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Defusing Diffuse Knapweed

Biological Control of an Explosive Weed

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Diffuse knapweed, *Centaurea diffusa*, a member of the plant family Asteraceae, is believed to have been accidentally introduced into Washington State during the early 1900s as a contaminant of alfalfa seed imported from Eurasia. The plant has since spread to infest nearly a half million acres across all counties east of the Cascade Mountains. It is also prevalent in many western Washington counties. Nearly 90% of the infested land lies in six counties bordering the Columbia River to the north and east: Okanogan, Ferry, Stevens, Chelan, Kittitas, and Yakima. Based upon the weed's calculated 17.8% annual rate of spread, about 12 million acres remain potentially susceptible to knapweed invasion during the next few decades.

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Typical diffuse knapweed infestation.

The plant is well adapted for survival in disturbed, semiarid environments as typified by degraded rangeland and pasture, fallow land, neglected residential and industrial properties, gravel pits, clearcuts, river and ditch banks, and transportation rights-of-way. Diffuse knapweed is a strong competitor for water and nutrients, and the plant's dense, spiny overstory reduces availability of more desirable forage species to grazing animals by as much as 90%. Dense infestations of the weed also restrict access to or diminish the visual appeal of recreational lands, lower property values, increase soil erosion rates, and provide fuel for late summer and early fall wildfires.

Life Cycle and Traits

Diffuse knapweed can be classified as either a biennial or short-lived perennial with a well-developed taproot. It exhibits a preference for well-drained, light-textured soils and is intolerant of flooding or dense shade. The plant overwinters as a rosette of deeply divided leaves or as seed in the soil. Seeds germinate in the fall or spring when environmental conditions are favorable. The overwintered rosettes bolt during May of the second year of growth to produce plants characterized by upright, diffusely branched architecture and small, stalkless stem

leaves. Plants stressed by drought, grazing, mowing, or some other form of physical disturbance may exhibit short-lived perennial characteristics. Diffuse knapweed flowers are usually white, but may be rose-purple or lavender. Flowering occurs from July to September. Flower heads are solitary or borne in clusters of two to three at the ends of the branches. Each head bract is edged with a fringe of small spines and tipped with a pronounced spine.

Diffuse knapweed reproduces by seed. Depending on moisture availability, each plant can develop from 1,000 to 18,000 seeds. Mature, seed-laden plants can be transported long distances when they become attached to the undercarriages of vehicles and equipment. When plants are broken at ground level by vehicles or wind, they can become tumbleweeds, dispersing seeds along transportation corridors. Such windblown plants may enter rivers, streams, and irrigation canals, where they may continue to move many miles before washing ashore. The seeds also can be carried in mud clinging to footwear, tires, and vehicles, and can be dispersed by wildlife foraging activity. Movement of contaminated forage and feed grains by livestock producers has also contributed to the weed's widespread distribution.

Herbicides can control diffuse knapweed short-term, but successful long-term management cannot rely upon repeated chemical applications. The weed's seed output is enormous and its infestations are extensive, frequently occupying lands that are difficult to access and/or of low value. Herbicide purchase and application are costly and can raise environmental concerns. Any long-term, economical, and environmentally sound solution to diffuse knapweed suppression must involve an integrated management approach wherein biological control

organisms are deployed along with a more judicious use of herbicides and other suppressive strategies.

Biological control is the planned use of various natural enemies to reduce the vigor, reproductive capacity, or effect of a pest—in this case, a weed. The technique is based on the premise that the attack of natural enemies stresses the pest population, eventually reducing its density. Biological control efficiency against weeds is dependent upon the type and number of control organisms present, their time of attack in relationship to the weed's growth cycle, the amount of damage inflicted, and the competitive abilities of the replacement vegetation.

During the last quarter century, Agriculture Canada (now Agriculture and Agri-Food Canada), the International Institute of Biological Control (now CAB Bioscience), the United States Department of Agriculture Agricultural Research Service (USDA-ARS) and Animal and Plant Health Inspection Service (USDA-APHIS), and several state universities have developed programs to find, evaluate, and introduce biological agents for the control of diffuse knapweed and its relatives. As a result of these combined efforts, a complex of exotic, host-specific root- and seed head-feeding insects have been identified, acquired, and released into North America for knapweed suppression. Root-infesting bioagents include the beetles *Cyphocleonus achates* and *Sphenoptera jugoslavica*, and the moth *Agapeta zoegana*. Seed head-attacking insects include the beetles *Bangasternus fausti*, *Larinus minutus*, and *L. obtusus*, the flies *Chaetorellia acrolophi*, *Urophora affinis*, and *U. quadrifasciata*, and the moth *Metzneria paucipunctella*. All of these organisms are important in reducing diffuse knapweed vigor and reproductive output, but

one in particular has proven to be highly effective in rapidly suppressing populations of the weed. That insect is the lesser knapweed flower weevil, *L. minutus*.

Weevil Superstar

Larinus minutus *adult.*

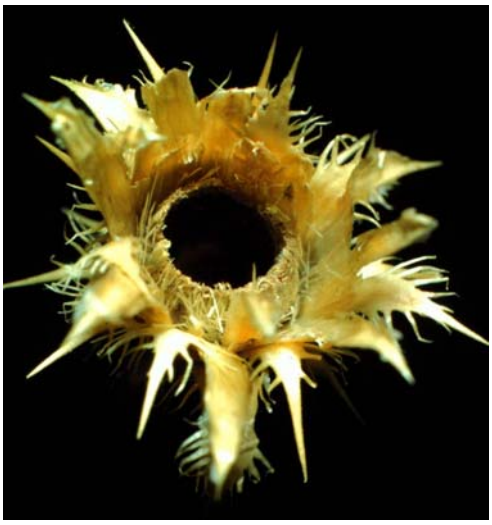
Larinus minutus was imported from Greece and first released in Washington in 1991. During the last decade, the beetle has been raised by university, USDA, and other weed management personnel at nursery sites within the state. Upon translocation into most counties in eastern Washington, *L. minutus* has readily established itself. The insect prefers to attack diffuse knapweed but will also successfully utilize spotted knapweed (*Centaurea maculosa*) and meadow knapweed (*C. pratensis*) as hosts.

Adults are active in the field from mid-May to early August. Upon emergence from their overwintering sites in the spring, the adults are one-quarter-inch long, have a large snout with chewing mouth parts, and are a golden to rust-brown color. As the beetles age, they become dark brown or black. Adults will congregate, often in massive numbers, beneath the leaves and in and around the root crowns of the rosettes, where they feed. Several dozen beetles can totally defoliate and subsequently kill an averaged-sized rosette in less than a week. Once the plant initiates stem development, the beetles will feed on the stems, branches, leaves, and

immature flower buds. Such feeding can kill the plant or cause pronounced stunting and flower head deformation. These injured plants assume a bluish-green or gray color and are easily detected in a knapweed stand.

Knapweed heavily damaged by adult weevil feeding.

Adult weevils are very active, readily moving many miles in search of knapweed. Mating begins approximately four weeks after the initial emergence and continues throughout the duration of their adult lives. Females feed on knapweed flowers and pollen to acquire nutrients necessary for egg production. They lay their eggs among the feathery structures known as pappus hairs of the opened flower heads. Each female can produce between 28 and 130 eggs during her lifetime, averaging 66. Up to seven eggs may be laid in a single day. The eggs have a three-day incubation period. Newly emergent larvae feed on the pappus hairs; subsequent larval instars feed on the developing seeds and receptacle tissue of the flower head. A single *L. minutus* larva, during its four-week developmental period, is capable of consuming all of the seeds in a diffuse knapweed head. The larvae may also eat the immature stages of other insect species found within the head. In areas where the weevil is well established, *L. minutus* larvae can readily destroy every seed head in a stand of knapweed.



Adult emergence hole in a knapweed seed head.

Mature larvae construct egg-shaped pupal chambers from seed fragments and pappus hairs within the damaged heads. Adults exit from the heads from mid-July to mid-August by chewing out a round hole at the top of the pupal cell. These hollowed-out heads are highly visible, providing a means to quickly assess the occurrence and extent of the beetle population. Adults feed on knapweed foliage for several weeks before seeking out sheltered overwintering sites. One generation is completed per year in Washington.

Biological Control Outlook

Larinus minutus is a highly effective biological control agent. It is unequivocally the most destructive of all the insects released against knapweed in North America thus far. It readily survives in most sites where released, develops huge populations, and is capable of severely impacting a weed population within three to five years after being released. We urge anyone plagued by diffuse knapweed to acquire and release this beetle on lands under their supervision. (For information on acquiring these agents, contact the authors.)

The goal of any biological control program is to shift the competitive balance away from the target weed to desirable grasses and forbs. The intended outcome is the return of weed-

dominated lands to more diverse and productive plant communities. In areas where *L. minutus* activity is pronounced, this goal is being realized with respect to diffuse knapweed.

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