NOBANIS – Invasive Alien Species Fact Sheet

Fallopia japonica

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Species description

Scientific name: *Fallopia japonica* (Houtt.) Ronse Decraene var. *japonica,* Polygonaceae

Synonyms: *Reynoutria japonica* Houtt*., Polygonum japonicum* Meissn., *Polygonum* compactum Hook.f., *Polygonum cuspidatum* Sieb. & Zucc., *Polygonum zuccarinii* Small, *Polygonum reynoutria* Makino, *Pleuropterus cuspidatus* (Sieb. & Zucc.) Moldenke, *Tiniaria cuspidata* (Houtt.) Hedb., *Polygonum sieboldii* Reinw. ex de Vries non Meissn., *Polygonum confertum* Hook.f., *Pleuropterus zuccarinii* (Small) Small, *Reynoutria yabeana* Honda, *Reynoutria uzenensis* (Honda) Honda, *Reynoutria japonica* var. *uzenensis* Honda, *Reynoutria hastata* Nakai, *Tiniaria japonica* (Houtt.) Hedb., (Heß *et al.* 1967, Ohwi 1984, Wisskirchen & Haeupler 1998, Flora Europaea 2001).

Common names: Japanese Knotweed, Crimson beauty, Donkey rhubarb, Fleece flower, German sausage, Hancock´s curse, Japanese bamboo, Japanese fleece flower, Japanese polygonum, Kontiki bamboo, Mexican bamboo, Pea-shooter plant, Sally rhubarb, Reynoutria fleece flower, Wild rhuburb (GB, USA), Japan-Knöterich, Japanischer Staudenknöterich, Gewöhnlicher Japanischer Flügelknöterich, Spieß-Knöterich, Spitzblättriger Knöterich, Zugespitzter Knöterich (DE), Japansk Pileurt (DK), Vooljas pargitatar (Vooljas kirburohi) (EE), Japanintatar, Sieboldin tatar (FI), Japoninė reinutrė (LT), Japānas dižsūrene (LV), Parkslirekne (NO), Rdestowiec (Rdest) ostrokończysty (PL), гречишка японская (RU), Parkslide (SE).

Fig. 1. *F. japonica*, ♀

Fig. 2. *F. japonica*, *F. sachalinensis* and *F. x bohemica*, Wolfach, Black forest, Germany (1993)

Fig. 3. *F. sachalinensis*, ♀

Fig. 4. *F. sachalinensis*, ♂

Fig. 5. Trichomes, *F. sachalinensis*

Fig. 6. Trichomes, *F. japonica*

Fig. 7. Trichomes, *F. x bohemica*

Fig. 8. F. *japonica* var. *compacta*, Gernsbach, Germany

Species identification
Fallopia japonica is a herbaceous perennial with annual, tubular, glabrous stems that ascend from an erect base (Ohwi 1984). Stems arise from strong rhizomes to form a dense thicket. The plants grow up in spring (main growing period in May to June) very quickly and reach a height up to 3 m (Beerling *et al.* 1994, Alberternst *et al.* 1995, Alberternst 1995, 1998). Where introduced, *F. japonica* is generally taller than in its native range in Japan (Holzner & Numata 1982) where it is recorded as being 0.3-1.5 m tall (Makino 1997). The stems are light green, often with reddish flecks, or reddish-brown, simple to minimally branched, weakly woody, hollow and swollen at the nodes. The top of the stems and the branches often arches over and twigs often zigzag slightly from node to node. The ochrea sheathes the stem above each node and is usually fringed at the top. The leathery, broadly ovate leaves are usually 10-15 (18) cm long, sometimes wider than long and up to 13 cm wide. Leaves appear usually without trichomes on the veins of the underside of leaves (important for identification! See figs. 5, 6, 7). At the base of each petiole is located a small gland that functions as an extra-floral nectary (*e.g.* Wisskirchen & Haeupler 1998).

Japanese knotweed is dioecious (unisexual male and female flowers are located on separate plants) and flowers from (July) August to September (October). Plants have male flowers with vestigial ovaries and 8-9 anthers, and female flowers with infertile stamens (staminodes). The panicles are axillary on upper stems, up to 15 cm long (longer in fruit), with small cup-like bracts at nodes, branched, open, lax, with numerous flowers. Tepals are 5 (6), more or less fused at the base, +/- white, 2-8 (9) mm long, outer 3-keeled. The fruits are shiny, dark brown triangular nuts (achenes), 2-4 mm long (Steward 1930, Ohwi 1984).

Fallopia japonica var. *compacta* (Hook.f.) J.P. Bailey is a dwarf form of *F. japonica* (fig. 8). The plants grow up to a height of 1.8 m. The leaves are smaller than of *F. japonica* var. *japonica*, up to 11 cm long and 10 cm wide, hard, leathery, and broadly ovate. The edges are wavy. Male and female forms occur in Europe (*e.g.* UK). *F. japonica* var. *compacta* is in Europe quite rare for example in Germany or the Czech Republic (On-line key, Alberternst 1995, Mandák *et al.* 2004).

F. sachalinensis (F. Schmidt ex Maxim.) Ronse Decraene, or giant knotweed, is a closely related species which is less distributed in Europe than *F. japonica* (Pýsek & Prach 1993, Alberternst 1998, Wisskirchen & Haeupler 1998, Mandák *et al.* 2004). *F. sachalinesis* is native to north Japan (middle part of Honshu), Korea, South Sakhalin and the Kurile Islands (Jäger 1995). The species is similar to *F. japonica* var. *japonica* in many respects but is generally a much larger plant (4-5 m tall) and with much larger leaves; up to 43 cm long and 27 cm wide (*cf.* Alberternst *et al.* 1995). The base of the leaves is rounded, forming a heart shape. About 1 mm long, white trichomes are located usually on the veins of the leaves' lower side. In Europe both male and female plants occur.

F. japonica hybridises with *F. sachalinensis* to build the commonly occurring hybrid *F. x bohemica* (Chrtek & Chrtková) J.P. Bailey. *F. x bohemica* is variable in habit and sometimes morphologically similar to *F. japonica* or to *F. sachalinensis*. In some cases the hybrid grows up to a height of 4.5 m and is in many characteristics intermediary. Leaves are up to 25 cm long and 18 cm wide. The leaf base is truncate up to cordate, the tips acuminate. Trichomes, which are the most important diagnostic feature, are about 0.5 mm in length, and are located on the veins of the lower side of leaves (figs. 5-7; Bailey 1988b, Bailey 1990, Bailey & Stace 1992, Alberternst *et al.* 1995, Alberternst 1995, 1998).

Polygonum wallichii Greuter & Burdet (syn. *P. polystachyum* Wallich ex Meisn., *Reynoutria polystachya)*, or Himalayan knotweed, is closely related. It grows up to a height of 2 m and can be distinguished from *F. japonica* by its slightly hairy stems, and longer and more slender leaf shape.

The leaves are up to 38 cm long and 13 cm wide (Alberternst 1995). It grows in similar habitats as *F. japonica* and can cause ecological problems (weedmapper, Swiss fact-sheet). This species is established but not invasive in Poland (seven known localities) (Bartoszek *et al.* 2005). It is also established in Norway at four known localities (Lid & Lid 2005).

Native range

F. japonica is native to Japan, Sakhalin Island, the Kurile Islands, Korea, SW China, Taiwan, and Vietnam (Ohwi 1984, Jäger 1995). In its native range in Japan, *F. japonica* occurs in various plant communities and is distributed in different habitats (Sukopp & Sukopp 1988). It grows at riversides (Ohno 1979), in swamp forests (Makita *et al.* 1979), near roads *e.g.* at the Meishin road (Kameyama 1979), or in a *Quercus serrata* forest (Miyawaki *et al.* 1984). After Bailey (2003) the main habitat for tall forms of *F. japonica* in Japan is at the edges of forests or river-sides in forests.

F. japonica is a dominant pioneer in the primary succession of volcanic slopes and settles on bare volcanic gravel and lava fields (Maruta 1976, 1983, Hirose & Tateno 1984). On Mt. Fuji *F. japonica* appears above the timber line at an altitude up to 2500-2600 m which is the upper limit of its distribution (Maruta 1994).

Alien distribution

History of introduction and geographical spread

Detailed descriptions of the naturalisation history in the alien range are given by Conolly (1977) for the British Isles, and by Jäger (1995) for other areas. After its introduction to Holland in 1823, *F. japonica* was frequently cultivated as an ornamental plant in parks and gardens in many European countries (Kosmale 1981, Jäger 1995). In Germany, *F. japonica* was also used as a forage plant (Hegi 1912) and for erosion control (v. Schlechtendahl *et al.* 1882). The species escaped in the middle of the 19th century and was naturalised in many European countries at the end of the 19th century, *e.g.* in England, France, Germany, Holland, Poland, Scotland, and Wales (Jäger 1995). Kosmale (1981, 2000) gives reports of naturalisation in Germany since 1872, where *F. japonica* spread after a nursery that cultivated and sold *F. japonica* plants gave up in 1866 (or 1868?). V. Schlechtendahl *et al.* (1882) describes naturalisation of Japanese knotweed at the railway in Jena (Germany). Storrie (1886) also reports naturalisation of *F. japonica* in the British Isles.

Today, *F. japonica* is naturalised in many European countries (Sukopp & Sukopp 1988, see fig. 9 after Jäger 1995), up to at least 68 degrees N latitude (Jalas & Suominen 1979, Sebald *et al.* 1990, Lid & Lid 2005), and also in south European countries like Croatia, Macedonia, and Bosnia and Herzegovina (Trinajstic 1990). In the U.K. *F. japonica* has spread extensively, occurring in half of the 10 km x 10 km quadrates in the national grid (Shaw & Seiger s.d.). Clumps more than 500 square meters in size occur (Palmer 1990).

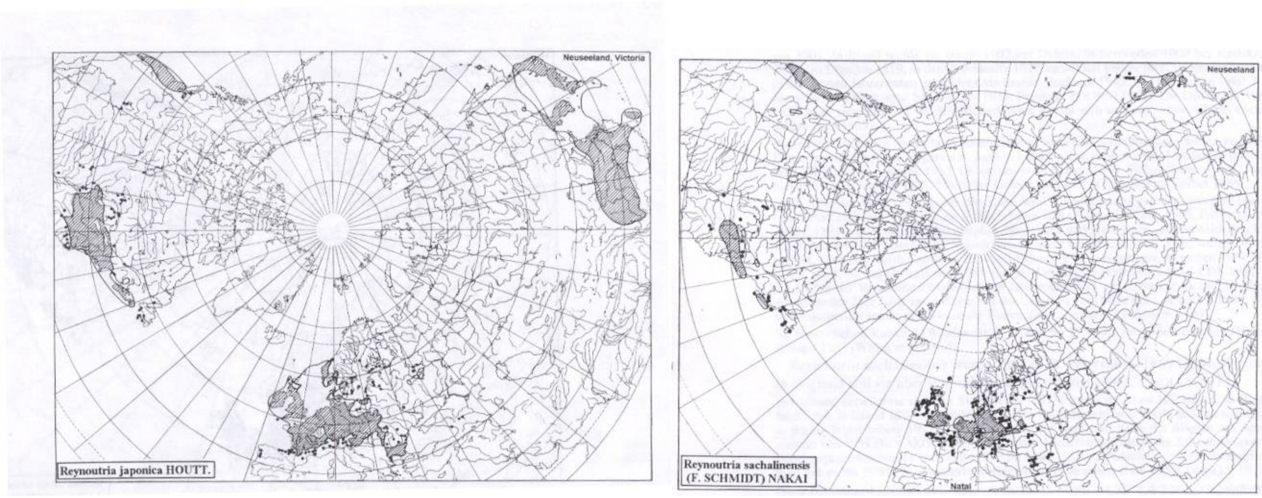

Fig. 9. Native range and alien distribution of *F. japonica* and *F. sachalinensis* (from Jäger 1995).

F. japonica is widely distributed in Germany. Locally the plant is very common for example in the south-western part of Germany where it occurs very often at road sides, pathways, ruderal places and especially at river sides, *e.g.* in the Black Forest where it dominates the vegetation (Fig. 2, Kretz 1994, Alberternst 1995, 1998).

The first report of *F. japonica* in Poland dates back to the second half of the 19th century. Findings were reported by Cybichowski (*herb.* POZ) in 1882 in Gniezno; by Baenitz in 1893 in Wrocław (*herb.* WU), and by Graebner (1894) in the same year in Darzlubie (Baltic Coast). Schube (1903, 1904, 1905, 1908, 1910) reported the location of a dozen findings occurring in Lower and Upper Silesia (south-western and south Poland). These data may not be complete as *F. japonica* had undoubtedly more localities, including in western and central Poland, especially in large cities. In the 1960s the number of findings increased to 342 and it continues to grow. It is fairly widespread over the whole country, reaching elevations of 750 m a.s.l. in the Karkonosze Mts., in Działy Orawskie 535 m a.s.l., and in the Tatra Mts. 860 to 1000 m a.s.l. (Tokarska-Guzik 2005a and literature cited therein).

In Latvia the naturalisation of *F. japonica* started about 100 years ago. In the first half of the 20th century the spread of Japanese knotweed in semi-natural and natural habitats has been slow, and an increased intensity of naturalisation has been observed only in the last decades. Until 1970 there were just eight known localities, but from 1971 to 2002 the number of localities has increased to 199. It has spread more in the western part of Latvia with a milder climate than in the eastern part, where the climate is more continental (Laiviņš 2003).

In Lithuania, this species was first recorded as naturalised alien in 1935, in the vicinity of Juodkrantė (Curonian Spit) (Gudžinskas 1999). The species is now distributed all over the country, but is more frequent and abundant in the western and the eastern districts. In some areas it occupies rather large areas, but spreading occurs mainly with garden wastes and earth movements during construction of buildings etc. (Gudžinskas 1999).

In Estonia it was first found naturalised in 1957 (Toomas Kukk, pers. comm.).

In Russia *F. japonica* was recorded in 1924 in Moscow district. Since 1970 species expansion was observed although the rate of spreading is confined because the predominance of vegetative reproduction: in northwestern and many central district of European Russia seeds were not found

(Игнатов и др. 1990). It has local distribution and grows along roads, railways and near settlements (Гусев 1974, Алексеев, Макаров 1977, Александрова и др. 1996).

F. japonica was used as a garden plant around Oslo in Norway since at least the 1870s, and at the same time it is known that this species was thriving in gardens in Nordland County at almost 68 degree N latitude (Schübeler 1883). The first record of a naturalised specimen is from 1901, and the species has been steadily spreading in the country since then (Fremstad & Elven 1997). Today it is fairly common in a broad belt along the coast from the south-east to about the polar circle, and with the northernmost locality known at about 68.5 degree N latitude (Lid & Lid 2005). The highest locality in Norway so far has been recorded at 480 m a.s.l. (Fremstad & Elven 1997).

Pathways of introduction
F. japonica was introduced from Eastern Asia to Europe for ornamental purposes and once introduced it was sold by gardeners in many European countries (Jäger 1995). The plant species was also used as a forage plant, for erosion control *e.g.* on sandy soils, for hiding stalking paths, and for raised hides (v. Schlechtendahl *et al.* 1882, Hegi 1912, Weis 1987, Kosmale 1989). From cultivations the plants became naturalised or were spread unintentionally (see section on dispersal and spread).

Alien status in region
F. japonica is established in Europe, North America, Asia, Australia, and New Zealand (Izco 1974, Stypinski 1977, Pyšek & Prach 1993, Trinajstić *et al.* 1994, Jäger 1995, Madák *et al.* 2004, and internet links), see table 1.

Country	Not found	Not established	Rare	Local	Common	Very common	Not known
Denmark					X		
Estonia				X			
European part of Russia				X			
Finland				X			
Faroe Islands	X						
Germany					X		
Greenland	X						
Iceland	X						
Latvia			X				
Lithuania				X			
Norway					X		
Poland					X		
Sweden				X			

Table 1. The frequency and establishment of *Fallopia japonica*, please refer also to the information provided for this species at www.nobanis.org/search.asp. Legend for this table: **Not found** –The species is not found in the country; **Not established** - The species has not formed self-reproducing populations (but is found as a casual or incidental species); **Rare** - Few sites where it is found in the country; **Local** - Locally abundant, many individuals in some areas of the country; **Common** - Many sites in the country; **Very common** - Many sites and many individuals; **Not known** – No information was available.

Ecology

Habitat description

F. japonica has a wide ecological amplitude and can thrive in many different habitats. In its alien range it has been observed growing on a variety of soil types, including silt, loam, sand, and even raw soils. It grows on xeric as well as hydric sites (Locandro 1973, Alberternst 1998). The pH of the soils where *F. japonica* grows ranges from 3.5 to 7.4, and knotweed plants have even been observed on limestone (Locandro 1973, Kosmale 1981). *F. japonica* is a light demanding plant and prefers sunny places (*cf.* Beerling 1994, Schlüpmann 2000). It also occurs in semi-shaded habitats as forest paths or forest edges. In a few cases *F. japonica* grows inside of forests (Kosmale 1981, Alberternst 1995).

F. japonica spreads in its alien range along river banks, in wetlands, waste places, along roads and railways, on coal mines, on fallows and in other disturbed areas (Conolly 1977, Wittig 1981, Kosmale 1989, Beerling *et al.* 1994, Boehmer *et al.* 2001, Tokarska-Guzik 2005a).

Reproduction and life cycle

Fallopia japonica is a perennial plant (hemicryptophyte) and reproduces mainly vegetatively. Sexual reproduction occurs rarely in the alien range. The plant reproduces predominately via rhizomes that grow horizontally and have reduced leaf scales at about 2 to 4 cm intervals. On the lower side adventitious roots are growing into the soil. The thick and extensive rhizomes store large quantities of carbohydrates (Adler 1993). Rhizomes are often 5-6 m long, but a length of up to 20 m is documented (Fuchs 1957). Rhizomes grow up to 1 m laterally within a single vegetation period (Hagemann 1995). Lateral growth up to 2.5 m was reported by Kretz (1994). Rhizome fragments of some centimetres can produce new plants (Brock & Wade 1992, Adler 1993, Alberternst 1995). Brock & Wade (1992) showed that rhizome fragments weighing as little as 0.7 g are capable of regenerating into a new plant. Rhizomes buried to soil depths of 2 m are able to regenerate (Kosmale 1976). An experiment showed that a rhizome fragment of 130 g and a diameter of 2 cm can penetrate a soil layer of 1.5 m within a single vegetation period (Alberternst 1995, 1998). Rhizomes are even able to penetrate an asphalt layer (Locandro 1978).

In Europe most *F. japonica* plants are female and are derived 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 & Bailey 2000). Male *F. japonica* plants occur in Europe (*e.g.* in Germany), but are very rare (photo in Alberternst 1995). In England no male fertile forms of *F. japonica* have been found (Bailey 1990). Although pollen of *F. japonica* is mostly lacking, the plant often produces seeds. The amount of seed set differs: Some plants produce plenty of seeds; in some stands seeds are minuscule. Because of the lack of *F. japonica* pollen, seeds are usually of hybrid origin (Bailey 1985, 1988a, 1990). *Fallopia* seedlings occur rarely. Seedlings have been observed *e.g.* in Germany by Kosmale (1981), Schwabe & Krachtochwil (1991), Adler (1993), and Alberternst (1995, 1998). Viable seeds and seedlings have also been found in the field in the USA (Forman & Kesseli 2003).

Dispersal and spread

Dispersal by vegetative means occurs naturally when rhizome fragments are washed downstream by the water current and deposited on banks, or, more commonly, by humans when soil is transported and used as fill dirt (Locandro 1973, 1978). The plant also regenerates from stem fragments. Even internode tissue can occasionally develop and initiate shoots (Locandro 1973, 1978, Brock & Wade 1992).

In the last decades *F. japonica* has spread enormously, predominantly by rhizomes in soil which is transported unintentionally by humans and used as fill dirt at different places like river sides, roads, buildings, and parks.

Impact

Affected habitats and indigenous organisms

Since *F. japonica* is able to build up dominant dense stands, the plant community structure and light and energy conditions of the ecosystem are changed (Kowarik 1996). Seedlings of woody species are not able to germinate in many cases and succession is retarded (*e.g.* Lohmeyer 1969). One of the most serious problems is that it modifies or expels the native vegetation by shading (Sukopp & Sukopp 1988, Schepker 1998, Schlüpmann 2000, Tokarska-Guzik *et al.* 2005). Investigations conducted by Alberternst (1998) show that the number of plant species in vegetation transects with *Fallopia* were lower than in transects without the species. Japanese knotweed is capable of invading and forming dominant stands at almost any vegetation of perennial herbs and ruderal sites, especially in sunny places (Adler 1993, Sukopp 1996, DVWK 1997). At shaded sites its competitive capacity is much weaker.

Out-competing the indigenous flora has also negative impact on the fauna, mainly on specialised insects, when their forage plants are replaced by *Fallopia* taxa (Westrich 1989, Schwabe & Kratochwil 1991). Effects on abiotic parameters (*e.g.* soils and hydrology) are not probable.

Genetic effects

Chromosome numbers are important in differentiating *F. japonica* varieties and related species. Two varieties of *F. japonica* with different chromosome numbers are known in Europe. The chromosome number of *F. japonica* var. *japonica* is in Europe 2n=8x=88 (Bailey & Stace 1992, Alberternst 1998, Mandák *et al.* 2003). *F. japonica* var. *compacta* has in U.K., the Czech Republic and Germany 2n=4x=44 chromosomes (Bailey & Stace 1992, Mandák *et al.* 2003, Alberternst unpublished data). *F. japonica* hybridises with related *Fallopia*-species (Bailey & Stace 1992, Bailey 2003). *F. sachalinensis* has in most cases 2n=4x=44 chromosomes, but plants with 2n=6x=66 or 2n=8x=88 have also been found (Mandák *et al.* 2003). The hybrids between the different varieties of *F. japonica* and *F. sachalinensis* are known as *F. x bohemica* and have 2n=4x=44, 2n=6x=66 or 2n=8x=88 chromosomes, depending on the chromosome numbers of their parents (Bailey & Stace 1992). The hybrid between *F. japonica* and *F. sachalinensis* was surprisingly not described in Japan until 1997 (Bailey 2003). According to Bailey (2003) this hybridisation is apparently a recent phenomenon in Japan caused by the practice of planting *F. japonica* on road embankments in order to stabilise the soil. *F. x bohemica* might have developed in its new range in areas where both parent species occur. In different field and *ex situ* experiments for testing control methods rhizome fragments of *F. x bohemica* and *F. japonica* were planted. *F. x bohemica* had in most cases a larger biomass than *F. japonica* (Konold *et al.* 1995, Alberternst 1995, 1998). Possibly the hybrid is more vigorous than its parent species.

In many cases *F. japonica* hybridises with the commonly planted and invasive climber called Russian vine, *F. baldshuanica* (Regel) Holub, which has a chromosome number of 2n=20. The hybrid between *F. japonica* var. *japonica* and *F. baldshuanica* has 2n=54 chromosomes (Bailey 1988a, 1988b, Bailey & Stace 1992). The seedlings from this hybrid very rarely survive in the wild and possess none of the aggressive attributes of either of its parents (Bailey 1988a).

Human health effects
Fallopia japonica has no negative effects on human health.

Economic and societal effects (positive/negative)
F. japonica has both positive and negative economic and societal effects. It was used, and in some cases is still used, as an ornamental plant for gardens and parks. In Japan and China it is a traditional medicine. Dried rhizomes are used for the treatment of suppurative dermatitis, gonorrhoea, favus, athlete's foot, hyperlipemia, allergy, and inflammation (Jayasuriya *et al.* 1992, Ignatowicz & Baer-Dubowska 2001). The roots of *F. japonica* contain relatively high levels of resveratrol, an anti-cancer drug that shows anti-tumour effects in mice (Kimura & Okuda 2001, Ignatowicz & Baer-Dubowska 2001).

Investigations of Latten & Scherer (1994) and Schmitt (1995) showed that an extract from *F. japonica* inhibits the performance of the fungals *Plasmopara viticola* on *Capsicum* and *Phytophtora infestans* on tomatoes. It was tested whether the extract can be used to protect plants against fungal diseases (Schmitt 1995). Leaf extracts from the closely related giant knotweed, *F. sachalinensis*, have been shown to inhibit the performance of common fungal pathogens of crops (Herger *et al.* 1988, Herger & Klingauf 1990). A product from *F. sachalinensis* called Milsana (Compo) is sold since 1990 (Kowalewski & Schmitt 1993, Schmitt 1995).

At the end of the 1990s *F. x bohemica* was tested for use as a renewable energy resource alternative to *Miscanthus* x *giganteus* which often does not survive cold winter temperatures. While *Fallopia* showed advantages in winter hardiness, the removal of the plant was very difficult. For this reason *Fallopia* x *bohemica* was not recommended as a renewable energy resource (Pude & Franken 2001).

Many Polygonaceae are capable of growing in heavy metal contaminated soils. After Kubota *et al.* (1988) *F. japonica* is able to concentrate large amounts of Cu, Zn, and Cd in its roots. In different countries, for example in Germany or in the Czech Republic, *F. sachalinensis* has been tested for decontaminating metalliferous soils (Haase 1988, Metz & Wilke 1994, Schwerder *et al.* 1994).

Strong negative economic impacts of *F. japonica* have been described from south-west Germany (see Reinhardt *et al.* 2003). *F. japonica* occurs in this region predominantly at the banks of rivers and streams. In south-west Germany annual floods are very common and therefore many watercourses are contained within stone walls. *F. japonica* loosens the foundations of these stone walls by growing its rhizomes below the foundations. It also displaces the stabilising herbaceous layer by shading and makes the river banks more susceptible to erosion. The annual floods wash away the soil substrate and destroy the stone walls (Kretz 1994, Alberternst 1995, 1998, Bauer 1995, Walser 1995). Reinhardt *et al.* (2003) calculated the annual costs to repair these foundations in Germany to 3.5 - 10.5 million €. According to these authors the costs to control the plants in Germany are estimated to 5.9 - 6.6 million € per year, and the annual costs to stabilise the river banks are calculated to 12.3 - 21.2 million €.

F. japonica causes problems at roadsides, pathways or along railways. Plants grow up and reduce sight, which might be problematic *e.g.* at crossings. They also damage pathways or parking lots by growing through asphalt layers causing high costs for resurfacing (Beerling 1991). Reinhardt *et al.* (2003) estimated the annual control costs for *Fallopia* species at railways in Germany to 2.0 - 7.7 million € per year. In Wales, UK, the estimated annual control costs for one county council in 1994 was £300,000. To control *F. japonica* on a national scale in the UK would annually cost an extrapolated £1.56 billion. A spraying programme on a development site is estimated to cost £27.19

per m² and including finance costs this almost doubles to £50.88 per m² if soil has to be removed and clean soil imported and compacted (Child & Wade 2000).

Management approaches

Prevention methods
Establishment can be prevented by monitoring the introduction of *Fallopia japonica*. New plants should be removed manually. Soil containing *Fallopia* fragments should not be used as fill dirt *e.g.* for pathways, streets, fastenings. After mowing, Japanese knotweed the plant material must be removed from the area. It should be composted by at least 70°C (*cf.* Bollens 2005).

Eradication, control and monitoring efforts
Different control measures include mowing and flailing at various intervals, chemical and thermal procedures, plantings, browsing, and various technological procedures (Kretz 1994, Walser 1995, DVWK 1997, Bollens 2005).

Horses and cattle like to feed on young leaves of *F. japonica* (DVWK 1997). However, this results in a broken turf (Walser 1995) and is therefore not viewed by DVWK (1997) as an ideal method for ecologically oriented watercourse management, because it equally prevents the growth of native riverside woody species. In the opinion of the agencies concerned, however, browsing by sheep is the most effective and least expensive control method in large sized areas of vegetation along non-natural sectors of streams (Walser, pers. comm.). It is important to remove the old dry stems from last year before a browser is introduced to *F. japonica*. The dry stem is sharp as a knife and will cut the grazing animals.

Round-up (glyphosate) was applied at those locations where satisfactory results were not achievable by other control methods. This herbicide quantitatively removes the vegetation from the area of application, but its use is prohibited in the immediate proximity of surface waters. Moreover, stands of *F. japonica* need to be re-treated because of the high resistance of the rhizomes (Kretz 1994). An environmentally adequate alternative is to inject the herbicide (1:1 with water) into the large pith cavities of the basal internodes of the stem (Hagemann 1995). This treatment also needs to be repeated in the following year, and it is required to maintain a distance of 5 to 10 m from the watercourse.

According to Kretz (1994), Alberternst (1995), and DVWK (1997), the establishment and spreading of *F. japonica* is hindered by reed grass (*Phalaris arundinacea*), common reed (*Phragmites communis*), butterbur species (*Petasites* spp.), and alder (*Alnus glutinosa*). The suppression of Japanese knotweed by native riverside woods requires plantations sufficiently wide on both banks. Flood damage to river banks should be repaired by applying earth that is free of knotweed. The sites should be covered with jute sacking (or sprigs of spruce) and planted densely with willow cuttings. Excavated soil containing knotweed rhizomes should be composted with fresh compost (1:1); in light soils, mechanical screening of rhizome fragments can be achieved with a drum sieve. The latter methods, however, entail a residual risk of contamination (Kretz 1994).

Adler (1993) observed that mowing for several years in succession transforms dominant stands of Japanese knotweed into diverse communities. The plants must be mown before mid-May in order to prevent the transport of assimilation products to the rhizomes. Complete elimination of the species was impossible, however, even after seven years. Removal of the mowed plant material has no effect, because the loss in biomass is compensated by the reserves stored in the rhizomes (Kretz

1994), even though it reduces the mass of the storage corms (Adler 1993). Frequent mowing weakens desirable plants as well (Adler 1993, Konold *et al.* 1995). The so-called "flailing" procedure does not cut the shoots cleanly, but damages them more seriously by striking them off (Kretz 1995). This method is now favoured over the traditional mowing procedure, because it also leaves the turf undamaged (Walser pers. comm.).

The effect of burning is similar to that of mowing, except that the ashes directly re-fertilise the soil. Covering with black foil is another method that has been tried without much success. The foil needs to be weighted throughout its entire surface, because otherwise it will be lifted by the shoots.

Information and awareness
Management efforts should be combined with information to the local inhabitants to ensure acceptance of the measures and to prevent new plantations or escapes. According to Kretz (1994) the principal method to control *F. japonica* is to disseminate information on its characteristics. This is the only means to prevent an establishment of new primary populations and further involuntary spreading of the plant. Successful management therefore requires the dissemination of comprehensive information to a wide sector of the public.

Knowledge and research
Knowledge about the biology of the species and its management is quite good and ensures a basis for effective management measures.

Recommendations or comments from experts and local communities
When taking measures against established populations, it should be taken into account that the impact of conservation value of habitats and species affected by *Fallopia japonica* differs. Continued monitoring of the spreading of *F. japonica* and its hybrid *F. x bohemica* is advisable (*cf.* Alberternst 1998).

References and other resources

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Links

Invasiveness Assessment - Japanese Knotweed, Victoria Resources on-line (Australia)
The virtual flora of Sweden – *Fallopia japonica*
Element Stewardship Abstract prepared by The Nature Conservancy
Global Invasive Species Database – *Fallopia japonica*
NeoFlora – fact sheet on *Fallopia japonica* – (in German)

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