Centaurea stoebe L. ssp. *micranthos* (Gugler) Hayek
(= *Centaurea biebersteinii* DC., *Centaurea maculosa* Lam.)

Spotted knapweed

Family: Asteraceae
Range: Most contiguous states except parts of the southeast.
Habitat: Fields, roadsides, disturbed open sites, grassland, rangeland, especially degraded rangeland, logged areas. Seldom persists in shaded places. Serious infestations often occur on light, well-drained soils in areas that receive some summer rainfall.
Origin: Europe, Asia Minor; introduced into the U.S. in the 1890s.
Impact: Highly competitive with native vegetation. Forms dense stands that can exclude desirable vegetation and wildlife in natural areas.
Western states listed as Noxious Weed: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Spotted knapweed is a bushy biennial to short-lived perennial, to 3 ft tall, with a long, sturdy taproot. Plants form basal rosettes during winter and early spring (sometimes persisting as rosettes for several years) and develop erect, highly branched flowering stems in late spring and summer. Its alternate leaves are pinnate-lobed, dotted with resin ducts, and covered with short to medium interwoven grayish hairs.

The 30 to 40 disk flowers in each flowerhead are white, pink, or purple, and the phyllaries have comb-shaped, dark-colored tips which give the flowerheads a "spotted" appearance. After the flowerheads mature and dry out, they pop open, ejecting achenes near the parent plant. Achenes have a short (1 to 2 mm) bristly pappus on the top. Spotted knapweed can also reproduce vegetatively from lateral roots just below the soil surface. New rosettes may develop at about 3-cm intervals along lateral roots, expanding populations peripherally. Achenes can remain dormant in the soil for 8 years and have three germination patterns: non-dormant seeds that germinate with or without light exposure, dormant seeds that germinate in response to light, and dormant seeds that are not light sensitive. All germination types occur on each plant. Spotted knapweed has been shown to occasionally hybridize with diffuse knapweed.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand pulling is feasible for scattered spotted knapweed plants, or for areas where other control methods are not feasible and sufficient labor is available. Generally, this form of control is limited to small infested areas. Repeated hand pulling is necessary during the season and over many years. Successful control has been reported when plants were hand removed 3 times a year (spring, summer, and late summer) over a period of 5 years. Every effort should be made to remove the entire taproot with little soil disturbance. If not possible, then cut the root 2 to 4 inches below the soil surface to remove much of the reproductive crown. Gloves should be worn when hand pulling. The best timing for hand removal is before plant produce viable seed. Hand pulling has not been effective in all areas. When soil dries, it may be difficult to remove the root crown and this can lead to rapid reestablishment. Manual control methods may pose less risk to high quality waters and high value fisheries than do chemical applications. Although time- and labor-intensive, several manual control methods, including propane torching of seedlings early in the season, hand digging with small tools, mulching with black plastic, and mowing with weed eaters have proven successful for smaller populations. Mowing typically doesn't kill knapweeds; cut plants generally survive and recover to set seed. Plants

	mowed at the rosette stage will quickly recover, and mowing too late (after seed set) can disperse seed. However, mowing at the late bud to early bloom stage will reduce seed production. Mowing can also remove dead growth to improve herbicide coverage. A program of cutting only bolted plants, particularly in the early bloom stage, 2 to 4 times per year for several consecutive years can greatly suppress spotted knapweed and may shift the competitive balance in favor of desired grasses. Mowing is not possible in areas that are too rocky or steep, or with desirable shrub species. Spotted knapweed does not persist under annual cultivation, which is why it is not typically a cropland weed. However, tillage in wildland or rangelands can spread spotted knapweed, because tillage creates an ideal weed seed bed.
Cultural	Maintaining pasture and rangeland health by preventing overgrazing and minimizing disturbance can help limit knapweed establishment and spread. Grazing is not considered to be an effective eradication method. In addition, intensive grazing can create ideal seedbeds for further invasion. However, researchers have shown that cattle, sheep and goats will readily graze spotted knapweed in early spring, suppressing seed production. Sheep are the most effective. Sheep typically graze spotted knapweed from the rosette through bud stage or when it is the only plant available. The timing of grazing may be critical to its success. Early and late-season grazing appear to be the most effective control timings with sheep: early season (spring) to reduce flower production, and late season (fall) to reduce density of young plants. In one study, two consecutive years of early and late sheep grazing prevented spotted knapweed seed production, and the sheep were healthy. In addition, this grazing program had little effect on the native grass community. There is little information on the use of prescribed burning for control of spotted knapweed. On the one hand, burning has been shown to control diffuse knapweed while stimulating grass regrowth, and under the right conditions perhaps the same response might occur with spotted knapweed. On the other hand, spotted knapweed can be the first species to recover from a burn. A low-severity fire is not likely to kill the below-ground reproductive structures of spotted knapweed, but a severe fire may kill some of the plant crowns. Burning removes current growth but may enhance seed germination. Dry soil conditions at the time of burning can reduce germination. Another potential benefit of burning is that it can remove dead growth to improve the effect of herbicide applications.
Biological	Currently, there is no single biological control agent that effectively controls spotted knapweed populations. The banded gall fly (*Urophora affinis*), knapweed seedhead fly (*U. quadrifasciata*), lesser knapweed flower weevil (*Larinus minutus*), broad-nosed seedhead weevil (*Bangasternus fausti*) are established in the United States to date. The hairy weevil (*Eustenopus villosus*) that primarily attacks yellow starthistle has also been reported on spotted knapweed. These insects cause plants to produce fewer viable seeds and to abort flowers. *Larinus minutus* in particular is an aggressive and effective biocontrol insect for diffuse and spotted knapweed. Its larvae may destroy up to 100% of the seeds in an infested seedhead. Larvae pupate in the seedhead; the adults emerge and consume the foliage until they enter the litter and soil to overwinter. Three moth species (*Agapeta zoegana*, *Pelochrista medullana*, and *Pterolonche inspersa*) and a weevil (*Cyphocleonus achates*) that feed on spotted knapweed roots have also been released. Root-feeding insects may have a more detrimental effect on knapweed populations than seed-feeding ones. It is hoped that the collective stress on the plant caused by these insects will reduce seed production and lead to decreased competitiveness.

CHEMICAL CONTROL

The following specific use information is based on published papers and reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use. Herbicides are listed by mode of action and then alphabetically. The order of herbicide listing is not reflective of the order of efficacy or preference.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 1 to 2 qt product/acre (0.95 to 1.9 lb a.e./acre) **Timing:** Postemergence from rosette to beginning of bolting, or fall rosette. Optimal at early flowering stage. **Remarks:** Control with 2,4-D is only temporary and does not prevent seedling establishment the following year. Generally requires repeat applications. 2,4-D is not considered as effective as other growth regulator herbicides for season-long control. Broadleaf-selective and may injure other non-

	target species, particularly crop plants. 2,4-D has no soil activity. Do not apply ester formulation when outside temperatures exceed 80°F. Amine forms are as effective as ester forms at the small rosette stage, and amine forms reduce the chance of off-target movement.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 4.75 to 8 oz product (*Perspective*)/acre **Timing:** Postemergence and preemergence. Postemergence applications are most effective when applied to plants from the seedling to the mid-rosette stage. **Remarks:** Aminocyclopyrachlor gives control of spotted knapweed similar to aminopyralid. *Perspective* provides broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for use in California and some counties of Colorado (San Luis Valley).
Aminopyralid *Milestone*	**Rate:** 5 to 7 oz product/acre (1.25 to 1.75 oz a.e./acre) **Timing:** Postemergence and preemergence. Postemergence applications are most effective when applied to plants from the rosette to the bolting stage. Effective control can also be obtained with a fall application to new regrowth. **Remarks:** Aminopyralid is one of the most effective herbicides for the control of spotted knapweed. It is safe on grasses, although preemergence application at high rates can greatly suppress invasive annual grasses, such as medusahead. Aminopyralid has a longer residual and higher activity than clopyralid. Other members of the Asteraceae and Fabaceae are very sensitive to aminopyralid. For postemergence applications, a non-ionic surfactant (0.25 to 0.5% v/v spray solution) enhances control under adverse environmental conditions; however, this is not normally necessary. Other premix formulations of aminopyralid can also be used for spotted knapweed control. These include *Opensight* (aminopyralid + metsulfuron; 1.5 to 2 oz product/acre) and *Forefront HL* (aminopyralid + 2,4-D; 2 to 2.6 pt product/acre), both applied at the rosette to bolting stages.
Clopyralid *Transline*	**Rate:** 0.67 to 1.33 pt product/acre (4 to 8 oz a.e./acre). Use higher rate for older plants or dense stands. **Timing:** Applied preemergence to seedlings or postemergence to seedlings or mature plants, but generally optimal to apply postemergence in spring, at beginning of bolting up to the bud stage. Can also apply to fall regrowth. Results are best if applied to rapidly growing weeds. **Remarks:** While clopyralid is very safe on grasses, it will injure many members of the Asteraceae, particularly thistles, and can also injure legumes, including clovers. Most other broadleaf species and all grasses are not injured.
Clopyralid + 2,4-D *Curtail*	**Rate:** 2 to 4 qt *Curtail*/acre **Timing:** Same as for clopyralid **Remarks:** The addition of 2,4-D can increase the damage to other non-target broadleaf species. Add a non-ionic surfactant.
Dicamba *Banvel*, *Clarity*	**Rate:** 1 to 2 pt product/acre (0.5 to 1 lb a.e./acre). Use higher rate for older plants or dense stands. **Timing:** Postemergence from rosette to beginning of bolting, or fall rosette. Optimal at early flowering stage. **Remarks:** Dicamba is a broadleaf-selective herbicide often combined with other active ingredients. It is not typically used alone to control spotted knapweed. Dicamba can also be mixed with 2,4-D (1 pt dicamba + 2 pt 2,4-D/acre) or picloram (1 to 2 pt dicamba + 0.5 to 1 pt picloram/acre) for spot treatments. Dicamba is available mixed with diflufenzopyr in a formulation called *Overdrive*. This has been reported to be effective on spotted knapweed. Diflufenzopyr is an auxin transport inhibitor which causes dicamba to accumulate in shoot and root meristems, increasing its activity. *Overdrive* is applied postemergence to rapidly growing plants at 4 to 8 oz product/acre. Higher rates should be used on large annuals and biennials or when treating perennial weeds. Add a non-ionic surfactant to the treatment solution at 0.25% v/v or a methylated seed oil at 1% v/v solution.
Picloram	**Rate:** 1 to 2 pt product/acre (4 to 8 oz a.e./acre). Use higher rates for older plants or dense stands. **Timing:** Postemergence and preemergence. Postemergence applications are best at rosette to mid-

Tordon 22K	bolting stage (before flowering to prevent current year seed production), or fall rosette stage. Apply when plants are growing rapidly. Under favorable growing conditions, application in summer can be effective if higher application volumes are used. **Remarks:** Picloram is a broadleaf herbicide. It gives a broader spectrum of control than aminopyralid, aminocyclopyrachlor, and clopyralid, and has a much longer soil residual. Lower rates may require annual spot treatments. Treatment made in bud stage may not prevent seed production in the year of application. Picloram has been shown to provide selective control of spotted knapweed for 3 to 4 years. Although well-developed grasses are not usually injured by labeled use rates, some applicators have noted that young grass seedlings with fewer than four leaves may be killed. Do not apply near trees. Picloram is a restricted use herbicide. It is not registered for use in California. Control with lower rates may be improved by tank mixing with dicamba or 2,4-D; picloram and dicamba (0.25 to 0.5 pt/acre + 0.125 to 0.25 pt/acre) and picloram plus 2,4-D (0.5 to 1 pt picloram + 1 to 2 pt 2,4-D/acre). A backpack sprayer or a wiper is recommended in small areas to minimize damage to non-target plants.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup*, *Accord XRT II*, and others	**Rate:** Broadcast foliar treatment: 3 qt product (*Roundup ProMax*)/acre (3.375 lb a.e./acre). Spot treatment 1.5% v/v solution **Timing:** Postemergence to rapidly growing knapweed when most plants are at bud stage. **Remarks:** Glyphosate will only provide control during the year of application; it has no soil activity and will not kill seeds or inhibit germination the following season. Glyphosate is nonselective. To achieve selectivity, it can be applied using a wiper or spot treatment to control current year's plants.

RECOMMENDED CITATION: DiTomaso, J.M., G.B. Kyser et al. 2013. *Weed Control in Natural Areas in the Western United States*. Weed Research and Information Center, University of California. 544 pp.