Invasive Species Compendium

Selected sections for: Fallopia japonica (Japanese knotweed)

Datasheet Type(s): Invasive Species, Pest

Identity

Preferred Scientific Name

Fallopia japonica Houtt. Ronse Decr.

Preferred Common Name

Japanese knotweed

Other Scientific Names

Pleuropterus cuspidatus (Sieb. & Zucc.) Mildenke
Pleuropterus zuccarinii (Small) Small
Polygonum cuspidatum Sieb. & Zucc.
Polygonum reynoutria Makino
Polygonum seiboldii Vriese
Polygonum zaccharini Small
Reynoutria japonica Houtt.

International Common Names

French

renouée du Japon

Local Common Names

China

huzhang

Czech Republic
kridlatka japonska

Denmark
Japansk-pileurt

Estonia
vooljas kirburohi, vooljas pargitatar

Finland
Japanintatar, sieboldintatar

Germany
Japan-knöterich

Ireland
glúineach bhiorach, glúineach sheapanach

Japan
itadori, itamidori

Netherlands
duizendknoop, Japanse

New Zealand
Asiatic knotweed

Poland
rdesh sachalinski, rdest ostrokoñczysty, rdestowiec ostrokoñczysty

Sweden
parkslide

United Kingdom
donkey rhubarb, German sausage, gypsy rhubarb, Hancock's curse, pea-shooter plant, Pysen saethwr, Sally rhubarb

USA
elephant-ear bamboo, fleece flower, Japanese bamboo, Japanese

fleece flower, Mexican bamboo, wild rhubarb

EPPO code

POLCU (Fallopia japonica)

Taxonomic Tree

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Polygonales
Family: Polygonaceae
Genus: Fallopia
Species: Fallopia japonica

Summary of Invasiveness

F. japonica is an extremely invasive weed despite its lack of sexual reproduction in most of its introduced range. It is included on various lists of invasive weeds and is one of the 100 worst invasive species as identified by the IUCN. It is a potential contaminant of soil, and its ability to tolerate a remarkable range of soil types and climates means that it has the potential to spread much further than it has to date. It has gained a fearsome reputation for breaking through concrete and being almost impossible to eradicate once it has taken hold and is often recognized as one of the most pernicious weeds in any recipient country.

Notes on Taxonomy and Nomenclature

Fallopia japonica was independently classified as *Reynoutria japonica* by Houttuyn in 1777 and as *Polygonum cuspidatum* by Siebold in 1846. It was not until the early part of the twentieth century that these were discovered to be the same plant (Bailey, 1990), which is generally referred to as *Polygonum cuspidatum* by Japanese and American authors. Recent evidence vindicates Meissner's 1856 classification as *Fallopia japonica* var. *japonica* (Bailey, 1990). The two most common introduced varieties are var. *japonica* and var. *compacta* and it is the former that is the main problematic weed. The closely related *Fallopia sachalinensis* can hybridize with *F. japonica* to form *Fallopia* x *bohemica*, first described in 1983, which is proving to be more problematic than *F. japonica* var. *japonica* in the UK.

The common name in English is Japanese knotweed. The Japanese common name 'itadori' has a literal meaning 'take away pain'. Other common names used in the UK include: 'Hancock's curse', believed to be named after a plant supplier in Cornwall, UK; 'German sausage' referring to the characteristic flecking on the round stems; and 'pea-shooter plant', coined by children who used the cut stems to blow pellets at each other.

Description

The plant is a vigorous growing herbaceous perennial with annual tubular, glabrous stems that ascend from an erect base. These stems are light green often with reddish flecks, branched and reach up to 3 m in height (Beerling et al., 1994). Where introduced, *F. japonica* is generally taller than in its native range in Japan (Holzner and Numata, 1982), where it is recorded as being 0.3-1.5 m tall (Makino, 1997). Stems arise from strong rhizomes to form a dense thicket. Rhizomes are thick and woody when old, and have been recorded as spreading 5-7 m laterally (Pridham et al., 1966). The rhizome has ring-like structures at about 2 to 4 cm intervals which are reduced leaf scales, whilst on the underside are adventitious roots travelling into the soil. The rhizome snaps like a carrot when fresh to reveal a yellow/orange colour. The main aerial shoots emerge from the large bulbous rhizome crown about 30 cm x 30 cm across. This acts as a carbohydrate store in the winter months when it represents the complete live biomass of the plant. Spreading out from this central region are a number of radial penetrating rhizomes that twist together to form a sizeable and considerable penetrating force. The leaves are 5-12 cm x 5-8 cm, broadly ovate, cuspidate at the tip and truncate at the base. At the base of each leaf petiole is located a small gland that functions as an extra-floral nectary. The flowers are off-white and borne in ochreate clusters of 3 to 6 on terminal and axillary panicles, with the main axis up to 10 cm long and with slender branches 5-9 cm long (Lousley and Kent, 1981). Sepals 5, the outer 3-keeled; stamens 8, included within a perianth in male-sterile plants, filaments 0.4 mm, anthers small, flat, empty 0.3 mm, styles 3, distinct, stigma fimbriate, exceeding the perianth; perianth greatly enlarged in fruit and conspicuously winged, completely enclosing the trigonous achene. Achenes (or nuts) 2-4 mm long, 2 mm wide, dark brown and glossy, mean weight 1.6 mg. Inflorescences initially erect but drooping at maturity. Male fertile plants are not known from the introduced range.

Plant Type

Descriptors

Broadleaved
Herbaceous
Perennial
Shrub
Vegetatively propagated

Distribution

It is likely that the plant has spread further than can be deduced from the literature because of under reporting.

Distribution Table

Country	Distribution	Last Reported	Origin	First Reported	Invasive	References	Notes
ASIA							
China	Present, no further details		Native		Not invasive	USDA-ARS, 2003	
-Anhui	Present, no further details		Native		Not invasive	Kim & Park, 2000	
-Fujian	Present, no further details		Native		Not invasive	Kim & Park, 2000	
-Guangdong	Present, no further details		Native		Not invasive	Kim & Park, 2000	
-Henan	Present, no further details		Native		Not invasive	Kim & Park, 2000	
-Hubei	Present, no further details		Native		Not invasive	Kim & Park, 2000	
-Jiangsu	Present, no further details		Native		Not invasive	Kim & Park, 2000	

-Jiangxi	Present, no further details		Native		Not invasive	Kim & Park, 2000	
-Zhejiang	Present, no further details		Native		Not invasive	Kim & Park, 2000	
Japan	Present, no further details					EPPO, 2009	
-Hokkaido	Present, no further details		Native		Not invasive	USDA-ARS, 2003	
-Honshu	Widespread		Native		Not invasive	Bailey, 2003; USDA-ARS, 2003	
-Kyushu	Widespread		Native		Not invasive	Bailey, 2003; USDA-ARS, 2003	
-Shikoku	Present, no further details		Native		Not invasive	Bailey, 2003; USDA-ARS, 2003	
Korea, DPR	Present, no further details		Native		Not invasive	Kim & Park, 2000; USDA-ARS, 2003	
Korea, Republic of	Present, no further details		Native		Not invasive	Kim & Park, 2000; USDA-ARS, 2003	
Taiwan	Present, no further details		Native		Not invasive	Kuo, 1996; USDA-ARS, 2003	
NORTH AMERICA							
Canada	Widespread					EPPO, 2009	

-British Columbia	Present, no further details		Introduced		Invasive	AAC, 2003	
-Manitoba	Present, no further details		Introduced		Invasive	AAC, 2003	
-New Brunswick	Present, no further details		Introduced		Invasive	AAC, 2003	
-Newfoundland and Labrador	Present, no further details		Introduced		Invasive	AAC, 2003	
-Nova Scotia	Present, no further details		Introduced		Invasive	AAC, 2003	
-Ontario	Present, no further details		Introduced		Invasive	AAC, 2003	
-Prince Edward Island	Present, no further details		Introduced		Invasive	AAC, 2003	
-Quebec	Present, no further details		Introduced		Invasive	AAC, 2003	
USA	Widespread					EPPO, 2009	
-Alaska	Present, no further details		Introduced			USDA-NRCS, 2002	
-Arkansas	Present, few occurrences		Introduced			USDA-NRCS, 2002	
-California	Restricted distribution		Introduced			USDA-NRCS, 2002	
-Colorado	Present, no further details		Introduced			USDA-NRCS, 2002	

-Connecticut	Present, no further details		Introduced			USDA-NRCS, 2002	
-Delaware	Present, no further details		Introduced		Invasive	USDA-NRCS, 2002	
-Georgia	Present, no further details		Introduced			USDA-NRCS, 2002	
-Idaho	Present, no further details		Introduced			USDA-NRCS, 2002	
-Illinois	Present, no further details		Introduced			USDA-NRCS, 2002	
-Indiana	Present, no further details		Introduced			USDA-NRCS, 2002	
-Iowa	Present, no further details		Introduced			USDA-NRCS, 2002	
-Kansas	Present, no further details		Introduced			USDA-NRCS, 2002	
-Kentucky	Present, no further details		Introduced			USDA-NRCS, 2002	
-Louisiana	Present, no further details		Introduced			USDA-NRCS, 2002	
-Maine	Present, no further details		Introduced			USDA-NRCS, 2002	
-Maryland	Present, no further details		Introduced			USDA-NRCS, 2002	
-Massachusetts	Present, no further details		Introduced			USDA-NRCS, 2002	
-Michigan	Present, no		Introduce			USDA-	

	further details		d			NRCS, 2002	
-Minnesota	Present, no further details		Introduced			USDA-NRCS, 2002	
-Mississippi	Present, no further details		Introduced			USDA-NRCS, 2002	
-Missouri	Present, no further details		Introduced			USDA-NRCS, 2002	
-Montana	Present, no further details		Introduced			USDA-NRCS, 2002	
-Nebraska	Present, no further details		Introduced			USDA-NRCS, 2002	
-New Hampshire	Present, no further details		Introduced			USDA-NRCS, 2002	
-New Jersey	Present, no further details		Introduced		Invasive	Seiger, 1991	
-New York	Present, no further details		Introduced		Invasive	USDA-NRCS, 2002	
-North Carolina	Widespread		Introduced		Invasive	Patterson, 1976	
-Ohio	Present, no further details		Introduced		Invasive	ODNR, 2003	
-Oklahoma	Present, no further details		Introduced			USDA-NRCS, 2002	
-Oregon	Widespread		Introduced		Invasive	Seiger, 1997	
-Pennsylvania	Widespread		Introduced		Invasive	Seiger, 1997	
-Rhode	Present, no		Introduce			USDA-	

Island	further details		d			NRCS, 2002	
-South Carolina	Present, no further details		Introduced			USDA-NRCS, 2002	
-South Dakota	Present, no further details		Introduced			USDA-NRCS, 2008	
-Tennessee	Widespread		Introduced		Invasive	TEPPC, 1997	
-Utah	Present, no further details		Introduced		Invasive	USDA-NRCS, 2002	
-Vermont	Present, no further details		Introduced		Invasive	USDA-NRCS, 2002	
-Virginia	Widespread		Introduced		Invasive	USDA-NRCS, 2002	
-Washington	Widespread		Introduced		Invasive	Hickman, 1993	
-West Virginia	Present, no further details		Introduced			USDA-NRCS, 2002	
-Wisconsin	Present, no further details		Introduced			USDA-NRCS, 2002	
SOUTH AMERICA							
Chile	Present, no further details		Introduced			Saldaña et al., 2009	
EUROPE							
Austria	Present, no further details		Introduced		Invasive	Jalas & Suominen, 1979	
Belgium	Present, no further details		Introduced			Van Rompaey &	

						Delvosalle, 1979	
Bulgaria	Present, no further details		Introduced			Jalas & Suominen, 1979; Beerling & Bailey, 1994	
Croatia	Present, no further details		Introduced			Carnet, 2003	
Cyprus	Present, no further details					EPPO, 2009	
Czech Republic	Widespread		Introduced	1892	Invasive	Pysek & Prach, 1993; Mandák et al., 2004	
Denmark	Present, no further details		Introduced			Jalas & Suominen, 1979	
Estonia	Present, no further details					EPPO, 2009	
Finland	Present, no further details		Introduced			Jalas & Suominen, 1979	
France	Widespread		Introduced		Invasive	Jalas & Suominen, 1979	
Germany	Widespread		Introduced		Invasive	Jalas & Suominen, 1979	
Hungary	Present, no further details		Introduced			Jalas & Suominen, 1979	
Ireland	Present, no further details		Introduced		Invasive	Reynolds, 1998	
Italy	Present, no		Introduce			Bailey,	

	further details		d			2003	
Latvia	Present, no further details		Introduced			Jalas & Suominen, 1979	
Lithuania	Present, no further details		Introduced			Jalas & Suominen, 1979	
Luxembourg	Present, no further details		Introduced			Van Rompaey & Delvosalle, 1979	
Macedonia	Present, no further details		Introduced			Jalas & Suominen, 1979	
Netherlands	Present, no further details		Introduced		Invasive	Mennema, 1985	
Norway	Present, no further details		Introduced		Invasive	Fremstad, 1997	
Poland	Widespread		Introduced		Invasive	Stypinski, 1977	
Portugal	Present, no further details		Introduced			Jalas & Suominen, 1979	
Romania	Present, no further details		Introduced			Jalas & Suominen, 1979	
Russian Federation	Restricted distribution					EPPO, 2009	
-Southern Russia	Present, no further details		Introduced			Jalas & Suominen, 1979	
Serbia	Present, no further details		Introduced			Jalas & Suominen, 1979	
Slovakia	Present, no further		Introduced			Jalas & Suominen,	

	details					1979	
Slovenia	Present, no further details		Introduced			Jalas & Suominen, 1979	
Spain	Present, no further details		Introduced		Invasive	Izco, 1974	
Sweden	Present, no further details		Introduced			Jalas & Suominen, 1979	
Switzerland	Present, no further details		Introduced		Invasive	Landolt, 1991	
United Kingdom	Widespread		Introduced	1850	Invasive	Conolly, 1977	
-Channel Islands	Present, no further details		Introduced			Jalas & Suominen, 1979	
OCEANIA							
Australia	Present, no further details					EPPO, 2009	
-New South Wales	Present, no further details		Introduced		Invasive	Ainsworth et al., 2002	
-Tasmania	Present, no further details		Introduced		Invasive	Ainsworth et al., 2002	
-Victoria	Present, no further details		Introduced		Invasive	Ainsworth et al., 2002	
New Zealand	Present, no further details		Introduced	1935	Invasive	Bailey, 2003	

History of Introduction and Spread

F. japonica is native to Japan, China, Taiwan and the Korean peninsula. The most likely date of its introduction to Europe was 1849, at the nursery of

Philip Von Siebold, who later sent it to the Royal Botanical Gardens at Kew, UK, in 1850 (Conolly, 1977). That was also the first year that *F. japonica* var. *japonica* was made available to the public by Von Siebold as an ornamental, and later promoted as a potential source of forage. *F. japonica* was sent to the Royal Botanical Gardens at Edinburgh, UK in 1854, where it was then further distributed across the UK and most likely into the USA also. It had certainly become naturalized in the UK by the late 1880s, since it was reported as growing in abundance on cinder tips near Glamorgan, Wales, and had appeared on most patches of cultivated ground in Oldham, Lancashire (Storrie, 1886; Walters, 1887). It was intentionally introduced as an ornamental into the Czech Republic as early as 1892 (Pysek and Prach, 1993). Early in the 1900s the number of reports of naturalizations increased rapidly. These establishments were most likely to have been escapes from gardens as it was a popular exotic plant whose rapid growth made an ideal natural screen for the privy house in the garden (which lead it to be called the 'outhouse plant' in the USA). Introduction and spread in other countries followed a similar exponential pattern as that in the UK.

Introductions

Introduced to	Introduced from	Year	Reason	Introduced by	Established in wild through		References	Notes
					Natural reproduction	Continuous restocking		
Czech Republic	Japan	1892	Ornamental purposes		Yes	Unknown	Pysek & Prach, 1993	
United Kingdom	Japan	1825	Ornamental purposes		Yes	Unknown	Synge, 1956	Naturalized by 1880s

Risk of Introduction

F. japonica is now a well-known invasive species in most potential recipient countries, so is no longer sought after as an ornamental. However, the risk of introduction of rhizome material as a contaminant of soil and manure remains high in those countries where the plant is well established.

Habitat

In its native range of Japan, Taiwan and Korea *F. japonica* is found growing in sunny places on hills, high mountains and along road verges and ditches. Other typical habitats are gravel riversides and managed pastures, where high levels of nitrogen fertilizer are applied (Child and Wade, 2000). In its introduced range, the plant can be found as a riparian weed as well as an invader of man-made environments such as spoil heaps, derelict land, road and railway verges and gardens. There is a clear association with disturbed sites and urban areas thanks to its use as a horticultural plant. It is found primarily in open sites, and its growth and abundance are depressed in shady sites (Beerling, 1991; Seiger, 1993) and it is consequently unable to invade forests.

Habitat List

Category	Habitat	Presence	Status
Littoral	Coastal areas	Present, no further details	Harmful (pest or invasive)
	Coastal dunes	Present, no further details	Harmful (pest or invasive)
Terrestrial-managed	Buildings	Present, no further details	Harmful (pest or invasive)
	Cultivated / agricultural land	Present, no further details	Harmful (pest or invasive)
	Disturbed areas	Present, no further details	Harmful (pest or invasive)
	Rail / roadsides	Present, no further details	Harmful (pest or invasive)
	Urban / peri-urban areas	Present, no further details	Harmful (pest or invasive)
Terrestrial-natural/semi-natural	Riverbanks	Present, no further details	Harmful (pest or invasive)
	Rocky areas / lava	Present, no further details	Harmful (pest or

flows invasive)

Hosts/Species Affected

There are no specific species that are affected but any native species forced to compete with knotweed, i.e riparian plants, are likely to suffer consequences.

Biology and Ecology

Genetics

The most important aspect of *F. japonica* in its introduced range is that it has spread solely by vegetative means and from a very small number of initial introductions. Thus much of the invasive *F. japonica* in the world may be clonal, as is the case in the UK (Hollingsworth and Bailey, 2000). However, recent research in the USA has shown that wild *F. japonica* can produce large quantities of viable seeds, and seedlings have been found in the field (Forman and Kesseli, 2003).

As introduced plants there is inevitably less genetic diversity in *F. japonica* abroad, at least in terms of the parental species. This is balanced by an extraordinary burst of hybridization involving species and cytotypes not normally sympatric in their indigenous regions (Bailey, 2003). Hybridization and relative chromosome numbers are important in differentiating *F. japonica* varieties and related species. The chromosome number of *F. japonica* var. *japonica* is 2n=88; *F. japonica* var. *compacta* is 2n=44; *F. sachalinensis* is 2n=44; and *F. baldshuanica* is 2n=20. The hybrid between *F. japonica* var. *compacta* and *F. japonica* var. *japonica* can produce plants with 2n=44 chromosomes. These tetraploid plants are very rare, although they are able to interbreed with either of their parents. The most commonly observed hybrid is between *F. japonica* var. *japonica* and *F. baldshuanica*, a commonly planted and invasive climber called Russian vine. Fortunately the seed from this hybrid very rarely survives in the wild and possesses none of the aggressive attributes of either of its parents (Bailey, 1988). The cross between *F. japonica* var. *japonica* and *F. sachalinensis* is known as *F.* x *bohemica* and has 2n=66. These hexaploid plants are reasonably common but only partly fertile, and any pollen produced usually contains between 30 and 66 chromosomes. If a pollen grain with 66 chromosomes were to pollinate a *F. sachalinensis* flower in Europe, a fertile octoploid *F.* x *bohemica* would be produced. Such plants would be able to cross-pollinate the all-female *F. japonica* and potentially be a replacement for the absent male *F. japonica*, allowing *F. japonica* to reproduce by seed again.

Reproductive Biology

In its native range *F. japonica* spreads both by seed and vegetatively. The small winged seeds enable the plant to colonize recently exposed land, such as that resulting from recent volcanic activity. *F. japonica* is functionally dioecious, but in the UK and the USA the plants are female with male sterile flowers. Therefore the primary regeneration strategy is asexual and spread in the introduced range is solely by root and stem fragments, often along waterways and by humans. However, recent studies in Belgium revealed extensive sexual reproduction by hybridization, and that a small percentage of seeds may be dispersed outside the maternal clone (>16 m), allowing the formation of genetically differentiated individuals (Tiébré et al., 2007). This is also supported by observations in North America (Forman and Kesseli, 2003) where it is now thought that hybridization and seed germination is becoming increasingly common (J Bailey, Dept. of Botany, Leicester University, UK, personal communication, 2008).

Physiology and Phenology

Vegetative spread is normally through tiny pieces of rhizome, stems and even internodal sections of stem capable of establishing roots (Locandro, 1978; Palmer, 1990), even in water (Figueroa, 1989). Rhizome fragments weighing as little as 0.7 g are capable of regenerating into a new plant (Brock and Wade, 1992), whilst rhizome pieces with a mean weight of 4.39 g generated shoots 70% of the time in controlled greenhouse experiments, giving a conservative estimate that a 1 m^2 stand could produce 238 new shoots (Brock and Wade, 1992).

Associations

F. japonica is capable of colonizing land within 20 years of volcanic activity, where it is often the sole pioneer species and is reported to be replaced by other herbaceous species after 50 years or so (Yoshioka, 1974). It is often found in association with *Miscanthus sinensis* grassland on active volcanic fumaroles, and stands often give way to grass species from the centre after die-back (Adachi et al., 1996).

Environmental Requirements

F. japonica requires high light environments in many ecoclimatic ranges. *F. japonica* can survive very harsh conditions with a pH range of 3.0-8.5 (Beerling et al., 1994), and an ability to survive extreme heavy metal and salt pollution and areas with low available nitrogen. *F. japonica* requires high light environments and competes effectively for light in such situations. It is generally associated with regions of higher precipitation in the UK (Conolly, 1977). However, Locandro (1973) reported it growing on xeric as well as hydric sites in the USA. It grows from sea level in its native and introduced ranges up to altitudes of 2400 m in Japan (Maruta, 1983), and to 2400-3800 m in Taiwan.

Climate

ClimateType	Status	Description	Remark
C - Temperate/Mesothermal climate	Preferred	Average temp. of coldest month > 0°C and < 18°C, mean warmest month > 10°C	
Cf - Warm temperate climate, wet all year	Preferred	Warm average temp. > 10°C, Cold average temp. > 0°C, wet all year	
Cs - Warm temperate climate with dry summer	Tolerated	Warm average temp. > 10°C, Cold average temp. > 0°C, dry summers	
Cw - Warm temperate climate with dry winter	Tolerated	Warm temperate climate with dry winter (Warm average temp. > 10°C, Cold average temp. > 0°C, dry winters)	
D - Continental/Microthermal climate	Preferred	Continental/Microthermal climate (Average temp. of coldest month < 0°C, mean warmest month > 10°C)	
Df - Continental climate, wet all year	Preferred	Continental climate, wet all year (Warm average temp. > 10°C, coldest month < 0°C, wet all year)	
Ds - Continental climate with dry summer	Tolerated	Continental climate with dry summer (Warm average temp. > 10°C, coldest month < 0°C, dry summers)	
Dw - Continental climate with dry winter	Tolerated	Continental climate with dry winter (Warm average temp. > 10°C, coldest month < 0°C, dry winters)	

Air Temperature

Parameter	Lower limit	Upper limit
Absolute minimum temperature (ºC)	-17	0
Mean annual temperature (ºC)	5	17

Mean maximum temperature of hottest month (ºC)	14	32
Mean minimum temperature of coldest month (ºC)	-7	4

Rainfall

Parameter	Lower limit	Upper limit	Description
Mean annual rainfall	580	2200	mm; lower/upper limits

Soil Tolerances

Soil Texture

heavy
light
medium

Soil Reaction

acid
alkaline
neutral
very acid

Soil Drainage

free
impeded
seasonally waterlogged

Special Soil Tolerance

infertile
saline
shallow
sodic

Means of Movement and Dispersal

F. japonica has been able to spread without the aid of sexual reproduction and the resulting seed. Thus it is remarkable that it has managed to spread as far and wide as it has through passive means, i.e along river corridors and through human assistance, intentional or accidental. In the areas where it is introduced it is still on its expansive phase after the usual lag phase.

Natural Dispersal (Non-Biotic)

Flooding events can facilitate the spread of *F. japonica*, as whole plants and/or stem parts can be dislodged and transported to new areas downstream, where they can establish easily.

Vector Transmission (Biotic)

There are no reports of animals disseminating propagules in the introduced range, though means of seed dispersal in the native range has not been investigated. It is possible that hoofed animals could redistribute small pieces of rhizome in much the same way as vehicle tyres can.

Accidental Introduction

Accidental dissemination is the most common pathway for the establishment of populations, often as a result of inappropriate control measures such as flail-mowing on a riverbank. Contamination of imported growing medium, and failure to kill rhizomes by adequate heat treatment or composting is another common means of accidental introduction by gardeners. Contaminated soil imported to development sites or for use in trench filling causes new introductions, as well as allowing the spread of previously contained infestations.

Intentional Introduction

Some gardeners still consider *F. japonica* to be an attractive ornamental plant and may therefore plant it in ignorance. It was also promoted in the past for soil stabilization.

Pathway Causes

Cause	Comments	Long Distance	Local	References
Botanical gardens/ zoos	Original cause	Yes	No	
Breeding/ propagation	cultivars still sold	Yes	No	
Erosion control/ dune stabilization	has been used for this	Yes	No	
Flooding/ other	common	Yes	No	

natural disaster			
Garden waste disposal	common	Yes	No
Horticulture	varieties still for sale	Yes	No
Interconnected waterways		Yes	No
Landscape improvement/ landscaping industry	as contamiinant of topsoil	Yes	No
Cut flower trade	stems used	No	Yes
Disturbance		No	Yes
Escape from confinement/ garden escape	most common	No	Yes

Pathway Vectors

Vector	Comments	Long Distance	Local	References
Debris and waste associated with human activities	Excavations and topsoil	Yes	No	
Floating vegetation/debris	During flood events or after flail mowing	Yes	No	
Land vehicles	Small fragments of rhizome	Yes	No	
Machinery/equipment	Rhizomes can be moved on tracks of earth movers	Yes	No	
Mail/post	Internet plant sales	Yes	No	
Soil, sand, gravel etc.	Topsoil movement	Yes	No	

Plant Trade

Plant parts liable to carry the pest in trade/transport	Pest stages	Borne internally	Borne externally	Visibility of pest or symptoms
Bulbs, Tubers, Corms, Rhizomes	roots; stems	No	No	
Growing medium accompanying plants	roots; stems	No	No	
Roots	roots; stems	No	No	
True seeds (inc. grain)	seeds	No	No	

Plant parts not known to carry the pest in trade/transport
Bark
Fruits (inc. pods)
Leaves
Seedlings, Micropropagated plants
Stems (above ground), Shoots, Trunks, Branches
Wood

Notes on Natural Enemies

F. japonica in Japan is attacked by a suite of natural enemies, both arthropod and fungal, not present in its native range. To date, 186 species of arthropod and around 40 species of fungus have been recorded from the plant in its native range of Japan (R Shaw, CABI, UK, personal communication, 2008). As a result of this attack it is not able to compete with local flora as effectively as it does in the introduced range and does not normally reach the same massive size. Of these natural enemies, some exert significant damage such as *Gallerucida nigromaculata*, which is described as having potential as a biocontrol agent by Zwoelfer (1973). This is now thought to be *G. bifasciata* Motchulski and not adequately specific. Recent observations by CABI Bioscience show fungal pathogens, as well as arthropods, are significant controlling factors in Japan across the climatic range of the plant. This includes a number of obligate biotrophic fungi, as well as an ubiquitous leafspot pathogen. In its introduced range, *F. japonica* is attacked by the green dock beetle *Gastrophysa viridula*, but this is only when its normal *Rumex* host has been consumed and beetle populations are elevated.

Natural enemies

Natural Enemy	Type	Life Stages	Specificity	References	Biological Control in	Biological control on
Aecidium polygoni cuspidati	Pathogen	Leaves	to genus			
Aphalara itadori	Herbivore	Leaves/Stems	to species			
Gallerucida nigromaculata	Herbivore	Leaves	not specific			
Lixus impressiventris	Herbivore	Stems	to genus			
Machiatella itadori	Herbivore	Leaves	not specific			
Mycosphaerella polygoni-cuspidati	Pathogen	Leaves	to species			
Puccinia polygoni-amphibii var. torariae	Pathogen	Leaves	not specific			

Impact Summary

Category	Impact
Biodiversity (generally)	Negative
Cultural/amenity	Negative
Economic/livelihood	Negative
Environment (generally)	Negative
Native flora	Negative
Tourism	Negative

Impact: Economic

The estimated annual control costs for one county council in Wales, UK, in 1994 was £300,000 (approximately US $600,000). The budget needed to control the 64 ha knotweed infestation in the City and County of Swansea was estimated to be £5.79 million in 1998 (Shaw, 2001). To control *F. japonica* on a national scale in the UK would cost an extrapolated £1.56 billion (approximately US $3 billion) were it to be attempted, as reported by the UK Department of Environment, Food and Rural Affairs in its recent non-native species policy review. An accepted estimate of control costs is £10,000 per hectare for a 3-year spraying regime, with two sprays per year, but this is probably an underestimate if revegetation costs are taken into account. Its presence can add around 10% to the costs of a development project, especially if soil is considered contaminated and subject to additional removal fees. Indeed, a spraying programme on a development site is estimated to be £27.19 per m^2 (approximately US $54 per m^2), and including finance costs this almost doubles to £50.88 per m^2 (approximately $100 per m^2) if soil has to be removed and clean soil imported and compacted (Child and Wade, 2000). The worst case scenario for a $1m^2$ stand of knotweed in a development site has been put at £46,000 (M Wade, RPS Group, UK, personal communication) because of the cost of soil removal to landfill, the associated landfill tax as well as the best practice of using a geo-textile membrane to prevent reinvasion.

Impact: Environmental

Impact on Habitats

Apart from the obvious biodiversity impact, *F. japonica* also damages the environment through an increased risk of flooding and its impact. In times of flood, dense stands can impede water flow and exacerbate flooding. Also, dead stems can be swept away and cause blockages downstream. In addition, rapidly growing *F. japonica* can actually disrupt the integrity of flood defence structures.

Impact on Biodiversity

As is often the case with invasive species, the impact that *F. japonica* has on biodiversity is often referred to but little studied. A riverbank that used to support a wide range of native species but now supports a monoclonal stand of *F. japonica* certainly has less biodiversity. Its early emergence and great height combine to shade out other vegetation and prohibit regeneration of other species (Sukopp and Sukopp, 1988). Thus it reduces species diversity and damages wildlife habitat (Palmer, 1990; Scott and Mars, 1984). Dead *F. japonica* stems can persist for 2-3 years producing large quantities of debris and slowly decomposing litter which also leads to a reduced floristic diversity (Child and Wade, 2000).

A recent European study by Gerber et al. (2008) showed that habitats invaded by knotweeds support lower numbers of plant species, lower overall abundance and morphospecies richness of invertebrates, compared to native grassland-dominated and bush-dominated habitats. Total invertebrate abundance and morphospecies richness in *Fallopia*-invaded riparian habitats was correlated with native plant species richness. This suggested a link between the replacement of native plant species by exotic *Fallopia* species and the reduction in overall invertebrate abundance and morphospecies richness. Moreover, the biomass of invertebrates sampled in the grassland and bush-dominated habitats was almost twice as high as that in *Fallopia*-invaded habitats. Large-scale invasion by exotic *Fallopia* species is therefore likely to seriously affect biodiversity and reduce the quality of riparian ecosystems for amphibians, reptiles, birds and mammals, whose diets are largely composed of arthropods.

A knock-on effect can be observed further up the food chain, as knotweed-invaded sites appear to be less suitable habitats for foraging frogs, probably due to reduced invertebrate populations (Maerz et al., 2005).

Impact: Social

F. japonica infestations are often a sign of poverty in development regions of Wales and Cornwall in the UK, a factor compounded by the extra cost of development associated with *F. japonica* infestations. Stands become litter traps, which become evident in winter once the leaves fall. In addition, the plant can create a fire hazard in the dormant season (Ahrens, 1975).

Risk and Impact Factors

Invasiveness

- Abundant in its native range
- Fast growing
- Has a broad native range
- Has high reproductive potential
- Has propagules that can remain viable for more than one year
- Highly adaptable to different environments
- Is a habitat generalist
- Long lived
- Pioneering in disturbed areas
- Proved invasive outside its native range
- Reproduces asexually
- Tolerates, or benefits from, cultivation, browsing pressure, mutilation, fire etc

Impact outcomes

Altered trophic level
Conflict
Damaged ecosystem services
Ecosystem change/ habitat alteration
Increases vulnerability to invasions
Infrastructure damage
Modification of hydrology
Modification of nutrient regime
Modification of successional patterns
Monoculture formation
Negatively impacts livelihoods
Negatively impacts tourism
Reduced amenity values
Reduced native biodiversity
Threat to/ loss of native species

Impact mechanisms

Allelopathic
Competition - monopolizing resources
Competition - shading
Rapid growth

Likelihood of entry/control

Difficult to identify/detect as a commodity contaminant
Difficult/costly to control

Uses

Owing to its rapid rate of growth, *F. japonica* has been considered as an energy source (Bernik and Zver, 2006), although in early studies it was not found to be economically viable (Callahan et al., 1984). It is unlikely that any biofuel material would be harvested from the wild.

Economic Value

Owing to its rapid growth rate, *F. japonica* has also been considered as a source of biofuel, although it was not found to be economically viable (Callahan et al., 1984).

Social Benefit

F. japonica is a commonly used food source in certain areas of Japan (R Shaw, CABI, UK, personal communication, 2008), and it allegedly tastes like rhubarb or asparagus.

F. japonica is not without its uses, and in its native range is believed to have medicinal properties, not surprising when the Japanese name 'itadori' means "take away pain". It is used in Japan and China as a traditional medicine for ailments such as schistosomiasis, hyperlipemia, gonorrhoea, dermatitis and athlete's foot, where it is known as hu zhang, hu chang, tiger cane, kojo-kon and hadori-kon. The roots of *F. japonica* and *F. sachalinensis* contain relatively high levels of resveratrol, an anti-cancer drug, and are the source for most of the resveratrol sold in nutritional supplements. This extract has shown anti-tumour effects in mice (Kimura and Okuda, 2001). *F. japonica* is reported as having other therapeutic properties, with extracts appearing to have antipyretic and analgesic activities on mice and rats. It protects the gastric membrane against stress ulcers and inhibits gastric secretion with no effect on blood pressure. However, the drug depressed the activity of the central nervous system in mice. Leaf extracts from the closely related giant knotweed, *F. sachalinensis*, have been shown to inhibit the performance of common fungal pathogens of crops (Paik, 1989; Herger and Klinghauf, 1990).

Environmental Services

Where it is introduced *F. japonica* is claimed to be of value to bees and invertebrates as it flowers later than most native plants. The true benefit as a bee forage has not been evaluated, but since *F. japonica* plants in the UK do not produce pollen it could only serve as a late nectar source. As is often the case with invasive weeds, apiarists consider *F. japonica* to be of value to bees and invertebrates, with an increase of 45 kg in hive weight in 5 days being reported from a knotweed stand (Andros, 2000).

Knotweed has been used to stabilise riverbanks and other steep slopes, and the microclimate under its canopy has been likened to that of oak woodland (Gilbert, 1992).

Uses List

General

Botanical garden/zoo

Environmental

Erosion control or dune stabilization

Materials

Chemicals
Pesticide

Medicinal

Source of medicine/pharmaceutical

Fuels

Biofuels

Animal feed

Fodder/animal feed

Ornamental

Cut flower

Detection and Inspection

The UK Environment Agency have produced a Code of Practice, and the Cornwall and Devon Knotweed Forum have produced an excellent guide which has advice on identifying the plant in the field at various stages of the season.

Similarities to Other Species/Conditions

F. sachalinensis, or giant knotweed, a closely related species which is not normally as much of a problem weed as *F. japonica*, is similar in many respects but is generally a much larger plant; 4-5 m tall and with much larger leaves, 20-40 cm long. Another distinguishing characteristic is at the base of the leaf, which in *F. sachalinensis* is rounded acuminate forming a heart shape. The hybrid between *F. japonica* and *F. sachalinensis* is called *Fallopia* x *bohemica* and is very similar to *F. japonica*, though it can be distinguished from its parents by having an intermediate leaf base shape similar in size to *F. japonica*. The closely related *Polygonum polystachyum*, or Himalayan knotweed, can be distinguished from *F. japonica* by its slightly hairy stems and longer, more slender leaf shape. It grows up to 1.8 m tall and can cause localized problems itself in similar habitats to *F. japonica*.</P< body>

Prevention and Control

Prevention

F. japonica appears on the UK Wildlife and Countryside Act (1981) and as such it is illegal to cause the plant to grow in the wild. It is listed as a noxious weed in many states and provinces of North America and appears on many weed lists around the world.

SPS measures

Vehicles should be inspected when moving from infected sites to new ones.

Rapid response

It is possible to eradicate knotweed if a new infestation of rhizome is spotted quickly and the resultant plants pulled or treated before roots have become well established.

Public awareness

The success of knotweed management is greatly improved if the public buy in to the process of prevention and control. There are many examples of knotweed information material around the world from t-shirts to mugs. The media are impressed by the concrete-cracking ability of the weed and it often features in invasive reviews.

Eradication

Although present in Australia for around 100 years and naturalized a number of times in New South Wales, Tasmania and Victoria *F. japonica* appears to have so far achieved only very limited spread. Based on the information presently available, eradication of this species from Australia appears both feasible and highly desirable (Ainsworth et al., 2002). See Control.

Control

Due to a large and persistent rhizome system knotweed is highly resistant to control efforts (Ainsworth et al., 2002). The effectiveness of control and eradication interventions has recently been reviewed thoroughly by Kabat et al. (2006), who included 65 articles in their meta-analysis. Six categories of intervention were included, none of which could eradicate Japanese knotweed or its hybrid in the short term. Cutting treatments alone were not found to result in significant decreases in knotweed abundance. However, statistically-significant reductions in abundance can be achieved by short term application of a) glyphosate, b) imazapyr, c) imazapyr + glyphosate, d) cutting followed by filling stems with glyphosate, and e) cutting followed by spraying with glyphosate (Kabat et al., 2006). However, these authors were still unable to conclude long term efficacy for any control measure.

Cultural control and sanitary measures

There is little cultural control that is appropriate for *F. japonica*, although goats and cattle will graze newly emergent shoots in the spring.

Physical/mechanical control

Mechanical control is difficult but continual mowing will reduce the resources of the extensive rhizome system if carried out throughout the growing season. Glasshouse trials have shown that repeated cutting at least every 4 weeks and at least 7 weeks prior to senescence can be effective (Seiger and Merchant, 1997). Pulling up plants complete with root systems can eliminate small stands and is appropriate for local eradication in sensitive areas, but only if carried out continually over a number of years (Baker, 1988). Digging up roots, however, is even more challenging since they can extend to a depth of 2 m, and 7 m away from the crown, and despite the best efforts, it normally results in an increased stem density. This may be useful for integrated control.

Biological control

F. japonica is an ideal candidate for biological control since it has been introduced without any of the suite of natural enemies that keep it in check in its native range. It has been identified as one of the best targets for biological control in the UK, with the likelihood of success being high (Shaw, 2003). It also scores highly in a review of targets for Europe (Sheppard et al., 2006). Recent unpublished findings have reaffirmed the potential for classical biocontrol, and a full programme for the UK has recently been funded and is expected to be completed in 2007. A programme has been underway, on behalf of UK and North American sponsors, since May 2003 with two candidate agents, namely a *Mycosphaerella* leafspot and the psyllid *Aphalara itadori*. Both of these agents have undergone extensive host range testing and have good potential as biological control agents. Given the difficulty faced by property developers, there would appear to be a market for a mycoherbicide, although registration costs are hindering this approach.

Chemical control

The use of chemicals to control *F. japonica* will depend on the intended goal and the restrictions in place for the environment invaded. For example, chemicals that are permitted on or near water are normally restricted as will be the potential for full control. Child and Wade (2000) recommended five herbicides for *F. japonica* control, to be applied as foliar sprays. Triclopyr and imazapyr can be applied to young, actively growing shoots when grasslands need to be protected; glyphosate is suitable during active growth periods when leaves are fully expanded, although larger plants may need to be sprayed using a telescopic/long lance sprayer; picloram can also be used as a soil drench due to its persistence, but not where planting is required within 2 years; and 2,4-D amine is used during the active growing period and as a selective translocated herbicide to be used in grassland, amenity areas and forest situations, although this may depend on which formulation is used in which country. Of the five herbicides, only glyphosate and 2,4-D amine can be used near water. In general, cutting and removing dead stems at the end of the season prior to a spraying regime the following season is advisable to aid access. *F. japonica* is a very resilient plant and unless extremely toxic chemicals are appropriate, repeated well-timed applications should be anticipated, and follow up spot treatments of any regrowth will often be required.

Stem injection of various herbicides is a relatively modern phenomenon and can produce very good results in some conditions but concerns remain over the amount of chemical that is actually applied per hectare exceeding statutory maxima. Hagen and Dunwiddie (2008) discovered that using glyphosate, through the injection method results in the short-term dieback of injected stems. However, drawbacks to its use in certain scenarios should be considered when developing an integrated management plan for knotweed control.

IPM programmes

Using a combination of mechanical and chemical techniques can be effective, such as cutting and a follow up spray of new growth, but it is necessary to apply the chemical more than once a season (de Waal, 1995). There are two basic methods: to cut plants to 5 cm height and immediately apply a 25% solution of glyphosate or triclopyr to the cut stems; or cut or mow infestations when the plants reach the early bud stage in the late spring or summer and treat the regrowth in the autumn with glyphosate or triclopyr. If deep digging is used to effectively increase the above ground:below ground biomass ratio, then subsequent chemical application can reduce the time required to achieve effective control (Child et al., 1998). Another herbicide strategy is an integrated strategy with mowing or cutting.

Control by utilization

Owing to its rapid rate of growth, *F. japonica* has been considered as an energy source (Bernik and Zver, 2006), although in early studies it was not found to be economically viable (Callahan et al., 1984).

Monitoring and Surveillance

There are various GIS surveys on-going in the UK, the first being in Swansea, followed by Cornwall and Devon. These have provided a useful resource to planning authorities as well as national bodies.

Mitigation

Rapid eradication of newly-established *F. japonica* is possible but only if the rhizome has not become too extensive.

Ecosystem Restoration

Knotweed's ability to hyper-accumulate heavy metals, including copper, zinc and cadmium, more effectively than other angiosperm species has been proven in Japan (Nishizono et al., 1989) and Croatia (Hulina and Dumija, 1999).

Gaps in Knowledge/Research Needs

Considerably more work is required to investigate the reproductive strategy in North America since there is increasing evidence of seed set and seed germination. Unfortunately this means that this region does not have the luxury of dealing with a clonal target weed.

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Links to Websites

Website	URL	Comment
Japanese Knotweed Alliance	http://www.cabi-bioscience.org/html/japanese_knotweed_alliance.htm	
Japanese Knotweed EA Code of Practice	http://www.environment-agency.gov.uk/commondata/acrobat/japnkot_1_a_1463028.pdf	
Japanese Knotweed - Guidance for Idenitification and Control	http://www.devon.gov.uk/knotweedbooklet.pdf	
BBC News - Alien invaders hit the UK	http://news.bbc.co.uk/1/hi/sci/tech/7531221.stm	

Organisations

United Kingdom: Environment Agency, National Customer Contact Centre PO Box 544, Rotherham S60 1BY, http://www.environment-agency.gov.uk/

Pictures

Picture	Title	Caption	Copyright
	Habit	Roadside stand of Japanese knotweed showing foliage and young flowers. UK.	Richard H. Shaw/CABI BIOSCIENCE
	Habit	Japanese knotweed pushing through road surface in car park. UK.	Richard H. Shaw/CABI BIOSCIENCE

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