

Understanding & Controlling Invasive Knotweeds in BC

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A. Background / Identification:

The invasive “Knotweed Complex” is comprised of four herbaceous, perennial plant species that are native to eastern Asia (i.e. Japan, China and Korea). These garden ornamental plants were first introduced to BC in the early 1900's. They have now become aggressive invaders of rural and urban environments, not only in British Columbia, but around the world. As such, they are regarded by experts as being among the world's worst invasive species for their incredible persistence and numerous negative impacts.

- **Japanese knotweed** (*Fallopia japonica*) or **JK** is the shorter (up to 2-3 m tall), female species and is the species most commonly associated with knotweed problems. It spreads vegetatively.
- **Giant knotweed** (*Fallopia sachalinensis*) or **GK** is the larger (up to 5 m tall), male species which spreads vegetatively and produces viable pollen, allowing it to hybridize with Japanese knotweed.
- **Bohemian knotweed** (*Fallopia x bohemica*) or **BK** is the hybrid produced by Giant and Japanese knotweed and it exhibits a mix of characteristics of its parents. It can produce viable seed, back-cross with both parent species, and is spread vegetatively.
- **Himalayan knotweed** (*Polygonum polystachyum*) or **HK** grows up to about 2 m tall and spreads mainly through vegetative means.

Knotweeds are easily identified by their layered form, bamboo-like canes/stems with distinctly raised internodes and large, alternating, toothless leaves. Their roots can extend 2-3 m deep and rhizomes can extend 15-20 m laterally underground from parent plants. Knotweeds emerge early each growing season, reaching full height by early summer. Flowering occurs in late summer/early fall. The stems turn brown and sometimes collapse after the first hard frost; but not before the plants have drawn significant energy reserves into their roots. This sustains the plants over winter to enable early emergence the following year.

Japanese, Giant & Bohemian knotweed:



Himalayan knotweed:



	Height (m)	Leaf Size/Shape	Stem Form / Markings	Stem Density
JK	2 - 3	Smaller, heart-shaped, up to 12 cm long, Coarse, flat/square base	Hollow with internodes Purple to red specks	High
GK	3 - 6	Large, heart-shaped, up to 40 cm long Rubbery but with a heart-shaped base	“ “	Less than JK
BK	2 - 5	In between JK & GK	“ “	Less than JK More than GK
HK	2 - 3	Lance-shaped, up to 20 cm	Thinner / Semi-hollow with internodes / No red specks	Extremely high

For additional information, see the **Key to Identification of Invasive Knotweeds in BC**:

http://www.for.gov.bc.ca/hra/Publications/invasive_plants/Knotweed_key_BC_2007.pdf

B. Preferred Site Requirements:

Landscape level (based on existing data)

- Mean annual precipitation: minimum 735 mm/year
- Elevation: 0 - 2,500 m
- Minimum temperature: -35 °C
- Frost free days/year: 120 +
- Degree days: 2500 +

Site level

- Soil moisture: moist to wet sites are preferred (but can tolerate drought and total submersion)
- Soil textures: all (loams, silts, sands and gravels)
- Soil pH: tolerant of alkaline soils
- Shade tolerance: prefers open sites in full sun, but only requires 20% full sunlight to thrive

C. How it Grows, Spreads & Persists:

- Growth rates of 4 cm per day have been recorded
- Knotweed spreads primarily vegetatively in three ways:
 - i. internodes along stems/canes (when in contact with wet soil)
 - ii. rhizomes/root material (typically when it is broken through soil disturbance)
 - iii. buds in root crowns
- 0.7 grams of rhizome (a 10 mm long piece), or a living stem containing an internode, can regenerate a new plant in about 6 days in warm, wet conditions. Conversely note that if living, green stems are elevated and allowed to desiccate (i.e. reached the orange/brown woody stage), then the above-ground biomass will not regenerate
- Underground rhizomes may remain dormant for up to 20 years
- Human activity, beavers and high water events can spread populations from existing stands
- Improper disposal of knotweed parts (including contaminated soil) from infested ditches, development sites, landscaping and yard waste is perhaps the greatest single cause of spread
- Roadside mowers, flailers and graders assist the spread of the plants along roadsides and ditch lines

- Knotweed stands will grow in waterways where the plant material can fragment and then disperse throughout a riparian system
- A majority of the root and rhizome is confined to the top 50 cm of soil. However, there can be significant biomass associated with it which makes complete removal nearly impossible. One study found 14,000 kg/ha of JK may exist in the top 25 cm. Landfilling is very expensive.

D. Negative Impacts:

1. Riparian Systems (streams and rivers)

- a. Knotweed displaces lower, slower growing native plants and young trees beneath its extensive canopy, due to competition for light, moisture and nutrients; then:
 - aquatic insects (food source for fish) that prefer woody plants as food, leave the area;
 - shade from the natural multi-canopy plant community is simplified to a single knotweed shade layer, which is not enough to protect fish from rising water temperatures caused by direct mid-summer sunlight; and
 - without riparian trees providing the continuous input of coarse woody debris, stream nutrient levels decrease and important in-stream pool habitats, as well as critical cover for juvenile salmon, are lost.
- b. Unlike most native riparian vegetation, knotweed root systems lack well-defined root hairs that are necessary to bind and hold stream bank soil in place. Once extensive knotweed monocultures form, knotweed plants will often collapse upon themselves (and other surrounding plants) in late fall, exposing bare soil to the heavy rain events. Stream banks have been known to collapse, assisting with the downstream migration of stem and root material; which eventually lodges and perpetuates new knotweed stands. In the process, sedimentation occurs, resulting in:
 - filling in riverbed gravels that salmon utilize for spawning (i.e. smothering viable eggs) and rearing;
 - decreased feeding success of resident fish (due to lack of visibility); and
 - damage to fish gill filaments.
- c. In the UK, where knotweed is much more widespread than in BC, knotweed is believed to exacerbate flooding by clogging river and stream channels with its large stalks, and changing natural erosion and deposition patterns.

2. Biodiversity & Wildlife

- Thick patches can alter established wildlife migration routes, especially along watercourses
- No indigenous wildlife species are known to feed on knotweed
- Knotweed stands support fewer species and smaller populations of arthropods and amphibians than native habitats
- Knotweed stands provide poor bird nesting habitat as stems snap readily in summer and collapse each winter
- Dense monocultures can displace both rare and endangered species, as well as many important native plant species such as: Ferns, Salmonberry (*Rubus spectabilis*), Vanilla Leaf (*Achlys triphylla*), Thimbleberry (*Rubus parviflorus*), Red-Osier Dogwood (*Cornus stolonifera*) etc.

3. Recreation, Safety, Infrastructure & Amenity Values

- Dense thickets lining lakes and rivers impede viewsapes and make access difficult for anglers
- Rapid sprawling growth reduces highway sightlines (visibility), and therefore is a safety concern
- Hydrological changes can lead to over-widened stream channels, undercutting existing adjacent roads and highways
- Knotweed can grow through small cracks in pavement or concrete and thereby reduce the structural integrity of affected structures (e.g. roads, tarmac, building foundations, drainage, dams and retaining walls) – ***a huge potential burden to tax payers***
- If knotweed becomes embedded into riprap, it is very problematic (and may require the complete disassembly of such structures)
- There is significant cost associated with treatment and disposal of knotweed, hence land values will be negatively impacted, if a given area becomes knotweed infested

Example: A 2006 BC Forest Service study indicated that a one-time mechanical removal of knotweed, including disposal and remediation costs, was about **\$200,000 per hectare**

E. The Challenge

Invasive knotweeds can be found in 39 of the 50 United States and in six Canadian provinces. They have devastated natural systems in several parts of Europe. Reclamation efforts worldwide are estimated to be in the tens of millions of dollars. In England (whose climate resembles that of coastal BC), there are two separate pieces of legislation that refer to knotweed. There are steep fines and long jail terms for persons possessing or moving such “*controlled waste*” without a license. Disposal of knotweed in the UK must occur at landfills authorized to receive it.

There is still an opportunity to contain invasive knotweeds in BC. To be successful, invasive knotweed control requires a long-term management commitment, secure funding, and the full participation of affected stakeholders. It also requires acceptance of the fact that combined treatment methods that include strategically-targeted, judiciously used herbicide may be necessary.

F. Control Methods:

For landscape-level management programs, eradication programs must span several years and consist of multiple, annual treatments. Small knotweed outbreaks (<0.001 hectares and <10 stems per m²) can be eradicated using mechanical/ manual treatments. However, it has been found that medium to large sites (>0.005 ha and >10 stems per m²) must integrate herbicide use in order to be effective.

Watershed focused control must implement measures at the furthest extent upstream in order to prevent continual migration of knotweed downstream.

In terrestrial settings, management efforts should focus first on sites adjacent to water courses and work outward from these areas as human and financial resources allow.

1. Small Patches e.g. 300 stems or less (5 options)

Digging (*proper disposal is required*)

1. Cut off all stems with loppers, machete or brush saw as low to the ground as possible
2. Remove cut material and leave in a pile elevated above the ground to allow desiccation by the wind and sun, when conducting work during the summer. During any other season, carefully transport all cut material to the landfill for deep burial
3. Using a sharp mattock or shovel, dig up as much of the main root mass and lateral rhizomes as possible when soil is soft
4. Carefully transfer dug up root material to land fill for deep burial (the soil is “contaminated”)
5. Monitor the treatment site throughout the growing season and ensure that all new sprouts and associated roots are removed, searching at least 10 m away from parent plant. Gently lifting new sprouts with a hand trowel or small shovel will minimize soil disturbance.
6. Repeat 3. until knotweed stops re-sprouting, usually after 3-5 years (or more)

Considerations:

- This method is only effective with very small patches (due to smaller root size) that exist in soft soils e.g. uniform coarse sands
- Pull plant and major rhizomes up by the root crown to remove as much of root system as possible before digging, noting that it is nearly impossible to remove all rhizomes
- Aim to remove every last piece of root and rhizomes larger than 0.7 grams. In small areas, small root fragments can be removed by screening the disturbed soil
- Repeat mulching using a thick layer (e.g. 30 cm) of bark chips has been used to deplete root reserves of small patches. Roots colonize the thick mulch layer more readily than the compact, underlying soil making them relatively easy to remove from the patch. Over time, root reserves are depleted and the small knotweed patch can be eradicated.
- This method is labour intensive and very time consuming

Cutting (*proper disposal is required*)

1. Use loppers, a machete or brush saw to cut stems as close to the ground as possible **twice per month or more between April and September**; then cut it once per month in October and November until the first hard frost. Never let plants grow beyond 15 cm in height.
2. Remove cut material and elevate it completely above the ground to allow total desiccation by wind and sun, when conducting work during the summer. During any other season, carefully transport all cut material to the landfill for deep burial
3. Repeat 1. and 2. until knotweed stops re-sprouting, usually after 3-5 years (or more)
4. During monitoring, search up to 10 m away from parent plant for new sprouts

Considerations:

- Cutting stimulates shoot production, deprives roots of energy and offsets rhizome production
- This method is best suited for private landowners who can monitor and treat the site on a regular basis

Smothering (*proper disposal is required*)

1. Use loppers, a machete or brush saw to cut stems to as close to the ground as possible
2. Remove cut material and elevate it completely above the ground to allow total desiccation by wind and sun, when conducting work during the summer. During any other season, carefully transport all cut material to the landfill for deep burial
3. Stomp down and flatten the area as much as possible by foot
4. Cover the treatment area with either woven, heavy grade geo-textile or thick cardboard (e.g. used to package refrigerators) followed by a continuous layer of heavy black plastic or a tarp (sealing any rips or overlap with multiple sheets, using duct tape) or old carpeting (contiguous, not torn or ripped),
5. Install a contiguous, plastic wedge/barrier into the ground to a depth of 75 cm and up to 8 cm above the surface several meters beyond the outer most perimeter of the infestation. If lateral shoots emerge over time from under the barrier, then pull them out immediately, as well as fix the barrier.
6. If carpeting or cardboard is used, cover with one layer of 5 mm (heavy-duty) black plastic/poly or geo-textile fabric. Extend plastic or fabric 2–10 m beyond the actual perimeter of the cut stems, depending on target plant size. Avoid creating holes in covering material or overlaps where “escapes” could occur.
7. Use logs, rocks, sandbags or stakes to anchor the covering material initially and then add a layer of 10-15 cm of sawdust, bark or wood mulch over the entire treatment area. Ensure that if black plastic/poly is used that it is kept entirely covered because some birds will mistaken the black plastic for a garage bag and attempt to puncture holes in it.
8. Continuously monitor edges and remove emerging stems if/when they occur around edges for several years. Repair material tears/breaks that may occur. Stomp on any plants that attempt to “stand up” and push through and puncture a seam.

Considerations:

- This method is best suited for small sites in flat open areas
- Not effective along stream banks, as peak flows will sweep away the covering material
- The bare soils that will occur after this treatment will be prone to erosion
- Introduce competitive, non-invasive grasses and/or native plants and trees e.g. evergreen conifers and shrubs such as Salal (*Gaultheria shallon*), Evergreen huckleberry (*Vaccinium parvifolium*), Ocean spray (*Holodiscus discolor*), Thimbleberry (*Rubus parviflorus*), and Snowberry (*Symphoricarpos albus*) to rehabilitate the site when knotweed succumbs to successive treatments. Note that knotweed will not grow in continuous, dense shade.

Stem Injection (*no disposal is required*)

Most Applicable Situations

- infestations 1 m or more above the high water mark
- patches encountered too late in the season for a spring cutting / fall foliar spray treatment
- patches with a high percentage of injectable stems (e.g. > 2 cm in diameter)

1. Purchase stem injector kit (injector, canister, needles, marking attachment). See Appendix C.
2. Calibrate the stem injector by pouring an undiluted, glyphosate-based formulation greater than or equal to 356 g/L (~36% active ingredient [a.i.] into the hopper, placing the allen key into the nut beneath the trigger and adjusting it so that the following amounts are ejected with each squeeze of the trigger into the small measuring vial:
 - 5 ml <- for products with 356-360 g/L of glyphosate e.g. Roundup Super Concentrate
 - 4 ml <- for products with between 445-480 g/L of glyphosate e.g. Vantage Plus Max II
 - 3 ml <- for products with 540 g/L or more of glyphosate e.g. Transorb HC
3. In late summer or early autumn, insert the injector needle horizontally through both sides of each stem between the 1st and 2nd nodes or just below the 3rd node up from the base of the plant, if the stem is too woody, insert further down. Orient the hole on the needle downwards before inserting and injection occurs.
4. Inject either 3, 4 or 5 mls of an undiluted glyphosate-based formulation (depending on formulation - see 2. above) into each cane over 2 cm in diameter, noting that each cane has its own rhizome system. Stems smaller than 2 cm in diameter do not have sufficient cavity size to accommodate injection. These stems will need to be injected when larger or sprayed in a follow-up treatment. Each injected stem should be marked.
5. Return to the site three to four weeks later to complete a follow-up injection on stems not treated initially.
6. Return the following year to repeat treatments on any re-sprouts that occur or use a backpack sprayer in early fall to treat re-growth with a 5% glyphosate solution using an application rate of 5 L a.i. (glyphosate)/ ha. See Appendices section for backpack sprayer calibration methodology.
7. Use warm, clean water to soak the stem injector after each daily usage, especially if it will not be used again for a few days, as crystallization will occur and the injector will stop working.

Considerations:

- 700 to 1200 stems per day can be injected per person
- Do not calculate the amount of herbicide used at a site by multiplying the number of stems injected by the delivery rate as this value will be greater than the actual amount of herbicide used. Record how much herbicide is placed in the hopper, each time it is filled.
- There may be some root-to-root contact between directly adjacent native plants and knotweed. This could result in transmission of glyphosate to the native plants, which may be enough to kill them. However, digging to salvage such native plants could result in soil disturbance that either severs or activates knotweed roots, causing additional problems.
- Monitor for re-growth for 3 years after the last herbicide treatment

Excavator / Backpack Foliar Spray (*no disposal is required*)

1. Dig out the existing plant adding at least 2 m beyond the outmost perimeter of the plant and down to a depth of 2-3 meters, if possible
2. Deposit the plant (and all of its parts) upside down into the very bottom of the hole, compacting it and ensuring all plant parts, especially root material is deposited at this location
3. Place old carpeting (with no rips or holes), new tarp, geo-textile material or thick (5 mm) plastic/poly over the inverted plant
4. Back-fill the hole with rock and soil, replacing productive upper soil horizons back on top
5. Promptly re-vegetate disturbed area using ecologically-suited grass seed, as well as conifer seedlings (if appropriate)
6. Monitor site for several years and if re-sprouting occurs, use a backpack sprayer to apply a 5% a.i. (glyphosate) solution to foliage using an application rate of 5 L a.i./ha. See Appendix A and B.

Considerations:

- Use of an excavator (including a bucket with teeth & a thumb) can be costly if equipment is not already on or near the treatment site
- Gently brush off knotweed leaves if they are become coated with roadside dust. Glyphosate will bind to dust particles on the leaves if brushing does not occur, rendering the foliar spray much less effective.

2. Large Patches e.g. 300 stems or more (2 options)

Brush saw (or Machete) / Backpack Foliar Spray (*proper disposal is required*)

- Especially beneficial in controlling Himalayan knotweed, which cannot be stem injected
1. Use brush saw (or machete) to cut down knotweed patch once in May and then again in late August or early September. Cut as low to the ground as possible.
 2. Dispose of cut material – see Section G., last bullet.
 3. About one month after cutting (longer if the growing season is droughty), use a backpack sprayer to apply a 5% a.i. glyphosate solution with 1% surfactant (e.g. Sylgard 309 or LI 700) and 1% blue dye using an application rate of 5 L a.i./ha, to re-growth ~ 0.5 m tall. See Appendix A and B.
 4. Regularly monitor the treatment site, as well as 15-20 m beyond, for two to three years. Spot spray any knotweed re-sprouting that occurs.

Cut & Insert / Backpack Foliar Spray (*proper disposal is required*)

Year 1

In late August to early September, set up one or more teams of three (3) people - one person dedicated to cutting, one person applying herbicide within 15 minutes after cutting, and one person hauling all cut material to a disposal location.

Cutting (Person #1)

- Use sharp loppers (with curved blade and anvil preferably) to cut JK, GK and/or BK stems in one of two places along each stem, depending on the stem diameter:

For stem diameters 0.75 – 1.5 cm (pinkie width) - cut just *below* the 3rd internode

For stem diameters > 1.5 cm - cut 1 to 2 cm *above* the 2nd internode

For stem diameters < 0.75 cm - *do not cut and do not trample* as these stems will need to be treated later

Herbicide Application (Person #2)

- Inject each stem within 15 minutes after cutting or plant will “seal itself”, preventing the translocation of the herbicide to the root system
- Use a cavity needle (i.e. the hole is at the very tip)
- See Appendix B for calibration instructions using a glyphosate-based herbicide diluted with water, which will vary depending on the formulation
 - a. **For stems diameter 0.75 – 1.5 cm**: vertically insert needle into the cut stem, slowly and carefully squeezing the trigger to deposit 3-5 ml of a herbicide/water/blue dye mixture containing a 25% a.i. glyphosate solution; noting that smaller stems may not accept the full amount. See the *Knotweed Chemical Treatment Cheat Sheet*.
 - b. **For stem diameters > 1.5 cm**: vertically insert needle through each internode, slowly and carefully squeezing the trigger to deposit 3-5 ml of a herbicide/water/blue dye mixture containing a 25% a.i. glyphosate solution; noting that back pressure may force some herbicide back out. See the *Knotweed Chemical Treatment Cheat Sheet*.
 - c. **For stem diameters < 0.75 cm**: apply a backpack foliar spray using a 5% a.i. glyphosate formulation with 1% surfactant (e.g. Sylgard 309 or LI 700 and 1% blue dye, using an application rate of 5 L a.i./ha. See Appendix A and B.

Plant Material Disposal (Person #3)

- Carefully remove all cut plant material away from the smaller stemmed plants (<0.75 cm in diameter) and place in an elevated pile away from treatment site, so that cut foliage is not sprayed unnecessarily
- Remove cut material and leave in a pile elevated above the ground to allow desiccation by the wind and sun, when conducting work during the summer. During any other season, carefully transport all cut material to the landfill for deep burial

Note:

- Within a 6 hour span, two people can treat a 125 m² (0.0125 ha) area using this method (and this includes signage, application, post-treatment documentation and clean-up)

Year 2 and beyond....

In May/June and then again in late August/early September (each year until the plant dies):

1. Clear dead foliage away from any living knotweed that has re-sprouted
2. Spot spray any foliage with a 5% glyphosate formulation with 1% surfactant (e.g. Sylgard 309 or LI 700) and 1% blue dye, using an application rate of 5 L a.i./ha

Advantages of Cut & Insert over Stem Injection:

- Less herbicide is required i.e. up to 50% less, because of dilution using water
- Eliminates problem of harder canes splitting and leaking spilling herbicide
- Marking system is not required as internode tissue and cane around cavity show dye readily
- No needle breakage



Cutter Preparing Site

Cut & Insert Application

Post-Treatment Site

G. Safety, Hygiene & Disposal

- Adhere to herbicide label instructions, as well as Pest Management Plan (PMP) or Pesticide User Licence (PUL) terms and conditions
- At minimum, wear rubber gloves, rubber boots and eye protection when doing any type of herbicide-related work, especially mixing.
- Post water resistant “Notice of Pesticide Use” (minimum 550 m²) sign to notify people about control measures being implemented, as well as an informational sign about the impacts of knotweed



- Treat knotweed in its original location whenever possible
- Do not disturb soil where past treatments have occurred or there may be substantial re-growth
- Never allow tracked equipment to drive through knotweed infested areas
- Always keep knotweed biomass (contaminated soil and cut stems) at least 50 m away from riparian areas, floodplains or watercourses at all times of year.
- **During the summer months only**, cut stems can be piled, elevated and allowed to thoroughly dry for subsequent disposal (burning, chipping or deep burial). Do not leave these piles to decay without subsequent monitoring, to ensure that they are undisturbed and re-growth is not occurring.
- **At any other time of the year** (especially in spring), cut stems need to be carefully taken to the landfill for deep burial. Similarly, knotweed contaminated soil that results from digging needs to be carefully transported to the landfill for deep burial.

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