This interactive pdf has been created to archive web pages from the decommissioned Japanese Knotweed Alliance website.

CABI | Japanese Knotweed Alliance

Japanese knotweed is one of the most high profile and damaging invasive weeds in Europe and North America

The Department for Environment, Food and Rural Affairs (Defra) and the Welsh Government have approved the release of the psyllid, *Aphalara itadori* to help stop the spread of Japanese knotweed.

The psyllid release programme began in Spring 2010 at two closely monitored sites in England. This, along with releases to outdoor cages, enabled safety testing in the field, which confirmed the extensive lab safety data. The next stage of the controlled country-wide release of the psyllid happened at eight carefully selected sites containing Japanese knotweed in England and Wales. Psyllids were released at these sites in 2011-2013. The sites, and paired control sites on which the psyllid has not been released, continue to be closely monitored. Sightings of psyllids at several sites in the Spring show that the psyllids can overwinter successfully. Large-scale field cage studies in 2014, where a greater number of psyllids have been released, confirm their safety at higher densities. It is hoped that establishment and population growth will follow, but this stage can take time.

CABI, who have undertaken the scientific research, are world experts in natural control. CABI has an excellent international track record for discovering, safety testing, and assisting governments release natural control agents. To find out more, visit www.cabi.org.

For further information, please use the links above, or download an information pack which will provide you with information about the plant, the project and the scientific research carried out.

About us

In 2001 a consortium of partners were brought together to form a project management board. The aim of the board was to oversee a scientific research programme which examined the potential for biological or natural control of Japanese knotweed in Great Britain.

The research is carried out by CABI and funded by a consortium of partners:

CABI

CABI is a science-based not-for-profit organization that specialises in agricultural and environmental research. Its mission and direction is influenced by its 45 member countries who help guide the organisation's activities. These include scientific publishing, projects and consultancy, information for development and mycological services.

CABI was contracted to undertake research on behalf of the project board. CABI scientists have been conducting research into potential natural control agents to combat Japanese knotweed since 2000. This work entailed the collection, identification and selection of Japanese knotweed's natural enemies. Potential agents were assessed in a Defra-licensed quarantine facility and all work was carried out according to international protocols. www.cabi.org

Defra

The Department for Environment, Food and Rural Affairs role is to help enable people to live within their environmental means. Defra's priority is to ensure that the resources we need and environment we enjoy continue to be available for us all, now and in the future.

Defra holds policy responsibility for non-native species and plant health. It is working with the Central Science Laboratory (the licensing authority) to ensure that a scientifically rigorous licensing process is followed before any release of a natural control agent for Japanese knotweed. www.defra.gov.uk

Environment Agency

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

The Environment Agency is committed to improving the ecological quality of our water environment. It is also responsible for managing flood risk. River corridors dominated by a dense monoculture of Japanese knotweed damage biodiversity and reduce the capacity of the watercourse to cope with floodwater. It also reduces the amenity value of the river and its aesthetic value to the local community. Currently, herbicides are used to manage Japanese knotweed. The Environment Agency seeks a safe, specific and sustainable alternative that will pose no risk to water quality or the wider environment. www.environment-agency.gov.uk

Welsh Assembly Government

The Welsh Assembly Government aims to ensure the development of 21st century Wales as a self-confident, prosperous nation, committed to social justice and sustainability. Accountable to the National Assembly for Wales, it offers a progressive agenda for improving quality of life for all communities, including measures to support the Welsh language.

The former Welsh Development Agency (WDA), now part of the Welsh Assembly Government's Department for the Economy and Transport, provided funding to conduct research into a natural control for Japanese knotweed. The WDA was one of the founding members of the research programme and the alliance. Funding for some of the preliminary research phases which has led to the current successful phase of work also came from Wales. Japanese knotweed has a huge economic cost to development and regeneration in addition to the impacts on biodiversity and landscape. The costs of eradicating Japanese knotweed from a site due to be developed can be extremely significant, particularly South Wales which is one of the worst affected areas in the UK. The Welsh Assembly has worked in partnership with a variety of other UK-wide funding bodies to support this research by CABI into the natural control of Japanese knotweed. www.new.wales.gov.uk

South West Regional Development Agency

The South West Regional Development Agency leads the development of a sustainable economy in South West England. The Agency's core strategy is focused on creating the conditions for productivity-led growth.

Network Rail

Network Rail is the 'not for dividend' owner and operator of Britain's railway infrastructure, which includes the tracks, signals, tunnels, bridges, viaducts, level crossings and stations - the largest of which we also manage. Their aim is to provide a safe, reliable and efficient rail infrastructure for freight and passenger trains to use.

Network Rail is working hard to create a lineside environment in order to run a safe and reliable railway, incorporating open space, grassland, low-growing shrubs and trees. Japanese knotweed undermines Network Rail's efforts owing to its fast, voracious growth rate, and it can cause damage to buildings and embankments while out-competing native species. Successfully controlling Japanese knotweed takes up valuable resources in terms of time and money – resources that could be better spent elsewhere on maintaining and improving the railway. www.networkrail.co.uk

Cornwall Council

Cornwall Council is Cornwall's largest democratic organisation and is focused on providing a strong and sustainable community for one and all. It aims to do this by improving individual development and well being, fostering the success of all communities, enhancing the living environment, promoting Cornwall to the world, being a strategic, ambitious, accountable and well-managed Council, providing leadership and delivering services.

Cornwall Council, on behalf of the Natural Control of Japanese Knotweed Board, is responsible for the co-ordination of the project. It is hoped that this research will identify another control method to complement and, in some cases, replace existing treatments. www.cornwall.gov.uk

Canal & River Trust

The Canal & River Trust (formerly British Waterways) cares for 2,200 miles of historic canals and navigable rivers, working to ensure that the 200-year old network continues to benefit the nation now and into the future. It works with a broad range of public, private and voluntary sector partners to unlock the potential of the inland waterways and generate income for reinvestment in the network for the benefit of the millions who visit the waterways every year. www.canalrivertrust.org.uk

News and information

Latest News

View the latest report on June 2013 update on CABI's weed biocontrol work in the UK

International Organisation for Biological Control, Newsletter 89, August 2011

"Japanese knotweed might just have met its match" (Telegraph, 3 Feb 2011)

"Insect that fights Japanese knotweed to be released" (BBC News online, 9 March 2010)

"Insects to be brought in to control Japanese knotweed" (Daily Telegraph, 9 March 2010)

Public consultation and government approval (9 March 2010)

"Could a tiny insect halt the invasion of Japanese knotweed?" (Guardian, G2, 14 August 2009)

BBC Radio 4's Today Programme (23 July 2009): interview with Dr Dick Shaw on the natural control of Japanese knotweed in the UK (YouTube video)

"Views sought on knotweed predator" (BBC online, 22 July 2009)

"UK may bring in insect to tackle Japanese knotweed" (Reuters UK, 23 July 2009)

"A knotty problem: could a tiny insect help rid us of knotweed" (Guardian Gardening Blog, 23 July 2009)

"Japanese knotweed out of control" (Wales online, 24 July 2009)

Useful links

For more information about Japanese knotweed:

Cornwall Council advice for managing Japanese knotweed

Cornwall Knotweed Forum

Devon Knotweed Forum

Environment Agency's advice of managing Japanese knotweed

Environment Agency's Knotweed advice for developers

For more information on natural/ biological control:

Biological Control Information Center

Biocontrol news and information

CSIRO weed biocontrol overview

The Biological Control of Weeds Book – Landcare research

For more information on invasive species:

CABI invasive species compendium

Global Invasive Species Database

Invasive Species Specialist Group

Non-native Species Secretariat (NNSS)

USA National Invasive Species Information Center

Other:

Wildlife & Countryside Act

Contact us

For all enquiries, please contact:

E: biocontrol@cabi.org

What is Japanese knotweed?

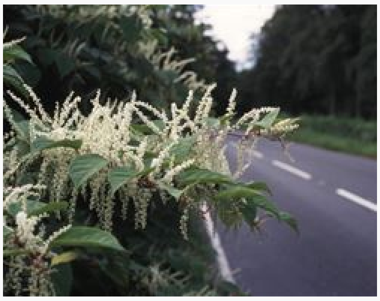
Japanese knotweed can grow more than a metre a month and is famed for pushing through tarmac, concrete and drains. Its effect on native species is often devastating as it out-competes indigenous species covering large tracts of land to the exclusion of the native flora and associated fauna.

Japanese knotweed was brought to Britain from Japan as an ornamental garden plant in the mid-nineteenth century. However, over time it has become widespread in a range of habitats, particularly roadsides, riverbanks and derelict land where it causes serious problems by displacing native flora and causing structural damage.

Due to its vigorous nature and the damage it causes it is one of only two terrestrial plants listed by the UK Wildlife and Countryside Act as illegal to cause it to grow in the wild.

An estimate in 2010 put the cost of Japanese knotweed to the British economy at £165 million (Williams *et al.*) and would cost £1.56 billion were control to be attempted countrywide. These control methods which rely mainly on chemicals have been deemed unsustainable by many and so a longer-term solution to the problem is required.

About the plant



Native to Eastern Asia, Japanese knotweed grows to a height of two to three metres in the UK. It has flecked bamboo-like stems, arching branches and large spear shaped green leaves of up to 12cm long. Clusters of creamy white flowers appear at the tips of the stems late in the season between August and September. The rhizomes (underground stems) can stretch up to seven metres from the parent plant and to a depth of three metres.

Reproduction

Male and female plants are required for reproduction to occur. Japanese knotweed however, is an extraordinary example of an invasive plant since almost every plant outside Japan is derived from the same mother plant. In total biomass terms, this clone is probably the biggest female in the world! In Swansea alone the infestation has been estimated to weigh 62,000 tonnes, which equates to 400 blue whales!

How does is spread?

Japanese knotweed thrives on disturbance. Pieces of rhizome or stem can be spread by fly-tipping or carried by waterways, especially after heavy rains or flooding. Thus, clusters of Japanese knotweed are often found on riverbanks, roadsides and redevelopment sites.

What's in a name?

Japanese knotweed belongs to the plant family Polygonaceae: ‘Poly’ means many, and ‘gony’ is from the Greek for ‘knee’, giving 'many jointed'.

The scientific name of Japanese knotweed in current use is *Fallopia japonica*, although some scientists still use *Polygonum cuspidatum* (USA) and *Reynoutria japonica*.

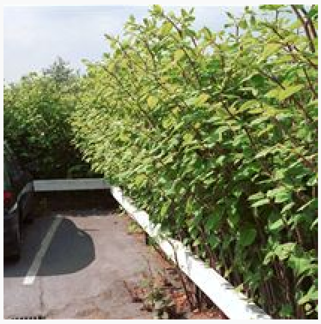
In Japan, the plant is commonly known as 'itadori' which translates as 'take away pain' as it’s used in traditional medicine. In its introduced range, other common names include Sally rhubarb, donkey rhubarb, gypsy rhubarb, Hancock's curse, pysen saethwr, ladir tir, glúineach bhiorach, Mexican bamboo, German sausage plant, Japanese bamboo, Japanese fleece-flower and wild rhubarb.

Why is Japanese knotweed such a problem?

Japanese knotweed is not native to Europe and was introduced to the UK without its natural enemies. In Japan, the plant generally grows in harmony with the environment and is not considered to be invasive.

One could say it has an unfair advantage over native species because the controlling influence of the many insects and fungi that attack the plant in its native range has been removed. Our native species have not taken a shine to knotweed and very few if any insects or fungi can be found on the plant even after almost 200 years.

An estimate put the cost of control, were it to be attempted UK-wide, at over £1.56 billion. Such control methods, relying mainly on chemicals, are widely considered to be unsustainable and so a longer-term and cost effective solution to the problem is required.



Biodiversity – Knotweed affects ecosystems by crowding out native vegetation and limiting plant and animal species diversity. Recent studies led by the CABI team in Switzerland have proved that knotweed areas suffer reduced species diversity. They have even found evidence of allelopathy (the release of chemicals that suppress the growth of other plants). It has been described as having the biodiversity value of concrete!

Water quality and flood risk – Aquatic organisms are less able to process knotweed leaf litter compared with the native vegetation it displaces and this has the potential to alter food chains. Dense summer foliage causes heavy shading of small streams, which reduces aquatic plant communities. Profuse knotweed canes also reduce the capacity of river channels to carry floodwater, as well as blocking sluices and grids. In winter, the riverbanks become exposed when the knotweed dies back, increasing erosion and silting fish spawning gravels.

Recreation – Knotweed is a nuisance to anglers, boaters and other river users as it impedes access. It is visually unappealing and can block panoramic viewpoints.

Infrastructure – Knotweed's stout rhizomes (underground stems) are notorious for pushing through asphalt, building foundations, concrete retaining walls and even drains, causing significant damage. This can add huge costs to development and regeneration schemes. Contaminated soil should be treated as controlled waste.

Housing devaluation – Knotweed found on or close to a property can have an impact on its actual and perceived value. An increasing number of mortgage providers are refusing applications for properties where knotweed is revealed to be present (RICS).

Safety – Knotweed is capable of obscuring railway signals and road signs as well as causing trip hazards in paving.

Costs – Japanese knotweed costs Great Britain an estimated £165m every year (Williams *et al* 2010) and the cost of eradication, were it to be attempted UK-wide, could be more than £1.56 billion. Such control methods, relying mainly on chemicals, are widely considered to be unsustainable and so a longer-term and cost effective and more environmentally friendly solution to the problem is required.

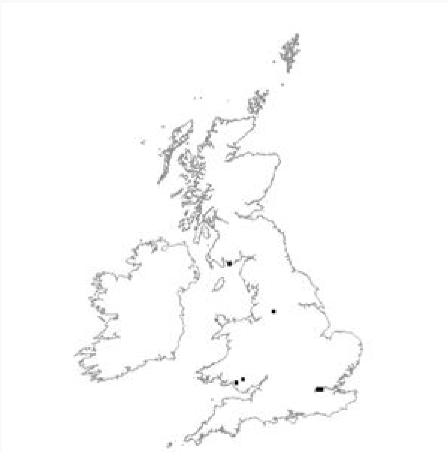
Distribution of Japanese knotweed

Japanese knotweed is still spreading rapidly despite our best efforts. Since its introduction the species has spread throughout the British Isles, only the Orkney Islands are exempt.

Its distribution also covers much of mainland Europe from southern France and northern Italy to Norway. Beyond Europe it is found in many states in the USA from California to Washington and throughout Canada and is increasingly being reported as a nuisance weed in New Zealand and Australia.

The spread of Japanese knotweed across the British Isles

1900



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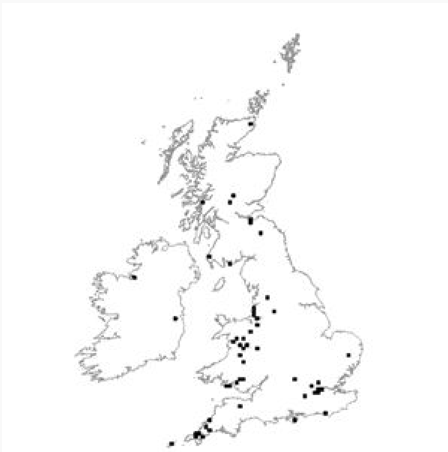

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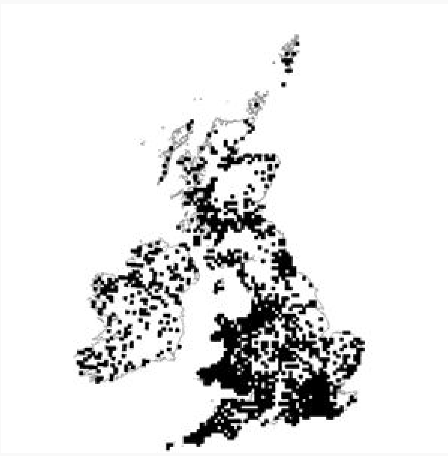

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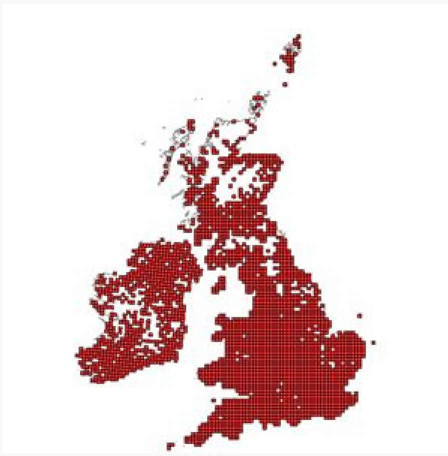

Current methods of control in the UK

Japanese knotweed is not an easy plant to control as the extensive underground rhizome system sustains the plant even when top growth is removed. Therefore treatment often needs to be repeated for long-term control to be achieved.

For detailed information on control and prevention measures, please see the Environment Agency's website.

Chemical control

Users must be aware of the risks involved when using chemicals to control any plant especially if it grows near water. Consent to use specific herbicides near UK waterways must be sought from the Environment Agency.

If there is no risk of run-off to watercourses, contamination of groundwater and where no sensitive vegetation will be affected, a wider range of herbicides can be used. Those chemicals that are persistent in the soil may delay the planting of replacement species. Herbicides are usually sprayed but can also be applied directly to target plants using a weed-wiper or herbicide glove. Commonly used glyphosate-based herbicides are most effective in late summer however specialist advice for the most appropriate treatment should be sought (see Useful links). Some herbicides can also be injected into the hollow stems of the plant immediately after cutting, however this is time consuming and costly.

Repeated herbicide treatments over several years are normally recommended for complete control of Japanese knotweed. Continued monitoring of the treated areas should also be carried out to ensure that no new shoots appear.

Physical removal

For short term control, Japanese knotweed can be cut, taking care that fragments of splintered stem are not spread. The young shoots of Japanese knotweed can also be eaten by sheep, goats, cattle and horses and grazing may be used in suitable situations to keep the plant under control. However, this will not eradicate Japanese knotweed and the plant will continue to grow once grazing ceases.

Japanese knotweed can regenerate from very small fragments of rhizome (as little as 0.7 gram). It is an offence to cause this plant to grow in the wild in the UK under the 1981 Wildlife and Countryside Act and any waste material from cutting, mowing or excavation, should be disposed of according to the Environmental Protection Act 1990 (Duty of Care) Regulations. Equipment that is likely to result in further spread of Japanese knotweed, such as a flail mower should not be used.

Costs

The British Government's Non-Native Species Policy Review gives an estimate of the costs to control knotweed countrywide of £1.56 billion were it to be attempted.

Swansea is one of the worst affected areas in the UK. Here alone, the cost of completely treating the infestation using chemical or manual treatment (£1 and £8 per sq/m respectively) would cost around £9.5 million. With the current rate of treatment standing at 2ha per year the current infestation will take 50 years to treat without accounting for its rapid spread to new areas.

It is the building sector that feels the financial impacts of knotweed the most with removal costs from development sites being very expensive. One 30mx30m site in Wales cost developers an extra £52,785 to deal with the removal of knotweed. The worst case scenario for a 1m2 patch of knotweed on a development site has been estimated to be up to £54,000.

Also, Knotweed found on or close to a property can have an impact on its actual and perceived value. An increasing number of mortgage providers are refusing applications for properties where knotweed is revealed to be present (RICS).

What is natural control?

Natural (or biological) control, is the use of living organisms to control pest populations.

Increasing trade and travel between countries has increased the number of plants and other non-native species arriving in the UK. The majority arrive without their natural enemies that keep them in check in their native range. In the case of plants almost all the insects, fungal pathogens or nematodes that would normally inflict damage on the plant are lost, giving the plant an unfair advantage over its new neighbours.

Natural control is a means of levelling the playing-field by re-introducing some of the specialist natural enemies that exert control on it in its native range.

A sustainable alternative

The use of self-replicating and co-evolved natural enemies for the long-term management of invasive alien species is a sustainable solution. Once established an effective agent provides control indefinitely without further cost or intervention.

Natural control has been used effectively against invasive species for over one hundred years.

What is known as the 'classical approach' is being proposed for Japanese knotweed. This method involves going back to where the invasive species originated (in this case Japan) and finding the natural enemies that keep the species in check.

Only after intensive research and vigorous safety testing to ensure this is specific to Japanese knotweed, will an agent be considered for release into the newly colonised area. In effect, this method utilises natures own in-built mechanisms to ensure equilibrium.

It is obviously important that potential control agents such as insects or pathogens don't attack other plants, especially crops or endangered species. Scientists therefore spend considerable time (at least three years) studying the host range of any potential agent within a secure quarantine facility adhering to the International Code of Conduct.

This testing enables them to predict which, if any, other plant species might be at risk. Only once these stringent tests have been carried out to prove the natural control agent is safe, is an application for release made.

Find out more about natural control successes

Natural control - the advantages

Environmental – Natural control is exactly that – natural – and does not rely on the use of man-made chemicals that can impact adversely on the ecosystem in which they are used. Furthermore, the amount of herbicides required for weed control can be reduced.

Cost – After the initial research costs there is virtually no need for further expenditure once the agents are established and having an impact on the weed, bar monitoring activities.

Sustainability – It is permanent and therefore completely sustainable. The weed is continually under attack from an army of natural enemies.

Spread – The control agents, be they insects or pathogens will locate and affect most, if not all, populations of a weed until stopped by physical, environmental or chemical barriers, just as they have done in their native range.

Safety – Natural control agents should pose no threat to human health, crop production or beneficial organisms.

Landscape – Whilst the agents are doing their job on the Japanese knotweed, the native flora, which was previously out-competed, should be able to gradually recover and re-colonise areas without the need for extensive replanting.

Disadvantages

Control not eradication – A successful agent should not eradicate the weed on which it depends, but should reduce it to acceptable levels. There may be costs associated with alternative control methods.

Timescale – It takes time. It can take five to ten years from release to achieve successful control.

Previous natural (biological) control successes

Natural (biological) control of rubber vine in Australia

The rubber vine weed was introduced to Australia from Madagascar in the 19th century as an ornamental garden plant and as a source of latex. An aggressive climber, capable of smothering trees up to 40 metres high, it was described as the single biggest threat to natural ecosystems in tropical Australia and had a huge impact on pastoral areas.

By the late 1980s the rubber vine infestations were vast, covering 40,000 km2 (that's twice the size of Wales) across often remote areas. Wide-scale chemical control was considered impractical, uneconomic and environmentally undesirable. As the weed advanced towards the prestigious national parks of the Northern Territory, urgent calls were made for its widespread control.

Exploratory surveys by CABI scientists in Madagascar revealed a rust fungus, *Maravalia cryptostegiae*, to be a highly promising biological control agent. After extensive trials to assess its safety, aerial releases were made in Australia in 1995 and it is proving to be one of the most successful biological control programmes ever carried out against an alien invasive weed.

Originally predicted to take 10 years, the rust delighted farming communities by bringing the weed under control earlier than expected, defoliating and killing the weed and allowing regeneration of native forests, providing a net value of AUD $232.5 million – a figure which grows year on year.

Natural (biological) control of the cassava mealybug in Africa

Cassava, yucca or manioc was introduced from South America into Africa by the Portuguese in the 16th century and is today the staple root crop for more than 200 million people in Africa alone. This major source of carbohydrates came under threat from a devastating pest, the cassava mealybug.

Cassava mealybug was first recorded in Congo and Zaire (now Democratic Republic of the Congo) in the early 1970s and quickly spread over the whole of the cassava growing area of Africa, since there were no natural enemies to control it in its new habitat.

In Africa, it led to the complete collapse of cassava production, depriving several hundred million people of one of their main carbohydrate sources not to mention livelihoods. In a combined effort involving IITA, CABI, IAPSC and other agencies, biological control agents were found in South America following extensive fieldwork. A parasitoid wasp *Anagyrus lopezi* was quarantined in the UK, then shipped to Africa, mass reared, and finally release was authorized for field trials.

The cooperation was so successful that in the whole of sub-Saharan Africa cassava mealybug is now under complete control and poses no threat anymore.

The programme cost, according to Swindale (1997) about US$ 27 million, while the benefits are estimated at US$ 4.5 billion! The real beneficiaries are the millions of cassava growing smallholders who – often unaware of the programme or the parasitoid wasp – enjoy the fruits of this work. Food security is increased through improved harvests and health through reduced pesticide use, both of which come at no cost for the smallholders who receive the full benefits.

Natural (biological) control of purple loosestrife in North America

The popular European native purple loosestrife (*Lythrum salicaria*) was introduced to the US and Canada as an ornamental plant, however it has since invaded the natural environment forming large stands and degrading many prime wetlands. Purple loosestrife is an herbaceous perennial which grows up to about 1.5 metres in height. In its native range in Europe, the plant can be found on the margins of lakes and swamps and rarely dominates these environments.

The costs associated with the control of purple loosestrife are huge – in the late 1980s around $45.9 million was spent each year to control this weed across 19 US states.

The weed is now found in 48 states of the US where it crowds out nearly 50 native plant species, endangers rare marsh wildlife, and restricts access to open water. A single plant can produce up to three million tiny seeds annually which are easily carried by wind and water, and germinate in moist soils after overwintering. The plant can also sprout anew from pieces of root left in the soil or water. Once established, loosestrife stands are difficult and costly to remove by mechanical and chemical means.

To bring this weed under control, a biological control programme began in 1987. CABI scientists evaluated more than 100 insect species that feed on purple loosestrife in its native range in Europe.

After extensive testing, six agents proved to be safe for release in North America. Of these, two leaf-eating beetles – *Galerucella calmariensis* and *G. Pusilla* – proved to be particularly effective at controlling the invasive weed.

As a result of this work, this aggressive invader is now being successfully controlled in the western and mid-western USA – 95% of purple loosestrife is destroyed within two to five years of release – allowing native wetland plants to flourish once more.

Scientific Research

CABI scientists have been researching the possibility of using natural control methods to curb the onslaught of Japanese knotweed in the UK since 2000.

Initial research

The first phase of the project saw a team of British scientists from CABI and Leicester University visit Japan to carry out an initial survey of the plant in its native range. With considerable assistance provided by Japanese scientists, the team visited 31 sites across nine regions. Altitudes ranged from sea level to 1,550 meters above sea level and in all, a total of 3,400 km were covered.

This research revealed that the plant was much less prolific in Japan than in the west due in part to the considerable stress it was under from a whole host of natural enemies. Many of these insects and fungi were collected for identification and initial testing in CABI's UK quarantine facilities.

Literature review

An essential step in natural control programmes is to carry out a thorough review of any previous literature on the subject. This ensures that all current knowledge on the plant and its known natural enemies is captured so future research will add to this. This review of both the Japanese and English language literature revealed that a large number of natural enemies present in Japan, were not present in the UK.

Further field studies

Following this initial research, a four year programme began in 2003. Regular field studies were carried out in Japan across the seasons to increase the knowledge of natural enemies in the field and ensure that none were missed. This involved crucial assistance from the team at the Biological Control Laboratory of the University of Kyushu in Fukuoka.

In all, more than 200 insects and fungi were found to feed on Japanese knotweed in Japan. A small proportion were prioritised based on their behaviour in Japan and what scientists believed would be their likely impact on Japanese knotweed in the UK.

Test plants

In order to check whether the insects or fungi were specific to Japanese knotweed (ie. didn't feed on or attack other plants), a comprehensive test plant list for the UK was compiled using standard International procedures. This consisted of more than 70 closely-related species. These included representatives from 23 families, of which 33 are natives, 15 are introduced species, 3 are native to Europe, 13 ornamentals were tested against, as were 10 closely related economically important species. 51 of these species are in the Polygonaceae, the same family as Japanese knotweed.

Work was carried out in CABI's strict quarantine facilities exposing natural enemies to non-target plants in order to ensure the safety of any future release.

Selecting the agents

Using the test plant list, host specificity can be determined in the laboratory. Techniques include starvation, development and choice tests for insects and infection and spore production studies for fungi. Any fungus or insect being considered for use as a natural control agent that threatened any of these plants would be dismissed. For example, during early studies a sawfly and a rust fungus were found to attack a few species of dock and were therefore instantly rejected as potential control agents.

From these studies a sap-sucking Aphalara psyllid, and a Mycosphaerella leafspot fungus where identified as potential control agents. These are both restricted to Japanese knotweed in Japan and as lab studies show, here in the UK too.

What now?

The psyllid release programme has a very thorough monitoring component that involves the regular survey of the knotweed, associated vegetation and invertebrates inside and outside knotweed stands at all eight pairs of release and control sites. At present, there is no obvious impact of the psyllid due to small population size but we hope to see positive impacts soon once population sizes increase.

For a brief overview of this and other biocontrol research in the UK, have a look at our latest report.

Compiling a test plant list for the biological control of Japanese knotweed

What is a test plant list

Besides the identification of potential biological control agents, the compilation of a test plant list is arguably the second most important component of any biological control programme. Any potential non-target effects must be critically evaluated prior to release to ensure the safety of native, economically important and ornamental plant species. The species on the test plant list are used to scientifically evaluate the specificity of the biological control agents, ensuring they only feed or infect the target weed.

Choosing which plants to test

All plant species are categorised into groups depending on their relatedness to one another. Based on morphological and phylogenetic similarities, the most closely related species form a group called the genus. Because of their similarities, members of a genus are much more likely to react in a similar way. This is the basic premise behind the scientific method used to draw up the test plant list for the proposed agents for Japanese knotweed.

Known as the 'centrifugal phylogenetic method', this model for test plant selection has been used to great effect for over 30 years. It focuses on the most closely related species to the target weed in the area of introduction, gradually expanding the number of species to include more distantly related plants until specificity is established. Within a framework of risk assessment, further plants considered to be at potential risk can also be added to the test list. This allows for plants which have a similar habitat or are ecologically similar to the target weed be tested against to ensure they won't be affected. Finally, plant species which are known to be attacked by related organisms to the proposed biological control agent, either in the plants native or introduced range, are also be included. This approach continues to serve as the basis of current host-range testing protocols as recognised by the IPPC Code of Conduct for the Import and Release of Exotic Biological Control Agents (ISPM No.3).

The test plant list for Japanese knotweed

Japanese knotweed belongs to the genus Fallopia. All plants of the genus native to the UK, and those which occur in the native range and have been introduced to the UK as ornamentals, were included on the list. We then move onto the 'family'. This is made up of a number of genera which each contain common ancestors. Although these plants may differ in form due to their evolutionary diversion, they still maintain common attributes. The genus Fallopia belongs to the family Polygonaceae which contains over 1,100 species worldwide and contains some well known genera which are native to the UK including Rumex (Docks and Sorrels), Polygonum (Knotgrass) and other genera not native to the UK but of economic importance including Rheum (Rhubarb) and Fagopyrum (Buckwheat). Where species were present in the UK from the genera of Polygonaceae, either in the form of native or introduced species, representatives were selected from each group.

Representative species were also selected from all major families of the order Cayophyllales (carnations, amaranths etc), as were plants species which have a similar biochemical and morphological composition to that of Japanese knotweed. Finally, 10 economically important plant species, mainly crop species, were included into the test plant list, as even though it is highly unlikely that these species would ever be affected, it is important to ensure their absolute safety given their importance.

In the UK, many of the most closely related species to Japanese knotweed are themselves invasive non-native species, such as *Fallopia sachalinensis* (Giant knotweed), *Fallopia baldschuanica* (Russian vine) and Fallopia x bohemica, which is a hybrid of Japanese and Giant knotweed. We only have two native species of Fallopia, namely *Fallopia convolvulus* and *Fallopia dumetorum*. Both bindweeds, the former is a widespread weedy species of gardens and wasteland and the later is a rather rare species which is found growing in hedgerows in central England. The test plant list included the entire native and introduced species from the genus Fallopia found in the UK.

In total, the test plant list for the biological control of Japanese knotweed contained 90 species and varieties including representatives from 19 plant families. This included 37 species which are native to the UK, 23 species introduced to the UK, 3 species native to mainland Europe, 13 ornamental species and 10 economically important UK species.

Sourcing and growing the test plants

The plant species in the test plant list were sourced from numerous suppliers throughout the UK, Europe and America in the form of seeds, whole plants and rhizomes (root matter). All species were grown in CABI's greenhouse facilities by plant technicians and their maintenance was by organic means only, as any chemical application may have affected the way the biological control agent behaves on the plants.

The potential agents

The sap-sucking psyllid *Aphalara itadori*

On 9 March 2010 approval was granted by Defra to release the psyllid and the release and monitoring programme is underway.

The psyllid Aphalara itadori is a true knotweed specialist that sucks the sap from the plant. It is about 2mm in length and capable of causing significant damage to the target weed.

It is the juvenile nymphs that cause the most damage to the plant and so where the adult psyllids choose to lay their eggs is highly important. In order to find out where the psyllid lays its eggs and whether any damage results, extensive tests were carried out on over 90 species of plants. In total, the location of more than 145,000 eggs were recorded. Only 0.6% of these were laid on non-target species or varieties and not one of those eggs was able to develop successfully to adulthood.

These findings were supported by further studies in which nymphs were physically transferred onto non-target plants and again, no adults developed. Research also shows that adult psyllids simply cannot survive even on the most closely related species to Japanese knotweed in Britain.

Based on this research, following an intentional release in Great Britain, the *A. itadori* psyllid should pose no threat to anything other than Japanese knotweed and the damaging hybrid variety – bohemian knotweed (Fallopia x bohemica). The rate and nature of its reproduction should mean establishment and multiplication would be successful. Furthermore, it should also be possible to integrate the psyllid control programme with current management regimes which would improve control efficacy at sites where traditional control remains necessary.

The leafspot - *Mycosphaerella polygoni-cuspidati*

During the original survey, work a leafspot fungus (Mycosphaerella sp.) was observed, with damage on knotweed very commonly seen all over Japan. Its potential as a biocontrol agent was assessed alongside a rust fungus (Puccinia sp.).

The rust was rejected after failing the rigorous safety testing procedure, but the leafspot showed promising impact and safety. However, the decision was made to focus research efforts on the psyllid, on which more progress had been made.Thanks to Defra funding, the research on the leafspot has resumed and we aim to finish the safety testing of this potential agent shortly.

Giant knotweed and hybrids

Japanese knotweed (Fallopia japonica) is not the only knotweed. In fact, there is both a dwarf variety (F. japonica var. compacta) and a separate species - Giant knotweed (Fallopia sachalinensis).

In addition there are some established hybrids: One is a cross between Giant and dwarf knotweed; and the other, a cross between Giant and standard Japanese knotweed. Both of these hybrids are called Fallopia x bohemica. There is also the rare hybrid between Japanese knotweed and Russian vine known as F. x conollyana.

The figure below shows the known extent of hybridisation. Many of these hybrids are only known about from the seeds collected from knotweed plants. So hybrids are being produced but for some reason are not generally becoming established. Any large knotweed plant that is 'male' and is not Giant knotweed (F. sachalinensis) is likely to be the hybrid F. x bohemica. This can be confirmed by an examination of the underside of the larger leaves, where a good hand-lens or low power microscope will reveal numerous short pointed hairs.

Frequently Asked Questions

Why has Japanese knotweed become such a problem?

Japanese knotweed is one of the most damaging invasive weeds in the UK, Europe and North America. Growing up to a metre a month, it can push through tarmac and concrete. Its effect on native species is often devastating as it out-competes indigenous species covering large tracts of land to the exclusion of the native flora and associated fauna. Fly tipping, inappropriate management and poor control efforts have exacerbated the problem.

Japanese knotweed costs Great Britain an estimated £165m every year (Williams *et al* 2010) and the cost of eradication, were it to be attempted UK-wide, could be more than £1.56 billion.

What is a psyllid?

The psyllid *Aphalara itadori* is a true knotweed specialist that sucks the sap from the plant. It is about 2mm in length and its nymphs are capable of causing significant damage to the target weed. More information on the psyllid.

How was the psyllid identified?

A six-year scientific research project was coordinated by a project management board including Cornwall Council, Defra, the Environment Agency, Welsh Assembly Government, Network Rail, South West RDA and British Waterways to establish whether natural control is a feasible method for the long-term, sustainable management of Japanese knotweed in Great Britain. The research was carried out by CABI.

Out of more than 200 insects and fungi feeding on the plant in its native range, extensive research has shown that *Aphalara itadori* is the best candidate to help control Japanese knotweed in Britain. The psyllid has been tested on 90 non-target species of plant including those closely related to Japanese knotweed as well as ornamental plants and important crops and these were not affected.

The research has been peer-reviewed by independent scientists and the risk assessment for the study assessed by the Advisory Committee on Releases to the Environment (ACRE) amongst others.

How can one tiny psyllid do the job?

One tiny organism on its own will not have much effect but once it has reproduced for a few seasons with a very large food supply, the population can grow to become a force to be reckoned with. Although the population of a species does not normally expand very rapidly, this is much more likely to occur in the case of a natural control agent, since they too have lost their natural enemies. The psyllid should continually debilitate the plant and prevent it from competing as successfully.

How effective will the psyllid be as a biological control agent for Japanese knotweed?

Efficacy studies have been carried out in the quarantine laboratory on potted plants; these showed that the psyllid nymphs, even in relatively low numbers, could reduce the rate of growth of potted knotweed plants, causing stunting and deformation of the upper leaves. However, the proof can only come in the real conditions in the field and the monitoring programme currently in place will reveal efficacy.

Was there a public consultation?

Yes. A full public consultation was carried out in the third quarter of 2009.

Has biological control been used for weeds before in the UK?

No. When the psyllid was released it was the first intentional release of a non-native organism to control an invasive non-native plant in Europe. However, there is a long history of using natural enemies to control insect pests in Europe. An example is the release of a specialist predator to control the invasive spruce bark beetle which to this day is still providing a long term solution to this economic pest. In addition biocontrols are regularly used on a smaller scale within the horticultural industry and even in householders' glasshouses for example to control aphids and other crop pests.

Are there any other examples of where non-native species have been used to control other non-native species in the UK?

Yes. There is an example regarding an animal species. The non-native predatory beetle, *Rhizophagus grandis*, was released under licence in the mid 1980's to tackle the invasive non-native spruce bark beetle (*Dendroctonus micans*). The predator is now well established and follows the spruce bark beetle as that spreads, keeping the latter under control. Occasional releases are made where distribution of the spruce bark beetle 'jumps' eg. is accidentally transported some distance. This is an example of natural, or biological, control as a non-native species was deliberately introduced in order to tackle another invasive non-native species. *Aphalara itadori* will be the first such example targeting an invasive non-native plant species.

What about the rest of the world?

There have been over 1,400 releases of natural control agents against weeds around the world. In all, more than 400 different agents have been released against more than 150 different target weeds. CABI is a world expert in natural control and played a vital role in the development of an

International Code of Conduct on the use of natural control. CABI also has a very good international track record of researching and releasing natural control agents. In countries like the US, Canada, Australia and New Zealand natural control is often viewed as the first line of defence when a new and problematic invasive species is identified. See more examples of natural control successes.

What if it goes wrong, for example, could the psyllid attack our native flora?
The scientific research into the psyllid has been published to the scientific community and conducted by an organisation with great expertise in this area. Further scrutiny by the UK regulators (FERA and WAG), the independent Advisory Committee on Releases to the Environment (ACRE), and a peer review by three independent scientific experts have all helped ensure that possible risks have been adequately identified and carefully considered so that the release is considered safe.

There are no examples of biological control agents shifting host to plants that were not within their original physiological host range. Research in the laboratory showed that the psyllid is a specialist and as such has sacrificed its ability to feed and reproduce on anything other than the target knotweeds. This conclusion is supported by results from both laboratory and field trials, and the subsequent in-depth monitoring of psyllid release sites, where no non-target impacts have been recorded.

Do you have contingency plans in place?
Yes. This is a phased release programme with in-built contingency plans. Further releases can only continue if no significant adverse effect on non-target species has been recorded.

When will the pysllid be released?
The psyllid was first released at isolated sites in Spring 2010. There have been further releases across eight sites in England and Wales since then, which are monitored intensively four times a year.

Why haven't you published the exact location of the release sites?
The exact location of the release sites has not been published in order to minimize risk of disturbance and avoid compromising the release phase and the monitoring requirements expected to form part of the conditions of the licence. This is not because of a risk or danger to the public but because we want to give the insect the best chance of establishing so that it can successfully survive the next winter, as well as ensuring that the sites are not disturbed and the data compromised. The release represents the culmination of a very long process of research that has taken years and it is important that we realise the benefits. These requirements have been written into our licence conditions by the regulators.

How are you going to release the psyllid?
Release of the psyllid into the wild is phased. The initial release in 2010 happened at two sites, which were then closely monitored to ensure that it behaved as expected according to the laboratory research and to detect any evidence of unexpected behaviour. Further phases of release to specified sites were approved in England and Wales and carried out in 2011-2013. If and when the psyllid is considered ordinarily resident the licence would be reviewed.

At release sites, adults are released from a container into mesh sleeves on a plant to give them the best chance of settling in, while others will be released more freely to enable their behaviour to be monitored. There are also a number of control sites at which no psyllids will be released but will also be part of the monitoring programme.

How are the psyllid and its effects being monitored?
A detailed five-year monitoring plan covering sampling, site visits and reporting amongst other things has been prepared and agreed with FERA and WAG. This ensures that FERA is kept adequately informed of developments and it is a requirement of the release license that funding for the monitoring plan and contingency measures was in place from the start.

How will we know whether the psyllid has been a success?
Natural control is not a quick fix and the benefits can take years to be fully realised. The monitoring programme will generate the data required to determine whether there is significant control of Japanese knotweed at the release sites, i.e. a reduction in size of the plants and the rate of knotweed patch expansion. The ultimate measure of success will be whether the presence of the psyllid leads to a reduction in the efforts and costs required to control knotweed as well as the reduction in its rate of spread. The general consensus is that any contribution to a reduction in current control costs and efforts that outweighs the cost of the programme should be considered a success.

How long will it take before a real impact is achieved?
Experience from around the world has shown that bio-control for most species takes between 5 and 10 years from the initial releases to the time significant control is achieved. Whilst more traditional management techniques such as mechanical and chemical control seem to offer more immediate control, one of the most important advantages of natural control is the long-term management it provides with minimal disturbance to the environment and reduced use of chemicals.

Will the psyllid destroy all the Japanese knotweed in Great Britain?
No. The psyllid will put natural pressure on it if it establishes successfully in Great Britain – but it won't make it disappear altogether. It is not in its interests to remove its only food supply. The ultimate aim of this project is to turn the weed from a destructive and expensive environmental burden, into a more manageable plant which poses less of a threat to economic interests and our biodiversity. The advantage of successful bio-control is that knotweed should not spread as fast or establish as well however, we might not see spectacular results for many years.

Can I sit back and wait or should I continue to try to control knotweed?
There is still a risk of spread of Japanese knotweed through bad management which could be harmful to the environment and make the problem even worse. It is anticipated that the biocontrol agent will be integrated with other management techniques and therefore facilitate, not replace, current management techniques.

What about the cane toad?
The cane toad, *Bufo marinus*, was introduced to Australia by the sugar cane industry in 1935 in an ill-judged attempt to control pest beetles. This was done against the recommendations of scientists at the time. Thousands of toads were released without any host specificity testing and not only failed to control the beetle but turned their carnivorous attention to anything that moved and was small enough to be swallowed. They went on

to become a significant problem themselves. Although carried out in the name of biological control, today's practitioners consider this unfortunate case to have been a highly irresponsible act in an age when there was no real regulation and safety testing. Today's pest risk analyses should prevent such a thing happening again

How do I identify Japanese knotweed?

Japanese knotweed can be identified by its tall, hollow and arching bamboo-like stems that often zig-zag. The leaves are large, green and spear shaped and stems produce clusters of creamy-white flowers in late summer. In winter the living material dies back leaving brittle brown stems but the rhizomes persist underground with an orange-yellow interior which snaps like a carrot when broken.

What are invasive non-native species?

An invasive non-native species is any animal or plant that has been introduced (ie. by human action) outside its natural past or present distribution and has the ability to spread causing damage to the environment, the economy and the way we live.

Invasive non-native species are estimated to cost the British economy £1.7 billion a year. They are one of the greatest threats to the environment worldwide, and their impacts can be far reaching – they have adverse impacts on the native environment by predation, competition and spread of disease. They also threaten economic interests such as agriculture, forestry, fisheries and development.

Invasive non-native species are often introduced either as pets or garden plants, and their pests, or as stowaways within imports of compost, timber, ballast water and other materials.

Why use natural control?

It is in all our interests that damaging invasive non-native species are not released into the wild, and the priority in the government's GB non-native species secretariat - GB Strategy is to educate the public about the risk of introducing these species. However where an invasive non-native species is found we need to consider whether to control it, and the possible tools available. Invasive non-natives usually have an advantage over native species as they have often left their natural enemies behind – one tool is the use of natural predators that target only the invasive species.

Does it work?

There have been many notable successes in the natural control of weeds, although of course some work better than others. The general consensus is that any contribution to a reduction in current control costs and efforts that outweighs the cost of the programme should be considered a success. A recent review of natural control programmes revealed a mean cost: benefit ratio in excess of 1:200 and though there was considerable variation, all were found to be positive. A good example of this is the use of the weevil *Cyrtobagous salviniae* to control Salvinia weed in Sri Lanka. This plant was introduced into the country during the Second World War to prevent enemy aircraft from identifying waterways. It did the job so well that almost all waterbodies in the country were affected. The weevil was released in 1986 and within four years it had destroyed around 80% of weed infestations. Since its discovery Cyrtobagous has been a successful control agent against this weed in more than 10 tropical countries around the world and is still working today.

What if it goes wrong?

Of the 1,400 worldwide releases against weeds, less than one percent produced non-target effects and all bar two were predicted by scientists prior to release. A famous case where a weevil ended up attacking native thistles in North America, as well as the target thistles, is a prime example. However, the predicted damage to, in some cases rare species, was deemed to be an acceptable risk at the time, given the scale of the problem. However, given the same data and situation, it is highly unlikely that today's decision makers would authorise such a release.

The care taken prior to releasing a natural control agent is in stark contrast to the wholesale importation of exotic species, either as pets or garden plants and their pests, or as stowaways within many commodities.

Why can't we just leave things as they are?

Japanese knotweed costs the British economy millions of pounds each year to manage. It damages buildings, delays developments, and forces out native plants.

If left unchecked, it will continue to spread rapidly. Even where there is a concerted effort to control the weed, it is still spreading. Doing nothing is not a low risk option.

Is there a danger of releasing another alien species that will become invasive?

The proposed control agents have been trialled on 90 plant species focusing on closely related native species as well as important crops and ornamental species to ensure they do not attack other plants. They will only be released after vigorous testing, peer review and public consultation.

Whilst the natural control agent is not native to the UK, it is 'native' to knotweed. Only co-evolved natural enemies are considered as control agents and some of these will have sacrificed their ability to feed on other species in order to specialise on the target weed. By applying internationally-accepted safety testing procedures to a selected agent, it is possible to demonstrate that the risk to UK native biodiversity or crops is negligible and the organism will not be harmful.

Is this anything like GM?

No. Genetic modification involves human intervention to provide an organism with certain genes that code for desirable traits. In the case of natural control 'Mother Nature' has done the modifying for us through the process of evolution. Natural control aims to allow a natural balance to be restored by the re-association of an invasive plant and its natural control agent.

How can it be that these natural enemies only attack one plant?

Most insects and pathogens are restricted in what they are able to feed on and some are monophagous, meaning they will only attack one species of plant. This is not as surprising as it seems. Many endangered insects are under threat because their only host plant or its habitat has become rare and they are unable to feed on anything else. Of course some insects and pathogens will eat all kinds of plants but these are rejected as potential natural control agents early in the safety testing regime.

What will it eat when it has eaten all the weeds?

A natural control agent does not do itself any favours if it completely eradicates its only host plant; it will be faced with certain death given that it cannot survive on anything else. Fluctuations in the pest and predator populations are normally observed until equilibrium is reached. This is when the weed population is pushed below a necessary threshold level. It should stay like this indefinitely, providing constant and perpetual control without any further cost. Because the selected natural enemy will be specific to knotweed it will not be able to move onto and affect another plant.

What about the Harlequin ladybird?

The harlequin ladybird (*Harmonia axyridis*) was introduced as a biological control agent to several European countries in the 1990's (not the UK). The aim of the releases was to provide temporary control of aphids in greenhouses and on orchards and other crops outdoors. However, the ladybird has since managed to spread into the wild across more than 15 European countries including the UK. The harlequin ladybird is a voracious predator and is out-competing native ladybird species through direct predation and competition for food.

Although this is not an example of classical biological control (as unlike the proposed release of the psyllid, the harlequin ladybird was never released for permanent establishment, nor subject to safety testing), this is an example of the need for appropriate regulation of the introduction of biological control agents. CABI supports international initiatives to ensure that biological control is carried out safely, most recently as a partner in the EU Policy Support Action REBECA (Regulation of Biological Control Agents) to develop more balanced procedure for risk assessment and regulation of all types of biological control agents in Europe.

Will releasing a natural control agent eradicate Japanese knotweed in Great Britain?

No. Eradication is not the normal outcome of natural control since it is not in the agent's best interest to eradicate its only food source. Long-term control, below an economic or environmental threshold, should be anticipated.

Is this like the azolla weevil?

In some way yes although it was not introduced as part of a natural control programme in the way it was in South Africa. The azolla weevil *Stenopelmus rufinasus* was an accidental but fortuitous introduction that has become ordinarily resident and is now currently being redistributed to control the problematic aquatic weed *A. filiculoides* on ponds and slow-moving rivers. See the AzollaControl website.

Will anyone make money out of a release?

No. Natural control projects are activities for the 'public good' and there is no money to be made. CABI is a not-for-profit organization and has only received the funding required for the research phase of the programme from the consortium of sponsors (see About us).

Is knotweed a problem in Europe?

Yes Japanese knotweed is a major problem in many European countries. It would be relatively easy to extend the release to countries on the continent as we would just need to add their test plants to the safety testing regime and consider the use of natural enemies.

Can I keep spraying knotweed even if the insect is on it?

The agent relies on knotweed for its survival and therefore any spraying regime will need to be carefully integrated with the lifecycle of the agent so as not to deplete its food supply and to maximise the impact on the weed in a synergistic way. Spraying knotweed in the autumn should allow the agent to have maximum impact throughout its growing season, draining nutrients, whilst then ensuring that systemic chemicals are taken down to the rhizome just before deterioration begins.

Are you looking at using natural control for any other invasive species?

Natural control could be considered for any non-native invasive species providing that its impact is deemed sufficient for the research to be justified. In the plant world, CABI is currently working on Himalayan balsam,floating pennywort, and Australian swamp stonecrop. CABI's team in Switzerland are also considering using natural control against insects such as the Lilly leaf-beetle and the horse chestnut leafminer as well as Ambrosia weed.

What is the Government's Invasive Non-Native Species Strategy

On 28 May 2008, England, Scotland and Wales launched a co-ordinated strategy to reduce the threat to Britain's native biodiversity from invasive non-native species.

The GB Non-Native Species Secretariat is the focal point for non-native action by the English, Welsh and Scottish administrations.

Further details on the strategy can also be found on the Defra website.

Here, there is also a report on the impact of non-native species on the economy of Great Britain.