Japanese Knotweed (*Reynoutria japonica*): Best Management Practices

SUMMARY: Japanese knotweed (*Reynoutria japonica var. japonica*) is an invasive species that invades areas that are highly disturbed and open areas. It is widespread throughout New York State and most of the United States. Japanese knotweed creates a dense canopy that prevents growth of native plants, allowing it to dominate large areas of land. Monocultures of knotweed lead to habitat loss and impacts on various levels of the food chain. It has the potential to increase soil erosion on riparian banks and flooding potential. Knotweed shoots can also push up through built roads, sidewalks, and foundations. Management of Japanese knotweed typically requires several years and become expensive.

Biology & Habitat

Prefers forest edges, water canals (wetlands and riparian banks), waste ground, and open and disturbed areas [6, 7, 13, 19-21]
Tolerates pH from 3.0-8.5, a variety of soil types, low nitrogen levels, heavy metals and high salt [2, 22]

Figure 1. Japanese knotweed flowers and leaves
http://www.thejapaneseknotweedcompany.com/japanese-knotweed/

Identification

- Perennial shrub with alternate, heart shaped leaves
- Hollow, bamboo-like stems, growing 3m- 4.5m tall [12, 16, 24, 25]
- Fleshy to woody rhizomes with a distinct orange interior [2, 26] that extend >2m in depth and 15-20m in length [6, 17, 25]
- White flowers blooming from July-August, eventually developing seeds [2, 27, 28]
  - Pollination occurs by bees, ants, butterflies and beetles [29]

Dispersal

- Propagation through rhizome fragments from human activities
  - excavation, construction, transporting soil and mowing, or washing down rivers during flooding events [6, 7, 16, 30]
- Clonal propagation through extension of the rhizome [2]
- Fresh stem and rhizome material can successfully regenerate as long as it has one node [31]
- Hybrid seeds are highly viable because some variegated varieties are sold as non-invasive but provide a pollen source for Japanese knotweed [18]
- Hybridizes with similar knotweed species and mile-a-minute (*Persicaria perfoliata)* [2, 18, 31, 32]
  - Treatments may have to be done before seed set to avoid additional propagules

Introduction & Distribution

Native to Japan, Taiwan and N. China
Introduced in Europe, UK, US, Canada, New Zealand and Austrailia [3,13,16]
Found in 42 states in the US and 8 out of 10 Canadian Provinces [13, 17]
Introduced as an ornamental [5,12,16]
Planted for erosion control, forage and stabilizing soils [2, 5, 18]

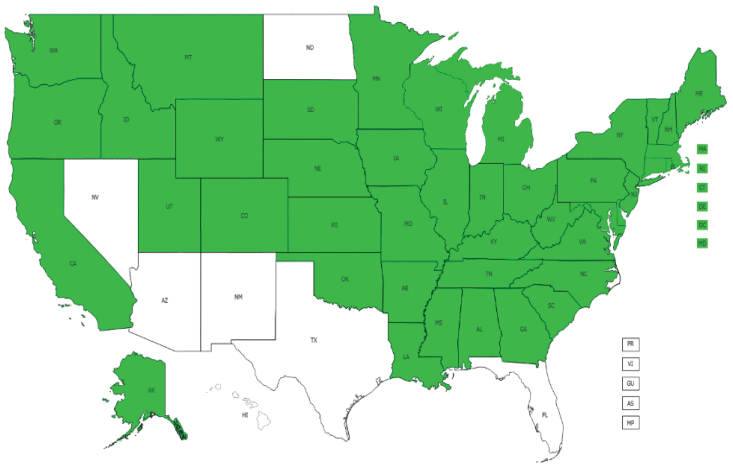

Figure 2. Distribution of Japanese knotweed within US
Retreived from EDDMapS

Management Strategies

One of the best ways to prevent its colonization is to ensure that disturbed habitats are rehabilitated with native vegetation before knotweed can invade [17]. However, if it does invade, digging or pulling can control, or locally eradicate early infestations of knotweed [33]. Integrated management may be more effective for larger infestations. The most focus should be on those stands that are most susceptible to erosion and propagule dispersal because these sites have higher probability of being invaded by invasive species [31]. Less disturbed habitats [34], and those with lower light availabilities [3, 34], are less susceptible to invasion. Extensive removal of vegetation and contaminated soil can be expensive and cause major disturbance on site [18].

Management Goal	Management Technique	Description of Technique	Drawbacks to Technique
Eradication/Containment	Digging/Pulling	Dig 4 ft down and hand-pull smaller plants [5, 33]. Remove all rhizomes and runners.	Follow-up monitoring required and multiple attempts. Expensive and high disturbance levels [33].
Eradication	Stem Injection	Cut stems 2 inches above the ground [5], inject 25% glyphosate or triclopyr into the stem between nodes, in early fall [35]. Treat regrowth with 4% glyphosate spray [36].	Follow-up monitoring required [2] and multiple applications [5, 18]. Ineffective for small stems. Laborious and expensive.
Eradication	Foliar Spray	Cut early in the season and wet all foliage with a 2% solution of glyphosate or triclopyr [5]. Treat regrowth when height reaches 1m and leaves are green.	Applications may be difficult due to plant height, may require multiple applications [5, 18]. Air temperature should be at least 65°F [5]. Laborious and expensive.
Weakening	Cutting/Mowing	Trim stems to the ground, every three weeks from early spring through late summer [2, 25]. Recommended to follow this treatment with herbicides [2].	Multiple seasons may be required to see effects. Care must be taken with equipment/biomass to prevent further spread [2]. Very labor intensive [2, 37].
Ineffective methods			
Eradication	Burning	Burn knotweed growth.	High water content of stems and rhizomes may remain unaffected [20].
Reduced height and density	Grazing	Goats, sheep, donkeys, horses and cattle graze on knotweed growth. Apply treatment in spring [2, 20].	Presence of dead stems is a deterrent to grazing and must be cut to ensure availability of young shoots [2]. Only short-term control.
Weakening	Barriers and Covers	Geosynthetic textiles/thick polythene sheeting encase excavated materials/act as a vertical barrier in the ground. Cut stems and then cover the site with light blocking material or wire mesh with 2 cm spacing [20, 37, 38].	Only provides short-term control. Will need to be used in conjunction with other treatments for eradication.

Digging and Pulling: requires all roots and runners be removed; special care must be taken to avoid missing any roots or rhizomes [5, 33]. Should only be done for mature stems, ensuring that it is pulled from the base of the stem [2]. Deep digging for well-established plants leads to a significant increase in stem density but if it is integrated with herbicide treatments it can be effective [2].

Cutting and Mowing: requires a brush cutter, lopper or strimmer and protective clothing and a face visor. Mowing is well suited for houses, resorts and lawn borders, parks and gardens. Cutting stems in early summer followed by herbicide application can improve effectiveness of treatment [39]. There is some evidence there is increased lateral growth and stem density after cutting [2]. Ginenthal [36] suggests against this treatment because there is less leaf area for herbicide treatment than knotweed that is left alone; additionally it is difficult to time mowing properly.

Disposal: Plant material must be removed and disposed of properly because the stems and rhizomes can resprout [35]. Solarized biomass in a bag in the sun for at least two weeks [5, 33] or material can be spread on a contained, impervious surface in a thin, even layer to ensure even heating. Contaminated soil and plant material should be buried at least 5 feet under surface in a disposal pit with annual monitoring to ensure there is no regrowth [2, 33]. If necessary, re-sprouting plants can be treated with herbicide; this material should not be composted [33]. Stem and other plant material could be burned to ensure there is no regrowth and then put into a landfill [2]. For contaminated soil, the environmental agency waste regulation department should be contacted or disposal can be in situ, to reduce landfill charges and decrease risk of spread and ensure that effectiveness of the disposal can be monitored [2]. It is extremely important to tamp down soil after removing plants [33]. The key is to avoid plant material from making contact with any type of watercourse [2].

Biocontrol: *Aphalara itadori,* is a knotweed specialist that may reduce the growth rate of Japanese knotweed [14]. This biocontrol was released in the UK in 2010 and Canada in 2014 and has been approved for release within the US [44]. A bio-herbicide is currently being researched, *Mycosphaerella polygoni-cuspidati*, a leaf spot fungus, which has been shown to cause some restricted disease symptoms on some non-target plants but a non-reproductive form may be able to be used for a mycoherbicide [40].

Chemical Control: Systemic herbicides are generally the most efficient and effective means of managing knotweed due to the chemicals being translocated to rhizomes following foliar applications [25, 37]. The ideal time to apply an herbicide is when flower buds are developing, in August or September, after cutting stems in late spring or early summer [2, 25, 35-37]. After treatment, all dead stems should be knocked down to ensure easy access for future management. Significant decreases in Japanese and hybrid knotweed abundance can be achieved by different combinations of herbicides; however, there is no robust evidence available regarding their long-term effectiveness [2, 33, 38].

Figure 3. Stem Injection tool for control of Japanese knotweed
https://www.jkinjectiontools.com/stem-injection/#

Figure 4. Foliar spray application for control of Japanese knotweed
Credit: S. Schultz

Treatments for sites near water [2]

Herbicide	Application Time	Effectiveness
Glyphosate	-May or June in New York, when plants are 1 m tall and leaves are fully developed	-95% population reduction seen in small patches after one treatment [36]
2,4-D amine	-1st application in May to reduce height and vigor of knotweed -2nd application midway or late in the season	-Effectiveness is unknown

Treatments for sites away from water [2]

Herbicide	Application Time	Effectiveness
Picloram	-When plants are 1m tall	-Effectiveness is unknown
Triclopyr	-1 application on non-cropland -2 applications on grasslands	-Effectiveness is unknown
Imazapyr	-For hard paving areas -Anytime during the season -Timing of application does not impact control levels after 1 year treatment [20]	-More effective after aminopyralid application, resulting in reduced stem density and height - Effects of one application were the same as multiple applications of imazapyr and aminopyralid -83-100% control up to 52 weeks
Synthetic auxin herbicides	-Early-season	-Field results are limited -Possibly improves management when used with other herbicides (dicamba, aminopyralid, picloram, clopyralid, 2,4-D)
Aminopyralid	-Anytime during the season	-Shoot heights were 21-42% shorter than control sites -Significant height reduction after 52 weeks -10-15% control after 52 weeks

Effectiveness of treatments [20, 37]

Stem Injection: Cutting stems and filling them with glyphosate (cut and drip method) or injecting directly into live stems [36, 38]. To use this method a stem injection tool that has a short, stout needle should be used [5, 33]. The Cornell Botanic Gardens uses this method as their first step in management of knotweed [36]. This method works best for small infestations and typically results in 95% reduction; it reduces the risk of spread and is quicker than many believe. This treatment is recommended when Japanese knotweed is growing with or near other species [5, 35].

Foliar Applications: Optimum timings for herbicide translocation are difficult due to height of established knotweed plants [37]. It may be beneficial to precede with cut and drip treatments to reduce risk of nontarget damage. To ensure there is sufficient uptake of the herbicide, applications should be completed when plants are 1 m tall and leaves are green [2]; most of the plant's energy is stored in the extensive rhizome system [41], therefore it is important to use a chemical that will be translocated to this area. However, the effects are slow to appear and effectiveness cannot be assessed until after 21 days and the full effects of the treatment cannot be observed until a year after application [2].

Equipment Requirements: Most efficient when using a commercial-grade spray bottle and/or backpack sprayer with an adjustable nozzle with most herbicide active ingredients [33]. A tractor with a sprayer is effective for large areas, a backpack sprayer or direct application with a weed wiper/ herbicide glove for smaller infestations and a controlled droplet applicator is preferred for specific application sites. A long lance sprayer is best for tall knotweed and inaccessible sites but drift should be minimized, making applications when winds are less than 2-4 mph and there is no chance of rain for 6-24 hours. Additionally, it is important to protect bees and other pollinators during treatment [2]; which is achieved by spraying at dusk or when the plant is not flowering because fewer bees will be foraging. The herbicide label may also have an EPA bee advisory box listing specific ways to reduce exposure [42].

Restoration

Land managers should annually visit treated sites to check for regrowth after each treatment; this allows smaller plants to grow tall enough for proper treatment and the concern for seed set is low. To determine if a population is eradicated, the locality context must be considered; shaded sites have smaller populations when compared to sites near a source population [36].

Planting trees and shrubs could potentially inhibit the monitoring of regrowth of knotweed but may limit future control options due to herbicide sensitivity. As an alternative, grass seed mixes may be a more effective way to allow for continued monitoring [2]. After the Salmon River was treated, annual and perennial ryegrass and little bluestem were planted. The first native species to volunteer were jewelweed, smartweed, ferns, grass and maple [43]. Plants recolonizing 3 and 6 years after knotweed removal, in another study, were seen to be annual exotic species but native perennials established as well [20]. Garlic mustard (*Alliaria petiolata*) was found to colonize treated sites but eventually natives re-establish in these regions and dominate without additional treatment of the area [36].

Knowledge gaps

Hybrid knotweed may produce viable seed, to determine the urgency of this, the sexual composition of knotweed within the US needs to be determined

Long-term effectiveness of management, as most studies only lasted 3 years or less

How to decrease underground biomass after management

Cost effectiveness analysis of management techniques

Effectiveness of excavation and barriers

Treating areas in hard to reach places without increasing exposure to herbicides

Further research on the establishment & effectiveness of the psyllid for biocontrol in North America

Additional research to meet the emerging challenge of the possibility of glyphosate resistance

Further research into how Japanese knotweed impacts life history traits of riparian birds

Figure 5. Zig-zag growth pattern of knotweed stems

https://www.farmanddairy.coml

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