seasonally variable growth in Britain. Maximum growth occurs in the late summer when it typically forms the extensive floating mats of vegetation, whilst it over-winters in the margins and on banks as a much flatter and smaller plant.

The plant is relatively restricted in its distribution, largely in southern England and south Wales. Its appearance at the 90 sites so far reported is likely to have been as a result of escapes from aquaria and garden ponds. *H. ranunculoides* has already proved to be difficult to control because of its rapid growth rates, its ability to re-grow from a single node, and its resistance to chemical control.

Control

Chemical control can be achieved with herbicides containing 2,4-D amine and diquat. Glyphosate is less effective.

Cutting and removal is a very good method of management, but it will not control or reduce the vigour of the plant. The cut or dredged material should be left on site at the top of the bank, well away from water.

Non-chemical control

Cutting	Pulling or dredging	Grazing
Regular cutting from May to October will prevent complete dominance of this species. Cut material should be removed from the water immediately. Cutting should be followed by hand pulling or by spot treatment with chemicals to reduce the risk of regrowth.	Hand pulling works very well in small infestations and as a follow-up after major mechanical removal. Eradication is possible using this technique.	Cattle grazing has been seen to damage the emergent stems, but it has no long-term effect on the dominance of the plant. There are no known biological control agents.

CONTACT THE ENVIRONMENT AGENCY FOR DISPOSAL ADVICE

Chemical control

Glyphosate	2,4-D amine	In general
Applying glyphosate at 6 litres product/ha in 400 litres of water is the most effective treatment with this chemical. Repeat treatments will be necessary throughout the growing season as soon as regrowth occurs. The use of wetting agents to increase effectiveness is currently being investigated.	Applying 2,4-D amine at 4.5 kg active ingredient in 200 litres/ha of water per hectare provides temporary control. Re-treatment after exactly three weeks is required for more effective control.	The plant does not rot down very quickly after chemical treatment, and treated vegetation in flood-risk areas should be removed after two to three weeks if possible. Follow-up spot treatment after mechanical removal is recommended. Regular treatment is necessary.

Glossary

2,4-D amine – a selective translocated herbicide.

Axil – the angle where the leaf joins the stem.

Biomass – the amount of plant material produced during growth.

Contact – a herbicide that kills the parts of plants to which it is applied, for example leaves.

COSHH – Control of Substances Hazardous to Health.

Diquat – a non-selective contact herbicide used mainly for the control of submerged weeds and some algae. NB Only permitted for use until June 2004.

Eutrophic – water that has an excess of plant nutrients.

Glyphosate – a non-selective, translocated herbicide.

Hybrid – offspring of closely related species that are often more vigorous than either of the parents.

Node – region of attachment of leaves to the stem and of swelling on rhizomes from which roots and shoots arise.

Petiole – the stalk of a leaf.

Riparian – the area at the edge of watercourses.

Selective – term used for a herbicide that kills only one type of plant, for example only grasses or only broad-leaved weeds.

Succulent – fleshy or swollen.

Translocated – absorbed and distributed throughout the plant to the roots and shoots.

Wetting agent – a herbicide additive used to increase absorption of the herbicide through the waxy leaves of aquatic plants.

Whorl – a circular set of leaves arising at the same level on a stem.

Further information

There are many sources of information about invasive plants and methods of controlling them. The Centre for Aquatic Plant Management (CAPM) provides advice on the control of aquatic and riparian invasive species.

The following websites are useful:

The Environment Agency:
www.environment-agency.gov.uk

The Centre for Aquatic Plant Management:
www.capm.org.uk

Invasive Species Project:
www.appliedvegetationdynamics.co.uk

CABI Bioscience:
www.cabi-bioscience.org

The Global Invasive Species Programme:
jasper.stanford.edu/gisp/home.htm

The World Conservation Union:
www.iucn.org

Publications

CAPM information sheets

Child, L. & Wade, P.M. (2000) *The Japanese Knotweed Manual*. Packard Publishing, Chichester.

De Waal, L.C., Child, L.E., Wade, P.M. and Brock, J.H. (1994) *Ecology and management of Invasive Riverside Plants*. John Wiley & Sons.

Environment Agency (1995) *The use of herbicides in or near water*.

Environment Agency (2003) *Aquatic Weed Control Operation – Revised Best Practice Guidelines*.

Environment Agency and English Nature (2002) *Crassula helmsii: focus on control – an update*. NERC-CEH.

MAFF (1995) *Guidelines for the use of herbicides on weeds in or near water*. Defra publications.

CONTACTS:

ENVIRONMENT AGENCY HEAD OFFICE

Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4UD
Tel: 01454 624 400 Fax: 01454 624 409

www.environment-agency.gov.uk
www.environment-agency.wales.gov.uk

ENVIRONMENT AGENCY REGIONAL OFFICES

ANGLIAN

Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough PE2 5ZR
Tel: 01733 371 811
Fax: 01733 231 840

MIDLANDS

Sapphire East
550 Streetsbrook Road
Solihull B91 1QT
Tel: 0121 711 2324
Fax: 0121 711 5824

NORTH EAST

Rivers House
21 Park Square South
Leeds LS1 2QG
Tel: 0113 244 0191
Fax: 0113 246 1889

NORTH WEST

PO Box 12
Richard Fairclough House
Knutsford Road
Warrington WA4 1HG
Tel: 01925 653 999
Fax: 01925 415 961

SOUTHERN

Guildbourne House
Chatsworth Road
Worthing
West Sussex BN11 1LD
Tel: 01903 832 000
Fax: 01903 821 832

SOUTH WEST

Manley House
Kestrel Way
Exeter EX2 7LQ
Tel: 01392 444 000
Fax: 01392 444 238

THAMES

Kings Meadow House
Kings Meadow Road
Reading RG1 8DQ
Tel: 0118 953 5000
Fax: 0118 950 0388

WALES

Cambria House
29 Newport Road
Cardiff CF24 0TP
Tel: 029 2077 0088
Fax: 029 2079 8555



ENVIRONMENT AGENCY GENERAL ENQUIRY LINE

0845 9 333 111

ENVIRONMENT AGENCY FLOODLINE

0845 988 1188

ENVIRONMENT AGENCY EMERGENCY HOTLINE

0800 80 70 60



**ENVIRONMENT
AGENCY**



www.environment-agency.gov.uk

We welcome feedback including comments about the content and presentation of this report.

If you are happy with our service please tell us. It helps us to identify good practice and rewards our staff. If you are unhappy with our service, please let us know how we can improve it.

For further copies of this report or other reports published by the Environment Agency, contact general enquiries on 0845 9333111 or email us on enquiries@environment-agency.gov.uk



**ENVIRONMENT
AGENCY**