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Systematic Review Protocol

KABAT, T.J., STEWART, G.B., AND PULLIN, A.S.

Centre for Evidence-Based Conservation - School of Biosciences - University of Birmingham – Edgbaston – Birmingham - B15 2TT - U.K.

Correspondence: T.J.Kabat@bham.ac.uk
Telephone: +44 (0)121 414 4090

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CENTRE FOR EVIDENCE-BASED CONSERVATION

SYSTEMATIC REVIEW NO. 21

ARE JAPANESE KNOTWEED (*FALLOPIA JAPONICA*) CONTROL AND ERADICATION INTERVENTIONS EFFECTIVE?

Lead Reviewer: **Tamara Kabat**
Postal Address: **Centre for Evidence-Based Conservation**
School of Biosciences, University of Birmingham
Edgbaston, Birmingham, B15 2TT, UK
Email Address: **T.J.Kabat@bham.ac.uk**
Telephone: **+44 (0) 121 414 4090**
Facsimile: **+44 (0) 121 414 5925**

REVIEW PROTOCOL

1. BACKGROUND

Japanese knotweed (*Fallopia japonica**) was first introduced into Britain from Japan in 1825 (Beerling *et al.*, 1994). Originally used as an ornamental or as cattle fodder, the first escape was reported in the late 19th century, with naturalisation occurring in the early 20th century (Bond and Turner, 2005). Due to the subsequent spread of this invasive weed, *F. japonica* is now established alongside railways, canals, rivers and streams, roadsides, and areas of human disturbance such as waste tips. It is widespread in the British Isles, occurring in the south and as far north as the Outer Hebrides and Orkney. The plant has also become a problem in the USA, Canada,

* Confusion has arisen over the taxonomy of this species, as it is often referred to by several different specific names, the three most common being *Fallopia japonica*, *Polygonum cuspidatum* and *Reynoutria japonica* (Beerling *et al.*, 1994). Throughout this document, Japanese knotweed will be referred to as *F. japonica*, as described by Stace (1997).

many European countries, Australia and New Zealand (Beerling *et al.,* 1994; Australian Weeds CRC, 2005). The species has been described as one of IUCN's top 100 invaders (Lowe *et al.*, 2000).

Spread in Great Britain is by vegetative means via rhizomes, as most individuals in Britain are female, and therefore the setting of fertilised *F. japonica* seed is not possible (Seiger, 1992). Within its native range, reproduction is assisted by wind- and water-dispersed seeds. Successful invasion has been facilitated mainly by the deposition of plant material or cartage of soil containing plant fragments; therefore, it can be transported great distances and released accidentally in a relatively easy manner (Child *et al.,* 2001). However, *F. japonica* hybridises with *F. sachalinensis*, the hybrid *F.* x*bohemica* (also known as *Reynoutria* x*vivax*) producing viable seed and being highly invasive (Bimova *et al.*, 2001). There is some indication that this hybrid is more invasive than its parents, as it is more difficult to control and has a higher regeneration rate (Bimova *et al.*, 2001, 2003). Hybridisation with *F. baldschuanica* to produce fertile *F.* x*conollyana* has also occurred (Bailey, 2001). Both species are widespread in Europe, and *F.* x*bohemica* is also widespread in the USA (known as *Polygonum* x*bohemicum*) (Zika and Jacobson, 2003).

Japanese knotweed can grow up to 3m high (Beerling *et al.,* 1994). This perennial plant forms tall thickets that exclude all other vegetation (Bond and Turner, 2005). A dense leaf canopy is created, and when the leaves are shed in autumn they decompose, forming a thick mulch that prevents germination of other plants (Kidd, 2000). Native plants therefore cannot compete with this invasive, and local plant biodiversity is reduced (Seiger, 1992).

Various methods for control and eradication of Japanese knotweed have been used. Mechanical methods such as grazing, cutting, mowing, pulling and digging have been used to control outbreaks, but without intensive applications over long periods of time, these will not eradicate the weed (Seiger, 1992; Soll, 2004; Bond and Turner, 2005). Herbicides are frequently used to control or eradicate the weed over several years, and several herbicides (selective and non-selective) and application methods (e.g. stem injection) are in use (Seiger, 1992; Soll, 2004). Large-scale excavation is usually the only method of rapid eradication (Japanese Knotweed Alliance website; Brian Tollitt, United Utilities, pers. comm. 2006). Geosynthetic textiles and thick polythene sheeting have been utilised to reduce the spread of Japanese knotweed. These can be used to encase excavated material or cover infestations and then buried, or they can be placed into the ground beside infestations to act as a vertical barrier (REC Ltd. website; Renals and Rene, 2001; Wreford Ltd. website). Combinations of the various control methods are also used. Investigations are being conducted into possible biological controls for Japanese knotweed (Japanese Knotweed Alliance website).

Defra (2003) estimated it would cost £1.56 billion to eradicate Japanese knotweed across all infestation in Britain, with £52 million of that estimate related to removal of the weed from riparian areas. Fasham and Trumper (2001) stated that £160,000 had been spent on controlling Japanese knotweed in the Swansea area since 1992, with estimated costs of full control in the area at nearly £8,000,000. The threat of this plant to native flora has been recognised and there is now legislation surrounding its

handling and planting (Fasham and Trumper, 2001). It is therefore necessary to be aware of the success of the measures taken to control or eradicate Japanese knotweed.

Using systematic review methodology, the interventions used to control or eradicate Japanese knotweed will be critically appraised. The review will consider the best available evidence of the effectiveness of different control and eradication methods in different situations (Table 1). The review will limit bias through the use of comprehensive literature searching (both published and unpublished), specific inclusion criteria, and formal assessment of the quality and reliability of the studies retrieved. Subsequent data synthesis (qualitative and/or quantitative) will summarise evidence, guiding the formulation of appropriate evidence-based management guidelines and highlighting gaps in research evidence.

The review should be of use to staff carrying out, or advising on, Japanese knotweed control and eradication for environmental organisations (statutory and non-statutory) and local authorities, as well as landholder stakeholder groups. It will have value at regional and national scales, informing local management or policy decisions, and has the potential to influence national policy and guidelines on Japanese knotweed management.

Table 1. Definitions of components of the primary systematic review question

Subject	**Intervention** **	**Outcome**		
		Primary	**Secondary**	**Tertiary**
Japanese knotweed	Cutting Mowing Pulling Digging/excavating Burning Herbicide application (inc. stem injection) Grazing Trampling Biological control Geosynthetic or polythene barriers Combination techniques	Change in abundance of Japanese knotweed: cover, stand density, frequency, and biomass.	Cost effectiveness of control and eradication methods	Changes in vegetation type: compare before control of Japanese knotweed with the community assemblage afterwards.

** The review will consider the various interventions in the following different control and eradication contexts:

1. In-situ eradication within 1-3 months
2. In-situ eradication over 12 months
3. In-situ eradication 12 months+
4. Excavate and move infestation to a 'safe area' for long term (2-3 years) treatment
5. In-situ treatment within 3-12 months adjacent to a watercourse
6. Creation of barriers to adjacent infestations on 3rd party land
7. Treatment of infestations whist protecting adjacent more favourable vegetation species

2. OBJECTIVE OF THE REVIEW

2.1 Primary question

- Are Japanese knotweed (*Fallopia japonica*) control and eradication interventions effective?

2.2 Secondary question

- Do environmental and geographical factors (e.g. habitat type, temperature, rainfall, soil moisture, soil type, ground slope, shading, latitude/longitude, altitude) alter the effectiveness of Japanese knotweed control and eradication?
- Do operational level variables, such as age of stand, height of stand, density of knotweed, size of controlled area, previous control, duration/effort/timing of control, chemical aspects of control methods (e.g. herbicide type, herbicide application method, concentration of herbicide, number of herbicide applications), mechanical aspects of control methods (e.g. cutting and digging/excavation techniques), and type of grazer, alter the effectiveness of Japanese knotweed control and eradication programs?
- Do hybridisation and species variety alter the effectiveness of Japanese knotweed control and eradication?

3. METHODS

3.1 Search strategy

3.1.1 General sources

The following computerised databases will be searched:

1) ISI Web of Knowledge (inc. ISI Web of Science and ISI Proceedings)
2) Science Direct
3) Directory of Open Access Journals
4) Copac
5) Scirus (All journal sources)
6) Scopus
7) Index to Theses Online
8) Digital Dissertations Online
9) Agricola
10) CAB Abstracts
11) English Nature's "Wildlink"
12) JSTOR
13) ConservationEvidence.com
14) Other databases deemed relevant by experts will also be included

A single reviewer will search the electronic databases, and the number of citations retrieved from each search will be recorded within an EndNote database.

An Internet search will also be performed using the meta-search engines www.alltheweb.com, www.dogpile.com, http://scholar.google.com and Scirus web search. A single reviewer will search these engines. The first 50 hits (Word and/or PDF documents where this can be separated) from each data source will be examined for appropriate data.

Searches will include the following English language search terms (* indicates a wildcard):

- *Fallopia* AND *japonica*
- *Polygonum* AND *cuspidatum*
- *Reynoutria* AND *japonica*
- Japanese AND knotweed
- *Fallopia* AND *japonica* AND control*
- *Polygonum* AND *cuspidatum* AND control*
- *Reynoutria* AND *japonica* AND control*
- Japanese AND knotweed AND control*

Less commonly used species and common names and the hybrid species names were searched in a scoping study. The references located had already been found via the search terms listed above, hence these terms will not be used for full searching. Further terms may be added as the search becomes more specific; for example, specific terms for interventions may be used. Where required due to a lack of wildcard ability in search engines, the following search terms will be used:

- Control* will be replaced with (control OR controlled OR controlling)
- Plus variations as required if further search terms are used.

The feasibility of foreign language searches will be scoped. Potential foreign literature and data sources will be identified via contact with subject experts.

3.1.2 Specialist sources

Bibliographies of articles viewed at full text will be searched for relevant secondary articles. Authors, recognised experts and practitioners in the field of Japanese knotweed control will also be contacted for further recommendations, and for provision of any unpublished material or missing data that may be relevant. Questionnaires will be circulated to practitioners in order to collate experience.

Searches of publications from United Kingdom statutory and non-statutory organisations will also be included (including but not limited to: Royal Society for the Protection of Birds, English Nature, Scottish Natural Heritage, Scottish Environment Protection Agency, Countryside Council for Wales, Joint Nature Conservation Committee, Dept. Environment Food & Rural Affairs, Dept. Agriculture and Rural Development, Centre for Ecology & Hydrology, Environment Agency, Irish Environment Protection Agency, European Environment Agency). Attempts will be made to identify overseas organisations (especially European and North American) that may hold information on Japanese knotweed. Organisational websites will be searched for potential data. One reviewer will search these sources, and the number of citations retrieved from each search will be recorded. The first 50 hits (Word and/or PDF documents where this can be separated) from each electronic data source will be examined for appropriate data.

Specialist websites will also be searched for relevant information, including: http://www.issg.org/database/welcome/, http://www.invasivespeciesinfo.gov/, http://www.nisbase.org/nisbase/index.jsp, http://invasivespecies.nbii.gov/ and Invasive Non-Native Species in the UK (http://138.253.199.114/IAAP%20Web/IAAPwebsite/index.asp). Specialist interest groups will be contacted for information, including the Cornwall

Knotweed Forum, Devon Knotweed Forum, Tweed Forum, Japanese Knotweed Forum, Japanese Knotweed Alliance, and the Japanese knotweed mail list.

3.2 Study inclusion criteria

The inclusion and exclusion criteria will be applied by one reviewer to all potential studies at the title or title & abstract stages. Where there is insufficient information to make a decision regarding study inclusion, then relevance to the next stage of the review process (full text assessment) will be assumed. A second reviewer will examine a random subset of at least 25% of the reference list (up to a maximum of 2000 references) to assess repeatability of the selection criteria. Kappa analysis will be performed, with a rating of 'substantial' (0.6 or above) being required to pass the assessment. Disagreement regarding inclusion or exclusion of studies will be resolved by consensus, or following assessment by a third reviewer. If the Kappa value is low, the reference list will be reassessed against adjusted inclusion and exclusion criteria. The same subset of references will be re-assessed by a second reviewer with Kappa analysis. Reviewers will then consider articles viewed at full text for relevance, either excluding them from, or admitting them to, the review.

- **Relevant subjects:** All studies looking at the control or eradication of Japanese knotweed in any habitat (including glasshouses) will be appropriate for inclusion into the systematic review. The scope will be worldwide. Studies will be included irrespective of habitat or spatial scale; however, the geographical area will be recorded in order to interpret any patterns of variation in the results.
- **Types of intervention:** Initially, all interventions that are implemented to control or eradicate Japanese knotweed will be considered valid for inclusion. The review may need to be restricted at a later stage if there is not enough literature available to assess all available interventions, or if there is too much information available. If this is the case, a scope of the literature will be carried out and the intervention(s) with the most available literature will be the focus of the review.
- **Types of comparator:** Comparators (temporal or spatial) are not necessary for inclusion of material in the review. However, they are a prerequisite for studies to be included in any subsequent inferential meta-analysis. A complete lack of comparators or controls may result in a study being included in correlative or qualitative analysis.
- **Types of outcome:** Initially, any outcome will be considered for inclusion. Ideally, changes in abundance or size of the treated Japanese knotweed population at a local scale are the primary outcome measures so an evaluation of the success of the intervention can be made. The definition of what constitutes an effective reduction in Japanese knotweed abundance will need to be defined in consultation with subject experts prior to commencing data extraction. Other outcomes that refer to changes in the population as a result of the control method, the cost effectiveness of different control methods, or the impact on species other than Japanese knotweed, will not be included in a formal synthesis, but they will be catalogued as outcome measures.
- **Types of study:** All studies investigating the control or eradication of Japanese knotweed will be included if they present primary data about a relevant subject, intervention and outcome.

- **Potential reasons for heterogeneity:** It is hypothesised that the following factors (in no particular order) will impact on the outcome of the control or eradication method:
  - Habitat type (e.g. forest, grassland, riparian, agricultural, urban)
  - Temperature
  - Rainfall
  - Soil moisture
  - Soil type
  - Ground slope
  - Shading
  - Longitude/latitude
  - Altitude
  - Age of stand
  - Height of stand
  - Density of knotweed (e.g. cover, stand density, frequency, and biomass)
  - Size of controlled area
  - Previous control programs (same or different to present one?)
  - Duration, effort (frequency of control) and timing (i.e. season) of control program or study
  - Mechanical aspects of control methods (e.g. cutting and digging /excavation techniques)
  - Chemical aspects of control methods (e.g. herbicide type, herbicide application method, concentration of herbicide, number of herbicide applications)
  - Type of grazer
  - Hybridisation
  - Species variety (*F.* var. *japonica* vs. *F.* var. *compacta*)

3.3 Study quality assessment

Reviewers will consider articles viewed at full text, excluding them from the review or admitting them to different categories of information quality. Study quality will be scored according to a hierarchy of evidence adapted from models of the systematic review process used in medicine and public health (Stevens & Milne 1997; Pullin & Knight 2003); e.g. a randomised control trial would be weighed higher than a site comparison study. A second reviewer will examine a random subset of at least 25% of the selected studies to assess repeatability of study quality. Disagreement regarding study quality will be resolved by consensus, or following assessment by a third reviewer.

3.4 Data extraction strategy

Data will be extracted by one reviewer, and a random subset of at least 25% of the selected studies will be checked by another reviewer to verify repeatability and accuracy. Data regarding the study characteristics, quality, design and results will be recorded using data extraction forms. It is likely that these forms will be subject to amendment following consultation with subject experts, statisticians and piloting the process of data extraction. Where information regarding the reasons for heterogeneity is presented in the studies, it will be recorded.

3.5 Data synthesis

Methods of data synthesis depend greatly on the type of data presented in the available studies. At the least, all studies that are selected for inclusion will be summarised qualitatively. Attempts will be made to collect primary data from the author/organisation if it is not presented in the study write up. Summary tables of study characteristics, study quality and results will be presented, accompanied by a narrative synthesis. Quantitative analysis will be undertaken on any data that is suitable for formal statistical treatment. If possible, meta-analyses for each of the interventions will be carried out with reasons for heterogeneity assessed by meta-regressions (univariate or multivariate). If meta-analysis is not possible, then correlative or Bayesian analysis may be performed.

4. POTENTIAL CONFLICTS OF INTEREST AND SOURCES OF SUPPORT

- United Utilities PLC and the NERC-Knowledge Transfer programme are providing funding for this review. There are no conflicts of interest to be recorded.

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