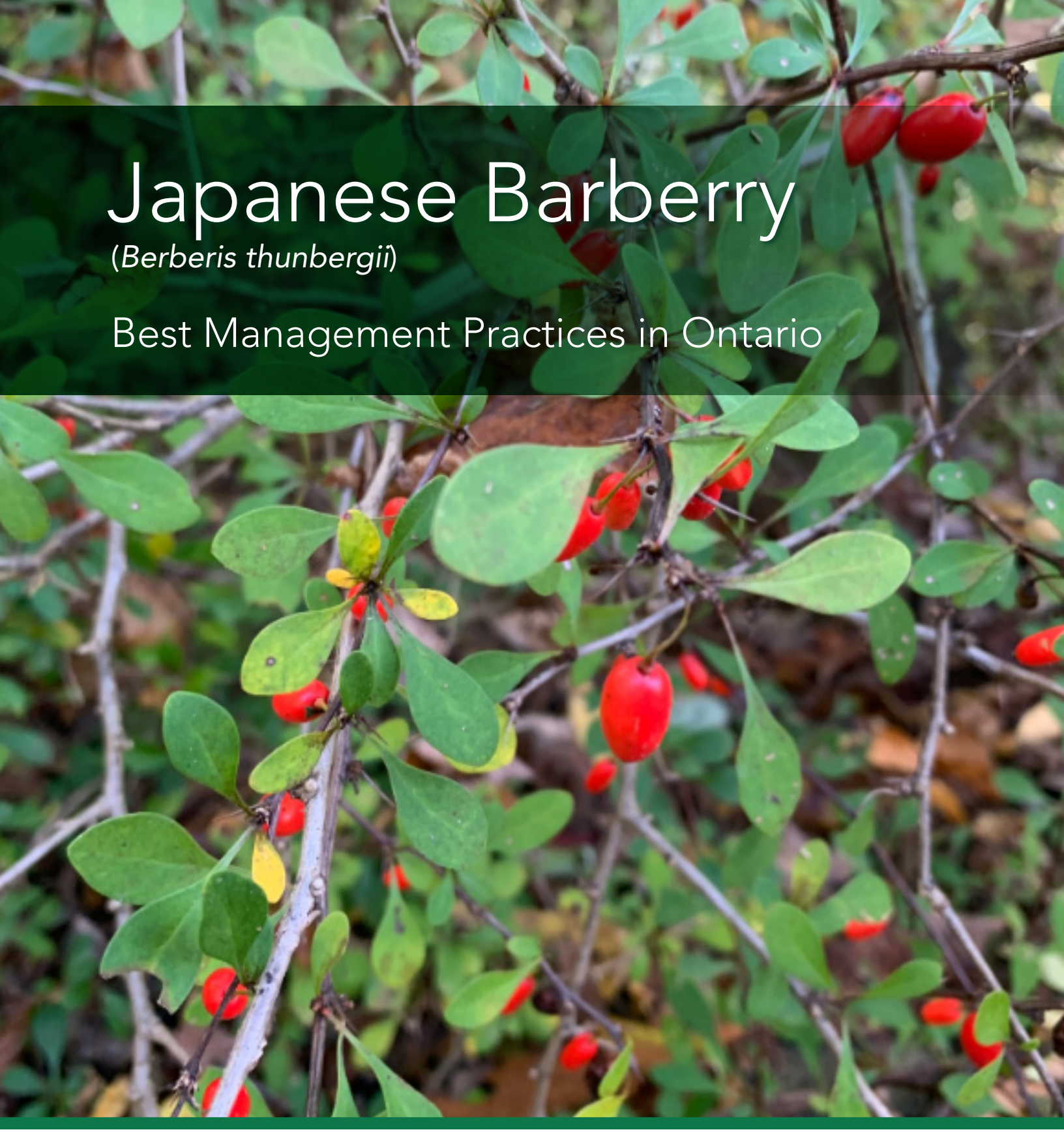
Japanese Barberry

(*Berberis thunbergii*)

Best Management Practices in Ontario



Environment and Climate Change Canada
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ONTARIO INVASIVE PLANT COUNCIL

Foreword

This Best Management Practices (BMP) document provides guidance for managing invasive Japanese barberry or épine-vinette du Japon (*Berberis thunbergii* de Candolle) in Ontario. Funding and leadership to produce this document was provided by Environment and Climate Change Canada, Canadian Wildlife Service – Ontario (CWS – ON). BMPs are developed by the Ontario Invasive Plant Council (OIPC) and its partners to facilitate invasive plant control initiatives by individuals and organizations concerned with the protection of biodiversity, agricultural lands, infrastructure, crops, and species at risk in Ontario.

The intent of this document is to relay information specifically related to invasive plant control practices that have been recommended by leading professionals across Ontario. This document contains the most up-to-date, effective, and environmentally-safe control practices known at the date of publication. Information provided within this document was curated, based on the most recent research, experience, and literature available at this time. It complies with current provincial and federal legislation regarding pesticide usage, habitat disturbance, and species at risk protection. It is subject to change as legislation is updated or new research findings emerge. The information provided in this BMP is not to be considered legal advice. Interested parties are advised to refer to the applicable legislation to address specific circumstances.

Check the website of the OIPC (www.ontarioinvasiveplants.ca) for updates.

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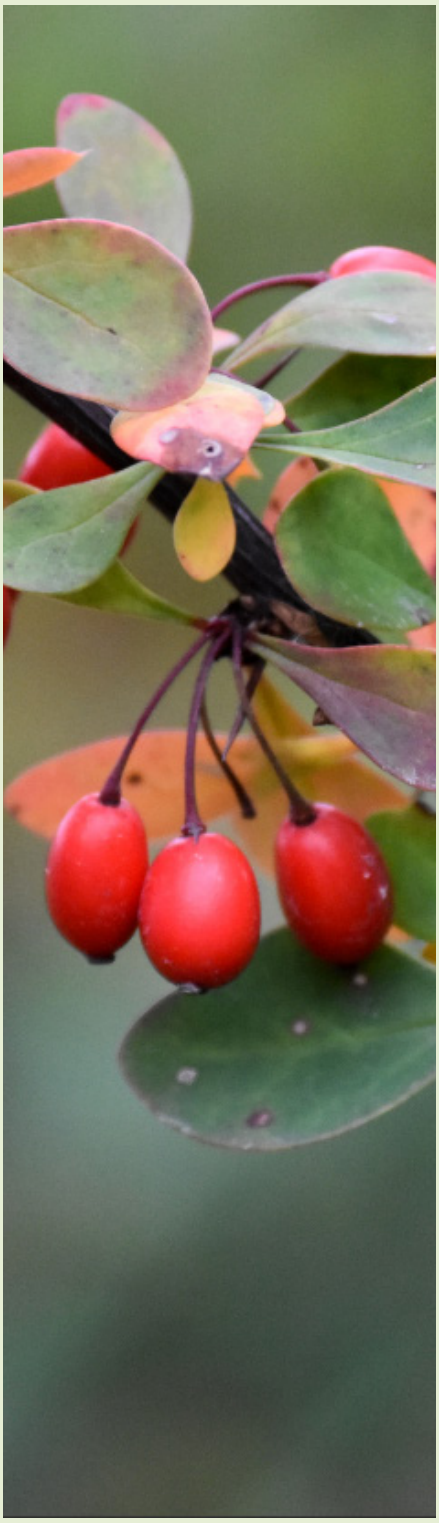
For more information on invasive plants in Ontario, please visit the following websites:
www.ontarioinvasiveplants.ca, www.ontario.ca/page/invasive-species-ontario, www.invadingspecies.com, or www.invasivespeciescentre.ca



Japanese barberry.

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Japanese barberry (*Berberis thunbergii*) growing in a forest.
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Introduction

Japanese barberry or épine-vinette du Japon (*Berberis thunbergii* de Candolle) is a deciduous, woody, invasive shrub in the barberry (Berberidaceae) family (Brouillet *et al.* 2010). Native to Japan and Asia, Japanese barberry was introduced to North America as an ornamental plant in the 1800s. It was originally marketed to replace common barberry (*Berberis vulgaris*) in hedgerow and garden plantings since *B. vulgaris* was found to be an alternate host for black stem rust disease (*Puccinia graminis*) (Silander and Klepeis 1999). Japanese barberry was first noted in North America in 1875 when seeds were sent from Russia to the Boston Arnold Arboretum (Silander and Klepeis 1999). It became an extremely popular ornamental plant in United States of America in the early 1900s, being noted in gardens as early as 1920 (Silander and Klepeis 1999). In Ontario, the date of its original introduction is unknown; however, it was noted to be present in Rondeau Provincial Park (southwestern Ontario) in 1958 (Ontario Ministry of Natural Resources 2014). In North America, Japanese barberry is found in many eastern and midwestern states of the United States and in Canada it is found in southern Ontario, Quebec, Nova Scotia, New Brunswick, and Prince Edward Island. Japanese barberry is still a very popular ornamental plant due to its low maintenance requirements, adaptability to a wide range of environmental conditions, beautiful foliage, and resistance to deer browsing (Zouhar 2008). There are currently over 70 cultivars of Japanese barberry, many of which are still commercially available in Ontario (Brand *et al.* 2012). Several states in the US have laws that ban the sale of certain Japanese barberry cultivars. This mainly applies to cultivars that are known to be alternate hosts for black stem rust disease (*P. graminis*) which are also illegal to import or move within Canada (Canadian Food Inspection Agency 2012).

Since its initial introduction to North America, Japanese barberry has escaped cultivation and become a problematic invasive plant in many natural areas, particularly woodlands. Japanese barberry has several traits that contribute to its success as an invader. It forms very dense and persistent infestations because it utilizes multiple reproductive strategies, thrives in a wide variety of habitats, alters soil chemistry and nutrient cycling, has a longer growing season compared to many native plants and is resistant to deer browsing (Silander and Klepeis 1999; Zouhar 2008). Japanese barberry tends to be a prolific seed producer, and depending on the cultivar, one plant can produce up to 35,000 fruits per plant (Brand *et al.* 2012). Japanese barberry can also reproduce vegetatively through aboveground and belowground shoots. Aboveground shoots give the plant its arching form and can produce new roots when they contact the soil (Zouhar 2008), which is called layering.

While this plant has significant wholesale value in the horticulture industry, it becomes extremely costly to remove once established (Zouhar 2008; Perdue 2022). The sharp spines on Japanese barberry may also pose a health and safety hazard and dense thickets may limit access to recreational activities.

This document was developed to help guide the effective and consistent management of invasive Japanese barberry populations across Ontario.

Description

There are many cultivars of Japanese barberry that vary in size, leaf colour and fruit production (Brand and Durocher 2022). The description below highlights the invasive Japanese barberry (*B. thunbergii*), the parent plant of the cultivars. If you are unsure if you have found Japanese barberry, consult Michigan Flora or a local botanist.

Size and Stem:

Japanese barberry is a deciduous, woody shrub that grows to be 1 m to 2 m tall and 1 m to 2.5 m wide. It is dense, compact and multi-stemmed. The stems arise from the root crown and additional shoots, belowground and aboveground, arise from rhizomes. Aboveground shoots arch from the plant and can generate new roots when they contact the soil which is referred to as layering. The stems are erect, angular, grooved and have a single needle-like spine (typically 1 cm long) at the base of each leaf cluster. New twigs are smooth, reddish and become rough and grey as the plant grows. The cambium layer (inner bark) is yellow.

Japanese barberry is a dense, compact, multi-stemmed, woody shrub.

Photo courtesy of: iNaturalist, Available: https://www.inaturalist.org/observations/44204057. Licensed under CC-BY-NC.

The stems of Japanese barberry are angular, grooved and have a single needle-like spine at the base of each leaf cluster.

Photo courtesy of: Ethan Dropkin, iNaturalist. Available: https://www.inaturalist.org/observations/56362292. Licensed under CC-BY-NC.

Leaves:

The leaves occur in clusters that have an alternate arrangement along the stem. The leaves are simple, entire (smooth leaf margins), obovate or spatulate (spoon-shaped), blunt to rounded at the tip and taper to the base. They are approximately 95 mm long and 25 mm wide. The lower surface of the leaf can have a waxy coating. The leaves of the invasive form of Japanese barberry are typically green and usually turn orange or red in the fall. Ornamental varieties may have red to purple leaves, but these forms typically revert back to green when grown in shade.

The leaves of Japanese barberry occur in clusters. They are small, obovate to spatulate (spoon-shaped), blunt to rounded at the tip and taper to a base.

Photo courtesy of: iNaturalist, Available: https://www.inaturalist.org/observations/90150312. Licensed under CC-BY-NC

Flowers:

The flowers are pale yellow (8 mm – 15 mm wide), occur solitary or in umbellate (umbrella-shaped) clusters of 2 – 5 flowers along the length of the stem. The flowers have six petals and four sepals. At the base of each petal is one stamen and at the center is a green, flat-topped ovary. Flowers are produced in mid-spring (mid-May).

The flowers of Japanese barberry are pale yellow and occur solitary or in umbellate clusters of 2 - 5 flowers.

Photo courtesy of: Gage Barnes, iNaturalist. Available: https://www.inaturalist.org/observations/112504058. Licensed under CC-BY-NC.

Fruits/Seeds:

The fruits are showy, bright-red drupes that are oval-shaped and elongated (7 mm – 13 mm long). They are borne on the stems and attached by a slender stalk under each leaf cluster. They are typically produced in late-summer (Mid-August). They can remain attached to the plant into winter.

The fruits of Japanese barberry are showy, bright-red drupes that are oval-shaped and elongated.

Photo courtesy of: iNaturalist, Available: https://www.inaturalist.org/observations/138312576/. Licensed under CC-BY-NC

Roots:

The roots are shallow, fibrous, with many rhizomes that can produce belowground and aboveground shoots, also called layering. These aboveground shoots arch away from the plant and they can produce new roots when they contact the soil, allowing the plant to quickly spread into adjoining areas. On the inside of the rhizome's bark, the plant material is yellow.

Japanese barberry rhizome.

Photo courtesy of: James H. Miller, USDA Forest Service, Available: https://www.forestryimages.org/browse/detail.cfm?imgnum=5379580

Lookalikes

The *Berberis* genus is large, with over 450 deciduous and evergreen shrubs, most of which are native to Asia. Many of these species are cultivars created for horticultural purposes. This genus is readily identified by the combination of yellow inner bark (for some species), sharp needle-like spines at leaf nodes and spiny teeth on the leaf margins (for many species), small yellow flowers in clusters (racemes), and fruit's that may be red, purple, or blue. As previously mentioned, there are currently over 70 cultivars of Japanese barberry (*B. thunbergii*) many of which are still commercially available, except for those known to be hosts for black stem rust disease (*P. graminis*). These cultivars differ in terms of growth form, foliage colour, fruit production and sterility (Brand and Durocher 2012; Brand *et al.* 2022).

Common barberry (*B. vulgaris*)

Common barberry was introduced to North America in the 1600s as an ornamental plant. However, it was discovered to be an alternate host for black stem rust disease (*P. graminis*) which causes significant mortality in wheat and barley crops (NC State Extension, 2023). As a result of this, common barberry was eradicated from many areas in the US. In Canada, common barberry is found in several Canadian provinces. It is very widespread across Ontario but has a very limited northern distribution. It is listed as a noxious weed in Alberta, Manitoba, and Ontario (Government of Alberta, n.d.; Government of Manitoba, n.d.; Government of Ontario 2022). Canada prohibits the importation and sale of common barberry. This plant is often found growing in woodlands, as a hedge or along roadsides. Common barberry grows to be 2 m to 3 m tall and it has looser branches, making it less compact than compared to Japanese barberry. Common barberry can also be distinguished from Japanese barberry by its leaves which have toothed margins with 20 – 30 sharp teeth, flower clusters with 10 – 20 flowers, and a three-pronged spine at the base of each leaf cluster.

Berberis x *ottawensis*

Berberis × *ottawensis* is an interspecific and invasive hybrid of Japanese barberry and common barberry and is found in areas where the range of these two parental species overlap. There are only a few sightings of this plant in Ontario (London and Mississauga) which are restricted to urban areas. This hybrid has intermediate physical characteristics compared to both parental species, although it typically grows very dense and has leaves with slightly toothed margins.

Table 1: The main identification features of Japanese barberry in comparison to three species that may appear similar (lookalikes). Key I.D. features that separate the lookalikes from Japanese barberry are in bold.

	Japanese Barberry (*Berberis thunbergii*)	**Common Barberry** (*Berberis vulgaris*)	**Multiflora Rose** (*Rosa multiflora*)	**Winged Euonymus** (*Euonymus alatus*)
	 Photo courtesy of: Sandy Wolkenberg, iNaturalist. Available: https://www.inaturalist.org/observations/97393223. Licensed under CC-BY-NC	 Photo courtesy of: Alexander Losipenko, iNaturalist, Available: https://www.inaturalist.org/observations/60726365. Licensed under CC-BY-NC.	 Photo courtesy of: iNaturalist, Available: https://www.inaturalist.org/observations/188148941. Licensed under CC-BY-NC	 Photo courtesy of: iNaturalist, Available: https://www.inaturalist.org/observations/140564704. Licensed under CC-BY-NC
Alternative Common Names	• NA	• European barberry	• Baby rose, Japanese rose, multiflowered rose	• Oriental spindle-tree, winged burning bush, winged spindle-tree
Accepted French Name	• Épine-vinette du Japon	• Épine-vinette commune	• Rosier multiflora	• Fusain ailé
Native Range	• Asia	• Asia	• Asia	• Asia
Habitat	• Post-agricultural fields • Woodland edges • Roadsides	• Post-agricultural fields • Woodland edges • Roadsides	• Open woodlands • Forest edges • Roadsides	• Ravines • Woodlots • Open areas
Size & Stem	• 1 m – 2 m tall • Multi-stemmed • **Very compact branches** • Stems droop at ends to give an arching form • Young twigs reddish and older twigs grey-brown bark • **Yellow inner bark** • **One needle-like spine (70 mm – 100 mm long) at the base of each leaf cluster**	• 2 m – 3m tall • Multi-stemmed • **Loosely arranged branches** • Stems droop at end to give an arching form • Young twigs reddish and older twigs grey-brown bark • **Inner bark is not yellow** • **Three-pronged needle-liked spines (each 100 mm – 200 mm long) at the base of each leaf cluster**	• Up to 4 m tall • Multi-stemmed, **long, arching climbing or trailing** • **Twigs have stiff, curved thorns or prickles**	• 1.5 m – 6 m tall • Multi-stemmed • **Broad corky winged stems** • **No spines or thorns**

	Japanese Barberry (*Berberis thunbergii*)	Common Barberry (*Berberis vulgaris*)	Multiflora Rose (*Rosa multiflora*)	Winged Euonymus (*Euonymus alatus*)
	 Photo courtesy of: Sandy Wolkenberg, iNaturalist. Available: https://www.inaturalist.org/observations/97393223. Licensed under CC-BY-NC	 Photo courtesy of: Alexander Losipenko, iNaturalist, Available: https://www.inaturalist.org/observations/60726365. Licensed under CC-BY-NC.	 Photo courtesy of: iNaturalist, Available: https://www.inaturalist.org/observations/188148941. Licensed under CC-BY-NC	 Photo courtesy of: iNaturalist, Available: https://www.inaturalist.org/observations/140564704. Licensed under CC-BY-NC
Leaves	• Green, red, yellow, purple (depending on cultivar) • Appear in clusters at a node • Alternate arrangement • **Spoon-shaped** • **Smooth margins** • 250 mm – 380 mm long	• Typically green • Appear in clusters at a node • Alternate arrangement • **Lance-shaped or egg-shaped** • **Finely toothed margins with 20 - 30 spiny teeth** • 150 mm – 500 mm long	• Green • **Pinnately compound** • Alternate arrangement • Obovate • **Serrated edges** • **Stipules at the base of leaves that are deeply fringed.**	• Dark green • Simple • **Paired, opposite arrangement** • 200 mm – 700 mm long
Flowers	• Small, pale yellow • Six petals, six stamens, four sepals • **Solitary or in a drooping raceme of 2 - 5 flowers** • 8 mm – 15 mm wide	• Small, pale yellow • Six petals, six stamens, four sepals • **Drooping raceme composed of 10 – 20 flowers** • 8 mm – 15 mm wide	• **Small, white** • **Five petals, five sepals** • **Clusters of many flowers** • 130 mm – 200 mm wide	• **Yellow-green** • **Four petals** • **Clusters of 1 – 3 flowers emerging at the leaf axils and tend to lie flat against the leaves**
Fruits	• Showy, **bright-red, dry or slightly fleshy drupes** • Oval-shaped and elongated • 7 mm – 13 mm long • Persist on the plant into winter	• Showy, **orange-red to purple, very fleshy drupes** • Oval-shaped and elongated • Up to 8 mm long • Persist on the plant into winter	• Showy, **bright red hip** • **Globular** • Up to 6 mm long	• **Dark red to purple capsules** • **Capsules open to expose orange to orange-red arils (fleshy coatings covering the seed)**
Roots	• Fibrous roots • Rhizomes • **Yellow inside**	• Fibrous roots • Rhizomes • Not yellow inside	• Simple, shallow roots • Not yellow	• Deep, fibrous roots • Not yellow

Biology and Life Cycle

Japanese barberry is a deciduous, woody shrub in the barberry family (Berberidaceae) with numerous adaptations which contribute to its success as an invader (Ehrenfeld 1999). This plant utilizes several methods of reproduction, having the ability to spread via seed and vegetatively through the production of aboveground and belowground clonal shoots (Silander and Klepeis 1999; Zouhar 2008). Aboveground clonal shoots arch away from the plant and can produce new roots when they contact the soil (called layering) (Zouhar 2008). This allows Japanese barberry to quickly colonize an area.

This invasive plant has a monoecious reproductive system whereby male and female flowers occur on the same plant. This means that one colony of plants can potentially be produced by a single individual (Silander and Klepeis 1999; Zouhar, 2008). Japanese barberry is insect-pollinated and its stamens respond to tactile stimuli by snapping towards the stigma to deposit a significant amount of pollen onto pollinators, such as bees (Lebuhn and Anderson 1994). Flowers bloom in the early spring; unripe green fruits are produced in mid-summer, ripen into red berries in late summer and persist on shrubs into the winter (Zouhar 2008).

Japanese barberry fruits can persist on shrubs into the winter.

Photo courtesy of: iNaturalist, Available: https://www.inaturalist.org/observations/8866871. Licensed under CC-BY-NC.

Japanese barberry is considered a prolific seed producer and when unmanaged in an area, some cultivars can produce over 35,000 fruits per plant which can lead to the establishment of hundreds of seedlings each year (Brand *et al.* 2012). Cultivars with green or purple foliage tend to have the highest number of fruits compared to cultivars with yellow foliage or those that are dwarf-sized. Fruit production is related to stem density and light availability and is much higher when plants grow in open areas with low stem density and in full sunlight (Ward *et al.* 2009; Lubell and Brand 2011). Fruit production has been found to be best in moderate light conditions, but even low light conditions (< 4%) can account for some seed production (Silander and Klepeis 1999). Most seeds fall underneath or within 1 m of the parent plant, while some seeds will be dispersed long distances by birds. Ground dwelling birds such as ruffed grouse (*Bonasa umbellus*) and wild turkey (*Meleagris gallopavo*) are known to favor the fruits (Zouhar 2008; CABI 2019). Generally, barberry fruits are low-priority food items for most birds but are consumed later in the season when desirable food sources are unavailable (Silander and Klepeis 1999).

The seeds of Japanese barberry have high viability, although most germination occurs in the first year and germination rates decrease drastically after one year, which suggests this plant does not have a persistent seed bank (Silander and Klepeis 1999; D'Appollonio 2006; Zouhar 2008). Japanese barberry seeds require a period of cold, known as cold stratification, to germinate. Optimal germination has been found to occur after cold stratification for several months at 5°C followed by alternating temperatures between 10°C and higher (Terabayashi 1987; Zouhar 2008; CABI 2019). Germination has been found to be best in moderate light conditions, but seeds can germinate under low light conditions (< 4%). Seedlings can grow up to 1.2 m in a single growing season; however,

seedlings with only one or two stems or are less than 50 cm tall have been noted to have the highest mortality rates (Silander and Klepeis 1999; Zouhar 2008). Seedling mortality rates are also very high in areas of high stem density (Zouhar 2008).

Japanese barberry can thrive in a variety of sites and soil conditions, giving it the ability to colonize a wide array of habitats. However, its growth is restricted under extreme drought conditions, prolonged wet conditions and in soils with high salinity (Zouhar 2008; Chen *et al.* 2017). This plant is shade tolerant and once established, it can persist under dense canopies in forests and become established in closed canopy forests (Zouhar 2008; CABI 2019). Studies have shown that Japanese barberry can direct growth into root biomass effectively throughout the growing season, often allowing it to have increased biomass compared to native plant species (Zouhar 2008). Link *et al.* (2018) found that plots with Japanese barberry had significantly lower native seeding densities of red maple (*Acer rubrum*) and oak species (*Quercus* spp.) and determined that this this species appears to be acutely detrimental to native tree recruitment, suggesting it may have allelopathic properties, although, this has not been documented in the literature. Japanese barberry is also one of the first plants to produce leaves in the spring and the last to lose its leaves in the fall. This gives this plant a longer growing season compared to many native plants (Silander and Klepeis 1999; CABI 2019). Xu *et al.* (2007) found that Japanese barberry has a high photosynthetic capacity, allowing it to utilize high light availability in the spring to start photosynthesis earlier than many native plant species.

Japanese barberry can increase soil nitrogen and pH, which affects nutrient cycling and can alter soil microbial activity. This can prevent the growth of desirable native species (Kourtev *et al.* 2002; Zouhar 2008). By doing so, Japanese barberry creates an ideal habitat for its seedlings as this plant thrives in areas of high soil nitrogen and has been shown to allocate more of this nutrient to its leaves compared to native plants (Cassidy 2002; Harrington *et al.* 2004; D'Appollonio 2006). Japanese barberry has very few natural predators in its introduced range and due to the sharp needle-like spines on its stem, it is unpalatable to browsing animals such as deer. This can cause increased herbivore pressure on native plant species, contributing to their decline (Pearl *et al.* 1995; Kulhanek 2022). Vanderklein *et al.* (2015) experimented with defoliation on Japanese barberry in New Jersey by cutting 50% or 100% of leaves from current year shoots. They found that there was no impact on growth or carbon storage, suggesting that even in the presence of herbivory, this plant can maintain growth and carbon resources, making it an effective competitor.

Japanese barberry and common barberry (*B. vulgaris*) readily hybridize to form the invasive hybrid *B. x ottawensis* which is still able to produce viable pollen and seeds (Connolly *et al.* 2013). In addition, over 70 cultivars of Japanese barberry have been created for the horticulture industry that vary in growth form, leaf colour, fruit production and sterility. Brand *et al.* (2012) evaluated these 70 cultivars and found that there are substantial differences in reproductive potential with some being able to produce over 35,000 fruits per plant with germination rates up to 90%. Cultivars that produced even 100 seeds were still found to have the potential to contribute to a few seedlings each year in natural areas (Brand *et al.* 2012), suggesting that commercial cultivars have different levels of ecological risk. The green-leaf form of Japanese barberry is more vigorous than other colour-leaved cultivars such as the purple form (*B. thunbergii* var. *atropurpurea*) (Lehrer *et al.* 2006; Silander and Klepeis 1999). A recent study documented four cultivars of Japanese barberry that are sterile due to polyploidy (Brand *et al.* 2012). This shows promise that cultivars with low reproductive potential, and therefore lower invasive potential, may be developed in the future.

Japanese barberry leaves emerging in the spring.

Seasonality for Japanese barberry:

(based on iNaturalist sightings in Ontario)

Leaves:

- Early April (leaves start to emerge)
- End of April (leaves fully leafed out)
- Mid-October (leaf color change to yellow-red-orange)
- Mid-November – end of November (leaves drop)

Flowering:

- Mid-May (flowers emerge)
- Early June (flowers drop off)

Fruit Ripening/Dispersal:

- Mid-June (green berries emerge)
- Mid-August (berries ripen, start to turn yellow to bright red)
- Mid-August – March (red berries remain on shrub through winter)

Habitat

Japanese barberry is native to Japan and China (Zouhar 2008). In its native environment, it is an understory forest shrub in mountainous regions. It was introduced to North America in the late 1800s as an ornamental species and was marketed to replace common barberry (*B. vulgaris*) which is a host for stem rust disease (*P. graminis*). Japanese barberry remains a popular ornamental species, but it has since escaped cultivation. In its introduced range, Japanese barberry found in a variety of habitats including woodland edges, roadsides, stream banks, and old fields.

In Ontario, this species is more common in post-agricultural fields that have transitioned to forest communities as opposed to less disturbed, continuously wooded areas (Zouhar 2008; DeGasperis and Motzkin 2007; Mosher *et al.* 2009). Invasions seem to be connected to land use history (Mosher *et al.* 2009). Japanese barberry occurs in a wide variety of habitat conditions that range from wetlands with saturated organic soils to xeric (dry) ridgetops (Kourtev *et al.* 1999). While it can tolerate a wide range of soils and environmental conditions, this plant grows best in sunny areas with mesic (moderate moisture) conditions, fertile soil and a variety of soil moisture conditions (Silander and Klepeis 1999; Cassidy *et al.* 2004). A 2014 survey of Japanese barberry in Rondeau Provincial Park in found that this plant occurred predominantly in dry to mesic forested areas and woodlands and was less abundant in lowlands and wetlands (Ministry of Natural Resources and Forestry 2014). High soil moisture tends to be a limiting factor for the spread of Japanese barberry (Silander and Klepeis 1999). Open meadow sites that receive high sunlight have a greater risk of being invaded than wooded areas because there is less competition and seedlings tend to grow better in full sun areas (Lubell and Brand 2011). Once this species invades an area, it creates a very dense thicket of vegetation.

Japanese barberry growing in the forest understory.

Pathways of Spread and Distribution in Ontario

Japanese barberry planted in a garden bed.

Photo courtesy of: Leslie J. Mehrhoff, University of Connecticut. Available: https://www.forestryimages.org/browse/detail.cfm?imgnum=5456748

Japanese barberry can spread via seeds and vegetatively through aboveground and belowground shoots. However, humans are the primary dispersal pathway for this invasive plant. Many infestations originate from intentional planting of Japanese barberry in gardens which can then spread to nearby natural areas such as woodland edges and recently disturbed fields or habitats (Zouhar 2008). Despite its negative ecological impacts, many cultivars of Japanese barberry are still sold in plant nurseries.

Japanese barberry was brought to North America in the late 1800s as a substitute for common barberry (*B. vulgaris*), which was determined to be a secondary host of black stem rust disease (Silander and Klepeis 1999; Zouhar 2008). Since this introduction, Japanese barberry remains a popular ornamental plant due to its low maintenance requirements, ability to spread rapidly, beautiful foliage and high resistance to deer browsing. As previously mentioned, there are over 70 known cultivars of Japanese barberry, some of which are prohibited in Canada. The Canadian Food Inspection Agency, through the Plant Protection Regulations, prohibits the movement of certain cultivars of Japanese barberry that may be hosts to black stem rust. For a list of cultivars that may be brought into Canada, consult this: https://inspection.canada.ca/plant-health/invasive-species/directives/horticulture/d-01-04/eng/1333479606359/1333480359713#app2

Japanese barberry is considered naturalized in Europe and is also present in the UK, Australia and South Africa (CABI 2019). It is widely naturalized across North America and is more abundant in the eastern US states including Minnesota, Wisconsin, Illinois, Indiana, Missouri, Kentucky, Tennessee, Georgia, North Carolina, Ohio, Virginia, West Virginia, Pennsylvania, New Jersey, New York, Massachusetts, Maryland, Connecticut, Vermont, New Hampshire, and Maine (CABI 2019; EDDMapS 2023; iNaturalist 2023). Several USA states have passed legislation that prohibits the sale of Japanese barberry, although some states still allow certain

cultivars that are either sterile determined not to be hosts of black stem rust disease. These include Maine (Maine Department of Agriculture, Conservation and Forestry, 2022), Massachusetts (Massachusetts Department of Agricultural Resources, 2022), New Hampshire (New Hampshire Department of Agriculture, Markets & Food, 2017), New York (New York State Department of Environmental Conservation, 2015), West Virginia (West Virginia Department of Agriculture, 2018) and Wisconsin (Wisconsin Department of Agriculture, Trade and Consumer Protection, n.d.).

In Canada, Japanese barberry has spread across southern Ontario, Quebec, Nova Scotia, New Brunswick and Prince Edward Island (CABI 2019; EDDMapS 2023; iNaturalist 2023). In Ontario, it occurs across the Greater Toronto Area including Toronto, Mississauga, Vaughan, and Brampton. It occurs throughout southern Ontario including Chatham, London, Kitchener, Guelph, Hamilton, and Niagara Falls; to the east it is found in Peterborough, Durham Region, Ottawa, Kingston, Brockville, and Cornwall and as far north as Sudbury.

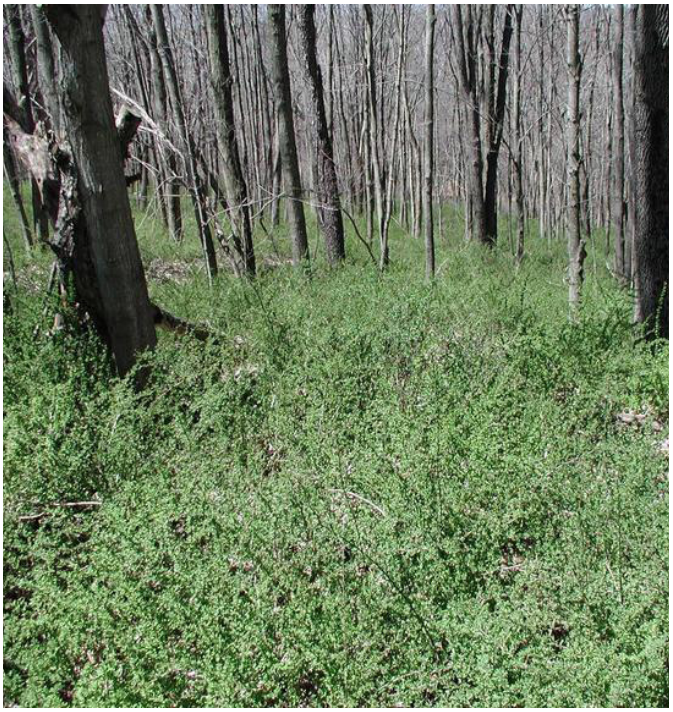
The northern limits of Japanese barberry are likely due to low temperature tolerances, southern limits by the requirement for cold stratification, and western limits by drought tolerance (Zouhar 2008).

For up-to-date distribution information, visit EDDMapS:
www.eddmaps.org/ontario or http://inaturalist.ca.

Japanese barberry growing in the understory of a forest

Photo courtesy of: Credit Valley Conservation.

Impacts



Japanese barberry infestation in a forest.

Photo courtesy of: Leslie J. Merhoff, University of Connecticut, Available: https://www.forestryimages.org/browse/detail.cfm?imgnum=5456952

Ecological:

Japanese barberry has escaped cultivation and become a problematic invader, causing a myriad of negative ecological impacts. This invasive plant can form very dense and persistent infestations, even in shaded conditions, which are particularly problematic in closed canopy forests (Ehrenfeld 1999; Zouhar 2008). Many cultivars of Japanese barberry are prolific seed producers and can reproduce vegetatively through aboveground and belowground clonal shoots, allowing this plant to quickly colonize an area (Silander and Klepeis 1999; Zouhar 2008; Maine Department of Agriculture, Conservation and Forestry 2019). When the stems of Japanese barberry are broken and contact the soil, they can reproduce vegetatively by generating a new root system, which is also called layering.

While Japanese barberry germinates best in moderate light conditions (Silander and Klepeis 1999), once established, it becomes very shade tolerant facilitating its invasion into closed canopy forests and formation of very dense thickets (Zouhar 2008). This enables Japanese barberry to persist at any successional stage and under almost any shade level (Silander and Klepeis 1999). Most seeds of Japanese barberry fall very close to the parent plant, which also contributes to the formation of dense thickets. The biomass of co-occurring native plant species has been found to be suppressed by Japanese barberry and is slow to recover following the removal of this plant (Link *et al.* 2018) suggesting it may have allelopathic properties, although this is not documented in the literature. Japanese barberry can alter soil chemistry through increasing nitrogen content and pH, which can prevent the growth of native plant species and alter soil microbial activity thereby resulting in a decrease in native plant biodiversity. By doing so, Japanese barberry creates ideal conditions for its own seedlings, giving it a competitive advantage (Kourtev *et al.* 1999; D'Appollonio 2006; Zouhar 2008). Japanese barberry has a longer growing season compared to most native species as it leafs out very early in the spring and retains its leaves late into the fall. This allows it to take advantage of the open canopy and start photosynthesis earlier than native species, giving it a head start in the spring (Xu *et al.* 2007; Silander and Klepeis 1999; CABI 2019). Finally, because of the spines on its stems, browsing wildlife such as deer avoid feeding on the seedlings of this plant. This increases herbivory of desirable native plants in invaded areas (Pearl *et al.* 1995; Kulhanek 2022).

A recent weed risk assessment performed in Maryland, indicated that Japanese barberry has high ecological impact potential because it forms impenetrable thickets, alters soil microbial activity and soil chemistry and changes community composition all of which result in a decline in species diversity (Maryland Department of Agriculture 2019).

Economic:

Despite its negative impacts, many cultivars of Japanese barberry remain available for purchase in Canada, even over the internet through online gardening sites. However, the Plant Protection Regulations prohibits the importation and movement of all species and cultivars of barberry; this includes hybrids and cultivars of Japanese barberry, unless they have been demonstrated to be resistant to stem rust disease.

Japanese barberry has an extremely high wholesale value in the horticulture industry. In 2019, the total wholesale value of Japanese barberry across North America was over 200 million dollars, with Oregon being the number one producer at over 1 million dollars (Perdue 2020). However, once established, Japanese barberry can become very costly to remove. A risk assessment conducted in Indiana estimated that it would cost more than $2,000 per acre to remove this plant (Jacquart *et al.* 2007). Ward and Williams (2012) conducted a study in to examine the efficacy of treating Japanese barberry in the dormant season and found that labor costs associated with herbicide application average 0.13 hours/acre/percent cover (determined by presence/absence in experimental plots).

Societal:

Japanese barberry infestations in the USA (Connecticut) have been indirectly connected with higher instances of Lyme disease carried by black-legged ticks (*Ixodes scapularis*) (Williams *et al.* 2009; Williams and Ward 2010). Dense growth of Japanese barberry creates an ideal habitat for deer mice (*Peromyscus* spp.) which are a host for black-legged ticks. D'Antonio *et al.* (2013) found that the mean number of feeding larval ticks per mouse was significantly higher on mice captured in dense barbery stands. This could potentially lead to more cases of Lyme disease and other tick-borne diseases in humans, pets, and livestock.

Thickets of Japanese barberry can be impenetrable which may limit recreational activities. In addition, the sharp spines could pose a health and safety concern (Maryland Department of Agriculture 2019).

While common barberry has a long, rich history of traditional medicinal and culinary uses, Japanese barberry is less well-known or used. However, like other species in the genus *Berberis*, it contains edible berries as well as an isoquinoline alkaloid called berberine (Beydoun 2023). Berberine is considered the main active constituent that gives barberry its medicinal value, due to its anti-inflammatory, anti-microbial, and alterative actions. It acts therapeutically on several systems of the body, including the regulation of blood sugar and lipid levels, tonifying gastrointestinal issues, modulating liver health, and supporting conditions of the cardiovascular system (Beydoun 2023). In vitro studies have demonstrated anti-bacterial action against skin infections caused by *Staphylococcus aureus*, and sore throats (*Streptococcus pyogenes*) (Villinski *et al.* 2003). There has been some support for harvesting Japanese and common barberry for its berberine content instead of goldenseal (*Hydrastis canadensis*). Goldenseal is the more commonly used species for its high berberine content but is Endangered or Threatened across much of its North American native range due largely to overharvesting pressures and increasing urbanization (Villinski *et al.* 2003).

Applicable Legislation

(Last Updated – April 2024)

Regulatory Tools – Japanese and common barberry:

Japanese barberry is not a federally or provincially regulated species, although common barberry, a related species, is listed as a Noxious Weed under the provincial *Weed Control Act*, 1990. *See Table 2 for details.*

Depending on the location, timing of work, and the type of management activities (e.g., mechanical/manual or chemical), permits, approvals or authorizations may be required from municipal, provincial or federal agencies before Japanese barberry control can be initiated. Individuals undertaking control activities for Japanese barberry are responsible for ensuring that these are obtained and complying with any applicable legislation. Please note that this is only for general guidance and is not intended as legal advice.

Additionally, if protected species or habitats are present, an assessment of the potential effects of the control project and authorization could be required. Depending on the species and its location, applications should be directed to the appropriate authorities.

While not an exhaustive list of permits or rules that may apply to Japanese barberry management, the following examples are provided for consideration. **Note that the following info in table 2 also applies to common barberry.*

Table 2: Legislation pertaining to Japanese barberry management.

Legislation & Regulating Body	Purpose	Application to Japanese barberry Management
PROVINCIAL		
Invasive Species Act *(2015),* Ontario Regulation *354/16* Ministry of Natural Resources and Forestry (MNRF) Applicable to Terrestrial and Aquatic Environments	Prevent the Introduction and Spread of Invasive Species	Japanese barberry is not regulated under the *Invasive Species Act* (ISA), 2015. For more information, visit: https://www.ontario.ca/page/managing-invasive-species-ontario

Legislation & Regulating Body	Purpose	Application to Japanese barberry Management
Weed Control Act Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)	Regulation of Noxious Weeds in Ontario	Japanese barberry is not listed in the Schedule of Noxious Weeds under the *Weed Control Act* (WCA), 1990. However common barberry is listed as a Noxious Weed. The WCA is administered by the Ontario Ministry of Agriculture, Food and Rural Affairs. The objective of the WCA is to minimize the impact of noxious weeds and weed seeds on agriculture or horticultural land. Landowners whose property contains noxious weeds and weed seeds that negatively affect agriculture or horticultural lands are responsible for weed control and associated costs. For more information on noxious weeds and what to do if you find them on your property visit: http://www.omafra.gov.on.ca/english/crops/facts/noxious_weeds.htm
Endangered Species Act Ministry of Environment Conservation and Parks (MECP) Applicable to Terrestrial and Aquatic Environments	Protection of Endangered and Threatened Species and their Habitat	The *Endangered Species Act* (ESA) prohibits the killing, harming, and harassing of species at risk (SAR) classified as extirpated, endangered or threatened, as well as damage and destruction of the habitat of endangered and threatened SAR. Management activities that may adversely impact protected SAR or habitat, such as herbicide application or mechanical removal, may proceed in accordance with an ESA authorization (permit or agreement) or regulatory exemption. For the full list of SAR in Ontario and for information on permit requirements consult: http://ontario.ca/page/how-get-endangered-species-act-permit-or-authorization

Legislation & Regulating Body	Purpose	Application to Japanese barberry Management
Pesticides Act & Regulation 63/09 Ministry of Environment Conservation and Parks (MECP) Applicable to Terrestrial and Aquatic Environments	Regulation of Pesticide Use in Ontario	The *Pesticides Act* and Ontario Regulation 63/09 govern the sale, use, transportation, storage and disposal of pesticides in Ontario including license and permit requirements. Most invasive species control projects will require a licensed exterminator. Only pesticides registered under the federal *Pest Control Products Act* by the Pest Management Regulatory Agency (PMRA) can be used in Ontario. **The pesticide label is a legal document that must be followed exactly.** Exterminations on land are subject to the cosmetic pesticide ban. Other than certain biopesticides and low-risk pesticides on Ontario's "Allowable List", pesticides can only be used in accordance with an exception (e.g., agriculture, forestry, public health and safety, natural resources and other legislation) to the cosmetic pesticide ban. The licensed exterminator in charge can provide guidance regarding how the exceptions to the cosmetic pesticide ban apply to the specific extermination and any requirements that must be met to perform work under the exception. For more information on these exceptions and the rules with respect to pesticide use visit: https://www.ontario.ca/laws/regulation/090063
FEDERAL		
Species at Risk Act **(SARA)** Environment and Climate Change Canada (ECCC) Applicable to Terrestrial Environments	Protection and Recovery of Species at Risk and their Habitats	For most extirpated, endangered and threatened species, the *Species at Risk Act* (SARA) applies automatically only on federal lands. This includes National Parks, National Wildlife Areas, and other protected heritage areas administered by Parks Canada. For control activities on federal lands that may affect non-aquatic species listed on Schedule 1 of SARA, or which contravene SARA's general or critical habitat prohibitions, permits may be required. For more information, consult: https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/permits-agreements-exceptions/permits-agreements-information.html

Legislation & Regulating Body	Purpose	Application to Japanese barberry Management
Migratory Birds Convention Act & Regulations Environment and Climate Change Canada (ECCC) – Canadian Wildlife Service (CWS) Applicable to Terrestrial and Aquatic Environments	Protection of Migratory Birds, and their Nests and Eggs	When undertaking your project, you should take precautions to avoid harming migratory birds, nests and eggs. This includes: • Understanding how migratory birds and their nests are legally protected • Consider species activity timelines (i.e. active nesting season) • Planning your activity ahead of time, evaluate if the activity may cause harm to migratory birds, and determine what measures can be taken to avoid causing this harm • Develop and implement preventative and mitigation measures, such as beneficial management practices. For more information please visit: https://www.canada.ca/en/environment-climate-change/services/migratory-birds-legal-protection/convention-act-regulations.html
Pest Control Products Act Pest Management Regulatory Agency (PMRA), Health Canada Applicable to Terrestrial and Aquatic Environments	Regulation of Pest Control Products in Canada	Before a pesticide can be sold or used in Ontario, it must be registered under the federal *Pest Control Products Act (PCPA)* by the Pest Management Regulatory Agency (PMRA) of Canada. The pesticide label is a legal document. Follow all label directions – and ensure you have the most current label and are aware of any re-evaluation decisions. Visit the PMRA's product label search site at https://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php

Invasive Plant Management Planning

Management Considerations

It is important to control Japanese barberry before it becomes locally established. Preventing the spread of this invasive plant will reduce its impact on biodiversity, the economy and society.

It is important to use a control plan that incorporates Integrated Pest Management (IPM) principles. This entails using existing knowledge about the invasive plant (i.e., its biology and life cycle), and its surrounding environment. This often requires more than one type of control measure to be successful.

Once Japanese barberry has been confirmed at a location, a control plan should be developed based on infestation size, site accessibility, potential for spread and risk to the environment, economy or society. Also consider site-specific conditions such as native plant richness and diversity and wildlife usage including bird migration routes and species at risk. It is strongly recommended to conduct a detailed inventory of each site prior to starting control efforts to ensure that proper methods and timings are used to mitigate potential negative impacts on native plant species and wildlife.

Mapping

If you are planning a restoration project on your property, conducting an ecological survey is a beneficial way to document current and future distributions of invasive plants that might be present, such as Japanese barberry. Conservation authorities or municipalities which manage large land areas may use internal staff or contractors, or have qualified volunteers conduct ecological surveys. However, private landowners with smaller properties may be able to conduct their own surveys or hire a contractor. If you know you have Japanese barberry in one area, survey the rest of the property to identify other infestations. Map the extent of the invasion, as well as any small satellite populations.

For detailed information on mapping techniques consult the Landowners Guide for Managing and Controlling Invasive Plants in Ontario.

To determine potential infestations in your areas, consult EDDMapS: https://www.eddmaps.org/

Landscape Level Management

A more detailed management strategy is likely to be needed if Japanese barberry has become widely established. A strategic, landscape-level approach to management should be undertaken that aids in bringing together partners, landowners, and land managers. This approach is designed to work towards common and shared goals that consider both site-level needs in conjunction with wider landscape considerations. It makes it easier to use resources efficiently, coordinate management activities and accomplish strategic goals. Failure to consider a broader landscape context, by only focusing on individual or local challenges, may increase management costs, be more labour intensive, and may not produce desired results across larger areas. Effective management of Japanese barberry requires repeat treatments and the combination of control methods (i.e., hand pulling or digging and herbicide use). It is important to determine the land use objective and desired plant community because it is not always realistic, especially for larger populations, to eliminate the entire infestation at once. From here, develop an appropriate IPM strategy which takes into consideration the biology and life cycle of the plant in addition to using a combination of management techniques.

Setting Priorities

Establishing your highest priority locations for control prior to management will help to determine the best course of action. Therefore, when developing a management strategy, it is important to consider the following considerations to help inform control decisions:

1. **Protect** federally, provincially, and regionally rare species and communities by removing invasive plants and ensuring rare species are not negatively impacted by control efforts. You are responsible for ensuring that your project follows provincial, federal, and municipal laws, including the provincial *Endangered Species Act*, and federal *Species at Risk Act.* For species-specific information consult: https://www.ontario.ca/page/species-risk-ontario

2. **Ensure** all landowners have been identified and consulted before control takes place.

3. **Contain**: If you have limited resources, try to remove the outlying populations of Japanese barberry first (isolated plants or satellite populations), to prevent further spread. Protect areas where Japanese barberry is absent or just appearing. When action is taken early it can significantly reduce the cost of control. Targeting new populations while they are still in seedlings can help to reduce seed source and spread. In these areas, the native habitat is likely also most intact, and will be fastest to recover from the infestation.

4. **Work inward:** If you have more resources, working from the outlying or satellite populations inward into larger, "core" populations of Japanese barberry and reducing the quantity of seeds can prevent spread into uninfested areas. In many cases, resource limitations may prohibit the immediate removal of entire core populations. Under these circumstances, core areas should be prioritized and addressed strategically.

5. **Consider sensitive ecological areas:** Concentrate on preventive strategies in high-priority ecological areas or areas where the plant is going to cause the most problems in terms of spread, such as the most productive or sensitive part of an ecosystem, along a creek, near species at risk, or a favourite natural area. Pay special attention to disturbed sites which can be quickly colonized by Japanese barberry and other invasive plants. Reduce the spread of Japanese barberry by following the Clean Equipment Protocol and removing invasive plant material from boots, clothing, and animal fur.

6. **Logistics and costs:** Review the different control options and costs with consideration to surrounding water, habitat, time of year, and type of land use (i.e., high-traffic recreational areas, agriculture, etc.).

7. Consider dedicating a certain time each year to control efforts and make it a joint effort with neighbouring landowners and/or land managers.

8. Begin to assess whether regeneration or restoration is appropriate, and if seeding or planting of native plants is needed to help jump-start natural succession and increase biodiversity in the area.

9. Follow-up monitoring is crucial to remove new plants or address resprouts that may emerge after initial control efforts. Control for Japanese barberry is most successful using a combination of techniques (mechanical removal, chemical control, directed flame) applied more than once per season, as well as repeat monitoring and control over multiple years.

Prioritizing within a Control Area

(This section is modified from *The Landowners Guide to Managing and Controlling Invasive Plants*, published by Credit Valley Conservation).

1. Focus on large blocks of un-invaded areas and keep them free of invaders.
2. Control small, younger, outlier (satellite) populations first.
3. Reverse the invasion, expand the cleared area outward and ensure that un-invaded areas are kept free of invasive plants (with regular monitoring).

This flow chart can help land managers choose where to first focus control efforts if controlling satellite populations due to limited resources:

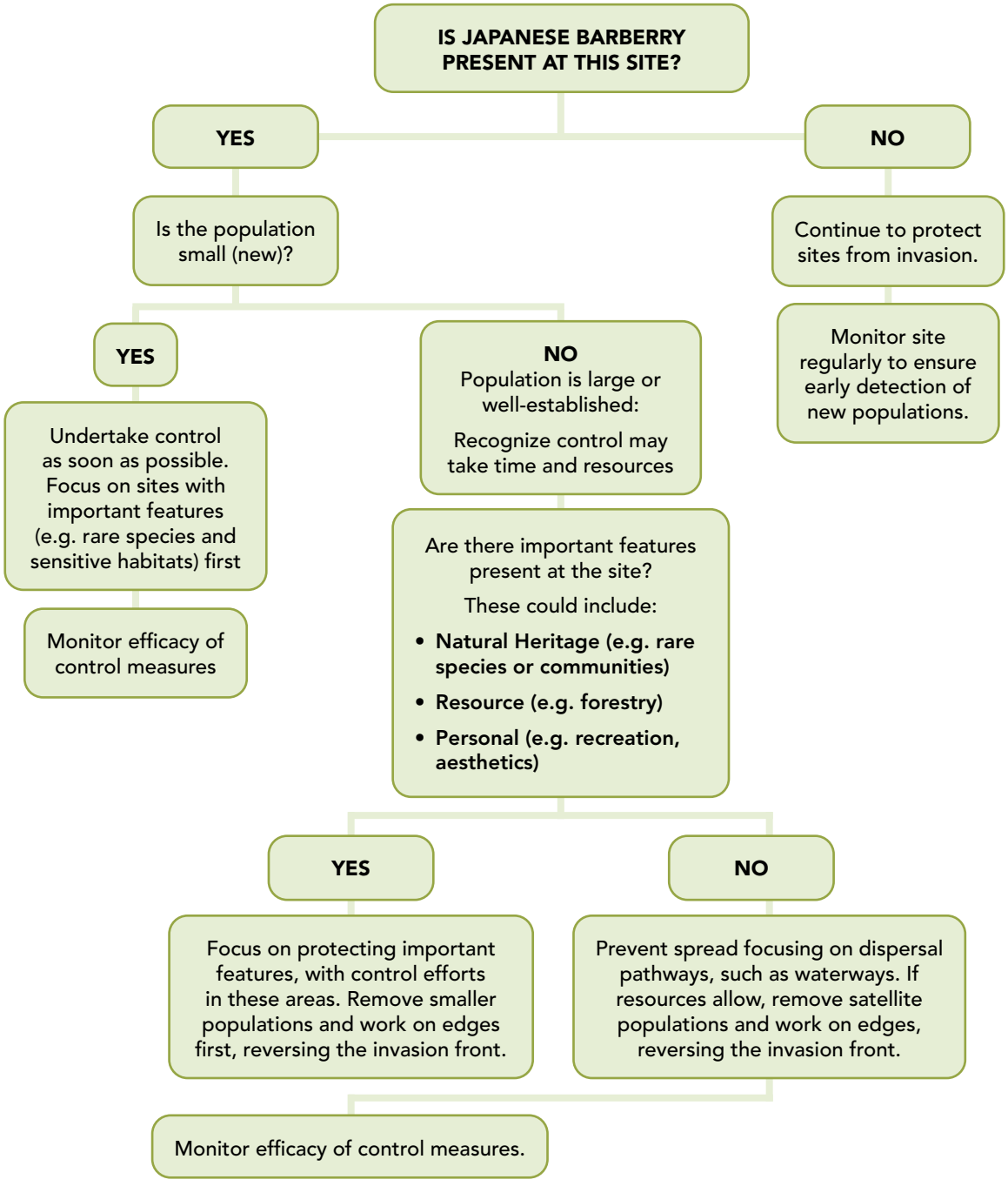


Figure 1: How to prioritize Japanese barberry sites for effective control

Long-term Management and Monitoring

A long-term management and monitoring plan should be developed prior to control efforts to help prevent the re-establishment of Japanese barberry. Established stands of Japanese barberry will likely need annual management. Monitoring after the initial control measures will enable the assessment of effectiveness and determine if follow-up treatments are needed. Ongoing management is essential to the success of a control project because after removal a site is at risk of reinvasion from nearby populations or other invasive plants.

Monitoring can be simple or complex ranging from taking photos or performing visual assessments to conducting extensive vegetation surveys. In general, annual control of Japanese barberry is needed and should focus on removing individual plants or small, isolated populations as they appear. This will help ensure that the invasive plant population remains under control while allowing for the regeneration of desirable native plant species.

For detailed information on monitoring consult the Landowners Guide for Managing and Controlling Invasive Plants in Ontario.

After Management: Assessing Regeneration vs. Restoration

Consider the following factors:

1. **Level of disturbance at the site:**
    - Was this a heavily invaded site (e.g., was much disturbance caused during control measures)?
    - Will it continue to be disturbed (e.g., through urban management activities or recreational use)?
2. **Biology of the invasive species removed:**
    - Is there a seed bank to consider?
    - Are there seed banks from other invasive plants in the area?
3. **Re-invasion risk:**
    - Are there invasive species nearby that could re-invade the site from nearby trails, watercourses or other pathways of introduction?
4. **Existing native vegetation:**
    - Will any native vegetation that still exists on the site regenerate quickly?
    - Does the existing native vegetation need help? Species with specific habitat requirements or reproductive strategies resulting in low fecundity, including species at risk, may require re-introduction. The majority of plant species should be able to recover naturally, especially if healthy populations exist adjacent to the controlled area.

If you answered **Yes** to most of the questions under 1 to 3, it is most likely that (a) the site will be re-invaded before it has a chance to regenerate on its own or (b) that Japanese barberry will continue to invade and be present among the native species so that annual control of Japanese barberry may be required. Restoration will be needed to reduce the risk of re-invasion. If you answered **Yes** to the questions under 4, your site may have a lower risk of invasion but could still require some restoration measures to help re-establish native vegetation.

Control Measures

Japanese barberry growing in a forest and outcompeting native plants.

Photo courtesy of: Leslie J. Mehrhoff, University of Connecticut.
Available: https://www.forestryimages.org/browse/detail.cfm?imgnum=5456909#javascript:fullscreen()

Since Japanese barberry is a prolific seed producer, the primary goal of management should be focused on preventing seed production and dispersal. Shrubs that are growing in full sun produce more fruit than those in shade and should be prioritized. As the root system is relatively shallow compared to many other invasive shrubs, seedlings and small plants can be removed in their entirety with relative ease by hand pulling or digging in moist soil.

Japanese barberry can be successfully controlled using a number of methods, such as mechanical treatments, herbicide applications, and directed heat. All these methods can be effective and should be tailored to infestation size and density, management goals, and characteristics of the site. Ward *et al.* (2013) recommends using a two-step process that combines multiple methods, including an initial treatment early in the season (from early April) to remove the above-ground portion of the clump, and a follow-up treatment to address new sprouts in mid to late season (from mid-June). Resprouts can be addressed by frequent cutting throughout the season, herbicide application, or directed flame techniques. Without a follow-up treatment, Ward *et al.* (2010) found that clumps recovered to 50% of their original size within 16 months of initial treatment. The success of follow-up treatments also depended on the initial size of barberry clumps: For smaller clumps (less than 120 cm), two follow-up treatments of directed heating with propane torches were as effective as herbicide use, whereas for larger clumps (greater than 120 cm) mortality was higher for herbicide use compared to direct heating. Chemical treatment can be applied almost anytime of year, including when the shrub is actively growing from April to October (foliar, cut stump, basal bark) or dormant (cut stump, basal bark) from November to March.

Summary of possible two-step processes to treat Japanese barberry:

- Mechanical (cutting, digging, hand pulling) early season with chemical follow-up (foliar, cut stump, basal bark) in mid- to late season.
- Mechanical early season with directed flame follow-up in mid- to late season.
- Mechanical early season with mechanical follow-up (repeated cutting throughout the season) in mid- to late season.

These techniques can be used alone as a first step or in various combinations and will depend on the characteristics of the site. Be sure to bag and dispose of any berries that are present to prevent seed spread. Continue to monitor the site for seedlings and resprouts and perform additional treatments in subsequent seasons until the seed bank has been exhausted.

***Note:** the methods described in this section can also be applied to control common barberry (Berberis vulgaris) or the hybrid Berberis x ottawanensis.*

Manual

Manual control can be used for sparse populations, seedlings and small saplings, or plants near sensitive habitat such as water.

Pulling and Digging:

Digging out a Japanese barberry plant.

Photo courtesy of: Upper Thames River Conservation Authority.

Since Japanese barberry has a shallow root system, seedlings and small saplings can be effectively hand-pulled from moist soil. Larger saplings can be dug out with a spade, mattock or pulled using equipment (i.e., Extractigator, weed wrench). Wear thick gloves and long sleeves to protect against the sharp spines. Remove as much of the root as possible, as leftover portions of root crown may resprout. Hand pulling or digging is most ideal in early spring and best before the plant produces berries (before July), in order to prevent seed spread. The pulled shrubs can be overturned, roots left to dry on site and kept above-ground. If no berries are present, they can be left on site, otherwise shrubs with berries should be bagged and disposed off-site. To limit soil disturbance, pull steadily and slowly, and pat disturbed soil down after removal. Pulling or digging can be time consuming and limited to smaller seedling populations. Hand pulling works best on small seedlings but is less reliable for larger seedlings or saplings as it becomes difficult to remove the entire root, and pieces of the root crown left behind will regrow. Digging out the whole root crown is therefore more reliable for larger seedlings/saplings.

Mechanical

Cutting or Mowing:

Cutting or mowing aboveground growth is **not recommended** as a stand-alone method because the roots remain intact, and the shrub will re-sprout shortly after cutting. Mechanical control works best when applied as an initial treatment and then followed-up with another treatment such as herbicide application, directed heating, or manual control (e.g., cutting top growth and then removing the root crown). Alternatively, repeat cutting of new sprouts throughout the growing season, ideally on a monthly basis, can help to stunt growth and prevent berry production. Although very labor-intensive, over time repeat cutting will eventually exhaust the root system and prevent resprouts from appearing. Although cutting can be done any time of year, it is best to cut before fruit production to prevent seed spread. Cut shrubs as low to the ground as possible.

A variety of means can be used to cut the aboveground growth. For small infestations and/or in ecologically sensitive areas, cutting can be done using a handsaw, loppers, or a chainsaw. To cut down the shrub using a handsaw, consider bending the shrub in one direction using a foot and then hand sawing the exposed stems.

A heavy-duty, hand-held brush cutter (not a string trimmer) is effective for most low-growing infestations, unless the infestation is very large or dense, or the plants are above chest height. If plants are above chest height this can pose a safety hazard due to spine strikes to the face while cutting and this can miss many low growing stems. Ward *et al.* (2013) recommends a three or four-lobed brush blade on hand-held brush cutter as opposed to string heads or saw-toothed blades.

Large, dense infestations on sites that are not ecologically sensitive can be mowed with a brush mower or drum chopper and will require follow-up with a hand-held brush cutter to cut missed stems near trees or boulders. Mowing is not feasible in sites with steep slopes or are too rocky, or on ecologically sensitive sites.

***Note:** Always wear protective clothing, hard hat, gloves, and safety glasses when using power equipment (personal protective equipment will depend on the method being used).*

Directed Heating:

Ward and Williams (2011) reported success using directed heating via propane torches to flame girdle small or scattered clumps of Japanese barberry. This method provides a non-chemical alternative in ecologically sensitive areas where herbicide use is prohibited, although it is labor-intensive and expensive. To apply, flame is directed to the base of the Japanese barberry clump, to heat-girdle stems and kill basal buds at the top of the root crown. For larger shrubs, top growth is removed to make the base of the stems more accessible, and the shrub is allowed re-spout to deplete root reserves before burning. Two flame treatments per season on targeted plants is most effective: an initial flame treatment in early spring before Japanese barberry leaf out (or any time from March to June), and a follow-up treatment from July – August. Or alternatively, shrubs can be mechanically cut earlier in the season and then directed flame can be applied as a follow-up on new sprouts that develop later in the season. This method is only recommended during wet, damp, and high-humidity conditions when risk of ground-fire is minimal.

*Prior to applying directed heat methods, ensure that the appropriate agencies have been contacted to confirm that directed heat is allowed at your site. There may be different agencies to contact depending on your treatment site location. If the treatment site falls Outside the Fire Region (OFR), consult your local Municipality, Band Council, or National Defense representative for more information. If the site falls Inside the Fire Region (IFR), there are multiple legislative requirements and regulations that must be adhered to, including the *Forest Fires Prevention Act* (FFPA) regulation 207/96. In addition to legislative requirements, please contact your local Municipality, Band Council, or National Defense representative.

Directed heating using a propane torch to control Japanese barberry.

Photo courtesy of Paige Walter, Available: https://www.michiganpublic.org/environment-science/2017-10-10/this-pretty-plant-is-causing-some-surprising-problems

Chemical

The management of pesticides is a joint responsibility of the federal and provincial governments. The federal government, through the Pest Management Regulatory Agency (PMRA), is responsible for approving the registration of pesticides across Canada under the *Pest Control Products Act*. Ontario regulates the sale, use, storage, transportation and disposal of pesticides including issuing licenses and permits under the *Pesticides Act* and Ontario Regulation 63/09. Federally registered pesticide products are assigned one of four product class designations (i.e., Manufacturing, Restricted, Commercial and Domestic). The class of pesticides determines who can sell or use the pesticides products as well as what restrictions are placed on its use (e.g., requires a license and/or permit). Most invasive species control programs using a pesticide will require an appropriately licensed exterminator.

The use of pesticides on land is subject to the cosmetic pesticide ban. Other than certain biopesticides and low-risk pesticides on Ontario's "Allowable List", pesticides can only be used if the use is permitted under an exception to the ban. Depending on the specifics of the extermination, invasive plant control may be permitted in accordance with exceptions for forestry, agriculture, public health and safety (e.g., plants poisonous to humans by touch and plants that affect public works and other buildings and structures) and compliance with other legislation (e.g., control of noxious weeds where required by the *Weeds Act*). There is also an exception for the management, protection, establishment or restoration of a natural resource that may be considered if other exceptions do not apply. The requirements that must be met for pesticide use under each exception are set out in Ontario Regulation 63/09 and may include conditions such as certification in integrated pest management, a letter from the relevant Ministry (MNRF or MECP) and/or others. The appropriately licensed exterminator in charge can provide guidance on requirements that apply to the specific extermination under consideration.

Herbicide Selection and Application

Pesticide applications can be an effective method for Japanese barberry management when used as part of an integrated pest management program and in consideration of Japanese barberry biology and site-specific information. Pesticides must be applied in accordance with the federal *Pest Control Products Act*, the *Ontario Pesticides Act*, Ontario Regulation 63/09 and all label directions. Most invasive species control programs using a pesticide will require an appropriately licensed exterminator. The availability of pesticides to control Japanese barberry may change over time, as may the label directions on how to use the pesticide so that it does not endanger human health or the environment.

Before using any pesticide, ensure you have the most current label. Pesticide labels can be accessed using the PMRA's label search tool, which can be found by searching "PMRA label search" in any major search engine. Always read and follow all directions on the label. The label is a legal document that must be followed exactly, including any applicable buffer zones. Using a pesticide to treat a species not listed on the label, or in a manner other than specified on the label violates the *Pest Control Products Act* and may incur penalties.

Chemical Control and Japanese Barberry:

Chemical control may be appropriate for larger patches of Japanese barberry that cannot be managed effectively using manual control. Several methods of chemical application may be used as an initial or follow-up treatment including foliar spray, cut stump, and basal bark. For control of Japanese barberry, a glyphosate-based product is recommended for foliar spray, and a triclopyr-based product is recommended for cut stump and basal bark treatment. Systemic herbicides such

as glyphosate and triclopyr are non-specific and can damage or kill desirable native plants that may be accidentally sprayed during treatment. Exercise caution if Japanese barberry is interspersed with desirable native species. Consult the label for herbicide use near water.

Note: Always refer to the specific directions listed on the pesticide label for the product you will be using. Visit the Pest Management Regulatory Agency's product label search site at http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php

Do not plant Japanese barberry!

Photo courtesy of John Ruter, University of Georgia, Available: https://www.forestryimages.org/browse/detail.cfm?imgnum=1581517

Table 3. Herbicides effective at controlling Japanese barberry.

Herbicide	Application/Timing	Herbicide Class	Benefits	Cautions
Triclopyr	Apply to bark or cut stump from mid-summer onwards. Avoid using during heavy sap flow in spring. Apply with a backpack or canister sprayer.	**Commercial** Only licensed professionals may apply this herbicide.	Remains active in the soil and can attack plant roots.	Affects woody species and will kill non-target trees and shrubs. Toxic to aquatic organisms. Observe recommended buffer zones. Triclopyr should not be applied during intense heat as the chemical will volatize or drip but can be used in high temperatures (over 26.6°C) or temperatures below - 10°C (see label)
Glyphosate	Apply as a foliar spray to seedlings or small shrubs (when foliage is green and fully leafed out from early spring to fall before leaf color change).	**Commercial, Restricted** Only licensed professionals may apply this herbicide.	Low rate of persistence in the environment. Does not travel though the soil (stays in the target plant).	Toxic to aquatic organisms and non-target plants. Observe required buffer zones. Avoid application if heavy rain is forecasted.

Foliar Spray:

Foliar application involves coating the leaves of target plants with herbicide. The leaves absorb the herbicide; it then translocates to other parts of the plant. Both targeted and broadcast foliar sprays can provide effective control of Japanese barberry. A backpack sprayer is the most common equipment for targeted foliar application, while broadcast treatments apply herbicide at a uniform rate across an entire treatment area.

Infestation Size:	• Large, dense infestation (broadcast foliar spray). • Small to medium-sized infestations (targeted foliar spray).
Goal:	Eradication.
Timing (season):	Effective once plants are fully leafed out in early spring (end April) until fall before leaf color change (October), when most native herbaceous plants are dormant.
Treatment frequency:	Single application (either alone or as a follow-up).
Best Practices:	• Spray until the leaves are just covered and the herbicide is not dripping off the leaves. • Foliar spray works best with a glyphosate-based herbicide. Add a vegetable (or tracker) dye to the herbicide mix to increase spray precision and minimize spray drift. • Spraying in mid-season is ideal when leaves are green and fully leafed out. • Weather may impact treatment effectiveness therefore is an important consideration for foliar spray. Avoid spraying during drought, hot, dry weather, and shortly before rainfall. Higher wind speeds may also increase the risk for drift. • Monitor for effectiveness and treat any resprouts or seedlings in subsequent years (follow up with chemical or non-chemical method). Check the pesticide label for restrictions regarding treatment frequency.

Advantages:	Effective after a single application, less labour-intensive and costly than other methods.
Disadvantages:	• Potential for spray drift and harm to non-target plants. • In natural areas, broadcast spray is only applied in areas of very dense infestations with little or no desirable vegetation, as it can negatively impact surrounding vegetation. Targeted foliar spray can help reduce impact to non-target plants.
Ideal For:	Targeted foliar spray with a backpack sprayer is an effective follow-up treatment on resprouts that emerge after mechanical cutting.

Cut Stump:

Stump cutting involves cutting at the base of the stem near the soil surface to sever the connection between the photosynthesizing parts of the plant and the roots. Cutting will also remove aboveground growth and reduce seed production. Following stump cutting, a herbicide is applied to the entire cambium layer of the cut stump surface. Japanese barberry will respond to cutting by vigorously resprouting at the root crown, therefore a follow-up treatment such as herbicide application is needed to effectively kill the shrub (Ward *et al.* 2013).

To cut: Wearing protective clothing, hard hat, gloves, and safety glasses. (**Note: personal protective equipment will depend on the equipment being used*), cut all stems of this multi-stemmed shrub horizontally near the soil surface.

Infestation Size:	Any infestation size for plants with medium to large stems.
Goal:	Eradication.
Timing (season):	Any season. Most effective later in growing season (August to October), although cutting prior to seed production in July can help prevent seed spread. Herbicide application is not effective if applied to the cut stump in spring during heavy sap flow.
Treatment frequency:	Single treatment or may need follow-up to address any resprouts.
Best Practices:	• Follow up stump cutting with herbicide applied to the entire cambium layer of the cut stump surface using a backpack sprayer. A triclopyr-based herbicide is recommended. An advantage of triclopyr products is that the cut does not have to be fresh allowing for flexibility in herbicide application, and herbicide can be applied even in freezing conditions, as long as it is above –10°C. It is however recommended to apply triclopyr to a cut stump as soon as possible, ideally within 48-72 hours after cutting. • Continue to monitor cut stumps and treat any resprouts using herbicide application, mechanical cutting, or directed heat (flame torch). Alternatively, the stump can be cut earlier in the season before seed production, then stumps allowed to resprout to deplete root reserves before herbicide is applied.
Advantages:	Selective and cost effective. Effective at killing whole shrub, and less disturbance to soil.
Disadvantages:	Labour intensive. As stem diameter is small, off-target spray drift may occur, and cut stumps may be difficult to find after cutting.
Ideal For:	• Shrubs that are too difficult to pull or dig out using mechanical methods. • Environmentally sensitive habitats, or in restoration sites where want to minimize damage to native understory. • Steep slopes where stumps can be left to rot.

Basal Bark:

Basal bark application can be effective and is a potential option when the shrub is dormant in winter (November – March) but is less effective than foliar spray and requires large volumes of herbicide.

Infestation Size:	Small to medium sized infestations.
Goal:	Eradication.
Timing (season):	Best mid-summer onwards, including when the shrub is dormant in winter (November – March). Less effective if snow or water prevents spraying at the desired height above ground level. Most effective in late summer and early fall when the sap of the tree flows towards the roots. Not effective in spring when the sap is flowing upwards.
Treatment frequency:	May need follow-up to address any resprouts. Monitor site to evaluate effectiveness of treatment.
Best Practices:	• A triclopyr-based herbicide is recommended as these products can penetrate bark. • Use a low-pressure, low-volume backpack sprayer. • Apply herbicide onto the root collar and lower parts of individual stems. • Wet bark thoroughly but not to the point of run off.
Advantages:	Can be done any time of year including the dormant period (November – March); selective.
Disadvantages:	Labour intensive. Basal bark is less effective on extensively multi-stemmed species such as Japanese barberry. In one study (Ward and Williams 2013), basal bark was found to be less effective than foliar spray for Japanese barberry control, and the authors did not recommend this method due to the high number of stems that need herbicide applied, resulting in large volumes of herbicide used. The stems are also quite small in diameter.
Ideal For:	• Shrubs that are too difficult to pull or dig out using mechanical methods. • Environmentally sensitive habitats, or in restoration sites where want to minimize damage to native understory. • Control during the dormant period (November – March)

Biological

There are no biological agents that have been studied for the control of Japanese barberry within North America.

Japanese barberry growing near a stream.

Photo courtesy of: Richard Gardner, Available: https://www.forestryimages.org/browse/detail.cfm?imgnum=5542470

Disposal

After Control

Seedlings can be hand-pulled and left on-site with the roots exposed and in full sun where they can dry out completely. Small and large plants should be removed from the site to prevent regeneration. Ensure that all viable plant material (rhizomes, flowers and fruits or seeds) is properly disposed by placing all plant material in thick, garbage bags and leaving it in the sun for 2 – 3 weeks. Following this, material can be disposed of in a landfill. Branches of Japanese barberry, without fruits or seeds, can be piled and burned on site (check with your municipality for burn permits) or chipped.

Japanese barberry seedling growing through leaf litter.

Photo courtesy of: Leslie J. Mehrhoff, University of Connecticut, Available: https://www.forestryimages.org/browse/detail.cfm?imgnum=5456970

Do not backyard compost

Backyard composters do not reach the temperatures necessary to kill seeds. Do not compost any viable plant material (i.e., rhizomes, flowers, fruits and seeds).

Municipal compost

Large-scale municipal composting facilities where the compost pile reaches temperatures high enough to kill living plant material can be used to dispose of viable plant material. Ontario composting facilities are required to routinely monitor the composting process and meet strict, provincially regulated time-temperature parameters for pathogen kill. Consult your local municipality to determine if this is an appropriate course of action.

Solarize

Place all viable plant material into thick plastic garbage bags. Seal the bags tightly and leave them in direct sunlight for 2 - 3 weeks. This will "cook" or kill viable plant material. The rotten material can then be composted or disposed of in a landfill.

Restoration

Following control measures, consider restoring the site to encourage the re-establishment of native plant species. Consider the following two restoration practices:

Seeding:

Seeding the site with native plant species immediately following plant control can help prevent the establishment of new invasive plants. This method can help native plants re-establish themselves. Seeding should only be done after management activities are completed to prevent new native plants from being killed. It is best to spread seeds from local native plants into the area. Collecting local seeds should be done ethically and sustainably.

Planting:

Once Japanese barberry has been successfully removed from a site, planting site-appropriate native species can help them out-compete invasive seedlings. This is especially important if there are nearby invasive plants that can colonize the sites. If management activities will be conducted in subsequent years, wait until all management is completed prior to planting to avoid damaging or killing newly planted stock. Consider site characteristics such as light availability and amount of space when choosing plant species for restoration as this will affect growth and soil conditions. A diverse mix of plants should be tailored to the region based on the site's growing conditions. Consider transplanting mature individuals from surrounding good quality habitat. Ensure that any plants brought into the habitat come from an appropriate ecoregional source.

See the **"Long-term Management and Monitoring"** on page 22

Regeneration of native plants following the removal of Japanese barberry.

Photo courtesy of: Brian Lockhart, USDA Forest Service, Available: https://www.forestryimages.org/browse/detail.cfm?imgnum=1118121#javascript:fullscreen()

Preventing the Spread

Prevention and early detection are the most effective tools for controlling the spread of invasive plants and everyone can help by following these suggestions:

☑ Report it.

If you think you see an invasive plant, take a picture, record the location, and report it using the following tools: contact the Invading Species Hotline at **1-800-563-7711** or report online at www.eddmaps.org or http://www.iNaturalist.ca/. For more information, call the Invading Species Hotline at 1-800-563-7711, visit *www.invadingspecies.com* or contact the Ontario Invasive Plant Council at info@oninvasives.ca.

☑ Watch for it.

Learn to recognize invasive plants and then monitor property boundaries, forested areas, fence lines, and trails. Early detection can make it easier and less expensive to remove or control them.

☑ Stop the spread.

Inspect, clean, and remove mud, seeds and plant parts from clothing, pets (including horses), vehicles (including bicycles, trucks, ATVs, etc.) and equipment such as mowers and tools. Clean vehicles and equipment in an area away from natural areas where plant seeds or parts are not likely to spread (e.g., wash vehicles in a driveway or at a car wash) before travelling to a new area. See the Clean Equipment Protocol for more details.

☑ Keep it natural.

Try to avoid disturbing soil and never remove native plants from natural areas. This leaves the soil bare and vulnerable to invasive species.

☑ Use native species

Try to use local native species in your garden. Encourage local garden centers and nurseries to sell non-invasive or native plants. The Grow Me Instead guide lists alternative species to plant instead of invasive species. For more information on alternative species to plant instead of invasive species, consult the Grow Me Instead guide at https://www.ontarioinvasiveplants.ca/resources/grow-me-instead/.

Tracking the Spread (Outreach, Monitoring, Mapping)

Several reporting tools have been developed to assist the public and resource professionals to report invasive plant sightings, track the spread, detect it early and respond to it quickly. These include:

1) **Early Detection and Distribution Mapping System (EDDMapS)**: An online reporting tool and **FREE** mobile application (iPhone and Android) where users can report sightings, review distribution maps, and explore educational resources of invasive plants and other invasive species. This tool is free to use at http://www.eddmaps.org and can be downloaded from your app store.

2) **The Invading Species Hotline**: A toll-free telephone number (**1-800-563-7711**) operated by the Invading Species Awareness Program where individuals can report sightings verbally.

3) **iNaturalist:** An online citizen science reporting tool where users can report sightings and review distribution maps. This tool is free to use at http://www.iNaturalist.ca/ and can be downloaded from your app store.

If you suspect you have encountered an invasive species, please take detailed photographs (e.g., entire plant, leaves, stem, flowers, or other identifying features), mark your location, and report it using one of the above methods.

Additional Resources

Japanese Barberry: Accurate Identification. Penn State Extension [Video]
https://www.youtube.com/watch?v=4bjMCV82occ

Japanese Barberry Removal. Riverbank Media [Video]
https://www.youtube.com/watch?v=VzC2rhppKEU

Woody Invasives of the Great Lakes Collaborative – Japanese Barberry
https://woodyinvasives.org/woody-invasive-species/japanese-barberry/

Japanese Barberry Control Methods: Reference Guide for Foresters and Professional Woodland Managers. Special Bulletin – February 2013
https://portal.ct.gov/-/media/CAES/DOCUMENTS/Publications/Special_Bulletins/SpecialBulletinFeb2013Wardpdf.pdf

Best Management Practices Document Series

Autumn Olive
Black Locust
Buckthorn
Dog-strangling Vine
Erect Hedge-parsley
Eurasian Water-milfoil
European Black Alder
European Frog-bit
Flowering Rush
Garlic Mustard
Giant Hogweed
Goutweed
Invasive Honeysuckles
Invasive Phragmites
Japanese Knotweed
Multiflora Rose
Norway Maple
Purple Loosestrife
Reed Canary Grass
Scots Pine
Spotted Knapweed
White Mulberry
White Sweet Clover
Wild Parsnip
Yellow Iris

Additional Publications from the Ontario Invasive Plant Council

A Landowner's Guide to Managing and Controlling Invasive Plants in Ontario

A Quick Reference Guide to Invasive Plant Species

Clean Equipment Protocol for Industry

Creating an Invasive Plant Management Strategy: A Framework for Ontario Municipalities

Grow Me Instead! Beautiful Non-Invasive Plants for Your Garden, a Guide for Southern Ontario, Edition 3, 2020 (EN)

Grow Me Instead! Beautiful Non-Invasive Plants for Your Garden, a Guide for Southern Ontario, Summer 2017 (EN, FR)

Grow Me Instead! Beautiful Non-Invasive Plants for Your Garden, a Guide for Northern Ontario

Invasive Aquatic Plant Species: A Quick Reference Guide

Invasive Terrestrial Plant Species: A Quick Reference Guide

The Landowners Guide to Controlling Invasive Woodland Plants

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