Japanese knotweed

Fallopia japonica (Polygonum cuspidatum)

Japanese knotweed is a non-native invasive plant that was introduced from Asia as an ornamental plant. Knotweed spreads vegetatively by rhizomes and also sprouts from fragments of root and stem material, which are dispersed by water, equipment or in fill. It forms fertile hybrids with giant knotweed (*Polygonum sachalininese*). Some populations, particularly hybrids, produce fertile seed.

Knotweed forms dense monocultures, with a thick layer of accumulated leaf and fibrous stem litter. A number of mechanisms contribute to its ability to exclude native species; light limitation, alteration in nutrient cycling and allelopathy—the ability to suppress growth of a potential plant competitor by releasing toxic or inhibiting chemicals.

Knotweed can contribute both to stream bank erosion and to flooding, when its large, fibrous stems wash into the water during periods of peak flow. Its rhizomes and shoots can penetrate asphalt and cracks in concrete. It is most aggressive on sites with natural or human disturbance; stream and riverbanks, roadsides and construction sites.

Japanese knotweed is legally prohibited in Michigan. It is illegal to possess or introduce this species without a permit from the Michigan Department of Agriculture, and Rural Development except to have it identified or in conjunction with control efforts.

Tom Heutte, USDA Forest Service, Bugwood.org

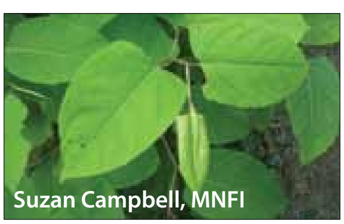
Identification

Habit:

Japanese knotweed is a perennial, herbaceous shrub growing from 1 to 3 m (3-10 ft) in height. It has a deep taproot and an extensive network of rhizomes that may extend laterally from 7 to 20 m (23-65 ft). Its hollow stalks persist through winter and resemble bamboo.

Leaves:

Its leaves are simple, alternate and broad, typically growing up to 15 cm (6 in) long and 12 cm (5 in) wide. They have an abruptly pointed tip and a flat or tapering base.



Suzan Campbell, MNFI

Stems:

Suzan Campbell, MNFI

Japanese knotweed stems are upright, round, hollow, and often mottled, with a fine whitish coating that rubs off easily.

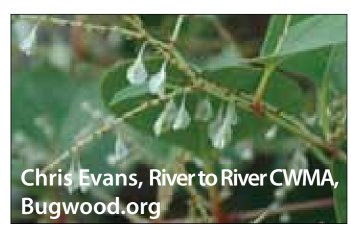
Flowers:

Suzan Campbell, MNFI

Knotweed has numerous, small, creamy white flowers. They are arranged in spikes near the end of the plant's arching stems. In Michigan, they bloom in August and September. Knotweeds are insect-pollinated.

Fruits/Seeds:

Knotweed fruits are three-winged and 8 to 9 mm (0.32 in) long. Its seeds are dark and glossy, and may be dispersed by wind, water, birds and insects. Not all seed is fertile.



Chris Evans, River to River CWMA, Bugwood.org

Habitat:

Japanese knotweed is semi-shade tolerant but grows best in full sun. It is found along roadsides, stream and river banks, wetlands, wet depressions and woodland edges, and can tolerate a wide array of soil and moisture conditions.

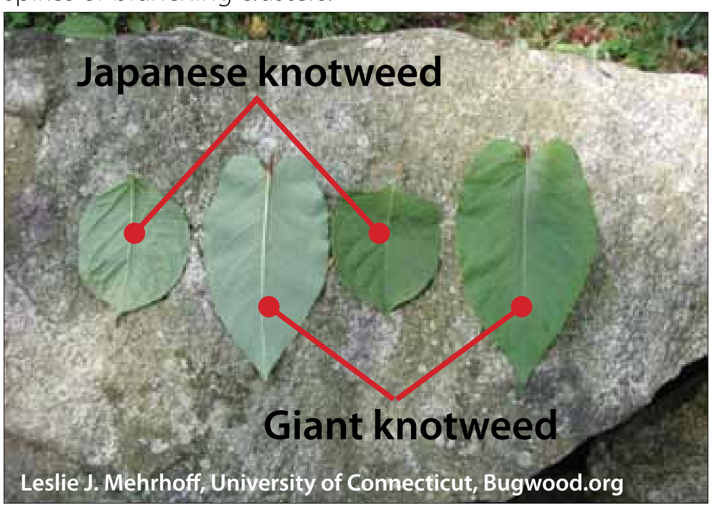
Similar species

Several other knotweed species are similar to Japanese knotweed. All are invasive non-natives, and control methods discussed here are appropriate for all three species.

Giant knotweed


Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Giant knotweed (*Fallopia sachalinensis*) is larger than Japanese knotweed, often reaching 4m (13 ft) in height. It can be distinguished by its larger leaves and heart-shaped leaf bases. Its leaves range from 5 to 30 cm (6-12 in) in length, while those of Japanese knotweed are usually 15 cm (6 in) long or less. They taper towards their tips, rather than being abruptly pointed. Giant knotweed leaves have long, wavy hairs on their undersides, while the hairs on Japanese knotweed are reduced to barely visible bumps. Use leaves from the middle of the stem for comparison as those at the tips are most variable. Giant knotweed flowers are held in spikes or branching clusters.



Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Giant knotweed and Japanese knotweed hybridize to form Bohemian knotweed (*Fallopia Xbohemicum*). The hybrids are fertile and back-cross readily, yielding a continuous range of variation between the characteristics of their parent species, including size, leaf bases and tips. The hairs on the leaf undersides are short with broad bases.

Himalyan knotweed


Vlado Lamiot, Creative Commons license

The related non-native Himalyan knotweed (*F. polystachyum*) has narrower, sharply-pointed lance-shaped leaves that are up to 20 cm (8 in) long. Its leaf bases may be tapered or slightly heart-shaped. It can grow up to 1.8 m (6 ft) tall. It has not been reported in Michigan to date.

Reproduction/Dispersal

Most reproduction in Japanese knotweed is believed to be vegetative, although the role of sexual reproduction is receiving increasing attention. As much as two thirds of the mature plant's biomass is stored underground in its extensive systems of thick rhizomes. Rhizomes can reach 7.5 cm (3 in) in diameter and penetrate at least 2 m (7ft) in suitable soils.

In addition, fragments of both stem and root material can sprout, giving rise to new plants or entire colonies. While fragments near the soil's surface are most likely to sprout, sprouting has been demonstrated from fragments up to 1 m (39 in) deep. Because of this, it presents an enormous threat along rivers, streams and floodplains, where plant parts may be washed downstream by flood waters. It can also be spread inadvertently during construction and road maintenance, by mowing crews and in fill dirt.

In Europe, all Japanese knotweed populations appear to be clones of a single female genotype and do not produce pollen. However, they are able to accept pollen from the closely related giant knotweed, producing the fertile hybrid Bohemian knotweed. The hybrid appears to be spreading faster than either of its parent species.

In North America, the situation is more complex and the potential for sexual reproduction both within the species and between related species is a focus of increased interest. Though the European female clone is widely dispersed in the US, other genotypes are also present. Populations have been documented with both male and female plants. Some may maintain reduced forms of the reproductive organs of the other sex. Though the female plants do not produce pollen, they can produce viable seeds. Male plants contribute pollen and may produce the occasional seed. Reproduction by seed has been documented in the Northeast and also in Wisconsin. The potential for spread of the hybrid knotweed may be even greater; both male and female fertile hybrids have been found without either of their parental species in New England. Japanese, giant and hybrid knotweed populations in Michigan should be monitored for seed production, which offers additional opportunities for spread.

Knotweed seedlings generally do not survive under the canopy of their parent plant and appear most likely to establish on bare soil, as they do in their native habitat. In western states, much of their most devastating spread has been along waterways, where soil is continually eroded and re-deposited downstream.

In Michigan, roadside maintenance equipment appears to contribute significantly to knotweed spread, as cut fragments are dispersed along roadways. Dumping of landscape waste by homeowners has also been documented as a source of new populations.

Planning a control program

Resources for invasive species control invariably fall short of the actual need, so it is important to prioritize sites for treatment and plan carefully. It should be noted that control for all knotweeds is similar. Assessing the scope of the problem in the region of interest is a critical first step:

- Map known populations.
- How was the knotweed population under consideration introduced—was it deliberately planted? Or did it disperse from another population that should be also be eradicated or controlled?
- Identify potential dispersal pathways and monitor them;
  - Is the population along a stream or lake?
  - Is it being spread in landscaping waste?
  - Does it lie in the path of road-mowing crews that might spread it further? Are there construction sites in the area where it might be introduced in fill dirt?
  - Are home owners disposing of landscape waste or distributing cuttings as an ornamental plant?
- How is the species behaving in your area? Is it spreading rapidly? Is it reproducing by seed?
- Does it occur in high quality habitat or on important recreational, hunting or fishing lands?

Given this information, develop a strategy for control:

1. First, prevent further spread; block pathways for dispersal, e.g. road maintenance practices, contaminated fill.
2. Choose appropriate control methods, given site conditions and available resources.
3. If using herbicide, be sure to read the product label before finalizing plans. Is there potential for harm to non-target species? Have you made adequate provisions to minimize damage?
4. Do these control methods require any permits (i.e. herbicide application in wetlands, prescribed burning)?
5. Prioritize high value sites for treatment where the potential for successful control is high.
6. Where knotweed is being spread along waterways, begin control efforts upstream and work downstream; concentrate on sites where erosion/dispersal of fragments is greatest.
7. Eradicate smaller satellite populations.
8. Treat larger core infestations of lower value as resources permit.
9. Monitor to ensure desired results are being achieved; adapt management to improve success.

Best survey period

Japanese knotweed is easiest to locate for mapping or control in August and September when it is in bloom. Its clustered spikes of creamy white flowers are distinctive and easy to spot.

Documenting occurrences

In order to track the spread of an invasive species on a landscape scale, it is important to report populations where they occur. The Midwest Invasive Species Information Network (MISIN) has an easy-to-use interactive online mapping system. It accepts reports of invasive species' locations from users who have completed a simple, online training module for the species being reported. MISIN can also accept batch uploads of large quantities of data for any species.

Herbaria also provide an authoritative record of plant distribution. The University of Michigan Herbarium's database can be searched online for county records of occurrence, for example.

When Japanese knotweed is first encountered in a county where it had not been known previously, specimens should be submitted to the Herbarium to document its presence. Check the "Online Resources" section for links to both of these resources.

Control

Mechanical methods alone will not effectively control large Japanese knotweed populations and may make them worse. Control efforts must target knotweed's massive underground system of rhizomes. This network allows it to spread to new areas even as it is being attacked mechanically. Accordingly, chemical treatments are given priority in the following section and then mechanical methods are discussed as some may enhance the effectiveness of chemical control. Specific herbicides, application methods and rates are listed on the reference table at the end of this fact sheet.

To date, a combination of chemical and mechanical techniques, in conjunction with on-going monitoring, provides the most effective control of this species. **Knotweed rhizomes that have not been completely killed off may send up new shoots as many as three years later.** In all cases, monitoring and follow-up treatment will be required for four to ten years, depending on the size and age of the population being treated.

Chemical control

Japanese knotweed has always been considered difficult to eradicate, even with herbicides. Differing levels of success have been reported for the same chemical on different sites. These results are probably related to differences in the amount of root mass underground.

Older infestations have more extensive root systems and are harder to eradicate or control. Specific site conditions, weather on the day of application, calibration of equipment and applicator experience can also contribute to differing levels of effectiveness.

General considerations

Anyone applying herbicides as part of their employment must become a certified pesticide applicator. In addition, certification is required for the use of some herbicides under any circumstances. The certification process is administered by the Michigan Department of Agriculture and Rural Development and a link to their website is included in the Online Resources section.

A permit from the Michigan Department of Environmental Quality is usually required to apply herbicide where standing water is present—in wetlands, along streams, rivers or lakes, or over open water. A permit is also required for herbicide use below the ordinary high water mark along the Great Lakes or Lake St. Clair shoreline, whether or not standing water is present. A link to their website is included in the "Online Resources" section.

A number of adjuvants or additives may be used with herbicides to improve their performance including mixing agents, surfactants, penetrating oils and dyes. Some are included in premixed products while others must be added. Adjuvants do not work with all products; consult the product label to determine which adjuvants may be used with a specific herbicide formulation.

Dyes are useful in keeping track of which plants have been treated and making spills on clothing or equipment apparent. Some premixed herbicide formulations include them or they can be added to others. Clothing dyes such as Rit® can be added to water soluble herbicides, while other products require oil-based dyes. Consult the product label for specific instructions.

Crop Data Management Systems, Inc. (CDMS) maintains a database of agro-chemicals that includes herbicide labels for specific products. Herbicide labels contain information on application methods and rates, specific weather conditions, equipment types, nozzles etc. to provide the desired coverage and minimize the potential for volatilization or drift. They also contain critical information about the potential for damage to valuable non-target species. A link to the CDMS website is included in the "Online Resources" section.

Read the entire pesticide label before use. Follow all directions on the label.

Herbicide specifics

Imazapyr (e.g., Arsenal®) has shown the greatest documented effectiveness on this species to date. Of all the herbicides included here, it also has the greatest potential for collateral damage to valuable species nearby. Imazapyr can move within roots and be transferred between intertwined root systems of different plants and other species. It has the potential to cause significant damage or death to trees and other species in the area. This movement of herbicide is exacerbated when imazapyr is incorrectly over-applied.

Because of its potential for collateral damage, imazapyr may not be appropriate for use in high-quality areas, with many desirable native species nearby.

Imazapyr acts slowly, reaching the massive root system before damaging the leaves. Although it appears to not be working initially, it results in significantly higher die-off rates a year later. Spray should be directed toward the actively growing portions of the plant. Imazapyr persists in the soils for long periods of time—an advantage in providing greater control. However, since it is non-selective it can also kill valuable non-target species wherever it contacts their roots.

Sites where imazapyr has been used should not be planted for at least one year, because of its lingering effects. Imazapyr is available in several wetland-approved formulations but they must be applied by a certified pesticide applicator. Wetland approved formulations must be used wherever standing or open water is present.

Imazamox (e.g., Clearcast®) is also effective against Japanese knotweed, although there has been less research on it than imazapyr to date. Some imazamox formulations are approved for aquatic and wetland sites and can be used in upland settings also. Because it is non-selective, it may kill or harm desirable non-target species, although its impacts vary with concentration and mode of application. See label for additional information.

Aminopyralid (e.g., Milestone®), a broadleaf herbicide, is being tested on Japanese knotweed in other states and also appears to provide effective control. Although it does not kill established native grasses, it may damage nearby trees. As it remains active in the soil for a long period of time, a soil bioassay is needed before planting wildflowers or legumes, which are particularly vulnerable to it. It may be added to the "Quick reference" chart at the back of this document later, as more information on its effectiveness becomes available.

Although glyphosate (e.g., Roundup®, Aquamaster®) kills knotweed foliage quickly, the herbicide is not effectively transported to the roots. In most cases, the plant rebounds the following year. In other cases, regrowth is reduced, but stems and foliage are deformed and do not provide enough surface area for re-treatment. With less surface area, less herbicide will reach the roots and eventually the plant will grow back. On sites where glyphosate is the only permitted herbicide, it should be used in conjunction with other control methods (see the section on Digging under Mechanical Control, including the discussion of cutting through roots to stimulate healthy new growth). Glyphosate, like imazapyr, is non-selective and will kill non-target species.

A number of other herbicides are also effective in controlling knotweed including dicamba, picloram and tebuthiuron but are not recommended because of their potential for groundwater contamination.

Foliar application

Herbicide can be applied to knotweed leaves in a number of ways; it can be wiped onto individual plants on sensitive sites or in very small infestations or sprayed on with hand-held, backpack or boom-mounted sprayers. A non-ionic surfactant should be added to allow the herbicide to penetrate the plant's cuticle. Dyes are also useful in indicating which plants have been sprayed and the extent of coverage. Other adjuvants may be suggested on the labels of the specific herbicide being used.

The herbicide applicator is responsible for calibrating equipment, and managing drift and damage to non-target vegetation. Wind speeds between 3 and 10 miles per hour are best for foliar herbicide spraying. At higher wind speeds, herbicide may be blown onto adjacent vegetation or water.

At lower wind speeds, temperature inversions can occur, restricting vertical air movement. Under these conditions, small suspended droplets of herbicide can persist in a concentrated cloud and be blown off-target by variable gusts of wind. Ground fog indicates the presence of a temperature inversion, but if no fog is present, smoke movement on the ground can also reveal inversions. Smoke that layers and remains trapped in a cloud at a low level indicates an inversion, while smoke that rises and dissipates indicates good air mixing.

In hot, dry weather, herbicide evaporates rapidly; set equipment to produce large droplets to compensate for this.

Some herbicides can be applied as invert emulsions; thickened mixtures designed to minimize spray drift and run-off and maximize the amount of herbicide that sticks to and covers leaves and stems. Always follow all directions on the label of the specific herbicide being used, in order to prevent damage to non-target vegetation or water bodies.

Injection

Injection is extremely labor intensive and impractical for most situations. It may be useful for applying herbicide on sensitive sites with very small knotweed populations. Typically, a measured amount of herbicide is injected into the plant stem between the second and third node or into the hollow of a cut stem. Stems that are not treated are not killed. For each type of herbicide, there is a maximum amount that can be applied safely per acre, per year, and with large populations, it is possible to reach this amount before all stems have been treated.

Mechanical control

Hand-pulling

Mature Japanese knotweed populations have deep, extensive root systems and hand-pulling the species is not an effective control method.

On sites where there is reproduction by seed, seedlings may be hand-pulled while they are still small. Typically, seeds will not germinate below mature plants but will do so on bare mineral soils nearby.

Cutting/Mowing

Cutting or mowing Japanese knotweed is not recommended. Stem fragments can root at the nodes and generate new plants. Frequently, knotweed is spread by roadside mowing crews in just this manner. Although cutting is often recommended to reduce the plant's height and facilitate treatment, unless all plant parts can be removed and destroyed, the risks outweigh the benefits.

Digging/Tilling/Excavating

For very small infestations (fewer than 50 stems), digging up and removing ALL of the plant's parts may provide control, but the site should be carefully monitored for at least four years. Again, all plant parts should be destroyed.

Since root fragments may sprout to form new plants, **for most populations, digging alone will not provide effective control.** Tilling or cutting through roots will also increase sprouting. Without herbicide, this is disastrous. When the plant's foliage has been burned by previous herbicide application, however, this will increase the surface area of new, healthy foliage that is available for herbicide absorption during re-treatment.

Excavating living rhizomes from previously treated, deformed plants will also result in new stems with healthy foliage, which will respond more favorably to herbicide treatment in the following year. In conjunction with herbicide applications, the removal of rhizomes may help to deplete a colony's stored energy. Excavating reduces root biomass and increases the stem to root ratio, allowing a more effective follow-up herbicide treatment for any new foliage. Without herbicide follow-up however, knotweed will quickly re-establish with renewed vigor.

Digging, tilling and excavating are never appropriate along river or stream banks, where soil disturbance may result in fragments being washed downstream.

Prescribed burning

Little information is available on Japanese knotweed's response to burning but it is not particularly flammable. Giant knotweed has been tested for use as a potential firebreak in Russia and researchers concluded that it "suffers little from the effect of fire."

On sites with fire-adapted communities, Japanese knotweed may alter fire ecology as it will not burn, and fuels do not accumulate beneath it. If prescribed burning is introduced as part of an overall management program, Japanese knotweed will still require additional control measures.

Biological control

Native North American pests do little damage to Japanese knotweed, but it has over 200 natural enemies in its native range. One species of sap-sucking plant louse, *Aphalara itadori*, has been tested extensively for host-specificity in Great Britain. It was released at several sites for field testing in Britain in March of 2010. It has not been tested for host-specificity in the United States.

Disposal of plant parts

If you must cut knotweed, all plant parts should be disposed of carefully to prevent regeneration, in accordance with Michigan's invasive species legislation. Options include landfills or some municipal incinerators. Materials to be placed in landfills should be bagged and tied in black plastic bags. Municipal solid waste treatment facilities that are engineered to inactivate potential pathogens in biosolids and maintain temperatures above 55° C for at least three consecutive days will safely destroy plant parts.

Where burning ordinances permit, plant refuse can be dried out thoroughly above ground and burned on site. Plant parts should not be allowed to contact soil during this time to prevent sprouting. Plant parts should not be composted.

Although landscape waste cannot generally be disposed of in land fills, Michigan law permits the disposal of invasive species plant parts. See the "Online resources" section below for a link to the relevant legislation.

Online resources:

CDMS - herbicide labels:
http://www.cdms.net/LabelsMsds/LMDefault.aspx?t=

Fire Effects Information System, *Polygonum* species**:**
http://www.fs.fed.us/database/feis/plants/forb/polspp/all.html

Invasive.org, *Fallopia japonica***:**
http://www.invasive.org/species/subject.cfm?sub=3414

Invasipedia at BugwoodWiki, *Polygonum cuspidatum*
http://wiki.bugwood.org/Polygonum_cuspidatum

Invasive Plant Atlas of New England, *Polygonum cuspidatum*
http://www.eddmaps.org/ipane/ipanespecies/herbs/Polygonum_cuspidatum.htm

Midwest Invasive Species Information Network, Japanese Knotweed
http://www.misin.msu.edu/facts/detail.php?id=25

The Michigan Department of Agriculture and Rural Development—Pesticide Certification
www.michigan.gov/pestexam

The Michigan Department of Environmental Quality—Aquatic Nuisance Control
www.michigan.gov/deqinlandlakes
http://www.michigan.gov/deq/0,4561,7-135-3313_3681_3710---,00.html

Michigan Department of Natural Resources—Local DNR Fire Manager contact list
http://www.michigan.gov/dnr/0,4570,7-153-30301_30505_44539-159248--,00.html

Michigan's Invasive Species Legislation
Natural Resources and Environmental Protection Act 451 of 1994, Section 324.4130
http://legislature.mi.gov/doc.aspx?mcl-324-41301

Michigan Legislation—landscape waste, disposal of invasive species plant parts
Natural Resources and Environmental Protection Act 451 of 1994, Section 324.11521, 2 (d)
http://legislature.mi.gov/doc.aspx?mcl-324-11521

The Nature Conservancy's Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas
http://www.invasive.org/gist/handbook.html

University of Michigan Herbarium - Michigan Flora Online
http://michiganflora.net/

Quick reference—Japanese knotweed

This chart has been provided as a convenience, to summarize the pros and cons of each herbicide and to present details on adjuvants, concentrations, etc. that do not fit into the discussion in the preceding sections. Although every attempt has been made to ensure accuracy, the product labels for the listed herbicides are the ultimate authority for their usage. Where there are conflicts, always follow the label directions. Techniques are listed in order of general preference by MDNR Wildlife Division staff but not all are suitable for wetlands or sensitive sites. Site conditions vary—choose a method that is best suited to conditions on the site being treated.

Anyone using herbicides in the course of their employment is required to be a certified pesticide applicator. Treatment in wetlands or over open water requires a permit from the Michigan Department of Environmental Quality.

These chemicals are available in a variety of formulations and concentrations. In some cases, concentration is listed below as a percentage of the active ingredient (AI) to facilitate use of different products. Where this is not possible, the label recommendation for the example product is used. Always follow all directions on the product label including mixing instructions, timing, rate, leaf coverage and the use of personal protective equipment.

	Herbicide	Conc.	Adjuvant	Timing	Pros	Cons
Foliar Spray	**Imazamox** (e.g., Clearcast®)	5% Clearcast® by volume	Use a wetland-approved non-ionic surfactant (e.g., Cygnet Plus®). Use dye for identifying treated areas.	Spray late September or October AFTER flowering.	Provides effective control. Available in formulations that are approved for wetland and aquatic sites.	Selectivity varies with concentration and mode of application but it may kill desirable non-target species.
Foliar Spray	**Imazapyr** (e.g., Arsenal®)	1-1.5 % AI or 2 qts/acre	Use a non-ionic surfactant (e.g., Cygnet Plus®). Use dye for identifying treated areas.	Spray late September or October AFTER flowering.	Provides effective control. Available in formulations that are approved for wetlands.	Imazapyr is non-selective, highly active in the soil and may kill nearby plants, including trees.
Foliar Spray	**Triclopyr ester** (e.g., Garlon 4 Ultra®)	3% AI	Use a non-ionic surfactant (e.g., Cygnet Plus®). Use dye for identifying treated areas.	Spray late September or October AFTER flowering.	Provides some control. Broad-leaf specific—may be used where desirable grasses are present.	Less effective than imazamox or imazapyr. May damage foliage without killing roots. Not approved for use in wetlands.
Foliar Spray	**Triclopyr amine** (e.g., Garlon 3A®)	3% AI	Use a wetland-approved non-ionic surfactant (e.g., Cygnet Plus®). Use dye for identifying treated areas.	Spray late September or October AFTER flowering.	Provides some control. Broad-leaf specific—may be used where desirable grasses are present. Can be used in wetlands.	Less effective than imazamox or imazapyr. May damage foliage without killing roots.

Note: Be careful not to move stems or other plant tissues as Japanese knotweed can regenerate from stem nodes. See section on disposal of plants for additional information. **Treated sites should be monitored for at least four years to ensure that there is no regrowth.**