BEST MANAGEMENT PRACTICES FOR

Purple Loosestrife

in the Metro Vancouver Region

metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION

ISCMV
INVASIVE SPECIES COUNCIL OF METRO VANCOUVER

Disclaimer

This publication is not intended to endorse or recommend any particular product material or service provider, nor is it intended as a substitute for engineering, legal, or other professional advice. Such advice should be sought from qualified professionals.

While the information in this publication is believed to be accurate, this publication and all of the information contained in it are provided "as is" without warranty of any kind, whether express or implied. All implied warranties, including, without limitation, implied warranties of merchantability and fitness for a particular purpose, are expressly disclaimed by Metro Vancouver. The material provided in this publication is intended for educational and informational purposes only.

Cover image credit Claire de la Salle.

Created by: Metro Vancouver and the Invasive Species Council of Metro Vancouver

In partnership with: Diamond Head Consulting

DIAMOND HEAD

Requested by: Metro Vancouver's Regional Planning Advisory Committee – Invasive Species Subcommittee

4730 Kingsway, Burnaby, British Columbia, V5H 0C6
metrovancouver.org

August 2021

Contents

Introduction ____ 4
- REGULATORY STATUS ____ 5
- IMPACTS ____ 5
- REPRODUCTION AND SPREAD ____ 6
- HABITAT AND DISTRIBUTION ____ 6
- CLIMATE ADAPTATION ____ 6

Identification ____ 8
- SIMILAR SPECIES ____ 10

Tracking ____ 12

Reporting ____ 12

Prevention and Control Strategies ____ 13
- PREVENTION: IMPERATIVE ____ 13
- BIOLOGICAL: RECOMMENDED ____ 13
- MANUAL/MECHANICAL: RECOMMENDED ____ 18
- CHEMICAL: CAUTION ____ 19
- CULTURAL: NOT RECOMMENDED ____ 24
- CONTROL SUMMARY ____ 25

Disposal ____ 26
- CLEANING AND DISINFECTION ____ 26

Follow-up Monitoring ____ 27

Restoration ____ 28

Additional Resources ____ 32

Acknowledgments ____ 32

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 Purple Loosestrife 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 that has been tested locally by many researchers and operational experts.

Purple loosestrife[1] was first introduced to Atlantic North America in the 1800's, both unintentionally by European ships, and intentionally as an ornamental, medicinal or apiary plant (Regional District Okanagan-Similkameen, 2006). It has spread across wetlands in most of North America, arriving in BC in 1915 (Invasive Species Council of British Columbia, 2017), and is commonly found in Metro Vancouver.

This attractive plant is a serious wetland invader. It is estimated that 200,000 ha of American wetlands are altered annually due to purple loosestrife invasion (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Its success is attributed to its great reproductive capacity. Strong root stocks give rise to new shoots and plants bloom throughout the growing season. A single mature plant can produce more than two million seeds each year.

Academic institutions, government, and non-government organizations continue to study this species in British Columbia. As researchers and practitioners learn more about the biology and control of purple loosestrife it is anticipated that the recommended best management practices will change over time and that this document will be updated. Please check metrovancouver.org regularly to obtain the most recent version of these best management practices.

1 Purple loosestrife is also known by the common names purple lythrum, spiked loosestrife (Page, 2006), loosestrife, and beautiful killer.

REGULATORY STATUS

Purple loosestrife is classed as a noxious weed within all regions of the province under the *BC Weed Control Act,* Weed Control Regulation, Schedule A. The Act states that "an occupier 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, states that "municipalities may regulate, prohibit and impose requirements in relation to control and eradication of alien invasive species" which includes purple loosestrife.

Section 47 (1) of the *Forest and Range Practices Act*, states that "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". Purple loosestrife is listed in the Invasive Plant Regulation under this Act.

IMPACTS

Purple loosestrife tends to grow as a monoculture, reducing biological diversity at the site of infestation (Invasive Species Council of British Columbia, 2017). It is associated with the decline of other species, including plant and animal species at risk (Invasive Species Manitoba, 2019) (Warne, 2016). In general, purple loosestrife provides little food and habitat value (Mann, 1991). Infestations prevent the establishment of native plant species which are critical for native wildlife, resulting in a decline in wildlife populations in the presence of purple loosestrife stands (Henne, Lindgren, Gabor, Murkin, & Roughley, 2005). Dense infestations also restrict waterfowl access to open water (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992).

CREDIT: ISCMV

The flowers are attractive to many pollinators, including bees; however, honey produced from loosestrife-feeding bees are apparently of low quality (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Researchers are also concerned about the recruitment of pollinators to purple loosestrife as a food source instead of native or beneficial plants (known as the pollinator diversion effect) (Brown, Randall, & Graham, 2002).

Purple loosestrife stands can be dense enough to trap sediments, which can alter landscapes and lead to a rise in the water table (King County Noxious Weed Control Program, 2011). Its dominance and competitive qualities allow purple loosestrife to easily spread and take over riparian and aquatic habitats. Purple loosestrife can spread into municipal drainage systems, agricultural ditches, and drainage/irrigation canals potentially leading to significant flow restrictions,

increased flooding, and decreased crop productivity. It can also decrease the forage value in agricultural sites by out-competing and replacing desirable vegetation (Invasive Species Council of British Columbia, 2017).

Since purple loosestrife damage is largely ecological, it is difficult to quantify economic impacts and therefore difficult for land managers to decide what resources to put into management (Frid, Knowler, Murray, Myers, & Scott, 2009).

REPRODUCTION AND SPREAD

Purple loosestrife is a perennial plant that is able to reproduce vegetatively from root fragments and by seed. The root and stem fragments are capable of growing into new stems when broken off from the main plant (Invasive Species Council of British Columbia, 2017). The root stock of purple loosestrife is quite extensive with large nutrient reserves, which leads to increased survivability in marginal environments or during control efforts (Regional District Okanagan-Similkameen, 2006). Every year the plants grow taller and denser and produce new stems, further monopolizing local resources (Regional District Okanagan-Similkameen, 2006).

Purple loosestrife stands are typically found in riparian areas where water can spread the seeds and help maintain seed viability. The primary dispersal mechanism for seeds and young seedlings is by water, but seeds can also be spread by other sources including wind, wildlife, waterfowl, livestock, and by humans, cars, and boats (Invasive Species Council of British Columbia, 2017). Each purple loosestrife produces an average of 2.7 million seeds (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Seed banks can persist for several years and longer if the seeds become dormant, but they will germinate when disturbed (US Department of Agriculture, 2019).

HABITAT AND DISTRIBUTION

Purple loosestrife is very tolerable to a range of habitats but prefers riparian areas and wetlands when establishing new populations. However, once a stand is well established it can tolerate drier soil types, which can lead to spread into crop fields and pastures (Invasive Species Council of British Columbia, 2017). Although purple loosestrife prefers full sun, it can tolerate up to 50% shade (Page, 2006). It also prefers high organic soils but can tolerate clay, sand and silt (Page, 2006).

Purple loosestrife is present in all provinces in Canada but not currently in the territories (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). It has been found in the lower half of BC (Invasive Species Council of British Columbia, 2017) and is prevalent in southwestern BC, from Vancouver Island to the Fraser Valley and the Okanagan (PlantWise, 2015). It is widespread in Metro Vancouver's natural areas where it can be found in wetlands, lake and river shores, ditches, marshes, tidal flats, wet meadows, and along the Fraser River and estuary (Page, 2006). It is rare in moist forest edges and manicured gardens (Page, 2006).

CLIMATE 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.

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

- **Extended growing season:** Purple loosestrife already has a relatively long florescence period from July to September. The longer growing season could extend florescence as well as the duration of pollinator activity, fostering the production of additional purple loosestrife individuals and seeds (Colautti, Agren, & Anderson, 2017).
- **Warmer temperatures:** Temperature is the main variable limiting growth and distribution of purple loosestrife (Shamsi & Whitehead, 1977) (Thompson, Stuckey, & Thompson, 1987) (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). With predicted warmer temperatures, it is speculated that purple loosestrife is capable of further range expansion to higher elevations within this region and further north.
- **Longer summer drought periods:** Purple loosestrife has an extensive, woody root system that ensures its survival under drought conditions (Kadrmas & Johnson, 2002).
- **Increased precipitation and flooding:** Seeds may remain viable even when subjected to saturated conditions and are capable of germinating underwater (US Department of Agriculture, 2019).

With these kinds of competitive advantages, this species is more adaptable than native species in a variety of ecosystems. Its ability to reproduce in multiple ways and its ability to spread quickly suggest that it will be able to withstand, and possibly thrive, with changing climate conditions.

CREDIT: ISCMV

Identification

Unless otherwise noted, the following identification information was collected from Klinkenberg (2019).

General: Perennial species, with taproot and spreading root stock (King County Noxious Weed Control Program, 2011). Aboveground portion of plants die back in the fall and the following year new shoots arise from the root stock (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992)

Stem: Annual stems 0.5-3 metres tall (Alberta Invasive Plants Council, 2019) with 30-50 stems per plant. The stems are erect, woody, square shaped, and sometimes have short hairs (Invasive Species Council of British Columbia, 2017). New growth is green but older stems may appear reddish-brown or purplish (Warne, 2016).

Leaves: Grow along stems in a variety of patterns from opposite to whorled in groups of three. Leaves are 3-10 centimetres long, pointed at the tips, and occasionally covered in fine hairs. Leaves lack stalks and attach directly to the stem.

Flowers: Inflorescence is a dense spike at the top of each stem, with many flowers (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Each flower has 5-7 pinkish-purple petals, approximately 10 millimetres in length (Invasive Species Council of British Columbia, 2017). Blooms July to September. Flowers are pollinated by bees and butterflies (Alberta Invasive Plants Council, 2019).

Fruits: Small, dark brown, egg-shaped seed capsules 2-3 millimetres in length (Invasive Species Council of British Columbia, 2017) and filled with many seeds. Each stem produces 900-1000 capsules (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Capsules at the bottom of the inflorescence mature first and disperse seeds even while the upper portion may still be flowering. On average 2.7 million seeds are produced per plant (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Plants start dropping their seeds in the early autumn when temperatures start to cool (Regional District Okanagan-Similkameen, 2006). Seeds can remain dormant and viable in the soil for several years, but they will germinate when disturbed (US Department of Agriculture, 2019).

The following photos show purple loosestrife plant parts.

Spring emergence (seedlings)
CREDIT: OHIO STATE WEED LAB, THE OHIO STATE UNIVERSITY, BUGWOOD.ORG

Multiple stems of mature, flowering plants during the growing season
CREDIT: ISCMV

Stem, leaves
CREDIT: STEVE~H (FLICKR)

Square shaped stem
CREDIT: ROB ROUTLEDGE, SAULT COLLEGE, BUGWOOD.ORG

Flower
CREDIT: ISCMV

Seeds and capsule
CREDIT: GARY L. PIPER, WASHINGTON STATE UNIVERSITY, BUGWOOD.ORG

SIMILAR SPECIES

Purple loosestrife can be mistaken for a few native and non-native plants in the region that have similar coloured flowers. The easiest way to tell purple loosestrife from many similar plants is by its square-shaped stems (Invasive Species Council of British Columbia, 2017).

NATIVE

- Fireweed (*Epilobium angustifolium or Chamerion angustifolium*) has a similar flower that emerges around the same time as purple loosestrife (Klinkenberg, 2019). Purple loosestrife is more typical in wetlands and riparian zones, whereas fireweed is found in drier areas. (Klinkenberg, 2019). Fireweed has four-petalled flowers and alternate leaves.
- Hardhack (*Spiraea douglasii*) stems are round, leaves are alternate with toothed margins on the upper half. The pink flowers are 5-petaled and smaller compared to purple loosestrife.

Fireweed

CREDIT: ISABEL GASIOR

Hardhack

CREDIT: LINDA WILSON, UNIVERSITY OF IDAHO, BUGWOOD.ORG

NON-NATIVE

Dame's rocket (Hesperis matronalis) is a weedy plant found in Metro Vancouver. Flowers have 4 petals, alternate leaves and seed pods that are longer than those of purple loosestrife (Invasive Species Council of British Columbia, 2017).

- Himalayan balsam (Impatiens glandulifera) is an annual plant found in similar habitats as purple loosestrife. One to several distinctive flowers grow from leaf axils. They are pink to fuchsia (rarely white), usually spotted inside and sepals are pouched with a short-recurved spur (Klinkenberg, 2019). This species is also a serious wetland invader in Metro Vancouver.
- Butterfly bush (Buddleja davidii) is a deciduous shrub 1-5 metres tall; leaves are opposite and 3-25 centimetres long. Inflorescence is a large, terminal, branched cluster 15-25 centimetres long. The base of each small flower is narrow and tubular, spreading into 4 lobes; they are purplish with an orange eye.

Dame's Rocket

CREDIT: ISABEL GASIOR

Himalayan balsam

CREDIT: ISCMV

Butterfly bush

CREDIT: JOHN RUTER, UNIVERSITY OF GEORGIA, BUGWOOD.ORG

The Invasive Species Council of BC's 'Grow Me Instead' Program brochure suggests the following varieties as non-invasive ornamental alternatives to purple loosestrife: blazing star (Liatris spicata), tall delphinium (Delphinium elatum), bloody iris (Iris sanguinea), hardhack (Spiraea douglasii) and spike speedwell (Veronica spicata).

Tracking

The provincial government maintains the Invasive Alien Plant Program (IAPP) application (BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development 2017), which houses information pertaining to invasive plant surveys, treatments, and monitoring. 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 IAPP 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. The Map Display module of IAPP is publicly accessible.

When carrying out purple loosestrife inventory it is useful to record the following information as it will later inform treatment plans:

- Size and density of infestation;
- Location in relation to the 10 metre Pesticide Free Zone adjacent to water courses; and
- Location in relation to other water sources, such as wells.

Reporting

Since purple loosestrife is common throughout the Metro Vancouver region and does not pose an imminent health or safety risk, there is generally little urgency in reporting individual occurrences. However, as mentioned above, tracking occurrences can improve monitoring and control strategies across the region..

CREDIT: ISCMV

Prevention and Control Strategies

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

Attempts at manual/mechanical, chemical control, or a combination thereof have proven extremely expensive, labour intensive, potential damaging, and largely ineffective for purple loosestrife (Evely, 2003). It may be impossible to eradicate purple loosestrife once it becomes established (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Biological control is considered the most promising control method.

Follow-up monitoring and treatment will be required for several years regardless of the treatment technique.

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 purple loosestrife over the long term

When working in or adjacent to purple loosestrife, it is best to inspect and remove plants, plant parts, and seeds from personal gear, clothing, pets, vehicles, and equipment and ensure soil, gravel, and other fill materials are not contaminated with purple loosestrife before leaving an infested area. Plants, plant parts, and seeds should be secured by tarps or bagged before transport to an appropriate disposal site (see Disposal section).

The Invasive Species Council of BC's 'Grow Me Instead' Program or Metro Vancouver's Grow Green website provide recommendations for non-invasive, drought-tolerant plants, and garden design ideas. All materials (e.g., topsoil, gravel, mulch, compost) should be weed-free. Healthy green spaces are more resistant to invasion by invasive plants, so it is also important to maintain or establish healthy plant communities.

BIOLOGICAL: RECOMMENDED

Biological control is the use of a highly host-specific predator that will selectively damage or kill the target invasive species. Biocontrol can be considered when loosestrife infestations are large and when immediate eradication is not the primary goal (Washington State University, 2019). It is expected that there will be fluctuations in the target species and biocontrol agent population cycles over time.

BIOCONTROL AGENTS

A number of biological control agents have been considered for purple loosestrife management in BC (Province of BC, 2019). These insects are native to Europe and are natural predators of purple loosestrife. Numerous studies have confirmed that these insects feed exclusively on purple loosestrife (Evely, 2003). It takes over 2 years of complete defoliation by the beetles to kill the plants (Meyers, 2019). If the insects do not have access to purple loosestrife plants (even in the presence of other food plants), the insects will die (Evely, 2003). The presence of purple loosestrife biocontrol agents is confirmed by defoliated, skeletonized plants (see photo below) (Washington State University, 2019).

The available insects/treatments are outlined below with descriptions, life cycle, impacts, history of release, and the current management status (Province of BC, 2019).

BIOCONTROL AGENT	COLLECT-ABILITY	DESCRIPTION	LIFECYLE
Neogalerucella[2] *calmariensis* (black-margined loosestrife beetle)	Mass+, transfers can be successful moving adults or plant material with larvae to new location, large releases are best	Larva pale yellow, adults 3-5 millimetres long, tan coloured with **dark band along wing margins, dark triangular marking behind the head**	Adults overwinter at soil surface, emerge mid-May to early June, eggs laid on lower stem in June, adults disperse well
Neogalerucella pusilla (golden loosestrife beetle)	Mass+, transfers can be successful moving adults or plant material with larvae to new location, large releases are best	Larva pale yellow, adults 3-5 millimetres long, light golden-brown, **lack dark markings**	Adults overwinter at soil surface, **emerge one week later than *N. calmariensis***, eggs laid in masses of 3 on lower stem in June, adults do not disperse far but create dense local populations
Neogalerucella calmariensis + N. pusilla	See above	See above	See above
Hylobius transversovittatus (root-mining weevil)	Not available for general distribution	Larva C-shaped and cream coloured with dark brown head, adults red coloured, stout, 8-13 millimetres long	Adults present April-October, nocturnal, feeding at night, adults live 2-3 years, slow to reproduce

2 Genus was formerly known as Galerucella.

BIOCONTROL AGENT	IMPACTS/ EFFECTIVENESS	APPLICABLE SITE TYPE	MANAGEMENT STATUS
Neogalerucella[2] *calmariensis* (black-margined loosestrife beetle)	Foliar feeding beetle: larvae and adults feed on early buds and foliage) which can stunt growth, delay flowering, reduce seed production, large beetle populations can destroy plants, may do better in colder conditions (Meyers, 2019)	Tolerant of varying habitats where purple loosestrife (PL) grows, flooding tolerable except continual, prefer full sun and wetland margins	First released in 1993 in Fraser Valley, significant feeding damage in from mid-summer onward; in Metro Vancouver, low PL densities and reduced flowering/seeding at release sites
Neogalerucella pusilla (golden loosestrife beetle)	Foliar feeding beetle: larvae and adults feed on early buds and foliage which can stunt growth, delay flowering, reduce seed production, large beetle populations can destroy plants.	Tolerant of varying habitats where PL grows, flooding tolerable except continual, prefer full sun and wetland margins	First released in 1994 on Vancouver Island, significant feeding damage in from mid-summer onward; in Metro Vancouver, low PL densities and reduced flowering/seeding at release sites
Neogalerucella calmariensis + N. pusilla	Combining both species increases efficacy: *N. calmariensis* feeds on early plant growth, causing plants to send out new shoots that N. pusilla prefers, the species also prefer different densities	See above	Most populations of *Neogalerucella* in BC are mixed although *N. calmariensis* may be dominant
Hylobius transversovittatus (root-mining weevil)	Root feeding beetle: larva root feed for up to 2 years which may cause plant death, adults feed on leaves producing ragged leaf margins	Tolerant of varying habitats and conditions, continual flooding not	Single release site in 1994 in Richmond tidal flat, since 2008 no agents found at site, difficult to handle and expensive to rear

+ Mass collectability are "agents that are present and exist as treatment tools and for which collectable numbers are typically plentiful, in the thousands, for any given site in a season. Historically, these agents could be described as either 'secondary' or 'tertiary'."

Two of the agents described above, *Neogalerucella calmariensis* and *Neogalerucella pusilla*, have shown good success managing purple loosestrife in Metro Vancouver and are a preferred management tool for this species. Myers (2019) noted that it is difficult to distinguish *Neogalerucella calmariensis* and *N. pusilla* with the naked eye; dissection of male genitalia may be required to identify to species.

Neogalerucella calmariensis
CREDIT: MARK SCHWARZLANDER, UNIVERSITY OF IDAHO, BUGWOOD.ORG

Neogalerucella pusilla
CREDIT: AGRICULTURE AND AGRI-FOOD CANADA, AGRICULTURE AND AGRI-FOOD CANADA, BUGWOOD.ORG

Leaf damage from beetles
CREDIT: LINDA WILSON, UNIVERSITY OF IDAHO, BUGWOOD.ORG

COLLECTION

Beetles can be collected from natural areas for use in a rearing facility. Whether collecting beetles from natural areas or a rearing tent, use a 'pooter' (specialized aspirator used in the collection of insects or other small, fragile organisms) or a paintbrush and container. Once collected, beetles must be kept in a cooler for transport until release (Cousins, 2019).

Beetles can be collected in late April to early May and again in late July to early August (Washington State University, 2019).

REARING

A rearing facility can be established outdoors with a mesh breeding tent (6-sided – walls plus top and bottom), water-tight wading pools, and 5-gallon pots (as many as can fit in the pool plus some spares – about 20) (Evely, 2003). Cousins (2019) estimated the start-up cost for a rearing tent and supplies at $587.00 in 2019. Staff/volunteer labour is also required for almost daily maintenance.

Tents must be installed on flat ground over landscape fabric to prevent the spread of purple loosestrife and the growth of other plants inside (Cousins, 2019). Healthy local purple loosestrife plants can be dug up placed into pots in the wading pools inside the tent. It is important to inspect the plants first for the presence of predators (Evely, 2003).

At least 100 adult beetles should be collected at the same time and placed into the tent. Research predicts that the collection of 100 beetles will yield approximately 3000 beetles at the end of the rearing season (Evely, 2003). If the beetles are already present at the plant harvest site, and there are eggs or larvae on the plants, this number could be higher. Once the beetles are inside, the tent must be sealed.

During peak feeding times, cut plants need to be replaced every other day in order to provide a constant food supply for the beetles (Cousins, 2019). Plants also need to be watered every day during the summer, keeping 3-4 inches of water in the pool so that the soil in the pots stays moist. Plants should not be watered from the top or into the pots directly or the larvae may wash away or drown (Greater Vancouver Regional District).

Tents must be monitored and protected from predators such as tree frogs, snakes, lady bugs, spiders and earwigs, which may impact rearing (Cousins, 2019). Any beetles found outside the tent should be gently moved back inside (Greater Vancouver Regional District). Plants should not be allowed to go to seed in the tent. Dead or defoliated plants should be kept inside the tent but placed outside the pool (Greater Vancouver Regional District). Although maintenance is simple, it requires dedicated, trained staff or volunteers during the growing season.

After the season, the tents and equipment can be taken down, stored and re-used the following year. The loosestrife plants in pots can stay there until the following year as well (Cousins, 2019).

RELEASE

Once beetles have reproduced and adults are ready for collection, they should be collected as per the instructions above and prepared for transport. Beetles can be released by brushing or dropping them onto purple loosestrife plants at the management site (Evely, 2003).

When releasing biocontrol agents, the location, date, time, weather, agent, etc. should be recorded (Cousins, 2019). The IAPP application (BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development 2017) allows for biocontrol release site and monitoring data, although it does not contain complete records for Metro Vancouver. Photo monitoring is also recommended (Cousins, 2019).

Small biocontrol agent populations will usually continue, but treatment will be more successful if large releases are conducted (Province of BC, 2019). When biocontrol agents are active at a site, no other treatment methods should be applied as they may impact the establishment and maintenance of the agent populations (Washington State University, 2019).

The efficacy of biocontrol varies with environmental conditions. Beetles often fail to establish in tidal areas where plants are periodically submerged and fluctuating water levels physically wash beetles away (Meyers, 2019). Continuous introductions are not recommended at these sites. Flooding in non-tidal areas can cause collapse of bioagent populations (Meyers, 2019). Seasonal variation in beetle abundance, especially overwinter survival and susceptibility to predation (from lacewings, wasps, spiders, ground beetles, stinkbugs, ants, etc.), will impact the success of biocontrol (Meyers, 2019).

Beetle rearing tent with staff person inside

CREDIT: SAM COUSINS

MANUAL/MECHANICAL: RECOMMENDED

The best time for manual/mechanical control methods is before the purple loosestrife goes to seed (Invasive Species Council of British Columbia, 2017).

- **Pulling or digging** is possible for newly established infestations of purple loosestrife (Invasive Species Council of British Columbia, 2017). Since the plant can reproduce through fragmentation, it is crucial to remove all parts of the plant including the all root material. Pull or dig purple loosestrife before seed maturity to prevent disturbance and dispersal (Invasive Species Council of British Columbia, 2017). Equipment used for this method could include hand tools (shovels, picks, etc.) or machines (excavator, backhoe, etc.).
- **Cutting** alone will not be an effective control method, but can be used in combination with other methods (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Cutting stems of mature plants late in the season reduces seed production, but re-sprouting can occur from the cut stems (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). When possible, this method must be undertaken prior to seed set, otherwise follow instructions for seed head clipping (below).
- **Seed head clipping** by hand can be used as a containment measure to prevent the release of seeds but it is not an effective control method on its own. It is a faster and less expensive manual control method that can be used if no other treatments will occur at the site that season or until a more comprehensive management plan is implemented. This method is best employed prior to seed maturity, however if seeds are already mature this is still possible by using garbage bags to collect the seeds heads and taking great care not to disperse the seeds (Invasive Species Council of British Columbia, 2017).
- **Brush cutting or mowing** and other forms of mechanical control are not effective on mature purple loosestrife stands due to their established root systems which are not impacted by these methods (Invasive Species Council of British Columbia, 2017). Mowing is likely to spread the plants and is not recommended except if done as a pre-treatment to herbicide application or another manual control method (Washington State University, 2019). Cutting the plants at the base may prevent seed spread and inhibit growth but should be used as a stop-gap measure only.

APPLYING MANUAL/MECHANICAL CONTROL METHODS IN RIPARIAN AREAS

Purple loosestrife 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 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.

CHEMICAL: CAUTION

When alternative methods to prevent or control invasive plants are unsuccessful, professionals often turn to herbicides. Chemical control may be required to control purple loosestrife infestations that are not feasible to only control manually/mechanically. This method is suited to control small populations or to contain large populations (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Once purple loosestrife is established at a site, it will be very difficult to control it by herbicides (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). This method should be used with caution for the following reasons (Crosby, 2018):

1. Weather conditions greatly influence treatment efficacy;
2. Purple loosestrife may grow in riparian areas where pesticide use is restricted; and
3. Native vegetation is often integrated with purple loosestrife infestations. Mortality of non-target plants is possible.

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[3]; 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 & Climate Change Strategy.
- Several municipalities have adopted bylaws that prohibit the use of certain pesticides.

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

3 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.

ONLY companies or practitioners with a valid Pesticide Licence and staff who are certified applicators (or 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' webpages listed in the Additional Resources Section for more information.

Questions? Contact the Integrated Pest Management Program: Telephone: (250) 387-9537
Email: bc.ipm@gov.bc.ca

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.

HERBICIDE LABELS

Individual herbicide labels must always be reviewed thoroughly prior to use to ensure precautions, application rates, and all use directions, specific site instructions, 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.

HERBICIDE OPTIONS

As purple loosestrife often grows in aquatic habitats, there are limited herbicides available for this species. The following herbicides can be used on purple loosestrife provided requirements listed on the product label are met, and all regulations are followed. Note that the aquatic forms of these herbicides will be more effective; however, most require a special pesticide use permit prior to use.

ACTIVE INGREDIENT (EXAMPLE BRAND NAMES)+	APPLICATION	PERSISTENCE	GROWTH STAGE	TYPE++	COMMENTS
Glyphosate (many products)	foliar application	non-residual	actively growing	non-selective	Spray after peak bloom (Page, 2006)
	spray-on, wipe-on	moderately persistent, mobile in soil	actively growing	non-selective	
Dicamba	foliar application	short residual	actively growing	selective	
2,4-D	foliar application	residual	actively growing	selective	Treat in early spring, 2,4-D products not currently permitted on BC Ministry of Transportation and Infrastructure jurisdiction
2,4-D + dicamba	foliar application	residual	actively growing	selective	Treat in May/June and follow-up later in growing season (Page, 2006), 2,4-D products not currently permitted on BC Ministry of Transportation and Infrastructure jurisdiction

+ 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.

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

APPLYING PESTICIDE 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 herbicide labels need to be followed (which means for glyphosate products 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) 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). A plant must be either a listed Noxious Weed (under the BC *Weed Control Act*) or appear in the *Forest and Range Practices Act* Invasive Plants Regulation to be treated within the 10 metre PFZ. **Purple loosestrife is listed and therefore glyphosate can be applied on purple loosestrife up to 1 metre away from the high water mark (HWM)**. 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.

When managing purple loosestrife 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.

APPLICATION METHODS

Foliar application by spraying or wicking just before flowering begins can be an effective form of control (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992) (Warne, 2016). The herbicide table above suggests optimal treatment times depending on the active ingredient.

CULTURAL: NOT RECOMMENDED

- **Flooding** trials on purple loosestrife have been largely unsuccessful and are very dependent on a variety of factors and conditions (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Studies with positive results required complete flooding for two or more growing seasons. Seedlings are more susceptible to flooding, but mature plant health and reproductive ability are generally unaffected by changes in water depth (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). Flooding is not recommended as a control method in Metro Vancouver and it is likely unfeasible at many sites.

- In an assessment of **grazing** feasibility in Metro Vancouver, Miller, Tarasoff & Salmon (2021) concluded that targeted grazing of purple loosestrife had low to moderate control efficacy. It is not palatable to most animals (Alberta Invasive Plants Council, 2019) and goats find it low to moderately palatable (Miller, Tarasoff, & Salmon, 2021). Many purple loosestrife infestations in the Metro Vancouver region are located in sensitive riparian areas. 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 and the potential for environmental damage, targeted grazing may not be a practical management option for purple loosestrife.

- **Burning** has been tested on purple loosestrife but was found not to impact underground root material (Mal, Lovett-Doust, Lovett-Doust, & Mulligan, 1992). This method is also ineffective because of the moist soil conditions where purple loosestrife is usually found.

CREDIT: ISCMV

CONTROL SUMMARY

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

CONTROL STRATEGY	TECHNIQUES	APPLICABLE SITE TYPE	PROS	CONS
Biological	**Neogalerucella species introduction**	Large infestations, preferably where plants are not submerged or influenced by tides	Selective, considered the most economic and recommended method long-term, low maintenance once biocontrol agents have established	Goal is containment and reduction of population not eradication, labour intensive start-up
Manual	**Pulling, digging**	Individual plants or small infestations, environmentally sensitive areas	Selective, low risk to environment, can be used at aquatic sites	Labour intensive, roots must be removed
	Cutting, seed head clipping	Individual plants or small infestations, environmentally sensitive areas	Selective, low risk to environment, reduce seed production and plant density	Must be done before seed set
Chemical	**Foliar application**	Small or large infestations except in environmentally sensitive areas and/or where herbicide use is restricted	Treatment method for plants that cannot be managed other ways, less labour intensive, treat large areas	Unintended environmental/health impacts, high public concern, weather dependent, requires trained staff, difficult to kill rootstock
Mechanical	**Brush cutting, mowing**	Use as a pre-treatment at sites where chemical control or other manual control method will be used	Non-chemical	Will likely spread fragments and seeds
Cultural	**Flooding**		Non-chemical	Unintended environmental impacts
	Grazing	Sites accessible to grazing herds	Non-chemical	Requires specially trained herds and special permits, non-selective, complex logistical considerations, unintended environmental impacts
	Burning		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 specialty equipment

CONTROL SUMMARY COLOUR LEGEND

GREEN: RECOMMENDED

ORANGE: CAUTION

RED: NOT RECOMMENDED OR NOT AVAILABLE

Disposal

ON SITE DISPOSAL

It is preferable to remove plant material offsite; however, if this is not possible, plants can be dried onsite then burned (Invasive Species Council of British Columbia, 2017), but consult your local fire department beforehand, as this may require a burning permit.

OFF SITE DISPOSAL

When disposed off site, transport plant parts in tarps or thick plastic bags to an appropriate disposal or compost facility. In the Metro Vancouver region, several facilities accept purple loosestrife plants and/or infested soil. Please consult this disposal facility list for current details. Note that there are limits to how much soil can be included in biomass for disposal.

When resources are available, it is possible to use a deep burial method of disposal. The Township of Langley's invasive species control program (municipal properties/projects only) transports purple loosestrife biomass in dump trucks to a municipal pit for burial in 5 metre holes capped with clay (St. Andrassy, 2020). This method could also be used on private development sites or farms if there is sufficient area at the site that will not be disturbed. Burial sites require monitoring

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

CLEANING AND DISINFECTION[4]

Before leaving a site, all visible plant parts and soil from vehicles, equipment, and gear should be removed and rinsed if possible. 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 parts 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.
- 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 area 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 purple loosestrife growth.

4 Adapted from Metro Vancouver 2017 Water Services Equipment Cleaning Procedures and Inspection Protocols.

Follow-up Monitoring

Whatever control method is used, follow-up monitoring and maintenance treatments are essential components of an effective integrated management plan or approach. Purple loosestrife management sites should be monitored for several years after treatment.

Note that for biocontrol, results often take longer to observe than with other treatment methods. Evely (2003) noticed that at Colony Farm Regional Park it took six years after the first biocontrol agent release until changes in purple loosestrife populations were observed.

CREDIT: CLAIRE DE LA SALLE

Restoration

Following any management activity for purple loosestrife, revegetation should occur (Washington State University, 2019). Note that purple loosestrife biocontrol sites are at risk of reed canary grass invasion (Meyers, 2019), another invasive plant in BC. Where both purple loosestrife and reed canary grass are present, removing one will likely increase the other.

Restoration will create competition, control purple loosestrife regrowth, and replace lost habitat. Planting should not take place until new seedlings have been removed. Bare or disturbed sites are easily recolonized by purple loosestrife or other invasive species if not revegetated with native species.

Mulch can be used to avoid leaving bare soil and reduce colonization from other invasive plant species. The International Society of Arboriculture and relevant municipal Parks or arboriculture departments offer guidelines for mulch application. Specific mulch depths can be used to control invasive weeds and encourage plant growth (International Society of Arboriculture, 2018).

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. 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.

Native plants listed in the Similar Species section above would also be suitable restoration species for purple loosestrife management sites.

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 purple loosestrife re-invasion.

Purple loosestrife sites are often found in areas with existing, or potential, wildlife populations that can damage restoration plantings (deer, beaver, muskrat, vole, etc.). 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.).

References

Alberta Invasive Plants Council. (2019). Invasive Alien Species: Purple Loosestrife.

BC Ministry of Environment. (2011). Canadian Pesticide Education Program: Applicator Core Manual. Federal, Provincial, Territorial Working Group on Pesticide Education, Training and Certification.

Brown, B. J., Randall, M. J., & Graham, S. A. (2002). Competition for Pollination Between an Invasive Species (Purple Loosestrife) and a Native Congener. Ecology, 2328-2336.

Colautti, R. I., Agren, J., & Anderson, J. T. (2017, January 19). Phenological shifts of native and invasive species under climate change: insights from the Boechera–Lythrum model. Retrieved from The Royal Society Publishing: https://royalsocietypublishing.org/doi/10.1098/rstb.2016.0032

Cousins, S. (2019, December). Natural Resource Management Technician. (T. Murray, Interviewer)

Crosby, K. (2018, December). Natural Areas Coordinator, City of Surrey. (F. Steele, Interviewer)

Evely, A. (2003). Pilot Program: Rearing Galerucella Beetles for the Biological Control of Purple Loosestrife (Lythrum salicaria) in Regional Parks. Great Vancouver Regional District.

Frid, L., Knowler, D., Murray, C., Myers, J., & Scott, L. (2009, March). Economic Impacts of Invasive Plants in British Columbia: Report #12. Invasive Plant Council of BC.

Greater Vancouver Regional District. (n.d.). Putting Beetles to Work: Galarucella volunteer instructions.

Henne, D., Lindgren, C., Gabor, T., Murkin, H., & Roughley, R. (2005). An integrated management strategy for the control of purple loosestrife Lythrum salicaria L. (Lythraceae) in the Netley-Libau Marsh, southern Manitoba. Elsevier Inc, 319-325.

International Society of Arboriculture. (2018, August). Proper Mulching Techniques. Retrieved from http://www.treesaregood.org/portals/0/docs/treecare/ProperMulching.pdf

Invasive Species Council of British Columbia. (2017, March). Retrieved from Purple Loosestrife Fact Sheet: https://bcinvasives.ca/wp-content/uploads/2021/01/Purple-Loosestrife.pdf

Invasive Species Manitoba. (2019, December). Purple Looestrife: An Invasive Plant Found in Manitoba: Lythrum salicaria L. Retrieved from Alien Invasive Aquatic and Wetland Plants: https://invasivespeciesmanitoba.com/site/uploads/pdf/Purple%20Loosestrife%20Info/fs_purpleloosestrifeplel.pdf

Kadrmas, T., & Johnson, W. S. (2002). Managing Purple Loosestrife: Fact Sheet-02-58. Reno: University of Nevada, Cooperative Extension.

King County Noxious Weed Control Program. (2011). Best Management Practices: Purple Loosestrife. Retrieved from https://your.kingcounty.gov/dnrp/library/water-and-land/weeds/BMPs/purple_loosestrife-control.pdf

Klinkenberg, B. (2019). Lythrum salicaria L. Retrieved from E-Flora BC: Electronic Atlas of the Plants of British Columbia: http://linnet.geog.ubc.ca/Atlas/Atlas.aspx?sciname=Lythrum%20salicaria

Mal, T. K., Lovett-Doust, J., Lovett-Doust, L., & Mulligan, G. (1992). The biology of Canadian weeds. 100. Lythrum salicaria. Canadian Journal of Plant Science, 1305-1330.

Mann, H. (1991). Purple Loosestrife: A Botanical Dilemma. The Osprey, 67-77.

Metro Vancouver. (2016). Climate Projections for Metro Vancouver. Burnaby, BC. http://www.metrovancouver.org/services/air-quality/AirQualityPublications/ClimateProjectionsForMetroVancouver.pdf

Meyers, J. H. (2019, October 24). Biological control of weeds in BC. RPAC Regional Invasive Species Subcommittee Meeting. Burnaby.

Page, N. (2006). Framework for Invasive Plant Management in GVRD Parks. Burnaby: GVRD Regional Parks Department.

PlantWise. (2015). Purple Loosestrife. Retrieved from https://bcinvasives.ca/invasives/purple-loosestrife/

Province of BC. (2019, December). Biological Control Agents & Host Plants. Retrieved from https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/management/plants/biological-control/biological-control-agents-host-plants

Regional District Okanagan-Similkameen. (2006). INVASIVE PLANTS OF THE OKANAGAN-SIMILKAMEEN. PURPLE LOOSESTRIFE (Lythrum salicaria L.)

Shamsi, S., & Whitehead, F. (1977). Comparative eco-physiology of Epilobium hirsutum L. and Lythrum salicaria L. IV. Effects of Temperature and inter-specific competition and concluding discussion. Journal of Ecology, 71-84.

Thompson, D., Stuckey, R., & Thompson, E. (1987). Spread, impact and control of purple loosestrife (Lythrum salicaria) in North American wetlands. Washington, DC: United States Department of the Interior, Fish and Wildlife Service.

US Department of Agriculture. (2019, August). Lythrum salicaria. Retrieved from Fire Effects Information System (FEIS): https://www.fs.fed.us/database/feis/plants/forb/lytsal/all.html#139

Warne, A. (2016). Purple Looestrife (Lythrum salicaria) Best Management Practices in Ontario. Peterborough: Ontario Invasive Plant Council.

Washington State University. (2019). Galerucells spp. Retrieved from Integrated Weed Control Project: http://invasives.wsu.edu/biological/galerucella.htm

Additional Resources

For more information please refer to the following resources.

- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Invasive Alien Plant Program (IAPP). www.gov.bc.ca/invasive-species
- E-Flora BC, an Electronic Atlas of the Plants of BC. www.eflora.bc.ca/
- Grow Green Guide. www.growgreenguide.ca
- Grow Me Instead. http://bcinvasives.ca/resources/programs/plant-wise/
- Invasive Species Council of British Columbia Purple Loosestrife Fact Sheet: https://bcinvasives.ca/wp-content/uploads/2021/01/Purple-Loosestrife.pdf
- Pesticides and Pest Management. Province of British Columbia https://www2.gov.bc.ca/gov/content/environment/pesticides-pest-management
- Province of BC. (2019, December). Biological Control Agents & Host Plants. https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/invasive-species/management/plants/biological-control/biological-control-agents-host-plants
- The biology of Canadian weeds. 100. Lythrum salicaria. Canadian Journal of Plant Science, 1305-1330.Mal, T. K., Lovett-Doust, J., Lovett-Doust, L., & Mulligan, G. (1992).

Acknowledgments

The project team would like to thank the following individuals and groups for their contributions related to the development and review of this document:

Dr. Judith H. Myers, University of British Columbia

Melanie Blendell, Metro Vancouver Regional Parks

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

Sam Cousins, Metro Vancouver Regional Park

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


metrovancouver
SERVICES AND SOLUTIONS FOR A LIVABLE REGION