Return to Start Page

Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix D:

Clark Fork River OU Weed Prevention and Management Planning Information and Weed Species Fact Sheets

U.S. Environmental Protection Agency
Region 8

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APPENDIX D

Clark Fork River OU Weed Prevention and Management Planning Information

Invasive Plant Species Prevention

Invasive plants specialize in colonizing disturbed ground. They possess a number of physical traits that allow them to arrive at disturbed sites sooner and grow faster than other plants. With these advantages, they are able to out-compete native species, at least for a time. To counter this, EPA plans to avoid disturbing existing vegetation whenever possible. Such disturbance exposes the soil surface and reduces desirable vegetation, creating ideal opportunities for weed colonization. If disturbance cannot be avoided, all disturbed areas would be re-seeded or re-planted immediately. Native species or carefully chosen non-invasive introduced species will be used so that "vacant" or bare ground is quickly occupied by desirable plants.

Weeds also invade plant communities that have been degraded by land management practices that expose the soil surface and stress the desirable vegetation. Healthy native plant communities resist weed invasion. One of the best ways to avoid damaging plant communities is to manage livestock grazing to maintain good vigor of native perennial vegetation, especially grasses. Recreationists can also damage vegetation by overusing popular camping areas and creating trails. Dense, vigorous stands of perennial grasses are highly resistant to weed invasion. However, certain very aggressive weeds such as leafy spurge (*Euphorbia esula*), spotted knapweed (*Centaurea maculosa*), and Canada thistle (*Cirsium arvense*) can invade even well managed lands that have dense, vigorous vegetation.

All remedial activities on a property will follow strict guidelines for preventing the spread or introduction of invasive species to the site. Specific practices designed to avoid transporting weed materials and introducing weeds will be strictly followed and monitored. These will include the following:

- Educating all project personnel in weed identification and prevention. Local Weed Boards, such as the Powell County Weed Board can provide assistance in this process.
- Ascertaining that all equipment used in remediation (including all vehicles and digging tools) be thoroughly washed and inspected for plant matter before entering the OU, and before entering a new property or new site.
- Requiring adherence by all personnel on site to prescribed practices for prevention of weed dispersal.
- Minimizing movement of personnel and vehicles on the property, and limiting access to specifically identified necessary routes, parking, and staging points.
- Designing all work to minimize soil surface disturbance.

- Re-vegetating all disturbed soil surfaces with appropriate vegetation (e.g., native species, including agronomic varieties for rangelands, and appropriate species for croplands, such as alfalfa) to deny opportunity to invasive species.
- Identification and control of pre-existing weed populations on the site to remove nearby sources of invasive species.

Integrated Weed Management Monitoring and Evaluation Plan

Factors to Consider

If a monitoring program is simple and straightforward, it is more likely to be completed and to provide useful information. The effort you invest in monitoring depends on what could happen if your management actions are not working or are counter productive. A higher risk of failure means more effort should go toward monitoring. For example, using high densities of livestock to control weeds requires close and frequent attention to the forage available to avoid overgrazing. Also, eradicating high-priority weed species may require more monitoring than the suppression of low-priority species because eradication of high-priority species will be a much more important goal.

Monitoring, like weed control, is an ongoing process. Although the information gathered in the early days of a monitoring study is certainly valuable, its value is enhanced by comparison with every future piece of data. Even a simple monitoring program may not yield easily interpreted results with the first few repetitions. However, the likelihood of detecting useful trends increases with each year of monitoring.

One of the limitations of most monitoring programs is their inability to determine cause and effect. Although monitoring data can tell you if a weed species decreased in abundance, the data cannot definitely tell you if your weed control actions *caused* the decline. It is possible that a decline in weed abundance would have happened anyway, due to unfavorable weather or other factors. Determining cause and effect requires replicated, controlled experiments where all relevant factors are closely controlled except for one that is varied. Such experimentation is normally performed by university, government, and industry researchers, and is not usually practical for private landowners or public land managers. However, there are some places where land managers could conduct experiments; for example, testing whether two weed treatments differ in their ability to control a weed species.

Setting Monitoring Priorities

Using your previously identified high-priority weed species and infestations, decide which of the species and infestations you will monitor, based on the number of weed species and weed infestations and the resources at your disposal. In addition, you need to decide how intensively to monitor the species and infestations, that is, how much effort you are willing to devote to monitoring.

Establish a minimal level of monitoring for each high-priority weed species and high-priority weed infestation in each of your weed management units. In addition, you should establish a system of recording and tracking herbicide applications and bio-control releases.

We suggest that you monitor at least:

- Two sites where each high-priority weed species occurs
- One high-priority weed patch

There will probably be some overlap in the above categories that will reduce your monitoring work. For example, if one of your high-priority weed species is Canada thistle (*Cirsium arvense*) and two of your high-priority weed infestations are patches of Canada thistle (*Cirsium arvense*), monitoring those two patches would satisfy your minimal monitoring needs for Canada thistle (*Cirsium arvense*).

Designing Monitoring Actions

The challenge of monitoring is to find a balance between the time and money spent monitoring and the value of the information you expect to obtain from monitoring. There is a direct relationship in monitoring between the time required to collect information and your ability to determine if your weed control objectives are being met. If you spend less time collecting and analyzing monitoring data, you will be less able to evaluate your weed management actions. Conversely, if you spend more time and money monitoring, you will have a better idea if you are meeting weed management objectives.

The methods used to monitor the high-priority weed species and infestations depend on weed management objectives. Thus, the complexity of monitoring depends on what you need to know to determine if weed management objectives are being met. Examples of several weed management objectives and monitoring methodologies are presented below. Note that many of the monitoring actions are very simple and their "analysis" is largely self-evident. Keep monitoring actions as simple as possible to increase the likelihood that you will actually monitor your weeds and understand the results of the monitoring. Most private landowners will not need to conduct complicated monitoring programs involving formal statistical tests, and will not need to monitor as many plots.

Review your weed management objectives to see if you can re-word them so they can be evaluated with simple monitoring actions. Make sure your objectives specify time, numbers, and location.

Written Records

The most basic form of monitoring consists of taking careful notes of:

- Sizes of the high-priority infestations and the general abundance of the weeds in those infestations.
- General extent and abundance of the high-priority weed species that are not found in the high-priority infestations.

For weed management objectives that specify eradicating a patch of weeds, the only monitoring required it to note whether the patch is present or not. A few sentences in a field notebook will be sufficient documentation. Consider buying a field book of the type that surveyors use. These books are very sturdy and will last for years. A very simple way to monitor weeds is to use a tape recorder to record observations while you drive, ride, or

walk around your property. You can transcribe the tapes during the winter when you are not as busy.

Photographic Records

Photographs can be extremely useful in documenting changes in weeds over time, especially if they are taken from permanent locations (called photo points) each time. Photographs work best for monitoring weed species, which can be easily distinguished from other plants during flowering. Examples of these types of species include leafy spurge (*Euphorbia esula*), whitetop (*Cardaria draba*), Dalmatian toadflax (*Linaria dalmatica*), and spotted knapweed (*Centaurea maculosa*).

Photo points can be established adjacent to high-priority weed infestations since these sites are likely be relatively small. Carefully select the location of the photo point so that all or nearly all of the area can be seen from the photo point. Mark the location of the photo point with a permanent marker to enable it to be relocated for subsequent monitoring photographs. Sturdy red 18-inch plastic stakes (Plastake®) are also available from mail order outlets such as Ben Meadows or Forestry Suppliers.

Take photographs when the target weed is most visible, usually during the period of peak flowering. Try to include obvious background features such as fences, trees, cliffs, and distant mountains as an aid to repeating the photograph with the same scene every year. Carry prints of last year's photographs mounted in plastic sleeves in the field, to help you frame the scenes correctly and to provide instant visual comparisons of weed abundance. One or more photographs may be taken at each photo point depending on the place. Use a 35-mm camera with color film or a digital camera. Note the locations of the photo points on your weed map with an arrow showing the direction of the photograph, and give each point a unique number. Keep a log of pictures taken (possibly in the field notebook), matching the number of the exposure with the number of the photo point and the scene being photographed. Write the photo point number and the date on each developed photograph or slide as soon as you receive them otherwise you may forget to do it. Cameras that automatically include the date in the picture are handy for photo monitoring.

Test Monitoring Actions

Monitoring actions should be tested to see if they will really work in the field. Often ideas that seemed great in the office do not work very well in the field. Testing your monitoring methods before embarking on your monitoring program can save time and money in the end. It is much easier to redesign a monitoring protocol after a failed test than to redesign the program half way through the monitoring period. Questions to consider during the pilot phase of a monitoring program include:

- Will the data collection methods really work in the field? You may discover that it is not practical to count certain species to estimate density, or that thick vegetation prevents sampling plots from being laid out uniformly. Permanently marked plots may not be easy to relocate after all. Such problems need to be identified and corrected before you commit large amounts of time and resources to a monitoring program.
- Is the cost and time of performing monitoring acceptable? You may discover that it takes too long to collect the data called for in your original monitoring design, or that

monitoring actions are too expensive. It is important to design a monitoring program that you can afford to implement. A less ambitious program is better than none at all.

- Will the observations allow you to detect changes? Given the constraints of field methods, time and money, the bottom line is whether or not the monitoring will allow you to evaluate the effectiveness of weed control actions.

Keep in mind that the usefulness of monitoring arises from its repeated nature. You must continue to monitor to detect changes, which will affect your management decisions.

Implement the Monitoring Plan

The most critical step in any monitoring program is to begin doing it. If you do not do the monitoring, you will not be able to determine if you are meeting your weed management objectives. Monitoring will save you money by insuring that your control efforts are as effective as possible. After you begin monitoring, perform the following cycle of tasks:

1. Perform monitoring by collecting field data according to plan.
2. Analyze and evaluate monitoring results immediately after each data collection.
3. Determine whether weed management actions need to be revised, given the results of monitoring analysis.
4. Implement weed management actions again, revise as necessary.
5. Evaluate monitoring actions (analyze data), revise as necessary.
6. Begin the cycle again.

Whenever possible, share the results of your monitoring with other weed managers, and help to build a base of weed control knowledge that others can use in the fight against noxious weeds. Do not over-respond to your monitoring results. You may need to give a treatment method more than one year of trial. Check with other land managers in your area to see if it was a particularly "good" year for your weed species.

Do not forget to include repeated reconnaissance for new weed species and infestations in your monitoring program.

Information on monitoring and evaluation used is from a variety of sources including the Center for Invasive Plant Management (CIPM) at Montana State University (2003) and the Colorado Department of Agriculture (2000). Monitoring is an essential component of a weed control program. Monitoring is the repeated collection and analysis of information to evaluate progress in meeting resource management objectives. Periodic observation of weeds being managed is necessary to evaluate the effectiveness of a weed control program. Monitoring saves money by helping to determine what is working and what is not.

Integrated Weed Management Options

The *Record of Decision* for the Clark Fork River Operable Unit (OU) states that on each remedial site, a plan for management and control of invasive species will be written to address those weeds already present, as well as the potential for further invasion. Taken into account will be the unique set of physical site and managerial factors identified for the

property in consultation with the landowner and other involved parties. This plan will be designed as an Integrated Weed Management approach based on the invasive species identified. It will draw from individually prescribed practices for each weed species using such types of options as those described herein (CIPM 2003, Colorado Department of Agriculture 2000).

Cultural Control

Cultural control seeks to control weed problems by establishing desired plant species in healthy populations that will deny opportunity for weed establishment. Cultural techniques include manipulating the plant community through seeding desired species, planting of established containerized material, and cultivating areas previously invaded by weeds (cutting through and turning over the soil, re-seeding, fertilizing and irrigating).

Best suited for:

- Large construction projects. Cultivating is often necessary to reduce the number of weed seeds in the soil before planting desirable plant species. Cultivating for a year prior to reseeding kills weeds that have sprouted since the last cultivation and progressively reduces the bank of weed seeds.
- Re-establishing native plant communities on disturbed or depleted areas so desirable plants can prevent or reduce weed infestation.

Limitations include:

- Cultivating is appropriate only for restoration of drastically disturbed sites.
- Lack of seeds from locally adapted plants.
- Lack of seeds of certain native species, especially forbs and shrubs.

Pitfalls include:

- Seed mixes may be contaminated with weed seeds.
- Cultivation may result in wholesale germination and establishment of weed species if there is not adequate follow-up weed control.
- Temporary cover crops such as wheat, rye, or barley used to reduce soil erosion must be mowed or grazed to eliminate their seed production.
- Promoting weed growth by adding unneeded nitrogen fertilizers. Native plant species are generally adapted to low-nitrogen conditions, while weed species are adapted to high nitrogen conditions. Only add nitrogen fertilizer if tests show that soil nitrogen levels are insufficient to support native species.
- Common components of commercial seed mixes such as yellow sweet clover (*Melilotus officinalis*), smooth brome (*Bromus inermis*), and Kentucky bluegrass (*Poa pratensis*) are often considered weeds in the context of natural lands and natural areas.
- Importing weed seeds on borrowed or rented equipment. You can reduce this risk by inspecting equipment before it enters your property or you can insist that the equipment must be cleaned first.

Biological Control

Biological control is the use of insects or other natural predators to control the growth of a specific plant species. The insects usually come from the invasive plant's native habitat and all have been extensively tested to ensure that they will not attack plants other than the one they are targeting. Once insect populations are established, they can often support their own growth and expansion. Different insects attack different parts of plants at different times, but over time may decrease seed production and growth rate.

Best suited for:

- Reducing seed production or weakening plants.
- Large, dense infestations where other control methods are not cost-effective.
- Situations where a reduced but effectively permanent presence of a noxious weed species is acceptable.

Limitations include:

- Failing to eradicate the target plant species. Do not use bio-control agents where you seek to eradicate a weed population. Eradication of weeds with biological agents never occurs.
- Use of biological control is effectively an admission that a particular weed species is here to stay and that this is acceptable.
- Feasible for only a handful of weed species because of the high cost of finding, screening and testing potential control organisms. Biological controls have a mixed record with some tremendous successes but also with many failures.
- Rarely successful as the sole means of control of a weed species.
- Lack of effective biological control agents for most noxious weed species.
- Biological control agents may be unavailable when you want them.
- Necessity of having a reservoir of host weeds to support biological agents over the long term. Thus, it may be necessary to leave some weeds to support populations of control organisms. This may be unpopular with neighbors or the public.
- Degree of control is variable and will take several years to achieve.

Pitfalls include:

- Insects attacking beneficial, non-target plants. The weevil *Larinus planus*, introduced for control of Canada thistle (*Cirsium arvense*), has been reported to attack native thistle species as well. Insects that have been released to control St. Johnswort (*Hypericum perforatum*) also feed on native *Hypericum* species, and some insects released for controlling leafy spurge (*Euphorbia esula*) also attack native spurge species.
- Inability to establish populations of biological control organisms for reasons relating to climate, soils and so forth that are not well understood.

Grazing

Grazing is the use of sheep, goats, cattle, or horses to control weed growth. Sheep and goats are most commonly used in this function because they often eat plants rejected by cattle and horses. Animals will eat plants at specific stages of the plants' growth, so it is important to be informed about what animal is the best agent at different times of the year. It is also very important to make sure the land is not over-grazed and that the animals are moved before they start to eat the desired plants, which would eliminate the desired plant community competition with the invaders.

Best suited for:

- Weeds that are palatable (at least at some point during the year) and non-toxic to livestock. Weeds vary greatly in their palatability to types of livestock. Generally speaking, the preference for grasses declines from horses to cattle to sheep to goats. Furthermore, goats and sheep are more likely than horses or cattle to relish broadleaf weeds (forbs).
- Leafy spurge (*Euphorbia esula*) control. Goats and sheep are very effective control agents for all but the smallest infestations, especially in riparian areas.
- Low-level, widespread weed infestations where other control techniques are not cost-effective.

Limitations include:

- Lack of availability of goats and sheep or even cattle when and where you need them.
- Need for water and fencing or herding to control livestock movement.
- The need to manage the intensity and duration of livestock grazing carefully to avoid overgrazing, and allow desirable species to recover from grazing impacts.
- Areas where predators such as coyotes, mountain lions, and black bears may kill grazing animals, especially sheep and goats.
- Using the proper kind of animal to manage the weeds on your property.
- Need for someone with knowledge of animal husbandry to manage the animals.
- Palatability of weeds varying widely throughout the growing season. For example, young shoots of Canada thistle (*Cirsium arvense*) are very palatable to cattle, while old, mature stalks are not. However, palatability of many weeds can be greatly increased by spraying them with a dilute solution of molasses.

Pitfalls include:

- Expecting livestock to control weeds without close management. Simply turning animals into a pasture and expecting weed problems to vanish would likely be counterproductive.

- Failing to manage the intensity and duration of livestock grazing to prevent the animals from depleting the desirable plant species they are grazing, or creating disturbance, which favors the establishment of weeds.
- Spreading weed seeds in fur or in manure when animals are moved from one area to another. Grazing should be done before weeds set seed.
- Toxicity of weeds such as poison hemlock, halogeton, St. Johnswort (*Hypericum perforatum*), and Russian knapweed (*Centaurea repens*) to grazing animals; toxicity can vary greatly by type of animal.

Herbicide

Although herbicides must be used with extreme care and caution, they are one of the most effective ways of quickly managing weed populations for the short term. When considering what herbicide to use, look at what weeds are present, how close they are to water, and what time of year is best to apply the chemical. Herbicides often work best if applied more than once and in conjunction with other control methods.

Best suited for:

- Eradicating some weed species in certain places. Herbicides are most effective on pure stands of a single weed species where desirable non-target plants are scarce or absent. In this place, one often has the option of selecting from several different herbicides.
- Rhizomatous weed species that are unpalatable to livestock, require repeated pulling or cutting for control, or are located in remote areas where pulling or cutting are not feasible.
- Small patches of weeds where hand pulling or cutting is not effective or feasible.
- Use in combination with other control methods. For example, Canada thistle (*Cirsium arvense*) can be controlled by repeated cutting during the growing season followed by treatment with clopyralid herbicide in the fall. Russian olive (*Elaeagnus angustifolia*) can be controlled very effectively by cutting stems very close to the ground in the fall then immediately spraying or painting the cut stems with triclopyr herbicide.

Limitations include:

- Damaging or killing non-target plants. Herbicides are not completely selective in their toxicity to the target plant species. Effects on non-target plants can be minimized by selecting an appropriate herbicide and using a wick or a backpack sprayer. A wick is made from adsorbent material and saturated with herbicide. This wick is rubbed directly against the weeds so the herbicide is not applied to adjacent, desirable plants.
- Difficulty of using herbicides to control small weeds when they occur among taller desirable plant species.
- Toxicity to humans to varying degrees. Thus, their use is regulated by federal and state laws. People who use herbicides need to know these regulations. Certain herbicides are classified as “restricted use herbicides” whose application is limited by federal and state regulations.

- Restricted use herbicides are often available only at licensed outlets such as your local farm co-op or by ordering through reputable distributors.
- Property owners must possess a private applicator's license to apply a restricted use herbicide on their property.
- Herbicides must be applied in conformance with the label. With herbicides, the label is the law, and applying an herbicide beyond the bounds specified on the label is illegal.
- Certain herbicides may not be used around or on water. This is an important consideration for weeds that grow in wetlands or riparian areas.
- One must possess the proper equipment and requisite knowledge to apply chemicals safely. Proper clothing must be used, and materials to contain spills must be on hand when using herbicides.
- Herbicides can move beyond the area where they are applied and affect non-target plants and animals. This drift can be eliminated by using a wick or reduced by spraying under calm wind conditions and by adjusting the sprayer apparatus to produce large droplets.
- Populations of weeds may develop resistance to a particular herbicide over time.
- Opposition to the use of chemicals in the environment, especially in urban areas. Local opposition in some areas may pose challenges for the use of some or all herbicides.
- Like most other control methods, herbicides are short-term solutions that do not address reasons for weed problems in the first place. Therefore, spraying an herbicide treats a symptom of a problem. Even if an herbicide eradicates a weed infestation, another infestation may appear if the underlying cause of the infestation persists.

Pitfalls include:

- Simplifying diverse plant communities by suppressing certain plant species, although this effect may be temporary.
- Herbicide applicators who cannot distinguish noxious weeds from desirable plant species, resulting in accidental damage to the latter.

Hand Pulling

One of the most labor-intensive methods of weed management, hand pulling is a viable option for small infestations. Hand pulling does not work on plants with rhizomatous root systems because it will stimulate the plant's growth. Pulling is often best in the spring before the weeds have an extensive root system. Tools like the weed wrench greatly assist in pulling small bushes or plants with long taproots.

Best suited for:

- Small infestations where the entire patch can be pulled.
- Annual and biennial plants (although seed banks will remain for some time).

- Shallow-rooted species that do not resprout from any residual roots.
- Plants growing on sandy or gravelly soils. (If possible, concentrate on pulling when the soil is moist and soft, such as after a soaking rain.)
- Places where more effective methods cannot be used or are undesirable.

Limitations include:

- Pulling generally may not remove the entire root system of the plant. Thus, pulling is ineffective for rhizomatous species such as Canada thistle (*Cirsium arvense*) or leafy spurge (*Euphorbia esula*), even if used in conjunction with other techniques. *If pulled weeds contain seeds, they should be removed from the site and burned or disposed in a landfill. Do not compost this material!*
- Pulling will not reduce a soil seed bank, although it can keep a seed bank in the soil from increasing.
- Pulling is not cost effective for large infestations.
- Pulling may not be cost effective for small infestations, either; unless plants are easy to pull and a volunteer work force is available.

Pitfalls include:

- Volunteer burnout from endless hours of boring work.
- Soil disturbance which stimulates germination of weed seeds in soil.
- Creating bare soil spots as sites for weed seed germination and establishment.
- Some weeds produce chemicals causing allergic reactions in some people. Always wear gloves and a long-sleeved shirt for pulling plants. Wash your hands with soap and water afterwards.

Cutting and Mowing

Mowing can be effective in some places if it is done at the correct time of the weed's growth cycle. However, mowing can stimulate many plants' growth. Additionally, mowing damages as many native plants as invasive and usually requires multiple field entries over a span of years to kill all the weeds. Generally, after mowing the sites will need to be re-seeded, which is another step in a labor-intensive procedure. Nonetheless, used in conjunction with other methods, mowing can be an adequate option in a long-term plan.

Best suited for:

- Large, relatively flat and dry areas that can be mowed with few safety or equipment concerns.
- Preventing tall, erect biennial weed species, such as mullein, from setting seed when other control techniques are not feasible.
- Preventing the "tumbleweed" action of certain weed species such as kochia and Russian thistle that spreads seeds across wide areas.

- Weakening the plants by depleting root reserves through repeated mowing.
- Combining with other control methods, such as herbicide treatment. Cutting can be extremely effective for killing certain trees and shrubs if it is combined with herbicide treatment of the cut stumps. For example, cutting the stems as close to the ground as possible in the fall and immediately (within 30 seconds) painting the cut stumps with triclopyr herbicide kills Russian olive (*Elaeagnus angustifolia*).
- Small infestations of fleshy-stemmed biennial thistles are easy to cut with a sharp machete. These thistles include Scotch, musk, plumeless, and bull thistles.

Limitations include:

- Rarely killing weeds.
- Sites that are inaccessible or too rocky cannot be mowed, although weed whips and machetes can be effective in such places.
- Having to repeat mowing frequently for control to be effective.
- Cut plants re-sprouting to larger sizes than prior to cutting (Russian olive [*Elaeagnus angustifolia*]).
- Weakening rhizomatous plants only slightly, unless the frequency of cutting is very high.

Pitfalls include:

- Failing to remove and dispose of cut stems if they contain seeds.
- Dislodging rocks from the mower may be dangerous to the mower operator.

Weed seeds spread by mowing equipment to areas previously free of infestations. Clean equipment which has been used in weed infested areas before moving it to another area. Make sure that borrowed or rented equipment is free of weed seeds by inspecting equipment before it enters your property. Or, you can insist that the equipment must be cleaned first.

Sources

Center for Invasive Plant Management (CIPM). 2003. On-line invasive plant textbook. Department of Land Resources and Environmental Sciences. Montana State University. Bozeman, MT, USA. http://weedcenter.org/textbook/index.html

Colorado Department of Agriculture. 2000. Caring for the land series, Vol. 4: Creating an integrated weed management plan, a handbook for owners and managers of lands with natural values. 341 p.

Invasive Plant Species of the Clark Fork River OU

Several invasive plant species are already well established within the Clark Fork River OU, while several others have quite limited occurrence in Reach A. Some species are among the most commonly encountered plants in some areas, while others are rare thus far. Included below is a list of twelve species of invasive plants. Brief individual fact sheets are provided for each weed species. The information for this list came from a variety of sources, including CIPM at Montana State University (2003), and the Colorado Department of Agriculture (2000). The species include the following:

- Canada thistle (*Cirsium arvense*)
- Common tansy (*Tanacetum vulgare*)
- Dalmatian toadflax (*Linaria dalmatica*)
- Houndstongue (*Cynoglossum officinale*)
- Kochia (*Kochia scoparia*)
- Leafy spurge (*Euphorbia esula*)
- Perennial pepperweed (*Lepidium latifolium*)
- Russian olive (*Elaeagnus angustifolia*)
- Russian thistle (*Salsola iberica*)
- Spotted knapweed (*Centaurea maculosa*)
- Yellow toadflax (*Linaria vulgaris*)
- Whitetop (*Cardaria draba*)

Canada Thistle

Cirsium arvense (L.) Scop.

Family: *Asteraceae* (Sunflower)
Other Names: field thistle, Californian thistle
Six Letter Code: CIRARV
USDA Code: CIAR4

Keys to Identification:
- Purple flowers form in clusters of 1-5 per branch.
- The floral bracts of Canada thistle are spineless.
- Small heads, vanilla scent.

Identification

Growth form: Perennial forb.
Flower: Flower heads are white to purple and borne in clusters of 1-5 per branch, with a strong vanilla scent. Heads are only about 1 cm in diameter.
Seeds/Fruit: One-seeded fruits (achenes) are straw or light brown in color, straight or slightly curved (Moore 1975).
Leaves: Leaves are spiny, alternate, oblong or lance-shaped, with the base leaves stalkless and clasping, or extended down along the stem.
Stems: Mature plants range from 2-4 ft in height.
Roots: Canada thistle has two types of roots, horizontal and vertical. The horizontal roots produce numerous shoots, while vertical roots store water and nutrients in their many small branches.
Seedling: Early spring growth appears as rosettes with spiny-tipped, wavy leaves.
Other: The floral bracts of Canada thistle are spineless.

Similar Species

Exotics: Bull thistle (*Cirsium vulgare*); flower bracts are somewhat tapered and covered with spines. Musk thistle (*Carduus nutans*); floral bracts are broad with spiny tips. Russian knapweed and Canada thistle are often confused.
Natives: Wavyleaf thistle (*Cirsium undulatum*): flower bracts often have a prominent white glandular dorsal ridge (often sticky to touch) and minutely hairy margins (Whitson et al. 1996).

Impacts

Agricultural: Canada thistle is an aggressive, creeping, perennial weed. It infests crops, pastures, rangelands, roadsides, and riparian areas (Beck 1996).
Ecological: Canada thistle spreads rapidly through horizontal roots, which give rise to shoots (Moore 1975). Its root system can be extensive, growing horizontally as much as 18 ft in one season (Nuzzo 1998). Most Canada thistle patches spread at a rate of 3-6 ft/year, crowding out more desirable species and creating thistle monocultures.
Human: Spiny thickets of Canada thistle can restrict recreational access to infested areas.

Habitat and Distribution

General requirements: Canada thistle thrives in the Northern Temperature Zone due to its day length response and a high temperature limitation on growth (Haderlie et al. 1991). Although Canada thistle mainly invades disturbed areas, it does invade native plant communities, open meadows

(including wetlands), and ponderosa pine savanna (Rutledge and McLendon 1998). Canada thistle is adapted to a wide range of soil types and environmental conditions (FEIS 1996). It is best adapted to rich, heavy loam, clay loam, and sandy loam, with an optimum soil depth of 20 inches (FEIS 1996, Rutledge and McLendon 1998). Canada thistle can tolerate saline soils (up to 2 percent salt) and wet or dry soil (Rutledge and McLendon 1998). However, it does not tolerate waterlogged or poorly aerated soils. Canada thistle usually occurs in 17-35 inch annual precipitation zones or where supplemental soil moisture is available (Beck 1996). Canada thistle is also somewhat shade intolerant. It can grow along the edge of forested areas, but is rarely found within forests.
Distribution: Canada thistle is found throughout the northern half of the United States and lower portions of Canada. It is common found along roadsides, fields, pastures, meadows, and other disturbed areas statewide in Montana.
Historical: Canada thistle is a native of southeastern Eurasia. It was introduced to Canada as a contaminant of crop seed as early as the late 18th century. Since its introduction, it has spread throughout North America (Whitson et al. 1996).

Biology/Ecology

Life cycle: Over-wintering roots develop new underground roots and shoots in January and begin to elongate in February (Nuzzo 1998). Shoots emerge between March and May, when mean weekly temperatures reach 5° C, and form rosettes (Nuzzo 1998). Early in the spring, plants remain near the soil surface until long days (over 14 hours of light) trigger flowering and stem elongation (Haderlie et al. 1991, FEIS 1996). Canada thistle is dioecious (male and female flowers are produced on separate plants). Female flowers can be readily distinguished from male flowers by the absence of pollen (abundant in male flowers) and presence of a distinct vanilla-like fragrance. Flowering occurs from June to October (Rutledge and McLendon 1998). Seeds mature July to October.
Mode of reproduction: Canada thistle reproduces primarily vegetatively through creeping horizontal roots, and can quickly form dense stands. Every piece of the root system is capable of forming a new plant (Rutledge and McLendon 1998). This allows dense monocultures of Canada thistle to form even without seed production. Canada thistle growth is limited or stopped when temperatures exceed 30° C for extended periods of time.
Seed production: A female Canada thistle plant can produce up to 5,200 seeds in a season, but the average is about 1,500 seeds/plant (Rutledge and McLendon 1998).
Seed bank: Mature seeds germinate most readily in mid-spring. Seeds that do not germinate may remain dormant for several years but most studies indicate that the majority of seeds do not remain viable after three years of burial (Rutledge and McLendon 1998).
Dispersal: Seeds are distributed by wind.
Hybridization: No information available.

Control

Biocontrol: Currently, there is no single biological control agent that effectively controls Canada thistle. However, there are several agents that have been reported to provide very limited control. One species, *Urophora cardui* (a gall fly), may hold some promise.

Keys to Control:
- Eliminate seed production.
- Reduce the plant's nutrient reserves through persistent management.

Mechanical: Mowing pastures and hay meadows can be an effective control if it is repeated at about one-month intervals throughout the growing season. Combining mowing with herbicides will further enhance control of Canada thistle. However, a recent study (Beck and Sebastian 2000) found that mowing or mowing plus herbicide was only effective where the root system of Canada thistle is restricted by a high water table, such as near rivers or subirrigated meadows.

Fire: Prescribed burning in the spring has been proposed as a means of slowing the spread of Canada thistle. Such fires could reduce the number of mature plants, decrease seed production, and stimulate the growth of native grasses (FEIS 1996).
Herbicides: Chemical control of Canada thistle should be conducted in the spring or fall depending on local environmental conditions. In general, fall treatments are more effective as herbicide absorption is enhanced in the late summer and fall when shoot to root translocation is the greatest. However, translocation of the herbicide is dependent on moist soil conditions. If fall is a dry period in your area, a spring application around the flower bud stage (early June), when root carbohydrate reserves are at their lowest, is recommended. Clopyralid + 2,4-D (commonly sold as Curtail®) applied at a rate of 2-3 quarts/acre will effectively control Canada thistle. Curtail should either be applied in the late spring (when Canada thistle plants are entering the bud growth stage) or in the fall (October) when Canada thistle roots are actively growing. The performance of Curtail can be improved when proceeded by two or three mowings under conditions when the root systems are restricted (Beck 1996, Beck and Sebastian 2000). Begin mowing when Canada thistle is 12-15 inches tall and repeat at about one month intervals (Beck 1996). Apply Curtail in October or about one month after the last mowing. Clopyralid alone can be applied at a rate of 2/3 to 1 pint/acre in the spring or fall. Spring applications should be timed to the rosette to bud growth stages. 2,4-D or picloram are effective when applied at a rate of 1 lb active ingredient/acre in the spring when Canada thistle is in the pre-bud to early bud growth stages (about 10-15 inches tall). For increased control, retreat with dicamba (1 lb active ingredient/acre) in the fall to prevent regrowth of plants.
Cultural/Preventive: Reduce the spread of Canada thistle seeds by always purchasing "weed free" seeds. Quickly eliminate new seedlings before they have a chance to form a well-developed root system.

Integrated Management Summary

The tendency of this species to grow in wet areas may restrict the use of certain herbicides. Control efforts should target Canada thistle plants in high-quality areas first (typically areas that contain mostly native species and few undesirable species), and then work on controlling lower quality areas (areas that are already infested with undesirable species and have fewer desirable species present). Management strategies should be adjusted to reflect weather conditions (Nuzzo 1998). For example, drought stress reduces the effectiveness of most herbicides, but increases the effectiveness of mechanical controls (e.g., mowing or burning). It takes at least two years of control to determine whether a particular method is effective. Several studies have recorded a temporary decline in Canada thistle in the first year of control followed by a return to the pre-treatment conditions the second growing season (Nuzzo 1998). For one example of Canada thistle control, see page 60.

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Common Tansy

Tanacetum vulgare L.

Family: *Asteraceae* (Sunflower)
Other Names: garden tansy
Six Letter Code: TANVUL
USDA Code: TAVU

Keys to Identification:
- Flower heads contain button like flowers without ray flower "petals."
- Stems are often purplish-red in color.

Identification

Growth form: Perennial forb.
Flower: Yellow flowers are numerous in flat-topped dense clusters at the tops of the plants. Button like flower heads lack ray flowers.
Seeds/Fruit: Seeds are yellowish brown achenes with short, five-toothed crowns.
Leaves: Leaves are alternate, deeply divided into numerous narrow, individual leaflets.
Stems: Mature plants are 1.5 to 6 ft tall. Stems are often purplish-red in color.
Roots: Rhizomatous.
Seedling: No information available.
Other: Rank smelling foliage.

Similar Species

Exotics: None known.
Natives: None known.

Impacts

Agricultural: Common tansy is considered undesirable forage for livestock. Although it may be toxic, animals rarely ingest it.
Ecological: May displace native, more desirable species.
Human: Can be toxic if large quantities are consumed.

Habitat and Distribution

General requirements: Common tansy is commonly found along roadsides, stream banks, in waste places, and in pastures. It grows best in full sun and on fertile, well-drained soil.
Distribution: Found throughout the United States.
Historical: Common tansy is a native of Europe that was introduced into North America as an ornamental and medicinal herb (Whitson et al. 1996). It has been used for treating various ailments and as an insect repellent.

Biology/Ecology

Life cycle: Flowering typically occurs from July to September.
Mode of reproduction: Reproduces by both seed and creeping rootstocks.
Seed production: No information available.
Seed bank: No information available.
Dispersal: No information available.
Hybridization: No information available.

Control

Keys to Control:
- Eliminate seed production and vegetative reproduction from creeping rootstocks.
- Re-seed controlled areas with desirable species.

Biocontrol: None known.
Mechanical: Common tansy can be mowed before flowering and seed set to eliminate seed production. This method may have to be repeated to eliminate regrowth from the rootstocks.
Fire: No information available.
Herbicides: Picloram or dicamba at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre can be used to control common tansy. The best time for treatment is between the early flower (bud) to bloom stage (Dow AgroSciences 1998).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Integrated Management Summary

As with other rhizomatous perennials, mechanical controls such as mowing or hand cutting are most effective in combination with other methods. Plants can regrow from severed roots, and cut stems may still produce viable seed. Control the spread of common tansy by preventing seed production and dispersal, minimizing the spread of cut rootstocks, and establishing healthy stands of desirable species on controlled areas.

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Dalmatian Toadflax

Linaria dalmatica (L.) Miller

Family: *Scrophulariaceae* (Figwort)
Other Names: broad-leaved toadflax, wild snapdragon
Six Letter Code: LINDAL
USDA Code: LIDAM

Keys to Identification:
- Dalmatian toadflax can be easily identified by its bright-yellow, snapdragon-shaped flowers.
- Dalmatian toadflax can be distinguished from yellow toadflax by its larger flowers and more ovate leaves (rather than the linear, somewhat pointed leaves that are characteristic of yellow toadflax).

Identification

Growth form: Perennial forb.
Flower: Flowers are borne in loose, elongate, terminal racemes. Flowers are bright yellow and resemble snapdragons.
Seeds/Fruit: Fruits are egg-shaped to nearly round capsules. Seeds are sharply angular, and slightly winged.
Leaves: Leaves are broad, ovate to ovate-lanceolate, and are alternate, generally clasping but crowded.
Stems: Mature plants are up to three ft tall. A single toadflax plant contains from 1-25 vertical floral stems which are thick-walled and somewhat woody.
Roots: The taproot may penetrate one meter into the soil. Horizontal roots may grow to be several meters long, and can develop adventitious buds that may form independent plants.
Seedling: No information available.

Similar Species

Exotics: Yellow toadflax *(Linaria vulgaris)* is similar in appearance, but has more linear pointed leaves, and is generally a smaller plant.
Natives: None known.

Impacts

Agricultural: Low-till cultivation practices have contributed to the resurgence of toadflax populations on agricultural lands (McClay 1992). Dalmatian toadflax contains a glucoside, a quinoline alkaloid, and peganine, which make it toxic to livestock (Rees et al. 1996). However, dalmatian toadflax is generally considered unpalatable, and reports of livestock poisonings are rare.
Ecological: Dalmatian toadflax is a persistent, aggressive invader and capable of forming colonies through adventitious buds from creeping root systems. These colonies can push out native grasses and other perennials, thereby altering the species composition of natural communities. New infestations of dalmatian toadflax can occur in naturally occurring disturbances or in small openings in pristine or excellent-condition rangeland (Lajeunesse 1999). Dalmatian toadflax can rapidly colonize open sites. It is most commonly found along roadsides, fences, rangelands, croplands, clear cuts, and pastures. Disturbed or cultivated ground is a prime candidate for colonization. Toadflax can significantly reduce crop yields and stress native communities. In one study, toadflax-free plots produced 2.5 times more grass than plots where toadflax was present (Robocker 1974). The seedlings of toadflax are considered ineffective competitors for soil moisture with established perennials and winter annuals (Morishita 1991).

However, once established both species of toadflax suppress other vegetation mainly by intense competition for limited soil water. Mature plants are particularly competitive with winter annuals and shallow-rooted perennials (Robocker 1974).
Human: No information available.

Habitat and Distribution

General requirements: Dalmatian toadflax can adapt its growth to fit a wide range of environmental conditions, and is tolerant of low temperatures and coarse-textured soils.
Distribution: Dalmatian toadflax in Montana this weed has escaped from gardens to become a serious invader of rangeland, mountain meadows, and waste areas. Large infestations of it are found in Missoula and Lake Counties in western Montana.
Historical: Dalmatian toadflax is a native of the Mediterranean region from Yugoslavia to Iran (Robocker 1974).

Biology/Ecology

Life cycle: Spring emergence occurs about mid-April and depends primarily on temperature. During the first year the plant forms a rosette and develops a deep root system. Prostrate stems emerge in September and produce ovate leaves. Prostrate stems are tolerant to freezing and are associated with floral stem production the following year (Robocker 1974). The strong upright floral stems that characterize mature toadflax plants develop after a winter's dormancy, and emerge about the same time as new seedlings in mid-April. A single plant will produce from 1-25 floral stems. Flowering occurs from May-August and seeds mature from July-September. Dalmatian toadflax can also reproduce vegetatively. Stems develop from adventitious buds on primary and lateral roots. Vegetative reproduction from root buds can occur as early as 2-3 weeks after germination, and is possible from root fragments as short as 1 cm in length (Zimmerman 1996). These buds can grow their own root and shoot systems, and become independent plants the next year. In addition to promoting growth, the large, deep, root systems of dalmatian toadflax exploit water efficiently. The taproot may penetrate 3-4 ft into the soil and lateral roots may be 6-12 ft long.
Mode of reproduction: By seeds and vegetatively
Seed production: A mature dalmatian toadflax can produce up to 500,000 seeds annually (Morishita 1991).
Seed bank: Seeds may remain viable in the soil for up to ten years.
Dispersal: Seeds are winged, and wind-dispersed.
Hybridization: No information available.

Control

Keys to Control:
- Maintain a dense cover of vigorous perennial plants.
- Picloram, dicamba, and glyphosate are effective when applied during flowering.
- Hand pulling is effective for small areas, especially in sandy soils.

Biocontrol: The Division of Plant Industry's Biological Pest Control Section currently has one species, *Calophasia lunula*, that may be available for redistribution on dalmatian toadflax infestations. *C. lunula* larvae feed extensively on leaves and flowers of toadflax, severely damaging the plants.
Mechanical: Cutting or removal of the above ground portion of toadflax plants reduces the current year growth, but it will not kill the plant. Cutting toadflax stands in spring or early summer is an effective way to eliminate plant reproduction through seed production and dispersal. However, the long dormancy of toadflax seeds requires that the process be repeated annually for up to ten years. Hand pulling toadflax before seed set each year can be an effective control method. The hand pulling experiment on The Nature Conservancy's Magnusson Butte Preserve in Washington showed that toadflax can be significantly reduced by pulling once a year as long as new seed is eliminated. Again, this method must be repeated annually for up to ten years to completely

remove a stand. Sheep can help suppress dalmatian toadflax infestations and reduce seed production. The sheep showed no ill effects from eating toadflax and showed good weight gain (Lajeunesse 1999).

Fire: No information available.
Herbicides: Herbicides have highly variable effects on dalmatian toadflax, probably due to its high genetic variability. Fall applications of picloram 0.5-1.0 lb active ingredient/acre has provided excellent control for one year. However, the higher concentrations of picloram may be injurious to desirable plants, plus picloram has been ineffective on some sites. A tank mix of picloram + 2,4-D controlled over 90 percent of dalmatian toadflax when applied pre-bloom or in the fall. A six-year study found that phenoxypropionic herbicides such as diclorprop were more effective at controlling toadflax than phenoxyacetic herbicides such as 2,4-D (Robocker 1968). 2,4-D, MCPA, MCPB, and mecoprop used alone do not control toadflax.
Cultural/Preventive: Intensive clean cultivation techniques are recommended for successful toadflax control on agricultural land. Discing can be an effective method of toadflax control on agricultural lands. This method requires at least two years with eight to ten cultivations in the first year, and four to five cultivations the second year (Morishita 1991). Weed control should be accompanied by reseeding with a variety of plant species to occupy the site so as to prevent re-establishment of toadflax. An ideal mix of species would include cool- and warm-season plants as well as plants that root at a variety of depths. For example, shallow rooted, cool-season species such as Sandberg bluegrass (*Poa secunda*) compete with toadflax seedlings.

Integrated Management Summary

Management of dalmatian toadflax must focus on both reducing the rate of vegetative spread and reducing seed production (Lajeunesse 1999). Successful management requires integrating as many control tactics as possible. Dalmatian toadflax has high genetic variability, and local populations can respond differently to control actions, especially herbicide treatments. Successful control can be obtained by pulling, or killing the plants with herbicide before toadflax seed production begins (Carpenter and Murray 1998). Since the plant also spreads through vegetative propagation, and the seeds can remain dormant for up to ten years, this process must be repeated every year for at least ten years to completely remove a stand. Competitive perennial grasses and forbs should be planted to utilize water and nutrients that would otherwise be readily available to toadflax.

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Houndstongue

Cynoglossum officinale (L.)

Family: *Boraginaceae* (Borage)
Other Names: hound's tongue, dog bur, gypsy flower
Six Letter Code: CYNOFF
USDA Code: CYOF

Keys to Identification:
- Five-petaled reddish-purple flowers in panicles.
- Prickly nutlets are distinctive.

Identification

Growth form: Biennial or short-lived perennial forb.
Flower: Flowers are reddish-purple, with five petals, arranged in panicles in the upper leaf axils.
Seeds/Fruit: The fruit is composed of four prickly nutlets each about 1/3 inch long (Whitson et al. 1996).
Leaves: Leaves are alternate, 1-12 inches long, 1-3 inches wide, rough, hairy, and lacking teeth or lobes (Whitson et al. 1996). Leaves often appear dusty and insect-ridden. Basal leaves are elliptical to oblanceolate and tapered at the base.
Stems: Houndstongue produces a single flowering stem. The stem is erect, stout, heavy, 1.5 to 3 ft high and usually branched above.
Roots: Houndstongue has a thick, black, woody taproot.
Seedling: Houndstongue forms a rosette the first year of its life cycle.

Similar Species

Exotics: Rosettes may resemble burdock.
Natives: If not flowering, could be mistaken for members of the *Hackelia* or *Lappula* genus (stickseeds).

Impacts

Agricultural: Houndstongue contains toxic alkaloids that stop liver cells from reproducing. Therefore, houndstongue reduces livestock and wildlife forage and grazing animals should be kept away from houndstongue infested areas. Animals may live six or more months after eating a lethal dose of houndstongue. Sheep are more resistant to houndstongue poisoning that cattle or horses. The burs may reduce the value of wool.
Ecological: Houndstongue is an early successional species on recently disturbed sites.
Human: Due to its toxicity to grazing animals, houndstongue should not be eaten by humans.

Habitat and Distribution

General requirements: Houndstongue prefers areas with more than 10 percent bare ground (Butterfield et al. 1996), and is common on gravelly, alkaline soils (Stubbendieck et al. 1995).
Distribution: Houndstongue is found over much of North America. It grows on rangeland, pastures, abandoned cropland, roadsides, and waste places (Butterfield et al. 1996). Houndstongue is found on rangeland, pastures, and roadsides throughout Montana.

Historical: Houndstongue is a native of Eurasia that was introduced to North America as a contaminant in agricultural seed.

Biology/Ecology

Life cycle: Houndstongue is a biennial that produces a rosette the first year. During the second year a flowering stem bolts and produces fruit.
Mode of reproduction: Reproduces solely by seed.
Seed production: Mature plants can produce up to 2,000 seeds (Butterfield et al. 1996).
Seed bank: Seeds remaining on the parent plant may remain viable for 2-3 years. Buried seed rarely survive more than one year (Butterfield et al. 1996).
Dispersal: Seeds stick to clothing and animals and have the ability to be spread great distances.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Mowing second year plants during flowering but before seed maturation reduces seed production and may kill the plant.
Fire: No information available.
Herbicides: Picloram at 0.25-0.5 lb, 2,4-D, or dicamba at 1.0 lb, or metsulfuron at 0.6 oz active ingredient/acre applied in spring provides control of houndstongue. Spring treatments with picloram, dicamba, or metsulfuron are more effective than fall treatments (Sebastian and Beck 1995). Chlorsulfuron applied 0.5 lb active ingredient/acre gave complete control when applied any time beginning with the rosette stage until the bolted plant had attained 10 inches in height (Butterfield et al. 1996).
Cultural/Preventive: Maintaining a healthy population of native perennials the best way to prevent the establishment and spread of houndstongue.

Keys to Control:
- Eliminate seed production.
- Re-seed controlled areas with desirable species.

Integrated Management Summary

Houndstongue is poor competitor with native perennials and requires disturbed or bare areas to establish. Once established, it quickly forms dense monocultures. Treat first year plants with herbicides. Mow bolted plants to eliminate seed production. Repeat this process for several years to exhaust the seed bank. It is imperative to establish a healthy population of native perennials on treated areas to prevent the re-establishment of houndstongue or other noxious weeds.

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Kochia

Kochia scoparia (L.) Schrad.

Family: *Chenopodiaceae* (Goosefoot)
Other Names: kochia, summer cypress
Six Letter Code: KOCSCO
USDA Code: KOSC

Keys to Identification:
- Flowers are inconspicuous forming dense spikes in leaf axils.
- Five-hook bassia (Bassia hyssopifolia) is distinguished from kochia by the five hooked structures on each seed.

Identification

Growth form: Annual forb.
Flower: Flowers are inconspicuous, stalkless in the axils of upper leaves and form short, dense, bracted spikes (Whitson et al. 1996).
Seeds/Fruit: Seeds are wedged shaped, dull brown, slightly ribbed.
Leaves: Leaves are 0.5-2 inches long, alternate, and lance-shaped. The upper surface of the leaf is usually smooth, while the lower surface is covered with soft hairs.
Stems: Mature plants are 1-6 ft tall with numerous branches. Stems are erect, simple to much-branched, and often form pyramidal or rounded tops. Stems are usually hairy, but are occasionally smooth.
Roots: Roots generally penetrate to depths of 6-8 ft.
Seedling: No information available.

Similar Species

Exotics: Five-hook bassia (*Bassia hyssopifolia*) is easily distinguished from kochia by the five hooked structures on each seed.
Natives: None known.

Impacts

Agricultural: Although kochia is readily grazed by livestock, it sometimes contains high nitrate levels and sulfate toxicity (Whitson et al. 1996).
Ecological: Kochia colonizes rapidly and may suppress other vegetation. It is an early successional plant on disturbed sites and can dominate vegetation for the first two years following disturbance (FEIS 1996). Kochia may spread into undisturbed sites when growing conditions are ideal.
Human: No information available.

Habitat and Distribution

General requirements: Kochia is most often found in open, sunny areas on disturbed sites. It grows on a variety of soil types, and is often found on saline/alkaline soils (FEIS 1996). Kochia can also be found in grasslands, mixed-grass prairie, shortgrass prairie, floodplains, riparian areas, sagebrush, and desert shrub communities. Other common associates include salt-cedar (*Tamarix* spp.), sand dropseed (*Sporobolus cryptandrus*), saltgrass (*Distichlis spicata*), and western wheatgrass (*Agropyron smithii*) (FEIS 1996).

Distribution: In Montana, kochia occurs on disturbed grasslands and desert shrub communities.
Historical: Kochia is a native of Eurasia that has become naturalized in the Great Plains and western states (FEIS 1996).

Biology/Ecology

Life cycle: Seedlings emerge very early in the spring. Flowering and seed production may occur from July to October. Kochia is very responsive to elevated soil nitrogen levels, either through some type of soil disturbance or due to fertilization. It will often grow rapidly for 1-2 years in abandoned fields or in badly overgrazed rangeland until the readily available nitrogen is depleted. Then kochia plants are often small, presumably due to the nitrogen limitation. Kochia is rarely a problem in areas where healthy stands of perennial grasses exist.
Mode of reproduction: Kochia reproduces exclusively by seed.
Seed production: Typically, a single plant will produce about 14,600 seeds per year.
Seed bank: Kochia seeds have little seed bank viability, as they either germinate or decay in one year (FEIS 1996).
Dispersal: The major means of seed dispersal is through a "tumbleweed" process.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Grazing or mowing alone will not control kochia or stop seed production (FEIS 1996). Small infestations can be pulled by hand.
Fire: No information available.
Herbicides: Kochia is commonly controlled with herbicides but it is not by phenoxy herbicides at rates recommended for crops (FEIS 1996). Dicamba at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre will control it. Metsulfuron+dicamba is effective.
Herbicides should be applied in early spring after seedling emergence (Whitson et al. 1996).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Keys to Control:
- Exhaust the root system and eliminate seed production by mowing or treating with herbicides.
- Maintain a healthy cover of perennial plants to discourage the establishment and spread of hoary cress.

Integrated Management Summary

Even though kochia exhibits extreme reproductive plasticity (in that one plant can produce over 50,000 seeds under favorable conditions, but only 5 seeds under stressful conditions), the limited viability of kochia seeds increases the effectiveness of control methods. As with other plants which reproduce solely by seed, integrated management efforts should focus on the elimination of seed production and the depletion of the seed bank. Combine herbicide or mechanical removal of rosettes with removal of seed heads from any plants that have bolted.

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Leafy Spurge

Euphorbia esula L.

Family: *Euphorbiaceae* (Spurge)
Other Names: none widely accepted
Six Letter Code: EUPESU
USDA Code: EUES

Keys to Identification:
- Flowers are yellowish-green and have a pair of heart shaped yellow green bracts below each inconspicuous flower.
- The entire plant contains white, milky latex.

Identification

Growth form: Perennial forb.
Flower: Flowers are yellowish-green, small, arranged in numerous small clusters and subtended by paired heart-shaped yellow-green bracts.
Seeds/Fruit: Seeds are oblong, grayish to purple, contained in a 3- celled capsule.
Leaves: Leaves are alternate, narrow, 1-4 inches long.
Stems: Mature plants are up to 3 ft tall. Stems are thickly clustered.
Roots: Extensive lateral root system.
Seedling: Seed leaves (cotyledons) are linear to lanceolate, with entire margins.
Other: The entire plant contains white, milky latex. Foliage of the plant is smooth and hairless.

Similar Species

Exotics: None known.
Natives: Leafy spurge is distinguished from native spurges such as *Euphorbia brachycera* by its long linear leaves.

Impacts

Agricultural: Leafy spurge can invade rangeland that is in excellent condition, making it worthless for cattle and horse grazing and reducing land values (Lajeunesse et al. 1999).
Ecological: Leafy spurge is an aggressive, long-lived, perennial weed that can displace all other vegetation in rangeland, pasture, and native habitats (Biesboer 1998). Leafy spurge decreases rangeland diversity, threatens native plants and degrades wildlife habitat (Lajeunesse et al. 1999). It produces a large number of seeds and underground shoot buds. These two reproductive techniques allow it to rapidly displace native species, and form a monoculture. Rapid re-appearance of treated stands often follows an apparently successful eradication because of the large nutrient reserve in the roots. Leafy spurge produces an allelopathic compound that inhibits the growth of other plants (Butterfield et al. 1996).

Human: The milky latex sap of leafy spurge can cause irritation, blotching, blisters, and swelling in sensitive individuals.

Habitat and Distribution

General requirements: Leafy spurge grows in a wide range of habitats. It is most aggressive in semi-arid areas, but can be found in xeric to subhumid and subtropic to subarctic habitats (Butterfield et al. 1996). Leafy spurge occurs most commonly on untilled, non-crop areas such as rangeland, pastureland, woodland, prairies, roadsides, stream and ditches, and waste sites. It grows on all kinds of soils, but is most abundant in coarse-textured soils and least abundant on clayey soils (Butterfield et al. 1996).
Distribution: Leafy spurge is widely distributed in Montana and throughout the United States.
Historical: Leafy spurge is native to Eurasia. It was brought to northeastern United States in 1829 as an ornamental, and had spread to the west coast by the early 1900s.

Biology/Ecology

Life cycle: Leafy spurge is one of the earliest plants to emerge in the spring, usually in mid-April to late May (Butterfield et al. 1996). The development of terminal flower clusters begins 1 to 2 weeks after stem emergence. Flower clusters have 8 to 16 branches. Each branchlet forms a greenish yellow bract in May. Flowering generally ends in late June to mid-July as the plants do not usually flower, and growth is reduced, during the hotter portion of the summer. However, if conditions are favorable, leafy spurge may produce a few lateral flowers throughout the summer and in the fall. Thus, it is possible for the plant to produce seed until frost. Seeds mature about 30 days following pollination. Peak germination occurs from late-May to early June. If adequate moisture is present, germination can occur throughout the growing season.
Mode of reproduction: Despite being a successful seed producer, leafy spurge primarily reproduces vegetatively through its extensive lateral root system. Long roots have the capability to produce shoots and can reach nearly 15 ft laterally, and about 30 ft in depth. As many as 300 buds have been counted on these long roots (Butterfield et al. 1996).
Seed production: Each flowering stem produces from 10-50 capsules with a seed yield range of 200-250 seeds per flowering shoot (Best et al. 1980). A large plant may produce up to 130,000 seeds (Rutledge and McLendon 1998).
Seed bank: Seeds can remain viable in the soil for 5-8 years although 99 percent of the viable seeds will germinate in the first two years (Butterfield et al. 1996).
Dispersal: The three-sided capsules explode when ripe, sending the enclosed seeds up to 15 ft from the parent plant. Seeds float on water, and can be transported and deposited by floodwater.
Hybridization: No information available.

Control

Biocontrol: Currently, there is extensive research on biological control agents for leafy spurge with over 15 insects being studied (Biesboer 1998). However, control of leafy spurge by insects is often limited by the thick milky latex, which tends to clog the mouth or sucking parts of most insects (Butterfield et al. 1996). Successful biological control will most likely require a combination of insects and a long-term management program to establish them. The Division of Plant Industry's Biological Pest Control Section has released eight species in an effort to control leafy spurge. Three of these species, *Aphthona nigriscutis*, *A. cyparissiae*, and *A. czwalinae/lacertosa*, have become established and may be available for distribution from the Insectary. The most effective biological control agents seem to be six species of root- and foliage-feeding beetles in the genus *Aphthona*, and a stem- and root-boring beetle *Obera erythrocephala* (Lajeunesse et al. 1999).Grazing sheep on infested areas has been used successfully to control spurge on ranches in Montana, but ranchers agree that once the sheep were removed the spurge

Keys to Control:
- Develop a management scheme that uses several control methods that are compatible with your site.
- Persistently monitor your area and quickly control new infestations.

would quickly return (Biesboer 1998). Sheep grazing is likely to be most effective in the spring and summer when the spurge plants are succulent and when sheep tend to prefer forbs over grasses, rather than in fall when sheep forage more on grasses (Lajeunesse et al. 1999). Two grazing periods during the spring-summer with a recovery period (for the grasses) between are recommended rather than season-long grazing. Fall grazing by goats followed by application of picloram and 2,4-D (each 1 quart/acre) can provide good control (Lajeunesse et al. 1999). A recent study near Denver found that sheep grazing for a short period in early July every year for 5 years reduced leafy spurge density by 90 percent. This study also produce excellent results by combining sheep with *Apthona* beetles (Beck and Rittenhouse, 2000).

Mechanical: Tillage is not generally a practical control method for areas where leafy spurge grows. Mowing can actually increase the density of leafy spurge, and may not be effective even when combined with herbicide (K.G. Beck, personal comm.). Pulling leafy spurge is ineffective, even for small infestations because of the deep root system and the presence of numerous root buds.

Fire: Burning alone will not likely provide adequate control of leafy spurge due to regeneration from the root system. However, combinations of burning and herbicide application 5 weeks later might provide adequate control (Biesboer 1998). In one study, plots of leafy spurge were sprayed with a mix of 2,4-D and picloram in September and burned the following April. The plots were sprayed again in June and burned again in October (Biesboer 1998). This process is designed to exhaust the nutrient reserves in the root system of the plant and hinder its ability to compete with other species. Therefore, reseeding desirable species is also necessary.

Herbicides: Herbicides can provide some control of leafy spurge. However, due to its extensive root system and general hardiness, follow up applications are necessary for herbicides to be effective. Picloram is recommended for eradication of small infestations, with herbicide application extending for 10-15 ft beyond the leafy spurge patches (Lajeunesse et al. 1999). A combination of picloram and 2,4-D (1-1.5 pints of picloram with 1-1.5 quarts of 2,4-D) was shown to provide the best control when applied in the spring when flowers emerge (Beck 1996). Research in North Dakota has shown that a tank mix of picloram (1 pt./ac) and 2,4-D (1 quart/acre) (based on concentrate of 4 pounds active ingredient/gallon) applied 2 weeks after the yellow bracts appear and applied annually is a cost effective treatment for leafy spurge (Lym et al. 1993). Picloram at 1 quart/acre for 2-3 consecutive years is also effective, but more expensive. An annual combination of dicamba plus 2,4-D (4-8 oz + 0.5-1 quart/acre) also provided good control (Beck 1996). Glyphosate is most effective when applied sequentially at 1 quart/acre at one month intervals, coupled with fall grass seeding (Beck 1996).

Cultural/Preventive: Long-term control of leafy spurge requires, among other things, a competitive plant community dominated by desirable species. For reseeding, select a mixture of grass species with early-, mid-, and late-season growth, and with shallow-, intermediate-, and deep-rooting depths. The resulting plant community will maximize the use of water and nutrients by the desirable species and will effectively compete with leafy spurge. After reseeding, it is imperative to manage grazing animals carefully so as to invigorate and not harm perennial grasses. Consider grazing sheep or goats with cattle so the former can graze spurge plants.

Note of Caution: The milky latex associated with leafy spurge can cause irritation, blotching, blisters, and swelling in sensitive individuals. The eyes should never be rubbed until after the hands are thoroughly washed. Gloves should be worn while pulling or coming into contact with this plant.

Integrated Management Summary

Persistent monitoring of areas with known or potential infestations is crucial to managing leafy spurge. New infestations are much more easily controlled than established infestations. 100 percent eradication of leafy spurge is rarely achieved, but infestations can be reduced to manageable levels. Herbicides are most commonly used to control leafy spurge. However, damage to non-target species is always a concern. Sheep and goats can be used to control leafy spurge. Leafy spurge is extremely difficult to control by chemical means and is almost impossible to control by cultural or physical

methods. Therefore a management scheme that combines control methods over four to five years is recommended (Beck 1996). Lym (1998) recommends combinations of re-seeding with competitive grasses, biological control insects, sheep or goat grazing and herbicide (2,4-D + picloram) treatment. Grazing animals and biological agents are generally appropriate only for larger infestations. Although leafy spurge can be poisonous to cattle, sheep can be taught to feed on it and goats will seek it out.

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Perennial Pepperweed

***Lepidium latifolium* L.**

Family: ***Brassicaceae*** (Mustard)
Other Names: tall whitetop, broad-leaved peppergrass, Virginia pepperweed
Six Letter Code: LEPLAT
USDA Code: LELA2

Keys to Identification:

- Perennial pepperweed has dense clusters of white flowers that appear in early summer.
- The leaves and stem are covered with a waxy layer.

Identification

Growth form: Perennial forb.
Flower: White flowers are packed in dense clusters near the ends of branches. **Seeds/Fruit:** Fruits are nearly round, about 0.1 inch in diameter and usually sparsely hairy.
Leaves: Leaves are alternate, lance-shaped, entire to toothed, bright green to gray-green, and do not have clasping bases (whitetop leaves have clasping bases). The basal leaves are larger than the upper leaves.
Stems: Mature plants are 1-3 feet tall.
Roots: Perennial pepperweed roots grow deep into the soil.
Seedling: No information available.
Other: The leaves and stem are covered with a waxy layer (Whitson et al. 1996).

Single flower - enlarged

Similar Species

Exotics: Whitetop (*Cardaria draba*) leaves have clasping bases; perennial pepperweed can also be distinguished by its waxy appearance.
Natives: Many native members of the sunflower *(Asteraceae)* family resemble this species in the rosette stage.

Impacts

Agricultural: Perennial pepperweed invades irrigated pastures, cropland, and native meadows (FEIS 1996).
Ecological: Perennial pepperweed is an aggressive colonizer of riparian habitats. It establishes rapidly and can eliminate competing vegetation (FEIS 1996).
Human: No information available.

Habitat and Distribution

General requirements: Perennial pepperweed is most often found in open, unshaded areas on disturbed, and often saline soils.
Distribution: Perennial pepperweed is found in riparian habitats of the Intermountain region (FEIS 1996).
Historical: Perennial pepperweed was introduced from Eurasia.

Biology/Ecology

Life cycle: Dense flower clusters appear in early summer and continue through August.
Mode of reproduction: Perennial pepperweed reproduces mainly by spreading rhizomes, and can be an aggressive colonizer of disturbed areas (FEIS 1996).
Seed production: Perennial pepperweed produces an abundance of highly germinable seeds. Seed production is from June to August.
Seed bank: Seeds have no apparent dormancy.
Dispersal: Seeds drop from the plant or travel short distances by wind/water.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Periodic mowing and spring burning have reduced perennial pepperweed density in Utah (FEIS 1996).
Fire: (See above)
Herbicides: Metsulfuron at the rate of 0.45 oz. active ingredient/acre is the most effective herbicide treatment. Dicamba at 1 lb. active ingredient/acre, glyphosate at 1.5 lb. active ingredient/acre or glyphosate+2,4-D at 54 fl. oz. product/acre will control perennial pepperweed. Other herbicides that proved to be effective include chlorsulfuron and imazapyr.

Keys to Control:
- Plants must not be allowed to produce seed if control is to be successful.
- Use a combination of mechanical techniques and herbicide applications to control

Cultural/Preventive: Treat new infestations of perennial pepperweed as soon as they are found.
Integrated Management Summary A combination of mechanical (cutting or pulling) and herbicide applications can provide effective control of perennial pepperweed. Plants should be cut or pulled during the flower bud stage. Herbicides should be applied to the recovering stems when they return to flower bud stage later the same year.

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Russian Olive

***Elaeagnus angustifolia* L.**

Family: *Elaeagnaceae* (Oleaster)
Other Names: Russian olive, oleaster
Six Letter Code: ELAANG
USDA Code: ELAN

Keys to Identification:
- Russian olive is known by its silvery-gray color, short tree stature, fragrant flowers, and small, silvery fruits.

Identification

Growth form: Russian olive is a large, spiny, perennial, deciduous shrub or small tree to 30 ft tall.
Flower: Highly aromatic, creamy yellow flowers appear in June and July.
Seeds/Fruit: Clusters of abundant silvery fruits, about 1/2 inch long, mature from August to October and stay on the tree through the winter.
Leaves: The dull green to gray, elliptical to lanceolate shaped leaves are alternate and simple, 1 to 3 inches long by about 1/2 inch wide, distinctly scaly above and silvery-scaly below.
Stems: The branches are silvery, scaly and thorny when young; and shiny, light brown when mature. The bark is at first smooth and gray, becoming unevenly rigid and wrinkled.

Similar Species

Exotics: None known
Natives: Silverberry *(Elaeagnus commutata)* is a smaller shrub of similar coloration that occurs on drier riparian and upland sites.

Impacts

Ecological: Russian olive, with its tendency to spread quickly, is a menace to riparian woodlands, threatening strong, native species like cottonwood and willows. Russian olive has out competed native vegetation, interfering with natural plant succession and nutrient cycling, and choking irrigation canals and marshlands, displacing native plants and critical wildlife habitats. Areas dominated by Russian olive do not have a high concentration of wildlife. Although Russian olive is a source of food and habitat for some wildlife, ecologists have found that bird species richness is actually greater in areas with a higher concentration of native vegetation.
Human: Russian olive was introduced by humans as an attractive landscape species. Its dense, silvery foliage forms a good hedge to screen out unwanted views. Until recently, it was planted for wildlife habitat and windbreaks by the USDA Natural Resource and Conservation Service.

Habitat and Distribution

General requirements: Russian olive can tolerate a variety of temperature, water, and soil conditions, including bare mineral substrates. The species is very adaptive and is an initial colonizer of disturbed sites. It grows along floodplains, riverbanks, streams and marshes. It can tolerate large amounts of

salinity and can grow well in a variety of soils from sand to heavy clay. It can survive temperatures from –50 to 115 degrees F. It is shade tolerant, allowing it to withstand competition from taller trees. It can absorb nitrogen into its roots, giving it the ability to grow on bare, mineral surfaces.
Distribution: Russian olive is found throughout North America, but mainly in the central and western portions of the United States. It has naturalized and been planted in 17 western states from the Dakotas, Nebraska, Kansas, Oklahoma, and Texas westward to the Pacific coast. It is most abundant in the Great Basin Desert region and the riparian zones of the Great Plains.

Biology/Ecology

Mode of reproduction: Seed primarily, but also resprout of cut stems
Seed production: Abundant
Seed bank: Seeds are persistent
Dispersal: Birds and small mammals foraging on the fruit scatter seeds widely.

Control

Russian olive is very difficult to control or eradicate, due to its capacity to produce root sprouts and "suckers." Although the species can thrive without water, it becomes stressed when there is a severe lack of water, often causing fungus to appear.

Keys to Control:
- Eradicate initial colonizer plants by cutting and applying herbicide to the stump or digging out the roots.

Biocontrol: Few animals and insects feed or bother Russian olive, so there tends to be no effective biological control. There are two kinds of fungus that can affect it: Verticillium wilt and Phomopsis canker. Verticillium wilt attacks and usually kills Russian olive in eastern areas that are very humid and wet or poorly drained, causing the leaves to wilt. Canker disease is a reddish-brown to black canker that appears on smaller branches, resulting in a kind of "bleeding" on the diseased areas. Once the fungus covers the branch, lack of water causes the leaves to wilt and the branches die off.
Mechanical: Cutting has little effect on it, as it resprouts heartily from the stump. Mowing Russian olive with a brush type mower, removing cut material, and then spraying is probably the most effective way to eradicate the species.
Fire: Russian olive is fire resistant and tends to colonize burned areas, yet burning with a combination of herbicide spraying on the stump may prevent it from resprouting.
Herbicides: Systemic herbicides, such as Roundup®, Glypro®, Garlon 3A®, and Garlon 4® can be effective when applied to cut stumps or when used as a foliar spray. A small amount of Tordon Kit in the mixture will control resprouting. Basal bark application of Garlon 4® with Penevator Basal Oil® can also be an effective control.

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Russian Thistle

Salsola iberica Sennen

Family: *Chenopodiaceae* (Goosefoot)
Other Names: tumbleweed
Six Letter Code: SALIBE
USDA Code: SAIB

Keys to Identification:
- Stems of Russian thistle have purple stripes.
- Inconspicuous flowers are borne in leaf axils.
- Seedling plants have long, fleshy leaves.

Identification

Growth form: Annual forb
Flower: Inconspicuous flowers are borne in axils of the upper leaves. Each flower is accompanied by a pair of spiny, floral bracts (Whitson et al. 1996).
Seeds/Fruit: Small one-seeded fruits with winged tips. Seeds are round, black, smooth and shiny.
Leaves: Leaves are alternate; the first leaves are long, string-like and soft. Later leaves are short, scale-like and tipped with a stiff spine (Whitson et al. 1996).
Stems: Mature plants are 0.5-3 ft tall and are rounded, bushy, and highly branched. Stems are red or purpled striped.
Roots: The root system consists of a taproot that can grow 3 ft or more in depth with extensive lateral roots
Seedling: Seedling plants have long, fleshy leaves.

Similar Species

Exotics: Young Russian thistle plants resemble young halogeton plants, although halogeton lacks spines.
Natives: None known.

Impacts

Agricultural: It is well adapted to cultivated dryland agriculture, but is also found on disturbed rangeland, and wasteland.
Ecological: Russian thistle colonizes barren desert areas that cannot support other flora, and invades many different disturbed plant communities. Since its introduction, it has become one of the most common and troublesome weeds in the drier regions of the United States (Whitson et al.1996). Russian thistle occurs in many communities. It is most common along disturbed grassland and desert communities. In disturbed big sagebrush communities, Russian thistle dominated for the first two years. After this time plants became overcrowded and stunted, and were replaced by mustards (FEIS 1996).
Human: No information available.

Habitat and Distribution

General requirements: Russian thistle grows in disturbed or unoccupied sites. (FEIS 1996). It grows on any type of well-drained, uncompacted soil with a sunny exposure. Russian thistle cannot tolerate saturated soil for extended periods.
Distribution: Found throughout central and western North America, up to 8,550 ft (FEIS 1996).
Historical: No information available.

Biology/Ecology

Life cycle: In spring, Russian thistle seeds will germinate at virtually any conceivable seedbed temperature (FEIS 1996). Plants typically flower from July through October. Seeds mature during August through November. Russian thistle seedlings are poor competitors, and do not establish well in crowded communities (FEIS 1996).
Mode of reproduction: Reproduces by seeds.
Seed production: One plant can produce up to about 250,000 seeds (FEIS 1996).
Seed bank: Seeds remain viable less than a year.
Dispersal: After seeds mature in the fall the plant stem separates from the root. The plant is then blown by wind. Seeds, held in the leaf axils, fall to the ground as the plant tumbles.
Hybridization: No information available.

Control

Biocontrol: The Division of Plant Industry's Biological Pest Control Section has two moth species, *Coleophora klimeschiella* and *C. parthenica*, that may be available for redistribution.
Mechanical: Mowing or pulling young plants can be used to control Russian thistle. However this process may have to be repeated for several years to be successful.
Fire: Prescribed burning is not recommended for control of Russian thistle, since it favors disturbed communities and readily recolonizes burned areas (FEIS 1996).
Herbicides: Dicamba at 0.5 lb, 2,4-D at 1 lb, or glyphosate at 1.5 lb active ingredient/acre, have been used to successfully control Russian thistle (Calweed 1997).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Keys to Control:
- Maintain vigorous stands of perennial plants.
- Herbicides should be applied at the seedling growth stage for best results.
- Small infestations can be controlled by mowing or pulling young plants.

Integrated Management Summary

For effective control of Russian thistle, control methods should be accompanied by a program to maintain or enhance the natural plant cover. As with other annual plants which reproduce by seeds, Russian thistle can eventually be controlled by eliminating seed production until the soil seed bank is depleted. Cut/pull or treat plants with herbicide prior to seed set.

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Spotted Knapweed

***Centaurea maculosa* L.**

Family: *Asteraceae* (Sunflower)
Other Names: none widely accepted
Six Letter Code: CENMAC
USDA Code: CEMA4

Keys to Identification:
- Spotted knapweed can be distinguished from other similar looking knapweeds by the dark tips and fringed margins of the floral bracts.

Identification

Growth form: Short-lived perennial forb (rarely biennial).
Flower: Flowering heads are solitary at the ends of branches. The floral bracts are stiff and tipped with a dark comb-like fringe. The flowers are pinkish-purple or rarely cream colored.
Seeds/Fruit: Seeds have a tuft of persistent bristles.
Leaves: Rosette leaves are up to 6 inches long, and deeply lobed. The principal stem leaves are pinnately divided, have smooth margins, and become smaller toward the top of the shoot. Leaves are alternate.
Stems: Mature plants are 1-3 ft tall with one or more stems.
Roots: Spotted knapweed has a stout taproot.
Seedling: Rosettes of spotted and diffuse knapweed are nearly indistinguishable. Leaves are narrow and 1-2 times pinnately divided (Stubbendieck et al. 1995).
Other: Closely related to diffuse knapweed (*Centaurea diffusa*).

Similar Species

Exotics: Other knapweeds include diffuse knapweed (*Centaurea diffusa*) which has a distinct terminal spine on the floral bracts, Russian knapweed *(Centaurea repens)* whose flowers are smaller than those of spotted knapweed and do not have black mottling on the flower bracts, squarrose *(Centaurea virgata)* and black *(Centaurea nigra)* knapweeds.
Natives: American star-thistle *(Centaurea americana)*. Other native members of the sunflower family can resemble knapweed in the seedling/rosette stage.

Impacts

Agricultural: Spotted knapweed reduces or displaces desirable plant species, thereby reducing livestock and wildlife forage (Sheley et al. 1999).
Ecological: Spotted knapweed is a highly competitive weed that invades disturbed areas and degrades desirable plant communities. It forms near monocultures in some areas of western North America (FEIS 1996). There is evidence that spotted knapweed produces allelopathic chemicals that inhibit growth of other plants (Rutledge and McLendon, 1998). This allows it to form dense monocultures. However, Kelsey and Bedunah (1989) reported that resource capture was more important than allelopathy in spotted knapweed success. Although it is usually found in disturbed areas, once a colony is established, it may invade adjacent undisturbed areas (Rutledge and McLendon, 1998).

Human: The sap of spotted knapweed can cause skin irritation in some people. As a precaution, anyone working with spotted knapweed should wear protective gloves and avoid getting knapweed sap into open cuts or abrasions. Workers should wash hands and exposed skin with soap and water following contact with this plant.

Habitat and Distribution

General requirements: Spotted knapweed is adapted to well-drained, light to coarse-textured soils. It is not tolerant of shade. It tends to inhabit somewhat moister sites than diffuse knapweed, preferring areas that receive 12 to 30 inches mean annual precipitation.
Distribution: Spotted knapweed has heavily infested large areas of several states in the Pacific Northwest, with lesser infestations throughout much of the United States.
Historical: Native to central Europe and Asia.

Biology/Ecology

Life cycle: Spotted knapweed germinates in spring or fall (Beck 1997). Spotted knapweed seedlings develop into and remain as rosettes for at least one growing season while root growth occurs (FEIS 1996). It usually bolts for the first time in May of its second growing season and flowers August through September (Rutledge and McLendon, 1998). Individual flowers bloom for 2-6 days (FEIS 1996). Plants are self fertile and are also cross-pollinated by insects.
Mode of reproduction: Spotted knapweed reproduces entirely by seed and is a prolific seed producer.
Seed production: Plants may produce up to 140,000 seeds/m2 (Rutledge and McLendon, 1998). Most seeds are shed immediately after reaching maturity.
Seed bank: Spotted knapweed seeds exhibit three germination behaviors: dormant light-sensitive, dormant light insensitive, and non-dormant (FEIS 1996). Dormant seeds form a seed bank and may remain viable in the soil for over 8 years (Rutledge and McLendon, 1998).
Dispersal: Knapweed seeds are often spread in hay and on vehicle undercarriages.
Hybridization: No information available.

Control

Biocontrol: Currently, there is no single biological control agent that effectively controls knapweed populations. Some researchers believe that it will take a combination of up to twelve different insects to reduce knapweed infestations (Beck 1997). The Division of Plant Industry's Biological Pest Control Section has five species that may be available for redistribution. These five species are *Urophora affinis*, *U. quadrifasciata*, *Agapeta zoegana*, and *Sphenoptera jugoslavica*, *Cyphocleonus achates*. The seedhead flies *U. affinis* and *U. quadrifasciata* have been released in many Front Range communities (Beck 1997). These insects cause plants to produce fewer viable seeds and abort terminal or lateral flowers (Beck 1997). Biological control insects may help reduce knapweed plants in stands of desirable plant species. For this reason, insects may be beneficial in combination with other control methods. Cattle and sheep will both graze spotted knapweed, although sheep appear to be the more effective control animal. Olson et al. (1997) found that limited duration sheep grazing of spotted knapweed when associated grasses were dormant reduced knapweed seedlings and rosettes and reduced knapweed reproduction.

Keys to Control:
- The most effective method of control for spotted knapweed is to prevent its establishment. Areas should be monitored two to three times a year (spring, summer, and fall) and any new rosettes should be destroyed.
- Established plants or stands of spotted knapweed can be pulled or spot treated with picloram, or a combination of picloram and dicamba.
- Burning may be an effective means of controlling knapweed in areas where seasonal or occasional fires are part of the natural ecosystem.

Goats would also probably be effective in controlling spotted knapweed.

Mechanical: Cutting, mowing, or removing the above ground portion of the plant after flowering, but before seed set, may be an effective way to eliminate seed production. However, spotted knapweed seeds can remain dormant in the soil for nearly a decade, requiring any cutting program to be repeated annually to be effective. A long-term program with repeated cuts of bolted plants only for several years will strongly reduce numbers and cover of spotted knapweed. Pulling can control spotted knapweed in small areas. Pulling works best when the soil is wet so the entire plant crown and taproot can be removed.

Fire: Burning has either promoted or controlled spotted knapweed; this variability in effect probably reflects differences in environmental conditions before and after the burns occurred and differences in the competitiveness of the native plant communities that were burned. Burning has been shown an effective control of knapweed with strong grass re-growth occurring on burned sites (Watson and Renney 1974). However, herbicide efficacy may increase when applied on post-burn rangeland, possibly due to the removal of standing dead material that would otherwise intercept herbicide (Lacey et al. 1995). A low-severity fire may only top-kill knapweed, but a severe fire will probably kill the plant. Dry soil conditions associated with burns may discourage knapweed re-infestation as moisture is the limiting factor for knapweed seed germination. Re-seeding desirable species should be part of any burning program to deter a re-infestation of knapweed or other exotic species.

Herbicides: Several herbicides are relatively effective at controlling knapweed. Picloram at 1.0 lb active ingredient/acre is the most effective, but has a long soil life and can damage non-target species (Harris and Cranston 1979, Watson and Renney 1974). Davis (1990) found that picloram applied at 0.25 lb active ingredient/ac provided 100 percent spotted knapweed control for 3-5 years. Other effective herbicides include dicamba or 2,4-D at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre. To save money and reduce grass injury resulting from higher use rates of a single herbicide, several of these herbicides can be combined (Beck 1997). Tank-mixes of picloram and dicamba (0.25 to 0.5 lb/acre + 0.125 to 0.25 lb/acre), picloram plus 2,4-D (0.188 lb/acre + 1.0 lb/acre), and dicamba plus 2,4-D (0.5 lb/acre + 1.0 lb/acre) all control knapweed (Beck 1997). Clopyralid applied at 0.24 lb active ingredient/ac and at 0.2 lb active ingredient/ac + 2,4-D at 1.0 lb active ingredient/ac provide control comparable to picloram when applied at the bolt or bud growth stages (Sheley et al. 1999). A backpack sprayer or a wick is highly recommended in small areas to minimize damage to non-target plants. Herbicides should be applied before the mature plants set seed to maximize effectiveness.

Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal.

Integrated Management Summary

Spotted knapweed can spread readily by stems that are carried on vehicles or in infested hay or seed. Early detection and prompt control of small spotted knapweed infestations are by far the most economical ways to manage this weed. Spotted and diffuse knapweed can be managed similarly (Beck 1997). They are readily controlled with herbicides but will re-invade unless cultural techniques are used (Beck 1997). Sheley and Jacobs (1997) found that a ninety percent reduction in diffuse knapweed was necessary to shift the competitive relationship in favor of bluebunch wheatgrass. The sap of spotted knapweed can cause skin irritation in some people. As a precaution, anyone working with spotted knapweed should wear protective gloves and avoid getting knapweed sap into open cuts or abrasions. Workers should wash their hands and exposed skin with soap and water following contact with this plant.

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Whitetop

Cardaria draba (L.) Desv.

Family: *Brassicaceae* (Mustard)
Other Names: heart-podded whitetop, hoary cress, pepperweed
Six Letter Code: CARDRA
USDA Code: CADA

Keys to Identification:
- Whitetop can be easily identified by the clusters of numerous, four-petal, white flowers that give it a flat-topped appearance.

Identification

Growth form: Perennial forb.
Flower: Numerous white flowers with four petals, give the plant a white, flat-topped appearance.
Seeds/Fruit: Seed capsules are heart shaped, and contain two reddish brown seeds.
Leaves: Leaves are alternate, 1.6-4 inches long, blue green in color, and lance-shaped. Lower leaves are stalked, while the upper leaves have two lobes clasping the stem.
Stems: Mature whitetop plants are up to two ft tall with erect stems.
Roots: Roots are rhizomatous and usually occur at depth of 29-32 inches, but have been recorded to penetrate to a depth of 30 ft in the Pacific Northwest (FEIS 1996).
Seedling: No information available.

Similar Species

Exotics: Two other closely related species, *Cardaria pubescens* and *Cardaria chalapensis* are designated as noxious weeds in some states (Sheley and Stivers 1999).
Natives: Rosettes of gumweed *(Grindelia squarrosa)* are similar, and are found in similar habitat.

Impacts

Agricultural: Whitetop is generally considered unpalatable to livestock.
Ecological: Whitetop is invading rangelands throughout North America. It is highly competitive, once it becomes established, and spreads primarily by extremely persistent roots. Stands eventually eliminate desirable vegetation, becoming a monoculture.
Human: No information available.

Habitat and Distribution

General requirements: Whitetop is typically found on generally open, unshaded, disturbed ground. It grows well on alkaline soils that are wet in late spring and generally does better in areas with moderate amounts of rainfall. It is widespread in fields, waste places, meadows, pastures, croplands, and along roadsides (FEIS 1996).

Distribution: Whitetop is widespread in the United States except along the southern boundary of the western and southcentral states (USDA 1971). In Montana whitetop was first identified in Gallatin County in 1916. This weed has been introduced in all but two of Montana's 56 counties and infests about 32 thousand acres. It is predominantly found in alfalfa, pastures, rangeland and small grain.
Historical: Whitetop is a weed of Eurasian origin.

Biology/Ecology

Life cycle: The root system of whitetop consists of vertical and horizontal roots from which new rosettes and flowering shoots arise (Mulligan and Findlay 1974). Plants emerge in very early spring. The first leaves appear aboveground 5 to 6 weeks after planting (Mulligan and Findlay 1974, FEIS 1996). During this period, the first leaves emerge and form a loose rosette (Mulligan and Findlay 1974, FEIS 1996). Stems arise from the center of each rosette in late April (FEIS 1996). Plants flower from May to June, are self-incompatible, and are pollinated by insects. The plants set seed by mid-summer (Whitson et al. 1996). If conditions are favorable, a second crop of seeds can be produced in the fall (Sheley and Stivers 1999).
Mode of reproduction: Whitetop reproduces both by seeds and vegetatively. It spreads vigorously by creeping roots (FEIS 1996). Within three weeks of germination, a seedling root can begin producing buds (FEIS 1996). One plant can eventually result in a large colony and push out other vegetation to form a monoculture.
Seed production: One plant can produce from 1,200-4,800 seeds.
Seed bank: 84 percent of seed produced are viable the first season (Mulligan and Findlay 1974, FEIS 1996). Buried seeds can remain viable for three years in the soil (Sheley and Stivers 1999).
Dispersal: No information available.
Hybridization: No information available.

Control

Keys to Control:
- Exhaust the root system and eliminate seed production by mowing or treating with herbicides.
- Maintain a healthy cover of perennial plants to discourage the establishment and spread of hoary cress.

Biocontrol: Currently, there is little information about biological controls that attack whitetop. Sheep grazing may control it, but evidence is limited. Managing the grazing is important so desirable species are not damaged.
Mechanical: Mowing 2-3 times a year for several years may slow the spread and reduce seed production. Mowing may increase the effectiveness of subsequent herbicide application (Sheley and Stivers 1999). Mowing should be conducted during the bud stage and repeated when the plants re-bud. The effectiveness of a mowing program can be increased by planting perennial grasses as competitors.
Fire: Rapid growth rate may favor hoary cress after fires, which temporarily eliminate native vegetation. Plants may resprout from rhizomes or establish from seeds (FEIS 1996).
Herbicides: Whitetop is most commonly controlled with herbicides. However, multiple applications are usually needed to provide lasting control. The best time to apply herbicides is in May or June before flowering. The non-crop herbicides metsulfuron and chlorsulfuron are most effective herbicides while the plants still have green tissue (CSU 1998a). It is important to use a non-ionic surfactant with the herbicide (Sheley and Stivers 1999). 2,4- D + dicamba is very effective when applied during the early pre-bud stage (late May through early June) (CSU 1998a). Glyphosate at 1.5 lb active ingredient/acre applied during the flower stage will provide good control. Picloram does not control whitetop. Spraying followed by spring mowing can control whitetop by up to 90 percent (FEIS 1996).
Cultural/Preventive: Cultivation alone will control whitetop when tillage begins at flower bud stage and is repeated every ten days throughout the growing season (FEIS 1996). Reseeding of depleted areas with competitive grasses would probably be an effective complement to sheep grazing.

Nitrogen fertilization can increase the growth of grasses and slow the rate of whitetop invasion (Sheley and Stivers 1999).

Integrated Management Summary

Whitetop is an aggressive weed, reproducing from seed and vegetatively. It can crowd out desirable species and form a monoculture. In the absence of competition, a single plant can spread over an area 12 ft in diameter in a single year (FEIS 1996). Whitetop is commonly controlled with herbicides and less commonly controlled by mowing. Control is difficult because of the perennial root system, abundant seed production, and diverse habitats of the plant (FEIS 1996).

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Yellow Toadflax

Linaria vulgaris P. Miller

Family: *Scrophulariaceae* (Figwort)
Other Names: butter and eggs, wild snapdragon, common toadflax
Six Letter Code: LINVUL
USDA Code: LIVU2

Keys to Identification:

- Yellow toadflax can be identified by its yellow, snapdragon-like, flowers and disagreeable turpentine-like scent.
- It can be distinguished from dalmatian toadflax by its leaves. The leaves of yellow toadflax are narrow, lance-shaped, and pointed at both ends. The leaves of dalmatian toadflax are shorter, wider, and broad-based.

Identification

Growth form: Perennial forb
Flower: Flowers are bright yellow and resemble snapdragons. Flowers are arranged in a raceme at the ends of the branches.
Seeds/Fruit: Seed capsules are round-ovate, 0.3-0.5 inches long, and two-celled. Seeds are brown or black, circular, and surrounded by a notched wing.
Leaves: Leaves are soft, lance-shaped, and pale green. Leaves are mainly alternate but lower leaves appear to be opposite due to crowding.
Stems: Mature yellow toadflax plants are 1-3 feet tall with 1-25 smooth erect floral stems.
Roots: Taproots may be up to a meter in length. Horizontal roots may grow to be several meters long, and can develop adventitious buds that may form independent plants.
Seedling: No information available.
Other: Closely related to dalmatian toadflax *(Linaria dalmatica).*

Similar Species

Exotics: Leaves of dalmatian toadflax *(Linaria dalmatica)* are shorter, wider, broad based, and clasping the stem.
Natives: None known.

Impacts

Agricultural: Yellow toadflax contains a poisonous glucoside that is reported to be mildly poisonous to cattle (Morishita 1991). However, the plant is considered unpalatable and reports of livestock poisonings are rare.
Ecological: Yellow toadflax is quick to establish in open sites and is capable of adapting growth to a wide range of environmental conditions. Yellow toadflax aggressively forms colonies through adventitious buds from creeping root systems. These colonies can push out native grasses and other perennials, thereby altering and simplifying the species composition of natural communities and reducing forage production for livestock and wildlife.
Human: No information available.

Habitat and Distribution

General requirements: Yellow toadflax has a highly variable habitat that depends on environmental factors such as shading, grazing, and soil type (Saner et al. 1995).
Distribution: Yellow toadflax now occurs throughout the continental United States and in every Canadian province and territory (Saner et al. 1995).
Historical: Yellow toadflax is native to the steppes of southeastern Europe and southwestern Asia. Yellow toadflax was introduced to New England in the late 1600s as an ornamental and medicinal plant and continues to be sold in nurseries and seed catalogs (FEIS 1996).

Biology/Ecology

Life cycle: Spring emergence occurs around mid-April and depends primarily on temperature. A smaller flush of seedlings can occur in the fall. Prostrate stems emerge in September and produce leaves that are ovate, 0.9-1.5 inches in size. Prostrate stems are tolerant to freezing and are associated with floral stem production the following year (Robocker 1974). The strong, upright floral stems that are characteristic of mature toadflax plants develop after a winter's dormancy, and emerge about the same time as seedlings in mid-April. Flowering occurs from May through August and seeds mature from July through October (Saner et al. 1995). Yellow toadflax is self-incompatible and relies on insects for pollination. The two most important pollinators are bumblebees and halictid bees (Zimmerman 1996).
Mode of reproduction: Yellow toadflax can reproduce both by seeds and vegetatively. Vegetative reproduction enables a stand of toadflax to spread rapidly. Stems develop from adventitious buds on primary and lateral roots. These buds can grow their own root and shoot system, and become independent plants the next year. Yellow toadflax colonies persist mostly via vegetation means while those of dalmatian toadflax persist both by vegetative and seed reproduction (Lajeunesse 1999).
Seed production: A mature plant can produce up to 30,000 seeds annually. A single stem has been reported to contain over 5,000 seeds (Saner et al. 1995).
Seed bank: Seeds can remain dormant for up to ten years.
Dispersal: Winged seeds aid wind dispersal. Seeds may also be dispersed by water and ants (Rutledge, 1998).
Hybridization: No information available.

Control

Keys to Control:
- Limit vegetative spread of colonies.
- Destroy seedlings that emerge from the soil seed bank.
- Maintain a cover of native perennial plants to discourage infestation elsewhere.

Biocontrol: The Division of Plant Industry's Biological Pest Control Section currently has one species, *Calophasia lunula*, that may be available for redistribution on yellow toadflax infestations. *C. lunula* larvae feed extensively on leaves and flowers of toadflax, severely damaging the plants.
Mechanical: Hand pulling toadflax before seed set each year can be an effective control method especially in coarse-textured soils where large portions of the roots can be pulled. However, this method must be repeated as long as there are viable seeds in the soil (up to 10 years). Cutting or mowing yellow toadflax reduces the current year growth and possibly seed dispersal, but will not kill the plant. These techniques are not recommended to control any toadflax species (Lajeunesse 1999).
Fire: Burning is not a recommended control method for yellow toadflax (Saner et al. 1995). The large, deep root system protects the plant from burning. In fact, areas that have been recently disturbed by fire are susceptible to increased toadflax infestation.
Herbicides: Effectiveness of herbicides on both toadflax species is highly variable, reflecting in part their high genetic variability (Lajeunesse 1999). Yellow toadflax is difficult to control with herbicides. Herbicides should be applied during flowering when carbohydrate reserves in the root of the plants

are at their lowest. Picloram or dicamba at 1 lb. active ingredient/acre, or glyphosate at 1.5 lb. active ingredient/acre, will kill yellow toadflax plants in some situations. 2,4-D, MCPA, 2,4-DB, MCPB and mecoprop are ineffective on yellow toadflax (Lajeunesse 1999). Picloram+2,4-D at 0.5+1.0 lb. active ingredient/acre (as Grazon P+D®) controlled 95-100% of yellow toadflax when applied for 1-3 consecutive years (Sebastian and Beck 1999).

Cultural/Preventive: In agricultural areas, minimum-till cultivation practices have contributed to the resurgence of toadflax populations (McClay 1992). By not tilling the soil, and subsequently damaging the root system of toadflax plants, toadflax colonies have been able to flourish. Intensive clean cultivation techniques are recommended for successful toadflax control on agricultural land. This requires at least two years with 8-10 cultivations in the first year and 4-5 cultivations in the second year (Morishita 1991).

Integrated Management Summary Yellow toadflax rapidly colonizes open sites. It is most commonly found along roadsides, fences, rangelands, croplands, clear cuts, and pastures. Disturbed or cultivated ground is a prime candidate for colonization. The seedlings of yellow toadflax are considered ineffective competitors for soil moisture with established perennials and winter annuals (Morishita 1991). However, once established, yellow toadflax suppresses other vegetation mainly by intense competition for limited soil water. Mature plants are particularly competitive with winter annuals and shallow-rooted perennials. The key to controlling yellow toadflax is to limit vegetative spread of established colonies (by cutting, pulling, or spraying seed stalks prior to seed set, or by using insects to destroy flowers, seeds, or damage plants). Once current seed production has been controlled, toadflax seedlings that emerge from the soil seed bank must be destroyed every year until the seed bank is diminished.

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