Appendix B: Natural History and Control of Nonnative Invasive Plants Found in Ten Northern Rocky Mountains National Parks

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Introduction

The Invasive Plant Management Plan was written for the following ten parks (in this document, parks are referred to by the four letter acronyms in bold): the Bear Paw Battlefield-**BEPA** (MT, also known as Nez Perce National Historical Park); Big Hole National Battlefield-**BIHO** (MT); City of Rocks National Reserve-**CIRO** (ID); Craters of the Moon National Monument and Preserve-**CRMO** (ID); Fossil Butte National Monument-**FOBU** (WY); Golden Spike National Historic Site-**GOSP** (UT); Grant-Kohrs Ranch National Historic Site-**GRKO** (MT); Hagerman Fossil Beds National Monument-**HAFO** (ID); Little Bighorn Battlefield National Monument-**LIBI** (MT); and Minidoka National Historic Site-**MIIN** (ID).

The following information is contained for each weed species covered in this document

(1) Park presence: based on formal surveys or park representatives' observations
(2) Status: whether the plant is listed as noxious in ID, MT, UT, or WY
(3) Identifying characteristics: key characteristics to aid identification, and where possible, unique features to help distinguish the weed from look-a-like species
(4) Life cycle: annual, winter-annual, biennial, or perennial and season of flowering and fruit set
(5) Spread: the most common method of spread and potential for long distance dispersal
(6) Seeds per plant and seed longevity (when available)
(7) Habitat
(8) Control Options: recommendations on the effectiveness of
    a. Mechanical Control
    b. Cultural Control
    c. Biological Control
    d. Chemical Control (herbicides listed by their active ingredients, then an example of a common trade name, and the optimal growth stage at time of application
(9) Integrated Pest Management Strategy: recommendations to use a combination, or more than one management option to improve efficiency of control efforts and to reduce the use of herbicides where possible

Weeds included in this document (see Table of Contents below or Table 6) currently pose a management challenge to one or more of the parks, or are included because of they have the potential to do so based on damages they have caused in similar habitats. This list was compiled using park records, interviews and park visits in 2009. This is not a comprehensive list of all non-native plants that may exist in one or more of the parks. A comprehensive list of additional species, such those on each park's county watch list (if available) is included at the end of this document (Table 9). At this time, these are weeds not considered high priority, but autecological and biological information (if available) has been collected on them and included in the Alien Plant Ranking System 5.1 in case they become concerns in the future.

The Alien Plant Ranking System (APRS) (Hiebert, R.D. and J. Stubbendieck. 1993. Handbook for Ranking Exotic Plants for Management and Control. National Park Service. Natural Resources Report NPS/NRMWRO/NRR 93/08.ed) was developed for NPS staff and others to evaluate the threat from and assist in prioritizing non-native plant species for treatment. It was incorporated into the seven-step decision making process in the Preferred Alternative described in the Northern Rocky Mts. Invasive Plant Management Plan of which this Appendix is part. The list of questions that need to be answered within the APRS are listed on p. 170.

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(To reference plants by common name, see Table 6, p. 166)

Guidelines for Management Strategies: Prevention, Eradication, Containment or Suppression

Prevention is the number one priority in any Invasive Plant Management Plan. Park staff must assess whether any of their daily or seasonal activities are likely to increase the chances of weed introduction and establishment on NPS land. An example is transporting seed from infested areas to uninfested areas on vehicles or machinery. The following preventive measures should be routine, and will reduce the spread of existing invasive species in the parks, and the chances of new species invading and establishing.

1. Thoroughly wash the undercarriage and wheels of vehicles and other machinery in a designated area routinely, and especially before using them in un-infested areas.
2. Following any major disturbance like construction of a new trail, expansion of a parking lot, or introduction of new soil or fill monitor the disturbed areas every 2-3 weeks through the growing season in the first year and monthly for an additional 2-3 years or more (depending on seed longevity). Hand pulling to eradicate new infestations while weeds are small is much more manageable compared to controlling large patches that have had one or more years to spread and develop a seed bank.
3. Reseed disturbed areas whenever possible (ideally using seed collected from within the park)
4. Roadways, trails, and irrigation ditches should be prioritized and maintained weed-free because these areas become sources for new populations.
5. Conduct a yearly education session to review weeds for permanent staff, and to teach seasonal staff how to identify high priority weeds. Print out pictures with brief descriptions of high priority weeds and make these available in a visible location/s.
6. Make sure there are an adequate number of signs throughout the park instructing visitors on the importance of staying on trails to reduce disturbance, and to prevent the spread of weeds.

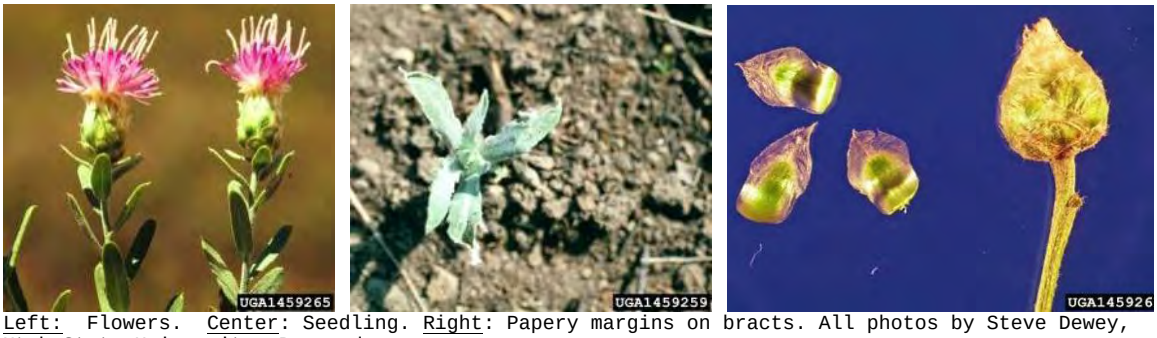
Eradication is recommended for small, recently emerged patches. Each year, educate all staff on likely invaders so species may be identified early in the invasion process and be successfully eradicated before they become well established. If possible, assign staff members to different trails, roads, and other high risk areas so they are checked on a routine basis (monthly, yearly, or every 2-3 years, depending on the size of the park and staff availability). Check the species life cycle: if tap rooted/not rhizomatous-hand pulling is recommended. If rhizomatous, or if the species grows back after hand pulling, refer to the chemical section for recommended herbicides and ideal application times.

Containment is recommended for larger, well established patches. First, prioritize patches in high quality habitats. For each patch, begin by delineating the outside of the patch and identify satellite patches that have expanded beyond the original patch. Spot spray or hand-pull these satellite patches to prevent further spread. Control of the patch should begin at the perimeter and work inwards. Consult the integrated pest management section for additional efforts such as: (1) releasing biocontrols (2) reseeding if there is a lack of desirable, remnant native species (3) combining herbicide and

reseeding. These additional efforts will be determined by the natural resource staff and will depend on the size and distribution of the patches, staff availability, and the priority of the species relative to other weed species.

Suppression is recommended for large, well established and widely distributed patches. First, prioritize patches in high quality areas. Determine the feasibility of releasing biocontrols in combination with other treatments as resources are available.

Acroptilon repens (formerly *Centaurea repens*), Russian Knapweed



Left: Flowers. Center: Seedling. Right: Papery margins on bracts. All photos by Steve Dewey, Utah State University, Bugwood.org.

Park presence: CIRO, CRMO, GOSP, GRKO, LIBI, HAFO, MIIN
Status: **ID**: control **MT**: priority 2B **UT**: control **WY**: noxious

Identifying characteristics: Flowers are pink to purple; bracts have papery margins and are not spiny (see right photo). Upper leaves are narrow and entire. Rosette leaves are lobed. Upper parts of roots are black, and plants are rhizomatous (both characteristics distinguish it from spotted and diffuse knapweed).

Life cycle: Perennial. Plants reproduce by seed and vegetatively by rhizomes. Seeds germinate in the early spring. Shoots emerge in the spring once soil temps are above freezing. Plants bolt in late spring to early summer and bloom from summer to fall.

Spread: Primarily vegetative which gives it the potential for moderate to rapid increase in population size (APRS #9). Recently established plants can spread rhizomatously to cover up to 12 square yards in two growing seasons. Competitive ability (APRS #15), is highly dependent on the surrounding plant community. Rhizomatous grasses can suppress this plant, but in sparse, or highly disturbed vegetation, or droughty conditions this plant will be highly competitive. Plants have limited potential for long distance dispersal as there are no adequate appendages on the seed for wind dispersal, or the bracts generally remain closed. Mechanisms for long distance dispersal are typically via contaminated hay and other seed (primarily alfalfa), or by movement of farm machinery or other vehicles.

Seeds per plant / longevity: Highly variable with 100 seeds per plant along roadsides, 292 in rangelands, and up to 1,200 in good conditions / 2-9 years

Habitat: Plants are commonly found along roadsides, riverbanks, irrigation ditches, pastures, waste places, clearcuts, and croplands, especially in areas of high water tables. It is not restricted by soil type, but it does especially well in clay soil. It has been shown to increase in dry sites, but decrease in moist sites if perennial grasses are present.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Partially effective for small, new (<1-2 yr old) infestations. However, given rhizomatous growth it may be better to spray to eradicate new, small patches before they establish unless hand pulling can be monitored and repeated regularly (every 7-10 days).
Cut/mow: Partially effective. Not recommended, will suppress above ground growth only. In the absence of other control measures, clipping off seed heads to reduce seed spread is recommended.
Till/cultivate: Ineffective when used alone. Tilling or cultivating alone will create rhizome fragments that will develop into new plants, increasing density. Research by Colorado State University suggests that the tilling may overcome or disperse residual allelopathic effects of Russian knapweed (Beck no. 3.111). However, some studies show that tilling prior to reseeding may improve establishment of seeded species (Mangold 2007).

Cultural
Reseed: Moderately to highly effective. Strongly recommended. Russian knapweed is sensitive to light competition. While species selection for reseeding will vary based on site conditions, studies have demonstrated that sod-forming native grasses like western wheatgrass (Bottoms and Whitson 1998) and streambank wheatgrass (Benz et al. 1999) effectively suppressed Russian knapweed (when preceded by a single herbicide application of clopyralid + 2,4-D). An allelochemical (7,8-benzoflavone) exuded by Russian knapweed roots suppresses some plant species while others are unaffected (Grant 2003, Tyrer 2007). In a study of four native grasses grown in the greenhouse and field with Russian knapweed root fragments, western wheatgrass (*Agropyron smithii*) was unaffected by Russian knapweed, blue grama grass (*Bouteloua gracilis*) was most sensitive and prairie June grass (*Koeleria cristata*) and sand dropseed (*Sporobolus cryptandrus*) were intermediate. The forb, Indian blanketflower (*Gaillardia artistata*), is not affected by Russian knapweed allelochemicals (Tyrer 2007). When selecting species for reseeding, consult the internet or your County Extension agents for information on susceptibility.
Tilling/cultivating has been shown to improve seeded species establishment (Mangold 2007) and this has been attributed to dissipating the allelochemicals. For dense infestations, an herbicide application prior to seeding (see IPM section below) is recommended, so that seeded species can establish.
Fire: Ineffective. Fire has a neutral to slightly positive response on Russian knapweed growth (Bushey 1995).

Biological
Insects: Partially to moderately effective where it establishes.
- ***Subanguinea picridis,*** aka *Paranguinea picridis, Mesoanguinea picridis,* Stem gall nematode: Galls are formed on the stems, leaves and root crown. It prefers areas that are moist during winter, and spring infection periods. It does not do well in dry areas. Availability is limited, but as of 2004, it was reported established in MT, and WY (Coombs et al 2004).
Grazing: Ineffective and not recommended. **Toxic to horses**. Unpalatable to livestock so likely to increase under grazing.

Chemical
Moderately effective. Rated excellent, good, fair, or poor when available from Dewey et al 2006.

Excellent: **Picloram +2,4-D** (Grazon P+D) in spring to early summer prior to full bloom or in fall. **Aminopyralid** (Milestone)[1] in spring and summer from bud to flower stage or to dormant plants in fall. **Picloram** (Tordon)[1] in spring prior to bolt and in the fall.
Good: **Clopyralid +2,4-D** (Curtail)[2] after rosettes form, prior to bolt; **Imazapic** (Plateau) in late fall; **Clopyralid** (Transline)[1] up to bud stage or in fall.
Fair: **Dicamba** (Banvel or Clarity), **imazapic + glyphosate** (Journey), **triclopyr + clopyralid** (Redeem R&P), **chlorsulfuron** (Telar)
Poor: **2,4-D**, **Cimarron Max, Roundup**[3].

[1]Colorado State University recommends late treatments in fall to dormant plants when using these herbicides.
[2] With Clopyralid+2,4-D (e.g. curtail), the growth stage at the time of herbicide application may not be as critical for effective control as it is for some other herbicides. In most cases, the effect of clopyralid + 2,4-D on Russian knapweed biomass or density did not depend on its growth stage (rosette, bud or flowering stage) at application.
[3] **Glyphosate** (Roundup) has been shown to increase Russian knapweed 1 or 2 years after application (Benz et al 1999).

Additional Notes

Re: Side effects of control measures (APRS #23): a fall herbicide application followed by seeding is likely to have a low impact on native plant communities (as long as genetically appropriate seed is used). However, if just herbicide is used, control measures are likely to cause major impacts on community. They will weaken the existing plant community and are unlikely to provide any long-term control. Glyphosate used alone has increased Russian knapweed density (Laufenberg 1995).

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

The combination of a single herbicide treatment followed by reseeding with native grasses is strongly recommended to provide long term control of Russian knapweed, and avoid annual reapplication of herbicide. In a Wyoming study, **clopyralid + 2,4-D** (Curtail) followed by seeding with streambank wheatgrass controlled 66-93% of the knapweed two years after the treatments (Benz et al 1999). By contrast, the herbicide alone provided only 7% control two years after application and **glyphosate** (Roundup) applied alone tripled Russian knapweed growth. In another study, a single application of clopyralid + 2,4-D followed by seeding western wheatgrass effectively controlled Russian knapweed (Bottoms et al 1998). Among the three herbicides: clopyralid + 2,4-D; glyphosate; and fosamine--clopyralid +2,4-D was most effective and increased native grass density.

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Aegilops cylindrical, Jointed Goatgrass

Left: Wheat (on left) compared to jointed goatgrass, on right. Center: Hairs on leaf margins. By Steve Dewey, Utah State University, Bugwood.org. Right: Flowering spikes form a long narrow cylinder and are jointed, easily breaking apart at the joints. Awns are barely visible in this photo. By Joseph M. DiTomaso, UC Davis, Bugwood.org

Park presence: Not reported in any of the parks.
Status: ID: contain **UT counties**: Tooele

Identifying characteristics: There are evenly spaced hairs on the edges of the leaves (above center). The flowering spike is a long narrow cylinder (above right) with distinct joints, or spikelets. Each spikelet is about one-half inch long and contains one to three seeds (above right). Glumes on the top spikelets have long awns (barely visible in photos above right).

Life cycle: Winter annual. Seeds may emerge at the surface or up to depths of four inches (Yenish 2008). Seeds emerge from late summer to late autumn, go dormant over the winter and head out after cheat grass (*Bromus tectorum*), but typically before wheat, and produce seed in late spring. Some may germinate in the spring and still produce viable seed.

Spread: Primarily from contaminated crop seed.

Seeds per plant and longevity: 600-3000 / ~3-4 years

Habitat: Common in wheat fields, grasslands, roadsides, and fencerows.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective. Recommended for small infestations.
Cut/mow: Partially effective. Recommended only on even ground, where plants are upright, and where clipped material can be bagged. Mow between the flowering and soft dough stage. New tillers will form and produce viable seed if mowed too early.
Till/cultivate: Partially-moderately effective. Where available, intense secondary tillage in croplands during the fallow season caused drastic reductions in jointed goatgrass densities. Such disturbances open up the canopy to reinvasion, and increase soil loss and erosion. Tillage is only recommended if it can be followed by reseeding.

Cultural
Reseed: Moderately effective. Strongly recommended, as densely seeding competitive grasses should reduce jointed goat grass seed production.
Fire: Ineffective.

Biological
Insects: NA
Pathogens: None available at this time, but bacterial pathogens are under investigation.
Grazing: unknown

Chemical
Moderately effective.
Glyphosate (Roundup): when plants are 6″ or less in height, before the boot stage.
Sulfometurn methyl + chlorsulfuron (Landmark II XP): apply in the fall 6 weeks prior to (expected) soil freeze date, or in the spring, 6 weeks after soil has thawed. Fall applications are recommended over spring applications for winter annuals, and spring applications typically require higher rates
Sulfometuron methyl (Oust XP): when plants are 6-12″ in height.
Quizalofop P-Ethyl (Assure II, a systemic herbicide for selected grasses): apply when plants are 2-6″ tall. See label for directions in non-crop areas and the use of surfactants. This herbicide is toxic to fish and invertebrates. Pay special attention to the Environmental Hazards section on risks of runoff and contamination.
For Alfalfa: **Pronamide** (Kerb 50-W): applications may be made postemergence to established, actively growing or dormant forage legumes or to new plantings after the legume has reached the trifoliate leaf stage. In established forage legume stands, applications should be made after the last cutting when the weather and soil temperatures are cool.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

This plant is primarily a problem in crop lands (particularly winter wheat), but also occurs in CRP lands and rangelands. Seed may remain viable in the soil for several years. Identifying small patches and pulling them before they spread is the best recommendation. For larger infestations, herbicide and reseeding are recommended.

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Ambrosia tomentosa, Skeletonleaf bursage

Left: Foliage. Right: flowers and developing seeds. Both by L.L. Berry, Bugwood.org.

Park presence: Not reported in any of the parks.
Status: ID: control, **WY**: noxious

Identifying characteristics: Plants grow up to 3 feet tall from an extensive rhizomatous root system. Leaves are alternate, have deep lobes, coarse toothed margins and are up to 5″ long. Lobes are smaller toward the leaf tip. Leaves are greenish-gray and may have rough hairs on the upper surface. Lower surfaces have white short, dense hairs. Inconspicuous yellow flowers are ¼ inch wide and are either male or female, not both. Fruits are 2-seeded, light brown burs with up to 10 short spines.

Life cycle: Perennial. Plants initiate growth early in the growing season. It flowers from early summer to early fall (typically June through August in Idaho).

Spread: Seed and creeping rhizomes.

Seeds per plant / seed longevity: Unknown. Likely more than 1,000 / Unknown. Seeds have an extended dormancy due to encapsulating bur, so likely more than 3-5 years.

Habitat: Native to the Great Plains region. Especially common in cultivated land, meadows, stream banks, waste places, pastures and poorly irrigated fields. While it can thrive on dry rangeland, it is especially severe in field depressions where water periodically accumulates.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Partially effective. This is recommended for very small, recently established plants only. Best done in late spring, before the flowering season and before a strong root system has developed.
Cut/mow: Ineffective. Will not kill plants, and likely to stimulate additional shoot growth from root buds. Mowing may delay or reduce seed production, but would need to be done repeatedly every 3 weeks.

The open canopy would likely encourage the recruitment of other invasive species.
Till/cultivate: Partially effective to ineffective, but information limited. Root fragments left by cultivation and shoots from lateral roots can produce dense clonal populations. However, repeated, persistent cultivation may deplete root reserves. If cultivation is used to reduce root reserves, managers must plan on reseeding with other species to provide long term control and prevent other invasives from establishing.

Cultural
Reseed: Unknown. Likely moderately effective since this plant typically occurs following a disturbance.
Fire: Information limited. Appears to be ineffective (was not effective on a closely related species *A. artemisiifolia,* Lewis 1973).

Biological
Insects: Not available.
Pathogens: Not available.
Grazing: Information limited. Not considered palatable.

Chemical
Chemicals are likely to be moderately to highly effective, but research is limited.
Application timing for all herbicides listed below: before bud stage.
2,4-D (many trade names), **Dicamba** (Banvel, Clarity), **Imazapyr** (Arsenal), **Picloram** (Tordon)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

This plant is likely to increase in agricultural settings via cultivation and disturbance. While the horizontal root system makes control difficult, more research is needed on the impacts of this weed in natural areas. It is not documented as having a high impact on natural processes in Rocky Mountain National Park (Rutledge and McLendon 1996). Based on studies in old fields with a similar species, *Ambrosia artemisiifolia*, researchers recommend no control efforts, compared to herbicides or burning (Lewis 1973). In the absence of treatment, *A. artemisiifolia* was displaced naturally through successional processes. By contrast, there was no decrease in *A. artemisiifolia,* but a decrease in non-graminoids (forbs), and an increase in annual grasses in 3rd year plots that were sprayed. Results may be different for *A. tomentosa*, but it is strongly recommended that managers set up control plots to determine whether this plant may naturally decline through time, and ensure that control efforts, such as herbicides are not doing more harm than good.

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Arctium minus, Common Burdock

Left: Flowers with Velcro-like spines beginning to appear. By Richard Old, XID Services, Inc., Bugwood.org. Right: The large rosette leaves. By Mary Ellen Harte, Bugwood.org.

Park presence: CIRO, CRMO
Status: MT counties: Lewis and Clark, Big Horn, and Powder River; **WY**: noxious

Identifying characteristics: Large, heart-shaped rosette leaves (easily more than 12″ inches long by the second year), and thistle-like flowers produce a Velcro-like ball in the second or third year. Plants may be exceed 4′ in height when flowering.

Life cycle: Modified Biennial or short-lived perennial. Seedlings establish the first year, large rosette and extensive root system typically form in the second year, and the plant bolts and flowers in the third year.

Spread: Velcro-like barbs on seed adhere to animals, and clothing allowing for long distance dispersal.

Seed per plant / longevity: 11-13,000 / 2-8 years. Seed longevity is not well documented, ranging from 2-20 years, but litter decreases longevity.

Habitat: Common on open, sunny, disturbed sites like roadsides, rail tracks, old fields,
meadows, and forest edges. Prefers moist fertile soils, but tolerates various conditions.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective on young plants. Use a shovel to remove as much root as possible. Repeated pulling will be necessary on mature plants.
Cut/mow: Moderately effective. Complete after they've bolted, but before flowering.
Till/cultivate: Highly effective. Will destroy rosettes (but increase erosion & of limited availability in most parks).

Cultural

Reseed: Highly effective for suppression and to resist invasion or reinvasion.
Fire: Ineffective.

Biological
Insects: Burdock moth *(Metzneria lapella),* is under investigation, but currently not available.
Pathogens: not available
Grazing: Moderately effective. Foliage palatable to cattle, and grazing may be effective with sheep. Note: populations likely to increase following removal of cattle (cattle are effective at suppressing it, but not eradicating it).

Chemical
Moderately to highly effective. Timing of herbicide applications for all herbicides listed here: most effective on 1st year rosettes, but can be applied from rosette stage to bolting. Ratings from Dewey et al 2006.
Excellent: **Aminopyralid** (Milestone)
Good: **Metsulfuron + dicamba + 2,4-D** (Cimarron Max), **Diflufenzopyr + dicamba** (Overdrive), **Triclopyr + clopyralid** (Redeem R&P), **Triclopyr** (Remedy), **Dicamba + 2,4-D** (Weedmaster)
Fair: **2,4-D***, **clopyralid + 2,4-D** (Curtail)

*If 2,4-D (ester or amine) is used early in the final year, the root sometimes forms new buds at the crown, even though the top is killed, and will still bolt to produce several flowering stems, instead of the usual one. 2,4-D ester applied after bolting, shortly before flowering, seems to kill the entire plant and prevent seed production.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Preventing establishment of the burred seed is essential to reduce and eventually eliminate the population. Mowing is most effective after the plant has bolted, but before flowering. If plants have bolted, clip and bag flowering stems. Encourage desirable vegetation by reseeding after disturbances.

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Berteroa incana, Hoary alyssum

(a.k.a. false hoary madwort, hoary berteroa)

Left Flowering plants growing along a trail. Center: Clear seed pods visible after seeds have dispersed. Photos by Hilary Parkinson. Right: Close-up up of flowers showing the notched petals (resemble rabbit ears). By Richard Old, XID Services, Inc., United States

Park presence: BIHO, LIBI
Status: ID: contain; **MT**: priority 2A

Identifying characteristics: Four small white flower petals are narrow at the base, and broader at the tip with a notch in each petal (petals look like rabbit ears, see photo above right). Plants are covered in tiny star-shaped hairs (visible with a hand lens). Leaves are entire, and leaves on the flowering stems have no stalk, or a very small stalk. Seedpods point upwards, positioned close to the stem, are rounded in shape and have a distinct membranous partition or septum visible after seed disperses (above center). The rosette may resemble foliage of some penstemon species before they flower.

Life cycle: Plants can grow as annuals, biennials, or short-lived perennials. Plants will remain as rosettes until the next growing season if they germinated after mid-summer.

Spread: Most seeds fall near the parent plant, as seeds have no mechanisms for long distance dispersal. However, long distance dispersal can occur when seed is transported as a contaminant in hay, soil, and gravel, or on mowers, vehicles, or other machinery.
Seeds per plant / longevity: 2500 / Unknown. Estimated 3-5 years.

Habitat: Commonly found growing along roads, and trails, gravely stream and lake banks, in lawns, farmyards, and vacant lots. It is also common on overgrazed pastures, rangelands, and in fields of alfalfa, clover, and birds foot trefoil.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective. Remove root crown when soil is moist, or use a shovel. Otherwise, plants can resprout if enough root remains.

Cut/mow: Ineffective, unless to revitalize grass pastures, and mow height is greater than 6". Plants mowed to 3-4" can still flower and produce seed.
Till/cultivate: Partially effective if accompanied by reseeding. Till 2-3 times to kill plants, and subsequent seedlings, then reseed in the fall.

Cultural
Reseed: Moderately to highly effective. Hoary alyssum growing in plots cleared of other vegetation produced an average of 2,407 seeds per plot, whereas those growing in plots with existing vegetation produced an average of only 104 seeds per plant, a 96% reduction in seed production[11].
Fire: Although information is limited on the use of prescribed fire to control hoary alyssum, fall burns may reduce seed production if seedpods are burned before seed release. However, fire may create a disturbance favorable to hoary alyssum establishment and sites should be monitored for weed occurrence and the need for follow-up weed control.

Biological
Insects: There are no insects or pathogens available to control hoary alyssum at this time.
Grazing: Not recommended with cattle (and toxic to horses, see note below). Cattle will utilize hoary alyssum in their forage areas, but they generally select more digestible forages. Because the disturbance of overgrazing favors hoary alyssum establishment and reproduction, proper grazing that maintains the competitiveness of forage plants is critical to prevent the spread of hoary alyssum in pastures and on rangeland. More research is needed to recommend goats or sheep. Domestic and wild mammals consume hoary alyssum where it occurs in sufficient quantities.
Note: poisoning has been reported in horses (but not other livestock). Horses will select for more palatable forage, but if none is available, and more than 20-30% of their feed is hoary alyssum-depression and swelling of the lower legs can develop 12 to 24 hours following ingestion. Just under 50% will develop a fever of 103ºF or higher, have warm hooves, pronounced digital pulse (laminitis), stiff joints, apparent founder, and reluctance to move.

Chemical
At this time, there are a limited number of herbicides that specifically list hoary alyssum on the label. For range, pasture and CRP lands, there is **Metsulfuron methyl + Aminopyralid** (Chaparral). Apply in the spring and early summer to rosette or bolting plants or in the fall to seedlings and rosettes before ground is frozen. Use higher rates after bolting through early flower. The University of Idaho extension bulletin recommends: **Metsulfuron** (Escort, 0.5-1oz/acre) or **Chlorsulfuron** (Telar, 1oz/acre) from rosette to bolting stages. Other extension sites recommend 2,4-D in the spring or fall as the most economical approach.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Because this is weed is a relatively new concern, IPM suggestions are limited. The best management recommendation is educating staff to

recognize it, and then hand pulling small infestations before they expand. In Montana, it is observed primarily in highly disturbed areas (personal observation) like gravel parking lots, and along trails. It does not respond well to competition, suggesting its ability to spread into undisturbed areas is limited, but this is unknown. If you do observe this plant spreading into healthy, undisturbed areas, please report it to your county extension specialist or weed coordinator.

Reseeding large infestations is strongly recommended to develop a healthy plant community that will suppress hoary alyssum and reduce the need for repeated herbicide applications. For dense infestations, herbicides may be needed to temporarily suppress hoary alyssum and allow seedlings to establish. Herbicides should be applied to rosettes in the spring to prevent seed production and again in the late summer if a large number of seedlings have emerged from the seed bank. This should be followed by reseeding in the late fall.

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Bromus inermis, Smooth Brome

(a) **(b)** **(c)** **(d)**

Figures: **(a)** Dense stand of smooth brome. By Joseph M. DiTomaso, University of California - Davis, Bugwood.org. **(b)** Flowering stem. By Ohio State Weed Lab Archive, The Ohio State University, Bugwood.org **(c)** Collar and sheath. By Joseph M. DiTomaso, University of California - Davis, Bugwood.org. **(d)** W- or M-shaped water mark that may occur on the leaf blade. By Purdue University Agronomy Extension.

Status: Not listed
Park presence: BEPA, CIRO, CRMO, FOBU, GRKO, LIBI

Identifying characteristics: Smooth brome is a rhizomatous, perennial grass that may reach heights of 4'. Stems are smooth and have an erect to decumbent growth form. Leaves are flat, firm, glabrous, and approximately 1/8 to ½ inch wide. Leaves may have a distinctive W- or M-shaped water mark on the leaf blade (Figure d). Ligules are less than 1/8 inch long, membranous, and lacerate (Figure c). Auricles are rudimentary or absent. The inflorescence is a loosely contracted panicle, 4 to 8 inches long, moderately open, with the upper branches often ascending (Figure b). Distinguish it from most other *Bromus* species by the perennial rhizomes, and the non-pilose lemmas (Otfinowski et al 2007). The lemma is the outer bract of a floret (in contrast to the *palea*, the internal bract). The lemmas are rounded on the back; flushed with purple toward the margins; and awnless or with

awns up to 3 mm long. Additionally the first glume is 1-nerved rather than 3-nerved.

Life cycle: Grows as a perennial cool season grass, reproducing by rhizomes and seeds. Seedlings can form rhizomes 3-6 months following germination. Plants are capable of forming a monoculture like sod. Growth begins in early spring and flowering occurs from late spring to mid-summer (May to July). With adequate fall moisture, plants may reflower in the fall.

Spread: Spreads by seed and rhizomes. Seed spreads short distances by wind or in contaminated seed or hay. Its rhizomatous spread makes it highly competitive, and it may displace native vegetation (Dillemuth et al 2009).

Seeds per plant / longevity: 156-10,080 seeds / 2-10 years

Habitat: Smooth brome is often planted as a forage species, but it escapes to forests, prairies, fallow fields, lawns, roadsides, railroad right-of-ways, lightly disturbed areas and other waste places. It occurs in openings in mountain brush, pinyon juniper, aspen, spruce fir, ponderosa pine, lodgepole pine, and meadow communities. Smooth brome has a high moisture requirement, but it will tolerate drought. It prefers clays and loams, but will grow on sands. It tolerates shade, but seed production, and biomass will be reduced. It may have the greatest impact in open prairie communities where it can produce large, monospecific stands (Otfinowski et al 2007).

CONTROL OPTIONS

Mechanical

Hand pull/grub: Ineffective except for small, single plants. Extensive rhizomes in established patches will quickly recover from hand pulling.

Cut/mow: Partially effective. Timing is critical and mowing will need to be repeated 3-5 times within a growing season (Otfinowski et al 2007). Repeated mowing causes the most damage when conducted during internode elongation or during the early stages of panicle development. Mow at the lowest mower height. Competition from native species is necessary to provide long term control.

Till/cultivate: Ineffective.

Cultural

Reseed: Moderately effective. Smooth brome tiller density decreases with competition from surrounding plants. Strongly recommended, but it may be necessary to precede reseeding with herbicides.

Fire: Reports from the Great Plains suggest that fires during tiller elongation, heading, and flowering (but not tiller emergence) can reduce smooth brome density, but this is only where native warm season grasses occur and can fill in following the burn (Willson and Stubendieck 2000). This may need to be done repeatedly. In the intermountain region where cool season grasses are more common than warm season grasses, outcomes may differ, and result in an increase in invasive annual grasses.

Biological
Insects: Not available
Pathogens: Not available.
Grazing: Partially effective to ineffective. Smooth brome tolerates grazing.

Chemical
Partially to moderately effective. Efficacy depends on the composition of the surrounding plant community. Glyphosate has shifted community dominance from smooth brome and Kentucky bluegrass (*Poa pratensis* L.) toward native warm-season grasses (Otfinowski et al 2007). Where warm-season grasses predominate, herbicides can be applied in the spring with less impact on non-target plants because warm season grasses are still dormant. However, because it often occurs as a single stand, or monoculture, it is a good target for control among cool season grasses and forbs when carefully spot sprayed, but it must be followed up by reseeding or it will be ineffective (USGS 2006).
Bromacil (Hyvar X): Apply pre-emergence or early postemergence. Rainfall is needed to activate the herbicide. In areas with low or seasonal rainfall, rates as low as 5 pounds per acre control many perennial weeds and grasses. Where limited rainfall (usually less than 4 inches) occurs during the active growth period, such as some areas of the West, HYVAR® X usually will not provide satisfactory control of hard-to-kill, deep-rooted perennial weeds.
Glyphosate (Roundup Power Max): apply when most plants have reached boot-to-early seedhead stage of development. Apply to actively growing plants when most have reached 4 to 12 inches in height. Repeat treatments may be necessary to control weeds regenerating from underground parts or seed. Rates as low as 0.5 kg/ha of glyphosate have some effect, but control was better when rates approached 2.0 kg/ha (USGS 2006).
Glyphosate + diquat (Quickpro): apply when seed heads first form.
Imazapyr + metsulfuron (Lineage Clearstand): apply postemergence.
Tebuthiuron (Spike): apply prior to or just after emergence.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Whenever possible, managers are strongly encouraged to establish plots to monitor this species. It may be that control efforts only stimulate rhizomatous growth and weaken the surrounding plant community, thereby increasing smooth brome. Monitoring could be very simple, such as establishing a $1m^2$ frame so half the frame is within the plot and half outside the plot. Two metal stakes, nearly flush with the ground, could permanently mark the diagonal corners of the frame. A photo could be taken directly above the plot, and the data collector should record (1) percentage cover smooth brome, (2) the number of species in the frame that are not smooth brome and whether their native or exotic and (3) their percentage cover. A minimum of five frames should be set up and ideally monitoring should occur for 2 years or more before a decision is made about the need to implement a control plan. If control is deemed necessary, managers must carefully consider the existing plant community (particularly warm versus cool season grasses), the climate, and other weeds in the area that are likely to invade following control efforts. While controlled burns (during the tiller elongation, heading, or flowering stages) have suppressed smooth brome

in the Great Plains, it should be used cautiously unless warm season grasses naturally occur in the area and are abundant enough to fill in following the fire. If cheatgrass (*Bromus tectorum*) is prevalent in the area, burns are likely to increase this annual grass. If the surrounding plant community responds favorably to mowing, mowing may offer some control, but needs to be done frequently and will thereby open up the canopy to other weeds. Mowing may be effective to weaken smooth brome prior to other treatments. More research is needed on combining methods to control smooth brome in natural areas. At present, herbicides in combination with reseeding may offer the most effective control. For recently disturbed areas adjacent to smooth brome patches, managers are strongly encouraged to reseed to reduce expansion of smooth brome.

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Bromus tectorum, Cheatgrass or Downy brome

Left: Dense stand of *B. tectorum*. By Leslie J. Mehrhoff, University of Connecticut, Bugwood.org. Center: Nodding seed heads of dried plant. By Steve Dewey, Utah State University, Bugwood.org. Right: Ligule and short soft hairs on leaves. By Fred Fishel, University of Missouri, Bugwood.org.

Park presence: Occurs in varying densities in all of the parks.
Status: MT: priority 3

Identifying characteristics: Plant size varies from 4-30" depending on light, nutrients and moisture. Soft hairs cover leaf sheaths (see figure above fright). Ligules are short. Seed heads droop heavily to one side (see picture above), and foliage turns reddish purple as it matures. The straight awns are ⅜ to ⅝ inch long and turn purple at maturity.

Life cycle: Winter annual. Seeds typically germinate in the fall given adequate precipitation, but seeds can also germinate in the spring. Roots of fall germinated plants continue to develop through the winter, and initiate shoot growth in the spring before most native plants. The early spring growth makes it competitive for soil moisture with native plants. Plants produce seed in late spring and dry out by early summer.

Spread: Seeds may be dispersed by wind, or travel long distances when attached to animal fur or clothing. Seed is often a contaminant in hay, grain, and straw and is difficult to separate from crop seed.

Seeds per plant / longevity: +300 / 1-3 years (occasionally up to 5 years)

Habitat: Most common on roadsides, waste areas, pastures, rangelands, and cultivated crop areas. Also occurs on open slopes, salt desert shrub, sagebrush, pinyon juniper, and less commonly in aspen and conifer communities.

CONTROL OPTIONS

Mechanical
Hand pull: Highly effective for small areas. Always bag pulled material, as immature seed heads can still mature on the ground.
Cut/mow: Results are highly variable. Managers should note: (1) plants cut to less than 2" can still regenerate and produce seed given adequate soil moisture; (2) plants that are cut after seeds form will

die, but seeds will mature on the ground (negating benefits of mowing); and (3) mowing opens up the canopy, creating favorable conditions for cheatgrass and other non-native species to establish. However, in some areas mowing has been reported as an effective strategy: at LIBI, mowing appears to have reduced cheatgrass density; and FOBU is mowing and bagging designated areas on a trial basis. For areas where herbicide is prohibited, mowing every three weeks can reduce cheatgrass seed production. Areas where there are no desirable remnant native species will need to be reseeded to provide long term control.

Cultural

Reseed: Highly to partially effective. While cheatgrass plants are competitive, they do not respond well to shade. For dense infestations, an herbicide application is recommended prior to fall seeding. This method should be highly effective if the appropriate seed is used for the site, weather conditions are favorable to seedling establishment, and cheatgrass was suppressed with herbicide or other treatment to temporarily free seeded species from competition.
Fire: Ineffective. Not recommended. Dry cheatgrass plants fuel wildfires and the absence of perennials following the fire create ideal conditions for cheatgrass expansion. Dense monocultures of cheatgrass that typically follow fires are extremely difficult to rehabilitate to diverse perennial plant communities.

Biological

Insects: None available at this time.
Pathogens: Research is ongoing on head smuts (*Ustilago*) and other pathogens, but nothing is commercially available at this time.
Grazing: Grazing may help to reduce plant numbers, but it results are variable. Some research supports grazing with sheep in early spring and again when new inflorescences have developed. Grazing treatments that defoliate cheatgrass multiple times before seed maturity are the most likely to impact cheatgrass populations. However, as cheatgrass matures, it becomes less palatable, so timing is critical. Even at low densities, cheatgrass impacts native plant survival and establishment, so grazing would need to be combined with another management strategy.

Chemical

The following herbicides were rated for cheatgrass control (Dewey et al 2006).
Excellent: **Imazapic + glyphosate** (Journey): apply in the fall as a pre-emergent or early post-emergence when plants are no taller than 4″. **Imazapic** (Plateau) early post emergence, when 1-2 leaves have emerged, and cheatgrass plants are no taller than 2″. Label recommends 4-6 oz, but preliminary analysis of multiple studies across MT suggest 6 oz provide better control than 4 oz. (Mangold et al 2010). Preliminary analysis also suggests that early post-emergence (when plants are at the 1-2 leaf stage) is more effective than pre-emergence, or post-emergence (when plants are beyond the 1-2 leaf stage) applications. **Glyphosate** (Roundup): apply to actively growing plants before seed formation. Experimental tests are ongoing to investigate applying glyphosate early in the spring when cheatgrass seedlings are 2″ tall or less, and when desirable plants are still dormant.
Fair: Amber
Other herbicides not rated by Dewey et al. 2006. **Sulfometurn methyl + chlorsulfuron (**Landmark II XP): apply in the fall 6 weeks prior to (expected) soil freeze date, or in the spring, 6 weeks after soil has

thawed. Fall applications are recommended over spring applications for winter annuals, and spring applications typically require higher rates

For sites without desirable remnant native plant populations, chemicals alone will open up the canopy, likely increasing cheatgrass or other weeds in subsequent years. For these situations, chemical control will be most effective if used as site preparation prior to reseeding. Where native grasses are present, a single chemical treatment to target cheatgrass may be enough to release desirable grasses from competition, allowing them to effectively suppress cheatgrass in subsequent years. Results will vary based on the density and condition of the desirable plant community, and whether it is protected from grazing (the number of years to protect from grazing will vary depend on climate and site conditions). In parks where cheatgrass poses an ongoing problem, or appears to be getting worse, it is recommended that test plots be established to compare two or more different treatments. Examples:

(1) Apply glyphosate in early spring when cheatgrass seedlings are visible (and at least 1″ tall), but native grasses have not yet greened up. If a large duff layer, or dried cheatgrass stems from the previous year are present, they will need to be raked/cleared so herbicide can contact the cheatgrass seedlings.
(2) Apply imazapic in the early fall when seedlings are in the 1 to 2 leaf stage.
(3) Apply imazapic (at the 1-2 leaf stage) or other recommended herbicide in the early fall, and reseed in the late fall.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Except for parks with only small infestations, eradication of cheatgrass is not a reasonable, nor economically feasible goal. Re-establishing healthy plant communities so that cheatgrass is only a minor understory component is more realistic. This requires persistence, knowledge of the existing plant community, and an adaptive management style that is willing to experiment with and monitor the results of different control strategies. For parks where cheatgrass has posed a long-term problem and appears to be getting worse, the establishment of trial plots described in the chemical control section above is strongly recommended. This will help determine whether a single herbicide application to target cheatgrass is all that’s necessary to reinvigorate native plants and suppress cheatgrass. Alternatively, herbicides may be needed in combination with reseeding to provide long term control.

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Bryonia alba, White Bryony

Left: White bryony leaves, pale yellow flowers, curling tendrils, and immature green fruit (fruit turns reddish black when mature). Photo by Melissa Graves, Plant Diagnostician, Montana State University. Right: pale yellow flowers.

Park presence: MIIN
Status: **ID**: contain

Identifying characteristics: This herbaceous, perennial vine with large lobed leaves resembles ivy (above right). Flowers are arranged in clusters, each with five pale white to yellow petals (right). Small green berries in mid-summer turn red to purple in early fall. The fast growth rate and small tendrils allow it to reach up to 50' in length and blanket structures, trees or shrubs on which it grows.

Life cycle: Perennial. It flowers in early summer, fruits form in mid summer, and mature in early fall. Plants die back to the ground after the first hard frosts.

Spread: Plants have a high potential for long distance dispersal by seeds which are palatable to birds.

Seeds per plant / longevity: unknown

Habitat: Grows in semi-shade to direct sunlight, and grows in a range of soil types from light and sandy to heavy clay. Because seed is spread by birds, it is commonly seen at the base where birds roost: telephone wires, and fruit trees (abundant around Russian Olive trees at Minidoka).

CONTROL OPTIONS

Mechanical
Hand pull/grub: Partially to moderately effective and recommended. Cut roots 3-4 inches below the surface with a shovel. The deeper the better as the crown can re-sprout. Note: **all plant parts can cause inflammation and are considered toxic.** Wear gloves, and wash hands after handling.
Cut/mow: Ineffective. Plants easily grow back from the large root.
Till/cultivate: Unknown. Not possible where it typically occurs (at the base of trees, in shrubs).

Cultural

Reseed: Unknown. The plant can grow in semi-shade as well as direct sunlight.
Fire: Unknown.

Biological
Insects/Pathogens: Not available
Grazing: Unknown. May be toxic to horses and cattle.

Chemical
The most common recommendation is to cut root 3-4 inches below surface, and apply roundup 100% v/v to cut root. More information is needed.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

More research is needed on this species. Cutting alone is ineffective as plants can resprout from the large, nearly tuberous root. Cutting the stem off 3-4″ below the soil surface and applying herbicide to the cut stem is widely recommended. It is unclear whether this will kill the plant outright, or needs to be repeated for more than one year. Once it appears eradicated, be sure to revisit the site and surrounding area frequently throughout the growing season to locate and control new plants or resprouts.

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Butomus umbellatus, Flowering rush

Left: Growth form of flowering plants and triangular stems (inset). Center: Flowers, growing as a round topped cluster or umbel. Right: dense quantities of flowering rush in a riparian area. Inset photo by Ben Legler. All others by Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.

Park presence: Not reported in any of the parks. It is an aquatic species, so only a concern for parks with ponds, ditches, or slow moving waters.
Status: MT: priority 1B

Identifying characteristics: Flowering rush is an aquatic species that grows as an emergent plant with upright foliage in shallower waters (shoreline to roughly 10 feet), or a submerged plant with flexible floating leaves in deeper waters (approximately 10-20 feet depths). The leaves are triangular in cross section along their entire length (inset photo, above left), and narrower towards the leaf tip, typically spirally twisting above water level. It occurs in two forms: a fertile form that regularly flowers and a sterile form that occasionally flowers. The populations in Idaho, Montana and most of the Northwest are the latter type (flower occasionally but sterile). If plants flower, they are easy to identify: 20-50 flowers grow in a round cluster that resembles an umbrella (center photo), hence the species name *umbellatus*. Individual flowers are ¾ to 1 inch wide, consisting of three light pink to rose-colored petals, and three outer sepals that are smaller and may be slightly greenish. Flowers have nine stamens arranged in an outer whorl of six and an inner whorl of three. There are six carpels, each of which can produce about 200 seeds (not viable). The roots are fleshy and rhizomatous. Bulbils (small bulb-like plant sprouts) may occur at the base of flowers stalks and at the roots, but this rarely occurs in the Northwest genotype. Note: the saying ‘sedges have edges, rushes are round’, is unfortunately not useful for this plant. It is not a rush, nor a sedge (despite the edges), but belongs to its own family, Butomaceae. When not flowering, it may resemble a sedge (due to triangular stems), but it is typically much taller, and stouter than most native sedges.

Life cycle: Perennial. Leaves emerge from rhizomes in early spring. It blooms from June-August (but does not flower reliably). Leaves die back in late fall with cold temperatures.

Spread: The genotype in the northwest spreads by rhizome fragments only. Fragments are easily formed by minor disturbance and float, allowing long distance dispersal (rhizome fragments have survived after passing

through dams). Genotypes in the Midwest spread by vegetative and floral bulbils and seed.

Seeds per plant / longevity: unknown, but also not relevant for the northwest type which does not produce viable seed.

Habitat: Along lake shores, ditches or in slow moving water. Can grow from above the shoreline to depths of nearly 20', but will not flower in depths greater than 10'.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Partially effective. Hand digging will decrease abundance, and is recommended for small isolated patches. However, it can uproot rhizomes or buds, which can disperse and grow into new plants. Whenever manually removing, care must be taken to remove all plant fragments from the water.
Cut/mow: Ineffective. Not recommended. Trampling will increase root fragmentation, and leaves will rapidly grow back.
Till/cultivate: Not applicable.

Cultural

Reseed: Flowering rush has been observed to invade more quickly in areas where existing vegetation is absent or sparse. Maintaining healthy stands of riparian vegetation is recommended.
Fire: Not applicable

Biological

Insects: None currently available.
Grazing: Not applicable.

Chemical

Currently there are no herbicides labeled for use on flowering rush, but research is underway to test herbicides, rates, and application timing. Studies by the University of Montana and Salish Kootenai College investigated a number of herbicides on flowering rush, applied at low and high water levels. Preliminary results suggested that spring applications when 5-7" of leaves had emerged and plants were above the water line were most effective. Until more research is completed, recommendations for specific herbicide products are not possible. Check with your Extension Agent periodically to determine if more research becomes available.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Information is very limited on control strategies for this weed. Early detection while patches are small and isolated, allowing them to be manually removed is a top management priority. Due to the likelihood of plant rhizomes or buds dispersing during removal, the site should be marked, and checked repeatedly for possible regrowth.

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Cardaria chalepensis, Lens-podded white top and *Cardaria draba,* Whitetop, hoary cress

Left: *Cardaria draba* in pasture. By Chris Evans, River to River CWMA, Bugwood.org. Right: Line drawings of *Cardaria draba* flowering stalks, seed, and rhizomatous growth. Note the seed and the distinct constriction making it two-lobed, and how it forms an upside down heart shape. This is in contrast to *C. chalepensis* (not shown), which does not have the distinct constriction. By Britton, N.L., and A. Brown. 1913. Illustrated flora of the northern states and Canada. Vol. 2: 165. USDA PLANTS Database, USDA NRCS PLANTS Database, Bugwood.org.

Park presence:
Cardaria chalepensis: CIRO, FOBU, GRKO
Cardaria draba: CIRO, GOSP, GRKO, LIBI, HAFO, MIIN.
Status:
C. chalepensis not listed, but reported to be just as aggressive as *C. draba*.
C. draba: **ID**: contain **MT**: 2b **UT:** control **WY:** noxious

Identifying characteristics: For both species: stems are erect, sparsely to densely covered with simple, short hairs. Flowers are white, in round topped clusters. Leaves are gray green to blue green, and variable: obovate, oblong to elliptic with margins irregularly toothed to entire. Upper leaves sessile (no stem/petiole) with rounded-acute to lobed bases that clasp the stem.
C. chalepensis and *C. draba* appear nearly identical except for the seed pods. Distinguishing between them is important as anecdotal reports suggest *C. chalepensis* is more resistant to mechanical treatments and certain herbicides like 2,4-D. Examine seed pods to differentiate between *C. chalepensis and C. draba*:

- **Lens-podded whitetop** (*C. chalepensis)*: seed pods **not** constricted at septum or 2-lobed. Pods +/- disc-shaped, round to broadly (ob)ovate or barely kidney-shaped (indented at the apex) in outline, 2.5-6(8) mm long, 4-6(7) mm wide, glabrous
- **White top/hoary cress** (*C. draba*): seed pods **are** constricted at septum and are more or less 2-lobed (see figure above right). Pods upside-down heart-shaped to broadly ovate in outline, 2.5-3.5 mm long, 3-5 mm wide, glabrous.

(information below applies to both species except where noted)

Life cycle: Perennial. Reproduces by seed and rhizomes. Plants bloom in early spring. Under good conditions (high moisture for example), plants can increase vegetatively by more than 2’ per year. After flowering and seed production, plants can die back to the root crown

during summer drought, and may remain dormant until the fall if moisture conditions are favorable. Otherwise, growth resumes the following spring.

Spread: Spreads by seed, but predominantly by rhizomes. Seed has no mechanism for long distance dispersal, but when consumed by livestock, it survives through the digestive tract. Seed is also spread by contaminated hay, and farming equipment.

Seeds per plant / seed longevity: ~1600 seeds (both species) / *C. draba* less than 4 years; *C. chalepensis* less than 6 years.

Habitat: Plants occur on disturbed, open sites, on rangeland, in grain and vegetable crops-and thrive on irrigated crops such as alfalfa. They are very common along roadsides, and ditches. They often grow on moderately moist, alkaline to saline soils, but tolerate a wide range of soil types and moisture conditions. They increase with grazing and irrigation.

CONTROL OPTIONS (for both species except where noted)

Mechanical

Hand pull/grub: Partially to moderately effective for small, new sites, but must be aggressively repeated for several years. Remove as much of the root system as possible. It is strongly recommended for small infestations, in riparian areas, or for re-growth of small patches after herbicide application.

Cut/mow: Partially effective. Mowing may reduce seed production, but it will not control or suppress the population. See below for combining mowing with herbicide, and then reseeding.

Till/cultivate: Ineffective or partially effective. It must be done every 14-21 days all season long. However, this makes the area more susceptible to other invasive species by repeatedly disturbing the site and opening up the canopy.

Cultural

Reseed: Highly effective. Plants grow rapidly in the absence of competition, but perennial species, especially grasses can suppress both species (Lyons 1998). Where habitat is appropriate, shrubs are reported to provide the best long term control. Shrubs reported to compete well against *C. chalepensis* in Saskatchewan, Canada are *Rosa* spp. (wild rose), and *Symphoricarpos occidentalis* (western snowberry).

Fire: Ineffective. Many *Cardaria* species increase following fire.

Biological

Insects and pathogens: Currently not available

Grazing: Ineffective or partially effective. Plants are palatable, but likely to increase with grazing as grasses are depleted. Sheep will eat *C. draba*, and especially like seedlings.

Chemical (herbicides rated when available by Dewey et al 2006)
Control tends to be best when applied at the early bud or flowering stage.

Excellent: **Metsulfuron +chlorsulfuron** (e.g. Cimarron X-tra) at bud to bloom stages. **Metsulfuron** (e.g. Escort) at bud to bloom or rosettes in

fall. An 80% ai surfactant is recommended (Lyons 1998). **Chlorsulfuron** (Telar) at bud to bloom or rosettes in fall.
Good: Apply all at early bud to flowering stage: **Metsulfuron +dicamba+2,4-D** (Cimarron Max), **Imazapic+glyphosate** (Journey), **Imazapic** (Plateau): also to fall rosettes. With MSO at 1.0 qt/acre, imazapic provided 74% control 2 years after treatment (Ransom et al 2001).
Fair: **2,4-D** (anecdotal reports suggest that *C. chalepensis* is less susceptible to 2,4-D), **MCPA, Glyphosate** (Roundup)
Poor: **Picloram** (Tordon)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Cardaria draba and *C. chalepensis* are most invasive in agriculture settings, especially irrigated fields. With few or no disturbances, no irrigation, and with competition from perennial species, they are described as relatively easy to control (Lyons 1998). All control efforts must be persistent, and require at least 2-3 years of follow-up because *Cardaria* can reestablish quickly after eradication measures. In heavily infested areas accessible to a mower, mowing followed by an herbicide application to re-growth (when it's at the bud stage) has been reported as very effective. Seeding perennial grasses is strongly recommended to provide additional suppression of *Cardaria* spp. Heavy grazing should be avoided to maintain healthy cover. Where possible, shrub establishment may provide the most effective long-term suppression.

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Carduus acanthoides, Plumeless thistle

Left: Flower heads that may be solitary or in clusters and spiny wings on flowering stalks. By Todd Pfeiffer, Klamath County Weed Control, Bugwood.org. Right: Flowering plants may reach 4-5' tall. By Gary L. Piper, Washington State University, Bugwood.org.

Park presence: Not reported in any of the parks.
Status: ID: contain **WY**: noxious

Identifying characteristics: Plumeless has spiny wings on the flowering stalk (distinguishing it from Canada thistle, musk thistle, and milk thistle). Leaves are deeply lobed to the mid-rib, or almost to the midrib. Flowers may be solitary, but typically are in clusters and are less than 1 inch (2.5 cm) in diameter. Receptacles (flower heads) have rows of needlelike bracts tipped with sharp spines. Bracts are not broadly triangular in shape. It may resemble bull thistle (*Cirsium vulgare*), but bull's flower heads are typically greater than 1 inch in diameter.

Life cycle: Annual, winter annual, occasionally biennial. Reproduces only by seed. Rosettes form in spring (and occasionally in fall with adequate moisture), bolting occurs in early summer, and it flowers from mid-summer to fall.

Spread: No mechanism for long distance dispersal, 99% of seeds fall within 150' of the adult plant.
Seeds per plant / longevity: +1500 / short lived, probably less than 2 years

Habitat: Prefers moist, well-drained soil. Thrives with disturbance, typically invading pastures, roadsides, ditches and meadows.

Notes from APRS
Hybridization with native species (#5): Potential is high, but there is no record of it hybridizing with native plants. *Carduus* x *orthocephalus* is a hybrid between plumeless thistle and musk thistle (*C. nutans*).
Allelopathic properties (#16b): Possible. Closely related to musk thistle which exhibits allelopathic effects.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective for small patches. Cut or grub at or below soil surface to prevent crown buds from resprouting.
Cut/mow: Moderately effective at late bloom stage. Regrowth and seed production will occur if mowed before 1st terminal buds bloom.
Till/cultivate: Moderately to highly effective. It does not tolerate regular cultivation.

Cultural
Reseed: Highly effective. Competition by perennial grasses suppresses growth of thistles. Seedlings do not compete well with established forage grasses. Maintain healthy plant cover. Reseed after disturbance.
Fire: Unknown. Some research suggests high intensity fire may kill musk thistle, but it would be difficult to get a high intensity fire burning before plants are dry and mature, at which point seed would already have dispersed.

Biological
Insects: Partially effective. At this time, only *Trichosirocalus horridus* has established within any of the four states included in this plant management plan.
Cheilosia corydon Thistle stem hover fly. Larvae attack leaves, stems and crowns. While it will feed on plumeless thistle, availability is limited and its availability is limited to OR where it feeds on slenderflower and Italian thistle (Coombs et al 2004).
Psylliodes chalcomera a beetle, no commonly accepted common name. Larvae destroy growing tips of buds and stems and damage the vascular system. It is very difficult to collect large quantities of this insect, so establishment is unknown, and it is not currently available (Coombs et al 2004).
Rhinocyllus conicus, Thistle seed head weevil. Larvae attack seed heads, adults do some damage chewing holes in the leaves. **This insect is not recommended**, as it attacks more than 25% of the native thistles in the US. It can not be transported across state lines.
Trichosirocalus horridus Musk thistle crown weevil. Larvae attack growing tips, adults feed on rosette leaves. Established in ID, MT and WY.
Urophora solstitialis Musk thistle seed head fly. Larvae cause galls to form, reducing seed production and diverting energy from other parts of the plant. Ideal habitat is unknown and establishment has not been reported.
Pathogens: ***Puccinia carduorum***, a parasitic rust, infects plumeless thistle and has been introduced to N. America. Permission for use and redistribution is pending (Coombs et al 2004).
Grazing: Not recommended with cattle. Sheep, goats, horses, and donkeys may graze them.

Chemical
Moderately to highly effective. Herbicides preceded by an asterisk (*) were included in a Minnesota study that compared three herbicides and herbicide timing (rosette, bolting, fall rosette) on plumeless thistle. Rates are based on the specific herbicide product listed in the study, but always refer to labels.
-**Aminopyralid** (Milestone): apply in the spring and early summer to rosette or bolting plants or in the fall to seedlings and rosettes. Refer to label for higher rates when plants are at the late bolt

through early flowering growth stages. 2,4-D at 1 lb ae/acre should be tank-mixed with Milestone starting at the late bud stages.
-***2,4-D** (2 pints/acre) apply to spring rosettes (only 43% control on bolting plants compared to 87% control on spring rosettes and 76% control on fall rosettes).
-***Dicamba** (Clarity + NIS) (1 pt + 0.5%) apply to rosettes (only 53% control on bolting plants compared to 95 and 99% control on spring rosettes and fall rosettes).
-***Clopyralid + 2,4-D** (Curtail): 2pt/acre on rosette and bolting plants provided 100% and 80% control. 1 pt/acre to rosettes in fall provided 93% control.
-***Triclopyr + clopyralid** (Redeem R&P): Apply 1 pint per acre at rosette, 1.5 pint per acre at bolting, and 2 pint per acre at prebud stage of growth. In the Minnesota study, Redeem R&P provided adequate control at the bolting stage (87% control with 1.5 pt/acre), and control on fall rosettes (94% with 0.75 pt/acre) was very good, nearly equivalent to spring rosettes (99% with 1.5 pt/acre).
-**Picloram** (Tordon): Apply at the rosette stage before bolting in the spring or in the fall prior to soil freeze up.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

A combination of herbicides and mowing (or clipping if not accessible with a mower) is strongly recommended. Herbicides are generally most effective on the seedling and rosette stages, and mowing is most effective on the bolting and flowering stages. This plant will typically be a problem only in disturbed areas. Surveying disturbed sites, and pulling plants before they flower should enable managers to prevent this plant from establishing.

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Carduus nutans, Musk thistle, Nodding Thistle

Left: Drawing of flower heads, with bracts that end in a small spine. By Britton, N.L., and A. Brown. 1913. Illustrated flora of the northern states and Canada. Vol. 3: 554 , USDA NRCS PLANTS Database, Bugwood.org. Right: Flowering plant with solitary flower heads. By Richard Old, XID Services, Inc., Bugwood.org

Park presence: CIRO, CRMO, FOBU, GOSP, GRKO, MIIN
Status: ID: control **MT counties**: Beaverhead, Carbon, Choteau, Madison
UT: control **WY**: noxious

Identifying characteristics: Stems have spiny wings along lower section, but not on upper portion. Plant are 1½ to 6 feet tall, and have multi-branched stems. Flowers are solitary, up to 3 inches in diameter. Bracts are less then ½ inch long, end in small spine, and are not fringed with smaller spines. Bracts turn purple and flowers nod at maturity. Leaves are coarsely lobed, dark green, hairless, and waxy with white spines along margins and at lobe tip. Flower heads may droop to a 90-degree angle from the stem when mature, hence its alternate name, nodding thistle.

Life cycle: Biennial-reproduces only by seed. Flowers from early May to August and seed is released approximately one month after the flowers form.

Spread: Seeds may be wind blown for miles. Seeds require open soil to germinate.
Seeds per plant / longevity: 3,750-11,000 / 10-15 years.

Habitat: Pastures, rangelands, roadsides, and non-crop areas. It does not grow well in excessively dry, wet or shady conditions. It's considered sensitive to competition and increases with overgrazing. Most likely to increase in situations of declining fertility. While thistles are described as highly competitive, vigorously growing grass competes with musk thistle, and fewer thistles occur in pastures where grazing is deferred.

Note from APRS: Hybridization with native species (#5): High potential, but unclear if it can hybridize with native thistles. *Carduus* x *orthocephalus* (no common name) is a hybrid between plumeless thistle (*C. acanthoides*) and musk thistle (both exotic).
Allelopathic properties (#16b) Yes. At early bolting stage and when the larger rosettes are decomposing.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective. Pull before flowering, and bag seed heads.

Cut/mow: Partially effective. Mowing can reduce seed output if plants are cut when the terminal head is in the late flowering stage. However, a study in Maryland found mowing in the fall after plants had dispersed seed and died caused a significant decline in plant density compared to mowing at the bloom stage or post-bloom stage (Tipping 2008). In the fall, decaying musk thistle plants release allelopathic chemicals that inhibit cool season grasses. The authors speculate that removing this material allowed cool-season grasses to increase and outcompete musk thistle seedlings which typically germinate in the fall. It may be worthwhile for parks with large populations of musk thistle to establish trial plots and compare fall mowing (that includes bagging and removing mowed material) to other treatment options.

Till/cultivate: Mixed results. Musk thistle does not tolerate tilling, but tilling may be followed by a large increase in musk thistle plants as it will bring more seeds to the surface. If tilling is used, it should be followed by reseeding.

Cultural

Reseed: Moderately to highly effective. This plant is sensitive to competition, especially by grasses.

Fire: Ineffective. Spring burns do not reach high enough temperatures to kill crowns. If warm season grasses naturally occurred in relatively high densities, burns could result stimulate warm season grasses, suppressing musk thistle. In the Northwest, cool season grasses tend to dominate, and burns are typically followed by increases in exotic annual grasses.

Biological

Insects: Partially effective. Availability of most is very limited.

Cheilosia corydon Thistle stem hover fly. Larvae attack leaves, stems and crowns. Its availability is limited to OR where it feeds on slenderflower and Italian thistle (Coombs et al 2004).

Psylliodes chalcomera a beetle, no commonly accepted common name. Larvae destroy growing tips of buds and stems and damage the vascular system. Not currently available (Coombs et al 2004).

Rhinocyllus conicus, Thistle seed head weevil. Larvae attack seed heads, adults do some damage chewing holes in the leaves. **This insect is not recommended**, as it attacks more than 25% of the native thistles in the US. It can not be transported across state lines.

Trichosirocalus horridus Musk thistle crown weevil. Larvae attack growing tips, adults feed on rosette leaves. Established in ID, MT and WY.

Urophora solstitialis Musk thistle seed head fly. Larvae cause galls to form, reducing seed production and diverting energy from other parts of the plant. Ideal habitat is unknown and establishment has not been reported.

Pathogens:

Puccinia carduorum Musk thistle rust. Leaves, stems, and bracts become infected, reducing seed set and seed quality. Availability and permission to release is pending.

Grazing: Partially effective to ineffective. It typically increases under grazing when grasses are depleted, unless grazing is carefully managed to reinvigorate native grasses.

Chemical

Moderately to highly effective. (ratings from Dewey et al 2006 when available)

Excellent: **Metsulfuron + chlorsulfuron** (Cimarron X-tra): prior to flowering or in fall to newly emerged rosettes. **Metsulfuron** (Escort): to actively growing rosettes. **Picloram + 2,4-D** (Grazon P+D): apply early in the season to rosettes, or in mid- to late-season from bolting to bud stage. See label- rates increase for mid- to late-season application. **Aminopyralid** (Milestone): to rosettes, or bolting plants; or to late bolting to flowering plants. See label, rates increase for late bolting or flowering plants. **Picloram** (Tordon): spring at rosette growth stage; or in fall; use higher rates for older or denser stands

Good: **Metsulfuron + dicamba + 2,4-D** (Cimarron Max): in the spring or early summer prior to flowering or in the fall after newly emerged plants have reached the rosette stage of growth. Note: certain biotypes of Musk Thistles are less sensitive to Cimarron Max. **Clopyralid + 2,4-D** (Curtail): late rosette to just prior to bud formation. **Imazapic** (Plateau): see label for directions and precautions.

Fair: **2,4-D**, **Dicamba** (Banvel, Clarity), **MCPA**.

Others (not rated by Dewey et al. 2006): **Triclopyr + clopyralid** (Redeem R&P): rosette to early bolting. **Chlorsulfuron** (Telar): after rosettes, before bolting in spring. **Clopyralid** (Transline): rosette to early bolt.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Preventing disturbance and removing plants prior to seed formation is the best management strategy. Because this species is not rhizomatous, hand pulling is strongly recommended. Biological controls are recommended for dense populations, but may take a few years to establish. The key to successful musk thistle control is to prevent seed production. Cultural methods that favor desirable plant growth (grazing management and seeding) should be combined with chemical or biological control.

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Centaurea diffusa, Diffuse Knapweed

Left: Basal rosette. Richard Old, XID Services, Inc., Bugwood.org. **Right**: white flowers surrounded by tan, fringed bracts ending in pointy spine. USDA APHIS PPQ Archive, USDA APHIS PPQ, Bugwood.org

Park presence: CIRO, CRMO, FOBU. Possibly eradicated from HAFO, MIIN
Status: **ID:** contain **ID counties:** Jefferson **MT:** priority 2B **UT:** EDRR **WY:** Noxious

Identifying characteristics: Basal leaves are pinnately divided and up to 6 inches long; stem leaves are entire, or with only a few slender lobes and are smaller. Flowers are typically white, or occasionally pink to purple, 1/3 inch wide, ½ inch long, and occur at branch tips. The small narrow bracts have a light brown comb-like margin and end in a short, stiff spine (above right). Plants have a bushy appearance from the single, much-branched stem. Diffuse is generally shorter than spotted knapweed at 6-24 inches tall. It resembles squarrose knapweed (*Centaurea virgata*), but the bracts on squarrose knapweed have a spine tip that is recurved (bends back to point outwards rather than straight up). If you're having trouble differentiating the knapweeds, see the booklet: Biology and Biological Control of Knapweeds (Wilson and Randal 2005) available at: http://www.invasive.org/weedcd/pdfs/KnapweedBook.pdf. Page 7 has an excellent knapweed key and diagrams of knapweed bracts.

Life cycle: Biennial to short-lived perennial, reproducing entirely by seed. Plants flower from mid summer to early fall (approximately July to September).

Spread: Seeds are shed as mature plants tumble in the wind after the stiff central stalk breaks off, allowing for long distance dispersal. Seeds are also spread by vehicles, animals, and people. Ecological impacts (APRS #16): Plants contain an allelochemical that may suppress the growth of other species (APRS #16).

Seeds per plant / longevity: 400-900 or greater / +8 yrs

Habitat: Prefers shrub-steppe zones and dry forest habitats, but is wide-ranging. Plants do not tolerate shading or flooding. Generally found on dry, light, porous soils. Regarding competitive ability, it can quickly invade disturbed sites, but is also capable of invading relatively undisturbed native plant communities. Seeds below depths of

3 cm do not germinate, so a flush of seedlings may follow a disturbance that brings seeds to the surface.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective. Highly recommend for small, new patches. Pull prior to seed formation. Pull when soil is moist, or use a trowel or shovel to remove part of the taproot. Plants cut at the crown regrew 38% of the time, while those which had the rosette removed along with 2-4" of taproot only survive 4% of the time (Roche 1995).
Cut/mow: Partially to moderately effective. Mowing can reduce seed production. The rosette growth of the first year resists mowing.
Till/cultivate: Ineffective. Not recommended.

Cultural

Reseed: Moderately to highly effective. Strongly recommended. Control efforts are of little value if native vegetation is scarce or absent. For dense infestations, seeding in the fall should be preceded by other control methods such as herbicides to increase establishment of seeded species.
Fire: Ineffective. Fire stimulates seed germination. Response to fire is neutral to slightly positive-may increase following fire (Bushey 1995).

Biological

Insects: Moderately effective and recommended for the long-term control of large patches. Information on establishment is from Coombs et al 2004.
-Agapeta zoegana (root boring moth) Feeds primarily on spotted knapweed, but also diffuse knapweed. Larvae feed on roots and can kill small rosettes, but it is best combined with other root-borers or seed feeders. Established in ID, MT, UT and WY.
Bangasternus fausti (seed head weevil) adults feed on foliage in the spring and flowers in the summer. Larvae feed on seed heads, reducing seed production by up to 100%. Prefers undisturbed sites with dry summers. Established in ID and UT.
-Chaetorellia acrolophi (seedhead fly) feeds on diffuse and spotted knapweed. Larvae feed in the flower buds, reducing seed production. More research is needed on this species. Established in WY.
-Cyphocleonus achates (root boring weevil) prefers spotted knapweed, but also feeds on diffuse. Larvae destroy the interior of the tap root and adults feed on interior leaves of rosettes. Intense feeding causes knapweed plants to become stunted and they may die one season after the initial attack. It is recommended in conjunction with other root-boring and seed-feeding insects. South facing slopes, or exposed soils with high temperatures are recommended for establishment. Established in ID, MT, UT and WY.
-Larinus minutus/obtusus (lesser knapweed and blunt knapweed flower weevil) Attacks both diffuse and spotted knapweeds. Larvae consume developing seeds. Adults feed on foliage and flowers. Established in ID, MT, UT and WY.
-Metzneria paucipunctella (spotted knapweed seed head moth): Adult moths lay eggs on bracts at the base of flowers. Larvae enter the flower, consuming florets and, later, seeds. Mature larvae mine the

receptacle tissue. This can destroy 90% of the seeds. *Metzneria* does not do well in areas that are very cold (does not tolerate temperatures below -22°F) with little snow cover. Established in ID and MT.
-Sphenoptera jugoslavica (bronze knapweed root borer). This insect attacks the roots of diffuse (preferred) and spotted knapweed. Surviving plants are stunted and produce fewer flowers. Often causes impressive population crash of diffuse knapweed. Established in ID, MT, UT and WY.
Urophora aphinis and ***Urophora quadrifasciata***: Gall flies that reduce seed production. Research at Montana State indicates that a complex of insects (perhaps 12) are needed to reduce diffuse knapweed populations. *U. aphinis, U. quadrifasciata Metzneria paucipunctella,* and *Larinus minutus,* although *Metzneria* and *Larinus* fly larvae may eat *Urophora. In Canada, Urophora* and *Sphenoptera* combined reduced diffuse knapweed seed production by 98% (Coombs 2004). Widely established throughout the northwest.
Pathogens: not available
Grazing: Moderately effective to use sheep or goats to reduce seed production. Consult "Targeted Grazing" at: http://www.cnr.uidaho.edu/rx-grazing/Forbs/Diffuse_Knapweed.htm if grazing is an option within the park.

Chemical
Moderately effective. Ratings (when available) are from Dewey et al 2006.
-Excellent: **Aminopyralid** (Milestone). Optimal results occur from rosette to the bolting stages of development or in the fall. Plants will be controlled by mid-summer and fall applications even though plants may not show any changes in form or stature the year of application. **Picloram** (Tordon). Apply in spring from rosette to early bolt.
-Good: **Clopyralid + 2,4-D** (Curtail). Apply to actively growing weeds after the majority of the basal leaves have emerged up to bud stage. **Triclopyr + clopyralid** (Redeem R&P). Apply from rosette to early flower or to fall regrowth. Optimum time is mid-bolt. **Clopyralid** (Transline): up to bud stage
Fair: **2,4-D**, **dicamba** (Banvel, Clarity), **diflufenzopyr + dicamba** (Overdrive), **glyphosate** (Roundup)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

For small infestations, persistent hand pulling should provide eradication. For larger infestations, multiple approaches are needed for effective control and these efforts will be of little value if native vegetation is scarce or absent. Cultural techniques to establish competitive grass cover are strongly recommended. Herbicides are recommended prior to reseeding to improve establishment. Biological controls should be used for suppression of patches that are large and well established.

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Centaurea pratensis, aka *C. debeauxii* ssp. *thuillieri*, Meadow knapweed

Note: The Latin name has changed many times and differs among institutions. The state of Idaho and ITIS (Integrated Taxonomic Information System) now refer to it as *C. debeauxii* ssp. *thuillieri*. USDA NRCS (Natural Resources Conservation Service) Plants Database refers to it as *Centaurea nigrescens*. The website, Invasive.org refers to it as *Centaurea x moncktonii*.

Left: Growth habit of meadow knapweed. Right: Pink flowers and fringed bracts. Both by Cindy Roche, Bugwood.org.

Park presence: FOBU
Status: **ID:** control

Identifying characteristics: This plant is a cross between black knapweed (*C. nigra*) and brown knapweed (*C. jacea*). Each plant can have multiple stems reaching 20-40" tall. Rosette leaves are entire or may have small lobes. Stem leaves are entire or with small lobes or teeth, can grow 6" long by 1 1/4" wide, but decrease near the apex. Colors range from pink to reddish-purple. Flower bracts are light to dark brown, with a papery fringe on the margin and may appear metallic-gold when the plant is flowering. The fringes are as long as or longer than the width of the bracts and they are not rigid. These two characteristics distinguish it from spotted knapweed which has fringes that are more rigid and the fringe length is shorter than the bract width. If you're having trouble differentiating the knapweeds, see the booklet: Biology and Biological Control of Knapweeds (Wilson and Randal 2005) available at: http://www.invasive.org/weedcd/pdfs/KnapweedBook.pdf. Page 7 has an excellent knapweed key and diagrams of knapweed bracts.

Life cycle: Perennial, seedlings are tap rooted, and mature plants develop a cluster of somewhat fleshy roots below the wood crown. Plants reproduce primarily by seed, but root and crown fragments resprout when disturbed by heavy equipment or cultivation. Plants flower from mid-summer to fall.

Spread: Seed is dispersed by wind or birds.

Seeds per plant and longevity: more than 1,000/ more than 5 years

Habitat: It typically colonizes roadsides, river and stream banks, and disturbed pastures. It is also capable of invading native prairies and meadows. It is common in open fields, mountain meadows and forest clearings, pastures and mesic habitats

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CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective if plants are dug to remove the upper 6″ of the taproot. If plants are flowering, bag pulled plants as seed may still mature on the ground.
Cut/mow: Ineffective. Mowing can stimulate growth.
Till/cultivate: Moderately effective for young plants. Roto-tilling or plowing will eliminate young plants and seedlings. Mature plants may survive if enough root fragment remains.

Cultural

Reseed: Moderately to highly effective in combination with other treatments.
Fire: Ineffective

Biological

Insects: Partially to moderately effective for large infestations. In its host range, ***Larinus minutus*** (Lesser knapweed flower weevil) prefers diffuse knapweed, but also feed on meadow knapweed. Larvae feed on the seed, adults feed on leaves. Established in ID, MT, UT and WY.
Larinus obtusus (Blunt knapweed flower weevil) larvae feed on seeds, and adults feed on leaves. As of 2004, it has established in MT and WY, but availability is limited to OR and WA (Coombs et al 2004).
Pathogens: NA
Grazing: Moderately effective to ineffective. The plant was initially introduced as a forage plant, but has become a problem because of its low palatability. Good grazing practices to stimulate grass and other forages will improve control on rangeland. Moderate control may be achieved if cattle are trained to eat it.

Chemical

Moderately to highly effective.
Clopyralid (Stinger): up to bud stage.
Aminopyralid (Milestone): apply when actively growing with the optimum time of application occurring from rosette to the bolting stages of development or in the fall. Plants will be controlled by mid-summer and fall applications even though plants may not show any changes in form or stature the year of application (directions for closely related species spotted knapweed).
Clopyralid + 2,4-D (Curtail): apply to actively growing weeds after the majority of the basal leaves have emerged up to bud stage. Later applications may result in less consistent control (directions for closely related species spotted knapweed).
Clopyralid + triclopyr (Redeem R&P): Apply from rosette to early flower or to fall regrowth. Optimum time is mid-bolt.
Glyphosate (Roundup): Apply when most plants have reached the late bud to flower stage of growth and where damage to non-target species can be tolerated. Good results reported when applied to rosettes in the fall.

Treatment with glyphosate should be combined with effective re-vegetation of the site to prevent seedlings from re-infesting the area.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Minimize disturbance and revegetate disturbed or depauperate areas to reduce the probability of invasion. Target small infestations by grubbing/digging early in the growing season when soils are moist. For larger infestations that require herbicides, determine what additional actions can be taken to reduce the need for repeated applications (improve health of existing plant community by reseeding, reducing grazing, using trained livestock for targeted grazing, etc.).

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Centaurea solstitialis, Yellow starthistle

Left: rosettes. Center: yellow flowers with long spines on receptacle. Right: Flattened or 'winged' stems. All photos by Steve Dewey, Utah State University, Bugwood.org.

Park presence: Possibly eradicated from HAFO, MIIN.
Status: **ID:** contain **MT:** 1A **UT:** EDRR

Identifying characteristics: Seedlings resemble dandelions with deep lobed leaves (above left). Bright yellow flowers grow singly at the ends of branches and have sharp spines, ¾ - 1" long at the base (above center). Foliage is grayish green from pubescent hairs and stems appear flattened, or with wings (above right). Plants from previous year have a cottony white tuft where flowers were. Plants grow from 1-5' tall.

Life cycle: Annual, reproduces only by seed. Plants may germinate in the fall and overwinter as rosettes, or germinate in the spring. Plants bolt in late spring to early summer. Flowering may occur from early summer to early fall until buds are killed by frost.

Spread: Plants spread only be seed. There are two types of seed, plumed and plumeless. The pappus, or plumed appendages on the seed are small relative to the weight of the seed, limiting dispersal by wind, and most seed falls within 2' of the parent plant, but gusty winds may propel seed 16' or more. Stiff, microscopic barbs on the pappus bristles adhere to clothing or fur/hair. Most long distance dispersal is due to human activities like movement of livestock, vehicles, equipment and contaminated seed or soil.

Seeds per plant / seed longevity: 150,000 / 5 years

Habitat: Grows on rangelands, along highways or roads, railroad tracks, and other transportation or communication lines. It is most common in disturbed areas in full sun. Seedling establishment is optimal in deep silt loam and loam soils with few coarse fragments, but seedlings can also establish on shallow, rocky soils (Zouhar 2002).

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective. Hand pulling is strongly recommended for small infestations and is best done after bolting and up to very early flowering. Note: remove all pulled plant material. A 2" piece of the stem with leaves and buds can develop into a new plant. Initiate hand pulling after plants have bolted but before they produce viable seed (early flowering).

Cut/mow: Mixed results. It may be used for moderate infestation levels, but timing is critical, and it is most effective on plants with an upright growth habit. Mowing should be done when less than 2% of population has developed seed (DiTomaso et al.2006). Over a three year period, timely mowing twice per year has led to 90% control. The best time to mow is when plants have bolted and just before flowering. It is not recommended in areas with high forb diversity as they will not recover as quickly from mowing compared to grasses (in which case mowing may increase yellow starthistle). For plants with a growth form that is not upright, but sprawling and highly branched, mowing will need to be repeated throughout the growing season, and efficacy is highly variable.
Till/cultivate: Partially effective. Till in the early summer so roots are detached from the shoots. Repeat after rainfall to target new seedlings. Follow by monitoring to detect and remove other weeds, and by reseeding to provide long term control.

Cultural
Reseed: Moderately to highly effective. Plants are not tolerant of shade. Revegetation is recommended to prevent establishment in susceptible areas. For existing patches, it is recommended as follow up to other treatments.
Fire: Moderately effective if the burn is complete and done at the very early flowering stage, when less than 2% of the plants develop the spiny flower heads (DiTomaso et al. 2006). However, in the intermountain region, it may be difficult to obtain a complete burn at this time (late spring, early summer).

Biological
Insects: Partially effective. Strongly recommended for existing patches, as it can reduce seed production by 50-75% (or more). Biocontrols will not be successful on their own, but are highly recommended in combination with other treatments. All information on establishment is from Coombs et al 2004.
Bangasternus orientalis (starthistle bud weevil). Larvae tunnel into flowering stalks to feed on receptacle and seeds. They do not feed on all seeds within a seedhead. Established in ID. ***Eustenopus villosus*** (starthistle hairy weevil): adults feed on flowers, larvae feed internally on all seeds within a seedhead. Considered a slow but good disperser, able to have a significant impact on seed production. Established in ID. ***Larinus curtus*** (starthistle flower weevil): larvae feed on developing seeds, may destroy 90% of seeds in infested heads. Established in ID. ***Chaetorellia succinea*** (false peacock fly): larvae feed in the flower head on seeds. Established in ID. ***Urophora sirunaseva*** (starthistle gallfly): larvae feed in the flower head on seeds. Not widely established.
Pathogens: *Puccinia jaceae* var. *solstitialis* (yellow starthistle rust). Rust attacks foliage and green stems reducing plant vigor. Check state officials for availability (not available in 2004).
Grazing: Partially effective. Graze with sheep or cattle when plants begin to bolt up to development of seed heads, goats may graze it later into the season (DiTomaso et al. 2006). Note: **poisonous to horses**, and may cause injury to other livestock if grazed during spiny stage.

Chemical
Moderately to highly effective.

Excellent: **Clopyralid + 2,4-D** (Curtail): apply after rosettes have emerged but before bud formation. **Aminopyralid** (Milestone): apply from the rosette stage through bolting. **Picloram** (Tordon): apply in spring to plants still in rosette through bud formation. **Clopyralid** (Transline): apply after most rosettes have emerged, but before bud formation. Milestone provides excellent control at low rates (3 oz product/acre), giving both pre- and post-emergence activity for full season control (DiTomaso et al. 2006). **2,4-D, Glyphosate** (Roundup): excellent for control of bolted plants, but must be applied before plants flower to prevent seed production.
Good: **Triclopyr + clopyralid** (Redeem R&P): apply from rosette to early bolt stage when plants are actively growing. **Chlorsulfuron** (Telar): apply as a preemergent, not effective when applied to the foliage.
Fair: **Dicamba** (Banvel, Clarity), **MCPA**
Poor: **Metsulfuron** (Cimarron, Escort)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Prevention is the number one goal for this plant. The plant's dispersal and invasion are strongly associated with human activity. In Montana, a new record of yellow starthistle was reported in March 2010 in a lot where construction equipment was stored. The majority of the other records were associated with construction equipment, farming equipment, or small patches that occurred along roads (Rice, INVADERS Database). If construction is planned, all vehicles should be washed off-site in a designated area before being brought into the park. A routine monitoring program that covers roads, trails and other vulnerable areas should be implemented. Monitoring should occur in early summer to coincide with the period when the plant is just beginning to flower, but before it sets seed, and be repeated in 3-4 weeks. If a plant is found, hand pulling is recommended over all other strategies for small patches. Because this plant is not rhizomatous, managers should be able to eradicate it with persistence. For slightly larger patches that preclude hand-pulling, herbicides should be used. For large, established populations, clopyralid and the release of biocontrols has been used effectively to reduce plant density and seed production (DiTomaso et al. 2006). Revegetation is strongly recommended for long-term control.

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Centaurea stoebe (formerly *Centaurea maculosa*) Spotted knapweed

Left: Spotted knapweed rosette. By Linda Wilson, University of Idaho, Bugwood.org. Center: foliage. By James H. Miller, USDA Forest Service, Bugwood.org. Right: flower showing darkened tips of bracts. By John Cardina, The Ohio State University, Bugwood.org.

Park presence: BEPA, BIHO, CIRO, CRMO, FOBU, GOSP, GRKO, LIBI
Status: **ID**: contain **MT:** category 2B **UT:** EDRR **WY:** noxious

Identifying characteristics: Grayish green rosette leaves are deeply lobed (above left), and up to 6" long. Stem leaves are finely divided into linear segments (above center). Bracts are not spiny, but have short, rigid, dark bristles like the teeth of a comb (above right). These characteristics differentiate it from diffuse and squarrose knapweed which lack the dark triangular tip on the bract, and have pointed spines. Spotted knapweed resembles black knapweed (*Centaurea nigra*) and meadow knapweed (*Centaurea pratensis*), except these species have fringes that are as long as or longer than the width of the bract and the fringes are not rigid. If you're having trouble differentiating the knapweeds, see the booklet: Biology and Biological Control of Knapweeds (Wilson and Randal 2005) available at: http://www.invasive.org/weedcd/pdfs/KnapweedBook.pdf. Page 7 has an excellent knapweed key and diagrams of knapweed bracts.

Life cycle: Biennial or short-lived perennial. Plants bloom from mid-summer to fall.

Spread: Seed does not have hairy pappus (plumes for wind dispersal), or barbs, but long distance dispersal occurs via vehicle undercarriages, contaminated hay, birds and animals (seed remains viable after animals consume and excrete). It is considered to be highly competitive (APRS #15) and able to form dense monocultures, excluding native species (Callaway 1999). It also produces allelochemicals (APRS #16) that may inhibit growth of other species.

Seeds per plant and longevity: +1000 / 8 years

Habitat: Grows in grasslands, open forests, and is most common on roadsides, and disturbed areas, but it is also able to invade intact, relatively undisturbed habitats. It is adapted to well-drained, light-textured soils. Seeds can germinate in a canopy cover from 0-100% whenever moisture and temperatures are adequate (APRS #13).

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective for small, new patches. Pull when soil is moist to remove the carrot- like upper root portion, or it will resprout. Pull prior to seed formation. Wear long sleeve shirt and gloves to prevent skin irritation.

Cut/mow: Moderately to highly effective. May be highly effective in combination with herbicide. Mow at late bud mow (mid summer), and apply appropriate herbicide to fall regrowth.

Till/cultivate: Ineffective. Not recommended.

Cultural

Reseed: Moderately to highly effective. Control efforts are of little value if native vegetation is scarce or absent. Reseeding as follow up to herbicides is especially effective and strongly recommended for dense infestations. Managers should note that species differ in their sensitivity to the allelopathic catechin released by spotted knapweed roots (Perry 2005). Table 1 below is from a study done to compare species' sensitivity to differing concentrations of the catechin by measuring its effect on germination, and root elongation. Two common restoration species, Sandberg bluegrass (*Poa secunda*), and Idaho fescue (*Festuca idahoensis*) were highly sensitive, while needle and thread was highly resistant. Lupine (*Lupinus sericeus*) while not included in this study, has also been described as resistant. In general, species with larger seed size have better resistance.

Table 1: Sensitivity of Native Plants to the Allelopathic Catechin of Spotted Knapweed

Highly resistant	Resistant	Sensitive	Highly sensitive
Mountain brome	Common blanketflower	Common yarrow	Palmer's penstemon
Curlycup gumweed	Boreal sweetvetch	Hairy false goldenaster	Rocky Mountain penstemon
Needle and thread	Cicer milkvetch	Scarlet globemallow	Sandberg bluegrass
	Basin wildrye	Slender wheatgrass	Idaho fescue
		Blue flax	Bigelow's tansyaster
		Blue grama	Intermediate wheatgrass
		Common sunflower	
		White sagebrush	
		Bluebunch wheatgrass	

Fire: Ineffective to partially effective. Fire will temporarily reduce native species as well, which can shift competitive advantage to the non-native species. Fire is likely to have a neutral or slightly positive response meaning it may increase following fire (Bushey 1995).

Biological

Insects: Insects are strongly recommended for large infestations of spotted knapweed. See IVM bulletin (http://www.efn.org/~ipmpa/Noxknapw.html) for more details on life cycle and release times. These are listed alphabetically, not by efficacy. All information on establishment is from Coombs et al 2004.

1. ***Agapeta zoegana*** (root boring moth) larvae feed on roots and may kill small rosettes, but are best combined with other root-borers or seed feeders. Established in ID, MT, UT and WY.

2. ***Bangasternus fausti*** (seed head weevil) adults feed on foliage in the spring and flowers in the summer. Larvae feed on seed heads, reducing seed production by up to 100%. Prefers undisturbed sites with dry summers. Established in ID and UT.
3. ***Chaetorellia acrolophi*** (seedhead fly) feeds on diffuse and spotted knapweed. Larvae feed in the flower buds, reducing seed production. More research is needed on this species. Established in WY.
4. ***Cyphocleonus achates***: (root boring weevil) is described as one of the most promising for knapweed control. Weevils do a great deal of damage to roots and can kill attacked plants. Adults feed on interior leaves of rosettes. Larvae destroy the interior of the tap root. Intense feeding causes knapweed plants to become stunted and they may die one season after the initial attack. It is recommended in conjunction with other root- boring and seed-feeding insects. South facing slopes, or exposed soils with high temperatures are recommended for establishment. Established in ID, MT, UT and WY.
5. ***Larinus minutus/obtusus*** (lesser knapweed flower weevil and blunt knapweed flower weevil) attack diffuse and spotted knapweeds. Larvae consume developing seeds; adults feed on foliage and flowers. Results from western Montana show that both *Larinus* spp. and *Urophora affinis* have contributed significantly to reduction in seed production over a 30-yr period (1974-2005) (Story, 2008). In areas where insects were well established seeds m^{-2} were 96-99% lower in 2005 compared to 1974. However, spotted knapweed density may not decrease significantly until the seed bank falls below a critical threshold. Livestock grazing while plants are bolting delays flowering, reducing efficacy of these insects. *L. minutus* has established in ID, MT, UT and WY; and *L. obtusus* has established in MT and WY.
6. ***Metzneria paucipunctella***(spotted knapweed seed head moth): Adult moths lay eggs on bracts at the base of flowers. Larvae enter the flower, consuming florets and, later, seeds. Mature larvae mine the receptacle tissue. This can destroy 90% of the seeds. *Metzneria* does not do well in areas that are very cold (does not tolerate temperatures below -22°F) with little snow cover. Established in ID and MT.
7. ***Sphenoptera jugoslavica*** (bronze knapweed root borer): First instar larvae feed in the leaf axils, second-instars tunnel into the root. Diffuse knapweed is the preferred host, but it will also feed on spotted knapweed. Established in ID, MT, UT and WY.
8. ***Terellia virens*** (seedhead fly) larvae feed on seeds, reducing seeds by up to 90%. Coexists with *Cheatorellia acrolophi* and *Urophora* species, but is a poor competitor with *Larinus* species. Does best on south facing slopes and dry locations. It was first released in Montana in 2002, but as of 2004, it has established in CA, and OR.
9. ***Urophora affinis* and *U. quadrifasciata*** (seedhead flies) larvae cause gall formation on the seedhead, aborting flowers. *U. affinis* lay eggs in immature flower heads, producing hard galls; and *U. quadrifasciata* lays eggs in mature flower heads, causing thin, soft galls. Both types of galls act as a nutrient sink, reducing seed production by up to 95%. They prefer open areas with full sun. Herbicides may increase mortality, but less so if herbicides are applied at the rosette stage. Established throughout the northwest.

Pathogens:

Alternaria alternata can destroy the majority of spotted knapweed foliage, but younger leaves and buds are not affected, allowing plants to resprout.

Sclerotinia sclerotiorum kills juvenile spotted knapweed, and all life stages are susceptible to the fungus, decreasing biomass. Inoculating

spotted knapweeds and seeding bluebunch wheatgrass can reduce spotted knapweed without affecting the native grass (Jacobs et al. 1996). *Fusarium avenaceum*, a stem blight fungus, stunts growth, causes yellowing, and stem decay. A strain isolated from Montana (No. 1003) caused a 100% decrease in seed (Czembor and Strobel 1997). It had no effect on *Triticum aestivum* or *Medicago sativa*, but it can affect the germination of other plant species. More research is needed.
Grazing: Grant-Kohrs has demonstrated that over an 18 month period, cattle can be effectively trained to eat spotted knapweed, reducing seed production, and shifting the competitive balance in favor of grasses. Research in Montana found that spring application of 2,4-D followed by grazing with sheep was better than either treatment alone at reducing spotted knapweed cover (rosettes) and biomass (Sheley 2004). Goats are also recommended to reduce seed production.

Chemical

Excellent: **Clopyralid +2,4-D** (Curtail): Apply to actively growing weeds after the majority of the basal leaves have emerged up to bud stage. Two years after treatments in northwestern Montana, application during the bolting stage was most effective; applications at the bud, flower, and fall-rosette growth stages were moderately effective; and application during the spring-rosette growth stage was least effective (Sheley 2000). **Aminopyralid** (Milestone): Optimal results occur from rosette to the bolting stages of development or in the fall. Plants will be controlled by mid-summer and fall applications even though plants may not show any changes in form or stature the year of application. **Picloram** (Tordon): Apply from spring rosette stage to mid-bolting, or to fall regrowth. **Clopyralid** (Transline): Apply up to bud stage. Where knapweed is the primary pest, best results are obtained by applying 2/3 to 1 1/3 pint of Transline per acre after basal leaves are produced.

Good: **Triclopyr + clopyralid** (Redeem R&P): Apply from rosette to early flower or to fall regrowth. Optimum time is mid-bolt.

Fair: **Dicamba** (Banvel, Clarity), **Metsulfuron + dicamba + 2,4-D** (Cimarron Max), **Diflufenzopyr + dicamba** (Overdrive)

Poor: **2,4-D, Metsulfuron** (Cimarron, Escort), **Imazapic** (Plateau), **Glyphosate** (Roundup), **Dicamba + 2,4-D** (Weedmaster)

Additional notes on herbicides:
In a Montana study, **picloram** (0.28 kg ai ha^{-1}) provided better long term control and increased grass biomass compared to **clopyralid +2,4-D** (0.21 kg ai ha^{-1}), or **dicamba +2,4-D** (0.56 kg ai ha^{-1}) (Sheley, 2000). However, **clopyralid +2,4-D** applied at the bolting stage was as effective as picloram at one of two sites, and provided 50% reduction in density at the second site. Due to the long soil residual time of picloram, clopyralid +2,4-D may be a better alternative to picloram for more sensitive areas, especially those with higher forb diversity. This plant generally is easy to control with herbicides. However, persistence in the form of monitoring and spot spraying or hand pulling for several years will be necessary as it reemerges from the soil seed bank.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Eradication has been achieved at FOBU by hand pulling, and BIHO has reduced populations on a hillside and along a road to a fraction of their original size by spot spraying and hand pulling. For containment of larger populations, spot spraying and reseeding is recommended. For suppression of widespread populations, releasing biological controls is strongly recommended. In Montana, suppression was improved when *Cyphocleonus achates* was combined with bluebunch wheatgrass (Jacobs et al 2006). If herbicides are released where biocontrols are used, herbicide applications of 2,4-D or clopyralid are better if delayed to late spring. Fall application reduced larval numbers of *A. zoegana* and *C. achates* (Corn et al 2009).

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Centaurea virgata, Squarrose knapweed

Figures: (left) Flowers showing floral bracts that are recurved (bend outwards). By Steve Dewey, Utah State University, Bugwood.org. **(center):** Growth form of flowering plant. By USDA ARS Archive, USDA Agricultural Research Service, Bugwood.org **(right)** Terminal bract that is bent backwards or outwards. Diagram by Cindy Roche.

Park presence: Not reported in any of the parks.
Status: **MT**: 2b **UT**: EDRR

Identifying characteristics: Plants grow 12-18 inches tall with pink flowers developing at branch tips. Leaves are alternate and deeply dissected. This is one of three *Centaurea* species with a spine-tipped terminal bract, but only squarrose knapweed has terminal bracts that are curved backwards or outwards (Figure c). Yellow starthistle (*C. solstitialis*) also has spine tipped bracts (that are long and quite sharp), but the flowers are yellow. The spine tipped bracts of diffuse knapweed (*C. diffusa*) point up, or only slightly outwards. See the booklet 'Biology and Biological Control of Knapweeds' (Wilson and Randal 2005) available at: http://www.invasive.org/weedcd/pdfs/KnapweedBook.pdf. Page 7 has an excellent knapweed key and diagrams of knapweed bracts.

Life cycle: Perennial. Reproduces by seed (not rhizomatous). It may grow as a rosette for several years before bolting. Flowering occurs in early to mid-summer. Seeds disperse from the seed head as a unit from mid- to late summer through late fall.

Seeds per plant / seed longevity: +1000 / more than 3 years

Spread: Long distance dispersal is primarily by humans (via farming equipment, machinery, contaminated seed etc.) and animals. Seed heads easily stick in the wool of sheep and other animals, allowing long distance dispersal. Seed heads fall off as a unit, allowing short distance dispersal via wind. The plant releases allelopathic chemicals that may inhibit growth of other plants, possibly increasing its potential to spread and displace the existing plant community.

Habitat: It occurs in disturbed sites, such as rangelands, roadsides, and grasslands. It is well adapted to drought and cold temperatures. California and Utah have the highest concentrations. In Utah, it is most common in sagebrush-bunchgrass rangeland, but also occurs in juniper and salt desert range. This species is more adaptable to drought and cold temperatures than diffuse knapweed (Coombs et al 2004).

CONTROL OPTIONS

Mechanical

Hand pull/grub: Partially effective to highly effective. If hand pulled, a portion of the stout taproot can remain and resprout. It must be removed at least 8 inches below the soil surface with a trowel or shovel to prevent resprouting. If patches are small, the soil is moist and tools are available, grubbing/digging is highly recommended.
Cut/mow: Ineffective. Not recommended.
Till/cultivate: Moderately effective, but must be deep. When dislodged by a single disking, rosettes continue to grow if they are attached to a piece of root that touches the soil.

Cultural

Reseed: Moderately effective. Strongly recommended after herbicides to prevent reestablishment and encourage long term control.
Fire: Unknown. No fire effects information, but it is speculated that it is unlikely to be negatively affected, and may increase after fire (Bushey 1995).

Biological

Insects: Partially to moderately effective. Many insects listed here prefer other knapweeds, but have been observed to feed on squarrose knapweed.
Establishment by state based on information in Coombs et al 2004.
Agapeta zoegana Sulfur knapweed moth. Larvae attack roots. Primarily for spotted knapweed, occasionally listed as attacking squarrose knapweed. Established in ID, MT, UT, WY. Availability limited due to collection difficulty.
Bangasternus fausti Broad-nosed seedhead weevil. Larvae consume up to 100% of seeds in the flower head. Established in ID, MT and UT. Larvae will attack any other insects occupying flower heads.
Chaetorellia acrolophi Knapweed peacock fly. Larvae reduce seed production. Released in MT, established in MT, WY. Spotted is the primary host, but may also attack squarrose knapweed. Currently not widely available.
Larinus minutus Lesser knapweed flower weevil. Larvae feed on seeds, adults feed on leaves. Established in ID, MT, UT, WY. Can be collected from established populations in MT (or OR, WA).
Sphenoptera jugoslavica Bronze knapweed root borer. Larvae feed on center of root, with some minor feeding by adults. Diffuse knapweed is preferred, but also feeds on squarrose. Established in ID, MT, UT, WY.
Urophora affinis Banded gall fly. Larvae in flower heads cause galls, reducing seed production. Established and available throughout the NW.
Urophora quadrifasciata UV knapweed seed head fly. Larvae in flower heads cause galls, reducing seed production. Established and available throughout the NW.
Pathogens: None currently available.
Grazing: Considered unpalatable. No other information available at this time.

Chemical

Moderately to highly effective
2,4-D: apply at the early stage of flower stem elongation

Aminopyralid (Milestone): apply when plants are actively growing with the optimum time of application occurring from rosette to the bolting stages of development or in the fall. Plants will be controlled by mid-summer and fall applications even though plants may not show any changes in form or stature the year of application.
Clopyralid (Stinger or Transline): apply after the majority of basal leaves have emerged up to bud stage.
Clopyralid+2,4-D amine (Curtail): apply after most rosettes emerge but before flower stem elongates.
Triclopyr + clopyralid (Redeem R&P): Apply from rosette to early bolt stage when weeds are actively growing.
Picloram (Tordon): Apply during active growth prior to bud stage. Lower rates in rate range may require annual spot treatments. Control with lower rates may be improved by tank mixing with 1.0 lb ae per acre of 2,4-D.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Information on squarrose knapweed is limited compared to other knapweed species. It has not been reported in any of the parks at the time of this publication. It is widely reported in Oregon (Rice, Invaders Database), but it has only been reported once in Montana (Stanford, MT in Judith Basin County in 1999), and once in Wyoming (Uinta County in 1998). The best management strategy is to monitor all recently disturbed sites frequently and to educate staff and seasonal crew on how to differentiate this plant from other knapweeds (see link to Biology and Biological Control of Knapweeds in bibliography for an excellent knapweed key). When patches are found, aggressively treat by spot spraying or hand pulling. Hand pulling is recommended, but the sight must be checked frequently to ensure plants don't resprout from the long tap root.

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Chondrilla juncea, Rush skeletonweed

Left: hairless basal leaves with irregular teeth, and stiff, downward pointing hairs on stem. By Richard Old, XID Services, Inc., Bugwood.org. Right: Yellow flowers, plumed seeds enabling wind dispersal. By Steve Dewey, Utah State University, Bugwood.org

Park presence: CRMO, HAFO. Possibly eradicated from MIIN
Status: **ID:** contain **MT:** 1b

Identifying characteristics: Rosettes resemble dandelions; basal leaves are hairless, 2-5 inches long and ½-2 inches wide with deep irregular teeth that point backward toward the stem. Stems have few, tiny leaves. There are stiff downward-pointing hairs on the lower 4-6 inches of the stem; the remainder of the stem is smooth or with a few rigid hairs. Yellow flowers, about ½ inch in diameter, grow along the stem in the leaf axils or at the branch tips. All plant parts exude a white milky sap when cut or broken. In the rosette stage, it can resemble hawksbeard (*Crepis* spp.), hawkbit (*Leontodon* spp.), dandelion (*Taraxacum* spp.), lettuce (*Lactuca* spp.), agoseris (*Agoseris* spp.), and various mustards (Brassicaceae), but these have a short, stout taproot. Rush skeletonweed seedlings only a few inches wide may have a slender root up to 14 inches (36 cm) long. It may also be confused with the *Lygodesmia juncea* (Rush Skeletonplant) which has pink, or occasionally white flowers. Rush skeletonweed occurs in three forms, that have narrow (termed form 'A'), intermediate ('B'), and broad ('C') rosette leaves (Sheley and Petroff 1999).

Life cycle: Seeds germinate in the fall. Plants overwinter as rosettes. Growth continues in the spring when temperatures are above freezing (early to mid-spring). In late spring, a spindly stem elongates, and flowering begins in early summer and may continue until fall. In the intermountain region, flowering period is described as July through September. Seeds mature 9-15 days after flowers open, and exhibit no dormancy (can immediately germinate if conditions are right).

Spread: Light weight seed with plumes enables long distances dispersal by wind. Plants can also spread by root fragments transported in machinery.

Seeds per plant and longevity: +15,000 but highly variable / 6-18 months (1-5 years in APRS). Seeds germinate readily, so may not form a persistent seed bank.

Habitat: Flourishes in very dry to very wet environments, tolerating precipitation ranges from 9-59 inches/year. It dominates disturbed

areas like roadways, waste areas, and areas weakened by drought or improper grazing.

CONTROL OPTIONS

Note: there are hundreds of biotypes of rush skeletonweed, which are differentiated by leaf morphology, height, branching patterns, or flowering times. Biotypes can vary in their susceptibility to herbicides and biocontrols. Plants at CRMO are believed to be the "Banks biotype".

Mechanical

Hand pull/grub: Mixed results. Roots in established patches can reach depths of 8 feet, and severed roots will easily re-sprout. Hand pulling is only recommended for very small infestations, where it can be repeated diligently. It may take hand pulling three times per year for 6-10 years to successfully remove older plants. If hand pulling can not be done diligently 3 or more times per year, it may make the infestation worse.

Cut/mow: Ineffective. Mowing is not recommended. It does not affect carbohydrate reserves, only limits seed production in very dry years. However, frequently mowing plants infested with and impacted by the gall mite (*Eriophyes chondrillae*) may decrease the rate of spread of this plant (McLellan 1991).

Till/cultivate: Ineffective. Not recommended. Will spread root fragments, likely increasing infestation.

Cultural

Reseed: Partially to moderately effective. Rush skeletonweed is less tolerant of shade and is seldom found in closed forest canopies. Where possible, maintaining competitive stands of vegetation will help prevent rush skeletonweed invasion. Reseeding infested areas alone will do little to control the plants, but reseeding and applying biocontrols will do more than either control method alone (Prather 1993).

Fire: Variable. The impact depends on surrounding plant community. If the area was not dominated by perennial plants, rush skeletonweed will persist at higher levels following fire. Areas with good perennial grass cover may have initial increases, but skeletonweed will decrease particularly when grass competition is coupled with biological control (T. Prather, personal communication).

Biological

Insects: Partially to moderately effective. All establishment information is from Coombs et al 2004.

- ***Cystiphora schmidti*** (gall midge): Larvae damage the rosette and flowering stems. It is established throughout the Pacific Northwest, and impacts the rosette and flowering stems of all biotypes in this region. Affected plants are often a noticeable purple to reddish color (Martin 1996; Rees et al. 1996). Efficacy may be variable because it is often parasitized by a wasp.
- ***Eriophyes chondrillae*** (aka *Aceria chondrillae,* gall mite): Nymphs and adults attack axillary and terminal buds. Some consider it the most effective biological control agent available (to date), effective against all biotypes of skeletonweed. Flower buds develop leaf-like galls, (up to 2" in diameter), which can reduce or prevent seed

production; reduces carbohydrate reserves; and prevent the formation of and reduce the survival of satellite plants and seedlings. However, bud production is stimulated by the feeding mites (Prather 1993). Soil disturbance associated with cultivation interferes with the life cycle of the mite (Martin 1996; Rees et al. 1996). Established in ID.
- *Bradyrrhoa gilveolella* (root moth) larvae feed externally on the roots, destroy the cortical and vascular tissues of the roots, deplete carbohydrate reserves, adversely impacting plant vigor and overwintering ability, and exposing the plants to soil borne pathogens. Populations' establishment has not been widely successful in the field. This insect was released and is being monitored at **CRMO**.
Pathogens:
- ***Puccinia chondrillina*** (a rust): Leaves, stems, buds and flowers are attacked. Fall and spring rosette infection may cause death, especially of seedlings. Infected rosettes have brown pustules that erupt through the leaf and stem surfaces. It causes wounds or lesions, desiccation, reduces photosynthetic surface, increases susceptibility to other pathogens, reduces production, weight, viability of seeds, and ability to regenerate from root buds. It effectively controls only the narrow-leaf biotype form of rush skeletonweed. The banks biotype (present at **CRMO**) is considered susceptible, but some other biotypes in ID are resistant to this rust (Martin 1996; Rees et al. 1996). Some weed managers in California consider it more effective than the midge or the mite (Coombs et al 2004). Like other biocontrols, it may take four or more years to see an impact and the time required to reduce the infestation will depend on the size of the population and the amount of inoculum released. Established and available in Idaho.
Grazing: Partially effective. Rosette leaves and pre-flowering stems are palatable and nutritious (Coombs et al 2004). Cattle will graze early flowering plants, horses will graze plants in the vegetative stage, and sheep will graze plants in the rosette to flowering stage. Continuous sheep grazing in the summer months can keep the plant in the rosette stage (preventing seed production).

Chemical
Partially to moderately effective. For established patches, most plants will reappear 1-3 years after herbicide application. Herbicides rated excellent, good, fair, or poor when available from Dewey et al 2006)
Note: the morphology of rush skeletonweed, specifically the lack of leaf area, reduces herbicide translocation. Translocation can be improved with silicone surfactants and water conditioning agents. Plants less than five years old are more susceptible to herbicides.
Excellent: **Picloram** (Tordon): rosettes in fall or spring. **Aminopyralid** (Milestone): Apply to rosettes before bolting in the spring.
Good: **Clopyralid + 2,4-D** (Curtail): Apply to rosettes before bolting in spring. **Triclopyr + clopyralid** (Redeem R&P): Apply from rosette to early bolting stage.
Fair: **2,4-D, Dicamba** (Banvel, Clarity), **diflufenzopyr + dicamba** (Overdrive), **metsulfuron + dicamba + 2,4-D** (Cimarron Max),
Poor: **Metsulfuron** (Cimarron), **glyphosate** (Roundup)
Anecdotal reports suggest: Picloram (Tordon-one quart product per acre) or picloram combined with 2,4-D (one quart plus one quart per acre) applied to autumn rosettes are the herbicide treatments that give the best root kill.
Not rated: **Clopyralid** (Transline): up to bud stage. Field trials in Washington found applications after the first frost in November showed

95% effective control rate. However, plants did show up three to five years later.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

For parks without rush skeletonweed, early detection, rapid response is paramount as young plants are much easier to control. Disturbed areas and roadways should be surveyed regularly. For isolated patches, seeds heads should be clipped at a minimum, or spot sprayed for a more aggressive treatment. For areas with large infestations, biocontrols should be released.

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Chrysanthemum leucanthemum, Oxeye daisy

Left Growth form of flowering plant. From Pacific Northwest Weed Management Handbook.

Park presence: BIHO, GOSP
Status: ID: contain **MT**: priority 2B **UT**: EDRR **WY**: noxious

Identifying characteristics: Looks like a common daisy: flowers are solitary (one flower per stem) with white petals (rays) and a yellow center (disk flowers). Basal leaves are stalked, spatula-shaped, with toothed to deeply lobed margins; upper leaf stalks are short and clasp the stem. Numerous stems arise from the base, and plants grow up to 3 feet tall. All leaves are hairless, dark green and glossy.

Life cycle: Perennial, reproduces by seeds and short rootstocks. Flowers June to July, but capable of flowering all summer if moisture is adequate. Most seeds germinate in the fall of the year they were shed or the following spring.

Spread: Seed disperses short distances from mother plant (typically < 4 yards). Small colonies can form by spread of rhizomes.

Seeds per plant and longevity: 1,300-26,000 seeds / 2-6 years or more

Habitat: Escaped from gardens and establishes in meadows, pastures, old fields, waste grounds, roadsides and other disturbed sites.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Moderately effective for small infestations. Remove as much of the rhizome as possible, and follow up is necessary due to the persistent seed bank, and/or re-growth from rhizomes.
Cut/mow: Partially effective. Clipping or mowing before bloom will reduce seed production but will not reduce populations. Mowing before herbicide application can improve herbicide contact on rosettes.
Till/cultivate: Not recommended-rhizome fragments will increase growth.

Cultural
Reseed: Moderately effective. Plants have a low tolerance for shade. Competitive desirable plants will improve control and reduce the spread. Reseeding is strongly recommended where no desirable vegetation is present. Reseeding with a mix of grasses and forbs is

recommended (based on a study in the Netherlands where oxeye daisy all but disappeared after four years of growth in more diverse mixtures).
Fire: Ineffective. It will readily resprout after fire.

Biological
Insects: NA
Pathogens: NA
Grazing: Partially effective. Palatable to sheep, goats and horses, but not cattle.

Chemical
Moderately effective.
Metsulfuron (Escort): from rosette to bolting. In a Montana study, 1oz/acre (w/Escort) in the spring provided two years of control, with an average 9 rosette/m^2 three years after treatment. A non-ionic surfactant is needed (0.5% by volume).
Aminopyralid (Milestone): from rosette to bolting
Picloram (Tordon 22K): from rosette to bolting, or to fall regrowth. In a Montana study, a mid-May application (1pint/acre with Tordon 22K) provided two years of control with an average 23 rosette/m^2 three years after treatment (this was not significantly different than Escort).
Clopyralid (Transline): from rosette to bolting
Glyphosate (Roundup): from rosette to bolting. Recommended prior to re-vegetation.
Note: oxeye daisy may be somewhat resistant to MCPA, 2,4-D and dicamba (Banvel).

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Use a combination of herbicides and hand-pulling followed by reseeding to eradicate it and prevent reinvasion. If herbicides were not applied in spring (all except picloram should be applied from rosette to bolting stages), mow and bag plants to prevent seed formation, and spray with picloram in the fall, or other herbicides the following spring.

For eradication, aggressive herbicidal control or hand pulling should be combined with cultural practices that strengthen the competitiveness of the plant community (limit grazing, reduce disturbance). Follow-up monitoring after control is important to target populations growing from the long-lived seed bank.
For containment, priority should be herbicide application to eradicate small, satellite populations and to reduce spread along the invasion front of the parent population. Second priority should be to reduce the parent population using herbicide management, and re-vegetation with diverse competitive plants if desirable plant population is low. On highly disturbed sites, pastures, and rangeland where competitive plants have been lost, re-vegetation following control with herbicides is strongly recommended to improve the longevity of the control application.

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Cirsium arvense, Canada Thistle

Left: Flower heads. By Steve Dewey, Utah State University, Bugwood.org. Center: Spiny leaves. By Leslie J. Mehrhoff, University of Connecticut, Bugwood.org. Right: Dense growth in a pasture. By Steve Dewey, Utah State University, Bugwood.org

Park presence: BEPA, BIHO, CIRO, CRMO, FOBU, GOSP, GRKO, HAFO, LIBI, MIIN
Status: ID: contain **MT**: 2B **UT**: contain **WY**: noxious

Identifying characteristics: Characteristics to differentiate it from other thistles: (1) spines do not extend along the entire length of stems; (2) flowers heads are in clusters (not solitary); and (3) each head measures less than 1 inch (2.5 cm) in diameter. Additionally, bracts on receptacle are not spiny and flower color may be white to deep lavender (see photo above left). Plants are rhizomatous, so rarely appear as single plants.

Life cycle: Perennial. Reproduces both vegetatively and by seed. Seeds can germinate and form rosettes whenever moisture is sufficient, but majority are formed in spring. The primary shoots grow as rosettes for 2-4 weeks, and then bolt or elongate and develop flower buds approximately 10 weeks after emergence, or in late spring. Shoots produced from root buds (secondary shoots) emerge throughout the summer so several growth stages may be simultaneously present. In late summer when there is less than 16 hours of daylight, plants will not initiate elongation of new shoots, but instead send energy to the root system to prepare for the winter.

Spread: Rhizomatous roots allow it to spread aggressively in a localized area and form dense stands. Extremely small root fragments (<0.5" long) can develop into new plants. Long distance dispersal occurs by hairy pappus on seeds, or seed may be spread in contaminated crop seed, feed, manure, straw, and irrigation water. Disturbance, minimal competition, and adequate light are required for initial establishment (for APRS 5.1, #13, seeds requires open soil to germinate). However, once established Canada thistle may readily spread by rhizomes and seed to form monocultures. One plant can occupy an area of 3-6' in diameter in two years. Depending on site conditions vegetative reproduction can result in moderate to rapid population growth (APRS #9).

Seeds per plant / longevity: 1,500-5,000 / highly variable: 3-21 years

Habitat: Common in open meadows, including wetlands, roadsides, fields, pastures, meadows, and other disturbed areas. It does not grow well in shade and is not common in undisturbed areas, but it can invade native plant communities. It can tolerate saline soils (up to 2% salt) and

wet or dry soils, but does not tolerate water-logged or poorly aerated soils.

Other: Allelopathy (APRS #16): aqueous extracts from Canada thistle inhibit growth of neighboring species. Actual impacts in naturalized areas are unclear. Hybridization (APRS #5): yes. Canada thistle can hybridize with *Cirsium hookerianum* (Hooker's thistle, native to ID, MT, OR, WY).

CONTROL OPTIONS

Mechanical

Hand pull/grub: Moderately effective for new patches. Remove as much of the root system as possible using a shovel and monitor for re-growth. When re-growth occurs, a study recommends clipping when the new shoots have approximately 8 expanded leaves (Sather 1998). For recently disturbed root fragments, this is typically the period when they have a minimum regenerative capacity (or the period when underground organs have the lowest dry weight), thereby decreasing their chances of survival.

Cut/mow: Mixed results. May be moderately effective in combination with herbicide. Plants are most susceptible to mechanical control during drought years. Clipping is effective if done after mid-summer and followed by a fall herbicide application. Dense canopies of thistle and grass can inhibit new thistle shoot growth in the fall which can greatly reduce the efficacy of fall herbicide applications. Some studies suggest that mowing 1-3 times per year followed by a fall herbicide is more effective than herbicide alone, but the results are inconsistent, and likely depend on the water table and climate. Whenever possible, clipping to remove flower heads is always recommended to reduce seed spread. Mowing alone will not control or suppress, but may be useful when combined with other strategies.

Till/cultivate: Ineffective unless it can be repeated annually, but this is not appropriate for most parks.

Cultural

Reseed: Highly effective as follow up to other control measures. Where vegetation is sparse, reseeding is strongly recommended to prevent establishment by seeds. Seedlings grow slowly and are sensitive to competition, particularly if shaded (Beck 2008).

Fire: Mixed results. Effects of fire are highly variable. Canada thistle will resprout following fire. The opening created by fire causes ideal conditions for wind blown seed to become established (Bushey 1995). However, dormant burning can stimulate the growth of native herbaceous species, increasing competition on Canada thistle (Sather 1998). Dormant season burning in mesic grassland in Oregon reduced flower and seed production, but did not reduce density. Growing season fires will reduce native plant cover as much as Canada thistle cover and are likely to do more harm than good, increasing Canada thistle growth in the next growing season. Generally not recommended.

Biological

Insects:

-***Ceutorhynchus litura*** (Canada thistle stem weevil). Larvae feed on roots in spring and early summer. Underground parts attacked by larvae often don't survive the winter and roots of attacked plants produce less than two shoots, compared to nine typically produced. Additionally, exit holes of larvae allow other pathogens to enter (Coombs et al 2004). When possible, combine it with other pathogens like *Sclerotinia sclerotiorum* to increase this effect. It prefers moist, disturbed areas where Canada thistle is dense and not stressed by drought, grazing, or other control methods (Winston *et al* 2008). Established in ID, MT, UT and WY.
-Rhinocyllus conicus (Thistle seed head weevil). Larvae attack seed heads, adults do some damage chewing holes in the leaves. **This insect is not recommended**, as it attacks more than 25% of the native thistles in the US. It cannot be transported across state lines.
-Trichosirocalus horridus (Musk thistle crown weevil). Larvae attack growing tips, adults feed on rosette leaves. The rosette boring weevil works best in open infestations and can reduce seed production. Established in ID, MT and WY.
-Urophora cardui (Canada thistle stem gall fly). Larvae deposited in stems cause galls and stunting, which reduces seed production and vigor. It works best in scattered populations that are not subject to grazing, mowing or chemical treatment. Evidence shows this fly is not particularly effective at controlling Canada thistle (Jacobs 2007). Established in MT, and WY.
Native biocontrols
-Platyptillia carduidactyla (Artichoke plume moth) is a native insect observed to attack bull, Canada and marsh thistles, and can impact the host plant enough to prevent flowering (Winston *et al* 2008).
-Vanessa cardui (Painted lady butterfly) is a native that can defoliate bull, Canada and Scotch thistles, although plants often regrow after defoliation.
Pathogens: ***Sclerotinia sclerotiorum,*** a fungal pathogen, may be most effective when combined with ***Ceutorhynchus litura*** (Sather, 1998). Effects were enhanced during drought years.
Puccinia punctiformis, a rust fungus, is not yet approved. It may have synergistic effects with other bio-control agents, but it is not expected to be effective if used alone (Jacobs 2007).
Grazing: Mixed results. Suppression of Canada thistle with grazing may be effective with goats. Sheep and cattle will consume it when plants are young, before spines develop. Grazing must be done repeatedly during the season and for multiple seasons in order to prevent seed production and to deplete root reserves. Plants will become smaller and weaker in successive years after repeated grazing, but grazing alone will not eradicate it. Additionally, managers must carefully monitor to make sure animals are targeting Canada thistle and not over-utilizing more desirable forages. Most information suggests best results are achieved when grazing is combined with herbicide treatments.

Chemical
Herbicide efficacy is dependent on growth stage, environment, and ecotype (there are ecotypes of Canada thistle that will respond differently to herbicide). Drought will decrease herbicide efficacy, but can increase efficacy of mechanical control. Managers should be aware of the following when considering herbicide applications:
a) Spring applications (June – early July):

   a. Efficacy of common herbicides, such as aminopyralid (Milestone), may be more consistent when applied in the spring compared to the fall.
   b. Target herbicide applications when Canada thistle plants begin the bud to early flowering growth stage. Herbicides applied in May (mid- to late-spring) can be less effective as several Canada thistle shoots may have not yet emerged. Herbicides applied in the late flowering growth stage may result in viable seed production as viable seeds may be produced 7 – 10 days after flower buds initially open.

b) Fall applications (September – October):
   a. Herbicide efficacy may be most consistent if applied in September compared to later dates in the fall. Herbicides may be effective as long as there is still green leaf tissue on the Canada thistle plants, but efficacy may decline as leaves die due to frost. It is often recommended to apply herbicides after some of the first light frosts of the fall, but conditions can become very cold quickly in the fall and thus prevent a timely herbicide application. Therefore, it is better to apply herbicides in September prior to a light frost than wait too long and have a hard frost completely desiccate the thistle shoots.
   b. Efficacy of fall herbicide applications will depend greatly on the amount of new fall shoot growth. In grasslands, this can be optimized with an early-summer mowing or grazing. Dry conditions in late-summer or fall can also reduce fall thistle growth.

It may be beneficial to vary herbicides at one site to prevent clones tolerant to one herbicide from becoming dominant (see modes of action in Table 7 and rotate herbicides with a different mode of action). Herbicides below are rated Excellent, Good, Fair and Poor if listed in Dewey et al 2006, and reviewed in 2009 by a specialist (Mike Moechnig). Additionally, results from study (Enloe 2007) comparing herbicides on Canada thistle in three states and at 10 locations are included for the herbicides used (aminopyralid; picloram; picloram + 2,4-D; clopyralid; and clopyralid +2,4-D). *A summary of the rates from the Enloe study is included below.

Excellent: (Dewey et al 2006) **Aminopyralid** (Milestone): Apply in spring to Canada thistle in the bolting, pre-bud ,or early bud growth stage or in the fall to rosettes before a killing frost. Aminopyralid may be moderately effective at low rates (3 – 5 oz/A), but the consistency and duration of control will be reduced at lower rates. Aminopyralid can be less detrimental to desirable broadleaf species than other auxin herbicides. Aminopyralid can also be applied near many tree species where dicamba and picloram cannot be used. However, legume species and some conifer species are susceptible to aminopyralid (Winston et al 2007). **Picloram** (Tordon): Apply after thistles emerge, throughout active growth stages, or in late summer or fall. Picloram requires a higher use rates than aminopyralid and has a longer soil residual period, which may reduce regrowth from roots or seedlings (Winston et al 2007). Managers should carefully consider other options before using Tordon because it is relatively soluble and more likely to be carried to the water table. **Picloram + 2,4-D** (Grazon P+D): should be applied to actively growing plants in spring and early summer before full bloom, or in the fall. In the Enloe study, this provided 89%

control 1 year after treatment. In another study, picloram + 2,4-D amine applied over 2 yr in the fall eliminated Canada thistle in the third year (rates were 0.28 + 1.12 kg/ha Beck and Sebastian 2000). **Clopyralid** (Transline)**:** Apply to young, actively growing thistles prior to the bud stage and on rosettes in the fall. It will generally not injure established grasses, but this depends on the rate. The risk of tree root uptake and injury may be less for clopyralid than aminopyralid. Clopyralid is more expensive than most other herbicides for thistle control, but can be very effective (Winston et al 2007). Generally clopyralid can be as effective as aminopyralid or picloram, but it is more costly so people use lower rates which are less consistent. **Clopyralid + 2,4-D** (Curtail): Apply when weeds are actively growing at the late rosette to bolting stages, but before the bud stage. Applications made from bud to flowering may result in inconsistent control. In the Enloe study, for spring or fall applications, the percentage control was 70% 1 year after treatment. In another study, control was best on 5-15 cm shoots, very good on 30 cm tall shoots and poor on 80 cm shoots (Donald 1992). Colorado State University found control with Curtail can be improved when preceded by two or three mowings (Beck 2008).

Good: **Chlorsulfuron** (Telar): Apply to fall rosettes or when plants are at the bud to bloom stages. Spring applications may be more consistent. May provide good foliar control, but root control may be less than that from aminopyralid, picloram, or clopyralid. **Clopyralid +triclopyr** (Redeem): Apply on rosettes to bud stage. **Glyphosate** (Roundup): Best applied in the fall prior to the first killing frost, or after plants have adjusted to colder weather. Glyphosate is a nonselective herbicide that kills or injures most grass and broadleaf species. Low concentrations (2.5%) are better than higher concentrations (5, 10 or 30%) at reducing growth and regrowth because high concentrations kill leaves too quickly, before the herbicide is translocated (Boerboom and Wyse 1988). Lower levels of surfactant are also recommended for this reason.

Fair **2,4-D; Metsulfuron** (Cimarron, Escort); **Metsulfuron + dicamba + 2,4-D** (Cimarron Max); **MCPA**; **Triclopyr** (Remedy); **Dicamba + 2,4-D** (Weedmaster); **Diflufenzopyr + dicamba** (Overdrive); **Dicamba** (Clarity, Banvel)

*The treatments from the Enloe study were fall or spring application and the following herbicides: Aminopyralid (Milestone) at 0.8, 0.9, and 0.11 kg ai/ha; Picloram (Tordon) at 0.42 kg ai/ha; Picloram+2,4-D (Grazon P+D) at 0.28 +1.12 kg ai/ha; Clopyralid (Transline) at 0.42 kg ai/ha; Clopyralid + 2,4-D (Curtail) at 0.32 + 1.68 ka ai/ha.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Prevention is especially critical with this weed, as once it is established it is much more difficult to control. Maintaining the health of existing plant communities will prevent or greatly reduce invasion by Canada thistle seedlings, which require high light and low competition to survive (Sather, 1998). It does not grow well in shade and is not common in undisturbed areas. Weed free areas with a high probability of occurrence should be monitored frequently (like disturbed sites including those recently sprayed to treat another weed species, moist sites, meadows, ditches, and stream banks).

Canada thistle is one the most challenging weeds at a majority of the parks because treatment efficacy varies depending on "growth stage (Tworkoski 1992), season of treatment, weather conditions, ecotype (Hodgson 1964), soil type, and control method(s) used" (Sather 1998). A single treatment is rarely effective, and a combination of treatments that are effective at one site, may be ineffective at another (Frank and Tworkoski 1994). When managers find their current methods are not effective, they should select control options and apply them as trials to determine what is most effective at their park. Results should be recorded as percentage cover compared to a control, with a minimum of three replicates for each treatment and the control. If time allows, in addition to percentage cover, managers should record stem density in a ¼ m^2 frame, and percentage cover of Canada thistle, natives and non-natives compared to a control. A minimum of two years is required to determine if a particular control strategy is effective.

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Cirsium vulgare, Bull thistle

Left: leaf with spiny tips. By Dan Tenaglia, Missouriplants.com, Bugwood.org. Right: seed heads and spines along stems. By Britt Slattery, U.S. Fish and Wildlife Service, Bugwood.org.

Park presence: BIHO, CIRO, CRMO, FOBU, GOSP, GRKO, LIBI
Status: UT counties: Tooele

Identifying characteristics: Spines extend along the length of the stems (distinct from Canada, and musk thistle). Flower heads are usually solitary (sometimes in clusters of 3), each head greater than 1 inch in diameter (distinct from plumeless thistle). Foliage is not gray in appearance, and plants never grow above 6' tall (distinct from Scotch thistle with gray foliage, and growth up to 12' tall). Basal leaves have coarse hairs on the upper surface, while the lower surface is woolly (distinct from Scotch which is wooly on upper and lower surfaces). This plant may resemble many native thistles. See "Biology and biological control of exotic true thistles" (Winston et al 2008, available on the web, see link in bibliography). It provides an excellent key and descriptions of exotic and native thistles.

Life cycle: Biennial, but also an annual or very short-lived perennial. Reproduces only by seed. Seeds germinate and form rosettes whenever moisture is available, but majority form in spring. Bolting occurs mid-spring (May), flowering from early to mid-summer (June to July).

Spread: Hairy pappus (tuft of hair on seed) allows for wind dispersal.

Seeds per plant and longevity: 4000 / 10 years (results variable, a study in coastal dunes and in British populations found longevity was less than 1 year)

Habitat: Commonly found in meadows, fields, roadsides, and other disturbed sites. It flourishes with any disturbance including forest clear cuts, riparian areas, and overgrazing, where it can form dense thickets that displace other vegetation. Grows best in neutral soils, with moderate moisture and prefers high nitrogen. It does not do well in shade or drought conditions. Studies have found that the spread of bull thistle is favored by trampling and soil disturbance. In Yosemite, infestations increase in areas that are heavily used by park visitors. Disturbance from digging by small mammals also favors the

spread of bull thistle. Hybridization: *Cirsium vulgare* hybridizes readily with other *Cirsium.*

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective. Pull or cut the plants after they bolt, but before they flower. For best effect, cut about an inch below the soil surface. This stops the plant from re-sprouting. Plants can re-sprout if cut at or above the soil surface.

Cut/mow: Partially to moderately effective. Fields should be mowed before seeds have a chance to ripen, and typically must be done twice per year to prevent seed production. Timing is critical: if mowed within two days of flowering of the terminal blooms, plants will not produce seed or regenerate significantly. If mowing occurs four days after full flowering of terminal blooms, a significant amount of seed is produced. Mowing may need to be repeated for 4 years or more to be effective. Mowing is only recommended in areas with a healthy grass cover that will respond well to mowing.

Till/cultivate: Highly effective. Recommended where possible, as it will not withstand cultivation. However, reseeding will need to follow to prevent the recruitment of other weed species.

Cultural

Reseed: Highly effective. Reseeding is strongly recommended as bull thistle does not tolerate shade.

Fire: Ineffective. Fire is likely to have a neutral effect, or slightly positive effect, meaning it could increase following fire (Bushey 1995). Expect high increases following severe burns.

Biological

Insects: Partially effective

Rhinocyllus conicus, Thistle seed head weevil. Larvae attack seed heads, adults do some damage chewing holes in the leaves. **This insect is not recommended**, as it attacks more than 25% of the native thistles in the US. It can not be transported across state lines.

Trichosirocalus horridus Musk thistle crown weevil. Larvae attack growing tips, adults feed on rosette leaves. Established in ID, MT and WY.

Urophora stylata Bull thistle seed head gall fly. Larvae feed on seed heads. Established in CO, OR, and WA, but not listed in any of the states included in this plan (ID, MT, WY, UT).

Pathogens: NA

Grazing: Partially effective. Sheep and goats will reduce seed production.

Chemical

Moderately to highly effective

2,4-D: apply to rosettes, ideally 10-14 days before bolting. Plants become resistant as the flower stalk is produced. If plants are too large, mow to prevent seed production and spray 2,4-D to inhibit regrowth.

Chlorsulfuron (Telar): in spring from rosette to pre-bloom stage.

Dicamba (Banvel, Clarity): apply in spring during rosette stage of growth.

Aminopyralid (Milestone): apply the spring and early summer to rosette or bolting plants or in the fall to seedlings and rosettes. See label for addition of 2,4-D at the late bud stages.
Tordon: Apply at the rosette stage before bolting in the spring or in the fall prior to soil
freeze up. See label for spring versus fall rates and the addition of 2,4-D.
Clopyralid+triclopyr (Redeem R&P): Apply in spring. Read label carefully to adjust rates based on plant growth stage.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Maintaining the health of the existing plant community and preventing seed production are the most important management strategies for this plant. It rarely occurs in undisturbed areas. Following a disturbance, monitor carefully and hand pull plants before they flower. Reseed disturbed areas where possible as bull thistle responds poorly to competition. For large patches where herbicides must be used, timing is critical. Application to rosettes is the most common time to spray. If plants have bolted, mowing can be used to prevent seed production. As demonstrated in Yosemite, patches are most common in high visitor use areas (Rutledge and McLendon 1996). Small barriers or other tools to guide visitors and keep them on trails should help prevent reinvasion by reducing trampling.

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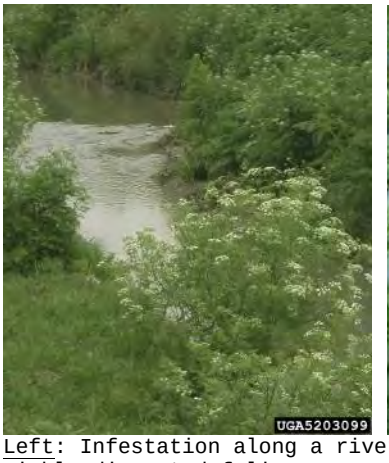
Conium maculatum, Poison hemlock



Left: Infestation along a river bank. By Pedro Tenorio-Lezama, Bugwood.org Center: Highly dissected foliage. By Robert Vidéki, Doronicum Kft., Bugwood.org. Right: Purple splotches on the stems. By Joseph M. DiTomaso, University of California-Davis, Bugwood.org.

Park presence:0
Status: ID: contain **MT counties:** Choteau, Beaverhead, Big Horn, Rosebud, and Yellowstone **UT**: control

Identifying characteristics: Grows as a highly dissected rosette in the first year. In the second year, plants may reach 2-10' tall. Leaves are opposite, highly dissected, fern-like (center photo). Stems are ribbed, hollow, with purplish splotches or streaks (photo above right). Small, white flowers grow in a compound umbel, or numerous umbrella-shaped clusters. May be confused with water hemlock (*Cicuta maculata*), but the leaf veins of water hemlock end in the notches between the teeth of the leaflets. In poison hemlock the veins end at the tips of the teeth. Resembles wild carrot (*Daucus carrota*), but stems of wild carrot are hairy, compared to smooth stems of poison hemlock. Also similar to giant hogweed (*Heracleum mantegazzianum*), but giant hogweed has larger, less divided leaves and a hairy stem.

Life cycle: Grows as a biennial, occasionally a perennial. Plants flower in mid-spring. Seed is mature in mid-summer, and plants dry out, but remain upright and shade out other plants. Seedlings may continually emerge throughout most of the growing season because seeds have a long dispersal period (summer to early winter); some of the seeds are dormant; and seeds can germinate under a wide range of conditions.

Spread: Seeds are **s**pread by water, wind, animal fur, human clothing, boots, and machinery. No means of vegetative reproduction.

Seeds per plant and longevity: 38,000 / 3 years.

Habitat: Occurs on roadsides, field margins, ditch banks and in low-lying waste areas, or moist places. May invades native plant communities in riparian woodlands and open flood plains of rivers and streams.

CONTROL OPTIONS

Poisoning occurs when the plant is ingested (the most toxic parts are seeds and young leaves). However, gloves should be worn when handling as some people develop dermatitis.

Mechanical
Hand pull/grub: Highly effective. Complete when soil is moist.
Cut/mow: Moderately to partially effective. Spring mowing may kill mature plants, but areas will need to be monitored for regrowth. Mowing will also clear the canopy increasing germination of seedlings, but mowing again in late summer should target this growth. If done consistently for three years, mowing may help reduce, possibly eradicate this plant given the short longevity of seeds. However, mowing will open up the plant community to other invasives, so it will need to be monitored regularly.
Till/cultivate: Moderately effective where possible.

Cultural
Reseed: Moderately effective. This plant expands most rapidly in recently disturbed areas. Reseeding vulnerable habitat (ditches, low lying areas) is recommended to prevent establishment.
Fire: Unknown, but unlikely to be feasible as it typically grows in moist areas with inadequate amounts of dried, flammable material.

Biological
Insects: None currently available, but many in development such as the hemlock moth (*Agonopterix alstroemeriana*)
Pathogens: None currently available, but many in development.
Grazing: Ineffective and toxic to livestock.

Chemical
Moderately to highly effective.
Picloram + 2,4-D (Grazon P+D): Apply from rosette stage in spring or fall up to 36" tall.
Chlorsulfuron (Telar) and **metsulfuron** (Escort), both provide excellent preemergent control.
Glyphosate (Roundup): reported to be especially effective with a surfactant and applied at the rosette stage. Approved aquatic formulations of glyphosate can be used to control plants near water.
2,4-D: (amine and ester formulations): early spring post-emergence with a wetting agent.
MCPA: early spring post-emergence.
The plant will become more palatable to livestock when sprayed with herbicides. Sprayed material should be fenced off from livestock and sprayed material should be carefully dumped where livestock can not access it.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Given the short seed longevity, the large stature of this plant, and the predictable habitat (disturbed, seasonally moist area) managers should be able to detect and eradicate this plant before it can establish. If plants do establish, care should be taken to dispose of plants away from animals or children. If herbicides are used, check the product label to determine the length of time between applications.

Once poison hemlock is depleted, it is important to implement proper grazing, fertilization, and irrigation management to promote the growth of desired species and to reduce the risk of reinfestation.

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Convolvulus arvensis, Bindweed, Field Bindweed

Left: Bindweed leaves and vining growth habit. By Steve Dewey, Utah State University, Bugwood.org. Right: Bindweed flower. By Mary Ellen Harte, Bugwood.org

Park presence: BEPA, BIHO, CIRO, CRMO, FOBU, GOSP, GRKO, LIBI, HAFO, MIIN
Status: **ID**: contain **MT**: 2B **UT**: contain **WY**: noxious

Identifying characteristics: Field bindweed grows as a vine with twining stems up to 6 feet long, forms dense mats and climbs over other plants. Leaves are arrowhead- or spade-shaped, with lobes at the leaf base (distinct from morning glory). Leaves are ¾-2 inches long, with entire margins. Five petals are fused together making the flower funnel-, trumpet-, or bell-shaped (see photo upper right).

Life cycle: Perennial. Plants reproduce by seed and vegetatively by rhizomes. They flower from early summer to mid fall, and occasionally until the first frost. Seed usually matures within three weeks of flowering, but seeds have been known to germinate within 10 days of flowers opening. Seeds typically germinate in autumn or the following spring. Germination is increased by chilling.

Spread: Plants spread by seed, root fragments and rhizomes. The hard seed coat allows seeds to remain viable in the stomachs of animals for up to 144 hours, allowing long distance dispersal when seed is ingested by birds and other animals. Seeds may be a contaminant in wildflower seed packets, or crop seed, and they may disperse in water. Small root fragments, created by tilling or other disturbance may form new plants. Once established, the extensive root system allows plants to rapidly colonize an area.

Seeds per plant / longevity: 25-300 / 20 years

Habitat: Cultivated fields, orchards, plantations, pastures, lawns, gardens, roadsides and along railways. It can survive long periods of drought.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Partially effective to ineffective. Hand pulling is only recommended on new, very small plants. Use a trowel to excavate as much of the root system as possible. Monitor the area frequently and continue grubbing. To eliminate established patches, hand pulling would need to be repeated every 14 days for 3-5 years.

Cut/mow: Ineffective. Mowing will miss stems and flowers which will lie flat on the ground.
Till/cultivate: Ineffective to partially effective. Twenty to twenty five cultivations spread over two years may have some effect, but this is not feasible for most parks, and the disturbance would invite other invasive species into the area.

Cultural
Reseed: Moderately effective and strongly recommended. Bindweed grows best in open communities with annual, biennial, and short-lived weeds. Dense plant cover causing low light can induce dormancy in field bindweed. Perennial grasses compete well with field bindweed because they grow early in the season and take advantage of the limited moisture (Callihan et al. 1990). However, bindweed will recover rapidly following a disturbance such as overgrazing (Wilken and Hannah 1998), meaning the area must be monitored and additional control methods may be needed.
Fire: Moderately effective, but impractical, unless using a small torch. Field bindweed may be eliminated by burning every 14 days for at least 3-5 years. Such practices are not feasible on most Park Service lands and the frequent disturbance would open up the area to other invasive species.

Biological
Insects: Partially effective. See IPM section for combining low doses of herbicide with biological controls.
Aceria malherbae (Originally identified as *A. convolvuli*, Bindweed gall mite): Nymphs and adults form galls on leaves, petioles and stem tips. At this time, this appears the most effective insect available. Established in MT, but also recovered in WY. Availability is increasing throughout the NW. For information on establishing it, see "Managing *Aceria malherbae* gall mites for control of field bindweed", available at http://aces.nmsu.edu/pubs/_circulars/CR%20600.pdf
Tyta luctuosa Bindweed moth: The larval stage feeds on flowers and leaves at night. It only impacts foliage, not roots, so efficacy is limited for this rhizomatous, perennial weed. Establishment is poor, and it is not currently widely available.
Chelymorpha cassidea, a tortoise beetle: feeds on the leaves of the plant and is native to the United States, but there is limited information on its efficacy or availability.
Not currently available, but under investigation (by APHIS and partners): ***Melanagromyza albocilia***, the stem-mining agromyzid fly and ***Longitarsus pellucidus***, a root feeding flea beetle.
Pathogens: Pathogens have not be been widely promoted for field bindweed, and information on their efficacy is limited. *Alternaria*, *Fusarium*, *Phoma proboscis*, and *Phomus convolvulus* have been tested as fungal biocontrols on field bindweed (Wilken and Hannah 1998). *Phomus convolvulus* sporulates only in conditions of high humidity. *Phoma proboscis* is resistant to herbicides, but also requires high humidity.
Grazing: Partially effective. Cattle, sheep and goats eat it; however, the alkaloid pseudotropine in field bindweed was reported to cause equine intestinal fibrosis. Targeted grazing may be used to enhance competition from desirable grasses, but managers should avoid early and mid-spring grazing to increase cover of grasses.

Chemical

Moderately effective. No herbicide or herbicide combination will provide 100 percent control of field bindweed in one growing season. Herbicide efficacy is reduced under drought conditions. The wax surface on field bindweed leaves is greater in high light and low humidity, further reducing herbicide efficacy.

Table 2: Herbicides for Bindweed Control

Modified from North Dakota Noxious and Troublesome weeds, (2010, available at www.ag.ndsu.nodak.edu/invasiveweeds/). Rates are included in this table because recommendations include combinations of herbicides. Grazing restrictions are not included in this table. Always refer to labels before applying herbicides.

Herbicide	Rate (ai/A)	Timing	Remarks
Glyphosate (Roundup) + **dicamba** (Banvel)	1.5 lb + 0.5 lb ae	Actively growing and when vines are at least 12 inches long. Apply at or beyond full bloom.	Less potential for soil residual than with higher rates of dicamba applied alone.
Dicamba (Banvel)	1-2 lb ae for fields. 2-8 lb ae for isolated plants	Actively growing and when regrowth is 12 inches long up to bud stage.	Mid to late fall treatments are more effective than summer treatments. Add NIS at 0.25% v/v to improve control.
Quinclorac (Paramount)	0.375 lb	Fall: Prior to frost when bindweed is at least 4 inches long and actively growing.	Allow 7 days before haying. Add MSO-type adjuvant at 2 pt/A.
Picloram (Tordon 22K) + **2,4-D**	0.5 to 1 + 0.5 to 1 lb ae	Actively growing and regrowth 12inches long to bud.	Picloram + 2,4-D is more cost-effective than picloram alone at higher rates.
Quinclorac (Paramount)+ **Dicamba & diflufenzopyr** (Overdrive)	6 oz + 3 oz ae & 1.2 oz)	Fall prior to a killing frost, to at least 4 inches of stem.	Add an MSO-type adjuvant at 2 pt/A.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

The perennial, rhizomatous growth form, seed longevity, poor response to herbicide, and ability of the plant to become dormant during periods of stress make control of field bindweed extremely difficult. Effective control requires a combination of treatments and diligence over a 3-5 year time span. Young plants (germinated within the existing growing season) in previously uninfested areas should be the top management priority. These plants should be targeted with herbicide, monitored, and retreated throughout the growing season for two to three years to prevent establishment. For established patches, management objectives should involve damaging the roots and root buds of the plants to weaken them and prevent seed production and seedling establishment. Where field bindweed grows in an open community without competition, reseeding following herbicides is strongly recommended.

In greenhouse trials, combining *A. malherbae* with either 2,4-DB (at 0.07 to 0.14 kg ae ha^{-1}) or glyphosate (at 0.14 to 0.28 kg ai ha^{-1}) reduced root and shoot biomass of field bindweed plants more than mites or either herbicide alone (Boydston and Williams 2004). There were no reductions of galls formed by mites due to herbicides. More studies are needed to determine whether the mites can tolerate higher herbicide rates, but these low rates will do less damage to the existing plant community. While *A. malherbae* may be slow to establish (McClay et al. 1999), this method deserves a 3-4 year trial for parks where field bindweed is widely distributed.

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Crupina vulgaris, Common crupina

Above left: Seedlings with dissected leaves. Above right: flowers. Photos by Steve Dewey, Utah State University; USDA APHIS PPQ Archive, USDA APHIS PPQ, Bugwood.org

Park presence: BIHO
Status: **ID**: control **MT**: removed from state list in 2010

Identifying characteristics: Seedlings have a prominent purple midrib. Flowers are pink to purple, surrounded by stiff bracts and grow one to two on a branch (may have 40 branches/plant). Rosette and stem leaves are pinnately lobed; with stiff spines on leaf edges; and lobes that are narrow and opposite. Plants range from 1-3 ft. tall.

Life cycle: Winter annual. Plants bolt in the spring, flowering occurs in late spring, early summer, and seed disperses by mid-summer.

Spread: Small seeds attach to livestock, wildlife, and people and float down rivers and streams. Seeds can also pass through cattle, deer, horses, and pheasant, but not sheep.

Seeds per plant / seed longevity: <1000 / 1-3 years.

Habitat: Occurs in a wide range of habitats including canyon grasslands, rangelands, and forests, gravel pits, roadsides, railroad embankments and other right-of-ways. Very common on steep south facing slopes.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective. This is best done when soil is moist so majority of roots can be pulled. A shovel or trowel should be used in dry soils.
Cut/mow: Ineffective. Cutting will stimulate lateral branching and flowering
Till/cultivate: Partially effective to ineffective. While plants do not occur in annually tilled croplands, this frequency of tilling is not feasible in parks.

Cultural
Reseed: Moderately to highly effective and strongly recommended. Healthy plant communities can deter common crupina from establishing. Disturbed areas or areas with poor vegetative cover should be reseeded to prevent establishment.
Fire: Unknown. Not recommended, as it typically favors other invasive species.

Biological

Insects and pathogens: NA

Grazing: Ineffective. It will increase with grazing. Seed can survive in the digestive tracts of animals.

Chemical

Moderately to highly effective

Clopyralid (Transline or Stinger): split-fall then spring. **Metsulfuron** (Escort XP - general use): apply at rosette to bolting growth stages (early spring to early summer). **Metsulfuron + chlorsulfuron** (Cimarron X-tra - general use): apply at rosette to bolting growth stages (early spring to early summer). **Metsulfuron +dicamba+2,4-D** (Cimarron Max): apply to actively growing plants. **Picloram** (Tordon 22K): apply at rosette growth stage or when plants are actively growing.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Monitor to identify new plants, and hand pull immediately. Be especially watchful for it on south facing slopes. Reseed bare spots caused by overgrazing or other disturbances. Healthy plant communities can deter common crupina from establishing.

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Cynoglossum officinale, Hounds tongue


Left: Growth habit of flowering plants. By Richard Old, XID Services, Inc., Bugwood.org. Center: Close-up of flowers. By Mary Ellen Harte, Bugwood.org. Right: Nutlets (seeds) grow in a tight cluster of four & are covered in tiny barbs.

Status: **ID**: contain **MT**: Priority 2B **UT**: contain **WY**: noxious
Park presence: BIHO, CIRO, FOBU, GRKO, LIBI, HAFO

Identifying characteristics: Rosette leaves are 4 to 12 inches long, covered in white hairs, rough to the touch and with prominent veining. Flowers are pinkish to reddish purple. The seed pods are distinctive, about ¼" long, brown, teardrop shaped, flat and covered with short barbs (above right).

Life cycle: Biennial. Seedlings emerge in the spring and early summer to form a rosette in the first year. If conditions are right, flowering occurs in the second year from mid-spring to mid-summer (May-July in MT).

Spread: Barbs on seed allow them to stick to clothing, or animal fur for long distance dispersal.

Seeds per plant / longevity: 50-2,000 / 2-4 years

Habitat: It commonly occurs in disturbed areas like trails, roadsides, logging areas, or abandoned cropland, but plants also occur in rangelands, pastures, riparian areas, and borders or openings of wooded areas. Plants are shade-tolerant, and survive well in wetter grasslands and moist draws on drier sites.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective for small patches. Must excavate 1-2" below soil to get root crown.
Cut/mow: Mixed results. Taproots often store enough nutrients to support normal flowering and seed production following mowing. If other options are not available, mowing can reduce seed production.
Till/cultivate: Moderately effective. Repeated cultivation may be an effective control measure as long as it severs the root one to two inches below the surface. Once seed supply is depleted, tilling should be followed by reseeding to provide long term control.

Cultural

Reseed: Moderately effective. Highly recommended for prevention, and as follow up to other control efforts. Reseeding is necessary if very little other vegetation is present.

Fire: Ineffective. Difficult to get temperatures near the soil surface hot enough to destroy the seeds. Fire will also remove competition, providing optimal condition for houndstongue establishment.

Biological

Insects and pathogens: None currently available. However, the houndstongue root-mining weevil (*Mogulones cruciger*) has potential. It has reduced houndstongue populations in British Columbia and Alberta, Canada. Status is pending.

Grazing: Not effective. Poisonous to cattle, horses, causing liver damage. Goats can reduce seed production, but their coats must be cared for to prevent spread into uninfested areas.

Chemical

Moderately to highly effective

Note: Herbicide application may increase the palatability of houndstongue foliage, so grazing too soon after treatment could increase the risk of livestock poisoning. Check labels for recommendations on surfactants, many will need it due to the hairiness of the leaves. Generally, spring applications are reported to provide better control than fall applications.

Excellent: **Metsulfuron** (Cimarron, Escort)**:** to actively growing plants that are less than 4" tall or in diameter.

Good: **Triasulfuron** (Amber): to actively growing plants when they are less than 6" tall or in diameter (note label for the suggested enhanced rate for this weed). **Metsulfuron + dicamba + 2,4-D** (Cimarron Max): treat when weeds are less than 4" tall or in diameter and are actively growing. **Imazapic + glyphosate** (Journey): apply pre or post emergence. **Picloram** (Tordon): apply pre or post emergence.

Fair: 2,4-D (Many trade names): to first-year and second-year rosettes. While rated fair, research in MT indicates that 2,4-D amine at a rate of 1.12 kg/ha in May controlled up to 97% of the first-year plants. Application at flowering to second-year plants controlled up to 77%. Second-year plants were most sensitive to 2,4-D when the bolted plants were 28 cm tall.

Not rated: **Chlorsulfuron** (Telar): to actively growing plants.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Prevention of seed formation is critical and will allow for eradication since seed longevity is only 2-3 years. Hand removal or herbicide spot treatments are recommended for small-scale infestations. Larger infestations may require herbicide treatments. If seeds have already formed, clip and bag plants to prevent seed spread. If desired vegetation is scare or absent control will be of little value. Reseeding is strongly recommended for long term control.

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Cytisus scoparius, Scotch broom


Left: Leaves by Tom Heutte, USDA Forest Service, Bugwood.org. Right Flowering plant by Steve Dewey, Utah State University, Bugwood.org

Park presence: Not reported in any of the parks.
Status: **ID**: control **MT**: priority 1B

Identifying characteristics: Grows as a perennial shrub, reaching up to 13 feet in height. Plants grow rapidly, and may reach 8 feet within the first two years (in ideal environments). Stems are strongly angled (young branches have 5 ridges), spineless, green when young, and become woody as they age. Deciduous leaves are alternate, with compound (three leaflets per leaf) leaves at the base, and simple leaves at branch ends. The pea flowers (with wings, keel and banner) are yellow, but they may have a purple tinge. Fruits are a black, flattened pod, 3/4 – 2 inches in length. Pods are usually hairless, or have a fringe of hairs on the outer edges.

Life cycle: Long-lived perennial. Reproduces by seed only, starting in the second or third year. Flowering occurs before leaves emerge in the early spring, and peaks in mid spring. Fruits mature in early summer and disperse in mid-summer.

Spread: Seed pods dry and twist, ejecting seed several feet from the parent plant. Ants also contribute to short distance dispersal. Seed is commonly spread by vehicles, and in contaminated gravel or soil.

Seeds per plant and longevity: 10,000 / 5-60 years

Habitat: Common in disturbed areas, open forests, roadsides, grasslands, pastures, cultivated fields, wasteland, dry meadows, dry riverbeds and other waterways. This plant fixes nitrogen which allows it to establish in nutrient poor conditions. It tolerates most soil conditions, but thrives best in dry, sandy soils and prefers a soil pH of less than 6.5. It does best in full sun, but it is very tolerant of shade, (seedlings can establish in less than 10% sunlight).

CONTROL OPTIONS

Mechanical
Hand pull/grub: Moderately effective for new, small plants. A shovel is recommended to excavate below soil level to reduce resprouting. Hand pulling is not feasible for adult plants. Bush hog removal, or

twisting the stem off instead of cutting it has been used, but resprouting is still possible.
Cut/mow: Partially effective. Mowing or cutting at the end of a dry season will reduce resprouting.
Till/cultivate: Not available given plant's stature.

Cultural
Reseed: Partially to moderately effective. Reseeding bare spots, or reseeding following herbicide application is recommended to prevent infestation or reinfestation.
Fire: Unknown. Burn trials on a similar species found it reduced the existing population but stimulated germination from the soil seed bank.

Biological
Insects: At this time, no biological controls are listed as established in ID, MT, UT or WY (Coombs et al 2004). Most have established in CA, OR, and WA where Scotch broom is much more prevalent.
-Bruchidus villosus (Scotch broom bruchid). Larvae feed on seed pods, adults feed on pollen. Prefers meadows and hillsides with southern exposure. Established in OR and WA.
-Exapion fuscirostre (Scotch broom seed weevil). Larvae feed on seed pods, adults on flowers. It prefers meadows and hillsides with a southern exposure. Established in CA, OR, and WA.
-Leucoptera spartifoliella (Scotch broom twig miner). Larvae attack stems, but actual impacts are questionable. Established in CA, OR, and WA.
Grazing: Moderately effective with goats (used successfully in New Zealand). Using other animals is not recommended. The plant is not considered palatable, but livestock poisoning (from quinolizidine alkaloids that cause muscle degeneration) has been reported in Europe.

Chemical
Moderately effective.
Glyphosate (Roundup): apply during active growth after all leaves have opened. See label for use of a non-ionic surfactant.
2,4-D + triclopyr (Crossbow): apply during active growth
Picloram (Tordon): apply during active growth

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Prevention is the number one priority for this plant. Managers should monitor disturbances, and ensure soil, or gravel brought from off site is monitored for years in case it is contaminated. Identifying and removing Scotch broom before it flowers (typically in the 2nd or 3rd year) is critical because seed production and seed longevity are so high. Control small patches with hand pulling and digging or herbicide. Reseed severe infestations after treating with herbicide.

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Echium vulgare, Blue weed

Left: Multi-branched growth form. By Robert Vidéki, Doronicum Kft., Bugwood.org. Right: Blue flowers with long, exserted stamens. By Richard Old, XID Services, Inc., Bugwood.org (both)

Park presence: Not reported in any of the parks.
Status: **ID**: control **MT**: priority 2A

Identifying characteristics: Plants are multi-branched, may grow over 3' tall, and have bright blue flowers (occasionally purple, pink and very rarely white) and red to pink stamens (above left). It grows as a biennial to short lived perennial. The basal rosettes have long lance-shaped leaves. Leaves and stem have appressed hairs, and long and short spreading hairs with red, purple or black bases that are swollen. Stems look spotted from these colored swollen bases. Flowers are funnel-shaped with five lobes and are located on the top of a curled cyme (flowers arranged like a scorpion's tail). There are bright pink or red exserted stamens, 4 long and 1 short. It may be confused with the native *Phacelia linearis,* which has purple/blue flowers with white stamens. The spotted stems on blue weed help differentiate it from other similar species.

Life cycle: Biennial to short lived moncarpic perennial (blooms in the second year of growth or thereafter and dies after flowering). Plants overwinter as small rosettes with a bud, and require a cold period before flowering. Plants may flower in their second year, but may take 3-4 years before flowering. For some plants flowering occurs early to mid-summer, and for others flowering occurs in the late summer and fall (August to October in Montana).

Spread: Seeds are dispersed by water, wind, animals, water (seeds float) and humans. Wind can disperse it 16' from the parent plant. Stems may also break and blow like tumbleweeds. It occurs as a contaminant in hay or grain, and gets carried in construction or farming equipment.

Seeds per plant / longevity: Average 1800 seeds per plant / variable, typically less than 3 years, but occasionally more than 5 years

Habitat: It is most common in disturbed areas and overgrazed range or pastureland. It is most competitive in sandy, well-drained soils with low nutrients, but it is also found in irrigated, well maintained pastures. It is tolerant of drought.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective. Pull when the soil is moist or use a trowel/shovel to ensure the taproot is removed. Pull before seed production or bag pulled plants to prevent seed dispersal. Stiff hairs may irritate the skin. A long sleeve shirt is recommended.
Cut/mow: Partially effective. Mowing can provide short term control by reducing seed production. The area will need to be monitored and mowing repeated to target resprouts. Subsequent regrowth and flowering may occur below the mower height (Graves et al. 2010).
Till/cultivate: Partially effective. Cultivating will need to be repeated several times during the growing season, and be deep enough to cut the roots. It will need to be followed by reseeding in the fall and monitored for plants emerging from the seed bank.

Cultural

Reseed: Moderately to highly effective. Revegetation may need to be preceded by herbicide to allow desirable seeded species to establish (Graves et al. 2010).
Fire: Information limited. Not recommended at this time. Plants do not dry out well so are difficult to burn. In burn trials conducted in western Montana, plants had to be hand pulled and air dried for several days before successful burning occurred (Graves 2010).

Biological

Insects: Not currently available.
Pathogens: Not currently available.
Grazing: Blue weed contains pyrrolizidine alkaloids which can be toxic to horses and cattle, but sheep and goats have shown resistance to alkaloid toxicity. Plants are not considered palatable, and there are few reports of poisonings (Graves et al. 2010).

Chemical

At this time, only the herbicide **2,4-D + triclopyr** (Crossbow) is specifically labeled for blue weed (based on www.greenbook.net). It should be applied during active growth.
In herbicide trials in Ravalli County, Montana, the following herbicides provided near 100 percentage control of blue weed on a rangeland site. Herbicides were applied to rosettes in the spring or fall (Graves et al 2010).
Metsulfuron (Escort) at 1 oz product/acre
Chlorsulfuron (Telar) at 1 oz product/acre,
Metsulfuron + chlorsulfuron (Escort and Telar) each at ½ oz product/acre.
Multiple applications may be required to ensure complete control of this species.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Blueweed is not reported in any of the parks at this time or it is only a minor constituent. Prevention and EDRR are the most important control strategies. If plants are encountered, they should be hand pulled before they flower and set see or bagged if they have flowered. For large, widespread populations, 'spray-grazing' has been used effectively in Australia and New South Wales (Graves 2010). This

involves applying herbicides and intensively grazing with sheep or goats to reduce or eliminate broadleaf weed species. The pasture is then rested, and then cattle are returned to the pasture. Some herbicides make plants more palatable, so only goats or sheep, not cattle or horses should be used for the intensive grazing after herbicide application. If this method is not available, herbicides followed by reseeding are recommended to provide long term control.

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Elaeagnus angustifolia, Russian olive

Left: Russian olive growing along a river bank. By David J. Moorhead, University of Georgia, Bugwood.org. Center: Silver-colored, long, narrow leaves. Right: Hard yellow fruits are palatable to and spread by birds. Both by Patrick Breen, Oregon State University, Bugwood.org.

Park presence: GRKO, LIBI, HAFO, MIIN
Status: UT counties: Carbon, Duchesne, Sevier, Uintah, Wayne counties
WY: noxious

Identifying characteristics: It grows as a deciduous tree or shrub, reaching up to 35 feet in height (above left). Leaves are alternate, ½ inch wide, and have silvery scales on their undersides. Stems may be slightly thorny. Small, yellowish flowers (center) are followed by hard green to yellow fruits (right) in the spring and summer. This plant may resemble the native shrub *Shepherdia* (e.g. buffalo berry), which has thorny stems, and long, narrow, silver-colored leaves. *Shepherdia* has opposite leaves, while Russian olive's are alternate.

Life cycle: Fast growing, long-lived perennial. After germinating, it can flower and set fruit within three years. It flowers in the spring, and fruit forms in the summer.

Spread: Reproduces by seed and can sprout from root suckers. Birds consume the seeds allowing for long distance dispersal. It is still planted for mine reclamation, and shelterbelts. It then invades old fields, woodland edges, and other disturbed areas. It can germinate and survive in the shaded understory of native trees, (e.g. cottonwoods). When native trees die, Russian olive becomes dominant, and the shade of Russian olive prevents re-establishment of native trees and shrubs.

Seeds per plant / longevity: unknown / 3 years

Habitat: Most common in floodplains, along river banks, stream courses, marshes and irrigation ditches. It tolerates a wide range of moisture conditions and can withstand flooding.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Moderately to highly effective for saplings with a trunk diameter less than 3.5 inches when the soil is moist. Pulling or

digging larger plants will leave behind roots fragments that will vigorously resprout.
Cut/mow: Partially effective to ineffective. Seedlings can be mowed, but this must be done repeatedly. For larger plants, mowing, or brush cutting are rarely effective in the long-term, unless labor is available to continually cut and remove resprouts. See the cut-stump method using herbicides described below.
Till/cultivate: Not effective.

Cultural
Reseed: Ineffective. Russian olive seedlings can tolerate shade. However, if there are plans to remove Russian olive from an area, reseeding is strongly recommended for soil stabilization, to prevent the invasion of other weeds into the disturbed area, and to replace structure (e.g. for birds) lost after removal of Russian olive. Russian olive can tolerate saline soils better than most native plants. The following are recommended for rapid site stabilization and cover for saline areas: slender wheatgrass (*Elymus trachycaulus*), western wheatgrass (*Pascopyrum smithii*); and shrubs and sub-shrubs such as silver buffaloberry (*Shepherdia argentea*), fourwing saltbush (*Atriplex canescens*), Nuttall's saltbush (*Atriplex nuttallii*), Gardner's saltbush (*Atriplex gardneri*), and winterfat (*Krascheninnikovia lanata*) (Scianna 2004).
If soils are not saline, refer to the native community for species selection (or NRCS ecological site description if highly disturbed).
Fire: Ineffective. It will send up suckers following fire.

Biological
Insects: None currently available.
Pathogens: None currently available.
Grazing: Not applicable

Chemical
Partially to moderately effective.
Cut stump, girdling, and foliar applications are options. Cut stump or girdling is recommended over foliar to reduce off target impacts (drift).
-Cut stump treatments are highly recommended for control. Cut the trunks as close to the soil surface as possible and apply herbicide immediately (within 15 minutes of cutting). At a study in Nebraska for example, cut stump with **2-4,D + Dicamba** (Weedmaster) applied in the spring or fall, with stump diameters ranging from 7-12", provided 100% control 2 years after treatment (no regrowth). Other herbicides included in this study that provided 100% control (no regrowth) 2 years after application (spring or fall application) are: **Imazapyr** (Habitat) + MSO (methylated seed oil); **Triclopyr** (Garlon 4); **Picloram** (Tordon RTU); **Glyphosate** (Roundup WeatherMax) + MSO; **Triclopyr** (Garlon 4) + **Picloram** (Tordon 22K) + Diesel. Note: **Velpar DF** did poorly in this study. For a summary of the study and the ratios of herbicide to carrier (diesel, or MSO), see a summary of Wilson's study at: http://www.extension.unl.edu/c/document_library/get_file?folderId=490838&name=DLFE-8336.pdf

-For girdling, make shallow, overlapping cuts into the bark around the trunk base using a hatchet or chainsaw. Lightly spray the entire cut surface with herbicide. Fall may be the best time of the year, since this when trees translocate reserves to their roots, but in the cut-

stump study described above, spring was equivalent to fall application for nearly all herbicides.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Large mature stands of Russian olive that occur throughout a watershed are nearly impossible to eradicate, so early detection and rapid response are imperative. Small patches of Russian olive can be adequately controlled with the cut-stump method, or hand pulling (for seedlings, small saplings). For larger, established plants, continual monitoring and follow up (re-treatment as necessary) for several years is required for successful long-term control since Russian olive typically resprouts from the root crown.

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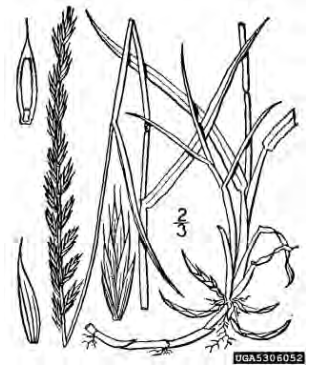
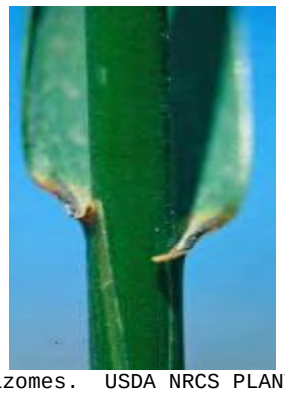
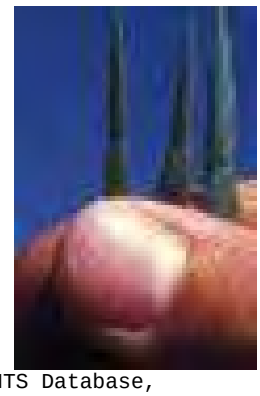
Elymus repens, aka *Agropyron repens*, Quackgrass

(a) **(b)** **(c)** **(d)**



Figures: (a) Diagram of flowers, leaves and rhizomes. USDA NRCS PLANTS Database, Bugwood.org. **(b)** growth habit of flowering plants. **(c)** leaf collar region. Both photos by Steve Dewey, Utah State University, Bugwood.org **(d)** leaf tips constricted Weeds of the West, 9th edition, ces.uwyo.edu

Park presence: CIRO, FOBU, GOSP, GRKO, LIBI, HAFO, MIIN
Status: **UT:** contain **WY**: noxious

Identifying characteristics: Leaves are rolled in the bud, hairless to sparsely hairy above and up to 8" long. Stems are erect and clump-forming (Figure b), up to 4' tall. Leaf sheaths are hairless except those near the base, which may be sparsely hairy. Clasping, claw-like auricles are present at the collar region (Figure c). Ligules are very short, membranous. Leaf tips are often constricted (Figure d). The prominent pale yellow or straw-colored rhizomes and tough brownish sheath at each joint distinguish it from most other species. Rhizomes are scale-like from sheathing. Seedhead spike is a 2-10" long, slender, unbranched, and made up of several alternating spikelets (Figure a). Each spikelet contains up to eight straw-colored, lance-shaped seeds. Each seed has a short to prominent awn.

Life cycle: Perennial. Rhizome growth begins in mid-spring, flowering occurs in from mid- to late-summer.

Spread: Seeds and rhizomes. No long distance dispersal mechanisms. Spread by rhizomes is more important than spread by seed.

Seeds per plant and longevity: 25-40 but up to 400 / less than 5 years

Habitat: Occurs in open areas with moderate to high nutrient levels including agricultural fields, lightly grazed pastures, and waste places. Considered an early successional species common in crop fields, roadsides, ditches, and other disturbed, moist areas. Will dominate recently disturbed areas, but will not tolerate shade so can fade out as other vegetation emerges. May be most problematic at the transition areas between riparian and upland prairies, grazed areas, and wet prairie sites with altered hydrologies where it can outcompete native vegetation.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Moderately effective to ineffective: only for new, very small patches. Remove as much of the rhizome as possible. The area must be monitored regularly to remove resprouts. Long term suppression will be improved by reseeding after plants appear to be eradicated.
Cut/mow: Ineffective.
Till/cultivate: Mixed results. Effective as a precursor to herbicides and then reseeding, but fragmenting rhizomes may increase spread. Used in some crop systems, but requires multiple years, and typically needs to be combined with other efforts.

Cultural
Reseed: Highly to moderately effective. This weed is considered an early successional species. Reseeding is strongly recommended to provide long term control.
Fire: Mixed results. Burning on a biennial basis for several seasons has been effective in other areas (e.g. Wisconsin, Ohio), but burning poses a high risk in the Pacific Northwest where fire creates ideal conditions for annual grasses like cheatgrass.

Biological
Insects: Not available
Pathogens: Not available.
Grazing: Ineffective.

Chemical
Moderately to partially effective. Herbicides will rarely work as the sole treatment. Recommended in combination with other treatments to improve vigor of existing plant community (to release community from competition, or prior to reseeding). Unless specified otherwise: apply herbicides in the spring or fall when plants are actively growing. This is a cool season grass meaning it will become dormant in the heat of the summer, making it unresponsive to herbicides.

The following provide selective control of annual and perennial grasses: **Quizalofop-P** (Assure II), **Fluazifop-P** (Fusilade,), **Fluazifop-P + fenoxaprop- P** (Fusion), **Sethoxydim** (Poast), **Clethodim** (Select)
For non-selective post-emergence control: **Glyphosate** (Roundup, Rodeo, and Touchdown). Fall application of glyphosate prior to hard frosts can be very effective.

Herbicide reports from various studies by the Nature Conservancy:
-At Kitty Todd Preserve in Ohio:
Glyphosate (trade name Roundup at 5%) provided excellent control.
Fluazifop-p (Fusilade at 1 quart + 2 quarts crop oil (adjuvant) to 50 gallons of water) provided good control. Treatments were followed by reseeding competitive species.
-At Ewauna Flat Preserve in Oregon: **glyphosate**, **sethoxydim**, and **fluazifop**, had little to no effect on controlling quackgrass. The author suspects this was likely because they were applied too late in the season (summer). Apply when plants are actively growing.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Recently colonized areas may be controlled or eradicated with consistent efforts including herbicide and reseeding (plants are intolerant of shade). For areas where quackgrass is widely established, control will require massive resource inputs such as tilling, herbicide, and reseeding over many years. Managers may select a less aggressive, multi-year approach where they start at the perimeter of a large patch with spot spraying and herbicide and work inwards. Reseeding to create a healthy plant community around the perimeter should prevent further spread.

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Euphorbia esula, Leafy spurge

Left: Dense infestation. By Richard Old, XID Services, Inc., Bugwood.org.
Right: Flower heads with showy bracts. By Chris Evans, River to River CWMA, Bugwood.org

Park presence: BIHO (possibly eradicated), CRMO, GRKO
Status: **ID**: contain **MT**: priority 2B **UT**: EDRR **WY**: noxious

Identifying characteristics: Leaves are alternate, linear to narrowly lance-shaped, sessile, and up to 4 inches long. Flowers are yellowish-green, with heart shaped yellow bracts that enclose small flower clusters (see photo, upper right). Plants exude a white milky latex when cut/broken (this substance is a strong irritant, especially if it contacts the eyes). Plants grow up to 3 to 4 feet tall.

Life cycle: Perennial, reproduces by extensive slender rhizomes and seeds. The majority of seeds germinate within the first two years, usually in May or June. Seedlings rarely flower in the first year. Flowers are a cluster of yellowish-green petal-like structures called bracts, which surround the true flowers. The showy, yellow bracts appear in late May and early June, giving the plant the appearance of "blooming." **Note**: true flowers, which are small and green, do not develop until mid-June (will vary depending on elevation, annual variation in climate etc.). Research shows that spring-applied herbicides are more effective on plants with developing or developed true flower parts than on plants with developed bracts but undeveloped flowers. Seeds often have a rather high germination rate, ranging from 60-80%, but seedlings are described as poor competitors, with around 80% mortality. However, survivors are highly competitive, and can outcompete most rangeland plants. Without competition, seedling roots can reach depths of 3 feet. Spurge is a good competitor for resources because of its early spring emergence. May also exhibit allelopathy toward other species.

Spread: Plants spread rhizomatously and by seed. Rhizomatous growth allows plants to spread laterally 15 feet per year. Rhizomatous spread is faster in lighter soils compared to heavy soils. Seed can be projected up to 15 feet when they dry and explode. Seeds can also float, causing new infestations along ditches, and rivers. Long distance seed dispersal is possible by animals such as birds, or sheep.

Seeds per plant and longevity: ~129,714 seeds per plant, or 140-150 seeds per stem / 5-8 years (both the crown buds and root buds can remain viable in soil for a number of years)

Habitat: Most common in open habitats like waste areas, pastures, roadsides, rangelands, and especially sub-irrigated meadows. It is not found in cultivated fields. It is tolerant of a wide range of soils, and may occur in rich damp soils such as the bank of rivers or on dry nutrient poor soils.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Mixed results. Recommended for very small infestations where it can be repeated diligently throughout the season and for many years.

Cut/mow: Ineffective when used alone, but may be used in combination with herbicides.

Till/cultivate: Moderately to highly effective, but requires intensive to moderate effort and persistence. There are two options, (1) intensive tillage throughout the growing season and (2) cultivation only in the fall. In the first method, cultivation should occur 2 to 4 weeks after leafy spurge emerges, and it should be tilled to 4 inches deep (using a duckfoot or similar cultivator). This must be repeated every three weeks until the soil freezes in the fall for one to two growing seasons. An interruption in this schedule will make control ineffective. The second option is to till in the fall when the plants are 3 to 6 inches tall post-harvest. North Dakota State University showed that cultivating leafy spurge twice each fall after harvest for three years provided complete control. The benefits of this method compared to the season-long program are that a crop or cover crop could be planted during the growing season, limiting erosion. The amount of time needed for control can be shortened when the cultivation program is combined with a chemical treatment. Apply effective herbicides to leafy spurge at rates labeled for use in the prospective crop at least seven days before the first fall cultivation.

Cultural

Reseed: Moderately to highly effective as follow up to other treatments. It is strongly recommended for dense infestations where desirable remnant grasses are lacking, but should be preceded by herbicides to allow seedlings to survive and establish. Bluebunch wheatgrass (*Pseudoroegneria spicata*) seeded at 12 lb per acre was very effective at containing leafy spurge when preceded by herbicide, and followed by release of insects (Jacobs and Knudsen 2006). 'Rodan' western wheatgrass (*Pascopyrum smithii*) was very effective in trials in North Dakota.

Fire: Not recommended. Plants resprout easily following fire (Bushey 1995). However, it may be used to remove trash/litter layer prior to herbicide application for better coverage.

Biological

Partially to moderately effective. Establishment by state based on information in Coombs et al 2004.

Insects:

For ***Apthona*** *species*: After first releasing them, a noticeable, but temporary reduction in plant density may occur. It is temporary because roots that are not attacked will send up numerous new shoots. However, when they establish successfully, a reduction in leafy spurge cover, density and biomass, and an increase in the abundance and cover of grasses and forbs can typically be observed in 3-5 years (Coombs et al 2004). No non-target impacts have been recorded for any of the *Aphthona* species, except for *A. nigriscutis*, which has been observed to feed on the native *Euphorbia robusta*, but no impacts have been recorded.

1. ***Apthona cyparissiae*** (Brown dot leafy spurge beetle): Adult beetles feed on leaves and flowers and larvae feed on/in the root hairs and young roots. Over prolonged periods, continuous pressure by the beetles weakens the taproot resulting in death of the plant. This insect prefers warm open sunny areas. It tolerates more moisture than *A. nigriscutis*. Established in ID, MT, UT and WY.
2. ***A. flava*** (Copper or amber leafy spurge flea beetle): Adult beetles feed on the leaves and flowers; larvae feed in/on the root hairs and young roots. Light populations reduce plant height and retard flowering while high populations reduce plant density. It is hard to get it established in sites with clay or acidic soils, or in deep shade. While it has done exceptionally well in some areas of Montana, in other areas *A. flava* is described as hard to find, and not a useful insect for controlling leafy spurge as populations have never built up high enough to be effective (Coombs et al 2004, and R. Lym, personal correspondence). Established in ID, MT, UT, and WY.
3. ***A. lacertosa/czwalinae*** (Brown-legged leafy spurge flea beetle): Now generally referred to as *A. lacertosa*. Larval feeding on root hairs and young roots reduces the plant's ability to take up moisture and nutrients. Adults feed on leaves and flowers. It does best in open, sunny mesic to moderately dry sites, and survives very cold temperatures (Coombs et al 2004). *A. lacertosa* is by far one of the most actively redistributed *Aphthona* species. It is established in ID, MT, UT and WY.
4. ***A. nigriscutis*** (Black dot leafy spurge flea beetle): Adults feed on leaves and flowers, but primary damage is from larvae feeding on roots. It contributes with other *Aphthona* spp. to a significant depression in plant density. Over a 14 year period (1994-2008) densities of leafy spurge declined 60% and mass declined 69% following the release of *A. nigriscutis* (Lesica and Hanna 2009). This insect seems to prefer dry habitats with coarse, well drained soils (tolerates drier sites compared to other *Aphthona* species). Needle-and-thread or porcupine grasses (*Stipa* spp.) are considered good indicators of suitable sites. Established in ID, MT, UT and WY.
5. ***Chamaesphecia hungarica:*** Larvae attack roots. In the native range, it grows in moist, shady habitats. It was first introduced to MT in 1993, but has yet to establish successfully (Coombs et al 2004).
6. ***Hyles euphorbiae*** (Leafy spurge hawk moth): Larvae feed on leaves and bracts. This insect is considered ineffective by itself as a biocontrol, but it periodically becomes abundant and can cause noticeable defoliation (Coombs et al 2004). It prefers open areas near trees with dense stands of leafy spurge. Established in ID, MT and WY.
7. ***Oberea erythrocephala:*** This beetle feeds on stem and leaf tissue as an adult. The adults often girdle the stem causing shoot death. Developing larvae feeding in the stem also cause shoot death. Larval

feeding in the crown and root tissues reduces root reserves, and shoots can die when adults lay eggs in them. Populations are generally slow to build to high enough levels to be effective, but it is recommended in wet areas where *Apthona* will not survive. It appears to be effective on only some biotypes of leafy spurge. Established in MT and WY.

8. ***Spurgia esulae*** (Leafy spurge tip gall midge): Larvae attack growing points of the plant, reducing or preventing the plants' ability to flower and produce seed. New tips will emerge below the attacked areas, and will be targeted by the next generation of midges. In MT, there are typically two generations, but 3-5 in warmer areas. This insect is not considered very effective, but if used in combination with other insects, it is recommended for sites with cool climates and dense spurge. It appears to tolerate some shading, unlike most other spurge biocontrols. Established in ID, MT and WY.

See "Biology and Biological Control of Leafy Spurge" for assistance on releasing and monitoring biocontrols. Available at: http://www.invasive.org/publications/LeafySpurgeBiocontrols.pdf

Grazing: Moderately effective. Sheep can be trained to eat it, and goats will eat it readily. It is considered somewhat toxic to cattle and horses. Strongly recommended with goats or sheep. The goal is to remove 95% of top growth, graze regrowth after the first treatment; prevent flowering and seed production.

Chemical

Herbicides rated excellent, good, fair, poor when available by Dewey et al 2006. Herbicides can be used to kill the upper portions of the plant, but resource reserves in the roots will allow new shoots to regenerate. Timing is critical to maximize herbicide efficacy. For spring application, see life cycle section above to distinguish true flowers from bracts.

Good

-**Imazapic** (Plateau): after summer dry period when plants begin to grow. From Plateau label: "For best results, apply PLATEAU at 8 to 12 oz per acre in late summer or fall (August through October, but timing may vary by state and/or altitude). Fall application should be made after good soil moisture is present but prior to the leafy spurge losing its milky sap flow due to a killing frost. Break the main stem of the leafy spurge and if milky sap flows from the break then imazapic can still be applied. (Note use gloves and prevent sap from contacting eyes).

-**Glyphosate** (Roundup, Rodeo): from Roundup Original Max: "apply 11 fluid ounces of this product, plus 0.5 pound of 2,4-D, in 3 to 10 gallons of water per acre in the late summer or fall. If mowing has occurred prior to treatment, apply when most plants are 12 inches tall". Glyphosate applied in the fall reported to have relatively good control if followed in spring with pretreatment of glyphosate or 2,4-D.

-**Picloram** (Tordon22K). From Tordon22K label: "2-4 pt/Acre, apply at true flower stage (see life cycle above for description of true flower) or apply to fall regrowth. Fall application may be as or more effective than spring application". Under ideal circumstances, picloram has yielded control as high as 80% for two years after a single application. When a mixture of 0.25 to 0.375 pound ai/A picloram mixed with 1 to 1.5 pounds ai/A of 2,4-D is applied for three to five consecutive years, shoot may be controlled 80-90%". Note: North Dakota University suggests June application of Tordon and 2,4-D, but research at Nebraska recommends the fall (September, October) based on

when plant is actively sending carbohydrates to roots. The Nebraska research found Tordon application in June was no different than the control. Parks with persistent, long term populations may want to compare the following:

1) Picloram and 2,4-D applied in spring when plants are in true flower stage
2) Picloram in the fall (mid-September to mid-October)

Not rated by Dewey et al, but recommended by weed control specialists

-Quinclorac (Paramount): Apply at yellow bract (prebloom) or in the fall prior to the first killing frost.

Fair: **2,4-D, Dicamba** (Banvel or Clarity)

Poor: **Metsulfuron** (Cimarron, Escort), **Clopyralid + 2,4-D** (Curtail)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

The extensive roots system containing large nutrient reserves makes leafy spurge extremely difficult to control. For new small patches, spot spray using herbicides and application times recommended above. If the park currently does not have leafy spurge, but is at risk it is **highly** recommended that staff members are assigned to different trails, roads, and other high-risk areas so they are checked on a routine basis (monthly, yearly, or every 2-3 years, depending on the size of the park and staff availability). For existing patches, integrated pest management is essential. Identify the perimeter and target satellite populations with the most aggressive actions (see chemical section) to prevent spread and target the main patch with a combination of treatments. Examples:

-Incorporation of *Aphthona* spp. with sheep or goat grazing. This can result in a larger decline in leafy spurge production than insects alone or grazing alone.

-A single fall application of herbicide followed by late fall seeding with native grasses, and release of biological controls the following spring. In a controlled study in the Bitterroot Valley (south of Missoula, MT), plots seeded with bluebunch wheatgrass (12 lb/acre), with healthy populations of insects, and grazed by sheep effectively contained (not eradicated) populations for more than 5 years and counting (no follow up herbicides have been required). The use of herbicides with Aphthona has been very effective. In North Dakota, spraying in the fall over the top of established infestations increased control and flea beetle populations (R. Lym, personal communication).

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Gypsophila paniculata, Babysbreath

Left: Growth form of flowering plant. Right: Inflorescence. Both by Steve Dewey, Utah State University, Bugwood.org

Park presence: GRKO
Status: MT counties: Blaine, Choteau, Deerlodge, Silver Bow, and Flathead

Identifying characteristics: Leaves are opposite, lance-shaped and arise at swollen nodes (characteristic of the Pink family-Caryophyllaceae). Tiny white flowers are star shaped, with 5 sepals and 5 petals. Fruit is a small capsule containing 2 to 5 seeds. Seeds are kidney-shaped and black. Many flowering branches grow in a rounded habit up to 3' tall. Branches and stems are a bluish-green color.

Life cycle: Perennial, reproduces by seeds. Flowering occurs from June to August. Does not reproduce vegetatively, but forms an extensive root system. Severed crown pieces can produce new shoots. Severed root pieces do not produce new shoots.

Spread: Most seed capsules drop off near the parent plant, but at maturity the plant often breaks off at the base and tumbles in the wind, spreading seeds widely.

Seeds per plant / longevity: 13,700 / ~2 years, but not well documented. Seeds reported to exhibit little dormancy, so likely less than 6 years.

Habitat: Commonly occurs in pastures, rangelands, and ponderosa pine communities. Also common in sub-marginal farmlands, roadside drainage ditches, and various ruderal habitats. Reported as most aggressive on coarse textured soils in areas of low rainfall.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Moderately to highly effective. For mature plants, this requires cutting below the thickened crown of the plant which may require digging to a depth of six inches to one foot. Regrowth is rare if the complete crown is removed.
Cut/mow: Ineffective to partially effective. Mowing will reduce seed production, but it will not control existing plants.

Till/cultivate: Moderately effective. Where possible, annual cultivation at a depth which severs the caudex from the root can destroy babysbreath plants.

Cultural
Reseed: Partially effective. Perennial grasses alone may not be competitive enough to suppress it, but reseeding is recommended as follow up to herbicides or other control methods where remnant vegetation is sparse.
Fire: unknown

Biological
Insects and pathogens: not available
Grazing: Partially effective. Heavy cattle grazing has reduced growth of mature plants and prevented seedling establishment, but light to moderate grazing had little effect on growth (Rutledge and McClendon 1996).

Chemical
Partially to moderately effective.
Metsulfuron methyl +aminopyralid (Chaparral or Opensight) to vegetative stage prior to bloom.
Imazapic (ammonium salt form) (Impose). Apply early post emergence for annual control. The addition of 1-2 pints of 2,4-D will aid in burndown.
At this time, these are the few herbicides with baby's breath listed on the label. Limited research indicates that it is susceptible to dicamba (2.24 kg/ha or more) and picloram (at 1.12 kg/ha or more) (Rutledge and McClendon 1996). **Glyphosate** (Roundup) may be used to target small patches. **Metsulfuron** (Escort) has been used by EPMT crews.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

At this time, there is limited information to suggest an IPM program. Most of the studies on herbicide efficacy are outdated, having occurred in the 60s and 70s (Skoglund and Darwent 1964a, 1964b; Vanden Born and Schraa 1972). These studies indicate herbicides like picloram and dicamba are limited in their efficacy, likely due to the sparse foliage and deep root system of baby's breath. Until more research is available, manually removing plant with a shovel is strongly recommended, but labor intensive. While clipping will not injure plants, it is recommended in the absence of other measures to reduce seed spread. Spot spraying small patches with glyphosate is recommended to prevent seed production, but retreatment may be necessary.

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Hieracium sp., Hawkweed Complex

Left: *Hieracium aurantiacum* (Orange hawkweed) growth form. By Michael Shepherd, USDA Forest Service. **Center:** *H. caespitosum* (Meadow hawkweed) with compact flat-topped clusters of flowers (typically 5-30). By Tom Heutte, USDA Forest Service, Bugwood.org. **Right:** *H. caespitosum* (yellow hawkweed) growth form. By Richard Old, XID Services, Inc., Bugwood.org

Table 3. Characteristics of Non-Native Hawkweed Species

Latin name	***Hieracium aurantiacum***	***Hieracium caespitosum***	***Hieracium piloselloides***	***Hieracium glomeratum***
Synonyms		*H. pratense and H. pratensis*	*H. florentinum*	
Common name	Orange Hawkweed	Yellow Hawkweed or Meadow Hawkweed	Tall hawkweed	Yellow devil hawkweed
Park presence	Not reported	Not reported	Not reported	Not reported
Status	**ID**: Control **MT**: 2A	**ID**: Control **MT**: 2A (Meadow hawkweed complex)	**ID**: EDRR	**ID**: EDRR
Identif-ication:	(Common to all non-natives): Milky sap in leaves and stems. Fibrous roots and short stout rhizomes, some with stolons. Flowering stalk is erect, but not stiff, typically leafless (or leaves only on the lower third of the stem). Basal leaves entire or minutely toothed, basal leaves persist-don't wither at flowering. See * below to help distinguish them from native hawkweeds.			
Species ID	Flowers orange to red-orange. Basal leaves have numerous simple hairs on upper surface, stellate (star shaped) hairs on lower surface. Flowers in round topped cluster of 20-50 heads. 4-24 inches tall.	Flowers yellow. Upper leaf surface with long simple hairs, lower with moderately dense stellate and long simple hairs. Lower stem with dense stellate, simple and glandular hairs (see glandular hairs in Figure b). Flowers in flat-topped cluster of 20-50 heads. 7.8-27.5 inches tall	Flowers yellow. Upper leaf surface glabrous or with few simple hairs on margin; lower surface smooth and glabrous except for a few simple or stellate hairs on the midvein. Basal leaves narrowly elliptic. Flowers in open round-topped cluster with 11-20 heads. Plants 15-35 inches tall.	Flowers yellow. Upper and lower surface of leaves with numerous stellate hairs: simple, short, and stiff giving a rough texture. Lower stems with sparse to dense stellate and short simple hairs. Flowers in round-topped cluster of 15-25 heads. Plants 10-35 inches tall.
Life cycle	Perennial. Reproduces by seed, rhizomes and some by stolons (see below). Blooms from late spring to early summer (in MT typically begins in late May and peaks in mid-June). A second flowering in September may occur. Seedling emergence is greatest in September and July. Summer germinated seedlings can reach adult size in eight to ten weeks. Seedlings emerging in March can produce flowers by mid-June and viable seeds by early August. In dense patches, only the perimeter plants typically flower.			

Spread	All disperse by wind as well as minute barbs along ribs of the seeds that enable them to stick to animals. Spreads vegetatively by rhizomes. *H. aurantiacum* and *H. caespitosum* also spread by stolons. **Stolons absent** in ***H. piloselloides*** and ***H. glomeratum.*** (Note: absence of stolons is not a reliable diagnostic feature)			
Seeds/ plant	432	600-45,000	Unknown. Likely more than 1,000	Unknown. Likely more than 1,000
Seed longevity	1-5 yrs	Up to 7 years, but not specific to species. (Jacobs 2007)	Up to 7 years, but not specific to species. (Jacobs 2007)	Up to 7 years, but not specific to species. (Jacobs 2007)
Habitat	Typically occur along roadsides, in moist mountain meadows, forest meadows and clearings, permanent pastures, hayfields, cleared timber units, and abandoned farmland. Prefers well-drained, coarse-textured soils with moderately low organic matter, but they can tolerate a range of conditions from gravelly to acidic soils, full sun to partial shade.			
Allelo-pathic	Phytotoxic chemicals have been isolated from the roots of hawkweeds. These chemicals may be exuded into the soil.			
Hybrid-ization	Yes	Yes	Presumably	Presumably

* Non-native hawkweeds are difficult to distinguish from each other and native hawkweeds. Generally, native hawkweeds tend to have leafy branched flowering stems and flower heads in open panicles. Diagnostic characteristics to differentiate hawkweeds are hairs (or pubescence) on the leaf, stem and involucral bracts. For an excellent key, diagrams and pictures of native and non-native hawkweeds see

Key to Identification of Invasive and Native Hawkweed in the Pacific Northwest (Wilson 2006, link in bibliography). If you believe you have a non-native hawkweed, submit a sample to a qualified botanist, or your state's Plant Diagnostician (see Plant Identification Assistance under Resources at end of document) before beginning a control program to ensure it is not one of the native hawkweeds.

-Native Hawkweeds reported in ID, MT, UT or WY:

H. albiflorum (white-flowered hawkweed): Occurs in ID, MT (western and central), UT and WY (only hawkweed with white flowers).

H. umbellatum (narrowleaf hawkweed). Occurs in ID, MT, and WY.

H. canadense (=*H. umbellatum*, Canadian hawkweed). Occurs in ID, and MT (north and central).

H. gracile (slender hawkweed). Occurs in ID, and MT (west and central) and WY.

H. scouleri* var. *scouleri (Scouler's hawkweed): Occurs in ID, MT, and WY.

H. scouleri* var. *albertinum (western hawkweed). Occurs in ID, MT, and WY.

H. scouleri* var. *cynoglossoides (Houndstongue hawkweed) Synonym: *H. cynoglossoides*. Occurs in ID, MT (west and southwest), WY (western and northwestern) and UT.

CONTROL OPTIONS

Studies on control measures have typically focused on *H. aurantiacum,* and *H. caespitosum*. Due to a lack of information on the other species, along with the similarity among these plants, these recommendations are not species specific, except where noted.

Mechanical

Hand pull/grub: Moderately effective for very small patches only, but must be repeated. Remove perennial buds at the soil surface, and stolons, and bag all material including stems. Otherwise they may root from stem material. Pulling, grubbing is most effective where competitive desirable plants are in the community and can fill in.
Cut/mow: Not recommended.
Till/cultivate: Not recommended. Likely to make conditions worse by breaking up rhizome fragments.

Cultural
Reseed: Moderately effective, and strongly recommended as follow up to other treatments, especially herbicides.
Fertilizer: Moderately effective in combination with herbicides and reseeding. Fertilizers typically favor invasive weeds, but not in the case of hawkweeds. 300 pounds/acre nitrogen, phosphorous, and potassium (15:15:15) are recommended for low productivity environments to improve growth of competitive plants and provide long-term control.
Fire: Ineffective. Not recommended.

Biological
Insects and pathogens: Currently unavailable. Research is ongoing.
Grazing: Poisonous. Not recommended.

Chemical
Moderately effective.
Check labels for recommendations on surfactants. They may improve efficacy of herbicides due to the hairy stems and leaves of hawkweed.
2,4-D: apply early in the growing season when hawkweeds are in the rosette stage of growth, before buds form. These species may need retreating and/or the higher rate even under ideal conditions.
Aminopyralid (Milestone): apply in the bolting stage of development. A nonionic surfactant at 1 to 2 quarts per 100 gal of spray enhances control under adverse environmental conditions.
Clopyralid (Transline): apply from rosette to bolting. Apply after most basal leaves emerge but before buds form. Fall treatments also may be effective, although research is limited
Clopyralid + 2,4-D (Curtail): Apply after most basal leaves emerge but before buds form. Fall treatments also may be effective, but research is limited.
Picloram (Tordon): Apply after most basal leaves emerge but before buds form. Fall treatments also may be effective, but research is limited. Tordon is labeled for the site, but not specifically for hawkweeds. Apply at 1 to 2 pints/acre (PNW 2009 Handbook). Picloram can suppress hawkweeds for up to six years (Jacobs 2007).
Dicamba (Clarity): apply to rosettes.
Glyphosate (Roundup): apply to hawkweeds prior to revegetation.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Hawkweeds are invasive due to their high seed production and germinability, long distance seed dispersal, rapid generation time, and the ability to regenerate and spread from root fragments, root buds, rhizomes and stolons. However, at this time hawkweeds are absent or sparse in all the parks included in this plan. Therefore prevention is the number one management strategy. A routine monitoring program of roads, trails, and recently disturbed areas should be established. This should occur in early summer when plants just began to flower, as

the showy yellow or orange flowers make them easy to spot (if possible, repeat in the early fall when a second flowering may occur). Plants are difficult to distinguish from native hawkweeds. Before beginning a control program, send a sample to a qualified botanist or your state's plant diagnostician for verification (see Resources at end of this document).

If a patch does become established, a combination of herbicide and reseeding is recommended. For large patches in low productivity areas, fertilizers combined with herbicide can reduce hawkweed infestations by improving the competitive ability of desirable plants (Jacobs 2007, Wilson 2006).

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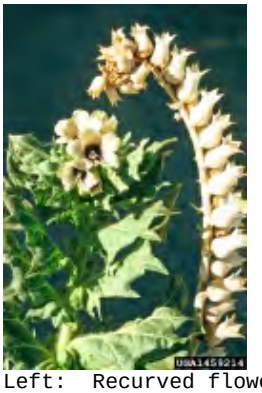
Hyoscyamus niger, Black henbane




Left: Recurved flowering stalk. By Steve Dewey, Utah State University, Bugwood.org. Center: Rosette. Right: Five-lobed, cream flowers with purple throats. Center and right photos by Jan Samanek, State Phytosanitary Administration, Bugwood.org
http://www.invasive.org/weedcd/images/768x512/1459214.jpg

Park presence: CIRO, FOBU

Status: **ID**: control **UT**: noxious **MT counties:** Beaverhead, Big Hole, and Lewis and Clark (not state listed).

Identifying characteristics: The recurved flowering stalk with the pineapple shaped fruits makes black henbane easy to identify when flowering (photo above left). The large rosettes are generally toothed to incised, are covered with fine hairs and may superficially resemble thistles, but they lack spines (center photo). Plants grow up to 3 feet tall. Stems are covered with dense glandular hairs. Leaves are alternate, dentate, up to 8 in. long by 6 in. wide, and fetid smelling. Flowers are cream to green, five-lobed, 2 in. (5 cm) wide, have purple throats, and produce small black seeds.

Life cycle: Annual to biennial. It usually emerges in mid-late spring and may flower from early summer to fall, with peak flowering in mid-summer (July). Seeds that germinate in the spring may flower in the same growing season, but later germinating seedlings will overwinter as rosettes.

Spread: Plants spread by seed. There are no mechanisms for long distance dispersal.

Seeds per plant and longevity: +50,000 / 1-5 years

Habitat: It is most common on disturbed or heavily grazed sites. It occurs in pastures, fence rows, roadsides, waste places, and riparian areas. It does well in most soil types. Growth is enhanced by soil nitrogen (Haderlie et al. 1991).

CONTROL OPTIONS

Mechanical

Hand pull/grub: Hand pulling is highly effective and strongly recommended (wear gloves to prevent skin irritation). If the soil is dry, dig to make sure that the thick, fleshy, taproot is completely removed. Plants with mature fruits should be carefully placed in bags to prevent seed dispersal.

Cut/mow: Ineffective. If cut, plants will regrow and set seed from a reduced height. Mowing will not affect rosettes, and when plant bolts, the thick, tough stem is difficult to mow.
Till/cultivate: Partially effective. Not recommended. Disking or plowing would need to be repeated annually for many years given the seed longevity.

Cultural
Reseed: Moderately to highly effective. This plant is most common in disturbed areas. Reseeding should prevent reinfestation following other treatments (hand pulling or herbicides).
Fire: Unknown.

Biological
Insects: Not currently available.
Pathogens: Not currently available.
Grazing: All parts of the plant, including the seeds, contain alkaloids which can be toxic to humans and animals if consumed.

Chemical
Moderately to highly effective
Metsulfuron (Escort) Apply to actively growing plants from the rosette to the bloom stage. Larger rosettes may require the higher rate (a range is provided on the label) for effective control.
Picloram (Tordon): Apply to plants from the rosette to the bolting stage. Tank mix low rates of picloram with 2,4-D (1 qt product/A, Dewey et al 2006).
Glyphosate (Roundup): Apply from the rosette to bolting stage.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Minimizing disturbance and overgrazing are the best preventive measures. In the majority of the parks with black henbane, plants are few and scattered, and hand pulling has been used successfully to prevent dense infestations. Hand pulling is especially effective because the distinct flowering stalk (see photo above left) makes the plants easy to detect once they bolt. Pulling should occur before seed set, or plants should be carefully bagged to prevent seed dispersal if flowering. Return to the site a month after the first treatment to pick up missed or late bolting plants. If the patch is too large for hand pulling, herbicides may be needed. Reseed following herbicides to provide long term control.

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Hypericum perforatum, St. Johnswort

Left: Five-petalled yellow flower. By Steve Dewey, Utah State University, Bugwood.org. Center: stands of St. Johnswort. By Carol DiSalvo, USDA National Park Service, Bugwood.org. Right: distinct rust colored branches remain upright after leaves shed in the fall. By Norman E. Rees, USDA Agricultural Research Service, Bugwood.org.

Status: MT: Priority 2B **UT:** EDRR
Park presence: FOBU, LIBI. Observed in the past at CRMO.

Identifying characteristics: The opposite leaves are sessile, entire, elliptic to oblong, and typically 1 inch long by 3/8 inch wide. A diagnostic feature are the small translucent glands that look like perforations when held up to the light (hence species name 'perforatum'). Flower petals are bright yellow to orange and may have black glands along the margins. There are five sepals and five petals, with petals twice as long as sepals. Flowers grow in an open, round to flat-topped group. There are conspicuous rust colored branches and stems in the fall.

Spread: Seed has gelatinous coat that becomes sticky when wet, adhering to fur, feathers, or clothing. Seed can also be transported long distances via deposition in feces and by water. Vegetative growth is stimulated by fire, grazing, cutting, mowing or pulling. Note: seedling survival is very low. Spread is considered to be primarily by vegetative growth rather than by seed. Seedlings are intolerant of shade, have a slow growth rate, and are vulnerable to intra- and inter-specific competition, and moisture stress.

Seeds per plant / longevity: 15,000-30,000 seeds / 6-10 years

Life cycle: Perennial. Plants reproduce by seed and vegetatively by rhizomes. Seed will not germinate in high litter layers or if buried deeper than 2mm below the surface. Seedlings emerge during warm summer months with adequate moisture. Plants take several years to flower. Flowers form in early summer and set seed by late summer. Lateral buds sprout in the spring and fall from lateral roots that grow 2-3 inches beneath the soil surface.

Habitat: Plants grow in cultivated fields, pastures, waste areas, and often on the edges of forests. St. Johnswort can be an aggressive invader of grazed lands due to lack of palatability. It is variously described as not highly competitive and persisting only in disturbed areas; somewhat intolerant of severe competition; and able to spread especially rapidly in pastures on dry soils. Competitive ability will depend highly on the condition of surrounding vegetation and climate.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Mixed results. Moderately effective for small, newly established patches only. New stems will resprout from rhizomes and root fragments, so as much of the root system must be removed as possible and efforts must be repeated diligently. For established populations, managers should use caution. There is some anecdotal evidence that hand pulling may actually stimulate the plant to produce new stems. If hand pulling will be a routine practice, it is recommended that control plots be established to determine if hand pulling increases stem density or plant growth.
Cut/mow: Ineffective. Plants resprout after defoliation. It may reduce seed production, but stimulates vegetative growth.
Till/cultivate: Ineffective. Root fragments will spread, and regenerate. It would only be effective in cultivated crops where land can be repeatedly tilled.

Cultural

Reseed: Moderately effective. Reseeding areas with competitive plant species is highly recommended to provide long term control. Seedlings are especially vulnerable to competition from established vegetation. Reseeding depauperate areas around existing patches may help prevent satellite patches from forming.
Fire: Ineffective and not recommended. Fire can stimulate germination of seeds and will reduce competitive pressure (by temporarily removing surrounding vegetation).

Biological

Insects: Moderately effective. Patience is required as populations are cyclical. Insects have been very effective on some sites (Coombs et al 2004), so they are definitely worth trying in areas with moderate to dense infestations.
--***Agrilus hyperici,*** St. Johnswort root borer (a beetle): Larvae feed on roots and may completely consume the tissues. Any stems produced from an infested root crown are stunted and flower production is reduced. Most plants infested by this beetle are killed. They do best in dry mountainous areas. Established in ID and MT.
--***Aplocerus plagiata,*** no commonly accepted common name (a moth). Larvae feed on foliage and flowers. It prefers dry open areas with sandy, rocky soils, soils with limestone parent material. It does not do well in areas with high rainfall. Effectiveness is quite variable: it needs a long, warm dry summer to complete both generations (first generation of larvae is in July, second is from mid-August to September). However, in some areas of Canada, it is has done very well at reducing St. Johnswort. Established in Idaho and Montana.
--***Chrysolina hyperici, C. quadrigemina,*** no commonly accepted common names. Beetles feed on foliage as plants begin to flower in April and May. The following spring, beetles feed on plants as they begin growth. Reports found that three years of heavy feeding can destroy the weed (Halloway 1964). It does best in mountainous, open, sunny, warm areas. Neither does well in shaded, barren, excessively rocky locations. Not recommended for arid, lightly grazed Douglas fir forests, or along stream banks and other shady moist areas, or at high elevations near tree line. *Chrysolina hyperici* prefers wetter sites and may tolerate

cold winter weather better than *C. quadrigemina* (Coombs et al 2004).
Note: *C. quadrigemina* was introduced in 1946 and did exceptionally well at controlling St. Johnswort in California, leading to the removal of St. Johnswort from the noxious weed list there. However, *C. quadrigemina* and *C. hyperici* are limited by climatic factors. Outside of California, managers should not expect their impacts on St. Johnswort to be equivalent to their impacts in some areas of California. Both have established in many eastern, mid-western and western states.
--***Zeuxidiplosis giardi***, a gall midge, which has not done well in Montana, or in dry, continuously windy, or heavily grazed areas, and prefers damp locations. It has established in California and Hawaii.
Non target impacts: *Agrilus hyperici* and *Zeuxidiplosis giardi* have caused minor impacts on native *Hypericum* in California. However, no long term or population level impacts have been reported for any of the biocontrols for St. Johnswort (Coombs et al 2004).
Grazing: Not recommended. The phytotoxic pigment hypericin causes blindness, swelling and soreness of the mouth, and may affect animals' ability to forage and drink. *Herbicide applications can increase the palatability of St. Johnswort, increasing risk of poisoning*. Horses are the most susceptible, than cattle, then sheep, and then goats.

Chemical
Moderately to partially effective. A single year is inadequate for eradication.
Metsulfuron (Escort, Cimarron): apply to actively growing plants. Include a non-ionic surfactant.
Aminopyralid (Milestone): apply pre-bloom.
Picloram (Tordon): apply to actively growing plants, prebloom.
Glyphosate (Roundup): to actively growing plants, prior to a revegetation program.
2,4-D*: on seedlings and prior to bloom.
*The ester formulations of 2,4-D are recommended over amine formulations.
Additional comments:
University of Nebraska recommends metsulfuron at 1 oz/acre in the fall (when plants are storing reserves in the root system), followed by 2,4-D at 2 lb active ingredient/acre in early spring to control plants from germinating and to prevent flowering.
Another recommendation to reduce large populations is to apply 1 quart picloram combined with 1 quart 2,4-D (4EC) per acre to actively growing plants pre-bloom (Jacobs 2007).

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

The extensive root system and long lived seed make this plant difficult to eradicate. A combination of treatments done over many years is necessary to reduce populations. While the effectiveness of biological controls can be cyclical, it is strongly recommended. Herbicides should be used to treat satellite patches to prevent spread. Reseeding uninfested, but disturbed areas adjacent to St. Johnswort populations may help contain the population and prevent spread. As herbicides take effect, reseeding should be done as soon as possible to suppress re-growth.

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Isatis *tinctoria*, Dyer's woad

Left: Growth form of flowering plants. Center: Flowers, immature seeds and mature seeds. Right: All photos by Steve Dewey, Utah State University, Bugwood.org

Status: ID: control **MT**: priority 2B **UT**: control **WY**: noxious
Park presence: CRMO, GOSP

Identifying characteristics: Height ranges from 1 to 4 feet tall and the taproot can grow 3-5 feet long with some lateral branching. The basal rosette leaves are stalked, 1½ - 7" long, succulent, bluish-green, have a white mid-rib (above right) and are covered in fine hairs. Up to 20 stems arise from the rosettes, but typically only 7-8 stems produce flowers. Leaves on flowering stalks are lance shaped, alternate, not stalked, have a notable white midrib, and clasp the stem with short basal lobes. Flowers are small and yellow, with 4 sepals, and 4 petals, the petals twice as long as the sepals. The seed pod (a silicle), is flattened, 3/8" long and ¼" wide, winged and slightly pear shaped and hangs from a small stalk (see photo above right). The seed pod is a distinguishing characteristic, and it is used for plant identification after flowering. Each pod produces 1 seed. The seeds are brownish yellow and cylindrical.

Life cycle: Dyer's woad grows as an annual, biennial or short lived perennial. It is common for the plant to persist for more than one year. Seeds typically germinate in the fall and overwinter as rosettes. Rosettes bolt in the spring, and the stems branch out to produce many flowering stalks which become stiff when mature. Plants flower from mid spring to early summer and into late summer at higher elevations. Plants die after seed production, except re-sprouting will occur for several years from the taproot if it is mechanically injured.

Spread: Spreads by seed, most fall within 22" of the parent plant. Long distance dispersal is possible if seed is contaminated in feed, crop seed and bedding. It produces an allelochemical (APRS #16B). Fruits contain a water soluble chemical that will inhibit germination and root elongation of other plants.

Seeds per plant / longevity: 350-500 (but some up to 10,000) / Seeds are likely viable in the soil for more than 5 years. While seeds lack dormancy, a water soluble chemical inhibits germination until it leaches out over time.

Habitat: Grows well in rocky soils with low water holding capacities. It poses a high threat in rangelands, pastures and forest lands. In UT, it is common on loose, alkaline bench soils and in ID it is most common on south-facing canyon slopes.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective. Target plants after they've bolted, but before seed production. The tap root with the root crown must be removed or the plant will re-sprout. Check plants in three to four weeks to target those that were missed in the first treatment, or that regrew from the tap root (if not adequately removed the first time).
Cut/mow: Ineffective. A routine mowing program will limit seed production, but will not provide any long term control.
Till/cultivate: Moderately effective where possible. Cultivating twice a year– once in the spring before seed production, and again in late fall for the late germinating plants can control it. Once the seed bank appears to be depleted, reseeding would need to follow.

Cultural

Reseed: Moderately to highly effective. Reseeding is strongly recommended
Fire: Ineffective. Tap-rooted plants are able to resprout after being top-killed. Only young plants still in the rosette stage can be killed (Bushey 1995). Response to fire is described as neutral or slightly positive (may increase after fire).

Biological

Insects: not available.
Pathogens: Moderately effective for large populations. *Puccinia thlaspeos*, a native rust pathogen prevents seed or fruit production. Following inoculation, it should maintain itself for approximately 3 years. Chlorsulfuron (up to 2.0 oz./ac.) and metsulfuron (up to 1.5 oz./ac.) were not found to affect *P. thlaspeos* culture, but 2,4-D (as low as 1 qt./ac.) and some brands of surfactant (0.25 percent by volume) may negatively impact it (Jacobs 2007). *Puccinia thlaspeos* 'strain woad' was registered (approved for distribution) as a pesticide active ingredient in June, 2002, with "Woad Warrior" as the only registered product (EPA Fact Sheet, 2002). See the EPA fact sheet in bibliography for more information on regulation and permitting.
Grazing: Unknown. Sheep may graze it early in the spring. There is no published literature on successful grazing of dyer's woad.

Chemical

Moderately effective.
Metsulfuron (Ally or Escort at 0.75 oz/acre) or **chlorsulfuron** (1 oz. acre) combined with **2,4-D** to rosettes and stems up to the late bloom stage is described as the most effective herbicide treatment (Jacobs 2007). A nonionic surfactant is needed with metsulfuron and chlorsulfuron.
Imazapic (Plateau) with MSO: apply to rosettes or bolting plants

*Note: If plants are flowering during application, clip and bag the flowering stalks and spray the rosettes. Not recommended: **Picloram** (Tordon 22K®) and **dicamba** (Banvel®)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Eradication is possible as this plant has been successfully eradicated or contained in the state of Montana via a state-wide effort. Hand pulling is strongly recommended for small infestations. Bag plants if flowering has already occurred as seeds of pulled plants may mature. For larger infestations, combine the herbicides chlorsulfuron or metsulfuron with the biocontrols. Hand pull satellite patches that form beyond the main patch.

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Kochia scoparia, Kochia


Left: Growth habit. Right: Seedling. Photos by Oregon State University Larry Burrell and Jed Colquhoun photo Collection.

Park presence: BEPA, CIRO, CRMO, FOBU, GRKO, LIBI, HAFO, MIIN
Status: not listed

Identifying characteristics: Erect, much-branched stems are 1-7 feet long, smooth below but usually hairy above. The alternate, simple leaves are pubescent to nearly glabrous, one to two inches long, lanceolate to linear with hairy margins, and without petioles. Small green flowers lack petals and are found in clusters in the axils of the upper leaves and in terminal spikes. Brown flattened seeds are about 1/16 inch long and grooved on each side. Plants develop a deep, stout taproot.

Life cycle: Annual, reproduces by seed. Seeds germinate in early spring, grow rapidly and flower in late summer. Stems become brittle allowing it tumble in the wind and spread seed.

Spread: Seed is dispersed after plant becomes a tumbleweed, allowing long distance dispersal. Its tolerance for drought may allow it to spread quickly. In California, it is not observed invading undisturbed sites. In Colorado, it begins in disturbed sites (logged areas), but has been observed to invade adjacent undisturbed sites.

Seeds per plant and longevity: 14,600 / <3 years (buried seeds have a 5% viability after one year

Habitat: Kochia is highly adaptable: grows well in drought conditions, tolerates most soil types. It's found on pasture, rangeland, roadsides, ditch banks, wastelands, and cultivated fields. It has large impacts on crop/cereal production. APRS 16: Litter has allelopathic properties that affect crop plants and kochia seedlings. It may be the pioneer in highly disturbed sites, but it is typically replaced by grasses.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective. Conduct when soil is moist or use a shovel as taproot is stout.
Cut/mow: Partially to moderately effective. Mowing or slashing before flowering can reduce seed production, but mowed or grazed plants resprout from base.
Till/cultivate: Moderately effective where possible. Early tillage in the spring gives good control of the kochia seedlings. This would need to be followed by reseeding of desirable species once kochia seed bank was reduced.

Cultural
Reseed: Moderately effective for long term control
Fire: Ineffective

Biological
Insects: Not available
Pathogens: Not available
Grazing: Ineffective. Can causes hepatotoxicity with photosensitization, renal disease, and polioencephalomalacia (damage to central nervous system) to livestock.

Chemical
Resistance to certain herbicides has developed in some infestations of Kochia in Idaho (ALS inhibitors, Group 2); Montana (Group 2, and Photosystem II inhibitors: Group 5); Utah (Group 2) and Wyoming (Group 2). If herbicide applications appear to be ineffective, you may have an herbicide resistant population. Contact your county weed extension office for assistance and rotate herbicide groups (shown in parenthesis below and in Table 7) to reduce the possibility of increasing Kochia plants tolerant to herbicides.

For timing of herbicide applications: apply when plants are actively growing, prior to seed formation and refer to labels where rates are listed in relation to plant height.
Excellent: **Glyphosate** (Roundup).
Good: **2,4-D** (various trade names), **Triasulfuron** (Amber); **Dicamba** (Banvel, Clarity, or Vanquish); **Metsulfuron + dicamba + 2,4-D** (Cimarron Max); **Clopyralid + 2,4-D** (Curtail); **Paraquat dichloride** (Gramoxone, Cyclone, Firestorm); **Imazapic** (Plateau, Impose); **Dicamba + 2,4-D** (Weedmaster).
Fair: **MCPA** (various trade names)
Poor: **Picloram** (Tordon, Trooper)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Managers should try to eliminate seed production for 2-3 years by hand pulling, repeated mowing or cutting, or herbicides. This can lead to eradication given the short longevity of the seed. This weed is primarily a problem in disturbed areas and not expected to pose a major problem in natural areas in good condition. Seeding grasses after control measures has reduced the population and should provide long term control and suppress reinvasion.

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Lepidium latifolium, Perennial pepperweed

Left: Inflorescence, roots, leaves and branching patterns of *L. latifolium*. By Steve Dewey, Utah State University, Bugwood.org Center: White flowers grow in clusters. Right: basal rosettes. Center and right photos by Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Park presence: GOSP, GRKO
Status: **ID**: contain **MT**: 2a **UT**: control **WY**: noxious

Identifying characteristics: Plants are erect, and multi-branched from a semi-woody crown and creeping rhizomes. Plant grow 1-3′ tall (may reach 8′ in wet areas). Basal leaves have a prominent white mid rib (above right), are up to 12″ long and up to 3.2″ wide. Margins are entire or toothed. Stem leaves are smaller, lanceolate, and with a less prominent mid rib. Ball like clusters of small white flowers grow at branch ends. Perennial pepperweed may be confused with *Cardaria* sp. (whitetop). Upper leaves of perennial pepperweed do not clasp the stem like *Cardaria*. Additionally, perennial pepperweed seeds are flattened, but *Cardaria* seeds are round or inflated.

Life cycle: Shoots emerge in late winter or early spring, typically before most native plants. Plants bolt in mid-spring, and flowering begins in late spring to early summer. Carbohydrate reserves are at their lowest at this time. Flowering may continue for several months. Stems senesce after seeds mature late in the summer, but they typically remain upright. Information on seedling phenology is limited, but they are expected to emerge from late winter to early spring and are stimulated by fluctuations in temperature.

Spread: Plants spread by seed, roots, and root fragments. Seeds have no mechanism for long distance dispersal, but they are easily transported by water. Seeds initially sink, but then form a mucilaginous cover causing them to become buoyant and float downstream (Renz 2000). Seed can also survive through the digestive tract of livestock. Seedlings are not commonly observed and spread by seed is not believed to be a major source of population growth. By contrast, spread by rhizomatous growth can be as great as 10′ per year (Jacobs and Mangold 2007). Long distance dispersal is possible when tiny root fragments (< 2″ long) are moved off site via farming equipment or other disturbance. They can regenerate, even if dried for 3 days in the sun.

Seeds per plant / seed longevity: +1000 / likely less than 5 years.

Habitat: Perennial pepperweed occurs in riparian areas, marshes, estuaries, irrigation channels,

wetlands, and floodplains. It also commonly occurs along roadsides, hay meadows, alfalfa fields, and rangeland habitats. It is less common in undisturbed areas.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Moderately effective. Hand pulling is strongly recommended for small new infestations. Remove as much of the root system as possible and bag (and burn if possible) pulled material to prevent it from regenerating. If hand pulling can be repeated several times, it can be very effective.

Cut/mow: Moderately effective, but must be repeated. It is only recommended at sites where existing plant community is tolerant of repeated mowing (e.g. predominantly grasses). Mow perennial pepperweed at the first sign of flowering (typically early summer), but before seed production. Mowing needs to be repeated to target regrowth and prevent flowering. See herbicide section and IPM section below for combining mowing with some herbicides like chlorsulfuron and glyphosate.

Till/cultivate: Partially effective to ineffective. Repeated tilling may reduce it, but it will also spread root fragments which will generate into new plants. It should be used cautiously and be combined with herbicide and revegetation.

Cultural

Reseed: Moderately effective. Strongly recommended as follow up to other control measures. Note: deep litter layers that form in areas long infested with this plant will need to be cleared before reseeding to improve seed-soil contact and so emerging seedlings have access to light.

Fire: Ineffective. Burning may help remove dense litter layer, but it does not harm below ground roots and density can increase following fire.

Biological

Insects: Not currently available.

Grazing: Partially effective. Cattle, sheep, and goats will graze perennial pepperweed. Cattle will graze the rosette leaves early in the spring, but have difficulty if previous year’s stems are not removed. Poisoning of cattle by pepperweed is suspected, but unconfirmed. Consistent grazing by sheep can suppress it, but it will resprout once sheep are removed.

Chemical

Partially to moderately effective.

This plant commonly occurs around water. If applying near water, be sure to use approved herbicides and check label for restrictions.

Chlorsulfuron (Telar): apply in the fall or in spring up through bloom stage. A surfactant is required and/ mixing with 2,4-D can improve control. University of Idaho recommends mowing perennial pepperweed and applying Telar with a surfactant to resprouts. Herbicides must be applied when plants are actively growing (not in the middle of summer). This will effectively suppress plants for 1-2 years (Jacobs and Mangold 2007). **Imazapic** (Plateau): Apply after blossoms open (full bloom)

until plants desiccate. Fall rosettes also may be treated if moisture permits (plants are actively growing). **Imazapyr** (Arsenal): apply at flower bud stage. **Metsulfuron + dicamba + 2,4-D** (Cimarron Max): apply from bud to bloom stages. **Metsulfuron + chlorsulfuron** (Cimarron X-tra): apply from bud to bloom stages. **Metsulfuron** (Escort): apply to actively growing plants before full bloom, see label for use of a surfactant. It will effectively suppress plants for 1-2 years (Jacobs and Mangold 2007).

The herbicides below will kill shoots, but root crowns will re-sprout new foliage:
Glyphosate (Roundup or Rodeo for riparian areas): apply to bud stage of growth and follow-up with reseeding.
2,4-D amine (Weedar): apply at the bud stage of growth.
2,4-D ester (Weedone): apply to resprouting stems late summer.
2,4-D will work best if patch is surrounded by grasses that can fill in following herbicide application.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Survey riparian areas, irrigation canals and other suitable habitat regularly to identify and eradicate new infestations before they establish. Control is easiest in small, recently established patches. Target these aggressively before the root system develops and expands. For well established patches, combining herbicides with mowing (where possible) may improve herbicide efficacy. The University of Idaho recommends mowing plants at the flower bud stage, and then applying glyphosate to regrowth when new stems reach flower bud stage (Prather et al 2009). They also recommend mowing, and then applying chlorsulfuron to resprouting stems. Following control with herbicides, revegetation is strongly recommended to provide long term control. Monitoring is recommended after plants appear to be eradicated as roots may remain dormant for several years.

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Linaria dalmatica, Dalmatian toadflax
Synonym: *Linaria genistifolia* ssp. *dalmatica*

(a) **(b)** **(c)** **(d)**

Figures: **(a)**: Snapdragon like flowers with long tail (spur). By Richard Old, XID Services, Inc., Bugwood.org. **(b)**: Split photo: Dalmatian toadflax foliage on the left, yellow toadflax (*L. vulgaris*) foliage on the right. Both by Elizabeth Goulet, Cornell University, Bugwood.org. **(c)**: Dalmatian toadflax flowering plant. By Steve Dewey, Utah State University. **(d)**. Dalmatian toadflax seedlings are thin, delicate, with linear leaves, resembling yellow toadflax. By Linda Wilson, University of Idaho, Bugwood.org.

Park presence: CRMO, GOSP, LIBI
Status: **ID:** contain **MT:** priority 2B **UT:** control **WY:** noxious

Identifying characteristics: Bright yellow flowers have an orange bearded throat and are similar to snapdragon blossoms with a distinct spur at the base (Figure a). Leaves are alternate but may appear opposite because they're so crowded. Plants may grow up to 3 feet tall. When flowering, it is not easily confused with other species except yellow toadflax (*Linaria vulgaris*). Leaves of Dalmatian toadflax are cordate or ovate and clasp the stem, while leaves of yellow toadflax are linear and pointed at both ends (Figure b), however seedlings of Dalmatian have narrow leaves like adult yellow toadflax (Figure d). Dalmatian and yellow toadflax can hybridize (Ward et al 2009). It is unknown whether the hybrids are more aggressive than either parent plant, and whether they differ in their response to herbicides, and biocontrols. If any of the parks have both and yellow toadflax, they should contact their weed coordinator, or university extension office for consultation.

Life cycle: Perennial, reproduces by seeds and underground rootstocks. Flowering can occur from early summer to late summer. Most seeds germinate early in the spring (typically earlier than yellow toadflax), but germination may also occur in the fall. Root energy reserves are greatest in the fall and lowest pre-bloom in late spring (Jacobs 2006).

Spread: Seed is relatively small, sharply angular and only slightly winged. While wind dispersal is possible, most seeds are found within 5' of the parent plant. Long distance dispersal is possible if the seed is consumed by birds, other wildlife, or livestock, and from blowing across snow crusts in winter. Local expansion occurs via seeds, rhizomatous growth and by root fragments (created by farming equipment or other disturbances).

Seeds per plant / longevity: highly variable, typically more >1,000 per plant / ~10 years.

Habitat: Plants can occur in a wide variety of habitats from open grassland to open forest sites. They are very common on roadsides, rangeland, waste places, and cultivated fields in semi-arid regions. Seedlings need a disturbance to survive, so grazed lands not given

sufficient rest are susceptible to invasion as are steep slopes, and areas disturbed by road construction or where the plant community is otherwise sparse or stressed. Dalmatian toadflax is more commonly associated with dry, coarse-textured soils, and yellow toadflax is more commonly associated with moist soils (Coombs et al 2004).

CONTROL OPTIONS

Mechanical

Hand pull/grub: Moderately effective to ineffective: recommended for new, small infestations only. For established patches, regeneration from roots makes hand pulling or grubbing ineffective.
Cut/mow: Ineffective to partially effective. Mowing has little effect on root reserves. In the absence of other actions, it could be used to reduce flower and seed production if repeated often.
Till/cultivate: Ineffective to moderately effective (requires high labor inputs). Cultivating a few times will increase the population by creating and spreading root fragments. Cultivation would need to be repeated 8-10 times in the first year and 4-5 times in the second year, followed by planting competitive species (Jacobs 2006).

Cultural

Reseed: Moderately effective. Strongly recommended to prevent re-establishment. Seedlings of Dalmatian are considered poor competitors for soil moisture with established perennials. Recently disturbed areas, especially those in the vicinity of an existing stand should be reseeded as soon as possible. In greenhouse competition studies, blue bunch wheatgrass (*Pseudoroegneria spicata*) seedlings were more competitive than Dalmatian seedlings, but only when the two species were planted at the same time (Jacobs 2006). For existing patches of Dalmatian toadflax, managers should consider seeding strips around the patches if the surrounding vegetation is sparse. This should help slow or prevent its spread, and also reduce Dalmatian seed production. In competition with other perennials, Dalmatian toadflax seed production can be reduced by more than half.
Fire: Ineffective. Expect increases in Dalmatian biomass and seed production following fires.

Biological

Insects: Moderately effective. Highly recommended. See the yellow toadflax summary for information on both Dalmatian and yellow toadflax biocontrols, with information on the insects' preferred host (Dalmatian or yellow) underlined.
Grazing: Plants are not considered palatable to cattle, but sheep and goats can be trained to eat them. In one case, trained sheep consumed nearly 90 percent of the weed vegetation with little effect on grasses or other forbs (Jacobs 2006). There may be a temporary increase in density following grazing due to root sprouting, but as long as grazing can be maintained, this method should ultimately weaken the population and decrease it. Sheep and goats will also consume flowers, reducing seed production. However, animals that have been feeding on flowers should be quarantined and fed weed-seed free forage for 5 days to prevent the seed from spreading to new areas in their feces.

Chemical

Moderately to partially effective.
Ratings (excellent, good, fair, poor) provided when available from Dewey et al 2006.
The efficacy of herbicides to treat Dalmatian toadflax ranges from very good in some applications to nearly no control in other applications of the same treatment. Long term control is highly dependent on the condition of the surrounding plant community. If the existing plant community is sparse or stressed, herbicides alone will be a waste of time. They must be coupled with reseeding or other actions to reinvigorate the surrounding vegetation (see the IPM section below for more details).
Good: **Imazapic** (Plateau): Apply in the fall when 25% of shoots are necrotic, usually after a hard frost (late October through November). This timing usually corresponds to fall basal growth. Applications made prior to this will result in poor control. See label for use of MSO (methylated seed oil).
Chlorsulfuron (Telar): Best results are obtained when perennial weeds are treated in the bud to bloom stage or to fall rosettes. Application in the fall appears to provide the most consistent control for Dalmatian toadflax (according to Telar XP label). See label for use of a surfactant.
Picloram (Tordon): Apply in the fall or summer when plants are actively growing through the full bloom stage of growth. Annual retreatment will be required at rates at the low end of rate range (see label). Control at the low end of rate range may be improved by tank mixing with 1 lb ae/acre 2,4-D. Use this herbicide cautiously. Off-target impacts to native forbs, and increases in cheatgrass (*Bromus tectorum*) may not warrant the potential reductions in toadflax (Rinella et al 2009).
Fair: **Metsulfuron methyl** (Escort), **Imazapic + Glyphosate** (Journey)
Poor: **2,4-D**, **Dicamba** (Clarity)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Mangers should develop a routine monitoring plan to scout for seedlings as seedlings are the easiest targets for management control. Reseeding sparse areas vulnerable to infestation (e.g. adjacent to existing patches) should be done where possible as toadflax seedlings respond poorly to competition and have a low tolerance for droughty conditions. The extensive, deep root system, along with the waxy leaf (that inhibits herbicide efficacy) makes mature plants very difficult to control. Managers must consider the existing plant community before herbicide applications. Research shows that in some rangeland plant communities, herbicides can do more harm than good in areas with high cover of native forbs and a low cover of Dalmatian toadflax (Jacobs 2006). Herbicides will decrease the existing forbs, but toadflax will recover more quickly and likely increase given the new absence of competition. Estimates from other studies suggest that when Dalmatian toadflax flowering density is less then 10 flowering stems/m^2, herbicides are likely not justified (Jacobs 2006). Grazing with trained sheep or goats along with prescribed cattle grazing management (to stimulate grasses) can prevent patches from increasing. An alternative to grazing is the release of *Mecinus janthinus* or other biological controls to prevent the patch from increasing (see the summary of yellow toadflax for a complete list of Dalmatian toadflax biocontrols). When densities are 25 flowering stems/m^2 or greater,

herbicides may be justified. Reseeding with grasses and other competitive plants should follow to provide long term suppression.

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Linaria vulgaris, Yellow toadflax

(a) **(b)** **(c)**

Figures: **(a)** Split photo of yellow toadflax (*L. vulgaris*, left) and Dalmatian toadflax (*L. dalmatica* right). By Elizabeth Goulet, Cornell University, Bugwood.org. **(b)**: Foliage and flowers of *L. vulgaris*. By Michael Shepherd, USDA Forest Service, Bugwood.org. **(c)** New growth emerging from rhizomes. By Steve Dewey, Utah State University, Bugwood.org

Park presence: GRKO
Status: **ID**: contain **MT**: priority 2b **UT**: EDRR **WY**: Noxious

Identifying characteristics: Bright yellow flowers have an orange bearded throat, and are shaped like snapdragon blossoms with a distinct spur at the base (see photo above, right). Plants rarely grow over 2 feet tall. When flowering, it is not easily confused with other species except Dalmatian toadflax (*L. dalmatica*). Leaves of yellow toadflax are linear and pointed at both ends, while leaves of Dalmatian are cordate or ovate and clasp the stem (see split photos above left). Dalmatian and yellow toadflax can hybridize (Ward et al 2009). It is unknown whether the hybrids are more aggressive than either parent plant, and whether they differ in their response to herbicides, and biocontrols. If any of the parks get both Dalmatian and yellow toadflax, they should contact their weed coordinator or university extension office for consultation.

Life cycle: Perennial, reproduces by seeds and underground rootstocks. Most seeds germinate early in the spring (typically later than Dalmatian), but germination may also occur in the fall. Buds form in early summer, flowering typically peaks in mid-summer but continues into early fall. Root energy reserves are greatest in the fall and lowest pre-bloom in late spring (Jacobs 2006).

Spread: Reproduces by seeds and rhizomes. Seeds are flattened with a papery circular wing, enabling dispersal by wind, but majority of seeds are found less than 5 feet of parent plant (Nader & King 1992, Jacobs 2006). Vegetative reproduction is important due to low seed viability (seed viability is highly variable). The extensive creeping rhizomes allow the plant to form dense stands and spread outwards. In Canada, lateral roots were observed to spread more than 4 feet per year. Root and rhizome fragments are also easily spread by farming equipment. Seed may be transported long distances when consumed by animals as it survives through the digestive tract.

Seeds per plant / longevity: 1,500-30,000 / 8 years or more

Habitat: Common on gravelly or sandy soils along roads, dry fields and rangeland, and cultivated fields. It generally does well in moist areas with high fertility, but will be displaced by other species when growing in less favorable conditions. Plants growing in dry soils tend to be stunted, but are relatively persistent. Yellow toadflax prefers moister soils compared to Dalmatian toadflax (Coombs et al 2004).

CONTROL OPTIONS

Mechanical

Hand pull/grub: Moderately effective to ineffective: recommended for new, small infestations only. For established patches, regeneration from roots makes hand pulling or grubbing ineffective
Cut/mow: Ineffective to partially effective. May help decrease seed production, but will need to be repeated regularly which opens up the canopy to other invasives.
Till/cultivate: Ineffective to moderately effective (with high labor input). In crops, repeated tilling has controlled yellow toadflax, but needs to be repeated at 3-4 week intervals. Such procedures would require consistent monitoring as this disturbance opens up the canopy to other invasives. It would also need to be followed by reseeding to provide long term control.

Cultural

Reseed: Moderately effective. Competition can effectively prevent seed production, but more information is needed to recommend specific species. Grasses can be used to compete with and suppress yellow toadflax.
Fire: Ineffective. Expect increases in yellow toadflax following fires.

Biological

Insects: Moderately to partially effective. Highly recommended as part of an integrated pest management plan. Information below is for both yellow toadflax and Dalmatian toadflax, with information on the insects' preferred host (Dalmatian or yellow) underlined. While availability and establishment may be limited for some, permits can be obtained for all species listed below (Coombs et al 2004).
Brachypterolus pulicarius Toadflax flower-feeding beetle. Adults feed on shoot tips, axillary buds at the base of leaves, and on reproductive parts (pollen, anthers, ovaries), stunting the plant and reducing seed production. Most common on yellow toadflax, but there is a Dalmatian toadflax adapted strain (availability of this strain is unknown).
Establishment: introduced accidentally, but now widespread and established in ID, MT and WY.
Calophasia lunula Toadflax moth. Larvae defoliate leaves and stems. Especially effective on seedlings and young plants. Prefers dry, xeric sites with coarse-textured soils. Common in northeast WA, but lack of establishment in colder, higher elevations suggests it is best for warmer sites. Attacks both Dalmatian and yellow toadflax.
Establishment: in scattered areas of ID, and MT.
Eteobalea intermediella Toadflax root-boring moth. Feeds on roots. For Dalmatian and yellow toadflax. Optimum habitat is undetermined.

Establishment: not successfully established in the US as of 2003 (Coombs et al 2004).
Eteobalea serratella Yellow toadflax root-boring moth. Feeds on roots. Optimum habitat is undetermined. Attacks yellow toadflax.
Establishment: appears promising, but wide spread establishment is unconfirmed, and availability is limited.
Gymnetron antirrhini Toadflax seed capsule weevil. Larvae develop inside of the fruit, and adults feed on leaves, buds and stems. Optimum habitat is unknown. Attacks yellow toadflax. This has been a very important biological control for yellow toadflax in the eastern provinces of Canada, British Columbia, and the northwestern U.S. It can reduce seed production by 85-90% (Nature Conservancy ESA 11/04).
Establishment: ID, MT and WY (for the yellow toadflax strain-a Dalmatian strain has been released but efficacy and establishment are unknown).
Gymnetron linariae Toadflax root-galling weevil. Larvae form galls in root and rhizomes and adults attack shoots of both Dalmatian and yellow toadflax. In its native region (Europe), it's common in grasslands.
Establishment: released in MT in 1996, establishment confirmed in WY, but not currently widely available.
Mecinus janthinus Toadflax stem weevil. Feeds on stems. Larvae bore in stems, and the adults feed on shoots. Prefers hot, dry, forested areas or grasslands. Attacks both Dalmatian and yellow toadflax, but prefers large-stemmed Dalmatian toadflax plants (Coombs et al 2004).
Established in ID, MT and WY.

Grazing: Ineffective. Not considered palatable to livestock. Goats and sheep have been trained to eat yellow toadflax. There is limited information on grazing to control yellow toadflax.

Chemical
Herbicides are partially to moderately effective. Ratings (good, fair, poor) provided when available from Dewey et al 2006.
Good: **Picloram** (Tordon): Apply when weeds are small and actively growing in the spring before full bloom. A retreatment program may be necessary for satisfactory control. Use this herbicide cautiously. Off-target impacts to native forbs, and increases in cheatgrass (*Bromus tectorum*) may not warrant the potential reductions in toadflax (Rinella et al 2009).
Chlorsulfuron (Telar): Fall timing is most consistent (Beck 2009). Use higher rate for dense stands. More than one year of application will typically be required. See label for including an NIS (non-ionic surfactant) or MSO (methylated seed oil). When the existing plant community is primarily grasses, control may be improved with a methylated seed oil, but if the existing community is more diverse with shrubs and forbs, the MSO will increase injury to forbs and shrubs.
Fair: **Metsulfuron** (Escort), **Imazapic + glyphosate** (Journey), **Imazapic** (Plateau), **Glyphosate** (Roundup)
Poor: **2,4-D** (may be resistant to 2,4-D amine), **Dicamba** (Clarity)

Comments: Yellow toadflax is generally considered more difficult to control than Dalmatian toadflax (Beck 2009), and permanent long term control is difficult. **Picloram** and **chlorsulfuron** are considered the most effective (Jacobs 2006), but 2-3 years of treatment will typically be necessary. Long term control is more likely if the existing plant community is healthy, or reseeding follows herbicide applications to increase plant density.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Prevention and EDRR (early detection rapid response) are top management priorities for this species. Once established, control will require many years of effort. For existing patches, the perimeter of the patch should be surveyed, reseeded where sparse and satellite populations should be hand dug or sprayed with herbicide to prevent establishment. Maintaining competitive plant communities and reseeding disturbed areas, especially those within the vicinity of an existing infestation are highly recommended. Herbicide applications must be followed by reseeding or other activities to improve the condition of the existing plant community in order to provide long term control. For large established patches, managers should release biological controls.

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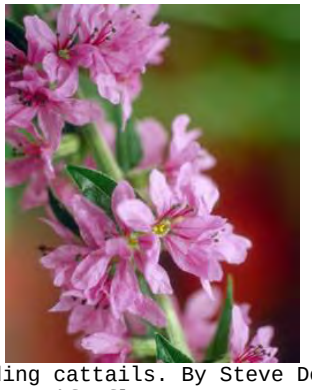
Lythrum salicaria, Purple loosestrife

http://www.invasive.org/images/768x512/0021091.jpg


Left: Purple loosestrife surrounding cattails. By Steve Dewey, Utah State University, Bugwood.org. Center: Purple loosestrife flowers. By Norman E. Rees, USDA Agricultural Research Service, Bugwood.org. Right: Seedling. From Ohio State Weed Lab Archive, The Ohio State University, Bugwood.org.

Park presence: HAFO
Status: **ID**: contain **MT**: 1b **UT**: EDRR **WY**: noxious

Identifying characteristics: Leaves are lance-shaped, 2-4 inches long, heart-shaped at the base and opposite or in whorls of three. The stems are angular to four sided, sometimes round at the base, covered in fine hairs, woody at the base and may reach up to 8’ in height. The small showy purple flowers have 5-7 petals. Two stamens are fused to each petal (10 to 14 stamens total). Purple loosestrife may be mistaken for fireweed (*Epilobium angustifolium*), which has only 4 petals.

Life cycle: Perennial, reproduces vegetatively and by seed. Seedlings on bare moist soil germinate in 3-4 days, faster than most native species, and they grow at a much faster rate (Jacobs 2008). Plants flower from mid-summer to early fall. In late summer and early fall, overwintering shoot buds form on the crown and carbohydrates accumulate in the crown and roots. The following spring, new shoots arise from buds at the tops of rootstocks.

Spread: Purple loosestrife spreads vegetatively and by seed. It may regenerate from cut stems and pieces of rootstocks. Plants resprout quickly following aboveground damage.

Seeds per plant / longevity: >100,000 / longevity under field conditions is unknown, but believed to be more than 2-3 years, (Young and Clements 2001), but less than 10.

Habitat: Grows in moist, riparian areas, typically in slow waters. Plants require open, moist, bare substrate for establishment (Munger 2002). Presence of cattails (*Typha* sp., see photo above left), reed canarygrass (*Phalaris arundinacea*), sedges (*Carex*) spp., and rushes (*Juncus* spp.) indicate suitable habitat. It is unlikely to occur on narrow streams with steep gradients and shaded areas. Established plants withstand seasonal flooding of 1-1 ½’.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Partially to moderately effective. Recommended for small, new infestations. Remove as much of the root system as possible. All plant material must be bagged and removed as plants can regenerate from stems, and root crown material. Revisit the site as hand pulling creates a disturbed site, ideal for seedlings to establish.
Cut/mow: Cutting is partially effective. Cutting stems to remove flowers heads prior to seed dispersal is recommended for small infestations to reduce spread by seed.
Till/cultivate: Not feasible given typical habitat.

Cultural
Reseed: Moderately effective and strongly recommended. Seedlings need light to establish. Herbicides alone are unlikely to provide long-term control as they will continually open up the canopy, allowing loosestrife seedlings to establish. Drought induced drawdowns or man-made disturbances also create habitat where reseeding should be used to prevent loosestrife seedling establishment. Collect seed from native riparian species in the area. If willows are present, try willow sprigs, or other native shrubs that may regenerate from stem cuttings. Until these species establish, carefully hand pull emerging loosestrife seedlings as they will grow more quickly than native species. However, once a native canopy is formed, the native vegetation has the potential to prevent or reduce purple loosestrife expansion.
Fire: Not feasible.

Biological
Insects: Partially to highly effective and strongly recommended for large, established stands.
Galerucella calmariensis (black-margined loosestrife beetle) and ***G. pusilla*** (golden loosestrife beetle) feed on buds and leaves and stunt growth. It may take 3-5 years for insects to establish and see an impact (Jacobs 2008). Non-target impacts: *Galerucella* has low impact (feeds, but does not reproduce) on swamp loosestrife (*Decodon verticillus*) and winged loosestrife (*Lythrum alatum*)-both natives, and the introduced crepe myrtle (*Lagerstroemia indica*) and *Lythrum hyssopifolia*. Both species of *Galerucella* are widely established and available in northern states.
Hylobius transversovittatus (loosestrife root weevil) feed on roots while in the larval stage and on foliage as adults. It is widely established and available in northern states.
Nanophyes marmoratus (loosestrife seed weevil) larvae attack unopened buds and adults feed on developing leaves. If *Galerucella* species are already present, they reduce availability of flowers, limiting efficacy. Established in ID and MT.
See Biology and Biological Control of Purple Loosestrife (Wilson et al 2004), available at http://www.invasive.org/weeds/LoosestrifeBook.pdf for recommendations on transport, release and monitoring of biocontrols.
Grazing: Ineffective. Grazing will damage sensitive riparian areas, increasing weeds due to the disturbance.

Chemical
Ratings of excellent, good, fair, or poor provided when available from Dewey et al 2006.

Good: **Glyphosate** (Rodeo): apply when plants are actively growing at or beyond the bloom stage of growth. Best results are achieved when application is made during summer or fall. Fall is much more consistent in Minnesota (Roger Becker, personal communication). Fall treatments must be applied before a killing frost. Carefully spot spray, or do a wick application to limit impacts on non-target plants. **Metsulfuron** (Cimarron, Escort): apply to actively growing plants. Metsulfuron may provide control lasting more than one season and have less impact on native grassy vegetation (Munger 2002). **Triclopyr** (Garlon 3A, Remedy): apply when purple loosestrife is at the bud to mid-flowering stage of growth.
Fair: **Metsulfuron + dicamba + 2,4-D** (Cimarron Max)
Not rated: **Glyphosate** (Rodeo) + **2,4-D**: before bloom.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Parks with suitable, but uninfested habitat (like riparian areas) should survey these areas regularly. For parks with existing infestations, managers should focus their efforts on eliminating recently established satellite populations before targeting the existing well-established populations in order to prevent spread. Prevent seed production and seed bank accumulation wherever possible by clipping flower heads and spot spraying. When applying herbicides, managers must recognize the trade-offs. Higher herbicide efficacy can be followed by increased seedlings density of purple loosestrife due to opening the canopy (Jacobs 2008). Following any disturbance, including herbicide application, revegetation is strongly recommended (using native willow sprigs, or other native shrubs, or seed collected on site). For large infestations, combining herbicidal control with *G. calmariensis* may be more effective than either treatment applied alone (Jacobs 2008). Introducing biocontrols is highly recommended. Biocontrols for purple loosestrife have been very effective, reducing plants by up to 90% over a 10 year period (Coombs et al 2004). Release the biological controls in the center of the patch and target satellite patches with herbicide or hand pulling.

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Melilotus officinalis, Yellow Sweet Clover

Left: Trifoliate leaf of Sweetclover – left; and alfalfa – right. By Steve Dewey, Utah State University, Bugwood.org. Right: Flowering plant. By Dave Powell, USDA Forest Service, Bugwood.org.

Status: Not listed
Park presence: BEPA, BIHO, CIRO, CRMO, FOBU, GOSP, GRKO, LIBI

Identifying characteristics: Erect plants emerge from strong taproots. Plants may grow 2-6.5′ tall and may be bushy or lanky. Alternate, pinnately three-foliate leaves (above left) have small sharp teeth almost to the base (see yellow sweet clover to the far left compared to alfalfa). Sweetly-scented yellow flowers grow in small, slender spike-like racemes. Seed pods are ovoid, leathery and wrinkled, with one (or rarely two) seeds.

Life cycle: Grows as an annual or biennial. Flowering can occur from late spring to early fall.

Spread: No mechanism for long distance dispersal (like barbs or plumes). It spreads by cultivation, and contaminated seed or soil. It is favored by honey producers, and has been promoted in the past for soil stabilization.

Seeds per plant and longevity: 14,000-350,000 / 20 years

Habitat: Common along roadsides, in open fields, pastures and other disturbed areas.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective. Use a shovel if soil is dry to excavate a few inches below ground level. Hand pulling first year stems is recommended in the fall when plants are easy to detect among drying grasses and in moist soil. Second year plants should be pulled before seed set.
Cut/mow: Partially to moderately effective. If plants are clipped close to the ground below the lowest branch axils, resprouting is unlikely, although in a prairie in Missouri; 30% did resprout after this treatment. Cut before flowers emerge. For very dense small patches, cutting with a power brush-cutter using a heavy duty saw blade

is effective. The stand should be cut just before flowering, and checked a week later for individuals missed or partly cut.
Till/cultivate: Unknown. Tilling would likely need to be repeated to target long lived seedlings that would be brought to the surface.

Cultural
Reseed: Moderately effective. This plant typically establishes in disturbed areas. Reseeding recently disturbed areas, and reseeding after control efforts should prevent establishment.
Fire: Ineffective to highly effective. Prescribed fire is an integral part of most of the control strategies in the mid-west (where plant communities are adapted to more frequent fire return intervals), but no studies are available on fire to control yellow sweetclover in the intermountain west. In the mid-west, spring burns every few years are not recommended, as they increase sweet clover infestations (Eckardt 1987). A fall dormant season burn is recommended to stimulate germination, followed by a late spring burn to target plants before they set seed. The spring burn must not occur until shoots elongate. If the plants are burned before elongation, the meristematic buds will be close to the ground and may escape fire injury. When this strategy was conducted twice over a six year period, it eliminated yellow sweet clover. This is most effective in even aged stands, but uneven aged stands (mix of first year seedlings and second year flowering plants) will require additional efforts.

Biological
Insects: The following insects have been found feeding on yellow sweet clover: *Sitona cylindricolis*, *Epicauta fabricii*, *Epicauta vittata* *Epicauta pestifera*, but availability and establishment is unknown. Check with your county weed coordinator or contacts listed under 'Status of Biocontrols' in the Resources section at the end of this document.
Pathogens: Not available
Grazing: Moderately effective. Infestations may be reduced with heavy grazing. Plants are more palatable in the early spring and summer. However, a late spring burn, followed by grazing in late fall at a high stocking rate has also been observed to decrease it. Note if heavy grazing is planned in the area: sweetclovers often cause bloat in cattle, and are high in coumarin which causes anticoagulation in the blood.

Chemical
Moderately effective
2,4-D (2,4-D LV4): Apply when weather is warm and plants are rapidly growing
Aminopyralid + metsulfuron (Chaparral): Apply in the spring and early summer to rosette or bolting plants or in the fall to seedlings and rosettes before ground is frozen. Use higher rates after bolting through early flower
Imazapyr + **metsulfuron methyl** (Lineage Clearstand): apply to actively growing plants.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

More studies are needed to understand the impact of yellow sweetclover on native plants and to recommend IPM strategies for yellow sweetclover

in the Intermountain Region. Until that time, managers should monitor existing yellow sweetclover patches and cautiously experiment using control efforts from other areas (primarily the mid-west) if deemed necessary. In the mid-west, fire is a part of most of the control strategies. Along with dormant fall burns followed by late spring burns, additional strategies involve mowing the first year plants in mid-to-late August, leaving the cut tops to dry in the field for several weeks, and then burning the area in mid-to-late September (Eckardt 1987). In early September, sweetclover starts a "critical growth period" when food is rapidly trans-located to the roots for storage over winter. Cutting before this critical period can encourage plants to resprout tops to store enough food to survive the winter. Burning this regrowth can reduce plant survival. In Illinois, managers recommend fall burning followed by 2,4-D applications in the early spring when seedlings are very small and before other forbs have emerged. On a preserve in North Dakota where burning is not possible, mangers mow in late spring/early summer. Flowering shoots will resprout from axils below the mow height, so a power brush cutter is used to cut those plants close to the ground before they flower.

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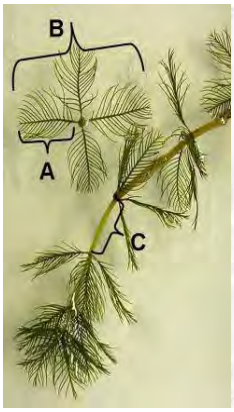
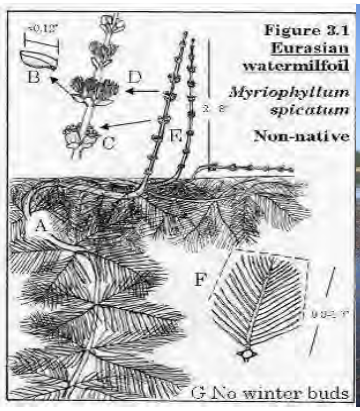
Myriophyllum spicatum, Eurasian watermilfoil





Left: (A) leaf with 14 or more paired leaflets, (B) a whorl of leaves, (C) internode. Photo by John Halpop.
Center: line drawing of (A) densely branching growth form, (B) bracts that do not extend beyond flowers, (C) female flowers lower on the stem, (D) male flowers on upper part of stem, (E) flowering stalks that are upright when they emerge, and then lean to the side as they mature, (F) Leaf with more than 14 paired leaflets (i.e. more than 28 linear leaflets/leaf), and (G) No winter buds (in contrast to native species *M. sibiricum* and *M.. verticillatum* that have winter buds). Line drawing by Hilary Parkinson.
Right: Dense stands of Eurasian watermilfoil by John Madsen.

Park presence: Not reported in any of the parks. Only parks with lakes, rivers, or slow moving waters are at risk.
Status: **ID**: control **MT**: priority 1B

Identifying characteristics: Eurasian Watermilfoil is abbreviated EWM throughout this document. Feathery leaves grow in whorls, typically four leaves/whorl (see figures above left and center). This plant has dense branching near the water surface, in contrast to native milfoils. If bracts are longer than the flowers and dissected it's the native *M. verticillatum.* Both EWM and *M. verticillatum* have more than 14 paired leaflets per leaf, but if there are less than 14 paired leaflets per leaf, it's likely another native, *M. sibiricum.* Native milfoils have winter buds and rounded apical meristem (in contrast to no winter buds, and flattened apical meristem of EWM). Leaflets tend to be of equal length, giving the leaf a squarrish shape (Figure 2 above, F) in contrast to the natives which are more rounded.

Life cycle: EWM can overwinter under the ice, and begins growth rapidly in the spring as the water warms and light intensity increases. As stems grow, they branch densely near the surface, and slough off lower leaves (dense infestations can change nutrient cycling, oxygen levels). Plants can flower from June to September, but flowering has been observed mostly in late July to September in Montana. The female flowers (seed producing) ripen first as the inflorescence spikes emerge from the water, well ahead of the male flowers (pollen producing), favoring cross pollination. Fruits have a stony surface that inhibits seed germination, giving seeds a prolonged dormancy (7 years). Germination is erratic, and seedlings are considered rare in nature. While flowering may be prolific, most reproduction is asexual from root crown buds and stem fragments. Stem fragments form due to natural wave action and recreational activities such as boating.

Spread: Transport on boating equipment likely plays the largest role in introducing fragments to new water bodies, but it may also occur via water birds, and fishing equipment (waders, float tubes, etc.). Following introduction, spread may be rapid. In Currituck Sound, North Carolina, it spread from approximately 1.5 to 103 square miles (400 ha to 26,800 ha) in one growing season.

Seeds per plant and longevity: <1000 / 7+ years

Habitat: It colonizes rivers, lakes and other water bodies. It can tolerate moving water, and water currents and wave action facilitate fragmentation.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Repeated mechanical harvests have been successful in reducing stem densities. A hand rake can be used for small areas (around docks, swimming areas). However, the risk of spread by stem fragments is high - fragment barriers around harvest operations have been developed to reduce spread. For single harvests, it should be done just prior to when peak biomass is obtained. However, if mechanical harvesting is considered, managers should ideally plan to do it repeatedly within a growing season, and for more than one year. Areas harvested only once can quickly re-colonize to pre-harvest levels in less than one year. Hand harvesting or diver operated suction harvesting has been successfully used to control scattered individual plants. These techniques are particularly valuable for early stages of infestation, but are not appropriate for any dense beds of EWM.

Benthic barriers (bottom-covering material that inhibits plant growth) anchored to lake bottoms have been used to kill or reduce EWM. This may be particularly helpful near boat ramps, and other areas frequently disturbed and at high risk of infestation. For example, a study conducted by the University of Idaho on Coeur d'Alene Lake showed benthic barriers applied in mid-spring and left on for eight weeks controlled EWM. Four weeks after removal of the benthic barrier EWM had not grown back, but native plants had begun to regrow. Barriers should be installed as early in the spring as possible, prior to EWM growth. Barriers must be monitored for sediment accumulation and cleaned because sediments deeper than 1.5 inches (4 cm) will facilitate rooting of EWM fragments on top of the barriers.

Water drawdown followed by exposure to freezing temperatures for 96 hours will kill plants and has also reduced infestations.

Cut/mow: not applicable

Till/cultivate: not applicable

Cultural

Reseed: Not applicable.

Fire: Not applicable.

Biological

Insects: Currently, there are no viable biological controls available. However, two insects – watermilfoil moth *(Acentria ephemerella),* native to Europe and the milfoil weevil *(Euhrychiopsis lecontei)* native to North America – are associated with Eurasian watermilfoil declines. More testing is needed to determine their effectiveness and host specificity.

Grazing: Not applicable.

Chemical

Diquat and endothall are fast-acting contact herbicides that quickly break down the stems standing in the water. Since the translocation of

the herbicide into the roots is minimal, plants will grow back after a contact treatment. These herbicides, however, require only a short contact time, and the effects are localized in the area of actual treatment. Triclopyr and 2,4-D require an intermediate length of contact time. They provide selective control of EWM without harming most native species. However, native watermilfoil species are susceptible to 2,4-D and triclopyr. Probably the most widely used herbicide for controlling EWM is 2,4-D, both for its selectivity and its relative low cost. For more recommendations on herbicides and rates, see Montana State University extension bulletin: Biology, Ecology and Management of Eurasian Watermilfoil (*Myriophyllum spicatum*).
Check state regulations before applying herbicides to water. For example, in Montana, applicators need a 308 permit from the Montana Department of Environmental Quality before applying aquatic herbicides to water
(http://www.deq.state.mt.us/wqinfo/MPDES/permits/308/308AppFinal.pdf).

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Prevention is the most important tool for this species. If parks learn that nearby water bodies have this species, they should conduct routine surveys to identify it early in the invasion process. Signs should be posted around docks, and put-ins stating that visitors must clean boats, trailers and watercraft on dry land, carefully inspecting all areas likely to have accumulated EWM fragments. Bilges must be pumped before entering another body of water as EWM can stay alive in bilge water for many days. Make cleaning boats, trailers and watercraft on dry land mandatory.

For susceptible Idaho parks, see "Eurasian Watermilfoil Identification and Management in Idaho" to help differentiate Eurasian watermilfoils from native milfoils. The bulletin includes diagrams of watermilfoil species native to Idaho. Available at: http://info.ag.uidaho.edu/pdf/CIS/CIS1108.pdf

For susceptible Montana Parks (especially BIHO), see "Biology, Ecology and Management of Eurasian Watermilfoil (*Myriophyllum spicatum*) for additional details on distinguishing it from native species, and more details on chemical control options. Montana State University SKU EB0193. Available at:
http://msuextension.org/publications/AgandNaturalResources/EB0193.pdf

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Onopordum acanthium, Scotch thistle

Left: Gray-green silvery foliage that ends in sharp yellow, green or white spine and a flower with narrow bracts and spines along the stem. Right: Growth form of a flowering plant. Both by Steve Dewey, Utah State University, Bugwood.org.

Status: ID: contain **MT counties**: Choteau, Carbon **UT**: control **WY**: noxious
Park presence: CRMO, GOSP, MIIN

Identifying characteristics: This plant can grow 8 – 12 ft tall, up to 5' wide, and is often multi-branched. Upper and lower leaf surfaces are covered with a thick mat of woolly hairs that give the foliage a gray-green or silvery appearance. The oblong leaves on the plant can be up to 2' long by 1' wide. Their lobes end in a very sharp yellow, green or white spine (above left). Flowers are usually solitary (not in clusters). The other exotic thistle with spines along the stems and flowers that are solitary is bull thistle (*Cirisum vulgare*). Leaves and foliage of bull thistle are not gray green.

Life cycle: Biennial. It reproduces only by seed. Seeds typically germinate in fall after the first rains, but seeds can germinate year round under favorable moisture and temperature conditions. It flowers from mid-summer through fall.

Spread: Seed are egg-shaped with bristle-like hairs (pappus) at one end. They disperse by wind, water, wildlife, and livestock, but the vast majority of seeds fall below the parent plant.

Seeds per plant / longevity: 700-60,000 seeds / 7-20 years. Note: A single plant can produce over 30,000 seeds, which have a high degree of dormancy. Scotch thistle can flower and produce seed at less than 12 inches tall.

Habitat: Commonly found in wet meadows, pastures, small grain fields, dry alfalfa, and disturbed areas in open rangeland. Scotch thistle grows best on the slope between arid rangeland and wet meadows along streams. Although Scotch thistle prefers disturbed areas with high soil moisture, drier areas do not limit its invasive nature. It is also commonly found on overgrazed lands, roadsides, and construction sites. The plant is considered highly competitive in nutrient deficient soils.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective. Plants do not reproduce vegetatively so small infestations are best controlled by hand pulling.
Cut/mow: Partially effective. Not recommended unless used with a follow-up herbicide application. Plants store energy that allows them to resprout when cut, but large stands could be mowed before seed dispersal, and thereby would create a uniform stand for herbicide application.
Till/cultivate: Partially effective, but not recommended unless combined with other control efforts.

Cultural

Reseed: Highly to moderately effective. Revegetating following treatment helps prevent the invasion and establishment of new scotch thistle plants. Competitive grasses can reduce or eliminate it.
Fire: Not recommended. Resprouts easily after fire.

Biological

Insects: None currently available
Pathogens: NA
Grazing: Only goats will graze it, but only in its early rosette stage. After it has developed a coarse stem and stout spines, goats refuse to eat it.

Chemical

Highly effective to spray the rosettes in the spring or fall, but described as generally most effective in the fall. Ratings from Dewey et al 2006.

Excellent: Metsulfuron (**Escort, Cimarron**), Aminopyralid (**Milestone**), Clopyralid (**Transline**), Picloram (**Tordon**), Picloram + 2,4-D (**Grazon P+D**)

Good: Metsulfuron + dicamba + 2,4-D (**Cimarron Max**), Chlorsulfuron (**Telar**), clopyralid + 2,4-D (**Curtail**), Triclopyr + clopyralid (**Redeem R&P**)

Fair: 2,4-D, Dicamba (Banvel, Clarity)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS:

This plant can be effectively controlled or eradicated by a combination of mechanical, chemical and cultural methods. Hand pulling isolated patches, especially those along a road or trail, is strongly recommended. Herbicide may be necessary for larger infestations. Reseeding is strongly recommended following herbicide application or other control efforts if the existing plant community is sparse as this plant does not respond well to competition.

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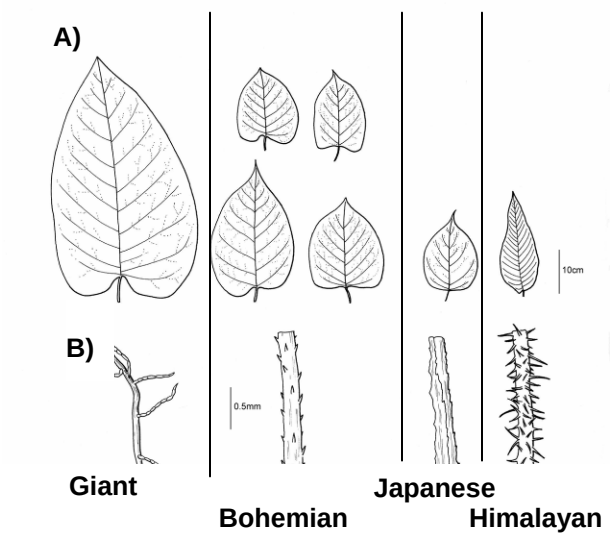
Polygonum sp., Knotweed complex

Polygonum cuspidatum **Japanese knotweed**
Polygonum x bohemicum **Bohemian knotweed**
Polygonum sachalinense **Giant Knotweed**
Polygonum polystachyum **Himalayan Knotweed**



Left: (A) Leaf shape and (B) hairs on the underside veins of leaves of Giant, Bohemian, Japanese and Himalayan knotweeds. Line drawings by Cindy Roché. Right: Membranous sheath at leaf nodes, a diagnostic characteristic along with hollow stems.

Park presence: Not reported in any of the parks.
Status:
P. cuspidatum: **ID**: control **MT**: priority 1B
P. x bohemicum: **ID:** control
P. polystachyum: **MT:** priority 1B
P. sachalinense: **ID:** control **MT**: priority 1B

Identifying characteristics: All are large, rhizomatous, herbaceous perennial plants varying in height from just under 5’ to over 19’ tall. Plants in the knotweed complex have two characteristics to distinguish them from most other native or non-native plants in the northwest: (1) the alternate leaves grow **on hollow, bamboo-like stems that grow in clumps**; and (2) **the nodes (which are not hollow) have a papery or membranous sheath** (above right). The narrow leaf of Himalayan helps distinguish if from the other three in the complex (above left). To differentiate giant, Bohemian and Japanese knotweeds one must investigate the hairs on the underside of leaf veins with a hand lens, or microscope (see description of hairs in Table 4 below and drawings in figure above left). Bohemian knotweed is commonly misidentified as Japanese knotweed.

Table 4: Characteristics of Plants in the Knotweed Complex

Species	*P. sachalinense*	*P. x bohemicum*	*P. cuspidatum*	*P. polystachyum*
	Giant knotweed	**Bohemian knotweed**	**Japanese knotweed**	**Himalayan knotweed**

Plant Size	9'9"-- 19' 8"	6'6"—16'5"	4' 10" – 8' 2"	6'6"-- 9'10"
Leaf Size (see figure below)	Deeply heart shaped. 7-16" long, 2/3 as wide	Shape may be like either parent (*P. sachalinense* or *P. cuspidatum*) 2-12" long, 2/3 as wide	Leaf base is truncate. 1- 4" long, 2/3 as wide	Long and narrow. Up to 8" long, < ½ as wide.
Hairs on underside of leaf veins	multi-cellular hairs	small stout hairs	rough ridges, but no hairs	long hairs

Life cycle: Perennial with rhizomatous growth. Following emergence, growth is rapid: Japanese knotweed can grow 2-4 inches per day in the spring. Flowering occurs in late summer, from August to September, with fruit set beginning in September. At the onset of cold temperatures above ground stems die, but canes remain upright and fruits often remain on the stem throughout winter.

Spread: Reproduction from seed is considered rare (especially for Japanese knotweed which typically occurs as female, and male plants are rare). Rhizome fragments are spread when soil from a knotweed patch is excavated and moved off site, or when rhizomes from plants growing along a river bank break off and float downstream. Rhizome fragments as small as 0.02 lb (7 g) can regenerate, provided a node is present. They can regenerate when buried up to depths of three feet, and they have been observed to emerge through two inches of asphalt.

Seeds per plant and longevity: Unknown, but not highly relevant due to plants' reproductive physiology. Seed production is generally rare and the most common form of spread is by rhizome fragments (or when intentionally planted as an ornamental).

Habitat: Occur in yards where they were intentionally planted as a screen or an ornamental. Escaped plants are most commonly found in moist areas such as along river banks, canals, wetlands, and lakeshores. However, they can tolerate a range of moisture conditions and also occur frequently in disturbed areas like utility pathways, waste places, strip-mining areas and along roadways. Japanese, Giant and Bohemian knotweeds are unlikely to invade forests or areas with a closed canopy because they do not tolerate shading (unknown for Himalayan).

Regardless of seed production, knotweed's invasiveness is primarily due to the vigorous rhizomes. In England, where only female plants are present, Japanese knotweed is extremely invasive: aggressive roots damage infrastructure, foundations of houses. Rhizomes can grow laterally 50 to 65 feet to produce new shoots meaning plants have a large potential to firmly establish and expand locally. Knotweed can form extensive, mono-specific stands, especially in wetland habitats. It can line the banks of creeks and rivers, forming nearly impenetrable walls.

CONTROL OPTIONS

Knotweed control efforts will typically require a combination of treatments and more than one year of treatments. Himalayan knotweed is considered to be the easiest to control, and Bohemian knotweed the most difficult. Most of the research on control methods has focused on

Japanese knotweed. Until more research is available, the recommendations for the other three species are based on recommendations for Japanese knotweed, except where noted. Following treatment, the area within a 60 foot radius of the original patch should be monitored regularly for several years, even after the patch appears to be eradicated.

Mechanical

NOTE: *Knotweed that is cut, hand pulled, or mowed can easily regenerate. Stems, roots and all excavated material should be placed on a dry surface such as a tarp or concrete until dried out and risk of regeneration is gone, or the material should be burned.*

Hand pull/grub: Partially to moderately effective if done consistently on small patches when plants are young and when the soil is soft and moist. The patch should be monitored twice monthly to remove new sprouts as they emerge.

Cut/mow: Partially effective. *Stem cutting,* while labor intensive, is recommended. Persistent cutting over many years is required and cutting at least three times per year is needed to significantly reduce rhizome reserves. For greatest effect, the last cutting should occur before plants begin to loose their leaves with the onset of winter. *Mowing* is effective if repeated for several years. Mower height should be as close to the ground as possible and mowing should be repeated when plants reach a height of six inches. Mowing should continue throughout the growing season until a killing frost occurs

Till/cultivate: Ineffective. Tilling alone is not recommended as it can increase new sprouts by breaking up rhizomes into fragments. However, it may be used in combination with other treatments, like mowing re-sprouts or to promote leaf production prior to herbicide application.

Cultural

Revegetation: Partially effective. Revegetation alone is unlikely to be an effective control method. Other measures should be taken to first control it (combination of hand pulling or mowing and herbicides). Once a patch appears to be eradicated, revegetation is strongly recommended to suppress reinvasion. The following species are recommended for revegetation (select what is native to the park): shrubs such as willow (*Salix* sp.), American elderberry (*Sambucus canadensis, S. cerulea* or *S. racemosa*), or alder (*Alnus serrulata* and *A. incana* ssp. *rugosa*); grasses such as streambank wheatgrass (*Elymus lanceolatus*) or Great Basin wild rye (*Leymus cinereus*).

Covering: Partially effective. Covering plants with heavy duty black plastic and cardboard for more than one year may suppress the plant. This is recommended for very small infestations only. Rhizomes may remain dormant for up to 20 years, so the lack of re-growth in years following removal of the covering does not mean the plant is dead, and regular monitoring is required.

Fire: Fire is ineffective and not recommended. These plants are the first to invade following lava flows in their native region. They will quickly reestablish following fire.

Biological

Insects and Pathogens: At this time no insects have been approved for release as biological control. A promising candidate is a leaf chewing beetle (*Gallerucida bifasciata*). More research is needed on host range and specificity. The rust pathogen *Puccinia polygoni-amphibii* var.

tovariae has been observed to damage Japanese knotweed in Japan. Like the beetle, more research is necessary before it can be approved for release

Grazing has been observed to reduce the establishment and growth of Japanese knotweed where grazing pressure is high. Young shoots are palatable to sheep, goats, cattle and horses. Goats may be most effective, but more research is needed. Grazing will not kill the plants, but repeated grazing can weaken them.

Chemical

Herbicides labeled for control of plants in the knotweed complex are described in **Error! Reference source not found.**5. At this time, there are no herbicides labeled for control of Himalayan knotweed. Stem injection is one of the more commonly recommended methods. Stem injection involves using a hand-operated injection device designed to deliver repeated, pre-measured doses. Prior to injection, a hole must be made using an awl or other pointed tool. All stems must be treated. Plants may also be broadcast sprayed (see formulation with imazapyr, Table 2).

While herbicide labels do not recommend a specific application time, reports suggest glyphosate products are most effective from July to September, or prior to leaves discoloring and falling off. Fall application may be most effective because leaves will translocate more herbicide to rhizomes.

Table 5: Examples of Herbicides for Management of Plants in the Knotweed Complex

Consult herbicide labels for additional rate, application, restriction, and safety information as well as recommendations for adjuvants or surfactants. Additional herbicide information can be found at http://www.greenbook.net.

Herbicide Active Ingredient **Trade name**	**Mode of action**	**Directions**	**Knotweeds listed on the label:**
Glyphosate Roundup Pro Max	Inhibition of ESPS synthase	Inject 0.17 oz (5 mL) into the hollow stem between the second and third node, or approximately 6" above the ground.	Japanese, Giant and Bohemian
Glyphosate Rodeo			Japanese and Giant
Glyphosate and 2,4-D Campaign	Inhibition of ESPS synthase; action like indole acetic acid (synthetic auxin)	Inject 0.2 oz (6 mL) into the hollow stem between the second and third node.	Japanese and Bohemian
Imazapyr, metsulfuron methyl Lineage Clearstand	Inhibition of acetolactate synthase	Apply as broadcast spray at 25 oz/acre for total vegetation control (non-selective). Apply postemergence at any time during growing season.	Japanese
Imazapyr Arsenal	Inhibition of acetolactate synthase	Apply 4-6 pints/acre using the higher rate for dense, well established patches. Apply when plants are actively growing and include a surfactant. For non-crop areas only.	Japanese

While currently not listed on the herbicide label, anecdotal reports suggest that **aminopyralid** (Milestone) is an effective herbicide for control of knotweed, and it may soon be included on the label (check www.greenbook.net for updates to herbicides labels).

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Prevention and early detection is the number one priority for plants in the knotweed complex. Large established stands of Japanese knotweed have been described as extremely difficult to eradicate; whereas small stands that have not had years to establish can be fairly easy to remove with persistent effort. If plants invade, an integrated management strategy is highly recommended. Cutting the stems one to three times during the growing season prior to mid-summer and then applying herbicide in late summer or early fall is effective. This can increase herbicide efficacy by stimulating new growth which is more susceptible to herbicide activity. Additionally, clipping will reduce the amount and height of foliage to be sprayed, and make the patch more accessible. Other mechanical treatments like grazing or mowing may be substituted for clipping (up to mid-summer) in combination with a fall herbicide application.

Patches should be monitored for many years after re-growth appears to have ceased. Herbicide applications and other mechanical treatments will leave the area exposed to other invasive weeds. After patches appear to be successfully controlled, the site should be revegetated with appropriate species if necessary.

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Potentilla recta, Sulfur cinquefoil

http://www.invasive.org/images/768x512/5243017.jpghttp://www.invasive.org/images/768x512/5243016.jpg



Left: flowering plant, showing palmate leaves and numerous leaves per stem. Center: Hairs grow at right angle to the stem. Both photos by Steve Dewey, Utah State University, Bugwood.org. Right: wrinkled or roughened surface of seeds create a net-like pattern distinct from native *Potentilla* seeds which are smooth. By Ken Chamberlain, The Ohio State University, Bugwood.org.

Park presence: GOSP, GRKO
Status: **MT**: priority 2B **UT**: EDRR

Identifying characteristics: One to several erect stems grow 12-28 in. in height. Leaves are palmate with five to typically seven leaflets. Flowers have five pale yellow petals and five sepals. To differentiate from the native northwest cinquefoil (*P. gracilis*), look for the following on *P. recta:* (1) long hairs at right angle to leaf stalk and stem (see photo above center); (2) numerous stem leaves, fewer basal leaves; (3) lower and upper leaf surface has sparse, coarse-stiff hairs. The native northwest cinquefoil has (1) short spreading hairs on stem and leaf stalk; (2) few stem leaves-mostly basal; (3) dense fine-wooly hairs that grow on the lower leaf surface. The quickest way to distinguish it from the native is to examine the seeds (if available) with a hand lens. Sulfur cinquefoil has a distinct netting pattern, or ridges on the seed coat (see photo above right of small seeds that look rough), while the seed coat of northwest cinquefoil is relatively smooth (no netting pattern).

Life cycle: A long-lived perennial (20-30 years) that does not reproduce vegetatively. However, as old roots die in the center, new shoots emerge from the edge, forming a ring-shaped cluster of individual

plants. Plants bloom in late spring, and will continue to flower throughout the summer given favorable conditions.

Spread: Seeds are heavy relative to their size and have no mechanisms for long distance dispersal by wind or animals. Most land within two feet (60 cm) of the parent plant in the direction of the prevailing winds. However, there is potential for long distance dispersal via livestock and wild ungulates that may transport seeds embedded in their fur and in soil on their hooves; seed-eating birds; and on all-terrain vehicles.

Seeds per plant / longevity: 1,000-5,000 / 4 or more years

Habitat: It is commonly found on roadsides, clearcuts, abandoned farm fields, waste places and other disturbed areas. It can grow in grassland, shrubland, pinyon juniper, deciduous and coniferous forests, and seasonal wetland eco-systems in all soil textures except silt. It is often associated with spotted knapweed.
Competitive ability (APRS #15) will greatly depend on surrounding vegetation. Reportedly it can invade native rangeland with low disturbance, shrub land, and open-forested sites. It does not tolerate shading from a closed canopy forest. Stem densities are up 29 stems m^{-2} on open sites, compared to 1 stem m^{-2} when growing in 50% canopy cover.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Moderately to highly effective. Highly recommended for small patches, but use a shovel: the upper portion or crown of root system must be removed, or the plant will re-sprout from crown tissue.
Cut/mow: Ineffective. Massive woody root system enables plant to send up new shoots after mowing (even if mowed repeatedly).
Till/cultivate: Ineffective to partially effective. Not recommended. On productive sites, cultivation and annual crops will control it, but this is not appropriate for most parks.

Cultural

Reseed: Moderately to highly effective. Seedling survival is low when growing under competition with other plants. Reseeding is strongly recommended as follow-up to herbicides, and to prevent invasion into recently disturbed areas.
Fire: Ineffective. Mature plants readily re-sprout from woody rootstock. Temporary removal of above ground litter creates conditions more favorable to sulfur cinquefoil establishment (Bushey 1995). In Montana, spring or fall burns did not kill sulfur cinquefoil plants one year or older. Spring burns are especially not recommended as seedling density was higher in spring burns compared to fall burns five years after the fires.

Biological

Insects: None available at this time. Most have not made it through initial screenings because they feed on the closely related domestic strawberry (as well numerous native *Potentilla* species).

Pathogens: A rust fungus, *Phragmidium invesiae* attacks the plant in the northwest, but it is not commercially available at this time (Coombs et al. 2004).
Grazing: Ineffective to partially effective and not recommended. Plants are not considered palatable and will increase under grazing.

Chemical

Moderately effective. Herbicides ranked Excellent, Good, Fair or Poor when available from Dewey et al. 2006. Majority of herbicides do best when applied early in the growing season (to rosettes, bolting or flowering plants), and poorly when applied in the fall.

Excellent: **Picloram + 2,4-D** (Grazon P+D): most effective (~95% control) when applied to rosettes or bolting plants, and nearly as effective when applied to flowering plants (90% control). Control is reduced when applied in the fall (60% control). **Picloram** (Tordon): provides ~95% control or greater on rosettes, bolting or flowering plants, or in the fall.

Good: **2,4-D ester**: apply to rosettes, or bolting plants (~95% control) or flowering plants (~90% control. Efficacy is reduced when applied in the fall (<60% control). **Aminopyralid** (Milestone) to pre-bud stage. **Triclopyr** (Remedy) to rosettes.

Poor: **Dicamba** (Banvel, Clarity), Curtail (clopyralid + 2,4-D)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

For small infestations, combine spot spraying or hand pulling with cultural practices to improve the competitive ability of the surrounding plant community (temporarily cease grazing if possible, reduce trampling, seed native species in bare spots). For larger patches, herbicides alone can cause the community to change from exotic forbs to exotic grasses. Combine herbicides with reseeding. Efforts should also be focused on eradicating satellite populations to prevent further spread. To reduce spread, reseed the perimeter if needed, especially disturbed areas.

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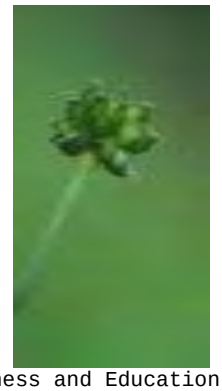
Ranunculus acris, Tall buttercup





Left: Glossy yellow flowers. By Montana Statewide Noxious Weed Awareness and Education Program Archive, Montana State University, Bugwood.org. **Center:** *R. acris* leaves on the left, deeply divided into 3-5 lobes. *R. acriformis* leaves on the right, (a native), with leaves not as deeply divided. By Dave Brink. MSU Extension, Mineral County. **Right**: Fruits which are disc-shaped with a short hook or beak. As they mature, they turn reddish brown. By John Cardina, The Ohio State University, Bugwood.org

Park presence: CIRO, FOBU, GRKO
Status: MT: 2A

Identifying characteristics: Plants are erect, leafy below and branched above (Figure a), and grow 1-3 feet tall. Stems are hollow and occasionally hairy. Leaves are deeply divided into 3-5 lobes (Figure b, leaf and stem to the left). This plant resembles the native *R. acriformis,* but the leaves are not as deeply divided in *R. acriformis* (Figure b, leaf and stem to the right). Basal and stem leaves are similar, but most stem leaves occur less than ½ way up the long flower stems. Flowers have 5 glossy, obovate yellow petals, and are about 1 inch wide (Figure A). The five sepals are half as long as the petals. Roots of tall buttercup are fibrous. However, *R. acris* subspecies *acris* has stout rhizomes with dormant axillary buds. When roots are damaged, these axillary buds are stimulated and the plant spreads laterally (Lamoureaux and Bourdot 2007). There are many native buttercup (*Ranunculus*) species that may be confused with this plant. Distinguishing among them often depends on minute details like the length of the beak on the seed (see small appendages on seed in Figure d), or the shape of the nectary at the base of the flower petals. Be sure to verify with a qualified botanist that the plant is tall buttercup before beginning a control program, especially if the plant occurs in an undisturbed natural area. See the Resources section at the end of this document for a list of labs that accept plant samples for identification.

Life cycle: Perennial, reproduces by seed and, in the case of *R. acris* subspecies *acris*, also vegetatively (see 'Spread' below). Seeds germinate in spring and require open soil. Plants may flower from late spring to early fall. However, it may take 2 to 10 years before plants first begin to flower.

Spread: Spreads by seed which is dispersed by wind, animals, clothing and machinery. A small hook on the seed allows them to adhere to fur, clothing. *Ranunculus acris* subsp. *acris* has a stout rhizome with dormant axillary buds. Trampling, defoliation, or other damage stimulates buds and the plant spreads laterally. In New Zealand, this

asexual reproduction is considered an important form of spread (Lemoureaux and Bourdot 2007). Subspecies *acris* occurs in Montana.

Seeds per plant and longevity: 240 / 2-4 years

Habitat: Common in pasture, meadows, along roadsides, in wet lowlands and woodlands. It prefers heavy, moist, more acidic soils but can grow in sandy or gravelly soils given sufficient moisture. It requires open soil to germinate and rapidly expands on bare ground in the year following germination.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Moderately to highly effective. Strongly recommended for new patches and when soil is moist. Pull or dig up plants, removing all of the roots. Be sure to wear gloves and long sleeves as the plant can cause blistering.
Cut/mow: Ineffective. Regular mowing is likely to favor this plant's growth.
Till/cultivate: Moderately to highly effective where possible. This plant will not survive routine cultivation. Cultivation is recommended in heavily infested pastures, but must be repeated for a couple of years and must be followed by reseeding.

Cultural

Reseed: Highly effective, especially as a follow up to other control measures. Seeds require open, disturbed areas to germinate.
Fire: Unknown.

Biological

Insects: None known.
Pathogens: *Sclerotinia sclerotiorum* is under investigation.
Grazing: Ineffective and poisonous, especially for cattle. When fresh leaves and stems are grazed they release toxic oil causing irritation and blistering of the skin, lining of the mouth and digestive tract. Because it is unpalatable, animals will avoid it if other forage is available. Hay containing tall buttercup is not harmful because the toxin does not survive the hay curing process but seeds may still be spread if the hay is moved off-site.

Chemical

Moderately to highly effective.
2,4-D + triclopyr (Crossbow): apply when plants are actively growing.
Aminopyralid (Milestone): apply when plants are actively growing.
Metsulfuron + aminopyralid (Chaparral): Apply to vegetative stage prior to bloom when plants are actively growing. .
Dicamba (Clarity): apply when plants are actively growing.
Triasulfuron (Amber): apply when weeds are less than 6″ tall.
Note: for grazed areas, animals should be removed following herbicide applications as plants are sometimes more palatable following herbicide application, increasing risk of poisoning.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Survey suitable habitat and pull plants before they flower, but check with a qualified botanist before initiating any control program to ensure the plant is not a native *Ranunculus* (see Figure B to differentiate it from *R. acriformis*). After removing it, reseed or replant bare ground to prevent it from re-infesting the area. This plant will most likely be a problem in grazed pastures where it will increase because it is unpalatable to livestock. For dense infestations, cultivation is recommended where possible. This may require a couple of years. Following cultivation, reseeding with competitive grass species should provide long term control. In natural areas where cultivation is not possible, herbicides may be necessary. This must be followed by revegetation to prevent reinfestation.

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Salsola tragus, Prickly Russian thistle


Left: Large shrubby growth form of prickly Russian thistle. By Forest & Kim Starr, U.S. Geological Survey, Bugwood.org. Right: red veining on stems. By Mary Ellen Harte, Bugwood.org.

Status: MT counties: Flathead (*Salsola kali*)
Park presence: CIRO, CRMO, GOSP, GRKO, LIBI

Identifying characteristics: Seedlings have finely dissected leaves that almost look like pine needles. Young Russian thistle plants resemble young halogeton plants, although halogeton lacks spines. Plant develop reddish stems, 8-36" long and small, indistinct, petal-less flowers in the upper leaf axils, surrounded by petal-like bracts. The leaves are narrow, alternate, and become stiff and spine-tipped in mature plants. Grows into large (+3'), round bushes that will dry, break off at the base, and tumble in the wind.

Life cycle: Germination normally occurs in late spring or early summer when moisture is available. Flowering occurs from midsummer to fall.

Spread: After the plant matures it detaches from the root system and tumbles in the wind, allowing long distance dispersal.

Seeds per plant / longevity: 2,000-100,000 / 1-2 years. Seed viability is rapidly lost in soil: over 90% of the seed either germinates or decays in the soil during the first year.

Habitat: The seed will not germinate successfully in firm soil-requires the soil to be loose. It's commonly found in vacant lots, abandoned gardens and agricultural fields, roadsides, fence lines, and any disturbed, open sites.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective. Young plants are easily pulled up. Large plants are tougher and require protection from the spines. Mature plants should be pulled or clipped at the base and bagged so they don't spread to new areas.
Cut/mow: Moderately effective for seedlings.
Till/cultivate: Ineffective. Tilled soil creates loose soil, ideal for germination.

Cultural

Reseed: Moderately to highly effective. Seeds need light to germinate and are not tolerant of competition. Planting competitive, desirable species can effectively prevent Russian thistle establishment.
Fire: Ineffective. Prescribed burning is not recommended for control of Russian thistle, since it favors disturbed communities and readily recolonizes burned areas.

Biological

Insects: In progress. May have potential in the future:
Coleophora klimeschiella and *C. parthenica*, two moth species.
Colletotrichum gloeosporioides a fungal pathogen.
Desertovellum stackelbergi , a gall midge
Grazing: Not recommended. Only young plants are suitable for livestock forage. Grazing is likely to open up the canopy, increasing seed germination.

Chemical

Rotate herbicides (refer to Table 7 and see herbicide groups with different modes of action). Some populations have developed resistance to chlorsulfuron (Telar, Corsair) or sulfometuron (Oust, Spyder) after only a few applications.
Apply herbicides to the early growth stages, preferably the early seedling stage, before plants become hardened and start producing the spiny branches, unless the herbicide is a preemergent. The following are described as moderately to highly effective: **2,4-D** (various trade names), **bromoxynil** (Buctril), **Dicamba + 2,4-D** (Weedmaster), **glufosinate** (Finale), **glyphosate** (various trade names), and **Paraquat dichloride** (Gramoxone, Cyclone, Firestorm), **simazine/prometon** (Princep, Pramitol), **trifluralin** (Treflan, Triflurex).

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

With persistence, eradication is feasible given short seed longevity. Monitor recently disturbed areas, hand pull plants when young and reseed disturbed areas wherever possible. Bag mature plants to prevent them from tumbling and spreading.

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Salvia aethiopsis Mediterranean Sage

Left: Basal rosette. Eric Coombs, Oregon Department of Agriculture, Bugwood.org.
Right: Flowering plant. L.L. Berry, Bugwood.org.

Park presence: Not reported in any of the parks.
Status: **ID**: control

Identifying characteristics: Leaves are covered with dense woolly hairs, especially when young and smell like sage when crushed. Rosette leaves become leafier, more fleshy and with prominent venations in 2nd year and plants may be 1' in diameter, but occasionally up to 4' diameter. Basal leaves have irregular, indented margins, range from 4–12" long, and have 1½-3½" stalks. Upper leaves are opposite, smaller and clasp the stem, with uppermost leaves decreasing to bracts with tapered points. Plants grow from a stout taproot. A single bolting stalk with a squarrish stem becomes highly branched with tiny flowers. The white to yellowish flowers are about ½" long and in clusters of 4-6. Flowers are shaped like other salvia plants: 2 upper petals form a hooked beak, the 3 lower petals form 3 lobes. Four smooth, egg-shaped seeds are produced per flower. As rosettes, they may resemble common mullein, but mullein leaves are not stalked, their margins are entire, and they don't emit a sage smell when crushed.

Life cycle: Biennial or short-lived perennial. Germination can occur in the spring or the fall. First year, it grows as a basal rosette, will send up a flowering stalk in the second year, typically in mid to late spring. It can flower from late spring to late summer. Plants may become dormant in summer to avoid drought. Most plants will die in late autumn after flowering.

Spread: Long distance dispersal possible via tumbling (stem has an abscission line 4-6" above ground where it breaks off after becoming brittle and light). It was originally introduced as an ornamental. Also spread by livestock, wildlife (including birds), roadside vehicles, contaminated gravel and agricultural crops (hay).

Seeds per plant and longevity: 50-100,000 / predicted to be more than 10 years (no formal studies)

Habitat: Primarily a rangeland weed and common on south-facing slopes in loose, gravelly soils. It's not palatable so it will increase with grazing. Adapted to dry, disturbed areas, but it can spread to non-disturbed land, particularly sagebrush/cheatgrass communities where it can reach dominance.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Moderately to highly effective. The taproot must be removed 2-3 inches below the crown to prevent resprouting. Recommended when plants just begin to bolt.
Cut/mow: Partially effective. To prevent seed formation it must be done several times during the growing season, but it will not affect the rosettes.
Till/cultivate: Moderately effective where feasible. Conduct prior to seed formation.

Cultural

Reseed: Information limited. Promoting healthy plant communities and reseeding sparse areas is likely to reduce invasion by Mediterranean sage.
Fire: Unknown.

Biological

Partially effective to ineffective. Recommended for large scale infestations where other efforts have failed.
-*Phrydiuchus tau*, European crown boring weevil. Larvae feed on root crowns, adults feed on foliage and flowering shoots. It reduces seed production, and density, but populations are slow to establish. While larvae can completely destroy the crown and associated meristematic tissues, this can result in the growth of new shoots, extending the longevity of the plant. Larger-crowned plants were targeted more frequently than smaller-crowned plants (Wilson and McCaffery 1993). This insect does best on warm, dry, sites, like south-facing slopes (Coombs et al 2004). It appears to do best in areas dominated by perennials that are not heavily grazed, and has less effect in salt-dessert shrub and sites with mainly annuals. Established in ID.
-*Stagmatophora pomposella.* The moth stage of this caterpillar is effective on first year rosettes only. Availability unknown.
Grazing: Ineffective. Not palatable. Effects with sheep, goats unknown.

Chemical

Information limited. Mediterranean sage is listed on only one herbicide label. There is not enough information to rate different herbicides and their effectiveness.
Picloram (**Tordon**): Apply during active growth prior to bolting stage. Lower rates in rate range may require annual spot treatments. Control with lower rates may be improved by tank mixing with 1.0 lb ae per acre of 2,4-D. Surfactant may improve efficacy, but if it causes foliar burn too rapidly, translocation will be impaired and control reduced. No other herbicides are labeled for this plant. Washington state control board lists **clopyralid** (Transline) along with **tordon** (Picloram) as potential herbicides.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Information on this plant is too limited to provide a specific IPM plan. Prevention, and monitoring to locate plants early in the invasion process is critical. Manual removal (with a trowel or shovel) should be used for new infestations to remove the plant and limit damage to the surrounding plant community.

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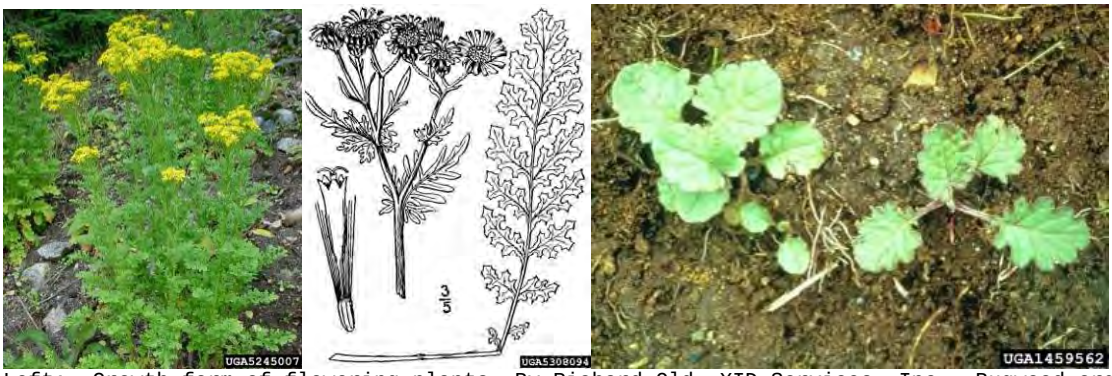
Senecio jacobaea Tansy Ragwort



Left: Growth form of flowering plants. By Richard Old, XID Services, Inc., Bugwood.org. Center: leaf and flower line drawing showing dissected leaves. From: Britton, N.L., and A. Brown. 1913. Illustrated flora of the northern states and Canada. Vol. 3: 542. USDA NRCS PLANTS Database, Bugwood.org. Right: Seedlings. By Steve Dewey. Utah State University Archive, Utah State University, Bugwood.org

Park presence: Not reported in any of the parks.
Status: ID: contain **MT**: priority 2A

Identifying characteristics: Rosettes are stalked with dark green leaves that are somewhat hairy on the underside, appearing whitish. Leaves are deeply indented, with blunt toothed lobes. Plants bolt in the second year, reaching heights of 1-5 feet. Leaves on flowering stems are alternate, lobed, and sessile. Yellow flowers grow in flat topped clusters. On each flower, there are typically 13 ray flowers. This plant is similar to *Tanacetum vulgare* (common tansy), except *T. vulgare* has disc flowers only (button-shaped in appearance, no ray flowers or standard petals)

Life cycle: Plants grow mostly as biennials, but also as winter annuals, and occasionally as perennials (especially if disturbed). Seeds typically germinate in the fall (occasionally in spring, depending on location and moisture), and plants bolt the following growing season. Flowering occurs from late summer into the fall. Plants usually die after flowering, but the crown and the root system may produce new rosettes, especially if mowed or clipped.

Spread: Long distance dispersal is possible by water, when seeds adhere to animals, or survive through their digestive tracts. In one study 60% of seed fell within 7 feet of the parent plant and wind is unlikely to carry it more than 46 feet (Jacobs 2009). Crown buds, root fragments or intact roots may also create new plants, particularly after a disturbance.

Seeds per plant / longevity: 5,000 to 200,000 / 10-16 years

Habitat: Tansy ragwort is most common on disturbed sites like roadsides, pastures, and forested areas, particularly following timber harvests or wildfires (not shade tolerant, so thrives after such disturbances).

CONTROL OPTIONS

Mechanical

Hand pull/grub: Partially to moderately effective. Strongly recommended for small infestations. Pulling should be done when the soil is moist to help remove the whole root, as tansy ragwort will resprout from root fragments. Seeds require light to germinate, and pulling will disturb the soil and is likely to bring additional seeds to the surface. Check the area at regular intervals and pull new seedlings.
Cut/mow: Ineffective. Mowing will stimulate vegetative growth, leaving roots intact. Mowing can also convert it to a perennial with many flowering stems (Mitich 1995). Mowing or cutting prior to seed set is ineffective as plants can still re-flower later in the season.
Till/cultivate: Ineffective.

Cultural
Reseed: Moderately to highly effective. Plants can not or rarely invade a closed canopy. Seedlings require sunlight and disturbance to establish. Competition from surrounding plants can increase seedling mortality.
Fire: Unknown. Prescribed fire during its reproductive stage may reduce it. Until more information is available, it's not recommended. Given its ability to rapidly invade following timber harvesting, such disturbance is likely to favor its invasion.

Biological
Insects: Moderately to highly effective. ***Longitarsus jacobaeae*** (root feeding flea beetle) larvae injure or kill plants by feeding on roots, adults feed on leaves. It is established in ID, MT, WA, OR and CA. ***Tyria jacobaeae*** (Cinnabar moth) larvae feed on foliage. It thrives at elevations less than 3,000 feet, but occurs at sites up to 5,000 feet in Montana. The cinnabar moth may not be permitted to be moved from state to state due to non-target concerns. It may severely defoliate *Senecio triangularis* (native), the ornamental dusty miller (S. bicolor), and *Packera psuedaurea* (stream bank butterweed), It is established in CA, OR, WA and northwestern MT. It should not be introduced to new area where it may impact native *Senecio* or *Packera*. ***Pegohylemyia seneciella*** (aka *Botanophila seneciella,* seedhead fly) larvae tunnel into and consume the receptacle. The fly is the least effective (it does better along the west coast). Good results may be obtained with the cinnabar moth and flea beetle or flea beetle alone (Littlefield, personal communication). There are different populations of the flea beetle (Italian & Swiss). The Italian populations do well along the West Coast whereas the Swiss are established in more continental climates (but somewhat limited in availability).
Grazing: Moderately effective with sheep only. This plant is toxic to cattle, horses, and to lesser extent-goats. Cattle will avoid mature plants, but they may accidentally graze immature plants (earlier in the growing season). Plants are palatable and meet nutrient requirements for sheep (Jacobs 2009). Targeted grazing with sheep has been very effective at controlling this plant in New Zealand. However, preventing overgrazing is critical. Grazing is effective only when used in competitive grasslands. Pastures with more than 25% bare ground are 40 times more likely to be invaded by tansy ragwort compared to those with less than 25% bare ground (Jacobs 2009).

Chemical
Moderately to highly effective.

2,4-D: from rosettes to before flowers open, or to new growth following fall rains. **2,4-D + dicamba** (Weedmaster): up to flowering stage. **Aminopyralid** (Milestone): up to flowering stage. **Dicamba** (Banvel, Clarity): up to flowering stage. **Metsulfuron** (Escort): to actively growing plants (see label for use of a surfactant). **Metsulfuron + dicamba + 2,4-D** (Cimarron Max): to actively growing plants prior to flowering. **Picloram** (Tordon): up to the flowering stage. **Triclopyr + 2,4-D** (Crossbow): before flowering.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Limit disturbance, and reseed disturbed areas quickly as seedlings require light to germinate and respond poorly to competition. Hand pull small infestations. For slightly larger patches, target with herbicides to prevent spread. The three biological control agents are strongly recommended for larger infestations, and may be combined with sheep grazing.

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Sonchus arvensis Perennial sowthistle

Left: Dandelion-like flower heads with bristly hairs on bracts. By Tom Heutte, USDA Forest Service, Bugwood.org Center: Growth form of flowering plant. By Steve Dewey, Utah State University, Bugwood.org.
Right. Prickly edges, and clasping base of stem leaves. By Michael Shepherd, USDA Forest Service, Bugwood.org.

Park presence: CIRO, GRKO
Status: **ID**: control **MT counties**: Choteau, Powder River **WY**: noxious

Identifying characteristics: Flowers resemble a dandelion, bright yellow in color, and 1½-2″wide, and flower bracts are bristly with sticky hairs (see photo above left). Stems are glabrous below, hairy above, branched near the top (see photo above center), and range in size from 1½-6′. Stems are erect, hollow, ridged and exude a bitter milky juice. Leaves are alternate, light green in color, and have prickly edges, pointed lobes, and a clasping base (see photo above right). Upper leaves are smaller and fewer than basal leaves. The oblong seeds are dark reddish-brown and notably ridged and wrinkled with a soft white tuft of many fine, barbed hairs

Life cycle: Perennial. Seedlings typically do not flower until the second year, but late summer flowering of first-year seedlings can occur under optimal conditions. In the spring, flowering stems begin to develop when plants have 12 to 15 leaves. Flowering occurs from mid to late summer, but can continue until the first frost. Seeds mature approximately 10 days after flowering.

Spread: Plants spread rhizomatously and by seed. Root sections as small as 1 cm can develop into new plants. Seeds have a hairy pappus and are hooked allowing them to disperse by wind, water, and by clinging to fur or feathers of animals and clothing of people. Disturbance increases emergence, and germination is inhibited by light. Plants are most often spread along roadsides and other frequently disturbed areas.

Seeds per plant and longevity: 1,000-8,000 / Seed longevity is relatively low for sowthistle, estimated at less than 4 years.

Habitat: Typically found in cultivated fields, disturbed areas, waste grounds, meadows, sloughs, woods, lawns, and along roadsides, ditches, and river banks, and lake shores. It is able to invade wet areas with little disturbance, but unlikely to invade or thrive on dry, coarse-textured sand.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Partially to moderately effective. Recommended for small infestations only. Bag plants that have flowered, as immature seed can continue to mature on cut stems.
Cut/mow: Partially effective to ineffective. Mowing would need to be done repeatedly during the growing season to control stem growth, prevent flowering, and seed production. Mowing can stimulate new plant growth that forms from rhizomes, increasing density. See glyphosate under the herbicide section for combining mowing with herbicides.
Till/cultivate: Partially effective to ineffective. If tilling could either deeply bury root fragments below 12" or leave them on the soil surface to desiccate, it could reduce infestations. If tilling is used, the optimal timing to reduce root energy reserves is when plants are in the 6-9 leaf rosette stage. See glyphosate under the herbicide section for combining tilling with herbicides.

Cultural

Reseed: Moderately effective. It occurs primarily in disturbed places. Reseeding recently disturbed or depauperate areas should reduce or prevent establishment.
Fire: Unknown. Will likely kill top growth, but not affect roots and rhizomes. Further research is needed to determine the effects of prescribed burns for sowthistle control. Plants are "likely to survive and persist on burned areas, even after high-severity fire, and the limited available data on post fire response of perennial sowthistle indicate little difference in abundance between burned and unburned sites" (FEIS).

Biological

Insects: Three insects have been released for biocontrol in Canada, but their status in the US is unknown. Larvae of ***Cystiphora sonchi*** forms galls on the leaves. Larvae of ***Liriomyza sonchi*** mine the leaves. Larvae of ***Tephritis dilacerata***, forms galls in the flower buds. Only ***C. sonchi*** has established in Canada (Harris and Peschken 2004).
Pathogens: Numerous pathogens are in development but none are commercially available at this time.
Grazing: Moderately effective. Cattle and sheep will graze on new growth, effectively weakening the plant and reducing infestations.

Chemical

Partially to moderately effective. This plant is relatively resistant to many common herbicides.
Aminopyralid (Milestone): apply to pre-bud, bud stage when plants are actively growing.
Dicamba (Banvel): Apply when plants are actively growing. Sowthistle may be controlled using lower rates than those recommended for other listed perennial weeds (see rates and timing on the label).
Glyphosate (Roundup): Apply when most plants are at or beyond the bud stage of growth. After harvest, mowing, or tillage in the late summer or fall, allow at least 4 weeks for initiation of active growth and rosette development prior to the application of this product. Fall treatments must be applied before a killing frost.

Picloram (Tordon): Apply when weeds are small and actively growing in the spring before full bloom. A retreatment program may be necessary for satisfactory control.
Aminopyralid + metsulfuron (Chaparral): Apply to vegetative stage prior to bloom.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Information on control of sowthistle in natural areas is very limited, as is information on its impacts on natural areas. In Saskatchewan, managers ranked it as having a relatively low impact, but as hard to control (Sumners 2007). This plant is resistant to common herbicides, but seedlings are easily controlled with mechanical and chemical treatments. Managers may be able to only chip away at established populations (with herbicides, hand pulling), but they should actively scout for new populations and eradicate them before they establish. Scouting should focus on roadsides and recently disturbed areas. Reseeding recently disturbed areas is strongly recommended to prevent establishment.

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Tamarix ramosissima Saltcedar

Left: Growth habit of flowering plant. By Steve Dewey, Utah State University, Bugwood.org.
Right: Dense populations in a riparian area. By Steve Dewey, Utah State University, Bugwood.org

Park presence: GOSP, HAFO, LIBI. Eradicated from FOBU prior to 2009.

Status: **ID**: contain **MT**: priority 2B **UT**: contain **WY**: noxious

Identifying characteristics: Much of the invasive saltcedar in the US is a hybrid between *T. ramosissima* and *T. chinensis* (Gaskin and Schaal 2002). They are difficult to distinguish (microscopic floral characters, such as where the filament is inserted into the nectary disk are used to differentiate them). Until more information is available, this summary does not provide separate recommendations for *T. ramosissima*, *T. chinensis* or hybrids. Saltcedar plants grow as shrubs or small trees, 5-13 feet tall. Glabrous branches are slender, with small, alternate, scale-like leaves (less than 1/16th of an inch), resembling cedar or juniper leaves. Leaves are rhombic to ovate, sharply pointed or gradually tapering. Flowers are pale pink to white in spike-like racemes. The distinct petals and sepals occur in fours or fives. The fruit is a capsule, containing thousands of tiny seeds.

Life cycle: Seedlings grow rapidly and can flower in the first year, but it typically takes 3 years. The flowers are most abundant from mid-spring to late summer, but may be found most of the year. Plants reportedly have one major and one minor peak of seed production over a 5.5 month period. Stems may die to the ground over winter and re-sprout to form multiple stemmed plants, typically less than 10 feet tall. Stems may grow up to 13 feet per season.

Spread: Spreads by seed and vegetatively by adventitious roots or submerged stems. Tiny seeds (1/25-inch diameter) have a tuft of hair for wind dispersal. Seeds can also spread by water. Seedlings require extended periods of soil saturation for establishment.

Seeds per plant / seed longevity: 500,000 / probably less than 2 years.

Habitat: Seedling establishment is greatest where soils are seasonally saturated at the surface and plants are most common on moist sand along river margins. It grows rapidly on river floodplains in arid and semi-arid climates. It may also grow in pastures, irrigation ditches, moist

lowlands and stream banks. It occupies the niche usually associated with willow and cottonwood. It is adaptable and tolerates a wide range of soils and environmental conditions including saline soils (up to 15,000 ppm sodium). Plants prefer full sun and do not tolerate shade from larger cottonwood or willow species.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective for very small, new patches. Until the stem diameter exceeds 1.18 inches (3 cm), saltcedar can be pulled up with relative ease while the soil is moist. Pulled plants must be removed from their growing site and bagged or dried to prevent re-sprouting and sites should be monitored for resprouts.
Cut/mow: Moderately effective. Saltcedar has been killed by frequent foliage removal, although mortality rates varied between treatment years. Mortality increases when plants are completely defoliated at frequent intervals. One season of mowing will not kill plants. Mowing or cutting may improve herbicide efficiency.
Till/cultivate: Ineffective.

Cultural

Reseed: Moderately effective. Plants do not tolerate shade from willows, or cottonwoods. For existing patches, revegetation (e.g. willow sprigs) is recommended after other control measures have reduced saltcedar.
Fire: Ineffective. Plants can resprout after fire.

Biological

Insects: Limited availability. The leaf beetle, *Diorhabda elongata* was released in Oregon, Nevada, Utah, Wyoming, Colorado, Montana, New Mexico and Texas. Its status is pending because in some areas it has so rapidly defoliated saltcedar, it reduces habitat and nesting sites for the endangered southwestern willow flycatcher (*Empidonax traillii extimus*). In Montana, this beetle has reduced populations on the Big Horn River, but it has failed to establish on the Fort Peck Reservoir in Montana. It is unknown if this due to predation, or climatic factors (Jacobs 2007). It may also be related to genotypic differences in plants, for example the insect's potential preference for *T. ramosissima* over a hybrid or vice versa (Gaskin and Schaal 2002). Its status is pending.
Grazing: Partially effective. Cattle will eat young shoots, but the disturbance in a riparian area would likely exacerbate the problem. If fenced in, Boer goats have been used effectively to reduce dense stands (Jacobs 2007).

Chemical

Moderately to partially effective. Ratings (good, fair, poor) provided when available from Dewey et al 2006.
Herbicide treatments for saltcedar are divided into three methods (Jacobs 2007):
1. Basal bark treatments: a single low volume basal bark treatment for scattered individual shrubs. Spray until thoroughly wet, but not to the point of runoff. The entire circumference of all stems including the root collar area from the ground up to 18 inches must be covered. Apply anytime including winter, except when the bark is frozen, when snow or water prevents spraying to the ground line, or when the stems are submerged in water. It may take one or two years for the herbicide to move throughout the plant, especially the roots, and for plants to die.

2. Cut stump treatments: cut stems using a saw or loppers and apply undiluted herbicides directly to the cut stem. Herbicides must be applied immediately to the cut because wound healing is fast and decreases herbicide penetration. Herbicide should be applied to wet the wood and surrounding cambium around the entire circumference of the cut stump. Apply any time of year except when stems are frozen or when plants are under water stress during late summer.
3. Foliar applications: for dense stands with a solid canopy where basal bark or cut stump are not practical. The best control is obtained when applied in late summer or early fall

Fair: **Glyphosate** (Roundup or Rodeo near water): Apply a 50- to 100-percent solution of this product to the freshly cut surface immediately after cutting. Delays in application may result in reduced performance. For best results, applications should be made during periods of active growth and full leaf expansion. May also be applied as a foliar spray when plants are actively growing.
Poor: **Banvel, Clarity, Tordon**
Not rated: **Triclopyr** (Remedy, Garlon 4). Cut stump: apply 100% v/v to wet circumference of cut stump. Apply year round, but avoid drought conditions. Low-volume basal bark: apply with oil-water mix at 20-30% v/v to thoroughly wet lower stems, including root collar. Apply year round unless snow covers root collar.
Imazapyr (Habitat). Spot spray: apply to actively growing foliage.
Comments: In Montana, basal bark treatment with 30% triclopyr in an oil carrier is described as the most effective (Jacobs 2007). The entire circumference of each stem from soil level to 18 inches up the stem needs to be evenly coated with the spray solution. A single application may cause the shrub to die in one two seasons.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Saltcedar is infamous for its ability to re-sprout after fire, flood or herbicide treatments. Management of saltcedar requires a long-term commitment to maintain it at low levels and prevent re-infestation. However, if the patch is not large, eradication is possible through a combination of treatments, and by monitoring the area regularly to identify and remove seedlings or re-sprouts. Basal bark treatment is considered very effective. For small stands of mature shrubs, cutting followed immediately by application of herbicide to stump ends is also very effective. For areas where native riparian species have been eliminated, revegetation using willow sprigs or other methods is recommended to provide long-term suppression.

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Tanacetum vulgare Common tansy

Left: Serrated, fern-like foliage and clusters of yellow, button-like flowers (consist of disc flowers only, no ray flowers). Right: growth form of flowering plant. Both photos by Steve Dewey, Utah State University, Bugwood.org

Park presence: BIHO, CRMO, GOSP, GRKO
Status: MT: priority 2B **WY**: noxious

Identifying characteristics: Plants grow up to five feet tall, have shiny, serrated, fern-like foliage, and clusters of button-like yellow flowers. Flowers consist of disc flowers only, no ray flowers (photo above left). Leaves are alternate, sessile or with a short petiole and smell like menthol or camphor when crushed.

Life cycle: Perennial, reproduces by seed and rhizomes. Buds along the rhizomes can grow into shoots or roots. Plants usually germinate or emerge after native grasses in the spring. Flower buds form in late spring to early summer. Flowering occurs from mid-summer to early fall.

Spread: Seeds have no mechanism for long distance dispersal. Seeds remain in the flower heads throughout the fall unless the stems are broken. Plants spread vegetatively when roots are fragmented. Rhizomatous spread is slow in vegetated areas, but rapid in disturbed areas or where vegetation is sparse.

Seeds per plant / longevity: ~2,500 seeds/unknown possibly less than 2 years. Rhizome fragments: 3-4 years

Habitat: Plants prefer open sites. They are common along roadsides and railroads, fields and pastures, ditch banks, riparian areas, and other moist places. Often co-occurs with smooth brome (*Bromus inermis*). Also occurs in gardens where they were intentionally planted.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Partially to moderately effective. Strongly recommended for small, recently established patches. Persistent hand pulling and grubbing that removes the rhizomes will reduce small-scale populations.
Cut/mow: Moderately effective. Mowing before bloom and repeated whenever plants reinitiate flowering will reduce seed. Mowing is most effective when patches are surrounded by perennial grasses which respond well to mowing.

Till/cultivate: Partially effective to ineffective. Not recommended. Where regular tillage can be implemented, it can control common tansy on croplands in rotation. For wildland sites, tillage will spread rhizomes and would need to be followed by other aggressive measures (herbicide and reseeding).

Cultural

Reseed: Strongly recommended to prevent establishment. Healthy plant community will reduce the spread of common tansy, as the seedling is tiny and not considered competitive. However, mature plants have a shallow but extensive root system that can occupy most of the upper two feet of the soil profile beneath a plant making common tansy competitive for soil moisture and nutrients. Existing stands would need to be controlled before reseeding.

Fire: Unknown. Controlled spring burns may clear vegetation, making the plants easier to target with herbicides or grazing, but it also makes the site more vulnerable to other invasive species.

Biological

Insects: Not available at this time.

Pathogens: Not available at this time.

Grazing: Moderately to highly effective with sheep (or goats). Horses and cows may browse it, but only when leaves are young. For dense stands of common tansy, domestic sheep can graze it down to release grasses from competition. Sheep should be removed from area four weeks prior to breeding to avoid risk of reproductive problems (Jim Jacobs, personal communication).

Chemical

Ratings of excellent, good, fair, poor provided when available from Dewey et al 2006.

For all herbicides: apply to young actively growing plants before bloom.

Excellent: **Metsulfuron** (Cimarron, Escort)

Good: **metsulfuron + dicamba + 2,4-D** (Cimarron Max); **Picloram + 2,4-D** (Grazon P+D); **Chlorsulfuron** (Telar); **Picloram** (Tordon)

Fair: **Dicamba** (Banvel, Clarity), **Clopyralid + 2,4-D** (Curtail)

Poor: **2,4-D**

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Identify new plants and target them aggressively with hand pulling or herbicide before they can establish. For large scale populations, combine mowing, grazing and/or herbicides. Reseed following other control efforts to prevent reestablishment.

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Tragopogon dubius Western Salsify




(a) **(b)** **(c)** **(d)**

(a) Growth form of a flowering plant. By Dave Powell, USDA Forest Service, Bugwood.org. **(b)** Seedling (with seed covering still attached). Resembles a grass. By Joseph M. DiTomaso, University of California - Davis, Bugwood.org. **(c)** Yellow flowers. By Dave Powell, USDA Forest Service, Bugwood.org. **(d)** Dandelion-like form of mature flowers composed of a long beak and mature hairy pappus.

Park presence: BIHO, CRMO, FOBU, GOSP, GRKO, LIBI
Status: not listed

Identifying characteristics: This tall (1-3 feet tall), tap rooted biennial contains milky white juice when stems or leaves are broken. Leaves are up to 12 inches long, clasping, alternate and grass-like (seedlings are commonly mistaken for grasses, Figure b). Flower heads have yellow ray flowers (Figure c), 1 to 2½ inches across that form on long, hollow peduncles (stems). Flower heads open and point towards the sun in the morning, follow the sun until midday and close during the afternoon. Ten to 14 bracts surround each head and the bracts are slightly longer than the ray flowers. The plant is most distinct when it sets seed, resembling a dandelion, with fruiting heads 2 ½ to 4 inches across (Figure d). This plant resembles meadow salsify (*Tragopogon pratensis*). Western salsify has hollow stems that are inflated below the flower head. Meadow salsify has solid stems that are not inflated below the flower.

Life cycle: Biennial to short lived monocarpic perennial (flowering occurs in the second or subsequent years of growth and the plant dies after flowering). Flowering can occur throughout the growing season, ranging from mid-spring to mid-fall, depending on climate and elevation. Majority of seeds germinate in two periods, in the fall and the early spring.

Spread: The hairy pappus on the seed and the tall stature of the plant allows long distance dispersal via wind.

Seeds per plant and longevity: Highly variable, approximately 100 seeds per flower, and 2 to 11 flower heads per plant / less than 5 years

Habitat: Given an opening in the canopy, it is able to establish in nearly any vegetation or community type. It is most common in disturbed sites, but it is able to establish in intact to moderately grazed grasslands.

CONTROL OPTIONS

Mechanical

Hand pull/grub: Highly effective. Use a trowel to excavate the stout taproot to prevent it from resprouting.
Cut/mow: Information limited. Mowing as soon as flowers appear, but before they mature may reduce seed dispersal, but plants will send up new shoots.
Till/cultivate: Ineffective. This plant is typically not a problem in cultivated fields, but cultivation would need to be a regular, ongoing practice, which is not reasonable in the majority of the parks.

Cultural

Reseed: Partially to moderately effective. Germination, growth and reproduction are reduced with increasing plant cover (Gucker 2008).
Fire: Partially effective to ineffective. Existing plants will die from a fire, but yellow salsify typically emerges post-fire from seed off-site. In a number of studies, salsify densities were not significantly different in burned compared to unburned plots (Gucker, 2008).

Biological

Insects: not available
Pathogens: not available
Grazing: Partially effective. This plant can be interpreted as a sign of overgrazing, but it also occurs in pastures protected from grazing (Gucker 2008). Prescribed grazing that maintains the health of the plant community and stimulates grass cover should help suppress it, but overgrazing will increase it.

Chemical

Partially effective.
Metsulfuron + chlorsulfuron (Cimarron Plus): treat when weeds are less than 4" tall or in diameter and are actively growing.
Imazapyr + metsulfuron methyl (Lineage Clearstand): Apply to young, actively growing plants.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

The majority of occurrences of yellow salsify are described as infrequent, occasional, locally common, or scattered (Gucker, 2008). A Montana flora describes it as a “harmless” introduced species (Lackschewitz, 1991). It is palatable to wildlife and contributes to the diets of elk, deer, pronghorn, birds (including sagegrouse), and various small mammals (Gucker 2008). However, management may be considered necessary from an aesthetic and historical perspective, as its tall stature makes it stand out in the landscape. Additionally, the plant has been observed increasing on CRP (conservation reserve program) lands in central Montana (Jane Mangold, personal communication). While it is palatable to wildlife, its increase in CRP lands poses risks (costs from herbicides, or other control methods) to surrounding croplands.

The best management strategy is to utilize cultural practices (reseeding, prescribed grazing) to improve the health of the existing plant community as neighboring vegetation should reduce the survival, growth, and reproduction of this plant (Gucker 2008). Research on herbicide efficacy is limited. However, research on sagegrouse habitat that recorded forb responses to various disturbances (fire, herbicide application, and grazing by cattle and sheep) found western salsify was undamaged and increased following herbicide application (Miller and Eddleman 2000). Herbicides alone are likely to open up the plant community and increase the prevalence of other weeds. Considering the benefits of this plant to wildlife, the typical sparse distribution, and the lack of effective control strategies, efforts may be best directed towards other weed species with higher impacts. However, managers should check in with weed coordinators, university extension agents, or other reliable weed specialists to determine if new research on effective control strategies becomes available.

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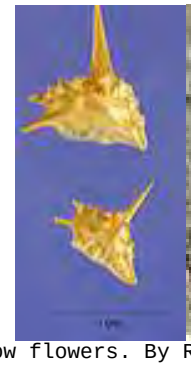
Tribulus terrestris Puncturevine




Left: Compound leaves and small yellow flowers. By Richard Old, XID Services, Inc., Bugwood.org.
Center: Sharp, thorny seeds can puncture bike tires. By Steve Hurst @ USDA-NRCS PLANTS Database.
Right: Seedlings. By Phil Westra, Colorado State University, Bugwood.org.

Park presence: CRMO, GOSP, HAFO
Status: ID: contain **UT counties**: Cache, Weber

Identifying characteristics: Plants are low trailing, to somewhat upright, mat forming, and highly branched. Dense mats may reach 5 feet in diameter. Opposite leaves are divided into 4 to 8 pairs of leaflets (above left). Leaves are hairy and about 1/4 to1/2 inch in length. Bright yellow, five-petaled flowers are 1/3 to 1/2 inch wide. Fruits consist of five sections that break into tack-like structures or burs at maturity (center). Burs are hard and extremely sharp.

Life cycle: Annual. Reproduction is by seed only. Seeds germinate in late spring and early summer. Flowers may form within three weeks and continue for several months. Fruits are produced through summer and fall.

Spread: The hard, extremely sharp spines on seed adhere to tires, and animals.

Seeds per plant/seed longevity: 800-1600 seeds/3-7 years

Habitat: It's found in pastures, roadsides, orchards, waste places, and agricultural areas. High temperatures are required for germination and growth, but it is highly adaptable to a range of conditions. It prefers light-textured soils, but will grow on almost any soil type

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CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective. Strongly recommended for small infestations when the soil is moist. Cut the plant off at the root with a hoe.
Cut/mow: Ineffective. Not recommended based on the low growth form.
Till/cultivate: Partially effective. Shallow cultivation and hoeing can reduce populations and limit spread of the plant if conducted prior to flowering and seed production. Cultivation should be repeated to prevent bur formation.

Cultural

Reseed: Moderately effective and strongly recommended. It most often occurs in disturbed areas. Healthy plant communities can outcompete this species.

Fire: Unknown, but not recommended as opens up the community to other invasive species.

Biological

Insects: Partially to moderately effective. Establishment may be limited by the cold climate in ID, MT and WY.

Microlarinus lareynii (puncturevine seed weevil) larvae consume fruits and seeds, adults eat stems, leaves, buds, flowers and fruits. (Coombs et al 2004). ***Microlarinus lypriformis*** (puncturevine stem weevil) larvae feed on stems and root crowns, adults feed on leaves and stems. Both weevils are sensitive to cold temperatures and as of 2004, they have established only in UT (and many other states outside of the four covered here, the northernmost one being OR).

Pathogens: N/A

Grazing: Not palatable, and harmful if ingested.

Chemical

Glyphosate (Roundup): see label for rates depending on plant size. **Dicamba** (Clarity): apply when plants are small and actively growing, prior to flowering. **Picloram + 2,4-D** (Grazon P+D): apply prior to flowering when actively growing.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

The main impacts are on livestock and recreationists due to the hard, spiny burs of the plant. Burs can injure the mouths and digestive tracts of livestock, or pierce thin soled shoes, bare feet, or bicycle tires. Its impacts on plant community composition and ability to crowd out other species are lacking. Best management practices are to clean tires, and soles of shoes regularly to prevent further spread, and prevent off road vehicle use to keep it from spreading beyond roadsides. For small infestations, frequent monitoring and hand pulling before flowering should be done consistently.

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Verbascum blattaria Moth mullein



Left: Showy flowers may be yellow or white. By John Cardina, The Ohio State University, Bugwood.org. **Center:** After flowering, plants look unique in the landscape. Solitary stems are upright and the round pods (developing seeds) face upwards on short, 1" long stems. The Ohio State University, Bugwood.org. **Right:** Basal rosette. By Theodore Webster, USDA Agricultural Research Service, Bugwood.org

Park Presence: CRMO, GOSP
Status: Not listed in ID, MT, UT, or WY.

Identifying characteristics: The basal rosette may be up to 16" in diameter (above right). Dark green leaves are deeply- and irregularly-toothed, lack hairs or are sparsely hairy and have prominent veins. Erect, solitary flowering stems form in the second year, and may grow 1.5-5' tall. White to yellow flowers are loosely clustered at the top of the stem on 1" long stalks (above left). Flowers are deeply five-lobed, have a tinge of purple at the center and form a saucer-like shape less than 1 inch in diameter. The five stamens are orange with purple hairs. Seedlings are very similar in appearance to common mullein but lack hairs. Plants have a tap-root and fibrous root system.

Life cycle: Biennial reproduces by seed only. Rosette forms in first year; flower stalk emerges in second year, and blooms throughout summer (June, July, August).

Spread: Seed falls close to the plant, with no mechanism for long distance dispersal. The fruit is a round capsule.

Seeds per plant and longevity: +20,000 / +90 years

Habitat: Moth mullein is most common in abandoned areas, pastures, meadows, old fields, right-of-ways, and open woods. It typically grows in full sunlight, and is adaptable to moist or dry conditions. It prefers rich soils, but it is tolerant of, sandy or gravelly soils. It prefers highly disturbed areas and is not considered invasive of natural areas to any significant degree.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Strongly recommended. This is best done in moist soil. If soil is dry, use a trowel or shovel to excavate slightly below the soil line.

Cut/mow: Cutting recommended only if done below root crown, and prior to seed production. Mowing is ineffective.
Till/cultivate: Moderately effective if done prior to seed production and followed by reseeding of desirable species.

Cultural
Reseed: Strongly recommended. Bare ground is prime habitat for moth mullein invasion. Any disturbances such as overgrazing, or off-road vehicle use should be reseeded. Planting desirable native species can decrease the amount of open niches that Moth mullein needs to establish in. Contact your local Natural Resources Conservation Service for seed mix recommendations.
Fire: Not recommended. It will create conditions ideal for invasion.

Biological
Insects: *Gymnetron tetrum*, a seed eating weevil is under investigation but status is pending.
Pathogens: Not available.
Grazing: Not recommended. It will increase with grazing.

Chemical
Moderately effective.
Aminopyralid (Milestone): Apply when plants are in the rosette to bolting growth stages. **Metsulfuron** (Escort): apply when plants are bolting. **Chlorsulfuron** (Telar): apply when plants are bolting.

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Manage native plant communities to limit disturbance, and reseed opens niches to prevent moth mullein establishment. Hand pull rosettes and bolting plants before they flower in the spring when soil is moist. If plants are flowering, clip off flowering stalk and put into a plastic bag, then hand pull the plant, using a trowel to excavate slightly below the soil surface. Seed can remain viable for 100 years, so monitor the site yearly, and reseed open niches. For large patches, begin at the exterior, and work inwards, hand pulling or spot spraying. Reseed bare areas after plants are removed.

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Verbascum thapsus Common mullein

Left: Basal rosette by Forest & Kim Starr, U.S. Geological Survey, Bugwood.org. Right: Growth form of flowering plant by Ted Bodner, Southern Weed Science Society, Bugwood.org.

Park presence: BIHO, CIRO, CRMO, FOBU, GOSP, GRKO, LIBI, MIIN
Status: MT counties: Beaverhead, Deerlodge, Lewis and Clark, Madison, and Yellowstone

Identifying characteristics: First year rosette leaves are felt-like soft, and bluish- green in color. In the second year a single, stout erect stem grows 2 to 8 feet tall, and has large, fuzzy, alternate leaves. One or more long terminal flower spikes develop per stem. Flowers are 5-lobed and sulfur to pale yellow in color. After flowering, the tall brown stalks remain standing throughout the winter.

Life cycle: Biennial. It grows as a rosette in the first year, the flower stalk emerges in the second year, and it blooms throughout the summer (June-August). The length of the flowering period is a function of stalk height; longer stalks can continue to flower into early October. The plant grows from a stout tap root, there is no vegetative spread.

Spread: Seeds typically do not fall far from the parent plant.

Seeds per plant/seed longevity: 150,000 / 100 years

Habitat: Mullein prefers dry, sunny, gravelly sites, but will appear on various exposed soils. It is one of the first weeds to germinate in a disturbed site.

CONTROL OPTIONS

Mechanical
Hand pull/grub: Highly effective if done prior to seed production.
Cut/mow: Ineffective unless done below root crown (with pruners), and prior to seed production.
Till/cultivate: Moderately effective if done prior to seed production. It must be followed by some other treatment to suppress new weed seed brought to the surface.

Cultural
Reseed: Moderately to highly effective and strongly recommended.
Fire: Not recommended

Biological
Insects: Moderately effective. Described as highly successful in WA. Information for ID, MT, UT or WY is limited.
-*Gymnetron tetrum*, mullein seed-eating weevil. Larvae are laid in seed capsules, feed on seeds and chew holes in seed capsules to escape. Check your county extension office for availability.
Pathogens: None available.
Grazing: Not palatable to livestock

Chemical
Moderately to highly effective. Given longevity of seed, it must be done in combination with other treatments for areas where it has established. Check labels for need for surfactants, which are typically necessary given hairy surface. Apply to actively growing rosettes. Ratings from Dewey et al 2006.
Excellent: Metsulfuron (**Cimarron, Escort**)
Good: **Metsulfuron + dicamba + 2,4-D** (Cimarron Max), **Picloram + 2,4-D** (Grazon P+D), **Glyphosate** (Roundup)
Fair: **2,4-D**, **chlorsulfuron** (Telar), **Picloram** (Tordon)

INTEGRATED PEST MANAGEMENT (IPM) RECOMMENDATIONS

Bare or recently disturbed sites are highly vulnerable to common mullein establishment. Reseeding is strongly recommended (Hoshovsky 1986) to prevent this. Mullein seedling growth rates were 4-7 times faster in bare soils compared to vegetated soils, and biomass of plants in unvegetated areas was 2000 times greater than vegetated areas. For established populations, a minimum control strategy should include bagging flowering stalks before seed matures. A more aggressive strategy is to spray or hand pull plants, reseed, and spot spray plants that will emerge in subsequent years. For large infestations, where resources aren't available for manual or chemical control, managers should contact their county extension agents regarding information on local establishment and the availability of a biocontrol.

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Glossary

alternate: Referring to a leaf or bud arrangement in which there is one bud or one leaf at a node (compare to opposite).

allelochemical: A substance produced by members of one species that influences (typically negatively) the behaviour or growth of members of another species.

allelopathy: Ability of one species to influence (typically negatively) the behaviour or growth of members of another species.

annual: A plant that lives one year or less. A winter annual germinates late one growing season and produces seed and dies during the next growing season.

appressed: Pressed close to or lying flat against

auricles: An appendage, which may resemble the ear of an animal, occurring at the base of a leaf-blade.

awns: a slender hair-like or bristle-like appendage on the spikelets of some grasses

basal: Refers to the base (of the plant or a structure on the plant).

biennial: A plant that lives for two growing seasons, normally producing a basal rosette the first year and the flower and fruit the second year.

bract: A small leaf-like structure surrounding or subtending the flower, usually below the petals.

capsule: Dry fruit with more than one seed.

clasping: Partly surrounding the stem.

fibrous roots: Root system with many, fine, diffuse roots.

flower head: A cluster of individual flowers in one compact unit, usually referring to compound flower of the Sunflower Family members.

glume: One of the two chaffy basal bracts of a grass spikelet.

inflorescence: One or more flowers which comprise the flowering part of the plant.

ligules: A straplike structure, such as the corolla of a ray flower or a membranous or hairy appendage between the sheaf and blade of a grass leaf.

lobed: Divided less than one-half the distance to the base or midvein, usually rounded or obtuse.

midrib: The central axis or vein of the leaf blade or leaflet.

nutlet: Hard, small, one-seeded fruit, usually referring to fruits of the Boraginaceae members.

obovate: Egg-shaped and flat, with the narrow end attached to the stalk

opposite: Term applied to leaves or buds occurring in pairs at a node.

palea: One of the pair of bracts (lemma and palea) enclosing the flower of a grass

palmate: Leaflets, lobes, or veins which arise from the same point at the tip of the stalk.

perennial: Plants which live two or more years.

pilose: with long, straight, rather soft, spreading hairs

pinnate: Leaflets or lobes developing from several different points on the main leaf axis.

plume: A hair-like or featherlike structure, often on a seed.

rhizomatous: Having rhizomes.

rhizome: A horizontal stem growing beneath the ground which can develop roots or sprouts at the joints.

rosette: A cluster of leaves radiating out from the base of the plant.

sepal: One of the outermost flower structures, usually enclosing the other flower parts in the bud.

sessile: Attached directly at the base, without a stalk

spur: Any long, narrow (sometimes tubular) extension of a petal.

stolon: A horizontal stem growing above the ground which can develop roots or sprouts at the joints.

taproot: The primary descending root along the vertical axis of the plant which is larger than the branching roots.

terminal: Borne at or belonging to the extremity or summit

Table 6: Weed Species' Latin Name, Family Name in Order of Common Name

Common name	***Latin name***	**Family Name**
Babysbreath	*Gypsophila paniculata*	Caryophyllaceae
Black henbane	*Hyoscyamus niger*	Solanaceae
Blue weed	*Echium vulgare*	Boraginanaceae
Bohemian knotweed	*Polygonum x bohemicum*	Polygonaceae
Bull thistle	*Cirsium vulgare*	Asteraceae
Canada thistle	*Cirsium arvense*	Asteraceae
Cheat grass	*Bromus tectorum*	Poaceae
Common burdock	*Arctium minus*	Asteraceae
Common crupina	*Crupina vulgaris*	Asteraceae
Common mullein	*Verbascum thapsus*	Scrophulariaceae
Common tansy	*Tanacetum vulgare*	Asteraceae
Dalmatian toadflax	*Linaria dalmatica*	Scrophulariaceae
Diffuse knapweed	*Centaurea diffusa*	Asteraceae
Dyer's woad	*Isatis tinctoria*	Brassicaceae
Eurasian Watermilfoil	*Myriophyllum spicatum*	Haloragaceae
Field bindweed	*Convolvulus arvensis*	Convolvulaceae
Flowering rush	*Butomus umbellatus*	Butomaceae
Giant Knotweed	*Polygonum sachalinense*	Polygonaceae
Hawkweeds	*Hieracium* sp.	Asteraceae
Himalayan knotweed	*Polygonum polystachyum*	Polygonaceae
hoary alyssum	*Berteroa incana*	Brassicaceae
Hoary cress	*Cardaria draba*	Brassicaceae
Hounds tongue	*Cynoglossum officinale*	Boraginanaceae
Japanese knotweed	*Polygonum cuspidatum*	Polygonaceae
Jointed goatgrass	*Aegilops cylindrica*	Poaceae
knotweed complex	*Polygonum sp.*	Polygonaceae
Kochia	*Kochia scoparia*	Chenopodiaceae
Leafy spurge	*Euphorbia esula*	Euphorbiaceae
Lens-podded white top	*Cardaria chalepensis*	Brassicaceae
Meadow hawkweed	*Hieracium caespitosum*	Asteraceae
Meadow knapweed	*Centaurea pratensis*	Asteraceae
Moth mullein	*Verbascum blattaria*	Scrophulariaceae
Mullein (common)	*Verbascum thapsus*	Scrophulariaceae
Musk thistle	*Carduus nutans*	Asteraceae
Orange hawkweed	*Hieracium aurantiacum*	Asteraceae
Oxeye daisy	*Chrysanthemum leucanthemum*	Asteraceae
Perennial pepperweed	*Lepidium latifolium*	Brassicaceae
perennial sowthistle	*Sonchus arvensis*	Asteraceae
Plumeless thistle	*Carduus acanthoides*	Asteraceae
Prickly Russian thistle	*Salsola tragus*	Chenopodiaceae
Puncture vine	*Tribulus terrestris*	Zygophyllaceae
Purple loosestrife	*Lythrum salicaria*	Lythraceae
Rush skeletonweed	*Chondrilla juncea*	Asteraceae
Russian knapweed	*Acroptilon repens*	Asteraceae

Common name	***Latin name***	**Family Name**
Russian olive	*Elaeagnus angustifolia*	Elaeagnacaeae
Saltcedar	*Tamarix ramosissima*	Tamaricaceae
Scotch Broom	*Cytisus scoparius*	Fabaceae
Scotch thistle	*Onopordum acanthium*	Asteraceae
Skeletonleaf bursage	*Ambrosia tomentosa*	Asteraceae
Smooth brome	*Bromus inermis*	Poaceae
Spotted knapweed	*Centaurea stoebe*	Asteraceae
Squarrose knapweed	*Centaurea virgata*	Asteraceae
St Johnswort	*Hypericum perforatum*	Clusiaceae
Sulfur cinquefoil	*Potentilla recta*	Asteraceae
Tall buttercup	*Ranunculus acris*	Ranunculaceae
Tall hawkweed	*Hieracium piloselloides*	Asteraceae
Tansy ragwort	*Senecio jacobaea*	Asteraceae
White bryony	*Bryonia alba*	Cucurbitaceae
white top	*Cardaria draba*	Brassicaceae
Yellow Hawkweed	*Hieracium caespitosum*	Asteraceae
Yellow starthistle	*Centaurea solstitialis*	Asteraceae
Yellow sweet clover	*Melilotus officinalis*	Fabaceae
Yellow toadflax	*Linaria vulgaris*	Scrophulariaceae
Yellow-devil hawkweed	*Hieracium glomeratum*	Asteraceae

Table 7: Herbicide Active Ingredients, Example Trade Names and Modes of Action

Trade names are not listed as an endorsement of these particular products, but only as an example.

Active Ingredient	**Trade Name**	**Mode of action***
2,4-D	2,4-D	Group 4
2,4-D amine	Weedar	Group 4
2,4-D ester	Weedone	Group 4
Aminopyralid	Milestone	Group 4
Bromacil	Hyvar X	Group 5
Chlorsulfuron	Telar	Group 2
Clethodim	Select	Group 1
Clopyralid	Transline	Group 4
Clopyralid + 2,4-D	Curtail	Group 4
Dicamba	Banvel	Group 4
Dicamba	Clarity	Group 4
Dicamba + 2,4-D	Weedmaster	Group 4
Diflufenzopyr + dicamba	Overdrive	Group 4
Fluazifop-P	Fusilade	Group 1
Fluazifop-P +fenoxaprop	Fusion	Group 1
Glyphosate	Roundup Pro	Group 9
Glyphosate + 2,4-D	Campaign	Group 9 & 4
Imazapic	Plateau	Group 2

Imazapic + glyphosate	Journey	Group 2 & 9
Imazapyr + metsulfuron methyl	Lineage clearstand	Group 2
Pronamide	Kerb 50W	Group 3
MCPA	MCPA	Group 4
Metsulfuron	Cimarron	Group 2
Metsulfuron	Escort	Group 2
Metsulfuron + aminopyralid	Chaparral	Group 2 & 4
Metsulfuron + chlorsulfuron	Cimarron X-tra	Group 2
Metsulfuron + dicamba + 2,4-D	Cimarron Max	Group 2 & 4
Paraquat	Gramoxone Max	Group 22
Picloram	Tordon	Group 4
Picloram + 2,4-D	Grazon P+D	Group 4
Quinclorac	Paramount	Group 4
Quizalofop P-Ethyl	Assure II	Group 1 & 2
Sethoxydim	Poast	Group 1
Simazine	Princep	Group 5
Sulfometurn methyl + chlorsulfuron	Landmark II XP	Group 2
Sulfometuron methyl	Oust	Group 2
Triasulfuron	Amber	Group 2
Triclopyr	Remedy	Group 4
Triclopyr + clopyralid	Redeem R&P	Group 4
Trifluralin	Treflan	Group 3

Group Definitions

*Group 1. Inhibition of acetyl CoA carboxylase (ACCase)
*Group 2. Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS). ALS inhibitors block protein synthesis.
*Group 3: Inhibition of microtubule assembly
*Group 4. Synthetic auxins, growth regulators
*Group 5. Inhibition of photosynthesis at photosystem II
*Group 9. Inhibition of EPSP synthase-blocks protein synthesis
*Group 22. Photosystem-I-electron diversion

Noxious Weed Definitions by State

Idaho

"**Containment**" means halting the spread of a weed infestation beyond specified boundaries.
"**Control**" means any or all of the following: prevention, rehabilitation, eradication or modified treatments.
"**Eradication**" means the elimination of a noxious weed based on absence as determined by a visual inspection by the control authority during the current growing season.
"**Prevention**" means any action that reduces the potential for the introduction or establishment of a plant species in areas not currently infested with that species; or

Montana

Priority 1A: These weeds are not present in Montana. Management criteria will require eradication if detected; education; and prevention.
Priority 1B: These weeds have limited presence in Montana. Management criteria will require eradication or containment and education.
Priority 2A: These weeds are common in isolated areas of Montana. Management criteria will require eradication or containment where less abundant. **Management shall be prioritized by local weed districts.**
Priority 2B: These weeds are abundant in Montana and widespread in many counties. Management criteria will require eradication or containment where less abundant. **Management shall be prioritized by local weed districts.**
Priority 3: Regulated Plants: (NOT MONTANA LISTED NOXIOUS WEEDS)
These regulated plants have the potential to have significant negative impacts. The plant may not be intentionally spread or sold other than as a contaminant in agricultural products. The state recommends research, education and prevention to minimize the spread of the regulated plant

Utah

"**Class A**" weeds have a relatively low population size within the State and are of highest priority being an Early Detection Rapid Response (EDRR) weed.
"**Class B**" weeds have a moderate population throughout the State and generally are thought to be controllable in most areas.
"**Class C**" weeds are found extensively in the State and are thought to be beyond control. Statewide efforts would generally be towards containment of smaller infestations.
Each county in Utah may have different priorities regarding specific State designated Noxious Weeds and is therefore able to reprioritize these weeds as they see fit for their own needs.

Wyoming

There are no definitions for Wyoming because it does not separate noxious weeds into categories.

Alien Plant Ranking System (APRS) Questions

23 questions total. Examples in italics are included to aid interpretation of some of the questions.

I. Significance of Threat or Impact (Site Characteristics)

1. Distribution relative to disturbance regime

A [0][0][0] found only within sites disturbed within the last 3 years or sites regularly disturbed
B [1][0][0] found in sites disturbed within the last 10 years
C [2][0][0] found in mid-successional sites disturbed 11 to 50 years before present (BP)
D [5][0][0] found in late-successional sites disturbed 51 to 100 years BP
E [10][0][0] found in high quality natural areas with no known major disturbance for 100 years

Examples

- *A. Occurs in a new parking lot put in 1-3 years BP; roadsides, along trails*
- *B. Occurs in a new parking lot put in 4-10 years ago; a site that burned 4-10 years BP*
- *C. Occurs where grazing occurred, but ceased 11-50 years BP; or in a staging area for construction 11-50 years BP, or examples in B that occurred to 11-50 year BP*
- *D. See examples of B and C, but 51-100 years BP*
- *E. Weed occurs in an area where there has been no known disturbance in the last 100 years (no livestock grazing, fire, heavy off road/off trail use, etc).*

2. Areal extent of populations (answer in percentages or hectares)

A [0][0][0] not in site, but in adjacent areas
B [1][0][1] found in less than 5% of site
C [2][0][2] found in between 5% and 10% of site
D [3][0][5] found in between 10% and 25% of site
E [5][0][10] found in more than 25% of site

3. Numerical dominance of species within a community

A [0][0][0] not found on site
B [1][0][1] usually observed as a single individual (or fewer than 5 per 5 square meters)
C [2][0][3] usually observed in numbers less than the 2 or 3 most common native species in the community (but more than 5 per 5 square meters)
D [3][0][5] usually observed in numbers approximately equivalent to the most common native species in the community
E [5][0][10] usually observed in numbers greater than the most common native species in the community

4. Association with native community

A [0][0][0] associated with weedy (early successional) species
B [3][0][0] associated with midsuccessional species
C [6][0][0] associated with dominant (late-successional) species
D [10][0][0] displaces native plant community

Examples of early, mid- and late-successional species will vary widely by park. Early successional species are generally characterized as colonizers-species that fill in rapidly after a disturbance, have high growth rates, and typically are able to reproduce in first year. When resources are available, they use them up quickly, but are less tolerant of low nutrient levels. Late-successional species are generally slower growing, take one or more years before reproductive capacity, and tolerate lower nutrient levels.

- *A. Will vary depending on park. Examples may include non-native species like Bromus tectorum, Alyssum desertorum, Salsola tragus, and many others. Examples of native early successional species include Poa sandbergii (instead of Stipa sp.), Elymus elymoides.*
- *B. Highly variable. Examples in shrublands: Chrysothamnus species (rabbitbrush) instead of Artemisia species (sagebrush).*

C. Highly variable. Examples in shrublands: Artemisia sp. predominate rather than Chrysothamnus, greater forb diversity
D. Invades and outcompetes native plants, reducing or eliminating them.

5. Hybridization with native species
A [0][0][0] not known to hybridize with native species
B [5][0][0] known to hybridize with native species

6. Degree of threat and impact
A[0][0][0] little or no increase in numbers of individuals and populations and no invasion of native communities
B [1][0][0] present in native communities, but static or decreasing
[2][0][0] moderate rate of increase in numbers of individuals and populations; little or no invasion of native communities
C [5][0][0] moderate rate of increase in numbers of individuals and populations; invading native plant communities
D[10][0][0] high rate of increase of numbers of individuals and populations; invading and replacing or highly modifying native plant communities

This question assumes park managers have been present for many years and have been fairly observant. This is very hard to answer for representatives new to the park (less than 2 years), or without some data collection records.
a) The majority do not occur in native, intact communities, only in disturbed areas. Over 2 or more years, no observed increase.
b) Occurs in native communities, but at low levels, not increasing, and possibly decreasing.
c) Spreading moderately, increasing beyond current patch size into native communities.
d) Spreading rapidly into native communities and displacing them/modifying them.

7. Effects on management goals
A[0][0][0] no effect
B[3][0][0] little impact on site management goals
C[5][0][0] moderate impact on site management goals
D[10][0][0] large impact on site management goals
Depends on the specific location of the weed within the park. Consider visitor experience and view shed; size of the population in the park; status (is it a listed noxious weed); ecological impact (is it changing fire regimes, modifying habitat for species of concern, outcompeting valued native species).
Examples
a) Weed is present, but in an area that is low priority (e.g. around a storage shed out of sight, not aggressive, nor likely to spread)
b) Weed is present in low priority areas, e.g. Canada thistle along an irrigation ditch. The area surrounding ditch is dry, not good habitat. It is not spreading into other areas of the park, but may become more of a problem in particularly moist years.
c) Cheatgrass occurring in a native plant display garden in front of the visitor's center.
d) Cheatgrass occurring on a jeep trail, likely to cause a fire after collecting in the undercarriage of vehicles.

II. Innate Ability to be a Pest (Species Characteristics)
8. Mode of reproduction
A[0][0][0] rarely, if ever, reproduces in area
B[0][1][0] reproduces almost entirely by vegetative means
C[0][2][0] reproduces only by seeds
D[0][4][0] reproduces vegetatively and by seeds

9. Vegetative reproduction
A[0][0][0] no vegetative reproduction (**if question 8 is C, this will be A, and therefore no need to review this question**)

B[0][1][0] vegetative reproduction rate maintains population
C[0][2][0] vegetative reproduction rate results in moderate increase in population size
D[0][4][0] vegetative reproduction rate results in rapid increase in population size
B, C or D will vary depending on site conditions (e.g. Canada thistle on a dry site may be B or C, whereas in a moister area, it could be D. Similarly, white top is considered a poor competitor in shrublands, but aggressive in grasslands. Consider surrounding plant community, and its vigor.

10. Frequency of sexual reproduction for mature plant
A[0][0][0] almost never reproduces sexually in area
B[0][1][0] once every five or more years
C[0][3][0] every other year (for biennials)
D[0][5][0] one or more times a year (annuals, perennials)
E[0][3][0] bursts of sexual reproduction in response to environmental stimulus, e.g., rain in the desert

11. Number of seeds per plant
A[0][0][0] rarely, if ever, produces seeds in area
B[0][1][0] few (0-10)
C[0][3][0] moderate (11-1000)
D[0][5][0] many (>1000)

12. Dispersal ability
A[0][0][0] little potential for long-distance dispersal
B[0][5][0] great potential for long-distance dispersal
A) For seeds that are heavy (no wind dispersal), not especially palatable to animals, or don't survive in the gut of animals.
B) For seeds with hairy pappus for wind dispersal, or appendages on seed that allow them to attach to fur, clothing, animals. Note: other ranking systems have this questions divided into two categories: innate dispersal ability and human caused dispersal ability. Because this is not separated, I've rated species like spotted knapweed as great potential for long distance dispersal. While spotted knapweed seeds do not have a hairy pappus or barbed seed, the most common method of dispersal is in the undercarriage of vehicles (based on plant height, ability to break off), meaning great potential for long distance dispersal.

13. Germination requirements
A[0][0][0] requires open soil and disturbance to germinate
B[0][2][0] can germinate in vegetated areas but in a narrow range or in special conditions
C[0][4][0] can germinate in existing vegetation in a wide range of conditions
   A) Requires a recent disturbance, open clearing to germinate, and in the spring, or only after a summer rain event.
   B) Can germinate in a relatively healthy plant community, but only in the spring when moisture is adequate, or only with unusually large summer rain event
   C) Can germinate in a nearly closed canopy, throughout the growing season.

14. Seed banks
A[0][0][0] seeds remain viable in the soil for less than 1 year
B[0][3][3] seeds remain viable in the soil for 1 to 5 years
C[0][5][5] seeds remain viable in the soil for more than 5 years

15. Competitive ability
A[0][0][0] poor competitor
B[0][2][0] moderately successful competitor
C[0][4][0] highly successful competitor
This will vary from park to park depending on the health of the existing plant community, disturbance regimes, and climate. If you don't know, you can use

what I've found in the literature, but if you can modify based on what you've seen in your park-that's much better.
Examples
A) *Only survives in open, recently disturbed areas. E.g. after a disturbance, it rapidly fills in, but through time, native plants return and the weed fades out.*
B) Can germinate and survive in an existing plant community. Doesn't necessarily outcompete existing plants.
C) Can germinate, survive and displace/outcompete existing plant community. Will often form a monoculture when conditions are ideal.

16. Ecological effects (select all that apply)
A[0][3][0] produces persistent litter or shade that affects germination or growth of native species
B[0][3][0] produces allelochemicals
C[0][3][0] affects availability of soil nutrients, e.g., a nitrogen fixer
D[0][4][0] affects water availability to native plants
E[0][4][0] changes natural fire regime
[0][0][0] none of the above

A) plants with large rosettes (some thistles), or tons of persistent litter (cheatgrass)
B) Self-explanatory. eg. spotted knapweed
C) self-explanatory.
D) While all weeds will affect water availability, this will focus on those that have a competitive edge spatially or temporally. Eg. cheatgrass can germinate in fall, continues growth all winter, exploits soil water in the spring before native plants begin growth. By contrast, bindweed has a long narrow taproot. Not expected to compete for soil water.
E) Produces abundant litter, eg cheatgrass, or has a high amount of volatile oils.

17. Known level of impact in natural areas
A[0][0][0] not known to cause impacts in any other natural area
B[0][1][0] known to cause impacts in natural areas, but with different habitats and climate zones
C[0][3][0] known to cause low impact in natural areas with similar habitats and climate zones
D[0][5][0] known to cause moderate impact in natural areas with similar habitats and climate zones
E[0][10][0] known to cause high impact in natural areas with similar habitats and climate zones and/or on the list of most invasive alien plants for the region
Examples

a) Early successional species. Occurs after a distrurbance, and typically naturally declines through time. Not poisonous, doesn't modify soil properties, nor displace native species, etc.
b) E.g. an aquatic species like Eurasian watermilfoil in a park without bodies of water. Another example: meadow knapweed is reported to be especially problematic in moister areas like Oregon and Washington. It may not be such a problem in the more arid parks.
c) Plumeless thistle which has low dispersal ability and is not considered highly competitive.
d) Cheatgrass that may exist as an understory plant, but then be particularly aggressive when native plant communities are under stress, potentially displacing them. Increases the risks of a major wildfire.
e) E.g. Japanese knotweed that may establish along roadsides, ditches, open fields and will aggressively outcompete native species, forming dense monocultures. Once established, it is extremely difficult if not impossible to eradicate.

III. Difficulty of Control
18. Likelihood of successful control

A[0][0][0] this species has been eradicated in a natural area
B[0][0][3] control (populations declining) of this species has been achieved in a natural area
C[0][0][6] limited control (species is no longer spreading, but persists near pre-control levels) of this species has been achieved in a natural area
D[0][0][10] control of this species has never been achieved in a natural area

This is assuming it's an established patch, where the chance for early detection, rapid response has been missed. The patch has existed for at least 3 years. While not a review question, if any park manager knows of a situation where it has been eradicated, please indicate if A is not already selected, and share this information with other parks.

19. Saturation in surrounding region
A[0][0][0] not present in areas surrounding the site
B[0][0][1] present in few areas surrounding the site
C[0][0][3] present in several areas but not entirely surrounding the site
D[0][0][5] present in most areas surrounding the site
Recall that question is regarding ease of control, not impact, or ability to be a pest. If the weed is on all sides of the park it's going to be much more difficult to control compared to it being on only one side, or not present in areas surrounding the site.
A) Not surrounding, nor likely to occur within next 2 years. Example: City of Rocks has reports of leafy spurge to the south, but it is more than ~2-5 miles away, meaning managers should keep their eyes out for it, but it is not within immediate vicinity.
B) On one edge of the park. Example: Craters of the Moon has spotted knapweed on the north side of the park along the highway. That is the main point of entry. While it's possible for it enter from other sides, they can focus the majority of their efforts in that area and are not constantly battling it from all sides.
C) On two sides of park. E.g. whitetop encroaching from the south and east side.
D) On three or more sides: Example: Bear Paw battlefield has Canada thistle bordering it along a neighboring ranch, and along two other sides of the park.

20. Effectiveness of community management
A[0][0][0] protection from disturbance effectively controls target species
B[0][0][2] cultural techniques (burning, flooding) can be used to control target species
C[0][0][5] restoration or preservation practices effectively control target species
D[0][0][10] the above options are not effective
   A) Eg plumeless thistle, Russian thistle, many others that rarely occur without a major disturbance.
   B) For the intermountain region, burning typically favors non-native species, and flooding is not an option for any of the parks. This will rarely be selected for any of the weeds.
   C) Over a two to five year period, a series of efforts can be undertaken so that the native plant community is on a trajectory to suppress the weed, and no or very minor weed control efforts (spot spraying small patches) will be required in the future. For example, Russian knapweed could be sprayed at the recommended time (see word document), and followed by fall seeding of rhizomatous grasses. Assuming the grass establishment is adequate, research has demonstrated that these efforts can control, and ultimately decrease Russian knapweed. The weed may still exist as a minor component, but is not expected to spread beyond the current location, nor displace the native plants.
   D) Needs very aggressive control methods. Yearly, or every other year, managers need to repeatedly use control efforts such as spot spraying in order to prevent the weed from spreading widely.

21. Vegetative regeneration
A[0][0][0] no resprouting following removal of aboveground growth
B[0][0][5] sprouts from roots or stumps
C[0][0][10] any plant part is a viable propagule
A) We're interpreting this to mean to hand pulling to remove some root, not mowing, clipping. For example, if you clip cheatgrass, it will grow back, but if you pull it, it will not resprout. Please note, that some species marked A, could be B if they are removed when the soil is dry, and the root breaks off near the surface. For species marked A, check descriptions of the weed in the word document for more details.
B) E.g Russian knapweed will resprout from rhizomes when hand pulled.
C) Any plant part is a viable propagule meaning it can sprout from stem fragments as well as rhizomes or seeds. Examples are Canada thistle, Japanese knotweed, or Eurasian watermilfoil.

22. Biological control
A[0][0][0] biological control feasible
B[0][0][5] potential may exist for biological control
C[0][0][10] biological control not feasible (not practical, possible, or probable)
B is when a biological control is currently under investigation, but has not yet been approved for release. C is for species where a biological control is unavailable and unlikely in the future, e.g. sulfur cinquefoil (Potentilla recta) which is very similar to native species and cultivated strawberries, or nearly all plants in the mustard family (Brassicaceae).

23. Side effects of control measures
A[0][0][0] control measures have little potential to affect native communities
B[0][0][3] control measures are likely to cause moderate impacts on community
C[0][0][5] control measures are likely to cause major impacts on community
D[0][0][5] side effects of control unknown
This depends on the control measures used and the surrounding plant community. Regarding C, some control measures are likely to cause major impacts on the community, but the assumption is the failure to act would result in a monoculture of this weed, or some other unacceptable result.
Hand pulling: If done at the appropriate time, it is likely to have little effect (A). However, if soil is excessively muddy, and desirable plants are trampled it could be B or C as this will increase disturbance, damage existing plant community, bring new weed seeds into the area on muddy boots.
Mowing will have little to major impacts depending on the surrounding plant community. If the existing community is only grasses, and mowing is recommended for the particular weed, it may reinvigorate the desirable species, causing little impact. If mowing in areas where existing plants are in poor condition, mowing may only further open up the community to other invasives, having a moderate to major impact.
Spot spraying is likely to have moderate impact, even if applicator is careful to spray only the target plant. However, if spot spraying a broadleaf weed in a grass meadow with a selective herbicide, the spot spraying is likely to have little potential to affect native communities (A). By contrast, if spot spraying a broadleaf forb like Canada thistle in a diverse community of shrubs, forbs and grasses, the spraying will weaken the forbs or shrub, the functional group most similar to Canada thistle. This means spraying will have a moderate to major impact (B or C). Spraying with herbicides like Tordon with long residual, are likely to have a major impact, even though it must be assumed that this will have less of an impact than not controlling the weed at all.
Spraying and not reseeding areas with no desirable remnant vegetation is likely to have a major impact, as spraying will need to be done repeatedly, and create conditions for other invasives as well.

Biological controls like insect are likely to have little potential to affect native communities. Exceptions are parks releasing insects for control of non-native thistles where they have high diversity of native thistles that may be targeted as well. Targeted grazing (e.g. with trained cattle at Grant-Kohrs) will have little potential to affect native communities as long as grazing is monitored closely.

Resources

Table 8: County Weed Coordinators for each Park

	STATE	COUNTY(IES)	WEED COORDINATOR	PHONE
Bear Paw	MT	Blaine	Peter Pula	406.357.2340
Big Hole	MT	Beaverhead	Jack Eddie	406.683.3790
City of Rocks	ID	Cassia	Gordon Edwards	208.878.4043
Craters of the Moon	ID	Butte	Brad Gamett	208.527.8595
	ID	Blaine	John Cenarrusa	208.823.4017
Fossil Butte	WY	Lincoln	Scott Nield	307.886.3394
Golden Spike	UT	Box Elder	Neil Lauritzen	435.734.2031
Grant Kohrs	MT	Powell	Karen Laitala	406.846.3348
Hagerman Fossil Beds	ID	Gooding	Terry Ruby	208.934.5569
Minidoka Internment Camp	ID	Jerome	Terry Ruby	208.934.5569
Little Bighorn	MT	Big Horn	Scott Bockness	406.256.2731

Sources to obtain an update on the status of biocontrols

'Biological Control of Invasive Plants in the United States' by Coombs, Clark, Piper and Cofrancesco (2004) was the source for the majority of information on biocontrols as it was the most comprehensive source available at the time of this publication. The status of biocontrols (e.g. permitting, approval for inter-state transport, etc.) may change frequently.

- For additional information on permits for biological controls, contact Mr. Robert Tichenor (Robert.H.Tichenor@aphis.usda.gov) or see http://www.aphis.usda.gov/plant_health/permits/organism
- For environmental compliance, contact Dr. Tracy Horner (Tracy.A.Horner@aphis.usda.gov).
- For information on the PPQ Biological Control Program please visit:

http://www.aphis.usda.gov/plant_health/plant_pest_info/biocontrol

Useful on-line publications

- Managing *Aceria malherbae* gall mites for control of **field bindweed**. (Lauriault, Thomson, Pierce, Michels and Hamilton, 2004). Available at http://aces.nmsu.edu/pubs/_circulars/CR%20600.pdf

- Key to identification of invasive and native **hawkweeds (*Hieracium* spp.)** in the Pacific Northwest. (Wilson, L. 2006). Available at: http://www.for.gov.bc.ca/hfp/publications/00230/Hawkweed%20key_PNW_R3-June06.pdf

- Biology and biological control of **knapweeds** (Wilson and Randall 2005). Available at: http://www.invasive.org/weedcd/pdfs/KnapweedBook.pdf.

See page 7 for excellent drawings of knapweed bracts to differentiate among the species. Also includes directions on releasing and monitoring.

- Biology and Biological control of **leafy spurge**. (R. Bourchier, R. Hansen, R. Lym, A. Norton, D. Olson, C. Randall, M. Schwarzlander and L. Skinner 2006). Available at: http://www.invasive.org/publications/LeafySpurgeBiocontrols.pdf

See for information on releasing, monitoring and combining biocontrols with herbicides.

- Biology and biological control of **purple loosestrife** (Wilson, L., M, Schwarzlaender, B. Blossey, and C. Randall 2004). Available at: http://www.invasive.org/weeds/LoosestrifeBook.pdf

See Chapter 3 for transporting, releasing, and monitoring biocontrols.

- Biology and biological control of true **thistles** (Winston, R., R. Hansen, M. Schwarzländer, E. Coombs, C. Randall, and R. Lym, 2008). http://www.invasive.org/publications/Thistles.pdf

See page 11 for a thistle key and drawings of the flower receptacles to differentiate thistle species.

- Biology and biological control of **yellow and Dalmatian toadflax**. (Wilson, L., S. Sing, G. Piper, R. Hansen, R DeClerck-Floate, D. MacKinnon and C. Randall 2005). Available at: http://www.invasive.org/weeds/ToadflaxBook.pdf

See Chapter 3 for transporting, releasing and monitoring biocontrols.

- Biology and biological control of **yellow starthistle**. (Wilson, L., C. Jette, J. Connett, and J. McCaffrey 2003). Available at: http://www.cnr.uidaho.edu/crissp/CRISSP%20pdf/StarthistleBook.pdf

See Chapter 3 for transporting, releasing and monitoring biocontrols.

- Livestock Grazing Guidelines for Control of Noxious Weeds in the Western United States EB 06-05. (Davison, J., E. Smith and L. Wilson 2005). Available at: http://www.cnr.uidaho.edu/rx-grazing/Livestock_Graizng_Guidelines(Davison_et_al.%202007).pdf

Also see links on the site "Targeted Grazing":
http://www.cnr.uidaho.edu/rx-grazing/index.htm
Additionally, contact staff at Grant-Kohrs for training livestock to eat weeds.

- www.Invasive.org

Photos of exotic species. Typically includes different life stages (rosettes, flowering, landscape shots).

Plant Identification Assistance by State (see forms at end)

- **Idaho**

Erickson Weed Diagnostic Lab
University of Idaho
Box 442339
Moscow, ID 83844-2339
This lab excepts scanned photos, or fresh samples. See this link for instructions on submitting samples.
http://www.cals.uidaho.edu/weeds/forms/Guidelines.pdf

- **Montana**

Schutter Diagnostic Laboratory
Attn: Melissa Graves
Montana State University
119 Plant BioScience Building
P.O. Box 173150
Bozeman MT 59717
Call 406.994.6297 with questions. See Plant ID form at end of document or go to this link:
http://diagnostics.montana.edu/Schutter%20Lab/Plant/PLANT%20IDENTIFICATION%20FORM.pdf

- **Utah**

Intermountain Herbarium
Utah State University
Attn: Michael Piep
5305 Old Main Hill
Logan, Utah 84322-5305
435-797-0061

- **Wyoming**

See links on the Wyoming Weed Identification Site.
http://ces.uwyo.edu/WYOWEED/wyoweed.htm

University of Idaho Plant/Weed Identification Request Form

http://www.uidaho.edu/weeds

Erickson Weed Diagnostic Laboratory Date: _____
PSES Dept., University of Idaho Phone: 208-885-7831
Moscow, Idaho 83844-2339 Fax: 208-885-7760

Submitter's Name: _____		**Client's Name:** _____	
Business: _____		Business: _____	
Address: _____		Address: _____	
City/State/Zip: _____		City/State/Zip: _____	
County: _____	Phone: _____	County: _____	Phone: _____
Fax: _____	E-Mail: _____	Fax: _____	E-Mail: _____

Required data for Plant Identification

Weed location (GPS or from county map): Latitude: _____ Longitude: _____or
Quarter-Section: _____ Section: _____ Range: _____ Township: _____

Approximate directions to or description of the location:

Web source for Latitude/Longitude data (http://terraserver.homeadvisor.msn.com/address.aspx). Do address search then click on Available Image (topo map) click on INFO button, Lat/Long will appear on map.

In what situation were the plants found

☐ Turf/Lawn	☐ Vegetable garden	☐ Flower bed	☐ Orchard
☐ Field/Crop	☐ Pasture	☐ Meadow	☐ Forest
☐ Riparian	☐ Aquatic	☐ Roadside	☐ Other _____

Plant Information

Plant size:	**Flowers:**	**Fruits:**	**Plant age:**	**Root system:**
Height (inches): _____	Color: _____	Color: _____	☐ Annual	☐ Taproot
Width (inches): _____	Size (inches): _____	Size (inches): _____	☐ Perennial	☐ Fibrous
				☐ Rhizomes
Plant type: ☐Tree ☐ Shrub ☐ Vine ☐ Herbaceous ☐ Evergreen				

Unique features (leaves, odor, thorns, etc.): _____

Additional Plant and Site Information

How many years at Location:	**Area infested:**	**Ground covered:**
☐ Less than 1 year	☐ A few plants	☐ Less than 1%
☐ 1 year	☐ Less than 1 acre	☐ 1 to 10%
☐ 2 to 5 years	☐ 1 to 10 acres	☐ 10 to 50%
☐ More than 5 years	☐ 10 to 100 acres	☐ 50 to 100%

If it is causing concern, describe the reason and the problem: _____

Information requested other than identification: _____

Prescription for control depends on a great many factors; more background information may be needed to prescribe a control measure. Inquire of your county agricultural Extension Educator weed specialist or other licensed consultant if control information is requested.

Montana State University Plant Identification Form

Schutter Diagnostic Lab
119 Plant BioScience Facility
Montana State University Bozeman, MT 59717
Date
(MM/DD/YY)
Client Name _____ **Email** _____
Address _____ **Phone** _____
Accompanying this form is a plant sample to be identified. Please answer all items before submitting the plant sample.
1. **Sample collected by:** _____ **Phone:** _____

Address: _____
2. **Sample was collected where? In this Montana county:**_____

In or near this Montana city, town, or major landmark: _____
If not Montana, specify where: _____
3. **Sample was collected in this habitat** (=PDIS "host"): (circle proper item or specify below)

cropland lawn garden house pasture forest roadside rangeland aquatic
crop-field: crop = other:
4. **Sample is this kind of plant:** (circle proper item)

landscape garden house wild plant other
5. **Sample is from this form of plant:** (circle proper item)

tree shrub vine herb cactus grass moss other
6. **Prevalence:** (circle proper item) abundant several scattered few or just one

7. **Other plant information:** _____

8. **Email identification info:** yes no **Email address:** _____

After receiving identification results, if you would like to have a control recommendation, please call either Melissa Graves (home/garden weeds) at 994-5690 or Fabian Menalled (cropland weeds) at 994-4783.
COUNTY **AGENT**
COMMENTS: (for use by Herbarium)
_____

Table 9: List of Potential Invaders

Key: X = Present, Z= observed in past, -- = not present, ? = unknown

APRS Rank	Latin Name	Common Name	CIRO	CRMO	FOBU	GOSP	GRKO	HAFO	MIIN	LIBI	NEPE BEPA	NEPE BIHO
1	*Acroptilon repens aka Centaurea repens*	Russian Knapweed	X	X	--	X	X	?	X	X	--	--
2	*Aegilops cylindrica*	Jointed Goatgrass	--	--	--	--	--	--	?	--	--	--
3	*Agropryon cristatum*	Crested Wheatgrass	X	X	X	X	X	X	?	X	Z	--
89	*Agropyron intermedium*	Intermediate Wheatgrass	--	X	?	--	--	?	?	--	--	Z
90	*Agrostis gigantea*	Redtop	--	--	--	X	X	?	?	X	?	?
4	*Alopecurus arundinaceus*	Creeping Foxtail	--	--	X	--	X	?	?	--	?	?
91	*Alyssum alyssoides*	Yellow Alyssum	--	--	--	X	X	?	?	X	?	?
5	*Ambrosia tomentosa aka Franseria discolor*	Skeleton-Leaf Burr-Ragweed	--	--	--	--	--	?	?	--	--	--
6	*Anchusa arvensis*	Annual Bugloss	--	--	--	--	--	?	?	--	?	?
92	*Anchusa officinalis*	Bugloss	?	--	--	--	--	?	?	--	?	?
7	*Arctium minus*	Common Burdock	X	X	--	?	--	?	?	--	--	--
93	*Artemisia absinthium*	Absinth Wormwood	?	--	--	--	--	?	?	--	?	?
94	*Asparagus officinalis*	Asparagus	--	--	--	--	--	?	?	X	?	?
8	*Berteroa incana*	Hoary Alyssum	--	--	--	--	?	?	?	X	--	--
95	*Bromus hordeaceus*	Soft Brome	--	--	--	--	--	?	?	X	?	?
9	*Bromus inermis*	Smooth Brome	X	X	X	?	X	?	?	X	Z	--
10	*Bromus japonicus*	Japanese Brome	X	X	X	X	X	?	?	X	--	--
11	*Bromus tectorum*	Cheatgrass Downy Brome	X	X	X	X	X	X	X	X	X	X
12	*Bryonia alba*	White Byrony	--	--	--	--	--	?	X	--	--	--
13	*Butomus umbellatus*	Flowering Rush	--	--	--	--	--	?	?	--	--	--
96	*Camelina microcarpa*	False Flax	X	X	X	--	X	?	?	X	?	?
14	*Cardaria chalepensis*	Lens-Podded White Top	X	--	X	--	X	?	?	--	--	--
15	*Cardaria draba*	White Top	X	--	--	X	X	Z	Z	X	--	--
16	*Carduus acanthoides*	Plumeless Thistle	--	--	--	--	--	?	?	--	--	--
17	*Carduus nutans*	Musk Thistle	X	X	X	X	X	?	X	--	--	--
97	*Carum carvi*	Caraway	?	--	--	--	--	?	?	--	?	?
18	*Centaurea diffusa*	Diffuse Knapweed	X	X	X	?	--	X	?	--	--	--
19	*Centaurea pratensis* aka: *C. nigrescens,* and *C. debeauxii* ssp *thuillieri*	Meadow Knapweed	--	--	X	--	--	?	?	--	--	--
20	*Centaurea solstitialis*	Yellow Starthistle	--	--	--	?	--	X	X	--	--	--
21	*Centaurea stoebe* aka *Centaurea biebersteinii*	Spotted Knapweed	X	X	X	X	X	?	?	X	X	X
22	*Centaurea virgata aka C.*	Squarerose Knapweed	--	--	--	--	--	?	?	--	--	--

	squarrosa											
23	*Chenopodium album*	Lambs Quarters	X	X	--	--	X	--	?	X	--	--
98	*Chicorium intybus*	Chicory	X	X	--	--	--	?	?	--	?	?
24	*Chondrilla juncea*	Rush Sketletonweed	--	X	--	--	--	Z	X	--	--	--
25	*Chrysanthemum leucanthemum or Leucanthemum vulgare*	Oxeye Daisy	--	--	--	X	--	?	?	--	--	X
26	*Cirsium arvense*	Canada Thistle	X	X	X	X	X	X	X	X	X	X
27	*Cirsium vulgare*	Bull Thistle	X	X	X	X	X	?	?	X	--	X
28	*Conium maculatum*	Poison Hemlock	X	--	--	--	--	?	?	--	?	?
29	*Convolvulus arvensis*	Field Bindweed	X	X	X	X	X	?	?	X	Z	X
30	*Crupina vulgaris*	Common Crupina	--	--	--	--	--	?	?	--	--	X
99	*Cynodon dactylon*	Bermuda Grass	?	--	--	X	--	?	?	--	?	?
31	*Cynoglossum officinale*	Houndstongue	X	--	X	?	X	X	?	X	--	X
32	*Cytisus scoparius*	Scotch Broom	--	--	--	--	--	?	?	--	--	--
33	*Descurainia pinata*	Western Tansymustard	--	?	X	--	--	?	?	--	--	Z
34	*Descurainia sophia*	Flixweed Tansymustard Herb Sophia	X	X	X	X	X	?	?	X	--	--
100	*Dipsacus fullonum*	Common Teasel	--	--	--	--	--	?	?	--	?	?
35	*Echium vulgare*	Common Viper's Bugloss	--	--	--	--	--	?	?	--	--	--
36	*Egeria densa*	Brazilian Elodea	--	--	--	--	--	?	?	--	?	?
37	*Eichhornia crassipes*	Common Water Hyacinth	--	--	--	--	--	?	?	--	?	?
38	*Elaeagnus angustifolia*	Russian Olive	--	--	--	--	X	X	X	X	--	--
39	*Elymus repens* aka Agropyron *repens*	Quackgrass	X	?	X	X	X	X	X	X	?	?
101	*Eragrostis cilianensis*	Strinkgrass	--	--	--	--	--	?	?	X	?	?
102	*Eremopyrum triticeum*	Annual False Wheatgrass	--	X	--	X	--	?	?	X	?	?
40	*Euphorbia dentata*	Toothed Spurge	--	--	--	--	--	?	?	--	?	?
41	*Euphorbia esula*	Leafy Spurge	--	X	--	?	X	?	?	--	--	X
103	*Festuca rubra*	Red Fescue	--	--	--	--	--	?	?	--	?	?
104	*Galega officinalis*	Goats Rue	?	--	--	--	--	?	?	--	?	?
105	*Galium aparine*	Catchweed	?	?	--	?	--	?	?	X	?	?
42	*Gypsophila paniculata*	Baby'sbreath	--	--	--	--	X	?	?	--	--	--
106	*Halogeton glomeratus*	Halogeton	X	X	X	X	--	?	?	X	?	?
43	*Heracleum mantegazzianum*	Giant Hogweed	--	--	--	--	--	?	?	--	?	?
44	*Hieracium aurantiacum*	Orange Hawkweed	--	--	--	--	--	?	?	--	--	--
45	*Hieracium caespitosum*	Meadow Hawkweed	--	--	--	--	--	?	?	--	--	--

46	*Hieracium floribundum*	Yellow Devil Hawkweed	--	--	--	--	--	?	?	--	--	--
47	*Hieracium glomeratum*	Queen Devil Hawkweed	--	--	--	--	--	?	?	--	--	--
48	*Hieracium piloselloides*	Tall Hawkweed	--	--	--	--	--	?	?	--	--	--
49	*Hydrilla verticillata*	Hydrilla	--	--	--	--	--	?	?	--	?	?
50	*Hyoscyamus niger*	Black Henbane	X	X	X	?	X	?	?	--	--	--
51	*Hypericum perforatum*	St. John's Wort	--	Z	X	?	--	?	?	X	--	--
52	*Impatiens glandulifera*	Policeman's Helmet	--	--	--	--	--	?	?	--	?	?
53	*Iris pseudacorus*	Yellow Flag Iris	--	--	--	--	--	?	?	--	--	--
54	*Isatis tinctoria*	Dyers Woad	--	X	--	X	--	?	?	--	--	--
107	*Knautia arvensis*	Field Scabious	?	--	--	--	--	?	?	--	?	?
55	*Kochia scoparia*	Kochia	X	X	X	--	X	X	X	X	Z	--
56	*Lactuca serriola*	Prickley Lettuce	X	X	X	X	X	?	?	X	Z	--
57	*Lepidium latifolium*	Perennial Pepperweed	--	--	--	X	X	?	?	--	--	--
108	*Lepidium perfoliatum*	Clasping Pepperweed	X	X	X	X	X	?	?	X	?	?
58	*Linaria dalmatica*	Dalmation Toadflax	--	X	--	X	--	?	?	X	--	--
59	*Linaria vulgaris*	Yellow Toadflax	--	--	--	?	X	?	?	--	--	--
109	*Lolium pratense*	Meadow Fescue	--	--	--	--	--	?	?	X	?	?
110	*Lonicera tatarica*	Tatarian Honeysuckle	--	--	--	--	--	?	?	X	?	?
111	*Lycium halimifolium*	Matrimony Vine	?	--	--	--	--	?	?	--	?	?
60	*Lythrum salicaria*	Purple Loosestrife	--	--	--	?	--	X	?	--	--	--
61	*Lythrum virgatum*	European Wand Loosestrife	--	--	--	--	--	?	?	--	--	--
112	*Matricaria maritima*	Scentless Chamomile	?	Z	--	--	--	?	?	--	?	?
113	*Matricaria perforata*	Scentless Chamomile	--	Z	--	--	--	?	?	--	?	?
62	Medicago lupulina	Black Medic	--	X	X	--	X	?	?	X	--	--
114	*Medicago sativa*	Alfalfa	--	X	X	--	X	?	?	X	Z	?
63	*Melilotus officinalis*	Yellow Sweetclover	--	X	X	X	X	?	?	X	Z	X
64	*Millium vernale*	Millium	--	?	--	--	--	?	?	--	?	?
65	*Myriophyllum aquaticum*	Parrot Feather Milfoil	--	--	--	--	--	?	?	--	?	?
66	*Myriophyllum spicatum*	Eurasian Watermilfoil	--	--	--	--	--	?	?	--	--	--
67	*Nardus stricta*	Matgrass	--	--	--	--	--	?	?	--	?	?
68	*Onopordum acanthium*	Scotch Cottonthistle	--	X	--	X	--	?	X	--	--	--
69	*Phalaris arundinacea*	Reed Canarygrass	--	?	X	--	X	?	?	--	Z	--
115	*Phleum pratense*	Timothy	X	X	X	--	X	?	?	X	--	X
116	*Poa bulbosa*	Bulbous Bluegrass	X	X	X	X	--	?	?	X	?	?
117	*Poa compressa*	Canada Bluegrass	--	--	X	--	X	?	?	X	?	?
118	*Poa pratensis*	Kentucky Bluegrass	X	X	X	X	X	?	?	X	?	?
70	*Polygonum cuspidatum*	Japanese Knotweed	--	--	--	--	--	?	?	--	--	--
71	*Polygonum polystachum*	Himalyan Knotweed	--	--	--	--	--	?	?	--	--	--

72	*Polygonum sachalinense*	Giant Knotweed	--	--	--	--	--	?	?	--	--	--
73	*Polygonum x bohemicum*	Bohemian Knotweed	--	--	--	--	--	?	?	--	--	--
119	*Potamogeton crispus*	Curly Leaf Pondweed	?	--	--	--	--	?	?	--	?	?
74	*Potentilla recta*	Sulfur Cinquefoil	--	--	--	X	X	?	?	--	--	--
75	*Ranunculus acris*	Meadow/Tall Buttercup	X	--	X	--	X	?	?	--	--	--
120	*Reseda lutea*	Yellow Mignonette	X	--	--	--	--	?	?	--	?	?
121	*Rumex crispus*	Curly Dock	X	X	X	X	X	?	?	X	Z	X
76	*Salsola tragus (aka S. kali and S. iberica)*	Prickly Russian Thistle	X	X	--	X	X	?	?	X	--	--
77	*Salvia aethiopsis*	Mediterranean Sage	--	--	--	--	--	?	?	--	?	?
78	*Senecio jacobaea*	Tansy Ragwort	--	--	--	--	--	?	?	--	--	--
122	*Silene alba*	White Campion	?	X	--	--	X	?	?	--	?	?
123	*Silybum marianum*	Milk Thistle	?	--	--	--	--	?	?	--	?	?
124	*Sisymbrium altissimum*	Tumblemustard	X	X	--	X	X	?	?	X	?	?
79	*Solanum elaeagnifolium*	Silverleaf Nightshade	--	--	--	--	--	?	?	--	?	?
125	*Solanum nigrum*	Black Nightshade	--	--	--	--	--	?	?	X	?	?
126	*Solanum rostratum* (this is native to the great plains)	Buffalo Bur	?	--	--	--	--	?	?	--	?	?
80	*Sonchus arvensis*	Field Sowthistle	X	--	--	--	X	?	?	--	--	--
81	*Sorghum halpense*	Johnsongrass	--	--	--	X	--	?	?	--	?	?
127	*Sphaerophysa salsula*	Swainson Pea	--	--	--	--	--	?	?	--	?	?
128	*Taeniatherum caput-medusae*	Medusahead	--	--	--	X	--	?	?	--	?	?
82	*Tamarix ramosissima*	Saltcedar	--	--	Z	X	--	X	?	X	--	--
83	*Tanacetum vulgare*	Common Tansy	--	X	--	X	X	?	?	--	--	X
129	*Taraxacum officinale*	Dandelion	X	X	X	X	X	?	?	X	?	X
130	*Thlaspi arvense*	Field Pennycress	X	X	X	--	--	?	?	X	Z	X
84	*Tragapogon dubius*	Yellow Salisfy	--	X	X	X	X	?	?	X	--	Z
85	*Tribulus terrestris*	Punctureveine	--	--	--	X	--	X	?	--	--	--
131	*Trifolium repens*	White Clover	X	X	X	--	X	?	?	X	?	Z
86	*Verbascum blattaria*	Moth Mullein	--	X	--	X	--	?	?	--	--	--
87	*Verbascum thapsus*	Common Mullein	X	X	X	X	X	?	X	X	--	X
88	*Zygophyllum fabago*	Syrian Bean-Caper	--	--	--	--	--	?	?	--	?	?
			39	47.5	39.5	40	48	13	12.5	49	8	18