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Russian Olive Trees: Control and Management in the Pacific Northwest

Danielle Gunn
Extension Educator, University of Idaho Extension, Fort Hall Reservation

Ronald Patterson
Extension Educator, University of Idaho Extension, Bonneville County

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At a Glance

- Distinct, fast-growing tree that is adaptable to a variety of environmental conditions.
- Introduced to North America in the late 1800s.
- Now considered very invasive across much of the Inland Pacific Northwest.
- Displaces native vegetation and decreases native plant, animal, and insect diversity.
- Effective in windbreaks and provides food and shelter for some animal species.
- Control measures are labor intensive and difficult.
- Mechanical removal, combined with herbicide treatments, provides the most effective control.

Introduction

The purpose of this publication is to provide a comprehensive guide containing the most relevant information and effective control methods available regarding Russian olive trees. This guide is intended to educate multiple audiences in the Pacific Northwest, particularly landowners and managers, about specific details regarding these trees and how they can be managed.

Figure 1. Mature Russian olive tree.

Russian olive trees (*Elaeangus angustifolia* L.) (Figure 1) were first introduced in North America in the late 1800s from Eurasia. Historically, they were used in ornamental plantings, as streambank stabilizers, and in windbreaks. They escaped cultivation between the 1920s and 1950s. They have since become invasive throughout many areas of the Inland Pacific

Northwest, particularly in riparian ecosystems. They have also become a dominant woody invader in many other western states and western Canada. Because of their invasive nature, some western states in the United States have listed them as a noxious weed.

One criterion that defines a plant as noxious is the degree of its potential to cause injury to public health, crops, livestock, land, or other related property elements, as defined by a state. If listed on a state's noxious weed list, individuals and agencies responsible for public and private lands within that state may be required to control, reduce, eliminate, and prevent the growth of Russian olive trees on property they own and/or manage. Control requirements differ, depending on the state in which an owner or manager resides.

Plant Identification and Characteristics

Russian olives are deciduous, fast-growing trees that reach heights of 10–30 ft, with an equal or greater spread, and trunks of 20 inches or more in diameter. The bark of first-year succulent growth is smooth and greenish gray in color. As the bark hardens off on young stems and branches, it turns reddish brown. As the tree matures, the bark thickens and changes in color to dark brown with a grayish tint. Tree branches produce sharp thorns that are 1–3 inches long (Figure 2). Leaves are grayish green, narrow, 2–3 inches long, and alternate on stems (Figure 3). Leaves are covered with tiny scales that give the foliage a distinctively silvery appearance. Flowers are yellow (Figure 4) and grow in clusters that later develop into small, olive-shaped fruit. Fruits, known as drupes (Figure 3), are initially silver then turn tan to brown at maturity. Mature trees (typically five years and older) reproduce by seeds that are viable up to three years in field conditions. Seeds are spread efficiently by mammals and birds and by floating in water. Russian olives also reproduce aggressively through stem and root suckers.

Root systems are extensive and can grow 40 ft deep. Roots also contain the microbe Actinobacteria frankia, associated with nitrogen fixation (Mineau et al. 2012). This process enables trees to establish and thrive on bare or nitrogen- depleted soil. This feature also increases algae growth and reduces oxygen levels in water adjacent to established Russian olive trees (Edwards 2011; Stannard et al. 2002; Stoleson and Finch 2001).

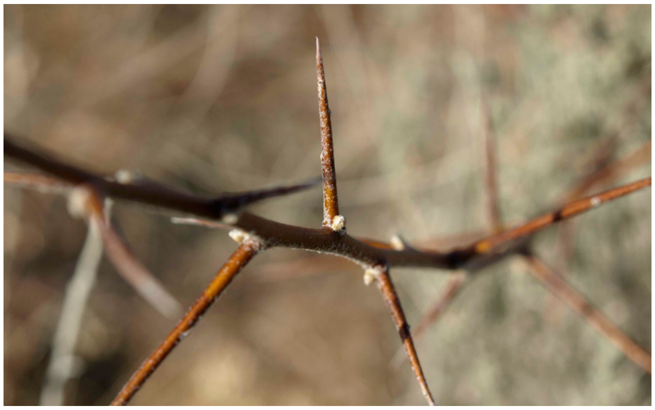

Figure 2. Russian olive thorns.

Figure 3. Russian olive leaves and drupes.

Figure 4. Russian olive flower. Courtesy of Joseph Berger, Bugwood.org.

Russian olives adapt to a variety of elevations, soil textures, and extreme temperatures. They can tolerate large amounts of salinity and alkalinity in the soil (Collins 2002; Tober et al. 2006; United States Department of Agriculture [USDA] 2014). They prefer moist areas and generally require mesic sites (moist areas) for germination but establish and grow well in arid conditions with as little as 8–10 inches of mean annual precipitation (Stannard et al. 2002; Shafroth et al. 2009). Russian olives are resistant to extended droughts, fire, flooding, silting, and other stressors.

Advantages. Russian olives establish well in windbreaks and have ornamental value. They also provide food and shelter for some birds and small animals, particularly as a potential nesting habitat for the endangered southwestern willow flycatcher (USDA 2014).

Disadvantages. Russian olives interfere with land uses, threaten the integrity of riparian areas, alter stream nutrients, displace native vegetation, and decrease plant, animal, and insect diversity (Mineau et al. 2012; USDA 2014; Heinrich et al. n.d.).

They are very invasive in irrigated pastures, meadows, riparian areas, and other waterways (Figure 5). They form impenetrable masses, create inferior wildlife habitat, and provide minimal forage value for big game and livestock. Water use by Russian olives has not been measured and documented. However, when large infestations of the trees become established, their competition with native vegetation for soil water is a potential problem (Huter 2021). Research indicates that streams infested with Russian olives suffer an increase in invasive carp populations and a decline in cutthroat trout (Baxter 2020). Additionally, the increase in subsequent carp eggs found in infested streams provides a robust food source for introduced fish species such as bass and perch (Sing and Delaney 2016).

Figure 5. Russian olive tree invasion.

Russian olive tree invasion. Russian olives also impede natural plant succession patterns (USDA 2014; Lesica and Miles 2001). They channelize rivers and streams, thereby reducing the natural flooding events native cottonwoods and willows require for germination and seedling survival (Jarnevich and Reynolds 2011; USDA 2014). Whereas Russian olives are shade tolerant and do not require high levels of sunlight or flooding to germinate and establish, native riparian trees have those requirements. Indeed, dense canopies of Russian olives block the higher levels of sunlight that cottonwoods and willows require for germination and growth (Jarnevich and Reynolds 2011; Sing and Delaney 2016). Russian olives also interfere with agricultural practices by choking irrigation ditches and damaging tires and equipment.

Furthermore, the invasive tree has very efficient reproductive mechanisms, armored with thorns and hard wood that protect them from predation and parasitism. For these reasons, Russian olives are very difficult to manage and require significant resources to eradicate.

Researchers have observed changes in the normal ecology of areas invaded by Russian olives. However, it is unknown if these changes are entirely due to the trees. Regardless, because Russian olives interfere with native plant communities, native wildlife communities are also impacted. For example, European starlings, an invasive bird, feed extensively on Russian olive fruits (Edwards 2011). Increases in populations of brown-headed cowbirds, which parasitize the nests of the endangered, native southwestern willow fly catcher and other birds, have been documented (USDA 2014). Researchers have also found more mosquitoes carrying the West Nile virus in Russian olive infestations (Sing and Delaney 2016).

Other environmental harm caused by Russian olive infestations involve soil and light quality. In selected areas in western states, they have been attributed to a twofold increase in soil nitrogen (Tuttle 2012). Indeed, infested streams studied in Idaho and Wyoming exhibit higher organic nitrogen levels compared to noninfested streams (Mineau et al. 2011). Equally problematic is that Russian olives can cause up to a 50% decrease in light availability for desirable vegetation (Mineau et al. 2012). These effects amplify in areas that provide more water and light. The result of increased soil nitrogen and decreased water and light availability equates to decreased native perennial species. Plus, the excess nitrogen leaches into streams and alters stream nutrients, which threatens to significantly change aquatic populations (Mineau et al. 2011).

Biochemical effects. Mineau et al. (2012) discovered that Russian olives create large amounts of recalcitrant (resists degradation) leaf and fruit litter that contain defensive chemicals. These chemicals are conducive to annual weedy plant and noxious weed growth. The litter also decomposes much more slowly (up to 35%) than native plant litter. Few native animals and insects use the excessive Russian olive plant litter. Native plants, already diminishing under Russian olive canopies, struggle even more to establish and flourish because of the excessive litter. As a result, the Russian olive tree's presence retards the population of indigenous fauna at best or eliminates them entirely, symptomatic of decreased ecosystem function.

Russian Olive Regrowth

Worwood et al. (2019) conducted trials in Utah demonstrating that cut Russian olive stumps produce an average of 51 sprouts per tree. Trees ground up by a stump grinder averaged 21 sprouts per tree when there was no follow-up herbicide treatment. Trees pulled out of the ground had exposed root ends, which produced an average of 38 suckers per tree. This regrowth arose from two different types of buds, epicormic and adventitious.

Epicormic buds (Figure 6) are dormant buds on a trunk or tree limb located just beneath the bark. Epicormic buds can remain inactive for decades. They break dormancy and produce prolific sprouts and dense regrowth when the upper part of the tree is removed, resulting in the growth of thick stands of shrubby Russian olives.

Adventitious buds (Figure 7) are new growth points that develop on shoots and roots from meristematic tissue (cells that actively divide throughout the life of the plant). Because callus tissue must form (and then cells need to differentiate), it can take three or more months after tree removal for shoots to develop from adventitious buds.

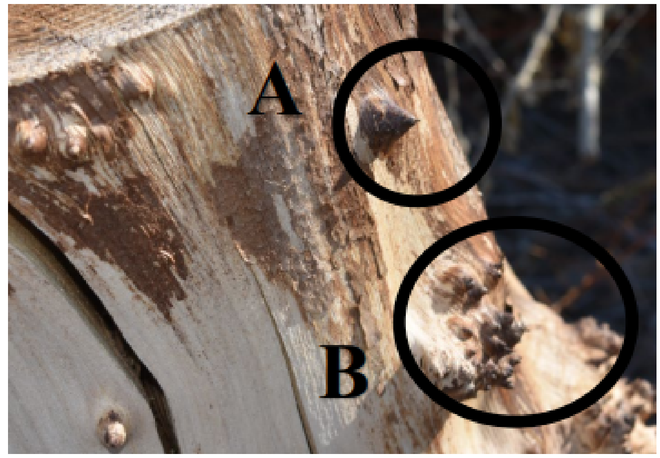

Figure 6. A, individual epicormic buds; B, clustered epicormic buds.

Figure 7. Suckers growing from adventitious buds that originate from the root's cambium (thin layer of actively dividing cells between vascular tissues in the plant that is responsible for secondary stem and root tissue growth).

Russian olive root suckers (Figure 8) form when roots are at or near (less than 3 inches) the soil surface. This can occur through erosion or other natural or anthropogenic (human-caused) disturbances or when roots are very shallow due to a high-water table or a hardpan. Deep roots do not develop suckers from either treated or untreated stumps (Patterson et al. 2018). Root suckering can be minimized or even eliminated by burying Russian olive tree roots that are exposed during the removal processes under at least three inches of soil (Patterson and Worwood 2012).

Regrowth (Figure 9) from epicormic and adventitious buds can be greatly reduced by completely removing all the crown tissue or by treating the remaining crown tissue with herbicide after tree removal. Patterson et al. (2018) demonstrated that applying glyphosate concentrate to freshly cut Russian olive stumps can result in nearly 100% control of regrowth (Figure 10).

Figure 8. Russian olive root suckers.

Figure 9. Regrowth of a cut Russian olive stump with no herbicide treatment.

Figure 10. Treated Russian olive stump with no regrowth. Blue dye denotes treated area. .

Preventing the Spread of Russian Olives

Because of the negative ecological impact and invasive nature of Russian olives, landowners, land managers, and land users are encouraged to prevent, identify, report, and actively control existing infestations. It is in the best interest of our environment and natural resources to disallow the sale and distribution of these trees. It is also appropriate to list Russian olives as a noxious weed and encourage their strategic removal throughout the Pacific Northwest.

Once established, Russian olives are very difficult to control. Treat small infestations early with the goal of their complete eradication; develop long-term management plans by including baseline inventory measurements for success markers; and annually monitor the trees post-treatment for several years. Russian olives are challenging invasive plants whose control demands an integrated management approach in aquatic and riparian systems. Thus, it is critical to destroy the root system and regenerative plant parts and decrease the soil seed bank. Control stands of young, immature trees immediately so that seed-bank reserves do not develop.

Integrated weed management. An integrated weed management program is critical for controlling and preventing the spread of Russian olives. To protect the Inland Pacific Northwest's natural resources, educational programs about this tree should include information on identifying, monitoring, mapping, and eliminating Russian olive infestations. From this kind of training, it should become clear that a combination of control and restoration methods is the most effective way to manage this tree.

Removing Russian olives is necessary to reverse its negative environmental impact. Best practices include removing seedlings and mature trees via the most appropriate techniques outlined in this bulletin and encouraging and protecting native plant establishment when possible—the more competition the better. Report infestations to your local Extension office and/or county weed superintendent.

Prevention strategies to adopt:

- Do not purchase and plant Russian olive trees.
- Carefully inspect vehicles and equipment that have been used in Russian olive infestations to prevent the unintentional spread of seeds.
- Individuals and groups traveling through infestations should inspect, remove, and properly discard seed from clothing, animals, and vehicles before entering treated or uninfested areas.
- Place any seeds that are found in a durable bag or other container and discard them in a waste bin or burn them.
- Use weed screens in irrigation canals to prevent seed from moving downstream.
- Use native and/or noninvasive plants as alternatives to Russian olives for windbreaks and stream-bank stabilization.
- Quickly revegetate disturbed and/or treated riparian areas with desirable plant species (see the Appendix 1 for a list of plant species).

Control Methods for Russian Olive

For all of the methods discussed below, use personal protective equipment (PPE). Because of thorns, hardwood, and dense infestations, the minimum PPE for working with Russian olive includes

- Leather chinks or chaps
- Leather gloves for the chain saw operator
- Chemical-resistant gloves for the applicator
- A hard hat and safety glasses
- A long-sleeved shirt, long pants, and adequate footwear for chain-saw work and herbicide treatment
- If applicable, chemical resistant shoe covers
- Any additional PPE as listed on herbicide labels
- Russian olive control methods include cultural, mechanical, herbicide, a combination of mechanical and herbicide, biological, and others.

Cultural control. Cultural control involves implementation of methods that help desired vegetation compete with undesirable plant species. Russian olives should not be sold, purchased, or used in any new plantings. Replace old plantings of Russian olives with more desirable trees, shrubs, forbs, and grasses (Appendix 1). Remove Russian olive seedlings before they begin to produce seeds.

Mechanical control. Several mechanical methods exist to control Russian olive trees, but their effectiveness is limited. When damaged, Russian olives develop prolific basal sprouts (Figure 11). Thus, mechanical removal methods may require years of retreatment. Combining mechanical and chemical control methods is often a more effective approach.

Mechanical control may require the use of heavy machinery, resulting in a high degree of site disturbance. Use caution to mitigate erosion and sedimentation of water bodies.

Mechanical control options include the following:

- *Hand pulling.* Seedlings that are one year old or less and/or ≤½ inch in diameter can be hand pulled. Seedlings pulled from the ground within a year of germination generally won't sprout suckers. When pulling seedlings, remove 3–4 inches of the root below the crown. Collect and dispose of all root fragments by burning or placing them in a secure container for disposal.

Figure 11. A cut stump without herbicide treatment results in profuse resprouting.

- *Mowing.* Seedlings that do not exceed 1 inch in diameter can be mowed to ½ inch in height with a tractor and brush mower. This technique must be repeated several times a year for several years. If mowing is not consistently repeated, the trees can become multistemmed and grow vigorously.
- *Digging.* Saplings (<3.5 inches diameter) can be dug with a shovel or hoe. Sprouting may occur after implementation of these methods if the root ends are exposed or if the root fragments are not removed. Bury the root ends beneath at least three inches of soil. Sprouting suckers must be removed or treated with herbicide.
- *Tilling.* Repeated tillage weakens Russian olives, particularly seedlings and saplings. Disks and plows effectively sever shallow root systems that have not reached mature root depths. The remaining roots and plant fragments must be tilled for several years to weaken the live tissues, inhibit resprouting, and deplete the soil seed bank.
- *Mechanical removal.* Cut down large trees (>3.5 inches diameter) with a chain saw or extract them with heavy equipment such as an excavator or backhoe (USDA 2014). Pile and burn the pulled tree material. The remaining stumps or exposed roots will readily sprout from epicormic and adventitious buds, making mechanical removal alone ineffective. Resprouts from remaining stumps and roots must be treated with herbicide.

Herbicide control. Several herbicide approaches are known to be effective, to varying degrees, in controlling Russian olive. Herbicides can be applied with hand, backpack, or ATV/UTV-mounted sprayers, or with aerial devices. Boom sprayers attached to a tractor or truck can also be utilized on smaller trees.

The goal of the herbicide application is to kill the roots. Timing of the treatment is critical and depends upon the chemical used and the application technique. Monitor all treated areas for several years. Retreat any resprouts or seedlings you discover. Always read and follow herbicide labels and use all of the required PPE.

Foliar applications. Russian olive leaf surfaces are covered with fine hairs and waxy scales, making it difficult for a leaf to absorb herbicide. Consequently, foliar applications may be less effective. The addition of a nonionic surfactant to tank mixes is highly recommended and will aid in herbicide contact, penetration through plant tissues, and overall effectiveness. Dye can also be added to the herbicide mix to aid in the identification of treated trees. Pay close attention to the tops of trees as all foliage and shoots must be sprayed thoroughly. Avoid wetting trees to the point that spray is dripping. Care must also be used to avoid spray drift to nontarget plants. Always select and use herbicide products that include the application technique you have selected and follow label instructions.

Foliar herbicide application from the ground. When accessible, the foliage of seedlings, saplings, and trees that are less than 6 ft high can be sprayed by ground applications. Ground application to taller trees is difficult and greatly increases the risk of applicator exposure to herbicides.

More than one treatment may be needed. Foliar herbicide treatment is most effective when conducted in late summer and early fall because plants begin actively moving and storing food in the root system after the first fall freeze. This process equates to quicker, more efficient movement of herbicide to the root system for a complete kill.

Foliar treatment is only minimally effective on sucker regrowth, as their leaves do not absorb enough herbicide to kill the large root system. Individual suckers may appear to die, but the epicormic buds at the base of the sucker will often sprout new stems.

Aerial spraying. Airplanes and/or helicopters can be used to spray monocultures of mature and tall (greater than 6 ft) Russian olive stands. Herbicides labeled for aerial application can suppress Russian olives, but complete eradication is uncommon (USDA 2014). When using an aerial application, use spray nozzles that deliver moderate- to large-sized droplets for maximum canopy coverage. Spray when temperatures are between 60°F to 80°F. Spraying when temperatures will reach over 80°F up to 72 hours after treatment can result in volatilization and nontarget drift of some herbicides. Follow-up treatments using mechanical control methods may be needed for a few years after treatment. Aerial applications are most effective from August to October on trees that are not stressed by drought or other environmental and climatic conditions (USDA 2014).

Girdling with spraying. Girdling, which means cutting through the bark the entire circumference of the tree, severs the xylem and phloem tissue so food and water cannot flow from the leaves and roots. Girdling alone is not an effective way to control the growth of Russian olives—it only introduces the herbicide to the vascular tissue of the plants. For a more effective use of girdling, use an axe or saw to make two horizontal cuts through the bark and cambium layer, with the second cut 3–4 inches above or below the first cut. Remove the bark between cuts and immediately spray the cut surface thoroughly according to the product label, paying particular attention to the girdle's lower edge. Leave treated trees standing for two to three years after a treatment. This method is the most useful when conducted during the summer months and is easier to implement on single-stemmed trees.

Basal bark treatment. This method involves spraying the entire circumference of the seedling, stem, and/or tree from ground level up to 12–15 inches up the tree's trunk with a herbicide. Ester formulations of herbicides can be used with a penetrating oil. The oil helps the herbicide penetrate the bark and absorb into the tree. Certain oils, such as methylated seed oil, may damage or dissolve the gaskets in spray equipment. Check the oil label to determine if you'll need special gaskets.

Spray the bark so it is wet (but not dripping) around every stem. Leaving one side of the trunk or a stem untreated might not kill the tree. This method can be used any time of the year, particularly in the winter, to avoid nontarget spray. However, do not use this method if the bark is saturated with water or when snow cover prevents application of herbicide all the way to the ground. Product labels provide specific directions on how to mix the herbicide with oil as well as information on application timing, safety, and required PPE.

Figure 12. Basal bark treatment. This method is more effective on young trees with thin, smooth bark.

Figure 13. Frill-cut method. Note the staggered frill cuts in this mature tree.

The basal bark method (Figure 12) is most effective on small- to medium-sized trees that are 6 inches or less in diameter. These young trees have thin, smooth bark that allows for better herbicide penetration. Tree trunks larger than 6 inches in diameter are often only damaged and not killed by this method because of their thick, rough bark (Worwood and Patterson 2011). The treatment is also quite effective on sucker regrowth if all sides of the stem(s) are sprayed.

Frill-cut treatment. This method involves making a notch or "frill" through the bark at a downward angle so herbicide can be injected into the frill for absorption into the tree (Figure 13). Use a pruning saw to remove small, thorny branches to provide adequate access to the trunk. Frill cuts are typically made with a hatchet or an axe in the lower trunk area; using a drill is another option, but the treatment technique takes longer.

Make one frill cut per inch of trunk diameter for adequate herbicide distribution around the trunk and translocation throughout the tree. For example, if a tree is 15 inches in diameter, make 15 frill cuts around the trunk. Then spray or squirt 1 cc (1 ml) of herbicide into each frill, at the application rate of 1 cc per inch of trunk diameter, equal to 15 cc of herbicide. Stagger the cuts so as not to girdle the tree. Alternating the cuts at slightly different heights also keeps the tree's vascular tissues intact so the tree can move herbicide through the system. When more than 1 cc is applied to a frill the herbicide runs out, resulting in wasted herbicide.

Mix the selected herbicide as per label instructions for the frill-cut application. Generally, using undiluted herbicide is the most effective, if allowed by the label. Glyphosate at 41% concentration was shown to have a 100% kill rate when used May through October (Patterson and Worwood 2020). Use a simple spray bottle to broadcast a herbicide concentrate or solution onto frill cuts. Spray bottles can also be calibrated with a measuring spoon to determine how much herbicide per squirt they are delivering. Another option is to use a simple needleless livestock syringe to squirt herbicide mixture into the frill cuts. This method, however, may require more frequent refilling than using a spray bottle.

After herbicide has been applied to each frill, leave the tree standing for at least one year to ensure complete root death. After a year, leave dead trees standing for habitat, remove them, or cut them to ground level. Leave any stumps in the ground to help stabilize the soil until revegetation efforts are complete. Certainly, frill-cut treatments are labor intensive, but they are very effective and environmentally friendly.

Recommended herbicides. Effective herbicides for control include aminopyralid, sold as Milestone, glyphosate sold as Roundup, triclopyr ester sold as Garlon 4 and Garlon 4 Ultra, imazapyr sold as Habitat, and triclopyr ester with 2,4-D ester, sold as Crossbow. These are general-use herbicides that can be purchased without a pesticide applicator license.

Some herbicides used to control Russian olives may be restricted use pesticides (RUPs). You must have a pesticide applicator license to purchase and use these products. Obtain these licenses through your state's department of agriculture. Most states require you to pass an exam to obtain a pesticide applicator license (contact your local Extension office, community college, or state department of agriculture for information regarding training).

Picloram sold as Tordon 22K is an RUP that is very effective at controlling sucker growth after cutting trees. Its residual properties also help control new seedling and sucker growth for an extended time period. Do not use Tordon 22K near any water sources, because it moves easily into surface water and streams. This can result in off-target damage to vegetation downstream and harm to crops if it infiltrates irrigation systems. As with all herbicides, avoid nontarget drift and water contamination, particularly in areas with a shallow water table. Read and follow the label thoroughly to avoid poisoning birds, mammals, fish, and aquatic invertebrates. Table 1 summarizes effective herbicides, techniques, and the timing of techniques for Russian olive control.

Table 1. Effective herbicides, techniques, and timing of techniques for Russian-olive control.

Active Ingredient	Product Example	Application Technique*
Picloram	Tordon 22 K (restricted-use pesticide)	Foliar, cut stump
Triclopyr ester	Garlon 4 Ultra, Pathfinder II	Basal bark, frill cut, cut stump
Triclopyr ester and 2,4-D ester	Crossbow	Basal bark, frill cut, cut stump
Aminopyralid	Milestone	Cut stump, foliar
Aminopyralid and triclopyr amine	Capstone	Cut stump, frill cut, foliar
Glyphosate (nonselective)	Roundup	Cut stump, frill cut, foliar, aerial spraying
Imazapyr** (nonselective)	Habitat	Cut stump, frill cut, aerial spraying

* Timing of technique for each active ingredient: cut stump—any time of year; foliar—during active growth when leaves are present (best in late summer and early fall); basal bark—any time of year, as long as snow is not blocking the trunk (especially effective in the winter); frill cut—during the growing season (May–October), NOT when trees are dormant; aerial spraying—August–October; girdling—summer months.

** Use caution with this product as it has a high degree of soil activity and can move through the soil profile and seep into canal systems. A ring of vegetative death around stumps will be observed with the use of this product.

Combination of mechanical and herbicide control. Mechanical removal combined with herbicide treatments can be very effective, depending on the techniques used. Common combinations:

Cut-stump treatment. This is one of the most effective control methods currently practiced and can be conducted any time of the year if the herbicide does not freeze and remains in liquid form. Spray herbicide using a handheld or backpack sprayer, or apply it with a paintbrush, wick applicator, or a needleless livestock syringe to allow for direct placement and measurement.

Cut trees evenly 12–18 inches in height. This will allow enough height so the stumps can be removed after the tree and its regenerative parts have died (typically after one year). Trees can be cut with a chain saw, a tree saw, or shears mounted on a skid steer. Cut off all stems and/or trunks at the same level to avoid nicking a stem. Nicks on stems below the flush cut prevent herbicide from being translocated to the roots. It may require several cuts before you can safely reach the proper height for your last flush cut.

Brush sawdust, soil, and debris from the cut surface before treatment to improve herbicide absorption into the stump or stem. Remember, if using glyphosate, soil minerals tie it up, making it less effective. Apply herbicide to the sapwood (growth rings directly inside the bark) of the stump (Figure 14). The center of the stump cannot translocate herbicide so that area should not be treated. Instead, focus on treating the outer rings of every cut stem.

Many labels allow for undiluted herbicide to be applied with the cut-stump method. Some require that the herbicide be diluted. If required, dilute and apply the selected herbicide according to the label. Treat the stumps as soon as possible (within 10–15 minutes) after the tree is cut. If there will be more than an hour between cutting and the herbicide application, cut the stump a little high and make a fresh cut just before treatment. The use of dye in tank mixes will help applicators track treated and nontreated stumps.

Patterson et al. 2018 showed that 1 cc (1 ml) of 41% glyphosate concentrate per inch of trunk diameter applied directly to the cambium layer provides over 95% control when observed at least 24 months after treatment. Treated stumps should be left in the ground for at least one year. The roots may still be alive, even after a year, so you can remove the stumps when no regrowth occurs for over a year as long as any roots that are exposed by the removal process are buried beneath at least three inches of soil. They can also remain in the ground to stabilize the soil during any revegetative work. All remaining suckers and seedlings, however, must be cut to the

Figure 14. Cut stump and treatment of cambium layer (denoted by blue dye applied to the cambium layer).

Figure 15. Damage caused by galling of young shoots by the mite, Aceria angustifoliae. Courtesy of Massimo Cristofaro, BBCA Rome.

ground and sprayed. Chip, remove, pile, and burn cut trees and debris when it is safe to do so based on environmental conditions. Implementing this practice will make it easier to manage any new seed germination in the pile area.

Basal-bark treatment combined with mechanical removal. Basal-bark treatment with triclopyr ester in either diesel or MSO kills the epicormic buds of the lower trunk. If the roots are not near the soil surface (3 inches or deeper), few root suckers should develop. Remove the treetop with a chain saw or a tree saw attached to a skid-steer implement below the upper line of the basal-bark treatment area. Mechanical removal can take place as early as two weeks after the herbicide treatment (Patterson et al. 2020).

Biological control. Very few known herbivorous insects feed on Russian olives in North America. However, researchers in other countries have witnessed some with an apparent proclivity to feed on the tree. A moth, Anarsia eleagnella (Lepidoptera: Gelechiidae) has been observed mining Russian olive shoots and fruits. However, it is not yet known how host specific and effective this insect is for biological control (Weyl et al. 2020b; Schaffner et al. 2014). Additionally, Weyl et al. (2020a) found that this moth has a broad host range that includes trees native to North America. This characteristic may make the moth unsuitable as a biological control method. Surveyors conducting their study in Kazakhstan, however, discovered a stem-mining weevil (Temnocerus elaeagni) whose mining activity of shoot tips from fresh growth may affect the reproductive capacity of Russian olives by forming galls on shoots and reducing fruit set. This species warrants further study.

The eriophyid mite *Aceria angustifoliae*, studied by researchers in Switzerland, is extremely host specific. It attacks and feeds on Russian olive leaves, shoots, buds, inflorescences, and young fruits. The feeding activity creates galls and leaf, flower, and fruit deformities (Figure 15). The mite prefers feeding during flowering and fruiting stages on developing buds and fruits in late May to June. Mites are also present in leaf galls during the spring and summer months and retreat to latent buds to overwinter. The mites negatively impact flower and fruit production at least threefold without harming established trees otherwise. Additionally, the mites affect the development and length of fruit-bearing stems. No known negative effects are expected from mites on native nontarget plants (Weyl et al. 2020a; Schwarzlaender 2021). This mite is currently undergoing US federal approval for release. Hopefully, this biological control agent will be released in the next few years.

Tubercularia canker, a North American fungal disease which occurs naturally, has been found overwintering in Russian olive stems. It is spread by precipitation, animals, or pruning implements to open bark wounds. Infected tissue becomes discolored or sunken and entire stems girdled or killed. Over a period of time, the disease can eventually deform trees and even kill stressed plants (Colorado State University 2015). Although damaging to the Russian olive, Tubercularia canker is not a potential biological control agent. It attacks several tree species and is not considered safe to use. Additionally, verticillium wilt and phomopsis canker are plant diseases that attack and sometimes kill Russian olive trees in North America. But they also are not potential control options because both attack multiple tree species and thus can have serious impacts on nontarget species.

Goat grazing has proven an effective practice for Russian olive seedling removal. Goats denude the lower areas of the trees, which eventually weakens them. If you choose this management technique, install good fencing and plan for predator control to further protect the goats from coyotes and other known predators in treatment areas.

Other methods. Flooding, burning, dozing, and chaining have been explored and documented elsewhere. But we have found these methods relatively ineffective in controlling Russian olive trees.

Revegetation. In certain habitats, particularly those that are mesic (wet), Russian olives outcompete native plant communities and become established as a monoculture. This is particularly true in riparian zones that provide an interface between terrestrial and aquatic ecosystems. In areas where Russian olives have displaced native plants it may be necessary to implement a revegetation plan after Russian olive removal.

In addition, Russian olives have been successfully established in sagebrush-steppe ecosystems as an integral component of windbreaks used by homeowners and landowners to reduce wind erosion and protect homes, agricultural land, crops, and livestock from inclement weather. Windbreaks need to be addressed on a situational basis. They serve as a seed source for Russian olive infestations that easily spread to unintended locations and damage native ecosystems. If practical, remove Russian olives in these locations and replace them with more appropriate plants. Many native tree options are available for windbreaks and should be considered as replacements for Russian olives.

The key to the control of Russian olive trees is to implement successful control strategies with repeated monitoring and follow-up treatments of any potential resprouts and seedlings. Revegetation of treated areas with competitive native trees, shrubs, grasses, and forbs will further help to restore native ecosystems. Indeed, restoration should always be a part of any control plan to achieve sustainable results.

When restoring habitat, consider seedbed preparation, seeding technique, and transplanting options in treatment areas. At a minimum, seedbeds should be firm but not packed. When feasible, drilling seeds at ⅛”–¼” depths will achieve good seed-to-soil contact. Also, consider methods to control secondary weed invasions that include but are not limited to mustard spp., Russian thistle, kochia, downy brome, and others. Other factors to consider for revegetation success include knowledge of groundwater availability, the salinity and alkalinity levels of soil, soil texture, site stability, and flood regimes. All of these factors play a critical role in the success of vegetation establishment and longevity.

The success of revegetation efforts depends on the selection of plants that do well in the environment and for the use in question. Most Inland Pacific Northwest environments fall into one of four categories: riparian, sagebrush steppe, high-elevation mountain, and northern mountain valley. Descriptions of native revegetation options are listed in the Appendix 1. Other alternatives may be available.

The list of plants in the Appendix 1 was adapted from the University of Idaho Extension Bulletin 862 PDF and Native Plants for Idaho Roadside Restoration and Revegetation Programs (https://itd.idaho.gov/wp-content/uploads/2016/06/rp171roadside_revegetation.pdf). The latter publication identifies plant-species options based on regional adaptation, drought tolerance, and those that can be used in windbreaks. In many locations throughout the Inland Pacific Northwest, windbreaks will be more successful with a moderate amount of supplemental irrigation.

Managing Native Vegetation

In many cases, it is not enough to simply remove Russian olives from sensitive environments. Maintaining vigorous native or other desirable vegetation is an important aspect of invasive species control. In the areas where Russian olive is the most invasive, promote the growth and establishment of native trees, such as cottonwoods and willows. The Appendix 1 includes a longer list from which to choose.

Desirable native, riparian trees such as cottonwoods and willows require natural flood regimes. This involves base flows that provide sustained high surface water and groundwater at critical times. Shafroth et al. (2009) concur, finding that the alteration of natural flood cycles severely limits native tree recruitment on highly regulated perennial waterways. Baxter (2020) adds that periodic big floods (approximately one per decade) help establish cottonwood stands, but only when regulated water sources are strategically controlled.

Controlled flood events can be managed to create bare and moist germination sites for desired vegetation. To provide these conditions, control streamflow releases from dams. To prevent seedlings from drying out, manage flood recession so it proceeds more slowly so as not to inhibit seedling root growth. In essence, synchronize managed floods with the seed dispersal of native trees and other vegetation—avoid abrupt, dramatic water changes. The complexity involved is substantial. To be sure, water management practices require the cooperation of all entities and individuals involved in the storage and distribution of water.

Success and Monitoring

Russian olive invasions can begin very quickly. Even small trees that are not mature enough to produce seeds should be controlled immediately, particularly if there are large numbers of them (Huter 2021). Once you have implemented your management plan, be diligent with it. It is critical to monitor treated areas and to treat resprouts on an annual basis for several years, regardless of the treatment method(s) implemented. By adopting the practices in this guide, we can restore ecosystems to healthier functioning with the help of larger, reintroduced populations of diverse native plant, animal, bird, and insect species.

Words of Caution

In areas where Russian olives have formed complete monocultures and where native trees and shrubs are scarce, consider removing Russian olive trees in sections followed by rehabilitation with native tree and shrub plantings. Remember that wide-scale removal does not allow native plants, insects, and wildlife time to adapt to habitat and food changes. Ideal habitat includes a diverse mixture of native plant species and plant functional groups, including grasses, forbs, shrubs, and trees of varying age. As plant life diversifies, the native animal, bird, and insect populations can in turn diversify and become more abundant.

Russian olive control and removal are difficult. Indeed, it takes several years to eliminate infestations. Failure to implement and/or maintain a control plan each year will allow Russian olives to reestablish themselves. At the same time, doing nothing will not solve the infestation problems and only encourage more trees to establish.

Conclusion

Russian olives are a fast-growing tree species that is highly invasive in a variety of ecosystems, particularly wet meadows and pastures and riparian areas. Because of the scope of the problem, it is everyone's responsibility to identify and prevent the spread of this tree. Whenever you identify an infestation, contact your local Extension office or local weed department for assistance. By working together, individuals and organizations responsible for land and water management can more fully consider and implement all the available treatment methods and plans and successfully solve this problem in the long run.

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APPENDIX 1: **Native Species Suitable for Revegetation of Russian Olive Removal Areas**

Scientific Name Common Name	Region*	Size	Wind**	Notes
Trees				
Acer glabrum Rocky Mountain Maple	1, 3–5	Up to 25’		Somewhat drought tolerant
Acer grandidentatum Bigtooth Maple	1, 3, 4	Up to 35’		Moderate drought tolerance
Betula occidentalis Water Birch	1, 4, 5	Up to 35’		Not drought tolerant
Celtis reticulata Netleaf Hackberry	2–4	Up to 15’	X	Very drought tolerant
Crataegus douglasii *Douglas Hawthorn*	3–5	Up to 25’	X	Moderate drought tolerance
Juniperus scopulorum Rocky Mountain Juniper	2–5	Up to 40’	X	Very drought-tolerant evergreen
Pinus aristata Bristlecone Pine	3–5	Up to 40’		Moderately drought tolerant, slow growing
Pinus monophylla *Pinus edulis* Pinyon Pine	2–5	Up to 25’	X	Very drought tolerant. Single-leaf pinyon best for Idaho.
Populus angustifolia Narrowleaf Cottonwood	1, 4, 5	Up to 60’		Not drought tolerant
Populus deltoides Eastern Cottonwood Plains Cottonwood	1, 4, 5	Up to 100’		Not drought tolerant. Prefers moist soils but tolerates dry soils.
Populus fremontii Frémont’s Cottonwood	1, 4, 5	Up to 60’		Not drought tolerant
Prunus Americana American Wild Plum	3–5	Up to 15’	X	Moderately drought tolerant
Prunus virginiana cv. ‘Schubert’ ‘Schubert’ Chokecherry	2–5	Up to 30’	X	Somewhat drought tolerant, tolerates shade, suckers badly
Quercus gambelii Gambel Oak	3–5	Up to 25’	X	Moderately drought tolerant
Sorbus scopulina Rocky Mountain Ash	3–5	Up to 15’		Moderately drought tolerant

* Regional Adaptation 1 = Riparian, 2 = Sagebrush steppe, 3 = Sagebrush steppe—supplemental irrigation, 4 = High-elevation mountain, 5 = Northern mountain valley
** Suitable for windbreaks

Scientific Name Common Name	Region*	Size	Wind**	Notes
Shrubs				
Amelanchier alnifolia Amalanchier utahensis Serviceberry	1, 3–5	Up to 20’	X	12–30 inches of precipitation. Variety of well-drained soils.
Artemisia tridentata Big Sagebrush	2–4	Up to 20’	X	8–30 inches of precipitation. Prefers well-drained, neutral to mildly alkaline soils.
Atriplex canescens Fourwing Saltbush	2, 3	Up to 6’	X	Extreme drought tolerance. Tolerates salty soils and heat.
Chamaebatiaria millefolium Desert Fernbush	2, 3	Up to 4’	X	Extreme drought tolerance
Cornus sericea Red Twig Dogwood	1, 4, 5	Up to 10’		18+ inches of precipitation. Prefers moist, organic soils.
Ericameria nauseosa Rubber Rabbitbrush	2–4	Up to 8’	X	6+ inches of precipitation. Prefers coarse soils.
Falugia paradoxa Apache Plume	2–4	Up to 6’		Very drought tolerant
Juniper spp. Various juniper shrubs	2–5	Varies	X	Extreme drought tolerance, full sun to partial shade
Penstemon fruiticosus Shrubby Penstemon	2–5	Up to 2’	X	8–18 inches of precipitation. Rocky, well-drained soils.
Philadelphus lewisii *Philadelphus microphyllus* Syringa	1, 3–5	Up to 15’		Moderate drought tolerance
Physocarpus malvaceus Ninebark	1, 3–5	Up to 5’		Moderate drought tolerance
Potentilla fruticosa Shrubby Cinquefoil	1, 3–5	Up to 5’		Moderate drought tolerance
Prunus virginiana Chokecherry	1, 4, 5	Up to 20’		Not drought tolerant. Good food source for neotropical birds.
Rhus trilobata Oakleaf Sumac	2–4	Up to 6’	X	Extreme drought tolerance
Ribes aureum Golden Currant	1, 3–5	Up to 5’		Moderate drought tolerance
Rosa woodsii Woods’ Rose	1, 3–5	Up to 5’		Moderate drought tolerance
Salix spp. Various Dwarf Willows	1, 4, 5	Varies		Not drought tolerant, includes several species

Scientific Name Common Name	Region*	Size	Wind**	Notes
Forbs				
Achillea millefolium Yarrow	1, 3–5	12”–24”		Very drought tolerant—8–20+ inches of precipitation. Grows in a variety of soils.
Artemesia ludoviciana Prairie Sage	2–5	To 40”		Prefers sandy soils. Quick to establish.
Balsamorhiza sagittata Arrowleaf Balsamroot	2–5	To 30”		Does well on southern exposures; needs 8–25 inches of precipitation and fine to medium-textured soils
Erigonum umbellatum Sulpherflower Buckwheat	3–5	To 12”		Very drought and cold tolerant. High tolerance for salinity.
Gaillardia aristata Blanketflower	1–5	18”–24”		Drought tolerant, grows best with 16–30 inches of precipitation. Prefers coarse-textures, well-drained soils.
Geranium viscosissimum Sticky Purple Geranium	1, 3–5	To 24”		10–20+ inches of precipitation and grows in a variety of soils
Ipomopsis aggregata Scarlet Gilia	1–5	To 42”		8–20 of precipitation. Prefers well-drained, sandy soils.
Linum lewisii Blue Flax	1–5	To 30”		10–24 Inches of precipitation. Very drought and cold tolerant. Moderate soils.
Symphyotrichum spathulatum Western Mountain Aster	1, 4, 5	To 30”		10–20 inches of precipitation. Deep soils.
Thermopsis montana Mountain Golden Pea	1, 3–5	To 36”		10–16 inches of precipitation and in a variety of soils
Grasses				
Achnatherum hymenoides Indian Ricegrass	2–4	To 24”	X	7–20 inches of precipitation. Needs sandy, well-drained soils and is very wind tolerant.
Elymus elymoides Squirreltail	2–4	To 20”	X	6–18 inches of precipitation. Tolerates moderate salinity. Variety of well-drained soils. Very wind tolerant.
Elymus trachycaulus Slender Wheatgrass	1–5	To 30”		8–25 inches of precipitation. Establishes rapidly.
Festuca idahoensis Idaho Fescue	1–5	To 36”	X	6–30+ inches of precipitation, best above 14”. Variety of soils. Excellent soil stabilizer.
Pascopyrum smithii Western Wheatgrass	3–5	To 36”		10+ inches of precipitation. Prefers fine to very fine soils.
Poa secunda Sandberg Bluegrass	2–5	To 12”		8–20 inches of precipitation. Prefers sandy to silty loam soils.
Pseudoroegneria spicata Bluebunch Wheatgrass	1–5	To 48”	X	6–35 inches of precipitation. Prefers well-drained soils and a variety of soil textures.