Ecology and Management of Russian Knapweed [*Acroptilon repens* (L.) DC]

by

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Abstract

Russian knapweed is a long-lived, persistent, perennial weed that forms dense colonies from vigorous spreading roots. Native to Eurasia, it was allegedly first introduced into North America around the turn of the 20th Century as a contaminant of alfalfa seed imported from Turkistan. In Montana, it was first reported from an open dry site with rocky soils in the Judith Mountains in Fergus County in 1934, and by 1991 was reported from all 56 counties in the state (Invaders Database http://invader.dbs.umt.edu). In 1998 Russian knapweed was estimated to infest 48,500 acres (19,600 ha) in Montana. It has been reported from railroad right-of-ways, along highways and roads, along ditch banks, in alfalfa fields, pastures, open rangeland, summer fallow, and under cottonwoods. Dense infestations suppress other plant species, reduce livestock carrying capacity, and reduce wildlife habitat. The combination of allelopathic chemicals produced in the leaves and roots, and competition for water and nutrients by its extensive creeping root system enable Russian knapweed to exclude other plants where it invades. Prolonged ingestion of Russian knapweed by horses has resulted in chewing disease (equine *nigropallidal encephalomalacia*), a fatal neurodegenerative disorder.

Russian knapweed can be temporarily controlled using herbicides. Picloram (1-2 qt./ac.) controls Russian knapweed for two to five years depending on the competitiveness of the plant community in which it is growing. The higher rate is most practical for an eradication program on small, recently established populations. Clopyralid (11-21 oz./ac.), clopyralid plus 2,4-D (3-4 qts. Curtail®) or imazapic (8-12 oz./ac.) provides control where picloram cannot be used. In areas where Russian knapweed has excluded competitive perennial plant species, herbicidal control will need to be followed by restoration of perennial plants to reduce re-establishment of Russian knapweed or other weeds. Research shows that sod-forming perennial grass species exclude re-establishing Russian knapweed better than bunchgrasses. The gall-inducing nematode *Mesoanguina* (*Subanguina*) *picridis* has been reported to stunt the growth of Russian knapweed. Cultural controls (tilling, mowing, and burning) when applied alone are ineffective in controlling Russian knapweed, but may improve the effectiveness of herbicidal control when used in an integrated management program that encourages the growth of perennial desirable plant species.

Biology and Identification

Russian knapweed was described as *Centaurea repens*. However, cytological, morphological and pathological data place it in the taxonomic genus *Acroptilon* in the Asteraceae family. In Russia, populations of this weed have been subdivided into two forms, A. repens ssp. *virens* and *A. repens* ssp. *incana* that differ in leaf shape and their susceptibility to herbicides. In Canada, populations of Russian knapweed differ in leaf shape and leaf margin characteristics but have not been differentiated into separate taxonomic forms (Watson 1980). Analysis of DNA indicates that populations of Russian knapweed in the United States may have originated in Uzbekistan and Kazakhstan.

Russian knapweed reproduces by seed and adventitious buds on creeping roots. Expansion of infestations is primarily by creeping roots. The roots are dark brown or black, scaly and they produce buds capable of developing into leafy shoots. Root growth to depths of eight feet (2.5 m) in the first year of establishment, and expansion laterally 130 square feet (12 m^2) over two years have been reported. The extensive root system of Russian knapweed allows populations to survive indefinitely; a population in Saskatchewan was reported to persist for over 75 years. The root system also enables Russian knapweed to exclude other plants through competition for soil water and nutrients, and through the exudation of the phytotoxic, allelopathic chemicals, including polyacetylenes. Root carbohydrate reserves peak at the end of the growing season and are lowest when plants bloom at the end of the spring. Shaded plants have lower carbohydrate and nitrogen content in their roots than plants growing in full sun.

Figure 1. The creeping root of Russian knapweed showing the dark brown to black color.

Shoots emerge from root buds early in the spring after soil temperatures remain above freezing. The first leaves have entire margins but rosettes develop pinnately lobed leaves 2-4 inches (5-10 cm) long and 1/3-1 inch (1-2.5 cm) wide. Floral stems bolt in late May to mid-June. Lower-stem leaves are irregularly notched, oblong- to linear-lanceolate, and the upper-stem leaves are progressively smaller with nearly entire margins. Stems grow up to three feet tall, are corymbosly branched, and young stems are canescent (covered with soft-gray hairs). The leaves are alternately arranged on the stem. Repin, acroptilin, and hyrcanin are three sesquiterpene lactones that have been isolated from the leaves of Russian knapweed. These compounds, along with root exudates may contribute to the allelopathic activity associated with Russian knapweed infestations.

Figure 2. The floral stem of Russian knapweed showing the corymbosly branching pattern, the small upper-stem leaves with entire margins, and the mature straw-colored flower heads with papery involucre bracts. The picture was taken in late August from a population on an upland site growing in association with crested wheatgrass.

Flowering begins in early July and continues into September. Flower heads are solitary on the branch ends. Involucre bracts are ovoid, entire, and greenish at the base with papery and finely-hairy margins. There are numerous pink or purple flowers per head that turn straw-colored at maturity. Seeds (achenes) are 1/4-inch (2-3 mm) long, oval and compressed, grayish or ivory and slightly ridged longitudinally. The pappus of short stiff bristly-like hairs is deciduous. Seeds are produced from August through September. Research in Canada showed a high abortion rate of ovules of Russian knapweed. The average seed production from populations near Kamloops, British Columbia was five to eight seeds per head and 100 to 300 seeds per plant (Watson 1980). Seeds are reported to remain viable for two to three years. A study in Oregon showed that germination is limited to areas where wetted soil conditions are maintained for extended periods of time (minimum ~7 days, peak germination ~ 25–32 days) and where seeds are covered by litter or soil. It is believed that Russian knapweed does not reproduce extensively by seed. The flowers have no active mechanism of seed dispersal; the bracts of the flower head remain closed and the pappus is too small and deciduous to facilitate wind dispersal. The urnshaped flower head has the potential to float intact with seeds in river currents. The major means of seed dispersal is believed to be by way of infested hay.

Habitat

The native distribution of Russian knapweed includes Iran, Asia Minor, Turkish Armenia, the area once considered western Turkestan, and Mongolia (Watson 1980). It is common and widespread in western and central North America. Russian knapweed can establish and persist as a near monoculture in a variety of habitat types and plant communities although it is more common in drier regions of North America. It remains competitive under irrigation. While Russian knapweed is found in a variety of soil types, damp clay soil has been suggested to provide abundant moisture and to permit easy penetration of Russian knapweed roots. Infestations are common in areas with shallow water tables or excess moisture, such as irrigation ditches, flood plains, and river corridors. Russian knapweed is competitive with almost any crop in tillable soil and is more competitive than other weeds in pasture and rangeland. It often grows in association with whitetop (*Cardaria draba*). It invades disturbed sites and can establish in existing perennial crops including alfalfa and grass hay.

Management Alternatives

Suppression of Russian knapweed populations will be most successful through actions that target its extensive root system because it reportedly does not reproduce extensively *via* seed.

Herbicide[1/]

Herbicides used to control Russian knapweed are listed in Table 1. In most cases, herbicidal control of Russian knapweed will be most cost-effective using a chemical that translocates into the roots, and for most chemicals, if applied during the bloom or seed stage rather than the rosette or early growth stage. Herbicide trials have shown that among chemicals tested, picloram provided the longest suppression of Russian knapweed in Montana. Picloram applied at 1 qt. product per acre (0.5 lb. acid equivalent per acre) provided two to three years suppression where perennial grasses were present to fill-in after control. Research in Wyoming showed that two years of 95 percent control was obtained when 1.5 pt. of product per acre of picloram was applied at the bloom stage. Along the Tongue River in Rosebud County, picloram applied at 1 qt. of product per acre in mid-May provided 90 percent control of Russian knapweed the year following treatment.

A greenhouse study using labeled carbon picloram applied to the leaf surface of Russian knapweed showed that only ten percent of the picloram was taken up by the leaf and that most of the uptake occurred within 30 minutes of application. Uptake increased linearly with, and proportionally to, increasing externally applied concentrations of picloram. Only about ten percent of the absorbed picloram was translocated out of the treated leaf within 96 hours of application, with approximately equal acropetal and basipetal translocation. Water stress before, at the time of, and after picloram application did not affect picloram uptake, but reduced total

[1/]Disclaimer:
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.

translocation and increased the relative amount translocated basipetally. Water stress reduced picloram efficacy. A surfactant increased picloram uptake into Russian knapweed leaves but it did not increase efficacy under water stress conditions.

In areas where picloram cannot be used, aminopyralid, clopyralid, and imazapic will suppress Russian knapweed. On bottomland along the Missouri River in Fergus County, clopyralid plus 2,4-D (Curtail® 3-4 qts. product/ac.) applied at the bloom stage of growth, reduced the density of Russian knapweed by 90 percent compared to untreated controls two years after application. The reduction in Russian knapweed density was accompanied by an increase in native or non-native perennial grasses, depending on the grass species present on the site. In the same study, glyphosate applied at bloom reduced Russian knapweed density by about 25 percent and perennial grass density by about 60 percent two years after application. There was an increase in non-native forb (mostly annual mustard species) biomass where glyphosate was applied indicating a need for re-vegetation of perennial grasses under this treatment.

Picloram, clopyralid, and aminopyralid are most effective in suppressing Russian knapweed when applied during active growth from bud to mid-flowering, or to fall re-growth. Imazapic (12 oz. + 1qt. methylated seed oil/ac.) is most effective if applied in the fall after the initiation of senescence in Russian knapweed. Control with imazapic improves as senescence progresses and may still be obtained after full senescence. Reduced control can be expected from applications of imazapic made before senescence.

Chlorsulfuron (Telar®) applied at 1 oz./ac. when Russian knapweed is in the bloom to post-bloom stage will also provide short-term control. Earlier applications do not control the weed effectively. Fall applications are also effective but may injure smooth brome or other brome species. Addition of a good agricultural surfactant to the spray solution at 0.25 to 0.5 percent of the total spray volume is required when using chlorsulfuron. Metsulfuron (Escort® 0.75 to 1 oz./ac. with a good agricultural surfactant) is labeled for control of Russian knapweed in pasture and rangeland. Optimum timing for metsulfuron is similar to chlorsulfuron.

Table 1. Chemical and product name, recommended application rate, soil residual half life, and eco-toxicity of herbicides commonly used to control Russian knapweed.

Chemical name	Product name	Rate	Half life	Eco-toxicity (LC_{50}/EC_{50})
2,4-D	Many names	1-2 qts	7	1-10 mg/L
Aminopyralid	Milestone	4-6 oz	30	>100 mg/L
Clopyralid	Stinger Transline	11-21 oz	40	>100 mg/L
Clopyralid+2,4-D	Curtail	3-4 qts	40	0.1-1 mg/L
Clopyralid+triclopyr	Redeem	3-4 pts	40	0.1-1 mg/L
Dicamba	Banvel Clarity	2-4 pts	10	>100 mg/L
Imazapic	Plateau	8-12 oz	31-233	>100 mg/L
Picloram	Tordon	1-2 qt	90	10-100 mg/L

Cultural

Re-vegetation

The reduced growth and development of Russian knapweed under low-light conditions suggests that competition from seeded plant species can provide effective and sustained control. Re-vegetation efforts in Russian knapweed-infested plant communities have been successful with both native and non-native perennial grasses (Whitson 1999). However, species-specific responses to the presence of Russian knapweed indicate differences in recovery, restoration, and re-vegetation of sites with different native grass species composition. In a Colorado field study, emergence and initial survival of prairie Junegrass (*Koeleria cristata*), blue grama (*Bouteloua gracilis*), and sand dropseed (*Sporobolus cryptandrus*) were decreased by the presence of Russian knapweed roots by 57, 32, and 36 percent respectively. When grown in the greenhouse, root weight of prairie Junegrass and blue grama were decreased by more than 55 percent by the presence of Russian knapweed roots. Western wheatgrass (*Pascopyrum smithii*) survival and growth were unaffected by Russian knapweed in either the greenhouse or the field.

Herbicidal suppression of Russian knapweed will increase grass establishment in a re-vegetation application. In addition, tilling the soil may reduce allelopathic chemicals in the soil. A treatment to reduce built-up plant litter may also be needed before seeding into Russian knapweed infestations. In Wyoming, application of clopyralid plus 2,4-D (3 qts./ac. Curtail®) applied to Russian knapweed at the late bloom stage (July 9, 1993), followed by November roto-tilling and seeding with a rangeland drill resulted in grass stands that produced 300, 3, 215, and 70 lbs./ac. of crested wheatgrass, Russian wildrye, streambank wheatgrass, and thickspike wheatgrass, respectively, two years after seeding. Russian knapweed production was 75, 135, 40, and 170 lbs./ac. in the crested wheatgrass, Russian wildrye, streambank wheatgrass, and thickspike wheatgrass, respectively, and 500 lbs./ac. where no grasses were seeded.

Near Lame Deer, Montana, large-scale demonstrations were implemented integrating fall mowing, fall herbicide treatment (glyphosate + picloram + ammonium sulfate), deep disking and re-vegetation to tame grasses. These demonstrations tested fall and spring seeded monocultures of ‘Luna’ pubescent wheatgrass, spring seeded Bozoisky ‘Select’ Russian wildrye, and one spring seeded dryland mix including even proportions of crested wheatgrass, intermediate wheatgrass, smooth brome and slender wheatgrass. Picloram (1qt./ac. product) was applied in the fall after grass establishment. The average annual precipitation on the sites ranged from 12 to 14 inches and the soils were deep sandy clay loam.

The first attempt at reseeding occurred May 15, 2002 with Luna pubescent wheatgrass (10 lbs./ac.) no-till drilled into 450 acres of Russian knapweed dominated cropland at the Northern Cheyenne Teepee Farm near Ashland, Montana. The site was mowed and sprayed with picloram (1 qt./ac. product) in the fall. This project yielded the least successful perennial grass stand, producing only trace bunches (< 2 percent cover) of pubescent wheatgrass after four growing seasons. Drought was a major factor influencing seedling survival as well as suspected allelopathic impacts of Russian knapweed litter on the soil surface. Disk-tilling the site prior to seeding to dissipate allelopathic chemicals in the soil may have improved establishment.

The identical seed lot and rate was used to fall seed (November 15, 2002) 80 acres of fall (2001) mowed and sprayed with picloram (1 qt./ac. product) fallow which was disked twice in the 2002 growing season. All seed was planted using a Truax Flex-II® drill with no-till colters cutting a one-inch furrow in front of the planters for all monoculture seedings. Fall seeded ‘Luna’ pubescent wheatgrass was slow emerging and sparse in 2003 and 2004, achieving no more than 30 percent field cover. This field was a candidate for inter-seeding in 2005 even after an application of 1 qt./ac. picloram in October of 2003. April, May, and June 2005 were very wet. Greater than 12 inches (23 cm) precipitation fell in 90 days. The stand established completely (> 95 percent cover) producing about 3,500 lbs. per acre of wheatgrass hay (see Figure 3).

Figure 3. Pubescent wheatgrass in an 80-acre field in Bighorn County in early June 2005. The pubescent wheatgrass was seeded in November 2002 after control of Russian knapweed in 2001. The site produced over two tons of hay per acre in one cutting in 2005.

One hundred sixty acres of fall mowed, sprayed (tordon 1 qt./ac. product in October 2003), spring disked and harrowed fallow was spring seeded to monocultures of Luna pubescent wheatgrass or Bozoisky Russian wildrye in May of 2004. The ‘Luna’ pubescent wheatgrass was planted at 10 lbs./ac. bulk seed in eight-inch rows while the Bozoisky Russian wildrye was planted at 6 lbs./ac. bulk seed in 16 in rows. Both species established well in 2004 achieving about 50 percent cover. Both species established to > 80 percent cover in 2005 and > 90 percent cover in 2006. The Truax Flex-II® drill was used for both species with no-till disks cutting 1-inch furrows.

The most recent project included 90 acres that was mowed and disked and fall sprayed in 2004 with 1 qt./ac. glyphosate and ammonium sulfate. The fields produced barley hay in 2005. The barley crop was treated once with 2,4-D + Dicamba (Brash® - recommended dryland barley) in June and then in the fall 2005 with glyphosate and ammonium sulfate. The fields were disked April 8, 2006 and then chain harrowed. The dryland mix of crested wheatgrass, intermediate wheatgrass, smooth brome, and slender wheatgrass was planted at 10 lbs./ac. bulk seed on

April 18, 2006 with a Truax Flex-II® drill with the no-till colters deactivated because of the seedbed prepared by producing barley hay. The stand is 100 percent established in 8-inch rows and will be sprayed with 1 qt./ac. picloram in fall 2006. Deactivating the no-till colters allowed for 0.75- inch planting depth and minimal soil surface disturbance that reduced early sub-soil moisture loss. Deactivating the colters also allowed for earlier seeding because mud-up of the openers on the drill was not a problem. This seeding was the most rapid establishing stand to date and indicates that no-till disks may not be necessary and possibly detrimental to seedling establishment in well developed seedbeds. In all of the demonstration sites, Russian Knapweed was reduced from 80 percent cover to < 10 percent cover in the presence of competitive species by 2006.

Cultivation

Research in Russia in the 1960's indicated that Russian knapweed can be controlled with intensive cultivation. Systematic cutting of the roots to a depth of one foot (30 cm) over three years destroyed the root system in the top three feet of soil. Russian knapweed was reduced by 99 percent in a four-year mono-culture of winter rye or wheat when it was harvested for silage, and by 78 percent when harvested for grain. A four-year rotation of fallow and winter cereal grain controlled Russian knapweed in three years if the fallow was disc-tilled before plowing.

Mowing

Research in Wyoming showed mowing infestations two times eight weeks apart, the first mowing at the bud-growth stage, suppressed Russian knapweed during the year of mowing. However, the weed recovered vigorously the subsequent season. Perennial grasses recovered in the mowing treatments but much less than in herbicide treatments. Two mowings per year for several years may suppress the spread of Russian knapweed. In Russia, mowing stimulated the regeneration of shoots and prevented dehydration of roots and the transition of the plants to dormancy.

Prescribed Burning

In Wyoming, prescribed burning did not reduce the live canopy cover of Russian knapweed following treatment. Prescribed burning may be used to remove plant litter build-up prior to seeding in a re-vegetation treatment.

Hand Pulling

Hand pulling is not a practical control treatment for Russian knapweed because of the ability of the weed to regenerate from the roots. Pulling may work for small infestations in sandy soils where it is possible to remove a significant amount of roots, and where pulling can be repeated over a long period of time.

Grazing

Prolonged grazing of Russian knapweed by horses has been shown to result in chewing disease (equine *nigropallidal encephalomalacia*), a fatal neurodegenerative disorder. Cattle avoid grazing in Russian knapweed infestations. There is little information on sheep grazing in

Russian knapweed. Goats will graze Russian knapweed; however, there is little information on long-term impacts of goat grazing on Russian knapweed control.

Biological Control

Biological control of Russian knapweed in North America has been limited. Only the gall-inducing nematode, *Mesoanguina* (*Subanguina*) *picridis*, has been introduced and established in North America with limited success. Other organisms are being considered for biological control. Host specificity testing has been initiated on two species of gall flies: *Urophora kasachstanica* and *Urophora xanthippe*, and an eriophyid mite, *Aceria sobhiani*. Both flies induce a lignified gall in the flower head; which reduces seed production. The mite feeds on the plant's leaves and stems causing distortions, stunting, and/or plant stress.

Integrated Pest Management

An integrated Russian knapweed management program will include prevention, early detection and small-scale eradication, containment, and large-scale population reduction. Prevention is guided by how Russian knapweed spreads and its requirements for establishment and includes managing disturbance, maintaining competitive plant communities, and preventing seed imports by using weed-free hay, feed, and seed, cleaning equipment before application on weed-free areas, and a 5-day containment period for grazing animals that have fed in and potentially eaten seeds in Russian knapweed infestations before moving them to weed-free areas. Early detection and small-scale eradication is achieved through persistent survey and herbicide application. Russian knapweed populations are contained by herbicidal control of population boarders and satellite populations, control actions that reduced seed production such as mowing and biological control, and cultivation of competitive desirable plants. Large-scale Russian knapweed population reduction over the long-term is limited to herbicide applications and re-vegetation with perennial, sod-forming grasses.

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