USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Plant Guide

SPOTTED KNAPWEED

Centaurea steobe L.

Plant Symbol = CEST8

Contributed by: USDA NRCS Montana Plant Materials Program

Figure 1. Spotted knapweed flower heads. Photo by Christina Herron, Montana State University, Bozeman, Montana. Used with permission.

Alternate Names

Common Alternate Names: None
Scientific Alternate Names: *Centaurea maculosa* Lam., *Centaurea biebersteinii* DC.

Taxonomy: Spotted knapweed is in the Asteraceae (sunflower) family. In its native range of Western, Central, and Eastern Europe, two sub-species have been identified; *Centaurea stoebe* spp. *stoebe* is diploid and biennial, and subspecies *C. stoebe* spp. *micranthos* is tetraploid and perennial. The perennial subspecies is considered more invasive in Europe than the biennial subspecies. The invasiveness of the North American taxon, *C. stoebe* spp. *micranthos*, has been ascribed to it being perennial because it can tolerate dense vegetation once it has become established, whereas the biennial is more dependent on disturbance.

In the Ukraine, spotted knapweed hybridized with diffuse knapweed (*Centaurea diffusa*) on sites where the two species coexisted. In North America, hybrids of the two species are only found on sites invaded by diffuse knapweed leading to the hypothesis that hybrid individuals were introduced into North America with diffuse knapweed (Blair and Hufbauer, 2009).

Uses

Bee keepers value the flowers of spotted knapweed because of the flavorful honey produced from its nectar.

Status

Spotted knapweed is listed as noxious, prohibited, banned or otherwise regulated in 16 states. Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Weediness

This plant is weedy or invasive in some regions or habitats and may displace desirable vegetation if not properly managed. Please consult with your local NRCS field office, cooperative extension service office, state natural resource, or state agriculture department regarding its status and use. Weed information is also available from the PLANTS Web site at http://plants.usda.gov/. Please consult the Related Web Sites on the Plant Profile for this species for further information.

Description

General: Rosette leaves grow from buds on the root crown of a deep taproot. They have short stalks and grow up to eight inches long and two inches wide and are deeply divided once or twice into oblong lobes on both sides of the center vein. Flower stems are eight inches to four feet tall and branch on the upper half. Stem leaves are smaller toward the stem apex, alternately arranged, sessile, and have few lobes or are linear and entire. Flower heads are solitary or in clusters of two or three on the branch ends, ovate to oblong, ¼-inch wide and ½-inch long. The involucres bracts of the flower head are imbricate, widest and yellow-green at the base, with black margins, obvious dark longitudinal veins, and a fringe of spines, the central spine shorter than the lateral ones. There are 20 to 30 purple to pink (rarely white) flowers per flower head. Seeds are ⅛-inch long, oval, brown to

black, with pale longitudinal lines and a pappus of short, simple, and persistent bristles.

Life History: There are four relatively distinct and measurable life history stages of spotted knapweed; seeds, seedlings, rosettes, and flowering plants. Spotted knapweed reproduces only by seeds. Seed production of spotted knapweed in western Montana ranged from 10,760 to 83,950 per square foot on an Idaho fescue habitat-type (Jacobs and Sheley, 1998), was measured at 46,285 per square foot in Colorado (Seastedt et al., 2007), and was reported as high as 430,550 per square foot in Washington (Shirman, 1981). In Montana, viable seeds were recovered from soil that had no seed inputs for eight years (Davis et al., 1993). Seedlings are first-year emergents and are difficult to distinguish from seedlings of other forb species. Spotted knapweed can persist for an entire growing season in the seedling stage. Rosettes can develop from seedlings within one growing season, and can be identified, in most cases, by the distinctive pinnatifid, oblong-lobed leaves. In addition, plants that flower in one year may persist in the following year as rosettes. Flowering plants are distinguished by the production of an upright (except when heavily grazed or repeatedly mowed) paniculate inflorescence with few to many branches and reaching heights of eight inches to four feet depending on the environmental conditions and plant competition. Development of flowering plants from seedlings in one growing season is common. Flower heads develop on branch ends and are distinguished by the comb-like fringed, black-tipped involucre bracts and the pink to light-purple flowers. Each flower head can have as many as 30 flowers each producing one seed. Sensitivity analysis of life history stages and calculated transitions has identified early summer rosette survival, the transition from the rosette stage to the flowering plant stage, flowering plant survival, and seeds produced per flowering plant as life history stages and transitions critical to spotted knapweed population fitness (Jacobs and Sheley, 1998).

Distribution: Spotted knapweed is native to Central Europe east to Central Russia, Caucasia, and Western Siberia. It was first reported in North America in 1883 from Victoria, British Columbia and has since spread to all but eight continental provinces and states. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: In its native range spotted knapweed commonly grows in the forest-grassland interface on deep, well-developed to dry soils. It forms dense stands in more moist areas on well-drained soils including gravel, and on drier sites where summer precipitation is supplemented by runoff.

Ethnobotany
Centaurea is appropriately derived from the Greek word for Centaurs, *kentaruion*, which were the mythical creatures with human heads, arms, and chests, and the rest of the body like that of a horse. The unruly Centaurs that lived in herds around Mount Pelion in Thessaly, Greece, were a plague to people around them.

Adaptation
In North America, Spotted knapweed has been reported from elevations ranging from 1,900 to over 10,000 feet, in precipitation zones ranging from 8 to 79 inches annually, and growing on a wide range of soils types.

Establishment
Spotted knapweed establishes from seed only. Seed crops have a high percent viability and will germinate in the fall of the year produced, the following spring, or will remain dormant and viable at a significant percentage for eight or more years (Davis et al., 1993).

Pests and Potential Problems
Spotted knapweed is a difficult to manage weed pest in the semi-arid west and in the mid-western United States and Canada.

Environmental Concerns
Areas with large-scale and dense infestations of spotted knapweed have increased surface water runoff and stream sedimentation and reduced soil water infiltration (Lacey et al., 1989), reduced forage production for some classes of livestock (Watson and Renney, 1974), and reduced wildlife habitat (Spoon et al., 1983).

Control
Herbicides: Short-term control of spotted knapweed populations is effective using herbicides. The length of control (i.e., the time the population regenerates from seeds in the soil) will depend on the size of the soil seed bank (effected by how long the population has been there), soil residual activity of the herbicide (effected by soil texture and precipitation), and the competitiveness of the plant community. Picloram applied at one pint product per acre (0.25 pounds active ingredient per acre) can provide 90 percent or more population reduction for three or more years on loamy soils with a well-maintained grassland community. However, picloram is a restricted-use herbicide and cannot be applied near surface water or where there is a high water table. It is water soluble, mobile, and will leach quickly from the rooting zone in sandy soils. Picloram also breaks down in sunlight which reduces its residual activity. Because of the residual activity, timing of picloram application is not as critical as with other herbicides with less residual activity. Spring, early summer, and fall applications result in the greatest control. Application during the hot and dry part of the summer should be avoided because uptake into the plant is limited when plants are dormant and the active ingredient breaks down rapidly in the sun.

An alternative to picloram is 2,4-D, a broadleaf selective herbicide, which can be applied to sensitive areas or where the use of picloram is prohibited. The timing of 2,4-D application is important for maximizing control

because this herbicide has brief residual soil activity. To have the greatest reduction of spotted knapweed populations, 2,4-D should be applied after most of the seeds have germinated and before plants flower, generally at the late bud stage but before flowers appear. This timing will target early summer rosettes, prevent the transition from rosette to flowering plant, and eliminate seed production. These are life history stages and transitions that are most important to spotted knapweed population fitness. Repeated annual applications of 2,4-D may be necessary to maintain control of plants that regenerate from the soil seed bank. However, re-application will depend on the degree of seedling suppression by competitive plants. Other herbicides available for control of spotted knapweed include products that contain aminopyralid, dicamba, clopyralid, or triclopyr.

Biological control: There are eight flower head insects and five root-boring insects that have been approved and released for biological control of spotted knapweed in the United States (Story et al., 2004). Most of these insects are available commercially or through state, federal, or private programs. Once insects are established they can be collected on site and re-distributed. Bio-control insects may reduce spotted knapweed populations where competitive plants are available, but without other management, are unlikely to eradicate populations.

Urophora seed head flies were released over 20 years ago and are well established throughout most of the spotted knapweed-infested areas in the western United States. These species have been observed to reduce seed production by 50 percent or more. Other flower head feeding insects are not as widely distributed, but may be as effective as the *Urophora* fly. The *Larinus* flower-head weevils and *Metzneria* seed head moth are believed to be effective in reducing seed production. *Larinus* species prefer hot dry sites and *Metzneria* does best on sites with winter snow cover. A Montana study calculated the reduction in seed production by the combination *Urophora* and *Larinus* feeding to be 84.2 to 90.5% (Story et al., 2008). However, seed feeding insect species are not compatible with each other. On a site in Colorado, *Larinus* consumed about 40% of *Urophora* in co-infested spotted knapweed flower heads (Seastedt et al., 2007) and in Montana *Urophora* reproduction was 71 percent lower when *Larinus minutus* was present (Smith and Mayer, 2005). Poor establishment of the *Chaetorellia* and *Terellia* flies is believed to be the result of competition with other flower head insect species. The larva of *Metzneria* and *Bangasternus* will attack other insects in the seed head. The *Bangasternus* seed head weevil feeds primarily on diffuse and squarrose knapweed, but reduces spotted knapweed seed production by up to 95%.

Of the root feeding insects, the *Agapeta* root moth, *Cyphocleonus* root weevil, and *Sphenoptera* root borer are well established in parts of the western states. These species prefer hot, dry, open sites. Reductions in spotted knapweed biomass and density have been noted 10 years after the release of root-boring weevils (Jacobs et al., 2006). Observations suggest that the *Cyphocleonus* root weevil reduces the longevity of spotted knapweed plants making their duration more biennial than perennial, and thus less competitive with perennial grasses. Combining the root herbivore *Cyphocleonus* with the seed feeding weevil *Larinu*s reduced spotted knapweed biomass and seed production additively compared to either insect alone in a common garden study, and the presence of plant competition further decreased knapweed growth (Knochel et al., 2010).

The *Pelochrista* root moth first released in Montana in 1984 has been slow to establish for unknown reasons. The *Pterolonche* root moth was released and established in Oregon in 1986 but has not been recovered since 2000, presumably because of the dramatic control of diffuse knapweed (another host for this species) by the seed head weevils (Story et al., 2004).

Reductions in spotted knapweed densities have been observed in southwestern Montana after the release of flower head-and root-feeding biological control insects. In most cases, two or more insect species establish on the spotted knapweed population. Ten years after the release and establishment of *Cyphocleonus achates* and *Larinus spp*. in large scale and dense populations of spotted knapweed, three different plant communities were observed depending on management treatments. Where the biological control insects were released and no other management was used, the plant community remained dominated by spotted knapweed. Where picloram was applied and the biological control insects established on spotted knapweed regenerating from the seed bank, cheatgrass (*Bromus tectorum*) was the dominant plant in the plant community. Where picloram was used and perennial grass seeded and established, and the insects established, the perennial grasses dominated the plant community. These observations illustrate how plant community composition was important in influencing the outcome of management actions.

Grazing Control: Spotted knapweed has adequate nutritional quality during the growing season to sustain livestock and wildlife based on crude protein and neutral detergent fiber concentration of harvested and dried rosettes, bolting, and flowering/seed set plants (Ganguli et al., 2010). Crude protein concentration was greater in rosettes (20%), than bolting (12%) and flowering/seed set plants (11%). Neutral detergent fiber was lowest in rosettes (30%), followed by bolting plants (29%) and highest in flowering/seed set plants (40%). In a cafeteria-type preference trial, sheep readily consumed all spotted knapweed phenological stages, but generally selected rosettes and bolting plants over flowering and seed set plants (Ganguli et al., 2010).

In a confined grazing study, five years of repeated sheep grazing reduced spotted knapweed density and biomass compared to a control and to a first year only application of 2,4-D (Sheley et al., 2004). Also in this study, repeated sheep grazing after a one time application of 2,4-D reduced spotted knapweed density and biomass compared to the one time application of 2,4-D after five years indicating confined sheep grazing can be used in an integrated pest management program to maintain spotted knapweed below a threshold achieved after pesticide application.

A prescribed grazing study herded a band of 800 ewes and 1,120 lambs on lightly infested (13% spotted knapweed vegetative composition) or moderately infested (36% spotted knapweed vegetative composition) rough fescue/bluebunch wheatgrass (*Festuca campestris/Pseudoroegneria spicata*) foothills rangeland in western Montana in mid-June or mid-July (Thrift et al., 2008). Sheep diets averaged 64% and 26% spotted knapweed in the moderate and light infestations, respectively. Fewer graminoids were eaten in June than July in the light infestation whereas fewer graminoids were eaten July than June in the moderate infestation. The authors concluded this prescription for sheep grazing on these sites would make herbicide application uneconomical suggesting prescribed sheep grazing can be used as an alternative to pesticide application in an integrated pest management program for spotted knapweed.

Prescribed grazing to maintain the vigor and competitiveness of grassland plant communities will prevent spotted knapweed invasion. On the other hand, intense and frequent grazing pressure opens grassland plant communities to spotted knapweed invasion and re-invasion after management treatments (Jacobs et al., 2000; Jacobs and Sheley, 1999; Jacobs and Sheley, 1997).

Mowing: A hand-clipping study in west-central Montana removed spotted knapweed buds and flowers at seven different timings and frequencies (Benzel et al., 2009). Clipping when plants were bolting to flower, or later in the season, reduced spotted knapweed seed production by 90% and 100%, respectively, compared to a no clipping control. The results suggest defoliation by mowing or prescribe grazing will suppress spotted knapweed viable seed production. The results of a mowing study led to the recommendation of a single annual mowing applied at the flowering or seed producing stage for partial control of spotted knapweed (Rinella et al., 2001). However, mowing at the flowering stage or later may cause mortality of biological control insect larvae where they are established on spotted knapweed (Story et al., 2010).

Prescribed Burning: A study in western Michigan applied prescribed burning to spotted knapweed-infested gravel mine spoils in late April or May for three years reducing spotted knapweed density and biomass and increasing the dominance of warm-season grasses (MacDonald et al., 2007). The results support using carefully timed burns to optimize the reduction of low-density spotted knapweed populations while benefiting fire-adapted plant communities with abundant warm-season grasses. Prescribed burns on sites in western Montana in cool season grass communities resulted in increases in invasive species biomass and seed production (Jacobs and Sheley, 2003).

Hand Pulling: Hand pulling that extracts the root crown can temporally reduce spotted knapweed on small-scale infestations or as a follow-up treatment to initial herbicide treatment on larger-scale infestations. Pulling or grubbing the root crown is most easily accomplished when the soil is moist and a shovel is used to pry-up the tap root. When the soil is dry the plant tends to break-off above the root crown enabling it to regenerate. If flowering plants have been pulled, they should be sealed in plastic bags and disposed of in the trash to prevent seed spread. Wearing gloves while pulling spotted knapweed will protect against potential skin irritation from chemicals produced by knapweed.

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

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Prepared By: *Jim Jacobs*: USDA-NRCS, Bozeman, Montana

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