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Ecology and Management of Sulfur Cinquefoil (*Potentilla recta* L.)

Figure 1. Sulfur cinquefoil flowers in early summer.

Abstract

Native to the eastern Mediterranean region, sulfur cinquefoil was first collected in Montana from Ravalli County in 1947. Its distinctive five to seven "fingered" palmately compound leaf and sulfur-yellow rose-like flower (see Figure 1) make it easy to find, and the bristly hairs distinguish it from the native northwest cinquefoil. Plants are perennial, re-grow from a persistent woody base that can persist for ten years or more. A high rate of seed production enables rapid spread of sulfur cinquefoil populations. This Category 1 noxious weed can be found on roadsides, disturbed pastures and meadows, native rangeland, clearcuts, and other disturbances in most of the western counties of Montana. Livestock and wildlife avoid grazing sulfur cinquefoil because of the high tannin content of the leaves and stems, and therefore infestations reduce livestock carrying capacity as well as wildlife habitat value.

Herbicides that temporarily reduce sulfur cinquefoil populations include 2,4-D, aminopyralid, metsulfuron, and picloram. Applications in the rosette or pre-bloom stages of growth are most effective. Tillage will control sulfur cinquefoil on cropland in rotation but follow-up management using herbicides may be needed to control re-generating plants. Persistent hand pulling and grubbing that removes the woody base will reduce small-scale populations. Mowing before bloom will reduce seed production but will not reduce populations. Prescribed fire is more likely to increase than decrease populations unless control measures are applied post-burn. There are no biological control insects available for management of sulfur cinquefoil. Applying practices that encourage competitive desired plants will improve control procedures and reduce the spread of sulfur cinquefoil.

PLANT BIOLOGY

Taxonomy

Sulfur cinquefoil is in the rose taxonomic family (Rosaceae) along with many closely related agriculturally important plants, including cherry, plum, raspberry, and strawberry. The genus name *Potentilla*, applied by Linnaeus in 1753 in his publication *Species Plantarum*, is from the Latin *potens*, powerful, and refers to the strong astringent properties of some species in this genus. There are over 50 *Potentilla* species in North America. The common name for the genus, cinquefoil, refers to the five leaflets of the palmately compound leaves. The genus is also commonly called "five-finger." The species name, *P. recta* is derived from the Latin root *rect* which translates to strait, and refers to the strait, erect stems. Erect cinquefoil, sulphur cinquefoil, and roughfruit cinquefoil are other common names for sulfur cinquefoil that are derived from stem, flower and seed morphological features. *Potentilla sulphurea* Lam. is a synonym for sulfur cinquefoil, named for the pale, sulfur-yellow flowers. Three varieties of *P. recta* are recognized; *P. recta* var. *obscura* (Nestler) W.D.J. Koch, *P. recta* var. *pilosa* (Willd.) Lebed., and *P. recta* var. *sulfurea* (Lam. and D.C.) Peyr. To date, no varieties have been listed in Montana. It is believed that *Potentilla* species do not readily hybridize. However, *P. recta*, *P. argentea*, and *P. norvegica*, all considered weedy in Canada, have been implicated in natural hybrid crosses, though no crosses are actually known to exist.

Figure 2. Sulfur cinquefoil lateral roots and stout woody caudex.

Figure 3. Sulfur cinquefoil leaf, flowering stem, and seed depiction.

Identification

Sulfur cinquefoil is an erect herb that grows from one to two feet (30 - 70 cm) tall. It has a dark brown tap root and branched spreading lateral roots that support a stout, woody, persistent stem base (caudex, see Figure 2). Basal and stem leaves are palmately compound with five to seven coarsely-toothed, leaflets that are longer than they are wide with nearly parallel margins (oblong), 1.2 to 1.5 inches (3 - 14 cm) long (see Figure 3). Basal leaves have long petioles. Stem leaves are smaller and have shorter petioles than the basal leaves. One to several flowering stems grow from buds on the caudex and are branched at the inflorescence, with a central stalk and two opposite branches at each node forming a somewhat flat-topped cyme (see Figure 3). Each branch terminates with a pale- to sulfur-yellow flower one-half to one inch (1.5 - 2.5 cm) across. Flowers have five small, green, linear bracts, five green sepals, five yellow petals, about 30 stamens with anthers 1 mm long, and many pistils. The sepals, petals, and stamens are fused together at the base and form a short floral tube that looks like a cup in cross section and surrounds the receptacle baring the pistils. The achenes (seeds) are small (about 1.2 mm), ovate, have narrow-winged margins, are dark brown with lighter, prominent, branched ridges that form a net-like (reticulate) pattern (see Figure 4). All the above-ground parts of the plant have relatively sparse, long (up to ¼ inch, 6 mm), coarse hairs (hirsute-hispid) (see Figure 5).

Figure 4. Sulfur cinquefoil achenes (seeds) are small (1.2 mm long), dark brown, have winged margins and a net-like pattern. Achenes of native cinquefoils are similar but without the net-like pattern.

There are three native *Potentilla* species in Montana with five-leaflet palmately compound leaves that could be confused with sulfur cinquefoil. *Potentilla quinquefolia* is reported from alpine and subalpine areas in Flathead, Glacier, Granite, Madison, and Park Counties and is small, only reaching 8 inches (20 cm) tall, has three leaflets on the basal leaves, the lower surface having grey, tangled, wooly hairs (lanate). *Potentilla diversifolia*, found in alpine areas in west and central Montana, has mainly basal leaves with few leaves along the stem, the flowers have only 20 stamens, the plant is not hirsute-hispid, and the achene surface is smooth. Sulfur cinquefoil is most often confused with northwest cinquefoil, *Potentilla gracilis*, found in most of Montana's counties. Northwest cinquefoil is variable in its morphological characteristics. It generally has fewer leaves along the stem than sulfur cinquefoil, the leaves can, but not always, have white wooly hairs on the lower (ventral) surface, or some plants are fuzzy with short hairs (pubescent) or appearing without hairs (but never hirsute-hispid), and the achenes are smooth. Because of the leaves, sulfur cinquefoil has been confused with hemp, *Cannabis sativa*. However, hemp plants are hairless annuals commonly growing to well over two feet tall, and the flowers are small, green, and dioecious.

Figure 5. Stems, leaves and flowers of sulfur cinquefoil showing the hirsute-hispid hairs that distinguish this species from similar native *Potentilla* species.

Life History

Sulfur cinquefoil is a perennial forb classified as a hemicryptophyte, with overwintering buds on the caudex at or just below the soil surface (see Figure 2). It does not have vegetative buds on roots nor produce rhizomes or stolons, and it is not capable of vegetative reproduction except from the caudex where infestations are tilled. The thick, woody caudex also stores energy. Individual plants have been aged by counting annual growth rings in the root crown (herbchronology); however aging after the sixth year is difficult because the central core may disintegrate with age. Estimates based on the diameter of individual plants suggest plants can live for 20 years. The average age of sulfur cinquefoil populations in northeastern Oregon was 3.5 years and ranged from one to ten years.

New plants grow from caudex buds in early-spring (as early as mid-March) with basal leaves that have been described as a semi-rosette (see Figure 6). Floral stems begin growth in May and flowering begins in June. On older plants the shoots emerge from the edges of the caudex often forming a circle of upright stems. Grasses have been observed to grow in the central area of the stems (see Figure 2). Flowering continues as long as soil moisture is adequate to support growth, however, plants dry rapidly as soil moisture is depleted. Flowers are believed to be pollinated by bees. They can self-pollinate, but cross pollination is more common. Achenes develop in July and disperse in late July and August. Most seeds (83%) are dispersed within two feet (60 cm) of the parent plant in the direction of the prevailing winds. After fall precipitation, sulfur cinquefoil will re-grow basal leaves that last until a killing frost. Research indicates sulfur cinquefoil plants can produce seeds during their first year and throughout their life spans at a constant rate, enabling rapid colonization after initial establishment.

Figure 6. A sulfur cinquefoil semi-rosette in Gallatin County. The photograph was taken in mid-May.

Seed production from populations of sulfur cinquefoil in the mid-western United States was measured at about 60 seeds per flower, and plants averaged 25 flowers per stem, with total seeds per plant greater than 1,650. Plants from populations in northeastern Oregon produced about 100 seeds per flower and from 13 to 30 flowers per stem on average totaling an estimated 6,000 seeds per plant. Plants averaged two to five flowering stems. Competition from other plants reduces the number of seeds per plant. Seeds are capable of germinating in the fall of the same year they are produced. Germination of seeds has been reported as low as 20% and as high as 70%. Apparently, germination is stimulated by exposure to light. The length of time seeds survive in the soil has not been measured, but it is believed to be at least three years. Little has been published about the seedling biology of sulfur cinquefoil. However, seedling survival is low when growing under competition with other plants.

Habitat

A study of 85 infestations in Montana found sulfur cinquefoil in 31 different habitat types including conifer, grassland, shrubland and seasonal wetland eco-systems. It was found on all soil textures except silt. It is often associated with spotted knapweed (*Centaurea stoebe*). It invades native rangeland with low disturbance, shrubland, and open-forested sites. It is commonly found on roadsides, clearcuts, abandoned farm fields, waste places and other disturbed areas. In abandoned fields, sulfur cinquefoil occurs from the earliest successional stages until extensive woody cover dominates. Sulfur cinquefoil is more common and stem densities are greater on open sites (29 stems/m^2) sites than sites with 50% canopy cover (1 stem/m^2), and it does not tolerate shading from a closed canopy forest. It has been found at elevations as high as 6,850 feet (2,006 m) in Montana.

Spread

Sulfur cinquefoil has a wide geographic distribution in North America, Europe, the Middle East, Northern Africa, west and central Asia, and Asia Minor, yet mechanisms of long-distance spread have not been defined. Probable vectors include people, vehicles, and animals. Livestock and wild ungulates likely transport seeds embedded in their fur and in soil on their hooves. Seed-eating birds also are vectors. People hiking, riding horseback, or driving all-terrain vehicles may transport seeds long distances. Movement of soil containing seeds on equipment, vehicles, and shoes is a probable means of long-distant transport. Sulfur cinquefoil seeds can be spread from infested hay meadows when plants with flowers are baled in hay. Sulfur cinquefoil has been classified as a horticultural plant, and population origins may be from escaped ornamentals.

Seeds disperse short distances by passively falling from the plants. The seeds are heavy relative to their size and they have no distinctive structure for wind or animal dispersal other than the narrow-winged margins. Seed-rain patterns suggest populations increase as an advancing front more or less in the direction of prevailing winds.

Impacts

Sulfur cinquefoil is one of the last plants selected by grazing animals. Utilization on infestations in Montana was measured at less than 1% on 98% of sites sampled. Therefore, the impact of sulfur cinquefoil on rangeland sites is to reduce carrying capacity for livestock and ungulate wildlife. In addition, selection of plants species other than sulfur cinquefoil by grazing animals may have the long-term impact of reduced bio-diversity. On infested hay meadows, sulfur cinquefoil reduces the quality of hay.

MANAGEMENT

Herbicidal Control [1/]

On pastures and rangeland, sulfur cinquefoil can be temporarily suppressed by aminopyralid, metsulfuron, picloram, or 2,4-D. Picloram should be applied at 1 pint product (Tordon®) per acre to actively growing plants before bloom or to fall re-growth. Aminopyralid should be applied at a rate of 4 to 6 ounces (Milestone®) per acre to plants in the pre-bud stages. Metsulfuron should be applied to sulfur cinquefoil rosette plants in the spring (May) at 1 to 2 ounces product (Escort® or Cimarron®) per acre. A non-ionic surfactant is needed in the spray solution at 0.5% by volume for metsulfuron to be effective. Pre-bloom foliar applications of 2,4-D at 1 to 2 quarts per acre with repeated applications to re-growth can also be used. Glyphosate applied at one to two quarts per acre will kill sulfur cinquefoil on cropland or where re-vegetation is planned. Label information for all herbicides should be carefully followed not only for application restrictions but also for restrictions that apply to grazing and harvest of forage after application.

[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.

Table 1. Chemical and product name, recommended application rate, soil residual half life, and eco-toxicity of herbicides commonly used to control sulfur cinquefoil. The eco-toxicity is the lethal concentration of the herbicide when applied in a single dose kills 50 percent of the tested organism (the lower the number the more toxic the herbicide). Follow label guidelines for rangeland use and all other label requirements when applying herbicides to avoid damage to desirable plant species.

Chemical name	Product name	Rate per Acre	Half life (days)	Eco-toxicity (LC_{50}/EC_{50})
2,4-D	Many names	1 to 2 qts.	7	1-10 mg/L
Aminopyralid	Milestone	5 to 7 oz.	30	>100 mg/L
Glyphosate	many names	1 to 2 qts.	32	8.2 mg/L
Metsulfuron	Escort/Cimarron	0.5 to 1.5 oz	14-180	>150 mg/L
Picloram	Tordon	1 pt.	90	10-100 mg/L

Hand Pulling

Hand pulling, grubbing, and hoeing may be practical on small populations of sulfur cinquefoil and if it is applied persistently can reduce populations. Pulling and grubbing must remove the caudex to be effective. Follow-up treatments will be necessary where a persistent seed bank exists.

Mowing

Mowing if applied before bloom will reduce flowering and seed production. Mowing will not reduce populations. Mowing after flowering when seeds have set may increase the spread of sulfur cinquefoil.

Tilling

Sulfur cinquefoil is not normally a problem in cultivated crop fields because it is controlled by tillage procedures that clean crop fields of weeds. However, because the caudex has regenerative buds, it is possible to spread sulfur cinquefoil within a crop field and between fields. Seeds are also believed to be spread with the movement of soil. Repeated tillage, or an application of glyphosate to sulfur cinquefoil plants that regenerate from caudexes or seeds following tillage, will reduce its spread on tilled fields. Cleaning tillage equipment of soil that may contain seeds or caudexes is recommended after use on fields where sulfur cinquefoil has been growing and before use on weed-free fields.

Prescribed Burning

Research on native grasslands in Montana showed prescribed fire applied in the spring or fall did not kill sulfur cinquefoil plants that were one year old or older. Also, spring and fall prescribed fires did not change population densities five years after fires compared to infestations that were not burned. This implies that the relatively low temperatures of prescribed fires do not damage regenerative caudexes. Temperatures generated by high intensity wild fires may be more destructive. Increases in seedlings were measured one year after prescribed fires, but there were no differences in seedling densities between burned and not burned areas after five years. Seedling densities were greater in spring prescribed burns compared to fall burns five years after the fires. Fires on infested sites that do not have competitive plants may increase the

invasiveness of sulfur cinquefoil. Application of picloram prior to a prescribed fire is likely to reduce the residual control on sulfur cinquefoil. Fire favors seed germination and vegetative growth and by itself will not control sulfur cinquefoil. Prescribed or wild fire on land infested with sulfur cinquefoil should be followed by control treatments such as herbicides and re-vegetation where needed.

Grazing Control

Livestock avoid grazing sulfur cinquefoil. For grazing management to be affective in reducing sulfur cinquefoil, animals with a tolerance for tannins (goats) should be confined on the infestation. This type of management may need to be followed by seeding of desirable species. Prescribed grazing to maintain the health and competitiveness of pasture and rangeland plant communities is important in preventing and retarding invasion, and to increase the effectiveness of other control treatments.

Cultural Control

Plant competition reduces the invasiveness of sulfur cinquefoil and increases the effectiveness of controlled applications. Therefore, practices that increase the competitiveness of desirable plant species and communities such as conservation crop rotation, conservation cover, and critical area planting (for example, after a wildfire) will make the environment less hospitable for sulfur cinquefoil to survive and spread.

Biological Control

Currently, there are no biological control agents available for management of sulfur cinquefoil and availability of agents in the near future is not likely because of the many close native and agricultural taxonomic relatives. Five insects have been screened for biological control including a root moth (*Tinthia myrmosaeformis*), a flower weevil (*Anthonomus rubripes*), two gall wasps in the *Diastrophus* genus, and a gall midge (unidentified). Screening for the root moth found that it attacked domestic strawberries and native *Potentilla* species preventing its release in North America. Work on the flower weevil was terminated because its host range is too broad. Initial screening on the other three insects found them to be host-specific to sulfur cinquefoil but further screening efforts have been suspended. Of the six native beetles and moths known to attack sulfur cinquefoil in Montana, three are known pests of strawberry. A rust fungus (*Phragmidium ivesiae*) infects sulfur cinquefoil in the northern Rocky Mountain region.

Re-vegetation

Species selected for re-vegetating disturbed sites and sulfur cinquefoil infestations should be appropriate for management objectives, adapted to site conditions, and competitive with the weed. Management objectives will determine if introduced or native species are seeded and the combination of species in the seed mix. The environmental conditions of the site including precipitation, soil texture and depth, slope and aspect, will affect species establishment. 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 seeding rate guidance and re-vegetation species selection. State and area resource specialists can help determine the most appropriate, site-specific species mix and timing of seeding.

In most cases, herbicidal suppression of sulfur cinquefoil is needed for re-vegetation of infested lands. The herbicides listed in Table 1 will control sulfur cinquefoil and reduce competition during the establishment period with little or no injury to emerging grass seedlings. This is especially important for species that are slow to establish like many of the native grasses. However, where herbicides have been applied, chemical carryover should be assessed prior to planting permanent vegetation, particularly if forbs or shrubs are included in the seed mix.

Integrated Pest Management

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. The integration of multiple management practices should be designed based on the stage of sulfur cinquefoil invasion. On small sulfur cinquefoil populations in the early phase of invasion, aggressive herbicidal or hand control should be combined with cultural practices that strengthen the competitiveness of the plant community. In areas with large-scale infestations in the later phases of invasion, first priority should be given to herbicide application to eradicate small-satellite populations and to reduce spread along the invasion front of the parent population. Second priority should be given to reducing the parent population using herbicide management and re-vegetation with competitive plants where needed. On grazing lands, prescribed grazing management should be timed to maintain the vigor of rangeland plants and prevent sulfur cinquefoil seed spread. On crop and hay land in rotation, tillage combined with herbicide treatment will be more effective than either treatment applied alone. On disturbed sites, pastures, and rangeland where competitive plants have been lost, re-vegetation following control of sulfur cinquefoil will improve the longevity of the control application.

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