

Dalmation and Yellow Toadflax

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Dalmatian Toadflax (*Linaria dalmatica*) and yellow toadflax (*Linaria vulgaris*) are aggressive, highly competitive noxious weeds that were introduced into North America as ornamentals, fabric dyes, and folk remedies. They soon escaped from gardens to infest farmland, pastures, and rangeland across the United States and Canada, displacing native plant species, livestock forage, and wildlife habitat. Unfortunately, toadflax continues to be sold commercially as an ornamental plant, and is recommended for xeriscape (low-water-use) landscape plantings. Toadflax thrives in a wide range of habitat types and climate zones and is expensive and extremely difficult to manage, partly because of localized biotypes that respond differently to herbicides and other management tactics.



Much of the information in this chapter applies to both Dalmatian and yellow toadflax; however, the differences between the species can be important in management efforts, and should be considered when designing a management program.

Identification

Three species of toadflax are considered noxious weeds in the United States and Canada: broad-leaved Dalmatian toadflax, all in the plant family Scrophulariaceae. These toadflax species are herbaceous perennials with stems that are robust and somewhat woody at the base and smooth toward the top.

Stems of broad-leaved Dalmatian toadflax grow 2 to 3 feet or taller. Both leaves and stems are waxy with a whitish or bluish cast. The leaves are usually heart-shaped, but can vary from broad to lanceolate shape, especially on lower portions of the plant, and the bases tend to wrap around the stem. Flowers grow at the bases of upper leaves and are bright yellow with an orange center and a spur on the end that is approximately as long as the rest of the flower combined. The mature narrow-leaved Dalmatian toadflax plant is quite similar in appearance to broad-leaved Dalmatian toadflax, except for the somewhat narrower leaves and smaller flowers. Management information for broad-leaved Dalmatian toadflax will apply to both Dalmatian species in this text.

Yellow toadflax stems are usually 1 to 3 feet high, are somewhat woody at the base and smooth toward the top, sparingly branched. Leaves are narrow, linear, somewhat pointed at both ends,

and 1 to 2 inches long. Stems and leaves are pale green. Flowers, which grow at the bases of upper leaves, are bright yellow with an orange center, with a spur that is approximately as long as the rest of the flower combined. Flowers occur at first in clusters near the ends of the stems, becoming more widely spaced along the stem as the season progresses.

Hybrids between yellow toadflax and Dalmatian toadflax can be produced in the laboratory, so natural occurrence of this hybrid in the field should be considered.

Origin, History, and Distribution

The Dalmatian toadflaxes are native to the Mediterranean region. In Europe the broad-leaved species has been cultivated as an ornamental for nearly four centuries, and was brought to the west coast of North America as an ornamental about 1874. Currently, heaviest North America infestations of this escaped ornamental are found in the northwestern states, British Columbia, and Alberta, and in widely scattered locations in other regions. In North America, broad-leaved Dalmatian toadflax is the most widely distributed of the two Dalmatian species. However, in the native Eurasian habitat narrow-leaved Dalmatian toadflax is the more widely distributed of the two, possibly indicating its potential to become widely distributed in North America as well. Narrow-leaved Dalmatian toadflax is currently found in several locations in western Oregon, northwestern Washington, and occasionally in British Columbia.

Yellow toadflax originated in south-central Eurasia where it has been used for centuries as a folk remedy and fabric dye. It was introduced into New England in the late 1600s as an ornamental and folk remedy and continues to be sold today in nurseries and seed catalogs as "Butter and Eggs," "Jacob's Ladder," or "Wild Snapdragon"; infestations still originate from these escaped plantings. By the 1950s yellow toadflax had spread throughout North America. Distribution is most common throughout the northeastern United States and southeastern Canada, and localized in other parts of the continent, particularly the western Canadian provinces.

In their regions of origin, Dalmatian and yellow toadflax evolved in plant communities that are grazed moderately to intensely, primarily by sheep and goats, and by cattle to a lesser extent. Because much of the land is arable in the region of origin, many populations have evolved with, and are adapted to, the periodic disturbances of agriculture.

Potential for Invasion

The toadflax species are unpredictable, variable weeds. High genetic variability enables these weed to adapt to a wide variety of conditions. Characteristic plant communities associated with toadflax species are those associated with disturbed, open habitats.

Dalmatian and yellow toadflax are often found in well-drained, relatively coarse-textured soils varying from coarse gravels to sandy loams, but are also sometimes found in heavier soils. They are highly competitive in areas where summers tend to be dry. Areas of low competition between species, sparsely vegetated soils, and drier, open areas on rangeland seem susceptible to invasion

in some cases, particularly south-and southeast-facing slopes. Sites where Dalmatian and toadflax can establish include roadsides, areas near dwellings, vacant lots, cemeteries, gravel pits, fields, waste areas, and other disturbed sites, spreading to valleys, sagebrush flats, and overstocked spring-grazed pastures.

Minimum and no-till farming methods could enable yellow toadflax to invade or re-invade areas where regular tillage has kept populations at acceptable levels. Wet or dark conditions appear to limit yellow toadflax, although it is often found on well-drained gravelly or rocky river banks. Roadsides, dry fields, grainfields, waste areas, gravel pits, pastures and rangeland, clearings, clearcuts, vacant lots, and railroad yards are sites typically colonized by yellow toadflax.

Even in pristine areas and on rangeland in excellent condition, new infestations of Dalmatian or yellow toadflax can establish in naturally-occurring disturbances or small openings. Once the highly competitive vegetative growth begins, the condition of the rangeland will probably do little to slow expansion of the infestation.

Impacts

~Ecological and Environmental

Dalmatian and yellow toadflax can displace existing plant communities and associated animal life. Loss of forage can impact big game species, especially on winter ranges. Although deer have been observed to browse Dalmatian toadflax and seed is used by some species of birds and rodents, it is not known to be heavily used by any native species. All toadflax species can provide cover for smaller animals. Where sod-forming or bunch grass communities are replaced by toadflax, soil erosion, surface runoff, and sediment yield can be increased. However, on harsh, sparsely vegetated sites toadflax can actually help stabilize soil.

~Economic

The toadflaxes can displace desirable plants, cause loss of forage for domestic livestock and some big game, and habitat loss for associated animal life. The economic impact of Dalmatian toadflax is primarily on rangeland and wildlife habitat, while yellow toadflax can be a serious problem on cultivated land as well as on rangeland.

Economic data specific to Dalmatian toadflax are scarce, but direct management costs averaged \$40 per acre in 1992 on a Montana ranch of which 30% of the 1,064 acres was severely infested with Dalmatian toadflax. Reduction in cattle-carrying capacity and reduction in the appraised value of infested ranch land increases the economic impact.

Cattle will sometimes casually browse flowering shoots. Occasional cases of mild poisoning have been reported for cattle, but the toadflaxes are usually avoided by cattle, and such cases are rare. Sheep will use Dalmatian toadflaxes as a major food source, showing no apparent ill effects.

Yellow toadflax can be a serious weed in cultivated crops, as well as on rangeland, and is believed to become more prominent in reduced-tillage farming operations. This problem is compounded by the ineffectiveness of herbicides in many cases. In Alberta, a 1987 survey showed an estimated 69,188 acres infested with the weed. Twenty percent of the infestation was on rangeland and non-agricultural land, and 30% was in annual crops and forages. These infestations cost more than \$360,000 per year, or about \$5.25 per acre.

In New York state, the root system has been found to provide an overwintering site for cucumber mosaic virus and broad bean wilt virus, disease pests of cultivated crops.

Yellow toadflax is reported to be mildly poisonous to cattle, but reported cases of poisonings are rare, probably due to avoidance of the plant.

Biology and Ecology

Dalmatian and yellow toadflax are deep-rooted, short-lived herbaceous perennials that reproduce by seeds and by vegetative buds on the roots.

~Seeds

A single Dalmatian toadflax plant can produce up to 500,000 seeds beginning in late June or early July in northern climates, and continuing until September or early October. In one study, 97% of total seed production occurred in the first five weeks. Seed production can begin on lower portions of the stems while upper portions are still in various stages of bloom.

Yellow toadflax seed capsules usually contain 10 to 40 seeds, with numbers being highly variable. Number of seeds produced per plant is considerably less than Dalmatian toadflax and have been estimated at 15,000 to 30,000.

Dalmatian toadflax seed dispersal begins as early as July in northern climates and continues into winter. Dried floral stalks can remain standing for two years, retaining some seeds but dispersing most during the first year. Yellow toadflax seed dispersal begins in August or September in northern climates and continues into winter.

Although wind has been considered a major means of seed dispersal for toadflax species, it may be less a factor than previously thought. Studies of yellow toadflax have shown that 80% to 90% of seeds fall within 18 inches of the parent plant.

Individual yellow toadflax plants live up to four years, but it is difficult to determine which parts are individual plants, because of vegetative reproduction characteristics. Theoretically, a stand may persist indefinitely.

Management

Successful management of the toadflax species requires integrating as many management

strategies as possible into the program design. This is especially important for the toadflaxes, because of their high genetic variability. This variability results in localized populations that respond differently to the same herbicides, management methods, biological control agents, and environmental conditions. Management programs for Dalmatian toadflax should emphasize equally the prevention of seed formation and vegetative spread, while programs for yellow toadflax can emphasize control of vegetative spread with secondary emphasis on prevention of seed formation.

~Prevention

Because the toadflax species are expensive, labor-intensive, and extremely difficult to manage once infestations become established, preventing infestations from occurring is time- and cost-effective. New infestations of toadflax originate from seeds or vegetative buds on root pieces; therefore, keeping seeds and contaminated materials or equipment out of uninfested areas is good strategy.

Farm operations, outdoor recreation, and other human activities can transport seeds into uninfested areas. Seeds can be transported in mud on motorbikes, construction equipment, vehicles, agricultural machinery, tires, and in mud on feet of livestock. Check and clean equipment before moving it into uninfested areas or before bringing it in from infested areas. Fill dirt and landscaping soil can also bring seeds into an uninfested area.

When moving livestock from infested to uninfested areas, hold them in corrals or small pastures until viable seeds have had time to pass through the digestive tract. Hold cattle six days and sheep 11 days. Monitor these holding areas regularly for seedling establishment. Avoid purchasing feed or seed that could be contaminated with weed seeds.

~Mechanical and Physical Controls

Pulling toadflax by hand can be effective for small infestations, especially in sandy soils or when soils are moist. Pulling each year for five to six years is necessary to deplete the remaining root system of reserves. Try to follow lateral roots to their ends. The site must be revisited for 10 to 15 years to remove seedlings produced from dormant seeds.

Because established infestations of yellow toadflax spread mainly by roots, physical removal can limit spread.

Mowing is not recommended for any of the toadflax species, since it does not affect root reserves or buried seeds, nor is it feasible on most sites. Hand-removal of the flowering tops from the plants is a marginal strategy even for very small infestations.

~Cultural Controls

Active growth of the toadflax species during all seasons enhances the competitiveness of the species. However, the initial vulnerability of toadflax seedlings often enables well-adapted plant species to outcompete toadflax seedlings. Through seeding and/or land management, encourage combinations of desirable species that can provide competition throughout the season and at all levels of the soil profile, providing competition with toadflax through time and space. After initial weed control activities, areas should be seeded with a mixture of competitive, well-

adapted species. Rangeland in excellent condition can outcompete many germinating toadflax seedlings.

Low viability of yellow toadflax seeds can make competition by desirable species an even more effective strategy for this species. In cropland, barley appears to inhibit vegetative reproduction of yellow toadflax to some extent.

~Grazing

Overgrazing by cattle in spring can increase establishment of toadflax because seedlings can more effectively compete with grazed plants for soil moisture and other resources. Timing of grazing is important in developing and maintaining competitive, desirable plant communities that reduce establishment of seedlings for long-term toadflax management. Grazing strategies will be less effective in restricting expansion of established stands, because of toadflax's deep, competitive roots.

However, preliminary results of field trials in Montana show that sheep can be used to help suppress stands of Dalmatian toadflax and limit seed production. In these studies, 1,000 ewes and lambs were placed in a hilly rangeland area of moderate to heavy infestations with Dalmatian toadflax densities of 25% to 100% of existing vegetative coverage. Approximately 35% to 45% of the toadflax foliage was stripped, including the terminal 6 to 10 inches of plant stems. Although initially the sheep only nibbled at the plants, in two to three weeks they were consuming Dalmatian toadflax regularly, even though other forages were present. In these studies, the sheep did well and showed good weight gain.

Burning is usually not effective for the toadflaxes, because root buds and buried seeds are unaffected. Burning can increase the competitiveness of the toadflax by removing desirable plants. Removal of top growth can also stimulate production of vegetative shoots. However, scorching of floral stalks using propane burners can help prevent seed production.

~Biological Controls

As of 1998, several species of insects have been released on Dalmatian toadflax, including a defoliating moth (*Calophasia lunula*), an ovary-feeding beetle, and two seed capsule-feeding weevils (*Gymnaetron antirrhini* and *Gymnaetron netum*). A stem-boring weevil and a root-boring moth have been released in Canada and the United States.

All insect species that have been released for control of Dalmatian toadflax also attack yellow toadflax, and are intended as biological control agents for that species, also.

~Chemical Controls

Effectiveness of herbicides used to manage the toadflax species is highly variable, partly because of the plants' high genetic variability. The waxy leaf surface of Dalmatian toadflax provides a protective barrier that hinders herbicide uptake in some cases. Soil type is also important, since it is more likely that the herbicide will leach below the plant root zone on sites with sandy soils or soils low in organic matter, especially in stands in which lateral roots are very close to the soil surface.

Even when herbicide treatment of toadflax appears to be effective, long-term control may not be achieved and reinvasion may occur. It is necessary to treat an infestation every three to four years for as long as 12 years to eradicate the weed on sites where herbicides are effective.

Source: Montana Weed Control Association