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Ecology and Management of Purple Loosestrife (*Lythrum salicaria* L.)

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Figure 1. Purple loosestrife growing along an irrigation ditch during July in Washoe County, Nevada.

Abstract

Purple loosestrife, also commonly referred to as lythrum, is a robust, perennial forb invasive in riparian areas and wetlands (see Figure 1). It reproduces both by seed and buds on spreading roots. It can grow to over six feet tall (2 m), has square stems, opposite or whorled, lance-shaped leaves with heart-shaped bases, and reddish-purple flowers that grow at stem tips in a spike-like inflorescence. Native to Europe and Asia and a member of the Litheraceae family, it was transported from Europe to North America in the early 1800's intentionally as an ornamental and accidentally as a contaminant of soil used for ship ballast. Initial spread across North America is believed to be mainly by waterborne commerce. Its spread to Montana was first reported from Toole County in 1980 as a wet roadside ruderal, and as of 2008, it has been reported from 16 counties across the state. In Montana, it has been found in gardens, gravel pits, wetlands and potholes, and along roads, railroads, irrigation ditches, creeks, and lakes. It is listed as a Montana Category 2 noxious weed. Currently, known infestations in Montana are being contained to about 300 acres.

The aggressive, clonal growth habit of purple loosestrife crowds out native riparian plants important to wildlife and channel stability. Its stout spreading roots and prolific seed production make purple loosestrife difficult to control and eradicate. Because it is a pest in wetland environments, herbicidal control is often limited to chemicals with an aquatic label including triclopyr, glyphosate, 2,4-D, and imazapyr. Five insect species have been approved for release in North America to manage purple loosestrife. Hand pulling and digging are effective on early establishing plants. However,

individuals can regenerate from stems, rootstocks, and the seed bank. Stems and roots should be disposed by burning or placed in the trash.

Figure 2. The leaves, inflorescence, and flower of purple loosestrife.

Identification

Purple loosestrife is a stout, erect, perennial herb with up to 50 stems growing from a well developed root system. Populations are variable, and stems can be four- to eight-sided, glabrous (hairless) on the lower stems, or pubescent on the upper stems and inflorescence. The tough stems normally grow to about six feet (2 m) tall but can reach heights up to 10 feet (3.5 m). The leaves are lanceolate, similar in shape to willow (*Salix* spp.) leaves, from which the species name is derived (*salicaria*, see Figure 2). The leaves are one to four inches (2.5 to 10.2 cm) long, with entire margins. Like the stems, the leaves can be glabrous or pubescent. The lower stem leaves are heart-shaped (cordate) at the base, and they are attached directly to the stem (sessile) in an opposite or whorled arrangement (lower leaves). The flowers have a tubular calyx with five to seven lobes (sepals) and linear ridges between the lobes. There are five to seven separate petals attached to the top of a hypanthium (see the flower cross section in Figure 2). Ten to 14 stamens of varying length are fused to the petals (two per petal). The petals are typically reddish-purple, but can be white, pink, purple, or red (the name *Lythrum* is from *lythron*, the Greek word for blood). The ovary has one style that can be short, medium, or long; the length of the style being different from the lengths of the stamen filaments. The spatial separation of stigmas and anthers, studied by Darwin in 1877, encourages self incompatibility and cross pollination. The flowers range from one-third to one-half inch (10 to 13 mm) long and are more or less densely arranged in numerous whorl-like cymes on a terminal spike (see Figure 2). The fruit is a brown capsule 1.25 to 1.9 inches (32 to 48 mm) long. The seeds are minute, light weight (<0.06 mg each), flat, angular, light tan, and thin-walled. There are many seeds per capsule and each spike can produce up to 120,000 seeds.

Purple loosestrife can be distinguished from the native winged loosestrife (*Lythrum alatum*, reported from Carbon County in eastern Montana), by the size of the plant, leaves, and flowers. Winged loosestrife plants grow from 16 to 40 inches (0.4 to 1.0 m) tall whereas purple loosestrife plants generally are taller. Leaves of winged loosestrife are 0.79 to 2 inches (2 to 5 cm) long and not cordate-based, and the petals are about 0.2 inches (5 mm) long compared to the 0.3 inch (7-10 mm) purple loosestrife petals. Winged lythrum has only one flower in the axils of opposite leaves, whereas purple loosestrife has pairs or clusters of flowers in axils of opposite leaves.

Purple loosestrife hybridizes with European wand lythrum (*Lythrum virgatum*), another ornamental that can be invasive. European wand lythrum is smaller, has smaller flowers and narrower leaves than purple loosestrife and the leaves have acute rather than cordate bases. Purple loosestrife is sometimes confused with fireweed (*Epilobium angustifolium*). *Epilobium* leaves are alternate, not cordate-based, the flowers lack a hypanthium (or it is not exerted beyond the ovary), and the flowers have four petals and eight stamens.

Life History

As an herbaceous perennial, purple loosestrife grows from a woody crown every year. The timing of shoot emergence in the spring is affected by temperature, but normally shoots emerge from crowns in late April or early May. Rapid shoot growth begins after day-light length reaches 13 hours. Flower bud formation begins in mid-June to early July and inflorescence growth continues until the first killing frost (indeterminate growth). Early flowering is associated with atypically warm and dry weather. Flowers are pollinated by honey bees (Apinae), leaf cutter bees (Megachilinae), carpenter bees (Xilopinae), bumble bees (Bombinae), European cabbage white butterflies (*Pieris rapae*), common sulphur (*Colias philodice*), and wood nymph butterflies (*Cercyonis pegala*). After fall senescence, ridged dead stems can remain standing for one to two years.

Carbohydrates accumulate in the crown and roots during the late summer and fall. Overwintering shoot buds form on the crown in late August and early September and use minimal amounts of carbohydrates for respiration and maintenance during the winter. Starch is the primary non-structural carbohydrate in the roots and crowns, and averages 19% and 15% by weight in the roots and crowns, respectively, in populations in Minnesota. Starch content of crowns decreases following shoot emergence in the spring and continues to decline until flower bud formation. Starch levels increase during flowering and peak when plants die back in late September and early October. Water stress (drought) reduces starch accumulation in the crowns. Sucrose is the predominant soluble sugar in roots and crowns and average 1.3% of total dry weight in populations in Minnesota. The sucrose level in crowns is lowest during bud and early flowering, and increases to the highest level in late August and September. Pre-winter elevated sucrose concentrations have been associated with increased cold tolerance in alfalfa and leafy spurge.

Fresh seed viability is nearly 100%, and after two to three years of submergence, 80% of the seeds can maintain viability. In late spring or early summer, seeds germinate on bare, moist soil, but not under flooded or shaded conditions. The seed bank of purple loosestrife can be as high as 400,000 seeds/m^2 and usually outnumbers seeds of native species. Seeds on bare, moist soil germinate in three to four days, generally faster than native species, and seedling growth rate is also faster than most native wetland species, giving purple loosestrife an advantage in capturing

light and shading competitors. After germination, flowering can begin in eight to ten weeks, and new plants can set seed in one growing season. However, growth and competitive ability are diminished under low fertility conditions.

Habitat

Purple loosestrife grows in a wide range of soil textures and in both calcareous and slightly acidic soils. Outside of gardens, purple loosestrife grows in freshwater marshes, open stream margins, irrigation ditches, and alluvial flood plains. It has also been found in moist borrow pits along roads and in swamps along railroad tracks. In North America, it is invasive in habitats that support cattails (*Typha* spp.), reed canarygrass (*Phalaris arundinacea*), sedges (*Carex* spp.), rushes (*Juncus* spp.), willows (*Salix* spp), common reed (*Phragmites australis*), and bulrushes (*Scirpus* spp.). Its growth and distribution are limited by cold temperatures and altitude.

Spread

Purple loosestrife is found throughout the Northern Hemisphere as far north as the 65th parallel and as far south as Italy in Europe. Immigrants to North America and across North America carried seeds for medicinal herb gardens and horticultural plantings. Seeds were carried in soil, often moist sand from tidal flats where purple loosestrife grew in Europe, used for ballast to balance loads in cargo ships. Seeds may have been intentionally introduced by beekeepers. Seeds are also believed to be transported by attaching to wool on sheep.

The seed containing capsules burst upon maturity facilitating short distance dispersal of seeds. In natural systems, seeds disperse long distances by floating in water currents and can be carried by waterfowl and wetland animals. The light seeds are also carried by wind. Adhesion to vehicles, boats, and boots may also disperse seeds. After mechanical disturbance, stems, root crowns, and root fragments can disperse by moving in water currents and initiate new populations. Draining of wetlands for agriculture and nutrient loading of waters is believed to have contributed to its colonization and spread.

Impacts

Studies indicate large-scale infestations can affect plant, animal, and water resources, and riparian/wetland community function. Purple loosestrife reduces wetland plant species richness and diversity. In competition experiments, purple loosestrife replaced cattail in shaded and full-sun conditions regardless of initial densities of each species. It similarly out-competed over 20 wetland plant species under variable nutrient levels and seasonal flooding within a few years. Forage production in wetland pastures is reduced by purple loosestrife infestations where livestock and wildlife only utilize young loosestrife plants prior to mid-June. The stems and roots are unpalatable to muskrats.

Many waterfowl species do not nest in dense stands of purple loosestrife including black terns, rails, grebes, and the least bittern. At the Montezuma National Wildlife Refuge in upstate New York, the disappearance of a population of 1,000 breeding pairs of black terns coincided with a population explosion of purple loosestrife. Purple loosestrife also affects water quality and wetland function. Its leaves have twice the phosphorous concentration of cattail leaves and decompose more rapidly resulting in a nutrient flush in the fall. Cattail and sedge leaves

decompose in the winter and spring. The change in timing of phosphorous release may accelerate eutrophication downstream of infestations, and may jeopardize detritivore communities adapted to decomposition of plant tissues in spring. This could have negative affects on some fish populations.

Along with being valued as an ornamental plant, purple loosestrife has a long history of medicinal uses. The first century Greeks juiced the leaves to relieve mouth infections, used stems and flowers as a wound dressing, and believed it was affective against sleepwalking. The Romans used it as a red dye, as a dressing for foot sores, and thought it kept away snakes. More recently, the tannin-rich leaves were used to remedy diarrhea, dysentery, bleeding, wounds, ulcers, and sores. Bees use the nectar and pollen, and beekeepers have been implicated in its spread.

Management Alternatives

Herbicide

There are four chemicals that can be used to manage purple loosestrife on sites with standing or moving water typical of where it invades. Triclopyr and glyphosate are used most commonly. However, 2,4-D, and imazapyr are also formulated for aquatic applications. The surfactants used in the formulation of herbicides or added to spray solutions to improve herbicide performance can be more toxic to non-target aquatic organisms than the active ingredient of the herbicide. Therefore it is important to only add surfactants with an aquatic label where the spray may come in contact with standing or moving water. In Montana, applicators need a 308 permit from the Montana Department of Environmental Quality before applying aquatic herbicides to water (http://deq.mt.gov/wqinfo/mpdes/pesticides.mcpx). Experimental treatments using glyphosate or triclopyr eliminated all purple loosestrife stems the first year after treatment. However, two years after herbicide application, purple loosestrife stem densities were almost nine times higher where triclopyr was sprayed and 4.5 times higher where glyphosate was sprayed compared to pre-treatment levels. This indicates repeated applications, or herbicide applications combined with biological control insects, are needed for long-term population suppression.

Triclopyr formulated for use in wetlands (Garlon 3A®, Triclopyr 3 SL®, and Renovate3®) applied as a foliar broadcast application at six to eight quarts per acre is most effective when purple loosestrife is in the bud to mid-bloom stage. This is when plants are actively growing, the toxic chemical is moved into roots, and when roots reserves needed to regenerate from defoliation are at their lowest level. The second optimum timing is in September when starches in the roots are being converted to sucrose important for cold tolerance and surviving freezing temperatures over winter. A wetland non-ionic surfactant (Agri-Dex®, LI 700®, Cygnet Plus®, and others) is needed at 0.5% by volume (two quarts per 100 gallons solution) in the spray solution. A minimum of 50 gallons spray solution per acre is recommended for thorough wetting of the weed canopy and adequate control. A 1% to 1.5% solution (5 to 7.6 fluid ounces in four gallons water) can be used for backpack spraying. All purple loosestrife plants should be thoroughly wetted. Annual application may be needed to target plants re-growing from root stocks and the seed bank.

Glyphosate, a non-selective herbicide that affects both broadleaf and grassy plants, can be broadcast sprayed at two quarts per acre, as a 1% solution, or wick applied in a 33% solution. A

formulation registered for use in and around water (Rodeo®) should be used, and a non-ionic

surfactant labeled for use in water can be included in the spray solution at 0.5 % volume (two quarts per 100 gallons solution). Glyphosate should be applied to actively growing plants and best results can be expected when it is applied during bloom. If applied at late bloom, plants may still produce seeds which can be clipped and bagged to prevent spread. One study found glyphosate most effective when applied in mid-August (late-bloom). Glyphosate is also effective when applied in September to actively growing plants. Selective spot treatment can be used to avoid injuring neighboring non-target plants that can fill in the areas opened by removing the purple loosestrife.

Imazapyr can be applied at one pint per acre (Habitat®) to actively growing plants. A non-ionic surfactant with an aquatic label is needed for imazapyr to be effective. Broadcast applications of 2,4-D with an aquatic label (DMA*4IVM®) at one to two quarts per acre or a 0.5% to 1% solution applied to the bud or early bloom stage will kill top growth. Repeated applications will be needed to target plants regenerating from roots. An aquatic surfactant can be used (0.5% by volume) to improve effectiveness.

Table 1. Chemical and product name, recommended application rate, soil residual half life, and eco-toxicity of herbicides commonly used to control purple loosestrife.[1/]

Chemical name	Product name	Rate	Half life-days	Eco-toxicity (LC_{50}/EC_{50}) for aquatic organisms
tryclopyr	Garlon 4®, Remedy®	6-8 qt./ac. or 1%-1.5% solution	14-180	0.1-1 mg/L
glyphosate	Rodeo®,	2 qt./ac. or 1% solution	47	3-11 mg/L
imazapyr	Habitat®	1 pt./ac.	31-233	>100 mg/L
2,4-D	DMA*4IVM	2 qt./ac. or 1% solution	7	1-10 mg/L

[1/] Any mention of products in this publication does not constitute a recommendation by the NRCS. It is a violation of Federal law to use herbicides in a manner inconsistent with their labeling.

Biological Control

Five biological control insects have been approved for release in the United States. Adults and larvae of the black-margined and golden loosestrife beetles (*Galerucella calmariensis* and *G. pusilla*, respectively) feed on buds and leaves, stunting plants and reducing seed production. Adults overwinter in the soil and vegetation surrounding infestations, and therefore soil cultivation within 50 yards (50 m) of the wetland edge should be avoided in the spring until adults move into the purple loosestrife plants. Adults disperse in the spring during the first few weeks of plant growth and lay eggs from May through June. The eggs incubate for 12 days. The three larval stages feed for about 14 days; pupate in soil beneath plants and in the spongy tissue

of stems in standing water. Pupation lasts seven days. Adults of a second generation can emerge

and disperse to new populations during July and August in warmer climates. This insect also feeds on, but does not reproduce on, the native winged loosestrife (*L. alatum*) and swamp loosestrife (*Decodon verticillatus*, only found in eastern North America), the introduced hyssop loosestrife (*Lythrum hyssopifolium*), and crapemyrtle (*Lagerstroemia indica*), neither of which are reported in Montana. The beetle can survive cold winter weather, but not continuously flooded areas, because adults need drier overwintering sites. Freshly overwintered adults collected by sweep net or hand picked can be transferred to new sites once egg deposition has begun. Release numbers from 250 to 500 adults are recommended to initiate a population. Loosestrife biomass decreased by 90% after release of these beetles in Oregon and Washington. Large plants can re-grow and flower after attack by the beetles. Studies indicate it takes three to five years after establishment for *G. calmariensis* to impact a purple loosestrife population.

Larvae of the loosestrife root weevil (*Hylobius transversovittatus*) feed continuously on the root storage reserves during the growing season reducing the plants ability to recover after defoliation. The adults feed on the foliage. The robust adults (8-12 mm long) emerge in mid- to late summer and live up to three years. Females lay one or two eggs in the soil or stems at the soil surface daily from June through August. Eggs hatch in 11 days. Larvae mine the roots from August through June, although the larval stage can last for two years. They pupate in the root crown during late spring and early summer. Adults are hand collected at night. As with the loosestrife beetles, this insect also utilized winged and swamp loosestrife in host specificity tests.

The loosestrife seed weevil (*Nanophyes marmoratus*) feeds on flower buds (larvae) and developing leaves (adults). Adults appear on plants in mid-May and lay eggs inside immature flower buds from June to September. The larvae eat stamens, petals, and ovaries in unopened buds. They form chambers in the damaged buds where they pupate. Adults are collected using a sweep net or by dislodging them from inflorescences with a stick onto a tray and capturing them with an aspirator. Releases of 100 to 200 adults are recommended. Severe defoliation by the loosestrife beetles can reduce inflorescence availability for weevil oviposition. Therefore release of the weevil is not recommended where there are heavy populations of loosestrife beetles.

Field release of the seed consuming weevil *Nanophyes brevis*, approved for release in North America, was postponed because the original shipment from Europe in 1994 was contaminated with a parasitic nematode.

Physical Control

Hand pulling or digging is most effective where infestations are small and composed of one to two year old plants without a well developed root system. Removal of as much of the root system as possible while minimizing soil disturbance that may favor purple loosestrife re-establishment is recommended. Roots and stems should be burned or bagged and disposed of in the trash to prevent re-growth. During flowering, stems can be cut to remove inflorescences and prevent seed production and spread. As with pulling and digging, cut stems should be disposed of to prevent re-sprouting. Burning favors purple loosestrife spread and is not recommended unless burning is used to remove old plant litter to improve herbicide contact with actively growing stems. Livestock grazing of purple loosestrife has not been studied, but it is likely not practical, considering the wetland habitats it invades. Similarly, control using tillage is not practical and the mechanical disturbance is more likely to spread the weed than control it.

Flooding populations with one foot or more of water for two consecutive years reportedly reduced purple loosestrife density. All seedlings have been killed with eight weeks of flooding at all depths tested. Three years of flooding with 16 inches of water reduced purple loosestrife density and increased cattail density threefold. However, flooding may threaten some desirable species and alter community composition, and may increase spread by increasing the area of moist, bare soil for seedling establishment. Flooding after purple loosestrife removal may prevent its regeneration from seeds.

Revegetation

Revegetation of disturbed riparian sites can be used to prevent purple loosestrife establishment and to reduce re-establishment after control procedures are applied. Native perennial plants adapted to site hydrologic conditions should be established to minimize exposed bare soil during periods of moisture availability and to create a shaded environment inhospitable to purple loosestrife seedling survival. Fowl mannagrass (*Glyceria striata*), foxtail sedge (*Carex alopecoidea*), and reed canarygrass (*Phalaris arundinacea*) have achieved dominance and prevented re-invasion in plots where purple loosestrife was experimentally removed. Smartweed (*Polygonum lapathifolium*) is reported to out-compete purple loosestrife during its first year of growth. Seeding Japanese millet (*Echinocloa frumentacea*, also called billion-dollar grass) at 30 pounds/acre on exposed moist soil after drawdown and before purple loosestrife seedlings began to grow provided control. Japanese millet is considered an exceptional wildlife plant. Guidance on seeding and planting techniques can be found in the NRCS Field Office Technical Guide (FOTG), Section IV, Practice Standards and Specifications for Riparian Forest Buffer (Code 391) and Riparian Herbaceous Cover (Code 390).

State, area and field resource specialists can help determine the most appropriate, site-specific species mix, timing of seeding or planting, and seeding or planting methods. Where herbicides have been applied, chemical carryover should be assessed prior to planting permanent vegetation.

Integrated Pest Management

Integrated pest management uses a combination of mechanical or physical, biological, and chemical pest control methods selected to optimize control efficacy while minimizing associated risks to human health, property, and the environment. Statewide, purple loosestrife can be considered in the early phase of invasion in Montana. Management strategies most appropriate for early phase invasions are prevention, early detection and rapid response, and containment, and should be applied according to local purple loosestrife population characteristics.

In riparian/wetland areas not infested with purple loosestrife, regular surveys (every three years) for new purple loosestrife populations should be planned. An early inspection should be made before or at early flowering, to initiate control before seeds set and have an opportunity to disperse. Individual plants should be considered high-priority targets for eradication programs. Records of plant densities and GPS location should be maintained and updated at each inspection. In addition, horticultural plantings of purple loosestrife should be replaced with non-invasive species.

Individual plants and populations detected along irrigation ditch banks should be prioritized for eradication using spot spray treatments (follow label instructions regarding restrictions for herbicide application on active irrigation ditches). Large-scale populations should be contained by early detection and eradication of satellite populations, and containment of the parent population using herbicidal control along its borders. One study suggests integrating herbicidal control with *G. calmariensis* is more effective at suppressing purple loosestrife populations than either treatment applied alone. Biological control insects should be established in the center of large-scale populations where herbicides are not sprayed. Over time, large-scale populations can then be reduced by herbicide applications from the edges to the center. Insects established in the center of the population will reduce seedling re-establishment where herbicides have been sprayed.

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