TEES RIVERS TRUST

Using psyllids biocontrol agents as a method to control Japanese knotweed (*Reynoutria japonica*) in Great Britain

BIOCONTROL HANDBOOK:
JAPANESE KNOTWEED (*Reynoutria japonica)*

Chloe Lawrence

2nd Edition

Organisation

Tees Rivers Trust is a charitable organisation committed to improving and conserving the River Tees and its tributaries. We take a whole catchment approach to river management, from Cross Fell to the North Sea. Our key areas of work are farm advice, invasive non-native species control, research, education, and practical habitat improvements. We are the host organisation for the Tees Catchment Partnership. This comprises partners including Local Authorities, Government Agencies, Environmental NGOs, and individual specialists. The Partnership aims to ensure catchment matters, planning and projects have a strategic and influential fit with other landscape and urban planning objectives to realise mutual benefits and avoid resource duplication. The trust is supported by a group of core trained volunteers, as well as support from regular corporate volunteers from local businesses.

This project focuses on tackling three big invasive plant species, causing three big issues to our environment with the aim of making the Tees catchment accessible, safe, and biodiverse.

Authors
Chloe Lawrence: Project Officer

2nd Edition*

**The contents of this best practice handbook are based off Tees Rivers Trust's experience of the psyllid biocontrol of Japanese knotweed from 2020-2022. As research and experience progress, the methods and outcomes may vary.*

This project if funding by Green Recovery Challenge Fund supporting a range of nature conservation and recovery and nature-based solutions projects, which will contribute towards the Government's wider 25 Year Environment Plan commitments.

Table of Contents

Figure 1. Japanese knotweed

Management Summary

Japanese Knotweed

Japanese knotweed (*Reynoutria japonica*) is an invasive non-native plant that has detrimentally impacted the environment and economy within the Tees catchment for decades, with similar issues mirrored throughout Great Britain. Natural predators for these invasive non-native plants are not present in Great Britain, consequently enabling the plant to easily out-compete native species, significantly reducing biodiversity, and limiting access to valuable and important natural amenities for local communities, interest groups and visitors.

Japanese knotweed costs the UK thousands annually to remove and control. If left, the invasive plant can cause structural damage to buildings with its ability to grow through materials such as concrete. Japanese knotweed spreads via rhizomes as opposed to seeds, meaning it can spread easily along watercourses such as rivers.

Psyllids

Biological control is a method of controlling pest species, specifically for invasive non-native species. It involves finding natural predators of the target species from its native range to control the invasive species in its non-native range. This requires extensive testing to ensure the biocontrol agent does not negatively affect non-target species in its non-native range, such as the UK.

We are currently using a specific species of psyllid (*Aphalara itadori*) which is a small sap sucking aphid reared by the Centre for Agriculture and Bioscience International (CABI). The

majority of the psyllids lifecycle is spent on Japanese knotweed. The species survive by sucking sap from Japanese knotweed, stunting the plants growth and reducing its chance to spread. Release of this biocontrol agent had been approved by DEFRA after rigorous testing in quarantine facilities and experimental field trials conducted by CABI.

Biocontrol will not completely eradicate Japanese Knotweed, but if psyllid establishment occurs, will naturally control this species to make it more manageable and less destructive. This will hopefully make it easier to manage Japanese knotweed and reduce its negative impacts on biodiversity and economic interests.

Alternative Methods

Below is a short summary of various management methods for Japanese knotweed:
See RAPID Good Practice Handbook Japanese Knotweed (*Fallopia japonica*) (CABI, 2009)

Table 1. Table of various methods used to control Japanese knotweed.

Method	Pros	Cons
Herbicide injection (glyphosate)	Plant carries the herbicide down to rhizome preventing regrowth. Does not affect non-target plants.	Time-consuming, so not ideal for large areas of Japanese knotweed coverage. Can be expensive. Must be conducted by competent and qualified person.
Herbicide spraying (glyphosate)	Can cover large areas quickly. Relatively cheap compared to other methods.	May negatively impact non-target species due to drift. Must be conducted by competent and qualified person.
Cutting or mowing	Effective method with clean single cut near base of stem.	Time consuming. Cut plant material needs appropriate disposal.
Biocontrol	Long term control method.	Takes a long time to fully establish. Limited success of psyllids to overwintering in the UK to date. Biocontrol will not completely eradicate Japanese Knotweed.
RootWave Pro	Great for organic farming land as no chemicals needed.	Limited by weather, generator needed so not suitable for hard to reach places, cannot be used near water courses.

Biosecurity

Biosecurity involves precautions that can prevent the spread and introduction of harmful organisms. There are a few ways in which you can prevent unnecessary spread when doing the biological control work on Japanese knotweed. Japanese knotweed spreads via rhizomes, which means the plant can expand and grow through the smallest root. The best way to prevent the rhizomes spreading is through the Check, Clean and Dry method.

Check: check your clothing and equipment for any Japanese knotweed fragments

Clean: clean all equipment, footwear, and clothing thoroughly

Dry: all equipment and clothing - some species can live for many days in moist conditions.

It is important to also be aware of any other invasive species which may be on site with Japanese knotweed such as Himalayan balsam, giant hogweed, and signal crayfish, to avoid spreading these species further.

For more information on how to reduce the spread of invasive non-native species, through good biosecurity practice, check out the Great Britain Non-Native Species Secretariat (GB NNSS) website.

Costs

The main cost of the biocontrol process is for the production of the biocontrol agents by CABI at £5,000 per site. This cost includes psyllid rearing, delivery of the psyllids to site, training to release psyllids, and equipment to conduct the psyllid releases and psyllid monitoring. A breakdown of cost at the time of writing is provided below*
*This includes VAT and may be subject to change due to inflation.

Table 2. Table of cost breakdown for psyllid biological control from CABI.

Activity	Cost per site
Psyllid mass rearing • Staff time to sequentially ramp up mass rearing for early summer, late summer and spring releases • Use of controlled temperature chamber with light banks for mass rearing • Equipment and consumables for mass rearing • Plant propagation facilities, time and consumables	£3,000
Psyllid release and monitoring • Provision of field training on release and monitoring to collaborators • Travel and subsistence for site visits by CABI staff	£2,000

• Supply of equipment for releases such as sticky traps and data loggers • Shipping costs for psyllid shipments • Advice and guidance by phone or email • Collaborator meetings and administration • Lab assessment of sticky traps for psyllids	
Total	**£5,000**

Please note that this table is cost for a mass production which requires allocated staff, CT chambers set to specific conditions and so on, it may not be feasible to do one off site releases for £5,000 but would require multiple site releases or releases for multiple partners to be viable. Otherwise, the cost per individual site would likely be higher, to cover the various overheads.

Methods

Funding

Funding options are dependent on the number of sites created. Smaller grants are available for singular sites which would ideally need to award finds up to/around £15,000 to cover the cost of obtaining the biocontrol agent, for staff time to undertake biocontrol application and monitoring, and to cover travel to the sites.
Our project has been funded by the Green Recovery Challenge Fund. Overall, our budget for this biocontrol project is £179,000, which covered the cost of:

- 11 Himalayan balsam biocontrol sites (see our Himalayan balsam biocontrol handbook for more information on this biocontrol method)
- 5 Japanese knotweed biocontrol sites
- Full time project officer
- Part time project manager
- Part time project coordinator
- Recruitment
- Training
- Staff mileage
- Equipment
- Full cost recovery
- Contingency

Project Timescale

Below is a suggested timescale to plan for the creation of a psyllid biocontrol site. This is based on our Project.

Table 2. Table of timeline for biocontrol release and monitoring over the first year.

April	Site Selection
May	Site Set Up
June	1st Psyllid Release
July	Physical monitoring for psyllid presence
August	2nd Psyllid Release

September	Physical monitoring for psyllid presence
October	Sticky Trap Monitoring
	Psyllids Overwinter in Canopy
May	Overwinter Monitoring
June	Top up Psyllid Release
July	Physical monitoring for psyllid presence

Securing Landowner Permissions

This is one of the most important aspects of the biocontrol and should be planned well in advance. As this is a long-term method to control Japanese knotweed, site selection is crucial. It is important to select sites where landowners are supportive of the work who are willing to understand that psyllid establishment can take many years. As the psyllid population must not be disturbed by means of other forms of Japanese knotweed management/removal within and around the release site, where possible it is recommended to work with landowners who expect to retain ownership of the land long-term.

In our experience, when contacting landowners about site creation on their land, it is best to share information regarding the psyllid life cycle and rigorous testing conducted by CABI before DEFRA approval for release was obtained to ease any worries about psyllid populations affecting non-target species. This was especially apparent when planning the creation of psyllid biocontrol sites adjacent to agricultural land.

Site Selection

There are a few criteria to take into consideration when selecting site for psyllid biocontrol. Firstly, a large and dense stand of Japanese knotweed should be present on the site.

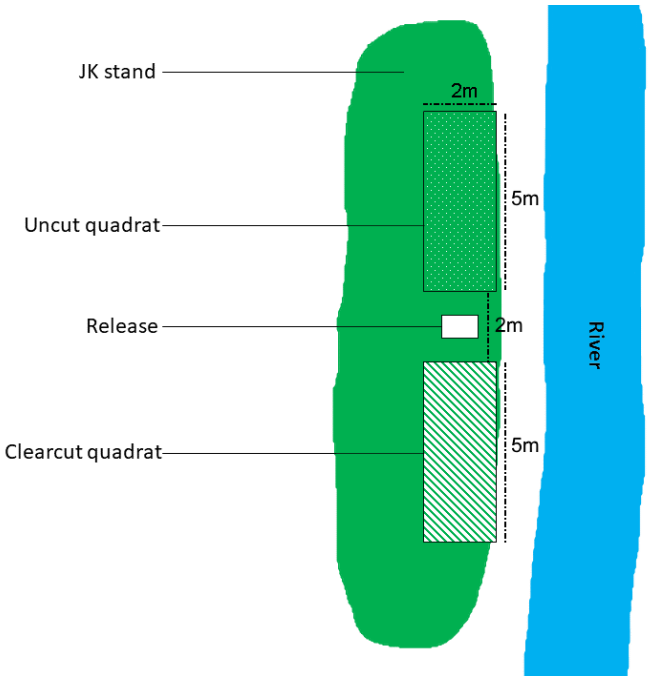

Figure 2. Diagram of Japanese knotweed psyllid site with cut quadrat, uncut quadrat and a central release area.

Our sites measure at a minimum of 12m in length parallel to the river, and 2m deep within a dense stand of Japanese knotweed. Anecdotal observations have shown that the psyllids prefer new Japanese knotweed shoots. Therefore, prior to release, we marked out two quadrats with canes within the overall site. This consisted of two 5m by 2m quadrats separated by a 2m by 2m section in between (see Figure 1). To see whether psyllids preferred new shoots or older shoots, we cut the Japanese knotweed stems in one quadrats above the third node (using loppers), and left the Japanese knotweed uncut in the other quadrat. Ideally, the biocontrol site should be located within a Japanese knotweed stand situated within a riparian habitat, as the psyllids have a better chance of survival in humid habitats similar to those found in their native range in Japan. All of our current biocontrol sites are situated along the River Tees.

Psyllid Releases

There are two psyllid releases approximately 5 weeks apart within a period of one year. For our project, the first release was conducted with a member of staff from CABI, whereby the psyllids were released in a box containing a small Japanese knotweed plant containing around 1000 psyllids per site. This was positioned in the central point between the cut and uncut quadrats, and will remain at the site for 1 year, before being removed by CABI. It is important to place the box in a secure area that will not be affected by flooding or may easily be removed. It is beneficial to choose a site which is not going to be disturbed by people, therefore private land without public access may be the most suitable option.

The second release is then conducted around 5 weeks later. This release adds an additional batch of psyllids to boost the population (around 300-500 per bread bag). The second batch of psyllids were delivered by next day delivery to be released on the day of arrival. The delivery of psyllids should be released on the site as soon as possible, as the longer the psyllids are left remaining in the packaging after delivery, the higher the chance of psyllid mortality which will reduce the likelihood of establishment.

The second batch of psyllids is reared on 3 plants per site, with an additional spare plant per site to allow for plant mortality or low egging rates. The plants and psyllids are packaged into bread bags for delivery and transport to site, with an additional sleeve and string. The sleeve and string should be secured around one of four delivered plants in each site to protect the psyllids from predators (such as spiders). This should allow the psyllids residing on the selected plant to lay eggs and develop for a period before removing the sleeve after a few weeks. See Table 3 below for instructions on where to place of each bread bag containing a Japanese knotweed plant and population of psyllids.

Table 3. *Table of contents for second psyllid releases and where they need to be located.*

Bag	**Location**
Bread Bag 1	Bread bag to be opened in **Cut** Quadrat and Japanese knotweed plant tied to an existing Japanese knotweed stem
Bread Bag 2	Bread bag to be opened in **Unut** Quadrat and Japanese knotweed plant tied to an existing Japanese knotweed stem
Bread Bag 3	Bread bag to be opened above the original release box in the 2m by 2m area between the cut and uncut quadrat
Sleeved Bread Bag 4	Bread bag to be opened carefully inside of sleeve and tied securely to existing Japanese knotweed stand

(a) (b)

Figure 3. (a) Photos of 2nd psyllid delivery via post (b) Placement of bread bag on stand of Japanese knotweed following 2nd release.

Monitoring

Monitoring of the psyllids may be conducted as little or often as required. For this project, the psyllids were monitored weekly. Prior to the first psyllid release, data loggers were placed within the biocontrol site to monitor humidity, temperature and rainfall.

The psyllids have a 3-stage life cycle (eggs, nymphs and adults) that can be monitored. Monitoring of the different stages will provide data on differing levels of establishment. If eggs are present, it is likely the psyllids are surviving well as reproduction will only occur in suitable conditions. As shown in Figure 4, the eggs are present with a white excretion normally found both on the leaves and stems of Japanese knotweed.

Monitoring of adult psyllids can be conducted by searching observing the leaves where the adults typically reside. However, this can be difficult as the adult psyllids are very small and tend to fly off the leaves when disturbed. This should be taken into consideration when undertaking monitoring using this method, as the data collected may not be representative of the actual psyllid population. It is also difficult to differentiate between individual psyllids by eyesight. Monitoring in this way is beneficial to see whether a population of psyllids is presence/absent on the site, but will not be an accurate way to predict population size.

Figure 4. (a) Psyllid eggs (and first instar nymph – bottom left, with legs) under predation by predatory bug for scale. Eggs <1mm and best viewed with a hand lens or magnifying glass. Mostly found on upper surface of leaf, (b) White frass produced by psyllid nymphs at high density. (c) Closer image of psyllid nymphs (mid-instar). Often found at leaf and branch nodes, sometimes on leaves. Can produce white frass, more visible at high density. (d) Psyllid adults. Often found on upper surface of leaf. Orange brown (darker brown in autumn). Can sometimes be found on flowers. Will ping off plant when disturbed.

Figure 4 shows the psyllids in each stage of its life-cycle, and what look for when monitoring. The psyllids are very small and orange/brown colour. Their colouration can help to distinguish psyllids from other insects that might be present on the leaves.

To confirm psyllid presence on site, the best method is to use sticky traps, which are provided by CABI. The sticky traps should be placed at 2m intervals upstream and downstream from the central point of the site to monitor psyllid presence in both the cut and uncut quadrats. The traps should be left at each site for 7-10 days. After this period, each sticky trap should be collected in individual plastic wallets (side opening plastic wallets are easiest) and labelled as follows:

- Site name - e.g. *Darlington 1*
- Date collected – e.g. *18/09/21*

- Whether it was collected from the cut or uncut quadrat – e.g. *cut/uncut*
- Position placed in site – e.g. *2m/4m/6m upstream/downstream*

The labelled sticky traps should then be sent to CABI where the presence/absence of psyllids will be identified by observing the sticky traps under a microscope.

Below are suggested times to put out sticky traps at each Japanese knotweed biocontrol site:

- One week before the second batch of psyllids are released, to see whether psyllids are still present on the site after the first release
- At the end of Autumn, before the Japanese knotweed plants die and the psyllids move up into the canopy where they will overwinter and monitoring will no longer be possible
- In spring when the Japanese knotweed plants have grown back, to see if overwintering has been successful.

Lessons Learned

There are pros and cons to using sticky traps.

Pros

- Psyllids caught on sticky traps will not be mistaken for other species
- Less time-consuming than monitoring for psyllids by eye

Cons

- Non-target species will be caught, including birds
- Psyllids caught on traps will be removed from the population, which is not desirable before the population has established

Attaching silver tape may deter birds from approaching sticky traps, reducing the risk of mortality

Health and Safety

A number of potential hazards should be acknowledged when undertaking biocontrol work and risk assessments should be completed before undertaking work. Although Japanese knotweed is found growing in a variety of habitats, it tends to grow near other plants that may cause injuries, such as common nettles and bramble. Giant hogweed is another problematic invasive species within the Tees catchment, and is present at 3 out of our 5 psyllid biocontrol sites. We therefore recommend that gloves should be worn when monitoring biocontrol sites. Management of such species may be required to ensure safe access to your biocontrol site, and this should be considered when planning biocontrol site locations. For example, giant hogweed is spot sprayed around our biocontrol sites. However, this must be conducted carefully ensuring drift from herbicide spraying will not affect the Japanese knotweed stands within the biocontrol site area.

When choosing a site, accessibility must be considered. Large stands of Japanese knotweed may be found that would be ideal for psyllid releases, but with limited/poor/unsafe access. Selecting a site where access is limited/unsafe should be avoided, due to the number of visits required for each site to undertake monitoring. For example, in this project where our biocontrol sites reside along the River Tees, many stands of Japanese knotweed are adjacent to steep banks and are not easily accessible. Additionally, as Japanese knotweed affects soil quality and increases the risk of erosion, caution should be taken be in case riverbanks are not as stable as they appear.

Tees Rivers Trust Case Study

Our Results:

Monitoring psyllid presence was difficult due to their small size and tendency to fly out of sight when leaves were disturbed.

Table 4. Table showing the results of monitoring each site and the date the site was monitored and whether psyllids were present.

Date Monitored	Site 1	Site 2	Site 3	Site 4	Site 5
24/06/21	First Psyllid Release				
15/07/21	Y	Y	Y	Y	Y
29/07/21	N	Y	Y	N	N
05/08/21	Y	Y	Y	N	N
12/08/21	N	N	Y	Y	Y
12/08/21	Sticky Traps Set Up				
18/08/21	Sticky Traps Collected				
19/08/21	Second Psyllid Release				
03/09/21	Y	N	Y	N	N
08/10/21	N	N	Y	N	Y
22/10/21	N	N	N	N	N
15/11/21	Sticky Traps Set Up				
26/11/21	Sticky Traps Collected				
01/12/21	Psyllids Overwintering in Trees				

*Y = Psyllid Presence - either seen directly or presence of eggs detected.
*N = Psyllid Absence - Important to note that this does not mean psyllids were not present, but instead reflects that psyllid were not detected during monitoring (psyllids can fly and may travel to other stands of Japanese knotweed in the area, or may simply have been missed at the time of monitoring).

Long-term establishment and biocontrol as a management method:

The research of biocontrol methods to control Japanese knotweed has been conducted since 2000 by CABI in the UK. Previous trials have shown some success. However, the success of getting psyllids to overwinter in the UK has been more limited. Research continues, with more climatically-matched psyllid cultures collected from Murakami, which is situated further north in Japan in relation to Kyushu, where the line of psyllids released within the Tees catchment originated. The Murakami line of psyllids have been observed to cause extensive and severe leaf-curling damage in Japan, and were approved by DEFRA for release in the UK in 2021 after host specificity testing. Two biocontrol sites were created using the Murakami strain at two sites, F. japonica and F. x bohemica site, with leaf curling damaged observed at both sites,

but more so at the F. x bohemica site, with initial studies showing that adult psyllids are hey to this process. Further trials and research are therefore required.
For trials conducted within the Tees catchment, longer-term establishment of psyllid populations will be required before impacts on Japanese knotweed may be detected, as higher numbers of psyllid adults may be required successfully control this invasive species (CABI, 2021).

Educational Partnerships:

We have been working with members of the Invasion Ecology Research Group at Newcastle University and MBiol student who have assisted with site set up and monitoring.

Lessons Learned

There are pros and cons to university partnerships.

Pros

- Gaining extra and more regular data
- Students gain practical experience

Cons

- Fewer psyllids were detected than expected during monitoring, which prevented the research project from being continued. As a result, the monitoring method should have been adapted at an earlier stage.

Volunteers

Our sites currently reside on private land with limited opportunities for volunteer engagement during this stage in the project. However, volunteers may be able to provide assistance with the following activities in future:

- Site access maintenance
- Psyllid monitoring
- Awareness raising

Acknowledgments: Stakeholder Involvement and Expertise

CABI

The Centre for Agriculture and Biosciences (CABI) is a not-for-profit inter-governmental development and information organisation focusing primarily on agricultural and environmental issues in the developing world. We would like to acknowledge those at CABI, specifically Corin Pratt, for his ongoing support and expertise during this project.

National Lottery Heritage Fund and Department Environment Food Rural Affairs (DEFRA)

Secondly, we would like to thank the National Lottery Heritage Fund and DEFRA who have financially supported this project as part of the Green Recovery Challenge Fund. Without their funding, this project would not have been possible.

Landowners

We would also like to thank all of the landowners across the Tees catchment for their ongoing support during the course of this project and for the future. Without their permissions, we would not be able to undertake this work, and we are lucky to work with such supportive landowners.

Bibliography and further resources

CABI. 2022. *CABI: Japanese Knotweed*. [online] Available at: <https://www.cabi.org/projects/establishing-the-psyllid-field-studies-for-the-biological-control-of-japanese-knotweed/> [Accessed 20 January 2022].

CABI. 2021. CABI: Weed Biocontrol Public Summary. [online] Available at: https://www.cabi.org/wp-content/uploads/CABI-weed-biocontrol-Public-Summary-WFD_Nov-2021.pdf

CABI. 2009. CABI: Information Pack. [online] Available at: https://www.cabi.org/Uploads/CABI/Japanese%20Knotweed%20Alliance/Info%20pack.pdf

Nonnativespecies.org. 2022. *Check, Clean, Dry*. [online] Available at: <http://www.nonnativespecies.org/checkcleandry/> [Accessed 20 January 2022].

Nonnativespecies.org. 2022. *Non-native Species Secretariat*. [online] Available at: <http://www.nonnativespecies.org/factsheet/factsheet.cfm?speciesId=1495> [Accessed 20 January 2022].