BEST MANAGEMENT PRACTICES FOR

Knotweed Species

in the Metro Vancouver Region

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INVASIVE SPECIES COUNCIL OF METRO VANCOUVER

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Introduction

The impacts of invasive species on ecological, human, and economic health are of concern in the Metro Vancouver region. Successful control of invasive species requires concerted and targeted efforts by many players. This document - "**Best Management Practices for Knotweed Species in the Metro Vancouver Region**" - is one of a series of species-specific guides developed for use by practitioners (e.g., local government staff, crews, project managers, contractors, consultants, developers, stewardship groups, and others who have a role in invasive species management) in the region. Together, these best practices provide a compendium of guidance which has been tested locally by many researchers and operational experts.

Four species of invasive knotweeds are found in the Metro Vancouver region:

Japanese knotweed (*Reynoutria japonica*)

Bohemian knotweed (*Reynoutria x bohemica*)

Giant knotweed (*Reynoutria sachalinensis*)

Himalayan knotweed (*Koenigia polystachya*)[1]

Throughout this document these species are collectively referred to as 'knotweeds'.

Native to regions in Asia, knotweeds were first introduced to British Columbia in 1901 as a cultivated horticultural specimen (Barney 2006). In the last few decades knotweeds have gained attention as one of the 100 worst invasive species in the world (Lowe, Browne and Boudjelas 2000). They are included as one of the top ten invasive species for control in BC (Invasive Species Council of British Columbia 2017) and they are high priority species for management in the Metro Vancouver region.

1 Nomenclature of these species is complicated and different scientific names are used worldwide. The following synonyms are also used for these species: *Fallopia japonica*, *Polygonum cuspidatum* (Japanese knotweed); *Fallopia x bohemica* (Bohemian knotweed); *Fallopia sachalinensis*, *Polygonum sachalinense* (giant knotweed); and *Polygonum polystachyum*, *Persicaria wallichii* (Himalayan knotweed)

In recent years best practices for identifying and managing knotweeds have advanced rapidly. Academic institutions, government, and non-government organizations continue to study these species in British Columbia. As researchers and practitioners learn more about the biology and control of knotweeds, it is anticipated that the recommended best management practices will change overtime and this document will be updated. Please check metrovancouver.org often to ensure you have the most recent version of these best management practices.

REGULATORY STATUS

Japanese, Bohemian, giant and Himalayan knotweeds are classed as noxious weeds within all regions of the province under the *BC Weed Control Act*, Weed Control Regulation, Schedule A, Part 1 – Provincial Weeds. Under this Act, "an occupier[2] must control noxious weeds growing or located on land and premises, and on any other property located on land and premises, occupied by that person".

Section 2 (1) (b) (iii) of the *Community Charter,* Spheres of Concurrent Jurisdiction - Environment and Wildlife Regulation, states that "municipalities may regulate, prohibit and impose requirements in relation to control and eradication of alien invasive species" which includes Japanese and giant knotweeds. Other knotweed species are not currently listed.

Under the *Forest and Range Practices Act,* Invasive Plants Regulation, a "person carrying out a forest practice or a range practice must carry out measures that are: (a) specified in the applicable operational plan, or (b) authorized by the minister, to prevent the introduction or spread of prescribed species of invasive plants." The list of invasive plants in the Regulation includes Japanese and giant knotweeds, but other knotweed species are not currently listed.

IMPACTS

Knotweeds can have significant social, economic and environmental impacts, including deleterious impacts on local ecosystems (Clements, Larsen and Grenz 2016). They appear to exude allelopathic[3] substances that have substantial negative effects on the growth of native plants (Murrell, et al. 2010). Once established, knotweeds displace surrounding vegetation, creating dense monocultures. Concern about knotweeds has been mounting around the world as more and more native habitat is being lost, particularly in riparian areas (Sea to Sky Invasive Species Council 2009).

Knotweeds' vigorous rhizome growth can damage concrete walls, pavement, bridge and building foundations, drainage works and flood prevention structures (Global Invasive Species Database 2017), and cause erosion of shorelines. Knotweeds can also affect motorist, cyclist, and pedestrian safety by blocking sightlines and signs along roads, highways, trails, and other transportation routes. Dense thickets can increase concerns about personal security in parks (Yong 2017). They can also be a nuisance for aquatic recreationalists frequenting lakes, streams, or rivers as uncontrolled infestations can impede access.

All levels of government and private property owners spend significant resources managing knotweed in the Metro Vancouver region every year. In 2016, local/provincial governments and several right-of-way partners on Metro Vancouver's Regional Planning Advisory Committee - Invasive Species Subcommittee spent over $660,000 on knotweed control efforts. This figure does not include control costs for private landowners across the region or costs associated with education and awareness activities.

2 An occupier is a person who (a) is in physical possession of land, premises or property, or (b) is responsible for, and has control over, the condition of, the activities conducted on and the persons allowed to enter or use, land, premises or property.
3 Allelopathy is the suppression of one plant by another through release of biochemicals.

REPRODUCTION AND SPREAD

Knotweeds spread by rhizomes, which can extend up to 3 metres deep and 20 metres wide (BC Ministry of Transportation and Infrastructure 2020). These expansive rhizomes are much larger than expected for a plant of its size, making knotweeds even more challenging to manage.

New plants sprout from fragments of root and stem material. Even very small fragments (0.7 grams or more) of the rhizomes or stems can regenerate (Beerling, Bailey and Conolly 1994), which enables knotweeds to spread very easily and effectively. Buried rhizomes can regenerate from depths of 1 metre or more. One common cause of spread is from unauthorized dumping of cut or dug knotweed in green spaces or natural areas.

Hybridization: Bohemian knotweed is a hybrid between Japanese and giant knotweed. Hybrid plants can produce large numbers of wind-dispersed viable seeds that germinate at rates approaching 100% in some populations (Gillies, Clements and Grenz 2016).

Dispersal: Knotweed fragments can be spread by infested equipment, mowers, improper disposal of removed plant material, wind, wildlife, flooding events, and horticulture activities such as selling, purchasing, trading, or maintaining plants, as well as the movement and use of infested soil. Disturbing the top growth of knotweed may encourage growth, resulting in a larger and denser infestation (Chadburn 2018).

HABITAT AND DISTRIBUTION

Knotweeds can tolerate a wide variety of site conditions, including challenging environments such as highly shaded areas, areas with high salinity, high heat, or drought. In the Metro Vancouver region knotweed is commonly found in riparian areas, in or around stockpiled material (e.g., soil, aggregate, mulch), on derelict land, along transportation corridors, and in gardens. Occasionally knotweeds are found growing in the water of shallow streams, waterways, and ditches.

All four knotweed species have been found in the Metro Vancouver region. Until recently it was thought that Japanese knotweed was the most prevalent knotweed species in the region; however recent genetic testing indicates that Bohemian knotweed is the most common taxon across western North America (Gaskin, et al. 2014). This finding is supported by unpublished data collected in the Fraser Valley by S. Gillies (University of the Fraser Valley) and by local mapping and observations of knotweed sites (Watson 2017). Himalayan knotweed is the least common of the knotweed species in the region (Watson 2017).

CLIMATE CHANGE ADAPTATION

Climate modellers predict that the Metro Vancouver region will experience warmer temperatures; a decrease in snowpack; longer dry spells in summer months; more precipitation in autumn, winter and spring; more intense extreme events; and an extended growing season. In the past, our region had an average of 252 days in the growing season. In lower elevations 45 days will be added to the growing season by the 2050s, and 56 days by the 2080s, resulting in nearly a year-round growing season of 357 days on average. In higher elevation ecosystems the growing season length will increase by 50% to 325 days by the 2080s (Metro Vancouver 2016). These changes will stress many sensitive ecosystems, increasing their vulnerability to invasive species.

Knotweeds may be able to adapt to our future climate in several ways:

- **Longer summer drought periods:** Drought and salinity tolerance and a related shift in habitat preference has been observed in Bohemian knotweed that neither parent species exhibit (Clements & Jones 2021). While Japanese and giant knotweeds are typically found in ditches, roadside and riparian zones, Bohemian knotweed has also been found abundantly at beaches, coastlines, and estuaries (Clements & Jones 2021).
- **Warmer temperatures:** Clements and Jones (2021) predict that Japanese, giant and Bohemian knotweeds will experience a range expansion with a warming climate.
- **Increased precipitation and flooding:** Knotweed roots lack the true hairs that are necessary to bind to the soil, contributing to erosion and stream sedimentation along banks of creeks and rivers (ISCBC 2017). With increased precipitation and flooding this effect of bank destabilization is expected to worsen at aquatic sites where knotweeds have established. An increase in storm frequency and severity has been shown to spread the rhizomes of Japanese and Bohemian knotweeds and will likely increase dispersal of the seeds as well (Clements & Jones 2021).

Clonal plants like knotweeds typically have a plasticity, which means the plants are better able to adapt over time, for example to the temperature increases brought by climate change (Clements & Jones 2021). With these kinds of competitive advantages, this species is more adaptable than native species in a variety of ecosystems. Its high environmental tolerance, aggressive reproductive capabilities and resistance to management efforts suggest that it will be able to withstand, and possibly thrive, with changing climate conditions.

Japanese knotweed
CREDIT: ISCMV

Giant knotweed
CREDIT: DHC

Bohemian knotweed
CREDIT: ISCMV

Himalayan knotweed
CREDIT: DHC

Identification

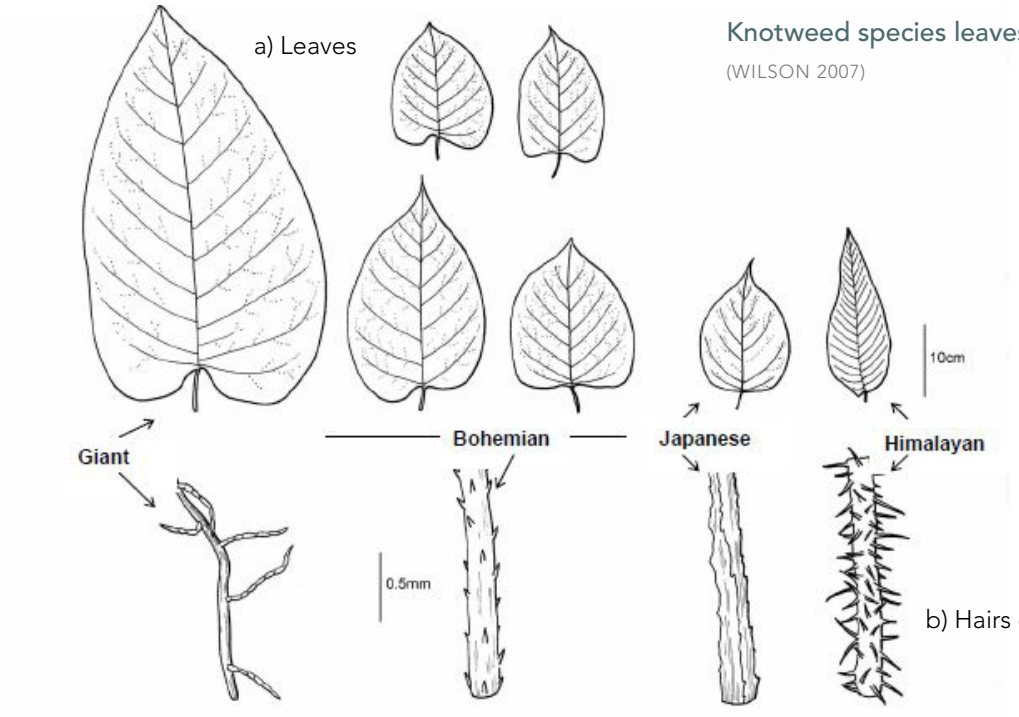
KNOTWEED SPECIES

Japanese, Bohemian, giant, and Himalayan knotweeds appear very similar in their biological attributes and growth characteristics. They are all perennial species; the above-ground vegetation dies off and the below-ground vegetation lies dormant during the winter. The distinguishing characteristics for these knotweeds are the mid-stem leaf shape, size, and other characteristics (Wilson 2007). The similarities between Japanese and Bohemian knotweed can make it difficult to distinguish between the two species.

	STEMS	LEAVES	FLOWERS	RHIZOMES	FRUIT
Common to all species	Hollow, upright, green with reddish-brown speckles	Heart to triangular shaped, 8-10 cm wide, 15 cm long except giant	Showy, plume-like, branched clusters along stem and leaf axils (places on the main stems where buds or branches develop)	Rhizomes up to 7.5 cm diameter, penetrate at least 2 m in suitable soils (although contamination zone is considered up to 3 metres deep and up to 20 metres wide)	Typically dark, glossy, 2.5-3 mm long, 3-winged; not all are fertile

SPECIES	STEMS	LEAVES	FLOWERS	FRUIT
Bohemian	1.5-2.5 m in height	Egg-shaped, 5-30 cm, about 2/3 as wide, base variable in shape, from ± straight to moderately curved, leaf tip gradually to sharply tapered Hairs – few or no hairs on leaf margin, veins on leaf underside have small, stout hairs	White or greenish white to pink	Dry seeds pods are 3-angled, black, smooth, shiny, 2.5-3 mm long

	STEMS	LEAVES	FLOWERS	FRUIT
Giant	2-4 m in height	Egg-shaped, 20–40 cm, about 2/3 as wide, deeply indented at the base (heart-shaped), leaf tip pointed, leaf texture thin and flexible; generally twice the size of the other 3 species Hairs – tiny stiff hairs on leaf margin, veins on leaf underside have long, multicellular hairs	Pale green or greenish-white	Dry seed pods are 3-angled, black, smooth, shiny, 2.5-3 mm long
Himalayan	1-2 m in height	Himalayan knotweed looks most different from the other species broadly lance shaped, up to 20 cm long and less than half that wide Hairs – copious stiff hairs on leaf margin, veins on leaf underside with numerous stiff hairs	White	Dry seed pods are small, 3-sided and have old sepals attached and are smooth
Japanese	1-3 m in height	Egg-shaped, 3-10 cm, 2/3 as wide, base straight not curved, leaf tip abruptly pointed, leaf texture thick and leathery; a distinguishing feature for Japanese knotweed is the zigzag pattern in which leaves are arranged along the plant's arching stems Hairs – no stiff hairs on leaf margin, veins on leaf underside have blunt knobs (sabres), giving them a slightly rough, ridged appearance	Whitish or greenish-white	Dry seed pods are 3-angled, black, smooth, shiny, 2.5-3 mm long



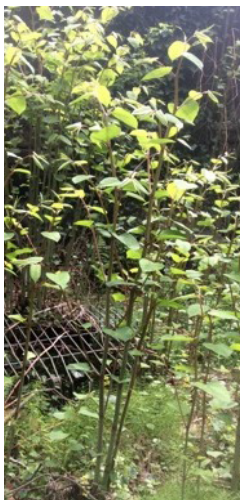
Knotweed species leaves and leaf hairs

(WILSON 2007)

Knotweed through the year

(ALL SPECIES SHOWN ARE BELIEVED TO BE BOHEMIAN KNOTWEED; APPROXIMATE HEIGHTS OF CANES ARE INDICATED)

EARLY SPRING (~15 CM)
CREDIT: DHC



Spring (~100 cm)

Early Summer (~180cm)

Late Summer/Fall (~210 cm)

Winter (~180 cm)

BOHEMIAN KNOTWEED FLOWERS
CREDIT: ISCMV

SIMILAR SPECIES

Knotweeds are often referred to incorrectly as "false bamboo" and can be confused with ornamental bamboo. Bamboo (*Bambusoideae spp.*) has harder stems that cannot be snapped easily like knotweed, and leaves that are very slender and long (varies between species and varieties, but bamboo leaves are usually up to 50 cm long). Bindweed (*Convulvulus arvensis*) has similar leaves but is a climbing or sprawling vine with thin, solid stems. The native species dogwood (*Cornus spp.*) and introduced lilac (*Syringa vulgaris*) have similar leaf shapes to knotweed, however their leaves grow opposite each other along woody stems, whereas knotweed leaves are alternate. Himalayan knotweed can be confused with dock (*Rumex* species) and several other species of Persicaria. Leaf length, leaf shape, flower structure, and flower colour can be used as distinguishing features.

Tracking

The provincial government maintains InvasivesBC, which is British Columbia's province-wide mapping and data collection system for invasive species. Many agencies, including local governments, have their own internal invasive species inventory and mapping protocols that are used by staff, contractors and, in some cases, the public. For example, the City of North Vancouver has its own system called AlienMap. Agencies in British Columbia that do not enter data into InvasivesBC are encouraged to check it regularly because it contains public reports and data from other agencies and it is important to consider as much data as possible when making management decisions.

When carrying out a knotweed inventory, be sure to record the following information as it will later inform your treatment plan:

- Size and density of infestation;
- Location in relation to the high water mark of watercourses; and
- Location in relation to other water sources, such as wells.

Reporting

Please report knotweed occurrences to:

- The Provincial Report Invasives program (via smart phone app www.gov.bc.ca/invasive-species).
- The Invasive Species Council of Metro Vancouver: 1-604-880-8358 or www.iscmv.ca.
- The municipality where the knotweed was found.
- The landowner directly – Most land managers are keen to be made aware of knotweed sites immediately so control can be arranged as soon as possible. If the landowner is unknown, the Invasive Species Council of Metro Vancouver can provide support to identify the appropriate authority.

Reports submitted through these channels are reviewed by invasive species specialists who coordinate follow-up activities when necessary with the appropriate local authorities. However, some people may be hesitant to report knotweed infestations as their presence may affect property values.

Snapshot of the Report Invasives app

CREDIT: ISCBC

Prevention and Control Strategies

Effective invasive plant management may include a variety of control techniques ranging from prevention, chemical, cultural, manual, biological, and/or mechanical methods. Each method is described below in order of effectiveness.

Coordinated management efforts across jurisdictional boundaries are critical. If infestations are shared, it is ideal for the entire infestation to be treated with the same method at the same time. Management efforts will be less successful if only a portion of the infestation is targeted. With herbicide use, partial treatment of the infestation can also contribute to herbicide resistance.

STRATEGY COLOUR LEGEND

GREEN: RECOMMENDED

ORANGE: CAUTION

RED: NOT RECOMMENDED OR NOT AVAILABLE

PREVENTION: IMPERATIVE

Prevention is the most economical and effective way to reduce the spread of knotweeds over the long term. Due to knotweed's ability to spread by small fragments, activities within knotweed-infested areas should be avoided if possible.

Disturbing the top growth may encourage growth, resulting in a larger and denser infestation (Chadburn 2018). However, if you cannot avoid disturbing knotweed in a project area, follow the guidelines below for manual/mechanical control. Be sure to inspect and remove plants, fragments, and seeds from personal gear, clothing, pets, vehicles, and equipment and ensure soil, gravel, and other fill materials are not contaminated with any knotweed parts before leaving an infested area.

Knotweed can be spread by land owners maintaining, cutting or digging the plant on their properties and dumping the waste into green spaces. Appropriate disposal techniques (see section below) are an essential prevention strategy. Do not purchase, trade, or grow knotweeds. Instead of knotweeds, grow regional native plants that are naturally adapted to the local environment and non-invasive. Consult the Invasive Species Council of BC's Grow Me Instead Program or Metro Vancouver's Grow Green website for non-invasive, drought-tolerant plants and garden design ideas. Ensure all materials (e.g., topsoil, gravel, mulch, compost) are knotweed-free. Healthy green spaces are more resistant to invasion by invasive plants, so it is also important to maintain or establish healthy plant communities.

CHEMICAL: RECOMMENDED

Due to the extensive rhizome system, chemical control with a systemic herbicide is the most effective treatment method for all four species of knotweeds.

The BC Ministry of Transportation and Infrastructure has trialed the use of several non-systemic chemicals (saltwater, vinegar, borax, foam, etc.) to control knotweed. Treatment efficacy was found to be as poor as some manual control methods; there was no impact on the roots. Authorization from Health Canada's Pest Management Regulatory Agency is required to test any non-registered pest control products.

When alternative methods to prevent or control invasive plants are unsuccessful, professionals often turn to herbicides. With the exception of substances listed on Schedule 2 of the BC Integrated Pest Management Regulation, the use of herbicides is highly regulated in British Columbia. Site characteristics must be considered with herbicide prescribed, based on site goals and objectives and in accordance with legal requirements. This summary of BC's *Integrated Pest Management Act* provides an overview of the provincial legislation.

PESTICIDE LICENCE AND CERTIFICATION

A valid pesticide licence is required to:

- offer a service to apply most pesticides;
- apply most pesticides on public land including local government lands[4]; and
- apply pesticides to landscaped areas on private land, including outside office buildings and other facilities.

Pesticides (e.g., herbicides, insecticides, fungicides) are regulated by the federal and provincial government, and municipal governments often have pesticide bylaws.

- Health Canada evaluates and approves chemical pest control products as per the *Pest Control Products Act*.
- The *BC Integrated Pest Management Act* sets out the requirements for the use and sale of pesticides in British Columbia. This *Act* is administered by the Ministry of Environment and Climate Change Strategy.
- Several municipalities have adopted bylaws which prohibit the use of certain pesticides.

Everyone who uses pesticides must be familiar with all relevant laws.

ONLY companies or practitioners with a valid Pesticide Licence and staff who are certified applicators (or trained assistant applicators working under a certified applicator) may apply herbicide on invasive plants located on public lands in British Columbia. Applicators must be either the land manager/owner or have permission from the land manager/owner prior to herbicide application.

On private property the owner may obtain a Residential Applicators Certificate (for Domestic class products only) or use a qualified company. Residents do not require a Residential Applicator Certificate for certain uses of domestic class glyphosate including treatment of plants that are poisonous for people to touch, invasive plants and noxious weeds listed in legislation, and weeds growing through cracks in hard surfaces such as asphalt or concrete. Refer to the 'Pesticides & Pest Management' and 'Home Pesticide Use' documents listed in the Additional Resources Section for more information.

Questions? Contact the BC Integrated Pest Management Program:

Telephone: (250) 387-9537

Email: bc.ipm@gov.bc.ca

4 on up to 50 ha/year by a single organization. Organizations looking to treat over 50 hectares of land per year are also required to submit a Pest Management Plan and obtain a Pesticide Use Notice confirmation.

Pesticide applicator certificates can be obtained under the category 'Industrial Vegetation Management' to manage weeds on industrial land, roads, power lines, railways, and pipeline rights-of-way for control of noxious weeds on private or public land. Assistant applicator training is also available and the online course and exam are free.

It is best practice for personnel supervising or monitoring pesticide contracts to also maintain a pesticide applicator licence so they are familiar with certification requirements.

For more information on how to obtain a licence and the requirements when working under the provincial *Integrated Pest Management Act* and Regulation, please review the Noxious Weed & Vegetation Management section on this webpage: gov.bc.ca/PestManagement.

Spray-on herbicide application

CREDIT: ISCMV

PHASED APPROACH

Chemical control plans should always include three phases: 1) control, 2) maintenance, and 3) ecological restoration. For knotweeds, the control phase takes at least two seasons, and often includes at least two treatments in year one, followed by at least one treatment in year two. After initial treatment during active growth, follow-up treatments should occur no sooner than 2 weeks, preferably 4-6 weeks or more (or as stated on the herbicide label), so there is sufficient foliage to absorb adequate quantities of herbicide for translocation to the tips of rhizomes (Ralph 2017). Note that some of the herbicides used for knotweed control are restricted to one application per site per year. After initial control efforts have nearly eliminated the knotweed, the site must be periodically monitored and new growth treated to prevent re-infestation (Gover, et al. 2008). Restoration should also be a priority, especially if there is risk the site will be colonized by other invasive plant species.

HERBICIDE LABELS

Individual herbicide labels must always be reviewed thoroughly prior to use to ensure precautions, application rates, and all use directions, specific site and application directions are strictly followed. Under the federal *Pest Control Products Act* and the BC Integrated Pest Management Regulation, **persons are legally required to use pesticides (including herbicides) only for the use described on the label and in accordance with the instructions on that label.** Failure to follow label directions could cause damage to the environment, poor control results, or danger to health. Contravention of laws and regulations may lead to cancellation or suspension of a licence or certification, requirement to obtain a qualified monitor to assess work, additional reporting requirements, a stop work order, or prohibition from acquiring authorization in the future. A conviction of an offence under legislation may also carry a fine or imprisonment.

Herbicide labels include information on both the front and back. The front typically includes trade or product name, formulation, class, purpose, registration number, and precautionary symbols. Instructions on how to use the pesticide and what to do in order to protect the health and safety of both the applicator and public are provided on the back (BC Ministry of Environment 2011).

Labels are also available from the Pest Management Regulatory Agency's online pesticide label search or mobile application as a separate document. These label documents may include booklets or material safety data sheets (MSDS) that provide additional information about a pesticide product. Restrictions on site conditions, soil types, and proximity to water may be listed. If the herbicide label is more restrictive than provincial legislation, the label must be followed.

Himalayan knotweed
CREDIT: K. LI

HERBICIDE OPTIONS

The following systemic herbicides can be used on knotweeds in British Columbia:

ACTIVE INGREDIENT (EXAMPLE BRAND NAMES)+	APPLICATION	PERSISTENCE	GROWTH STAGE++	TYPE+++
Glyphosate (many products)§	foliar application stem injection (only Roundup WeatherMAX® With Transorb 2 Technology)	non-residual*	actively growing	non-selective
Imazapyr (e.g. Arsenal™)**	foliar application	residual	actively growing	non-selective
Aminopyralid + metsulfuron methyl (e.g. Clearview™)***	foliar application	residual	actively growing	selective, no affect to grasses
Aminopyralid (e.g. Milestone™)	foliar application	residual	actively growing	selective, no affect to grasses
Triclopyr (e.g. Garlon™)#	foliar application	residual	during growing season	selective, no affect to grasses

+ The mention of a specific product or brand name of pesticide in this document is not, and should not be construed as an endorsement or recommendation for the use of that product.

++ Active growing periods vary from year to year depending on weather and other factors. There may be more than one active growing period for a plant in a year. Typically, the active growing period for knotweeds is from the spring until the plants mature and set seeds.

+++ Herbicides that control all vegetation are non-selective, while those that control certain types of vegetation (e.g. only grasses or only broadleaf plants) are termed selective.

§ Glyphosate can impact trees with roots within or adjacent to the treatment area.

* Non-residual herbicides are active only on growing plant tissue have little or no persistence in the soil whereas residual herbicides persist in the soil, remaining effective over an extended period of time.

** Only on non-crop areas.

*** Only Japanese knotweed is listed on this label. The federal Pest Management Regulatory Agency is satisfied that long-term control can also be achieved on the other three species (Herbison 2017).

Use higher rates for late summer applications when regrowth rates are reduced.

NOTE: Knotweeds are not specifically listed on the Milestone™, Garlon™ or Arsenal™ labels; however, they can be treated under the general application provision for broadleaved plants.

Additional information on products, rates and application methods can be found in 2019 Herbicide Guidelines for Control of Knotweed Species on Crown Lands (see resource section).

APPLYING HERBICIDE IN RIPARIAN AREAS

Provincial legislation prohibits the use of herbicides within 10 metres of natural water courses and 30 metres of domestic or agricultural water sources on public lands. On private lands only herbicide labels need to be followed (which means for glyphosate products and Milestone™, treatment can happen up to the water's edge) and other restrictions may apply (e.g., industrial sites, forestry sites, golf courses, etc.).

On public lands, glyphosate is the only active ingredient that can be applied within the 10 metre Pesticide-Free Zone (PFZ)[5] in British Columbia in accordance with the BC *Integrated Pest Management Act* and Regulation and all public land Pesticide Management Plans (PMPs), but not within 1 meter of the high water mark (HWM)[6].See the manual/mechanical section below for alternative control techniques that may be used with extreme caution at these sites. The 30 metre no-treatment zone around a water supply intake or well used for domestic or agricultural purposes may be reduced if the licencee or PMP holder is "reasonably satisfied" that a smaller no-treatment zone is sufficient to ensure that pesticide from the use will not enter the intake or well.

Application of pesticides to control knotweed in the PFZ or in the water may be possible via a pesticide use permit (PUP). Since bodies of water are owned by the Province, all decisions regarding potential pesticide use must be made by a responsible member of the Provincial government (or delegate). Proponents looking to apply herbicide in water should first contact Integrated Pest Management Program Telephone: (250) 387-9537 or Email: bc.ipm@gov.bc.ca. If the Provincial government deems a permit is required, the proponent (owner/land manager) must apply for a PUP and the application fee of $1,000. Proponents must also conduct public and First Nation consultation. Once all parties have been satisfactorily consulted and all requirements of the permit have been met, the province may issue a PUP for a maximum of 3 years. Issuance is a legal decision, but can be appealed. ONLY companies or practitioners with a valid Pesticide License and staff who are certified may apply the herbicide. A few PUPs have been granted in BC for control of knotweed between the water's edge and one meter above the high water mark, and a few more are in progress.

5 The Pesticide-Free Zone (PFZ) is an area of land that must not be treated with pesticide and must be protected from pesticide moving into it, under the *Integrated Pest Management Act* and Regulation.

6 The High Water Mark (HWM) is defined as the visible high water mark of any lake, stream, wetland or other body of water where the presence and action of the water are so common and usual and so long continued in all ordinary years as to mark upon the soil of the bed of the lake, river stream, or other body of water a character distinct from that of the banks, both in vegetation and in the nature of the soil itself. Typical features may include, a natural line or "mark" impressed on the bank or shore, indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics. The area below the high water mark includes the active floodplain (BC Ministry of Environment and Climate Change Strategy 2018).

When managing knotweeds with herbicide in riparian areas:

- Observe and mark all PFZs while on site.
- The HWM should be determined by careful evaluation by the applicator.
- Distances in PFZs should be measured as horizontal distance.
- Herbicides restricted in a PFZ must not enter these zones by leaching (lateral mobility) through soil or by drift of spray mist or droplets.
- Treatments should be conducted when water levels are low (e.g. summer months) to reduce risk.
- Note that efficacy may be dependent on site conditions, including moisture in the soil. Riparian sites in the City of Burnaby have taken longer to achieve eradication than sites with drier soils when identical treatments were used (Yong 2017).

FOLIAR APPLICATION METHODS

The preferred application methods to minimize non-target damage and applicator exposure are as follows:

- **Spray-on application** uses a backpack or handheld sprayer to completely cover the actively growing plant parts with herbicide, including the underside of the leaves. Spraying the undersides of the leaves maximizes the herbicide contact and uptake by the stomata, most of which are on the underside of the leaves of knotweeds. To access tall foliage and minimize the risk of applicator exposure to herbicide, long wands and wand extensions are recommended. If working in or under a knotweed canopy, applicators should take care to remove plant fragments, soil, and seeds from clothing, footwear, and equipment before leaving the site.
    - Small infestations (less than 300 stems): Work around the stand perimeter, spraying both the top and underside of the leaves.
    - Large infestations (300 stems or more): Target the foliage around the perimeter of the infestation first to reduce applicator exposure. After the treated foliage has died back, return to the infestation for a second treatment. Spray foliage that was not treated during the first treatment, and tackle the next "layer" during subsequent treatments. Continue until all foliage has been sprayed.
- **Wipe-on application** involves applying herbicide directly onto leaf surfaces (including the underside) using a simple hand-held wipe-on applicator (e.g., Red WeederTM). Wipe-on application is time-consuming and can be messy due to herbicide drips.
- **Knock down and spray method** is easier with two people. With a blunt end of a machete, a strong stick, or hand, one person knocks the new knotweed stems over (one by one), making sure not to break/cut the stem. With a handheld or backpack sprayer, the second person (applicator) follows the first person and sprays the leaves of the bent over stems, at waist height.

  This technique avoids spraying overhead, and provides applicators with easy navigation and the ability to account for what has been sprayed already. With the stems bent over, the undersides of the leaves are also exposed and easily sprayed. This technique is also more effective if done earlier in the season; if the stems become woody and brittle, it's more likely that the stems will break rather than bend.

  The knock down and spray technique has been trialed by the Sea to Sky Invasive Species Council with an average efficacy of 80.6% on 8 sites (Greenberg 2017).

Shrouding or shielding the spray nozzle(s) on the spray wand can minimize herbicide drift into pesticide free zones or other sensitive areas during foliar applications. Tarps or garbage bags can be suspended, wrapped, or draped as a buffer to adjacent sensitive areas including desirable

Stem injection

vegetation, waterbodies or structures. This technique can also be used to protect restoration plantings that have become overgrown with knotweeds (BC Ministries of Forests, Lands, Natural Resource Operations and Rural Development, and Transportation and Infrastructure 2019).

STEM INJECTION

This technique involves injection of herbicide into single stems using a hand-held tool that delivers a specified amount of product into the hollow stems. Currently in Canada, Roundup WeatherMAX® With Transorb 2 Technology Liquid Herbicide™ (pest control products number 27487) is the only product with stem injection listed the label and therefore the only product that can legally be applied using this method. While it can be used on any sized infestation, this method is useful for patches with few knotweed stems or when stems are growing interspersed between desirable vegetation. This method is more time-consuming as each stem must be injected and marked (some injection tools come with attachments for marking pens).

TREATMENT TIMING

Herbicide should be applied to actively growing plants. Treatment can start either early in the growing season or late summer. For early spring treatments, it is recommended to wait until there is sufficient foliage on the stem (starting when knotweed canes are at least one metre high and when the majority of canes in the infestation have emerged) (Watson 2017). This ensures adequate surface area for absorption. This early season treatment timing requires follow-up on regrowth later in the season. Advantages of early season treatments include avoiding the need for spraying overhead, reducing the risk of breaking canes, preventing flower/seed set from occurring, and using less herbicide. Initial treatments can also start in late summer/early fall when maximum surface area is available to spray because the leaves have all matured. This late season treatment timing requires follow-up the next spring. Both timing methods can be effective, and as with all management techniques, outcomes are site specific.

Knotweed treatment should cease at the end of the growing season once it shows extensive leaf discolouration or defoliation. Treatment efficacy will be reduced during drought periods (BC Ministries of Forests, Lands, Natural Resource Operations and Rural Development, and Transportation and Infrastructure 2019).

In order to minimize impact to insects, if possible, treat before the plants flower and avoid treatment during the flowering season. If Himalayan blackberry is present at the treatment site consider treating before the berries form or cutting any blackberry canes with fruit before treatment to eliminate concerns of berry pickers.

MAINTENANCE

Post-chemical treatment monitoring is required for licencees and PMP holders under the *Integrated Pest Management Act* to ensure that efforts are successful and to allow for adjustments to the management approach as necessary. After initial herbicide treatment, follow-up monitoring and treatment should occur at least once the same year for glyphosate. Note that some of the herbicides used for knotweed control are restricted to one application per site per year. Check the label for application timing and frequency.

Monitoring should continue on at least an annual basis, with follow up treatments occurring as necessary, until the infestation is eradicated. Some knotweed treatment sites may seem eradicated, however new growth has been observed up to three years after the last herbicide treatment or observation of knotweed growth (Watson 2017). Knotweed rhizomes can remain dormant for up to 20 years (Parkinson and Mangold 2010). Monitoring the site for many years is prudent due to knotweed's extensive rhizome system.

MANUAL/MECHANICAL: CAUTION

Manual/mechanical control methods (smothering, mowing, pulling, digging, burning, steaming, cutting, and removing by hand or machine) on their own are not effective knotweed control options. These methods may impact the above ground vegetation but do not target the extensive underground rhizome structure, which is essential for successful management. Manual/mechanical control is time-consuming and requires dedicated, frequent removal over numerous years and is likely to yield no change or a growth in the original infestation, at a high risk for spread to other sites.

Knotweed roots after an excavation project in the City of Delta. Knotweed outside the PFZ at this site had been chemically treated for multiple years, with a few stems remaining in the PFZ. At the time of excavation for a ditch project, some of the roots were still viable.

CREDIT: K. LI

Although they will not result in successful control or eradication of knotweeds, the following methods may be used to manage knotweed in specific circumstances (e.g. in the PFZ or for sight line safety) and should be carried out with extreme caution. Stems that are causing sight-line issues or falling onto trails can be bent back if the knotweed is not being managed. For all manual/mechanical methods, if soil is disturbed at a knotweed site, the infestation and a 20 metre radius should be flagged, and care must be taken when working in that "contaminated area" (BC Ministry of Transportation and Infrastructure 2016):

- **Smothering** involves the use of light blocking materials. Many smothering materials are unsuitable – they must be thick and heavy such as recycled conveyor belt. Maintenance visits will be necessary to ensure the cover has not been breached and new shoots do not sprout along edges. Be prepared to expand the covered area over the first few growing seasons as the knotweed spreads beyond the initial area smothered (Clegg 2018). Sites observed in BC where smothering materials were in place for over 10 years have not been successful (Chadburn 2018) (McLean 2018).

- **Cutting flower heads** is used at Bohemian knotweed sites where chemical control is not possible to reduce the seed bank and prevent dispersal (Chadburn 2018). This must be done before the plants set seed. Care must be taken as described below.

- **Pulling and digging** is used for areas where herbicide is not permitted. Extreme care must be taken at aquatic sites to prevent soil erosion. All plant parts must be prevented from entering the watercourse. The root mass volume is much larger than the aboveground growth so digging will encompass a large area around the infestation. If this technique is used, see Disposal section below to avoid spreading the knotweed.

- **Excavation with heavy equipment** requires all root material to be removed, which means digging 3 metres deep and up to 20 metres wide (BC Ministry of Transportation and Infrastructure 2016). Great care must be taken when excavating knotweeds as this activity has a high risk of spreading plant fragments. Equipment should be thoroughly washed onsite before transport to reduce risk of spread. Ensure a disposal plan is in place prior to excavating (see Disposal section below). Monitor and treat areas with herbicide after excavation.

  Additional caution is needed if excavation will occur near a body of water where knotweed is present or adjacent. Care should be taken to restrict the downstream movement of fragments and containment procedures should be implemented (e.g. use of sediment control fabric). A qualified environmental professional should oversee and monitor this work if there is risk of trapping amphibians, fish or other species in the contained area.

- **Foam, steam and other alternatives** are not recommended as they only act to kill top ground vegetation. Use of these methods have the same challenges as the manual control methods outlined above and do not have long-term evidence to support use.

- **Mowing** is not recommended as repeated frequent mowing causes an acceleration of new shoot development leading to lateral spread (Drinkwater 2017). It is suspected that plant fragments spread by mowing are one of the main vectors of spread for knotweeds in Metro Vancouver and other regions.

- **Cutting** is not recommended although may be necessary at particular sites. If top growth must be removed, the canes should be carefully handled and allowed to desiccate until completely brown and dead before transport or disposal. If this technique is used, see Disposal section below to avoid spreading the knotweed.

- **Burning and/or heat treatment** is not recommended as the plants contain high water content and all plant tissue, particularly the rhizomes, may not burn. Infrared heat treatment of over 800 degrees Celsius has shown to be time consuming, laborious, and did not affect the centre of large rhizomes (Clegg 2018). In addition, burning is prohibited in many municipalities unless a permit has been obtained from the fire department.

Knotweed re-growth a few weeks after a roadside fire

CREDIT: J. HERBERT

CASE STUDY: DEBOVILLE SLOUGH
(FRIENDS OF THE DEBOVILLE SLOUGH 2017)

Knotweed infestations along DeBoville Slough in Coquitlam, which cannot be treated with herbicide owing to its proximity to a waterbody, have been manually controlled by the Friends of DeBoville Slough volunteers since 2005. In partnership with the City of Coquitlam, volunteers attend regular knotweed control events in May, June, July and September/October. The last event of the year is planned a month before the knotweed goes dormant. The knotweed is cut at the base and the stems are collected for offsite high heat composting later.

The program has reduced the total area covered by knotweed by 50-95% depending on the site (Mounteney 2021). The areas under the best control are shaded spots where the volunteers have planted native species (Mounteney 2021). Native vegetation has also naturally moved into areas once covered by knotweed.

Project partners do not have the goal of eradication, but rather consider this a maintenance program to contain the knotweed and prevent spread. This work is only possible with long-term, sustained effort by volunteers, typically done four times throughout the year. These volunteer events also provide opportunities for public education as the area has high usage by pedestrians and cyclists.

Other similar projects have been undertaken around the province to manually control knotweed in areas that cannot be managed in other ways. Staff, volunteers, and disposal contractors working on these projects should be trained in best practices and have realistic goals.

Knotweeds in a riparian area

CREDIT: ISCMV

APPLYING MANUAL/MECHANICAL CONTROL METHODS IN RIPARIAN AREAS

Knotweed often grows in large contiguous patches right up to the edge of water courses. Consider the impact of control techniques and the resulting bare soil on the adjacent aquatic environment. Schedule removal works during a period of least risk to fish species, outside of the fish window. Adhere to Provincial and Federal riparian regulations. It is recommended to consult with a qualified environmental professional when working around water bodies.

CULTURAL: NOT RECOMMENDED

Miller, Tarasoff & Salmon (2021) researched the potential for targeted grazing as a control method in Metro Vancouver, but knotweeds were deemed unsuitable candidates. Although goats and cattle will graze newly emergent knotweed shoots right down to ground level in the spring and summer (Centre for Agriculture and Biosciences International 2017), grazing does not control the rhizome system and may in fact contribute to increased spread as sites have been shown to increase in size following infrequent disturbance due to aggressive re-sprouting (DiTomaso & Kyser, 2013). Grazing animals may also leave behind plant fragments and seeds that will likely regrow. Grazing opportunities may be limited in urban areas by municipal bylaws regulating animals, the need for specially trained herds, and the potential damage grazing animals may cause in sensitive ecosystems (e.g. off-target grazing and erosion). Due to these constraints, the potential for environmental damage, and risk of further spread, targeted grazing is not recommended for knotweed species.

BIOLOGICAL: NOT AVAILABLE

Biological control or biocontrol is the use of an invasive plant's natural enemies (chiefly insects, parasites and pathogens) — to reduce its population below a desired level. A sap sucker psyllid, *Aphalara itadori*, has been studied as a potential biological control in the Pacific Northwest (Centre for Agriculture and Biosciences International 2017). *A. itadori* feeds on the sap in the phloem cells of the leaves and stems resulting in twisted and deformed leaves and, more importantly, damage to the meristems and reduced biomass. In 2012, host range screening was completed for *A. itadori* and a permit to import the psyllid into Canada was submitted to the Canadian Food Inspection Agency (CFIA). The psyllid has been approved by CFIA for limited number of releases in Canada. Agriculture and Agri-Food Canada and the BC Ministry of Forests have released the psyllid in BC, Alberta and Ontario and is working on identifying the conditions for establishment and assessing impact. To date the insect has not established, that is, it has not persisted across multiple years (Bourchier 2018). The BC Ministry of Forests and other agencies in North America continue to explore potential biocontrol opportunities for knotweeds (US Department of Agriculture, 2018).

CONTROL SUMMARY

The following table provides a summary and comparison of control methods for knotweed.

CONTROL STRATEGY	TECHNIQUES	APPLICABLE SITE TYPE	PROS	CONS
Chemical	**Foliar application: spray-on, wipe-on, knock down & spray**	All sites	Does not require disposal of treated stems	Unintended environmental/health impacts, high public concern, weather dependent, requires trained staff
	Stem injection	All sites, useful for patches with few stems or when stems are growing interspersed between desirable vegetation	Does not require disposal of treated stems, more selective than foliar application	Expensive, uses more herbicide, unintended environmental/health impacts, high public concern, requires trained staff
Mechanical	**Smothering, cutting flower heads, pulling and digging, excavation**	For use under specific circumstances such as sites where herbicide is not permitted or for site line safety	Non-chemical	Will not eradicate the plants, may cause aggressive re-growth or spread
	Mowing		Does not require trained staff	Spreads fragments and accelerates growth, may require disposal of stems
	Cutting	May be required at sites where knotweed must be removed immediately (e.g. when posing a safety risk)	Does not require trained staff	Spreads fragments and accelerates growth, may require disposal of stems
	Burning/heat treatment, foam/ steam/other alternatives		Non-chemical	Labour intensive, has little impact on the plants, burning may be restricted in some municipalities and/or require permits, may require trained staff and speciality equipment
Cultural	**Grazing**	Sites accessible to grazing herds	Non-chemical	Requires specially trained herds and special permits, non-selective, complex logistical considerations, unintended environmental impacts
Biological	**No biological control agents are currently available for distribution in British Columbia**			

CONTROL SUMMARY COLOUR LEGEND

GREEN: RECOMMENDED

ORANGE: CAUTION

RED: NOT RECOMMENDED OR NOT AVAILABLE

Disposal

Best practice is to avoid offsite knotweed disposal due to the high risk of spread during transport. If best management practices are followed and chemical control methods are used, treated knotweed canes can be left on site to compost and disposal is not necessary. Canes left to dry and desiccate will not be viable to regrow. Dead canes can be mechanically or manually cut over winter to provide easier access for spring treatments, pedestrian access along paths/sidewalks, or aesthetics (Clegg 2018). Under special circumstances when manual/mechanical control methods are required, follow the recommended disposal procedures described below. Consult individual herbicide labels for information on environmental fate, safety hazards, timing and other considerations if contact of the plants or activities are planned at the site soon after treatment.

HANDLING

When handling or working in or near a knotweed infestation, ensure no plant fragments (or seeds in the case of Bohemian knotweed) fall away or are dropped, as they will likely regrow. When collecting the knotweed cuttings for disposal ensure plant fragments are contained in a bag or container to avoid dropping plant pieces (for green waste - brown paper bags; for garbage - sealed, heavy plastic bags).

ON SITE DISPOSAL

It is best to avoid manual/mechanical control methods to minimize movement of knotweed material or soils infested with plant parts, rhizomes, or seeds. If this control method is necessary, onsite disposal is the best option. If large knotweed infestations are cut to prevent a sight-line issue, stems can be thrown back into the patch.

For large operations, such as gravel pits, knotweed plant parts, rhizomes, and seeds can be buried on site to a minimum depth of 5 metres. Any regrowth should be chemically treated. These sites should be physically marked and records should be kept on file for future referral should re-development of the site occur. Burial sites should be monitored for regrowth on an ongoing basis. If knotweed is cut along large infestations to prevent a sight-line issue, stems can be thrown back into the patch.

Infested soils can be stock piled, but knotweed growth and stockpiled soil with knotweed growth should be chemically treated and monitored (refer to chemical treatment section). Disposal sites should be far enough away from water and drinking wells to enable herbicide treatment.

Home composting of untreated knotweed is not recommended as it will regrow and infest the composter.

OFF SITE DISPOSAL

If deep burial or stockpiling on site are not options, knotweed plants and soil infested with knotweed foliage, rhizomes, and/or seeds can be disposed at an appropriate facility. To reduce the risk of plant parts, rhizomes, or seeds escaping during transport, all material should be bagged, tarped and strapped securely. Alternatively the material could be placed in a sealed container before transport. The City of Chilliwack performed a one-time trial of deep burial of concentrated rhizome (as well as loose soil contaminated with low levels of rhizome parts) in sealed 200 litre plastic barrels in a municipal landfill with success (Clegg 2018). Most disposal facilities charge a surcharge upon arrival if loads are not secured.

In addition, clothing, vehicles, pets, and equipment should also be inspected for plant material and decontaminated if necessary.

In the Metro Vancouver region, several facilities may accept knotweed plants and/or infested soil. This list provides addresses and website links for the disposal facilities. This list is updated periodically.

PLEASE CONTACT ALL FACILITIES BEFOREHAND TO CONFIRM THEY CAN PROPERLY HANDLE THE MATERIAL.

CLEANING AND DISINFECTION[76]

Before leaving a site, remove all visible plant parts and soil from vehicles, equipment, and gear, and if possible, rinse these items. When back at a works yard or wash station, vehicles should be cleaned and disinfected using the following steps:

- Wash with 180 °F water at 6 gpm, 2000 psi**, with a contact time of ≥ 10 seconds on all surfaces to remove dirt and organic matter such as vegetation or seeds. Pay special attention to undercarriages, chassis, wheel-wells, radiators, grills, tracks, buckets, chip-boxes, blades, and flail-mowing chains.
- Use compressed air to remove vegetation from grills and radiators.
- Sweep/vacuum interior of vehicles paying special attention to floor mats, pedals, and seats.
- Run air intake fans in reverse where possible.
- Steam clean poor access areas (e.g. inside trailer tubes) – 200 psi @ 300 °F.
- Fully rinse detergent residue from equipment prior to leaving facility.

** Appropriate self-serve and mobile hot power-wash companies in the Metro Vancouver region include: Omega Power Washing, Eco Klean Truck Wash, RG Truck Wash, Ravens Mobile Pressure Washing, Hydrotech Powerwashing, Platinum Pressure Washing Inc., and Alblaster Pressure Washing. Wash stations should be monitored regularly for knotweed growth.

Follow-Up Monitoring

Whatever control method is used, follow-up monitoring and maintenance treatments are important components of an integrated management plan or approach. Monitoring should occur around the periphery of the initial infestation as stems can emerge many metres away even when the main portion of the original stand appears dead.

Restoration

Restoration may not be necessary for relatively young and small knotweed infestations. For older, large knotweed infestations, restoration is necessary to supress colonization by other invasive plant species. Although it is desirable to revegetate with native or non-invasive plant species as soon as possible, restoration activities must be carefully timed. If planting occurs before the knotweed is completely eradicated it will be much harder to manage the remnant knotweed without injuring the restored vegetation (Gover, et al. 2008). Planting broadleaved herbaceous or woody plants after application of a residual herbicide should be delayed until herbicide activity is deactivated in the soils. This will depend on soil type, environmental conditions, and herbicide type. If replanting of broadleaved species is planned soon after herbicide treatment, then a non-residual herbicide (e.g. glyphosate) should be used. For glyphosate products, delay preparation of the soils for replanting by at least 7-15 days to ensure complete translocation of herbicide to the root tips (Ralph 2017).

Clearview™ and Milestone™ are safe on established grasses. Grasses may be seeded 10 months following an application. Legume re-establishment may be affected for up to five years. Soil organic matter, rainfall and temperature all affect the rate of degradation (IVM Experts Dow Chemicals Canada 2016).

7 Adapted from Metro Vancouver (2017) Water Services Equipment Cleaning Procedures and Inspection Protocols.

Revegetation of the site to a domestic or cultured non-native plant species composition may be considered in some circumstances. Often domestic species establish faster and grow more prolifically which aids in resisting knotweed re-invasion.

Examples of common competitive native species prescribed in Metro Vancouver sites are summarized in the table below based on site moisture.

WET SITES	MOIST SITES	DRY SITES
Shrubs		
Salmonberry	Salmonberry	Thimbleberry
Hardhack	Willow	Nootka rose
Willow	Red osier dogwood	Red flowering currant
Red osier dogwood	Red elderberry	Snowberry
Pacific ninebark	Vine maple	Tall Oregon grape
	Indian plum	Oceanspray
Trees		
Western red cedar	Western red cedar	Douglas-fir
Red alder	Red alder	Red alder

Replacement species should be chosen based on the ecology of the site by a qualified environmental professional. Local biologists, environmental professionals, agronomists, agrologists, native and domestic forage specialists, seed companies, and plant nurseries are all good sources for localized recommendations for regional native species and regionally adapted domestic species, based on site usage. Native grass seed mixes are also available. There are several science-based resources available to guide restoration efforts, such as the South Coast Conservation Program's Diversity by Design restoration planning toolkit.

Knotweed sites are often found in areas with existing, or potential, wildlife populations (e.g., deer, beaver, muskrat, vole, etc.) that can damage restoration plantings. Therefore, any revegetation plan must consider impacts from wildlife and utilize appropriate mitigation measures to protect the restoration and existing native plantings (tree wrapping, exclusion caging/fencing, vole guards, etc.).

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Additional Resources

For more information please refer to the following resources.

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Dr. Jennifer Grenz, Greener This Side

Metro Vancouver's Regional Planning Advisory Committee (RPAC) - Invasive Species Subcommittee

To submit edits or additions to this report, contact Laurie Bates-Frymel, Senior Regional Planner at laurie.bates-frymel@metrovancouver.org.


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