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Ecology and Management of Whitetop [*Cardaria draba* (L.) Desv.]

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Figure 1. A whitetop infestation along a drainage ditch in Madison County, Montana.

Abstract

Whitetop, also called hoary cress, is a rhizomatous, long-lived perennial weed invading rangeland, pastures, moist meadows, and floodplain meadows in Montana. It is common along roadsides, railroad tracks, ditch banks, riverbanks, and often abundant on alkali soils (see Figure 1). It is in the mustard family (Brassicaceae) and there are three species in Montana, the most common being heart-podded whitetop (*Cardaria draba*). All three species spread by creeping roots and rhizomes, and prolific seed production. They can form dense patches that compete with crops, forage plants, and riparian plants. Infestations reduce crop yield and increase production costs, reduce livestock carrying capacity, and control is costly.

Whitetop is native to Russia, other eastern European countries, and the Middle East. First reported in Montana from Gallatin county in 1916, whitetop has spread to every county except Daniels and Roosevelt as of 2006 (http://invader.dbs.umt.edu). Whitetop is ranked as a Category 1 noxious weed in Montana, infesting an estimated 83,539 acres as of 2005 (Montana Department of Agriculture). In Montana's noxious weed management plan, the goal for management of Category 1 noxious weeds is to reduce established infestations and contain their spread by expanding cooperative weed management areas.

Whitetop can be temporarily suppressed using herbicides that contain metsulfuron, chlorsulfuron, or imazapic as active ingredients. Long-term herbicidal control requires repeated applications. Repeated cultivations or cultivation combined with herbicidal control are required to reduce whitetop populations in cropland. Irrigation favors increases in whitetop populations. Cattle, sheep, and goats will graze whitetop, but the effects on population fitness of long-term grazing with these animals are not known. Mowing and sheep grazing reduce density and standing crop for up to one year. Shrubby species including *Rosa* and *Symphoricarpos* are more competitive with whitetop than native grasses.

Biology and Ecology

Taxonomy. There are three species of whitetop in North America all of which are believed to be in Montana; lens-pod whitetop (*Cardaria chalapensis*), heart-podded whitetop (*C. draba*), and globepodded whitetop (*C. pubescens*). As the common names imply, the three species can be distinguished by the morphological characteristics of their fruits (silicles). Silicles of *C. draba*, the most commonly reported species in Montana, are hairless (glabrous), egg-shaped (ovate) and cordate-based (like the shape of a heart), and often notched at the tip where the style attaches. *Cardaria pubescens* silicles are covered with fine hairs (pubescent), more finely pointed (acute) than cordate at the base, more spherical than ovoid (obovoid), and often without a notch at the tip. Silicles of *C. chalapensis* are glabrous, rounded at the base and generally acute at the tip. *Cardaria draba* is taller in stature than the other two species. Otherwise, the root, leaf and stem features of the three species are similar. Resistances to herbicides differ slightly among species. *Cardaria draba* has the greatest economic impact in the United States, whereas *C. chalepensis* is the most common whitetop species in Canada and *C. pubescens* is most common in California. Hybrids of *C. draba* and *C. chalepensis* have been found in Canada but there is no evidence of their survival beyond the first generation. No natural hybrids between *C. pubescens* and the other two species have been found. Whitetop is also known by the common name hoary cress. The genus name, *Cardaria* is derived from the Greek word *kardia* which means heart and refers to the shape of the silicle of *C. draba*.

Roots. Whitetop populations rely on vegetative reproduction from extensive root systems, not seed production, to increase plant density and local population expansion. The perennating adventitious buds form on all parts of the root system and are capable of producing rhizomes (underground stems) and aboveground shoots. Whitetop produces vertical taproots and horizontal lateral roots that eventually turn downward and become taproots. Secondary lateral roots often form just below the point where lateral roots turn down. Shoots that give rise to rosettes tend to form where lateral roots are near the soil surface. Rhizomes form from more deeply buried lateral roots. Lateral roots develop from the seedling radicle two to three weeks after seedling emergence. The vertical taproots frequently penetrate two to three feet (74 to 81 cm) into the soil but can penetrate five feet (1.6 m) deep. Taproots of *C. pubescen*s in

Saskatchewan were tracked to a depth of 18 feet (5.6 m) in the soil. Roots are capable of rapid growth and can extend 12 to 30 feet (4 to 9 m) in two or three growing seasons.

Whitetop roots store abundant reserves. Accumulations of carbohydrates peak in August and the lowest levels have been found in April. Root fragments are capable of developing into new plants; however fragmented roots show poor re-generation in dry soil.

Whitetop roots produce glucosinolates. When released into the soil, glucosinolates, or the byproducts of their breakdown, may act as allelochemicals to reduce root growth and seed germination of other plant species. Extracted chemicals from whitetop roots were found to inhibit the germination of alfalfa, bluebunch wheatgrass, crested wheatgrass, and whitetop, and reduce the germination of winter wheat. Root growth of these species was also reduced by the extract.

Figure 2. Whitetop leaf and silicle features.

Rosettes and Stems. Whitetop plants produce rosettes and flowering stems. Rosettes emerge early in the spring. Rosette leaves are longer than wide and are widest near the tip (elliptic, see Figure 2). They taper to a short petiole. They are simple, the margins are entire or irregularly

dentate, and they have scattered to dense pubescence with short simple hairs. Stem leaves are also longer than wide, 3.5 by 1.5 inches (9 by 4 cm) but vary in shape from slightly egg-shaped (obovate) to wider at the tip or consistently wide the entire length (elliptic-oblong), to wider at the base and tapering to a point (lanceolate). The margins are entire or irregularly toothed. They have no petiole and clasp the stem with heart-shaped or arrowhead-shaped (cordate-sagitate) lobed bases (see Figures 2 and 3). Stem leaves are alternate along the stem and grayish-green. Leaves are usually shed at the time of seed maturity (July).

Stems of *C. draba* are erect to slightly trailing along the ground (procumbent) and grow from one to two feet (30 to 60 cm) tall. Stems of *C. chalepensis* and *C. pubescens* are shorter than *C. draba*, averaging 8 to 16 inches (20 to 40 cm) and 4 to 16 inches (10 to 40 cm) tall, respectively. The upper parts of the stems are hairless (glabrous) and the lower parts are slightly to densely pubescent. When rosettes and shoots develop from buds on roots they usually form where lateral roots bend down to become taproots. Individual plants can produce from 50 to 450 stems depending on environmental conditions and the degree of competition from other plants.

Figure 3. Whitetop stem leaves showing the leaf shape, clasping leaves, and irregularly toothed margins

Whitetop rosettes, stems, flowers and fruits have high levels of crude protein, favorable levels of digestible energy, and adequate levels of minerals to support livestock. Whitetop consumed before flowering satisfies the protein and energy requirements of a 130 pound (60 kg) ewe. After flowering, crude protein and digestible fiber decrease. Leaves, stems and silicles produce glucosinolates that are potentially toxic to livestock. Sulfur content associated with

glucosinolates may exceed the maximum tolerable level of 0.4% in whole plants and in silicles. Glucosinolates leached from plant material deposited on the soil surface may be an allelochemical that prevents seed germination.

Figure 4. Whitetop plants blooming in Jefferson County, Montana in mid-May.

Sexual Reproduction. Whitetop is capable of producing large amounts of seeds. The flowers are white, small, and have four glabrous white-margined sepals 1.5 to 2 mm long, four white petals 3 to 4 mm long, and six stamens. The flowers are attached to the inflorescence by a slender pedicel 1/2-inch (1.5 cm) long. The sepals of *C. pubescens* are pubescent. The flowers of all three species are numerous on many-branched, corymbose racemes (see Figure 4). The number of flowering stems, and the number and arrangement of flowers on the racemes give an infestation a solid white appearance from which the common name "whitetop" is derived. Whitetop is self-incompatible and outcrosses by insect pollination.

The flowers develop into fruiting pods (silicles) that vary in shape within and among species as described above (see Figure 2). The silicles are inflated at maturity and have two chambers, each capable of producing one seed. Seeds are oval to slightly compressed, 1.5 by 2.0 mm, and reddish-brown (see Figure 5). One whitetop plant can produce 1,200 to 4,800 seeds. The percentage of viable seeds is high. Seeds remain viable in the seed bank for three to four years. Seeds are dispersed through ruptures in the silicle side wall or as the silicles fall intact from the plant. Seeds exude mucilage when moistened that is believed to increase germination under low osmotic conditions. Seeds germinate in the fall or spring.

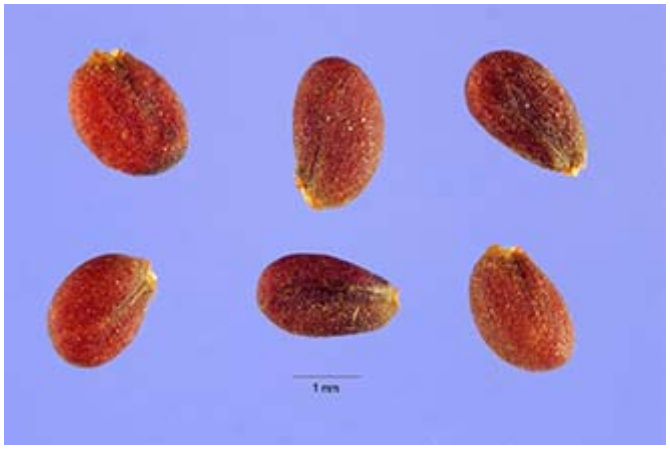

Figure 5. Whitetop seeds.

Whitetop plants grown from seed may not produce flowers until two years after establishment. Flowering and seed production from plants with established root systems is rapid. Rosettes growing from the root system in early spring initiate flower stem development about two weeks after emergence. Flower buds develop about one month after rosettes form (see Figure 6). About one and one half months after rosettes form, flowers have opened and developed into silicles. Seeds are fully developed within two months after the formation of rosettes from an established root system. Generally, plants die back to the root crown after the development of seeds and remain dormant during the summer drought period re-initiating growth in the fall if moisture conditions are favorable. Otherwise growth resumes in the spring.

Figure 6. Whitetop flower buds forming on plants May 10, 2007.

Spread. Whitetop spreads by seed, creeping roots, and root fragments. Population expansion is mainly through the extensive spreading root system and can be as much as 12 feet (3.7 m) in diameter during the first year when growing without competition. In Saskatchewan, patch radial expansion ranged from 2.0 to 2.5 feet (61 to 76 cm) per year. Root fragments can be dispersed within and between fields by cultivation equipment. Fruits with seeds can be transported long distances in wind, river currents, irrigation ditches, contaminated hay, and by animals and birds. The source of early introductions of whitetop in North America is believed to be from alfalfa seed imported from Turkestan.

Habitat. Whitetop occurs on a variety of soils on mesic sites. In an area with a 15-inch (38 cm) average annual rainfall, whitetop increased when precipitation was 20% above average and decreased when precipitation was 15% below average. In Oregon, increases in stem density occurred during years with cool, dry Aprils and warm, moist Mays. Whitetop is often abundant on alkali soils. Whitetop is commonly found in irrigated pastures and hay meadows, floodplains, along irrigation ditches, and along roadways where runoff water accumulates. It grows well in full sun. It is commonly found in brome, alfalfa, and growing with Russian knapweed. In sagebrush eco-systems, whitetop populations are restricted to moist microsites, toe slope positions, and areas of soil disturbance.

Economic impacts. Because of its clonal reproduction, whitetop often forms near monotypic stands that exclude desirable plants. Infestations reduce livestock carrying capacity by displacing nutritive forage plants. For every 90 pounds per acre increase in whitetop biomass there is an estimated 5% reduction of desirable forage. Hay contaminated by whitetop has lower nutrient content than weed-free hay. Wildlife habitat is diminished where whitetop displaces riparian plant species that provide browse and bird nesting sites. It reduces the yield of cropland and increases management costs.

Management Alternatives

Herbicide.[1/] Metsulfuron (1.0 oz product/acre) or chlorsulfuron (1.0 oz product/acre) applied from bud to early bloom are the most effective herbicide treatments and can suppress whitetop for one to two years on rangeland sites. For control of whitetop in annual cereal crops, follow label instructions when using metsulfuron. A non-ionic surfactant (0.5% by volume) needs to be added to the spray solution when using chlorsulfuron or metsulfuron. Imazapic (8-12 oz. product/acre) mixed with methylated seed oil (1 qt./acre MSO) applied after full bloom, when the plants go dormant, or in the fall to re-growth will provide similar control. Chlorsulfuron and metsulfuron have long residual persistence on alkaline soils.

In alfalfa, imazethapyr applied at 6 oz./acre product (Pursuit®) with a non-ionic surfactant (0.25%) will control whitetop for the growing season but not the year following application. Alfalfa yield will not be affected by this application but grass yield may be reduced. Using a non-ionic surfactant instead of methylated seed oil may reduce injury to grasses. Combining a nitrogen-based fertilizer in the spray solution may increase the risk of grass injury.

[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.

Shoots of whitetop can be killed using 2, 4-D (2 qt. product/acre), but root crowns will re-sprout new foliage. Glyphosate (2 qt. product/acre) provides similar control as 2, 4-D, however glyphosate is non-selective and re-vegetation may be needed to restore competitive plants. Imazapyr has an aquatic label (Habitat®) and can be used on whitetop where it grows in riparian areas. Picloram does not control whitetop. Repeated herbicide applications are needed in most cases to sustain population reductions regardless of the product used. Because of its clonal nature and ability to produce allelochemicals, whitetop can suppress other plants and competitive plants may need to be restored after herbicidal control of whitetop. Where herbicides with soil residual activity are used (i.e., metsulfuron, chlorsulfuron, and imazapic), consult the herbicide labels for replant intervals to avoid herbicide carryover injury to desirable seeded species.

Hand Pulling. Repeated hand pulling, digging, and rouging can reduce populations of whitetop where soil conditions allow removal of large portions of the root system. Though labor intensive, hand pulling may be practical for small infestations, in riparian areas, or for spot elimination of re-growth after herbicide application.

Grazing and Mowing. Cattle, sheep, and goats will utilize whitetop. Studies on the nutrient composition indicate levels of protein, digestible energy, and mineral nutrients are adequate to meet the nutritional requirements of most classes of livestock. The concern for livestock managers is the presence of toxic levels of glucosinolates which can cause anti-thyroid symptoms. The chances of animal poisoning can be lessened by providing supplemental iodine, alternative forage plants, and using mature non-lactating animals. Glucosinolate levels are lowest when whitetop is in the rosette to bloom stage. This is also when nutrition is greatest and is the recommended time for grazing whitetop. Cattle apparently prefer whitetop seed pods in the fall when other forages are less available. Glucsinolate levels are high in whitetop seeds and it is likely that the small, hard-coated seeds will pass through the digestive tract intact. It is therefore not recommended to graze whitetop infestations in the fall where seed pods are present to reduce the risk of poisoning and spread of the weed by seed. Grazing fall re-growth where seed pods are not present may reduce the fitness of the population.

Mowing by itself will not reduce whitetop populations. But mowing during flowering may reduce seed production. Mowing to reduce seed production followed by herbicide application to re-growth may improve the effectiveness of herbicides in controlling whitetop.

Biological Control. To date there are no biological control agents introduced into the United States to manage whitetop. Development of biological control agents is difficult because of the risk of damage to valuable crops that are closely related taxonomically, including canola, mustard, and cabbage. Currently, one mite and five insect species are being studied as potential biological control agents for whitetop.

Tillage. Whitetop, like other perennial rhizomatous weeds, may be controlled by persistent repeated tillage. Cultivation six inches deep must be repeated within ten days of re-growth. However, it takes three years of continuous tillage to kill the root system of whitetop. Tillage also spreads root fragments and should be followed by herbicidal control (glyphosate at 2 quarts per acre) and cropping or re-vegetation. Tillage equipment should be thoroughly cleaned before moving to a non-infested field.

Re-vegetation. Where whitetop forms dense near-monocultures, re-vegetation may be needed to establish competitive plants after control procedures. Establishing competitive perennial grasses on disturbed land, followed by prescribed grazing management to maintain grass vigor will suppress whitetop and prevent re-establishment and spread by rhizomes and seed. Refer to Montana Plant Materials Technical Note 46, 'Seeding Rates and Recommended Cultivars,' and Extension Bulletin EB19, 'Dryland Pasture Species for Montana and Wyoming' for recommended re-vegetation species and their appropriate seeding rates. State and area resource specialists can help determine the most appropriate, site-specific species mix, timing of seeding, and seeding methods. Where herbicides have been applied, chemical carryover should be assessed prior to planting permanent vegetation.

Integrated Pest Management (IPM). Integrated pest management is the application of two or more management alternatives so they are complimentary in weed suppression, increase the longevity of control procedures, and improve crop production, or conservation of resources. Mowing to a height of six inches (15 cm) prior to herbicide application may improve herbicidal control of whitetop. To reduce the frequency of herbicide re-applications, prescribed grazing with sheep, goats, or cows can be applied to prevent re-establishment from roots that survive herbicide treatment (follow herbicide label guidelines for grazing after herbicide treatment). On cropland, tillage followed by herbicide treatment will be more effective than either treatment applied alone. On pastures and rangeland where competitive plants have been suppressed, re-vegetation following control of whitetop will improve the longevity of the control application.

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