Purple Loosestrife
Lythrum salicaria L.
USDA Code: LYSA2
Keys to Identification:
Showy rose-purple flowers bloom in long vertical racemes.
Lance-shaped leaves have smooth edges.
Keys to Control:
Prevent new seeds from being added to the seed bank.
Maintain a healthy cover of perennial plants.
Any control effort should be followed up the same growing season and for several years afterwards.
Ecological: Purple loosestrife is an ornamental species that often escapes to sites such as streambanks or shallow ponds. The invasion of purple loosestrife leads to a loss of plant diversity, which also leads to a loss of wildlife diversity (Bender and Randall 1987). Purple loosestrife germinates at such high densities that it out competes native seedlings. Dense infestations can impede water flow in canals and ditches. When placed under moisture stress, purple loosestrife may produce additional roots, which may give it a competitive advantage over other species. It is an aggressive invader of wetlands. Once it is established, it often displaces native wetland species and degrades wildlife habitat. If purple loosestrife is left unchecked, the wetland eventually becomes a monoculture of loosestrife (Bender and Randall 1987). Where purple loosestrife is competing with cattails, it is favored by fluctuating water levels because marsh draw down aids in seedling establishment (FEIS 1996). However, where water levels remain constant and relatively deep, cattails may be able to out compete purple loosestrife (FEIS 1996).
Habitat and Distribution
General requirements: Purple loosestrife usually occurs in marshes, wet meadows, stream margins, shores of lakes and wetlands. A few of its most common associates include cattail, reed canarygrass (*Phalaris arundinacea*), sedge (*Carex* spp.), bulrush (*Scirpus* spp.), rush (*Juncus* spp.), and willow (*Salix* spp.). Purple loosestrife can tolerate a wide range of conditions (up to 50% shade), can grow on calcareous and acidic soils (Rutledge and McLendon) and will even grow in standing water.
Distribution: In Colorado, purple loosestrife is known to occur in the Denver/Boulder area and along the South Platte River, in Mesa County along the Colorado River, in Montrose County near Nucla, in Otero County near the Arkansas River, and in Colorado Springs. It is not known if purple loosestrife has upper elevational limits, but since it grows successfully in Canada, it should be considered a threat at higher elevations in Colorado.
Historical: Purple loosestrife is a native of Eurasia and was first recorded in America in 1814 (Bender and Randall 1987).
Biology/Ecology
Life cycle: Purple loosestrife begins its growth about a week to 10 days after cattail and reed canarygrass. Spring established seedlings grow rapidly and produce flowers 8 to 10 weeks after germination. After flowering, each stem supports a dense spiraling row of dark-brown seed capsules.
Mode of reproduction: Purple loosestrife is a perennial that reproduces by seeds and rhizomes. The rootstalk of purple loosestrife is the main organ of local propagation; therefore, wide vegetative spread is unlikely. However, detached root or stem fragments can take root and develop into flowering stems (FEIS 1996).
Seed production: A single flowering stalk can produce 300,000 seeds, and densities as high as 80,000 stalks per acre have been recorded (FEIS 1996).

Seed bank: Purple loosestrife seeds may remain viable for up to 20 years.
Dispersal: Seeds are mainly distributed by water, but can also be dispersed by animals and humans. Seeds do not drop from capsules until the air temperature becomes cold in the early fall.
Biocontrol: There are several biological control agents that show potential for controlling purple loosestrife (Rutledge and McLendon). The root-boring weevil (*Hylobius transversovittatus*), can seriously damage the root system of purple loosestrife, stunt growth, and reduce seed production (Rutledge and McLendon). This species is being reared at the Division of Plant Industry's Insectary, but is currently unavailable for general redistribution. Two leaf-eating weevils *Galerucella calmariensis* and *G. pusilla* also show potential as biological control agents (Rutledge and McLendon). Experimental releases of *Galerucella* in the Denver area by the Bureau of Reclamation have become established and appear to be providing effective control of purple loosestrife (D. Weber, pers. comm.). These two species may be available for redistribution upon request.
Mechanical: Hand removal of isolated individuals can be effective on a small scale. Pulling should be conducted prior to seed set. It is important to remove the entire rootstalk of the plant to avoid regrowth from root fragments.
Fire: No information available.
Herbicides: Purple loosestrife is found in very wet soils, thus great care should be used when using herbicides as these may endanger other water plants (Rutledge and McLendon). Glyphosate (in an aquatic formulation such as Rodeo) is commonly used to control purple loosestrife (Rutledge and McLendon). A non-ionic surfactant must be mixed with the Rodeo prior to spray application. The safest method is to cut off all stems about 6 inches from the bottom of the plant and then spray or drip glyphosate (20-30% solution) onto the cut surface (Rutledge and McLendon), however, it is more effective to spray individual plants using a backpack sprayer (D. Weber, pers. comm.). Colorado research by the Bureau of Reclamation has shown that loosestrife plants sprayed with glyphosate will still produce viable seeds if the flowers are 50% or more developed on the stalk when spraying occurs. Therefore, flower heads must be cut and hauled away to prevent seed spread if they are mature when sprayed (D. Weber, pers. comm.). Broadleaf herbicides (2, 4-D based) can be effective on loosestrife if applied to young plants in late May or early June (Bender and Randall 1987). The herbicide Garlon 3A is effective on purple loosestrife and like 2, 4-D is specific to broadleaved plants. It is currently only approved in Colorado for experimental use, but may soon be approved for general use (D. Weber, pers. comm.).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal.

Integrated Management Summary

Loosestrife populations which extend over three acres are difficult to eradicate and may be a better target for containment rather than control (Rutledge and McLendon). The key to effective control is early detection when infestations are small. It is fairly easy to control small numbers of loosestrife plants when the seed bank in the soil is small. Eradicating large populations with huge populations is much more difficult. Biological control should primarily be considered when populations of loosestrife have become large or are inaccessible. Small loosestrife infestations should be eradicated by hand-pulling or herbicide application.

References

Bender, J. and J. Randall. 1987. Element Stewardship Abstract for *Lythrum salicaria,* Purple loosestrife. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/lythsali.html [5 Feb 99].

FEIS - Fire Effects Information System . 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [Version 12 Mar 98].

Mal, T.K., J. Lovett-Doust, L. Lovett-Doust, and G.A. Mulligan. 1992. The biology of Canadian weeds. 100. *Lythrum salicaria. Canadian Journal of Plant Science* 72:1305-1330.

Rutledge, C. R. and T. McLendon. No Year. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97pp. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/Explant/explant.htm [Version 15 Dec 98].

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Purple loosestrife. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Spotted Knapweed
Centaurea maculosa L.; ***Acosta maculosa*** (L.) Holub
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.

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.

General requirements: Spotted knapweed is adapted to well-drained, light to coarse-textured soils that receive summer rainfall (FEIS 1996, Rutledge and McLendon, 1998). Spotted knapweed 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 infestations are not as severe in Colorado as diffuse knapweed (Beck 1997). However, this weed spreads rapidly and is quickly becoming more common. In Colorado, it is commonly found between 4,000 to 6,000 feet, but has been found as high as 10,000 feet (A. Green, pers. comm.).

Historical: Native to central Europe.

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.

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*, *Sphenoptera jugoslavica*, *Cyphocleonus achates*. The seed head 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. 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 can be removed, thereby killing the plant.

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 to be 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. ai/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. ai/ac provided 100% spotted knapweed control for 3-5 years. Other effective herbicides include dicamba or 2, 4-D at 1 lb. ai/acre, or glyphosate at 1.5 lb. ai/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. ai/ac and at 0.2 lb. ai/ac + 2, 4-D at 1.0 lb. ai/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. Spotted knapweed infestations are not as severe in Colorado as diffuse knapweed (Beck

1997). However, this weed spreads rapidly and is quickly becoming more common. 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.

References

FEIS - Fire Effects Information System . 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [Version 12 Mar 98].

Beck, K.G. 1997. Diffuse and spotted knapweed. Colorado State University Cooperative Extension Natural Resource Series, no. 3.110. http://www.colostate.edu/Depts/CoopExt/PUBS/NATRES/03110.html [24 Jan 00].

Davis, E.S. 1990. Spotted knapweed (*Centaurea maculosa*) seed longevity, chemical control and seed morphology. M.S. thesis, Montana State University, Bozeman, MT.

Fletcher, R.A. and A.J. Renney. 1963. A growth inhibitor found in *Centaurea* spp. *Canadian Journal Of Plant Science* 3:475-481.

Lacey, J.R., C.B. Marlow and J.R. Lane. 1989. Influence of spotted knapweed (*Centaurea maculosa*) on surface water runoff and sediment yield. *Weed Technology* 3:627-631.

Lacey, C.A., J.R. Lacey, P.K. Fay, J.M. Stry and D.L. Zamora. 1995. Controlling spotted knapweed in Montana rangeland. Circular 311. Montana State University Cooperative Extension, Bozeman, MT.

Olson, B.E., R.T. Wallender, and J.R. Lacey. 1997. Effects of sheep grazing on a spotted knapweed infested Idaho fescue community. *Journal of Range Management* 50:386-390.

Mauer, T., M.J. Russo, and M. Evans. 1998. Element Stewardship Abstract for *Centaurea maculosa*. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/documnts/centmac.html [28 Jul 98].

Rutledge, C. R. and T. McLendon. No Year. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97pp. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/Explant/explant.htm [Version 15 Dec 98].

Sheley, R.L., and J.S. Jacobs. 1997. "Acceptable" levels of spotted knapweed (*Centaurea maculosa*) control. *Weed Technology* 11:363-368.

Stubbendieck, J., G.Y. Friisoe and M.R. Bolick. 1995. Spotted knapweed. *Weeds of Nebraska and the Great Plains.* Nebraska Department of Agriculture, Bureau of Plant Industry, Lincoln, NE.

Watson, A.K., and A.J. Renney. 1974. The biology of Canadian weeds *Centaurea diffusa* and *C. maculosa*. *Canadian Journal of Plant Science* 54:687-701.

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Spotted knapweed. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Russian Knapweed
Acroptilon repens (L.) De Candolle; ***Centaurea repens*** L.
USDA Code: ACRE3, CERE6
Keys to Identification

Russian knapweed can be distinguished from other knapweeds by the pointed papery tips of the floral bracts.

Keys to Control:

Use an aggressive monitoring program to detect new infestations.

A combination of mechanical, chemical, and biological control and re-seeding is needed to remove an infestation of Russian knapweed.

General requirements: Russian knapweed is commonly found along roadsides, riverbanks, irrigation ditches, pastures, waste places, clearcuts and croplands. It is not restricted to any particular soil but does especially well in clay soil. Selleck (1964) observed that Russian knapweed infestations increased in dry locations but decreased in moist locations due to competition with perennial grasses.

Distribution: Russian knapweed is found throughout the western United States. In Colorado, Russian knapweed is widespread in the southwest portion of the state, with scattered infestations elsewhere on both the east and west slope.

Historical: Russian knapweed is native to Eurasia, and was probably introduced to North America as a contaminant in crop seed.

Biology/Ecology

Life cycle: Russian knapweed spreads by creeping horizontal roots and seed. Shoots emerge early in spring shortly after soil temperatures remain above freezing. All shoot development originates from root-borne stem buds (Watson 1980). These buds arise adventitiously at irregular intervals along the horizontal roots. Plants form rosettes and bolt in late May to mid-June. Russian knapweed flowers from June to October (Zimmerman 1996). It does not appear to reproduce extensively from seed.

Mode of reproduction: Russian knapweed reproduces primarily vegetatively. The root system consists of the original root (taproot), one too many horizontal roots, and their vertical extensions. Buds on the horizontal roots can form adventitious shoots that may grow to be independent plants.

Seed production: A single plant may produce 1,200 seeds per year.

Seed bank: Seeds may remain viable for 2-8 years (Carpenter and Murray 1998).

Dispersal: Knapweed seeds are often spread in hay and on vehicle undercarriages.

Biocontrol: The Division of Plant Industry's Biological Pest Control Section is working to establish *Subanguina picridis* (a gall forming nematode) at three sites in Colorado. However, this species is currently unavailable for general redistribution.

Mechanical: Cutting or removal of the above ground portion of the plant reduces the current year growth, and may eliminate seed production, but it will not kill Russian knapweed. Cutting several times before the plants bolt stresses Russian knapweed plants and forces them to use nutrient reserves stored in the root system. The plants that re-emerge are usually smaller in size and lower in vigor. Once plants have bolted there are no more buds on the roots capable of reproduction, until buds begin to form again in mid-August to September. A combination of cutting and herbicides can be used to control Russian knapweed. In the fall, apply picloram to any plants that have re-emerged. This process may have to be repeated annually for several years to exhaust the soil seed bank.

Fire: No information available.

Herbicides: Spraying 2, 4-D herbicide, which is a mixture of 2, 4-D and clopyralid, on dormant plants in the fall has been very effective at controlling Russian knapweed in Utah, but only if it is followed by reseeding during the year following treatment (Chad

Reid, pers. comm.). Picloram at 1 lb. ai/acre is widely used on Russian knapweed and is considered to be the most effective herbicide regardless of time of application (Duncan 1994). Clopyralid is also effective against knapweeds and thistles and will kill other composites, legumes and smartweeds, but has little or no impact on many other forbs. In Wyoming, picloram applied either at bloom or seed stage at 0.38 lb. ai/ac, clopyralid at 0.25 lb. ai/ac and the combination of clopyralid (0.18 lb./ac) + 2, 4-D (1.0 lb./ac) + picloram (0.25 lb./ac) provided 95% control two years after application (Whitson 1999). Glyphosate at 1.5 lb. ai/acre or dicamba at 1 lb. ai/acre can be applied during the bud-growth stage can be used to control the top growth of Russian knapweed. However, abundant regrowth from the root systems will occur the following year and additional applications may be necessary. Timing of applications to the late bud and fall growth stage is critical with most herbicides to achieve good control of knapweed. A backpack sprayer or a wick is highly recommended to minimize damage to non-target plants if they are abundant. The best way to control Russian knapweed is to combine herbicide treatment with seeding competitive grasses. Benz et al. (1999) found that clopyralid + 2, 4-D treatment of Russian knapweed in the late bloom stage followed by fall seeding of a bunchgrass and a sod-forming grass was the most effective method they tested. Substituting metsulfuron herbicide for the clopyralid + 2,4-D resulted in lower control but it was still effective.

Cultural/Preventive: Preventive measures include maintaining healthy native communities, and minimizing disturbance and seed distribution.

Integrated Management Summary

Russian knapweed is characterized by its extensive root system, low seed production, and persistence. It is a strong competitor and can form dense colonies in disturbed areas. The most effective method of control for Russian knapweed is to prevent its establishment through proper land management. The healthier the natural community, the less susceptible it will be to Russian knapweed invasion. Areas should be monitored three times a year (spring, summer, and fall) and all Russian knapweed plants should be destroyed immediately. Since Russian knapweed is so persistent, it is important to combine killing Russian knapweed with seeding competitive grasses.

References

Beck, K.G. 1996. Russian knapweed. Colorado State University Cooperative Extension Natural Resource Series, no. 3.111. http://www.colostate.edu/Depts/CoopExt/PUBS/NATRES/03111.html [24 Jan 00].

Benz, L.J., K.G. Beck, T.D. Whitson and D.W. Koch. 1999. Reclaiming Russian knapweed infested rangeland. *Journal of Range Management* 52:351-356.

Carpenter, A.T. and T.A. Murray. 1998. Element stewardship abstract for *Acroptilon repens*. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/acrorepe.html [19 Jan 99].

Duncan, C.L. 1994. Knapweed. Cooperative extension. Washington State University, U.S. Department of Agriculture and Washington Counties. Volume 8, No. 3.

Maddox, D.M., A. Mayfield, and N.H. Poritz. 1985. Distribution of yellow starthistle (*Centaurea solstitialis*) and Russian knapweed (*Centaurea repens*). *Weed Science* 33:315-327.

Rees, N.E., P.C. Quimby Jr., G.L. Piper, E.M. Coombs, C.E. Turner, N.R. Spencer, and L.V. Knutson (editors). 1996. *Biological Control of Weeds in the West.* Western Society of Weed Science in cooperation with USDA Agricultural Research Service, Montana Department of Agriculture, and Montana State University.

Selleck, G.W. 1964. A competition study of *Cardaria* spp. and *Centaurea repens*. Proc. 7th British Weed Control Conf. pp. 569-576.

Stevens, K.L. 1986. Allelopathic polyacetylenes from *Centaurea repens* (Russian knapweed). *Journal of Chemical Ecology* 12:1205-1211.
Watson, A.K. 1980. The biology of Canadian weeds. 43. *Acroptilon (Centaurea) repens* (L.) DC. *Canadian Journal of Plant Science* 60:993-1004.
Whitson, T.D. 1999. Russian Knapweed. In R.L. Sheley and J.K. Petroff, eds. *Biology and Management of Noxious Rangeland Weeds*. Oregon State University Press, Corvallis, OR.
Zimmerman, J.A.C.. 1996. Ecology and distribution of *Acroptilon repens* (L.) DC., Asteraceae. USGS Colorado Plateau Field Station, Southwest Exotic Plant Mapping Project.
http://www.usgs.nau.edu/swemp/Info_pages/plants/Acroptilon/Russianknapweed.html
[20 Jan 98].

Saltcedar
Tamarix ramosissima Ledeb. and ***Tamarix parviflora*** DC.
USDA Code: TARA, TAPA4
Keys to Identification:

Saltcedar is a tall shrub or small tree that has large sprays of small whitish or pinkish flowers that are born in finger-like clusters.

Leaves are very small and scaly.

Keys to Control:

Select the appropriate control method based on the size of the area and other environmental or cultural considerations.

Re-seed controlled areas with desirable species to protect the soil resource and to prevent or retard saltcedar reinvasion.

Ecological: Saltcedar is an aggressive, woody invasive plant species that has become established over as much as a million acres of the western United States (Carpenter 1998). Saltcedar crowds out native stands of riparian and wetland vegetation. It increases the salinity of surface soil, rendering the soil inhospitable to native plant species. Saltcedar provides generally lower wildlife habitat value than native vegetation. It uses more water than comparable native plant communities and dries up springs, wetlands, riparian areas and small streams by lowering surface water tables. However, in places where beaver dams or other structures have raised the water table, saltcedar can be outcompeted by *Salix exigua* (R. Roberts, pers. comm.). Saltcedar widens floodplains by clogging stream channels and increases sediment deposition due to the abundance of saltcedar stems in dense stands.

General requirements: Saltcedar grows well on moist sandy, sandy loam, loamy, and clayey soil textures (FEIS 1996). Saltcedar is tolerant of highly saline habitats, and it concentrates salts in its leaves. Over time, as leaf litter accumulates under saltcedar plants, the surface soil can become highly saline, thus impeding future colonization by many native plant species. Saltcedar is not tolerant of shading. Shaded plants have altered leaf morphology and reduced reproduction (FEIS 1996). Saltcedar commonly occurs along floodplains, riverbanks, stream courses, salt flats, marshes, and irrigation ditches in arid regions of the Southwest and the Southern Great Plains (FEIS 1996).

Distribution in Colorado: In Colorado, saltcedar is most commonly found between 3,400 to 7,000 feet (FEIS 1996), but can be found up to 8,000 feet (A. Green, pers. comm.). It is widespread in riparian areas throughout the western United States.

Historical: Introduced to North America for use as ornamental, windbreak, and erosion control.

Biology/Ecology

Life cycle: Saltcedar generally flowers in its third year of growth or later, but may flower during the first year (FEIS 1996). Saltcedar buds generally break dormancy in February or March. The flowers are most abundant between April and August, but may be found any time of the year in desert areas. Saltcedar flowers continuously under favorable environmental conditions but the flowers require insect pollination to set seed. Seedlings grow slowly and require saturated soils throughout the first 2-4 weeks of growth (FEIS 1996). Ideal conditions for first year survival are saturated soil during the first few weeks of life, a high water table, and open sunny ground with little competition from other plants.

Mode of reproduction: Reproduces by seeds as well as vegetatively. Saltcedar sprouts from the root crown and rhizomes, and adventitious roots sprout from submerged or buried stems (FEIS 1996). This allows saltcedar to produce new plants vegetatively following floods from stems torn from the parent plants and buried by sediment.

Seed production: A mature saltcedar plant can produce 600,000 minute seeds annually (FEIS 1996).
Seed bank: Seeds are viable for up to 45 days under ideal conditions during summer, and can complete germination within 24 hours following contact with water (Carpenter 1998). Saltcedar seeds had no dormancy or after-ripening requirements.
Dispersal: The seeds are readily dispersed by wind and water.
Biocontrol: The USDA has permitted the release of two species of insects for saltcedar biocontrol but widespread releases have not yet been permitted (A.T. Carpenter, pers. comm.).
Mechanical: As an alternative to herbicides, a bulldozer or prescribed fire can be used to open up large stands of saltcedar. Once opened, the resprouts can be sprayed when they are 1 to 2 m tall using imazapyr, or imazapyr plus glyphosate, or triclopyr.
Fire: See above.
Herbicides: For larger areas (> 2 hectares) that are essentially monotypic stands of saltcedar, the best methods would likely be foliar application of imazapyr herbicide to the intact plants or burning or cutting plants followed by foliar application of imazapyr or triclopyr to the resprouted stems. Foliar application of imazapyr or imazapyr in combination with glyphosate can be effective at killing large, established plants. Over 95% control has been achieved in field trials during the late summer or early fall (Carpenter 1998). The herbicide can be applied from the ground using hand-held or truck-mounted equipment or from the air using fixed-wing aircraft. Foliar application of herbicide works especially well in monotypic stands of saltcedar, although experienced persons using ground equipment can spray around native trees and shrubs such as cottonwood and willow. Saltcedar eradication in areas that contain significant numbers of interspersed, desirable shrubs and trees is problematic. Depending upon site conditions, it may not be possible to rapidly kill saltcedar plants without also killing desirable shrubs and trees. It such situations, it may be necessary to cut and treat saltcedar stumps with herbicide, as outlined in the next paragraph. While this method is relatively slow and labor-intensive, it will spare desirable woody plants. Alternatively, it may be more cost-effective to kill all woody plants at a site and replant desirable species afterward. For modest-sized areas (< 2 hectares), cutting the stem and applying herbicide (known as the cut-stump method) is most often employed. The cut-stump method is used in stands where woody native plants are present and where their continued existence is desired. Individual saltcedar plants are cut as close to the ground as possible with chainsaws, loppers or axes, and herbicide is applied immediately thereafter to the perimeters of the cut stems. Herbicides must be applied immediately to the cut because wound healing occurs very quickly and decreases herbicide penetration. The herbicides triclopyr and imazapyr can be very effective when used in this fashion. This treatment appears to be most effective in the fall when plants are translocating materials to their roots. The efficacy of treatments is enhanced by cutting the stems within 5 cm of the soil surface, applying herbicide within one minute of cutting, applying herbicide all around the perimeter of the cut stems, and retreating any resprouts 4 to 12 months following initial treatment.
Cultural/Preventive: No matter how effective initial treatment of saltcedar might be, it is important to re-treat saltcedar that is not killed by initial treatment. After saltcedars are killed, other vegetation must be established to protect the soil resource and to prevent or retard saltcedar re-invasion (Frasier and Johnsen 1991). Establishing a canopy cover on treated areas with seeded grasses and planted cottonwood cuttings could reduce the chances of saltcedar successfully re-invading an area (Frasier and Johnsen 1991).
Integrated Management Summary

Saltcedar is native of Eurasia that was introduced as an ornamental and stream bank stabilizer. It is a pioneer species that establishes on freshly exposed alluvium, sand and gravel bars, and stream banks or floodplains after disturbance (FEIS 1996). Once established it often occurs in pure stands, persisting indefinitely in the absence of disturbance (FEIS 1996). It can replace or displace native woody species, such as cottonwood, willow and mesquite, which occupy similar habitats, especially when timing and amount of peak water discharge, salinity, temperature, and substrate texture have been altered by human activities. Saltcedar produces massive quantities of small seeds and can propagate from buried or submerged stems. Saltcedar can be controlled by five principal methods: 1) applying herbicide to foliage of intact plants, 2) removing aboveground stems by burning or mechanical means followed by foliar application of herbicide to resprouts, 3) cutting stems close to the ground followed by application of triclopyr (Garlon) to the cut stems, 4) spraying basal bark with triclopyr, and 5) digging or pulling plants (Carpenter 1998). Selecting an appropriate control method involves considering the size of the area where saltcedar is to be controlled, restrictions on the use of particular herbicides or herbicides generally, the presence or absence of desirable vegetation where saltcedar is growing, the presence or absence of open water, adjacent land uses that might restrict prescribed burning, and the availability and cost of labor (Carpenter 1998).

References

Baum, B. 1967. Introduced and naturalized tamarisks in the United States and Canada (Tamaricaceae). *Baileya* 15:19-25.

Carpenter, A.T. 1998. Element Stewardship Abstract for Tamarisk. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/tamaramo.html [9 Feb 99].

DiTomaso, J.M. 1996. Identification, biology, and ecology of salt cedar. In *Proceedings of the Saltcedar Management Workshop*. June 12, 1996 Rancho Mirage, CA.

FEIS - Fire Effects Information System . 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [Version 12 Mar 98].

Frasier, G.W., and T.N. Johnsen Jr. 1991. Saltcedar (Tamarisk): classification, distribution, ecology and control. In L.F James, J.O. Evans, M.H. Ralphs and R.D. Child, eds. *Noxious Range Weeds*. Westview Press, Boulder, CO.

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Salt cedar. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Whitetop/Hoary Cress
Cardaria draba (L.) Desv.
USDA Code: CADR
Keys to Identification:

Whitetop can be easily identified by the clusters of numerous, four petaled, white flowers that give it a flat-topped appearance.

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.

Ecological: Hoary cress is invading rangelands throughout North America. It is a highly competitive weed once it becomes established. Hoary cress spreads primarily by extremely persistent roots and will eventually eliminate desirable vegetation and become a monoculture.

Human: No information available.

Habitat and Distribution

General requirements: Hoary cress is typically found on generally open, unshaded, disturbed ground. Hoary cress 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). Hoary cress is commonly found in saltcedar (*Tamarix* spp.), antelope bitterbrush / rough fescue (*Purshia tridentata* / *Festuca scabrella*), antelope bitterbrush / bluebunch wheatgrass (*Pseudoroegneria spicata*), big sagebrush (*Artemisia tridentata* spp.), and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) communities (FEIS 1996).

Distribution: It is widespread in the United States except along the southern boundary of the western and south central states (USDA 1971). In Colorado, hoary cress is commonly found at elevations of 3,500 to 8,500 feet.

Historical: Hoary cress is a weed of Eurasian origin.

Biology/Ecology

Life cycle: The root system of hoary cress 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. Hoary cress 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: Reproduces both by seeds and vegetatively. Hoary cress 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 hoary cress monoculture.

Seed production: One plant can produce from 1,200-4,800 seeds.

Seed bank: 84% 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.

Biocontrol: Currently, there is little information about biological controls that attack hoary cress. Sheep grazing may control

whitetop, but evidence is limited. Managing the grazing is important so desirable plant species are not damaged.

Mechanical: Mowing 2-3 times a year for several years may slow the spread and reduce seed production of hoary cress. 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: Hoary cress 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 noncrop herbicides metsulfuron and chlorsulfuron are the most effective herbicides as long as 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. ai/acre applied during the flower stage will provide good control of hoary cress. Picloram does not control whitetop. Also, spraying followed by spring mowing can control hoary cress by up to 90% (FEIS 1996).

Cultural/Preventive: Cultivation alone will control hoary cress when tillage begins at flowerbud 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. Also, nitrogen fertilization can increase the growth of grasses and slow the rate of whitetop invasion (Sheley and Stivers 1999).

Integrated Management Summary

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

References

FEIS - Fire Effects Information System . 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [Version 12 Mar 98].

CSU Cooperative Extension. 1998a. *Whitetop*. Weeds in Northwest Colorado. Colorado State University Cooperative Extension. http://www.yampa.com/Routt/CSU/nwcoloweeds.html [11 Nov 98].

CSU Cooperative Extension. 1998b. *Whitetop*. Colorado State University Cooperative Extension TriRiver Area. http://www.colostate.edu/Depts/CoopExt/TRA/whtop.html [11 Nov 98].

Mulligan, G.A., and J.N. Findlay. 1974. The biology of Canadian weeds. 3. *Cardaria draba, C. chalapensis*, and *C. pubescens*. *Canadian Journal of Plant Science*. 54: 149-160.

Sheley, R.L. and J. Stivers. 1999. Whitetop. In R.L. Sheley and J.K. Petroff, eds. *Biology and Management of Noxious Rangeland Weeds*. Oregon State University Press, Corvallis, OR.

U.S. Department of Agriculture, Agricultural Research Service. 1971. *Common weeds of the United States*. Dover Publications, Inc., New York.
Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Hoary cress. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Oxeye Daisy
Chrysanthemum leucanthemum L.; ***Leucanthemum vulgare*** Lam.
USDA Code: CHLE80, LEVU
Keys to Identification:

Oxeye daisy can be identified by its daisy-like flowers. Flowering heads are solitary at the ends of branches, have white ray flowers and yellow disk flowers and are about 2 inches in diameter.

Keys to Control:

Small infestations can be controlled by hand pulling or digging the plants before seed heads are produced.

Minimize the amount of bare soil exposed by land management practices.

Maintain a significant grass canopy to shade out oxeye daisy.

Ecological: If given the chance, this plant can become noxious and is capable of taking over and modifying natural areas, pasture and rangeland (Rutledge and McLendon, 1998), and may increase soil erosion compared to native plant communities (Olson and Wallander 1999)
Human: No information available.
Habitat and Distribution
General requirements: In Colorado, oxeye daisy is usually found at higher elevations in meadows, along roadsides, and in waste places. In many places this plant escaped from gardens and established in meadows, around mines and ghost towns in the mountains (Rutledge and McLendon, 1998).
Distribution: Widely distributed throughout the United States.
Historical: Escaped from cultivation as an ornamental.
Biology/Ecology
Life cycle: Basal rosettes must experience a period of cold temperatures to initiate flowering (Rutledge and McLendon, 1998). Flowering occurs from June through August. The plant grows vigorously in poorer soils, possibly because it is a poor competitor with established plants on better soils (Olson and Wallander 1999). Oxeye daisy may require reduced competition from neighboring plants or disturbance to establish (Olson and Wallander 1999).
Mode of reproduction: Oxeye daisy reproduces by seeds and short rootstocks.
Seed production: A typical plant produces over 500 seeds.
Seed bank: Seeds can remain viable in the soil for at least 2-3 years and sometimes far longer (Rutledge and McLendon, 1998).
Biocontrol: None known.
Mechanical: Hand pulling or digging before seed head production can used to effectively control small infestations. However, for this method to be successful it is important to remove as much of the underground part as possible.
Fire: No information available.
Herbicides: Larger infestations of oxeye daisy are commonly controlled with herbicides. Picloram 0.25 lb., dicamba, or 2, 4-D at 1 lb. ai/acre, or glyphosate at 1.5 lb. ai/acre will control oxeye daisy. Other herbicides that have proven effective include imazapyr, and sulfometuron methyl (Rutledge and McLendon, 1998). No biological control agents exist for oxeye daisy.
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
Oxeye daisy has the potential to invade disturbed areas, form small colonies, and modify existing communities. Integrated treatments potentially include nitrogen fertilization and

sheep or goat grazing; and nitrogen fertilization and picloram application. Nitrogen fertilizer stimulates other vegetation, especially grasses, which likely out-compete daisy plants for nitrogen, grow taller and shade out the daisy. Sheep or goat grazing is designed to selectively impact the daisy without adversely affecting the desirable species. Picloram can effectively control daisy plants but it can damage desirable forbs, as well.

References

Olson, B.E. and R.T. Wallander. 1999. Oxeye daisy. In R.L. Sheley and J.K. Petroff , eds. *Biology andManagement of Noxious Rangeland Weeds.* Oregon State University Press, Corvallis, OR

Rutledge, C. R. and T. McLendon. No Year. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97pp. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/Explant/explant.htm [Version 15 Dec 98].

Whitson, T.D. (ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Oxeye daisy. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Houndstongue
Cynoglossum officinale
USDA Code: CYOF
Keys to Identification:
Five-petaled reddish-purple flowers in panicles.
Prickly nutlets are distinctive.
Keys to Control:
Eliminate seed production.
Re-seed controlled areas with desirable species.
Ecological: Houndstongue is an early sucessional 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% 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 Colorado up to about 9000 feet.
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.
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. ai/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. ai/ac 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.
Integrated Management Summary
Houndstongue is poor competitor with native perennials and requires disturbed or bare areas to establish. Once established, houndstongue 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.

References

Butterfield, C., J. Stubbendieck, and J. Stumpf. 1996. Species abstracts of highly disruptive exotic plants. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page.
http://www.npwrc.usgs.gov/resource/othrdata/exoticab/exoticab.htm [Version 16 Jul 97].

Sebastian, J.R. and K.G. Beck. 1995. Houndstongue control on Colorado rangeland with spring- or fall-applied herbicides. Res. Prog. Rep. Wes. Soc. Weed Sci. pp. 11-12.

Stubbendieck, J., G.Y. Friisoe and M.R. Bolick. 1995. Houndstongue. *Weeds of Nebraska and the Great Plains.* Nebraska Department of Agriculture, Bureau of Plant Industry, Lincoln, NE.

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Houndstongue. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Russian Olive
Elaeagnus angustifolia L.
USDA Code: ELAN
Keys to Identification:

- Small tree or shrub.
- Russian olive has silvery leaves and small fruits that are generally silver in color.
- Young stems have stout spines.

Keys to Control:
Use a monitoring program to detect new infestations.

- Removing top growth, suppressing re-growth, and planting desirable shade producing vegetation are the key to effective control.

General requirements: Grows in uplands that receive as little as 8 inches of annual precipitation. Russian olive also grows well in wet-saline soils and certain riparian environments. Russian olive is considered to be tolerant of saline soils.
Distribution: Russian olive has been widely planted in the western United States. It was promoted as an excellent species for windbreaks, erosion control, and wildlife enhancement. Russian olive is troublesome in riparian areas. New Mexico and Colorado are the only states that currently list it as noxious.
Historical: Russian olive is native to southern Europe, central Asia, and the western Himalayas. It was introduced to North America during colonial times as an ornamental tree.
Biology/Ecology
Life cycle: Russian olive is considered a shrub or small tree. Single plants can reach a height of 45 feet.
Mode of reproduction: Russian olive reproduces by seed and vegetatively. The seed, achenes, are produced in small, fleshy fruits that are roughly one-half inch long. The seeds are hard. They are also impermeable to digestive juices. Birds, coyotes, deer and raccoons consume the fruit and disseminate seed. The fruits float and are dispersed via water transport.
Seed bank: Seeds typically need 60-90 days of cold stratification to germinate. Seeds remain viable up to three years.
Biocontrol: There are not any known insects that will kill Russian olive. There are fungal diseases that will attack the Russian olive. Effective inoculation is usually associated with injury to the bark where the fungal disease can enter the plant. One type of canker kills seedlings and saplings and causes dieback and cankers on older plants. These pathogens usually attack plants weakened by some type of environmental stress.
Mechanical: Russian olive saplings that are less than 1 inch in diameter are easily mowed. Repeated mowing will eventually reduce populations to acceptable levels. Mowing can improve pasture quality. Cut pieces need to be disposed of or they may root and re-sprout. Cutting larger trees with a saw will eliminate top growth for a short period. Sprouts will develop from the base of the stump. The cut trees need to be removed from the area or they may root and re-sprout. Larger trees can be girdled. Large areas can be chained and will uproot large diameter trees rapidly. Trees can be dozed out. Follow-up treatment is be required to control root sprouts.
Fire: Russian olive stands can be burnt when conditions support a hot fire. Saplings are the most sensitive. The fire must be hot enough and burn long enough to incinerate the stumps of larger trees.
Herbicides: There are several herbicides that will kill Russian olive, but repeat applications over several years are needed for good control. Some of the chemicals that

will suppress Russian olive are; 2, 4-D ester, triclopyr, imazapyr and glyphosate. Triclopyr is applied as a directed spray of the basal bark of the tree. Basal applications require good saturation of the bark and diesel fuel is frequently used as a carrier. Imazapyr and glyphosate can be applied undiluted to frill cuts made in the stem.
Cultural/Preventive: Preventive measures include maintaining healthy native communities, and minimizing disturbance and seed distribution.
Integrated Management Summary
Russian olive is invasive in wet-saline environments and certain riparian environments, and has the ability to displace native species. Plants can grow from stump sprouts, stem cuttings, and root pieces. Russian olive tolerates infrequent fire, temporary flooding, browsing, and mechanical cutting. Some herbicides will kill Russian olive, but applications need to be repeated over a span of several years for good control. Effective control includes removing top growth, suppressing regrowth, and filling the void with desirable shade producing vegetation. Russian olive is shade intolerant. Dense stands of tall trees can inhibit growth of Russian olive.

This information came from Technical Notes, USDA – Natural Resources Conservation Service, Plant Materials No. 47, March, 2002, History, Biology, Ecology, Suppression and revegetation of Russian-Olive Sites. (Elaeagnus angustifolia L.)

Musk Thistle
Carduus nutans L. subsp. ***macrolepsis*** (Peterman) Kazmi
USDA Code: CANU4
Keys to Identification:

Musk thistle can be identified by the broad, spine-tipped bracts located under the flower.

Flowering heads are terminal, solitary and usually nodding.

Keys to Control:

Managing rangeland to minimize the amount of bare soil is essential to long-term control.

Hand chopping at ground level just before flowering, or cutting and bagging seed heads before dispersal can be used to eliminate seed production.

Repeated treatments over the course of several years can eliminate a musk thistle infestation.

General requirements: Musk thistle does not appear to have any specific climatic requirements other than a cool period of vernalization for flowering (Butterfield et al. 1996). It occurs in areas with as little as 10 inches of annual precipitation (FEIS 1996). Musk thistle establishes best on bare soil, and small shallow cracks are ideal for seedling establishment (FEIS 1996). Musk thistle grows in all soil textures, but the soils must be well-drained (Butterfield et al. 1996). It occurs on soils with a pH range of 6.0 to 8.9 (Butterfield et al. 1996).

Distribution: In Colorado, musk thistle is found up to approximately 10,000 feet in elevation (Beck 1999). It is found throughout North America.

Historical: Native to Eurasia.

Biology/Ecology

Life cycle: Seeds germinate in the fall, forming a rosette of leaves. Typically, musk thistle over-winters as a rosette and bolts the following spring between April-June. Flowering begins in late May or early June and continues through mid-July (Butterfield et al. 1996). Seeds mature and are dispersed 1 to 3 weeks after flowering. Seedlings establish only on bare soils and grow less when shaded by neighboring plants (Beck 1999).

Mode of reproduction: Musk thistle reproduces solely by seed.

Seed production: Musk thistle is a prolific seed producer. Average productivity is approximately 10,000 seeds/plant, however, a single plant can produce up to 100,000 seeds (Beck 1999).

Seed bank: Musk thistle seeds appear to remain viable for at least 10 years.

Biocontrol: A number of insects have been used to help control musk thistle. The Division of Plant Industry's Biological Pest Control Section has two species, *Rhinocyllus conicus*, and *Trichosirocalus horridus* that may be available for redistribution. The most widely released insect is the weevil *Rhinocyllus conicus* (Butterfield et al. 1996). In the spring, adults will feed on the leaves, mate, and deposit eggs on the bracts (Butterfield et al. 1996). When the eggs hatch the larvae begin to bore into the flowerhead, reducing the ability of the plants to produce viable seed. In some cases the weevil has reduced musk thistle populations to less than 10% pre-release levels (Rutledge and McLendon, 1998). However, this weevil will attack native thistles, including rare species (Louda et al. 1997).

Mechanical: Repeated mowing, hand pulling, or cutting can be used to stop the spread of musk thistle. Mowing or hand-chopping after flowering, but before seed set, prevents seed development and dispersal (Heidel 1987). When pulling musk thistle, it is important to completely remove the crown so that the plant does not simply re-bolt and produce seeds. Repeated visits at weekly intervals over the 4-7 week flowering period

may be necessary because not all plants flower at the same time (Heidel 1987). Cut plants should be deeply buried or burned because seeds can mature and become viable after cutting (Rutledge and McLendon, 1998).

Fire: No information available.

Herbicides: Musk thistle is most often controlled with herbicides. The most effective chemical control occurs when musk thistle is still in the rosette stage, and quickly decreases once the plant has bolted (Butterfield et al. 1996). 2, 4-D, clopyralid at 0.25 lb., or dicamba at 1 lb. ai/acre are effective when applied 10-14 days prior to bolting. A combination of 2, 4-D plus dicamba provided 97% control in an experiment in Minnesota (Butterfield et al. 1996). Fall application of picloram at 0.25 lb. ai/acre to rosettes when other plants are dormant is often effective and has less impact on non-target species (Butterfield et al. 1996). Metsulfuron and chlorsulfuron are effective on bolted plants (Beck 1999).

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

The key to managing musk thistle is to prevent seed production. Most control methods will have a detrimental effect on other plants and may cause a disturbance that will favor re-invasion by other exotic species (Rutledge and McLendon, 1998). Dense musk thistle stands along roadsides and in degraded areas can be treated by spot use of herbicides, and in high-quality areas by a persistent program of pulling or cutting (Rutledge and McLendon, 1998). Due to the long seed viability of musk thistle, up to 10 years, control methods may have to be repeated for many years to completely eliminate a stand. One integrated approach to musk thistle management involves: 1) managing livestock grazing to increase grass vigor and reduce bare ground, 2) spray rosettes with clopyralid or 2, 4-D, 3) re-seed treated ground with competitive desirable plants in the fall after spraying, 4) follow-up with spot cutting of entire plants when first flowers appear annually for several years to deplete the seed bank in the soil.

References

Butterfield, C., J. Stubbendieck, and J. Stumpf. 1996. Species abstracts of highly disruptive exotic plants. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/exoticab/exoticab.htm [Version 16 Jul 97].

FEIS - Fire Effects Information System. 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [12 Mar 98].

Beck, K.G. 1999. Biennial thistles. In R.L. Sheley and J.K. Petroff, eds. *Biology and Management of Noxious Rangeland Weeds*. Oregon State University Press, Corvallis, OR.

Desrochers, A.M., J.F. Bain, and S.I. Warwick. 1988. The biology of Canadian weeds, *Carduus nutans* L. and *Carduus acanthoides* L. *Canadian Journal of Plant Science* 68: 1053-1068.

Heidel, B. 1987. Element Stewardship Abstract for *Carduus nutans*, musk thistle. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/documnts/cardnut.html [30 Jul 98].

Louda, S.M., D. Kendall, J. Connor and D. Simberloff. 1997. Ecological effects of an insect introduced for the biological control of weeds. *Science* 277: 1088-1090.

Rutledge, C. R. and T. McLendon. No Year. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97pp. Northern Prairie Wildlife Research Center Home

Page. http://www.npwrc.usgs.gov/resource/othrdata/Explant/explant.htm [Version 15 Dec 98].
Wardle, D. A., K. S. Nicholson and A. Rahman. 1993. Influence of plant age on the allelopathic potential of nodding thistle (*Carduus nutans*) against pasture grasses and legumes. *Weed Research* 33:69-78.
Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Musk thistle. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Bull Thistle
Cirsium vulgare (Savi) Tenore
USDA Code: CIVU
Keys to Identification:

Bull thistle can be distinguished from other thistles by rubbing the upper surface of its leaves. Bull thistle leaves are prickly, hairy above and cottony below.

Bull thistle has stiff pointy spines on its leaf tips and spine-tipped, purple flower heads.

Keys to Control:

Kill bull thistle plants after they have bolted, but before plants have flowered.

Repeat control for several years to deplete the bank of thistle seeds in the soil.

Ecological: Bull thistle is often a transient species, appearing in recent clear cuts or disturbed areas and becoming a dominant species for several years (Rees et al. 1996).

Habitat and Distribution

General requirements: Bull thistle grows in dry to moist habitats. It thrives on nitrogen-rich soils, and it grows on gravelly to clay-textured soils. Bull thistle cannot withstand deep shade, and is nearly absent if light is reduced to less than 40% of full sunlight (FEIS 1996). Potential habitats include pastures, overgrazed rangeland, roadsides, and logged areas.

Distribution: Distribution within Colorado is not well known, but it is certainly found along the Front Range, as well as throughout the Western Slope (A. Green, pers. Comm.). In Colorado, bull thistle is most often found between 5,000-10,800 feet in elevation. It is widespread throughout the United States and parts of Canada.

Historical: Bull thistle was introduced to North America as a seed contaminant and is now widespread.

Biology/Ecology

Life cycle: During the first year following germination a basal rosette is formed. The rosette grows until winter, partly dies back, and begins to grow again in early spring (FEIS 1996). Age at bolting is dependent upon plant size and almost all plants require a period of cold temperature to bolt. Flowering occurs from July through September. After flowering and seed production, the plant dies.

Mode of reproduction: Bull thistle reproduces solely by seeds.

Seed production: Mature plants can produce up to 4,000 seeds per plant (Zimmerman 1997).

Seed bank: Seeds have little dormancy, and germinate rapidly whenever conditions are favorable, usually in the spring and fall (FEIS 1996). Although most of the seeds on or near the surface do not remain viable for more than a year, seeds that are buried at a depth of 5 inches may remain viable for up to three years (Zimmerman 1997).

Dispersal: Seeds are capped with a circle of plume-like white hairs and can be windblown for long distances. However, it has been found that 65% of the seeds land within two meters of the parent plant (Zimmerman 1997). Seeds are also likely to be spread by birds, especially goldfinches.

Biocontrol: The bull thistle seed head gall fly (*Urophora stylata*) can reduce seed production up to 80% in some areas (Zimmerman 1997). This agent has been established in Colorado, and prefers open meadows (Rees et al. 1996). However, this species is currently unavailable for redistribution by the Division of Plant Industry's Biological Pest Control Section. Due to its spiny stems and leaves, bull thistle is unpalatable to most livestock (FEIS 1996). However, sheep will graze on bull thistle seedlings or small rosettes.

Mechanical: Cutting, mowing, and/or severing the taproot just below the root crown before seed set will eliminate current year seed production, and if continued annually,

eliminate an infestation. The best time to cut is late in the season when most of the plants have bolted, but before a significant number have flowered (FEIS 1996). Plants will re-bolt if they are mowed too early. Cutting again a month after the first sweep will eliminate any late bolting plants, and improve the effectiveness of the procedure.

Fire: No information available.

Herbicides: Spot applications of picloram at 0.5 lb., dicamba or 2, 4-D at 1 lb. ai/acre will provide effective control. Glyphosate at 1.5 lb. ai/acre is another herbicide that can be used to provide some control of bull thistle. Herbicides should be applied in rosette stage or after mowing as the plant becomes more tolerant of herbicides once the flower stalk is produced (FEIS 1996).

Cultural/Preventive: Minimize disturbance and establish healthy stands of tall grasses or forbs to out compete bull thistle.

Integrated Management Summary

Bull thistle does not tolerate shade and therefore does not compete well in areas that are populated by tall grasses and forbs. Improving the health of a natural area, and guarding against disturbance or overuse, can be a good preventive measure against bull thistle. Apply herbicides to rosettes in early spring (May, June), and then mow or sever taproots after the plants have bolted but before flowering (probably late June to July). A second mowing or cutting is suggested a month later to pick up late bolting plants. Do not cut or spray if using seed head biocontrols.

References

Calweed Database. 1997. California Noxious Weed Control Projects Inventory. Natural Resource Projects Inventory, Information Center for the Environment, University of California, Davis. http://endeavor.des.ucdavis.edu/weeds/ [6 Jan 99].

Carey, J. Boyd, James J. Kells, and Karen A. Renner. 1993. Common Weed Seedlings of Michigan. Department of Crop and Soil Sciences Michigan State University Extension Bulletin E-1363. http://www.msue.msu.edu/msue/iac/e1363/e1363.htm [27 Oct 99].

FEIS - Fire Effects Information System . 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [Version 12 Mar 98].

Rees, N.E., P.C. Quimby Jr., G.L. Piper, E.M. Coombs, C.E. Turner, N.R. Spencer, and L.V. Knutson (eds.). 1996. *Biological Control of Weeds in the West.* Western Society of Weed Science in cooperation with USDA Agricultural Research Service, Montana Department of Agriculture, and Montana State University.

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Bull thistle. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Zimmerman, J.A.C. 1997. Ecology and distribution of *Cirsium vulgare* (Savi) Tenore, Asteraceae. USGS Colorado Plateau Field Station, Southwest Exotic Plant Mapping Program. http://www.usgs.nau.edu/swemp/Info_pages/plants/Cirsium/cvulgare.html [29 Jan 99].

Canada Thistle
Cirsium arvense (L.) Scop.; ***Breea arvensis*** (L.) Lessing
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 **.**
Keys to Control:
Eliminate seed production.
Reduce the plant's nutrient reserves through persistent management.
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% 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 common found along roadsides, fields, pastures, meadows, and other disturbed areas statewide in Colorado (FEIS 1996, Rutledge and McLendon 1998). In Colorado, Canada thistle is typically found from 4,000-9,500 feet. Canada thistle is found throughout the northern half of the United States and lower portions of Canada.
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 in Colorado (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.
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 be available for redistribution from the Division of Plant Industry's Biological Pest Control Section.
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 + 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 Canada thistle *(Cirsium arvense)* 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 2, 4-D®) applied at a rate of 2-3 quarts/acre will effectively control Canada thistle. 2, 4-D 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 2, 4-D 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 2, 4-D 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. ai/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. ai/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).

References

Beck, K.G. 1996. Canada thistle. Colorado State University Cooperative Extension Natural Resources Series, No. 3.108. http://www.colostate.edu/Depts/CoopExt/PUBS/NATRES/03108.html [24 Jan 00].

Beck, K.G. and J.R. Sebastian. 2000. Combining mowing and fall-applied herbicides to control Canada thistle *(Cirsium arvense). Weed Technology*. In press.

FEIS - Fire Effects Information System . 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [Version 12 Mar 98].

Haderlie, L.C., R.S. McAllister, R.H. Hoefer, P.W. Leino. 1991. Canada thistle control. In L.F James, J.O. Evans, M.H. Ralphs and R.D. Child, eds. *Noxious Range Weeds*. Westview Press, Boulder, CO.

Moore, R.J. 1975. The biology of Canadian weeds. 13. *Cirsium arvense* (L.) Scop. *Canadian Journal of Plant Science.* 55:1033-1048.

Nuzzo, V. 1998. Element stewardship abstract for *Cirsium arvense*. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/cirsarve.html [16 Oct 98].

Rutledge, C. R. and T. McLendon. No Year. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97pp. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/Explant/explant.htm [Version 15 Dec 98].

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Canada thistle. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Chicory
Cichorium intybus L.
USDA Code: CIIN
Keys to Identification:
Flower heads are 1.5 inches in diameter and are normally blue, but may appear white or purple.
Flowers are square on the end and lobed.
Keys to Control:
Maintain a healthy cover of perennial plants.
Re-seed controlled areas with desirable species.
Minimize additional disturbance.
Ecological: Chicory is a ruderal species that invades disturbed areas.
Human: Milky latex may cause dermatitis.
Habitat and Distribution
General requirements: Chicory is widespread along roadsides and in disturbed areas. It can adapt to a wide range of soils and environmental conditions.
Distribution: Common throughout North America.
Historical: Chicory is a native of the Mediterranean region. It is often planted for use as salad greens and the root used as a substitute for or additive to coffee (Whitson et al. 1996).
Biology/Ecology
Life cycle: Flowering occurs from July to September.
Mode of reproduction: Reproduces by seeds.
Seed production: No information available.
Seed bank: No information available.
Dispersal: No information available.
Biocontrol: None known.
Mechanical: Chicory may be controlled by mowing, cutting, or pulling plants before seed production. This process may have to be repeated annually to exhaust nutrient reserves in the roots of plants as well as to control plants that emerge from the soil seed bank.
Fire: No information available.
Herbicides: Chicory can be controlled with a mixture of picloram + 2, 4-D (Grazon P+D) if it is applied when plants are actively growing (Dow AgroSciences 1998). In general, use 2-4 pints of the mixture in enough water to give a total spray volume of 10-20 gallons per acre (Dow AgroSciences 1998). Dicamba, 2, 4-D, and picloram at 1.0 lb. ai/acre, or glyphosate at 1.5 lb. ai/acre, will also control chicory. To provide more complete control, add an agricultural surfactant and/or a drift control additive for improved deposition (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
This perennial weed is difficult to eliminate. Because it prefers disturbed areas, the maintenance of healthy plant communities and regeneration of disturbed areas can help prevent the spread of chicory. Combine preventive measures with mechanical and chemical control.
References
Dow AgroSciences. 1998. Chicory-biennials/perennials. Dow AgroSciences. The Ranch, Pasture Improvement. http://www.dowagro.com/theranch/weedres.htm [5 Mar 99].

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Chicory. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Burdock
Arctium minus (Hill) Bernh.
USDA Code: ARMI2
Keys to Identification

Common burdock can be easily identified by its bur-like flower heads.

Plants are highly branched and may grow up to, and occasionally over, seven feet in height.

Keys to Control:

Eliminate first year rosettes through tillage or herbicide applications.

Eliminate seed production in second year plants through mowing or cutting.

General requirements: Common burdock can commonly be found growing along roadsides, ditchbanks, in pastures and waste areas. It generally prefers riparian areas that have moist, fertile soils with high nitrogen contents.
Distribution: Established throughout much of the United States. Very common in central and north central Colorado.
Historical: Common burdock is a native of Eurasia. The hooked spines of the flower heads gave rise to the idea of Velcro (Whitson et al. 1996).
Biology/Ecology
Life cycle: The bulk of germination occurs in early spring (Gross et al. 1980). During the first year the plant forms a rosette. The following year the plant produces a stout, grooved, rough stem with numerous branches. Flowering and seed production occur from July to September. Seeds are mature by September and are shed continuously throughout the autumn, winter, and following spring.
Mode of reproduction: Common burdock reproduces solely by seed.
Seed production: Common burdock typically produces between 6,000-16,000 seeds per plant.
Seed bank: No information available.
Dispersal: Bur-like seed heads are readily dispersed by sticking to animal fur or clothing.
Biocontrol: None known.
Mechanical: Tillage can be used to kill the plants in the first year rosette stage. Mowing or cutting can be used to eliminate seed production. Mow after the plant has bolted but before it has flowered.
Fire: No information available.
Herbicides: Common burdock can be controlled with 2, 4-D, picloram, or dicamba at 1 lb. ai/acre, or glyphosate at 1.5 lb. ai/acre. Herbicides are most effective when applied to first-year rosettes.
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 plants which reproduce solely by seed, integrated management efforts must include the elimination of seed production and the depletion of the seed bank. Combine herbicide or tillage treatment of rosettes with removal of seed heads from any plants that have bolted. Preventing dispersal of burs is particularly important.
References
Gross, R.S., P.A. Werner, and W. Hawthorn. 1980. The biology of Canadian weeds. 38. *Arctium minus* (Hill) Bernh. and *A. lappa* L. *Canadian Journal of Plant Science* 60:621-634.

Stubbendieck, J., G.Y. Friisoe and M.R. Bolick. 1995. Common burdock. *Weeds of Nebraska and the Great Plains.* Nebraska Department of Agriculture, Bureau of Plant Industry, Lincoln, NE.

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Common burdock. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Cheatgrass (**Downy brome)**
Bromus tectorum (L.); ***Anisantha tectorum*** (L.) Nevski
USDA Code: BRTE, ANTE6
Keys to Identification:

Downy brome can be identified by its drooping branches.

In the late spring and early summer downy brome changes from green to purple to tan or brown allowing for easy identification. It often remains purple during the winter months.

Keys to Control:

Maintain healthy stand of perennial plants.

Seeding may be needed where perennial grasses have been depleted.

Manage grazing carefully in seeded areas to promote the establishment of new perennial plants.

Ecological: Downy brome can greatly alter the species composition of dry native rangeland vegetation by competitive exclusion of reproduction of native plant species and by facilitation of wildfires (Mosky et al. 1999). Invasion of downy brome is greatest in drier environments, particularly in sagebrush-steppe communities. The process in which a pristine Great Basin shrub-steppe ecosystem deteriorates into one that is dominated by downy brome takes several years and has several distinct cycles. First, some sort of disturbance, such as heavy grazing, allows downy brome and other annuals to invade and proliferate. The dry stands of downy brome in the summer increase the frequency of fires. Initially, this creates an environment dominated by annual grasses, broom snakeweed (*Gutierrezia sarothrae*), and rabbitbrush (*Chrysothamnus* spp.). As fires become even more frequent, the area will be dominated by annual grasses alone, with the loss of surface soil, nutrients, and near permanent deterioration of the site. Species that are commonly displaced by downy brome include big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), bluebunch wheatgrass (*Agropyron spicatum = Pseudoroegneria spicata*), crested wheatgrass (*Agropyron cristatum*), western wheatgrass (*Agropyron smithii = Pascopyrum smithii*), Sandberg bluegrass (*Poa sandbergii = Poa secunda*), needle-and-thread grass (*Stipa comata = Hesperostipa comata*), and Thurber's needlegrass (*Stipa thurberiana*).

Human: No information available.

Habitat and Distribution

General requirements: Downy brome is common in recently burned rangeland and wildlands, winter crops, waste areas, abandoned fields, eroded areas, and overgrazed grasslands (Upadhyaya et al. 1986). It can invade rangelands that have never been grazed by livestock (Svejcar and Tausch 1991).

Distribution: Common throughout Colorado from 4,000 to 9,000 feet. Widely distributed throughout North America. Although downy brome occurs in a variety of habitats, it is most prominent on the Columbia-Snake River Plateau, Wyoming Basin, and the northern edge of the Great Basin in disturbed sagebrush steppe communities (Rice and Mack 1991, West 1983).

Historical: No information available.

Biology/Ecology

Life cycle: Vast numbers of downy brome seedlings usually germinate after the first fall rain in infested areas (West 1983). The leaves typically grow little in the fall, and plants are normally 1-2 inches in height when covered by snow in December. The young, fall-germinated seedlings often over-winter in a semi-dormant state and complete their lifecycle the following spring (Upadhyaya et al. 1986). However, downy brome roots can grow in soil temperatures approaching freezing (West 1983), and roots will continue to grow throughout the winter until soil temperatures drop below about 37 degrees F.

Plants head in late April to early May followed by flowering within a week (Upadhyaya et al. 1986). The seeds mature in mid to late June (Upadhyaya et al. 1986). During ripening downy brome flowers turn purple and then brown as they mature. Once the seeds have matured, plants dry and become flammable. There is a correlation between plant color and moisture status during the drying process (FEIS 1996). Downy brome passes from green (>100% moisture content), to a purple hue (30-100% moisture content), to a straw color (<30% moisture content) as it dries (FEIS 1996). The onset of purple coloring should be taken as a warning that hazardous fire conditions will develop within two weeks (FEIS 1996). Downy brome greens up earlier in the spring than most other species. Depletion of soil moisture is a mechanism by which downy brome suppresses seedlings of desirable, perennial grasses (Melgoza et al. 1990). In addition, thick
mulch in dense downy brome stands favors downy brome seedling germination and establishment while inhibiting that of perennial bunchgrasses (Svejar and Tausch 1991).

Mode of reproduction: Reproduces by seeds.

Seeds production: Downy brome can be a prolific seed producer and is capable of producing up to 400 lbs. of seeds/acre (Upadhyaya et al. 1986). Seed production per culm, per plant, and per unit area is dependent on plant density and environmental factors (Upadhyaya et al. 1986). Average seed production per plant is generally lowest where plant density is highest (Rice and Mack 1991). If precipitation is adequate, the majority of downy brome seeds will germinate in the fall, or within a year of maturation (Upadhyaya et al. 1986). However, dry conditions can cause environmentally induced dormancy, which may last several years and break down at erratic intervals (Young and Evans 1985).

Seed bank: Low survival rates in the soil, but seeds may last in the seed bank for a few years.

Dispersal: Seeds are dispersed short distances by wind, and the long awns can attach to the fur or feathers of an animal, as well as clothing.

Biocontrol: Livestock grazing can help control downy brome. Two grazing periods each spring are required for at least two
consecutive years. Plants should first be grazed at the stage just before the inflorescences emerge (“boot” stage), and then grazed again before panicles emerge (about 3-4 weeks). Grazing intensity needs to be light enough to leave at least a 3-inch residual height to protect desirable grasses (Mosely 1996). Winter grazing downy brome can reduce mulch, thereby hindering downy brome
establishment and favoring perennial grass establishment.

Mechanical: Cutting is not a recommended control method for downy brome. Plants that are cut before seed ripening will produce new stems and seeds at the cut height. Plants that are cut after seed ripening will die, but by this point the seeds are already viable. In one study, repeated mowing (every three weeks) during the spring and summer was as effective at controlling downy brome seed production as an application of glyphosate (Ponzetti 1997). However, this method was very labor-intensive and a cost/benefit analysis should be conducted before any choice is made. Hand-pulling downy brome plants in small infestations before seed set would effectively eliminate current seed production, but may not eliminate the infestation. The large seed production commonly associated with downy brome infestations will allow plants to recover for several years without noticeable reductions in plant density. Hence, any pulling program must be conducted for several years, or until the seed bank has been exhausted. Also, seeds that blow into the cleared areas from adjacent uncleared areas may negate the effects of pulling. When pulling, an effort should be made to extract as

much of the root as possible so that the plant cannot simply regrow and produce new seeds.

Fire: Burning is usually conducted in Colorado in June after the plant has dried, but before the seeds have dropped (Carpenter and Murray 1998). However, some seeds will survive and if a burn is not followed by reseeding downy brome will recover to pretreatment proportions within 3 to 4 years (Carpenter and Murray 1998). Reseeding should be done in late fall (a dormant seeding).

Herbicides: There are several types of herbicides that can be used alone or combined to provide effective control of downy brome. Refer to the product label for detailed application directions so as to minimize the damage to nontarget species. For relatively small infestations, a backpack sprayer is recommended to minimize the danger to nontarget plants. However, infestations are often so large that a four-wheeler, tractor, or truck fitted with a sprayer is necessary. The following herbicides are divided into two groups, spring applied and fall applied. In most cases, herbicide application should be made in early spring when non-target species are dormant to insure selective control. Downy brome was reported to be controlled best when the plants were 10 cm or less and growing vigorously at the time of application (Wiese et al. 1995). Spring applied herbicides include quizalofop, fluazifop-p-butyl, sethoxydim, glyphosate, and imazapic. On sites where desirable plants are largely absent, control of downy brome must be followed by reseeding. Chemical fallow with glyphosate at 0.5 lb. ai/ac applied in the early spring when plants are actively growing is one option. The site can be reseeded in the fall (Mosely et al. 1999). Alternatively, one could graze downy brome plants twice with livestock then apply glyphosate. Fall herbicide applications should be conducted after downy brome seeds have germinated and are beginning to grow. Fall applications are generally used in cropland situations by farmers growing winter wheat or other cool season crops. However, sometimes these herbicides are used in pastures and rangelands. Fall-applied herbicides for non-crop situations include sulfometuron methyl, and metribuzin.

Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, and maintaining healthy native communities.

Integrated Management Summary

Downy brome is characterized by its early maturation, high seed production, and vigorous growth under favorable environmental conditions. Although, downy brome readily invades perennial forage crops and rangeland under poor management, it also invades communities in the absence of disturbance (Douglas et al. 1990). In undisturbed sites, downy brome will most commonly spread along soil cracks and work its way outward into the natural community (Rice and Mack 1991). Downy brome has a dual role as a serious weed and important early season forage for cattle and sheep (Upadhyaya et al. 1986). Downy brome provides the bulk of early spring forage for all classes of stock on grazing lands in the Intermountain and Pacific Northwest regions (Upadhyaya et al. 1986). Lasting control of downy brome will require a combination of chemical control, physical control, vegetative suppression, and proper livestock management where land is grazed. This “cumulative stress” method will keep the plants constantly under stress, reducing their ability to flourish and spread. Also, a cumulative stress approach provides a level of redundancy in case one type of treatment is not implemented or proves to be ineffective (Carpenter and Murray 1998).

References

Carpenter, A.T. and T.A. Murray. 1998. Element Stewardship Abstract for *Bromus tectorum*. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/bromtect.html

Douglas, B.J., A.G. Thomas, and D.A. Derksen. 1990. Downy brome (*Bromus tectorum*) invasion into southwestern Saskatchewan. *Canadian Journal of Plant Science* 70:1143-1151.
FEIS - Fire Effects Information System . 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [Version 12 Mar 98].
Hironaka, M. 1961. The relative rate of root development of cheatgrass and medusahead. *J. Range Management* 14:263-267.
Hulbert, L.C. 1955. Ecological studies of Bromus tectorum and other annual bromegrasses. *Ecol. Monogr.* 25:181-213.
Melgoza, G., R.S. Nowak and R.J. Tausch. 1990. Soilwater exploration after fire: competition between *Bromus tectorum* and two native species. *Oecologia* 83:7-13.
Mosely, J.C., S.C. Bunting, and M.E. Monoukian. 1999. Cheatgrass. In R.L. Sheley and J.K. Petroff, eds. *Biologyand Management of Noxious Rangeland Weeds.* Oregon State University Press, Corvallis, OR.
Mosely, J.C. 1996. Prescribed sheep grazing to suppress cheatgrass: A review. *Sheep and Goat Research Journal* 12:74-81.
Ponzetti, J.M. 1997. Assessment of medusahead and cheatgrass control techniques at Lawrence Memorial Grassland Preserve 1996 Annual Report. The Nature Conservancy of Oregon.
Rice, K.J., and R.N. Mack. 1991. Ecological genetics of *Bromus tectorum*: intraspecific variation in phenotypic plasticity. *Oecologia* 88:84-90.
Svejcar, T. and R. Tausch. 1991. Anako Island, Nevada: A relict area dominated by annual invader species. *Rangelands* 13: 233-236.
Upadhaya, M.K., R. Turkington, and D. McIlvride. 1986. The biology of Canadian weeds. 75. *Bromus tectorum* L. *Canadian Journal of Plant Science* 66:689-709.
West, N.E., (ed.) 1983. Western intermountain sagebrush steppe. *Temperate Deserts and Semi-Deserts*. Elsevier Scientific Publishing Company, Amsterdam.
Whitson, T.D. and D.W. Koch. 1998. Control of downy brome (*Bromus tectorum*) with herbicides and perennial grass competition. *Weed Technology* 12:391-396.
Wiese, A.F., C.D. Salisbury, and B.W. Bean. 1995. Downy brome (*Bromus tectorum*), jointed goatgrass (*Aegilops cylindrica*) and horseweed (*Conyza canadensis*) control in fallow. *Weed Technology* 9:249-254.
Young, J.A. and R.A. Evans. 1985. Demography of *Bromus tectorum* in *Artemisia* communities. In J. White, ed. *The Population Structure of Vegetation*. Dr. W. Junk Publishers, Dordrecht, Netherlands.

Yellow Starthistle
Centaurea solstitialis L.
USDA Code: CESO3
Legal Status: Colorado List A Noxious Weed Species. (New in Colorado – call your county weed supervisor!)
Keys to Identification:

Yellow starthistle has rigid, branching, winged stems that are covered with cottony hairs.

Flower heads are distinguished by sharp, straw-colored thorns, which are up to 0.75 inches long.

Keys to Control:

Management and control will only be successful when several techniques such as prescribed burning and spot herbicide
treatment or large-scale herbicide spraying are combined to remove yellow starthistle and replace it with competitive native
perennials.

Identification
Growth form: Winter annual forb.
Flower: Flower heads are yellow, located singly at the ends of branches. Flower heads are distinguished by sharp, straw-colored thorns, which are up to 0.75 inches long.
Seeds/Fruit: Yellow starthistle has two types of seeds, plumed and plumeless.
Leaves: Basal leaves are deeply lobed while the upper leaves are entire and sharply pointed.
Stems: Mature plants are 2-3 feet tall and have rigid, branching, winged stems that are covered with cottony hairs (Whitson et al.1996).
Roots: Taproot.
Seedling: Seedlings have oblong, tongue-shaped cotyledons. (Herzog and Randall 1998).
Similar Species
Exotics: Purple starthistle *(Centaurea calcitrapa)* and Iberian starthistle *(Centaurea iberica)* are related exotics, but are not yet found in Colorado. Purple starthistle has been reported in Wyoming.
Natives: None known.
Impacts
Agricultural: Yellow starthistle causes a neurological disorder called chewing disease (equine nigropallidal encephalomalacia) in horses that eat it (Maddox et al. 1985).
Ecological: Yellow starthistle is a pioneering plant that becomes established on disturbed land. It forms dense infestations, reduces the available edible forage, and exhibits a suspected allelopathic effect on some associated species (Maddox et al. 1985).
Human: No information available.
Habitat and Distribution
General requirements: Yellow starthistle invades rangelands, pastures, roadsides, cropland, and wastelands. It is intolerant of shade and requires light on the soil surface for winter rosette and taproot development (FEIS 1996). Yellow starthistle is capable of establishing on deep, well-drained soils as well as on shallow, rocky soils that receive from 10-40 inches of annual precipitation. In the Pacific Northwest, yellow starthistle favors sites that were formerly dominated by big sage-brush, bluebunch wheatgrass, Idaho fescue and Sandberg bluegrass (Sheley et al. 1999).

Distribution: Well established in the Pacific coast states, and spreading west. Found in eight known locations on the Front Range and West Slope. Elevations range from 5,000-6,500' and it appears to favor dryland conditions.
Historical: Introduced from Europe, where it is native to the Mediterranean region.
Biology/Ecology
Life cycle: Seedlings usually emerge in the fall, form rosettes, and begin growing a taproot. Root growth continues throughout the winter. Yellow starthistle bolts in late spring and flowers June through August.
Mode of reproduction: It reproduces entirely by seed (FEIS 1996).
Seed production: Plants usually produce 700 - 1,000 seeds/plant, but vigorous plants may produce up to 170,000 seeds/plant (Herzog and Randall 1998, FEIS 1996).
Seed bank: Seeds may remain viable for several years (Herzog and Randall 1998).
Dispersal: Plumed and plumeless seeds are dispersed at different times. Plumed seeds are dispersed by wind shortly after maturity. Plumeless seeds remain in the seedhead until it disintegrates in the fall or winter.
Hybridization: No information available.
Control
Biocontrol: There are several biological control agents that can dramatically reduce seed production. The most commonly used biological control agent is *Bangasternus orientalis*, a seed head weevil. Larvae feed on the seeds and can destroy up to 60% of the seeds in a head (Rees et al. 1996). Reseeding with competitive grass species is a key part of integrated yellow starthistle control, with appropriate species varying by locality (Sheley et al. 1999). Cattle and sheep will graze yellow starthistle before it has spines. Multiple grazing periods are necessary to control yellow starthistle.
Mechanical: Hand pulling can be used to remove small infestations of yellow starthistle. Mowing can be used to control larger infestations. Mowing alone is ineffective as a control method, but it can be helpful in stressing yellow starthistle plants that grow above desirable seeded species during revegetation (Sheley et al. 1999).
Fire: Recent studies suggest that yellow starthistle was controlled with prescribed burning in California grasslands (Hastings and DiTomasso 1996). Burning should be conducted during the early flowering stage (before seed production).
Herbicides: Herbicides are most effective when applied from the seedling to bolt stages. Picloram at 0.25 lb., dicamba, or 2,4-D at 1 lb. ai/acre are the most commonly used herbicides. Chemical control is most appropriate for large infestations, particularly when desirable plants are abundant in the understory, on highly productive sites, and around the periphery of infestations to control their spread (Sheley et al. 1999).
Cultural/Preventive: Grazing management is imperative for yellow starthistle control, mainly to promote stands of healthy desirable plants.
Integrated Management Summary
This species is not yet well established in Colorado, and should be a priority for immediate eradication if found. Yellow starthistle favors disturbed sites such as roadsides, ditches, orchards, and overgrazed rangeland and pasture (FEIS 1996). Yellow starthistle will even invade undisturbed grassland communities where site conditions are ideal. The large seed bank in the soil combined with a long seed life make this plant extremely difficult to control. Management and control will only be successful when several techniques such as prescribed burning and spot herbicide treatment or large-scale herbicide spraying are combined to remove yellow starthistle and replace it with competitive native perennials. Anecdotal evidence indicates that yellow starthistle does not compete with planted, improved grass varieties on California foothills range (Bill Burrows, pers. comm.). Land management practices
should focus on promoting healthy native plant communities.

References

FEIS - Fire Effects Information System . 1996. Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. http://www.fs.fed.us/database/feis/ [Version 12 Mar 98].

Hastings, M.S. and J.M. DiTomasso. 1996. Fire controls yellow starthistle in California grasslands. *Restoration and Management Notes* 14:124-128.

Herzog, P. and J. Randall. 1998. Element stewardship abstract for *Centaurea solstitialis*, yellow starthistle. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/documnts/centsol.html [30 Jul 98].

Maddox, D.M., A. Mayfield, and N.H. Poritz. 1985. Distribution of yellow starthistle (*Centaurea solstitialis*) and Russian knapweed (*Centaurea repens*). *Weed Science* 33:315-327.

Sheley, R.L., L.C. Larson and J.S. Jacobs. 1999. Yellow starthistle. In R.L. Sheley and J.K. Petroff, eds. *Biology and Management of Noxious Rangeland Weeds*. Oregon State University Press, Corvallis, OR.

Leafy Spurge
Euphorbia esula L.; ***Tithymalus esula*** (L.) Scopoli
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.

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. 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).

Ecological: Leafy spurge is an aggressive, long-lived, perennial weed that tends to 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 leafy spurge monoculture. Rapid re-establishment of treated stands often occurs after an apparently successful management effort because of the large nutrient reserve stored in the roots of leafy spurge plants. Also, leafy spurge produces an allelopathic compound that inhibits the growth of other plants (Butterfield et al. 1996).

Human: The milky latex associated with 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.

Distribution: In Colorado, leafy spurge is common on disturbed soils between 5,000 to 6,500 feet (Rutledge and McLendon 1998), but can be found up to 9,000 feet.

Historical: No information available.

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 feet laterally, and about 30 feet 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% 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 feet from the parent plant. Seeds float on water, and can be transported and deposited by flood water.
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 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 qt./ac) 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%. This study also produced excellent results by combining sheep with *Apthona* beetles (Beck and Rittenhous, 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, pers. 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 feet 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 qt./ac) (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 qt./ac 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% 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.

References

Best, K.F., G.G. Bowes, A.G. Thomas, and M.G. Maw. 1980. The biology of Canadian Weeds. 39. *Euphorbia esula* L. *Canadian Journal of Plant Science* 60: 651-663.

Beck, K.G. 1996. Leafy spurge. Colorado State University Cooperative Extension Natural Resource Series, No. 3.107. http://www.colostate.edu/Depts/CoopExt/PUBS/NATRES/03107.html [24 Jan 00].

Beck, K.G. and L.R. Rittenhouse. 2000. Managing leafy spurge with sheep grazing and flea beetles. *Proc. Wes. Soc. Weed Sci.* In press.

Biesboer D.D. 1998. Element stewardship abstract for *Euphorbia esula*. The Nature Conservancy, Wildland Weeds Management & Research Program. http://tncweeds.ucdavis.edu/esadocs/euphesul.html [28 Jul 98].

Butterfield, C., J. Stubbendieck, and J. Stumpf. 1996. Species abstracts of highly disruptive exotic plants. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/exoticab/exoticab.htm [Version 16 Jul 97].

Lajuenesse, S., R.L. Sheley, R. Lym, D. Cooksey, C. Duncan, J. Lacy, N. Rees, and M. Ferrell. 1994. Leafy spurge: biology, ecology and management. Extension Bulletin EB 34, Montana State University, Bozeman, MT.

Lajuenesse, S., R.L. Sheley, R. Lym, and C. Duncan. 1999. Leafy Spurge. In R.L. Sheley and J.K. Petroff, eds. *Biology and Management of Noxious Rangeland Weeds*. Oregon State University Press, Corvallis, OR.

Lym, R.G., K.E. Messersmith, and R. Zollinger. 1998. Leafy spurge identification and control. North Dakota State University Extension Service Publication W-765. http://www.ext.nodak.edu/extpubs/plantsci/weeds/w765w.htm [20 Jan 00].

Lym, R.G. 1998. The biology and management of leafy spurge (*Euphorbia esula*) on North Dakota rangeland. *Weed Technology* 12: 367-373.

Rutledge, C. R. and T. McLendon. No Year. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97pp. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/Explant/explant.htm [Version 15 Dec 98].

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Leafy spurge. *Weeds of the West.* Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark, CA.

Yellow Toadflax
Linaria vulgaris P. Miller
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.

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.

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.

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). In Colorado, yellow toadflax is abundant on the Western Slope, but can be found on the Front Range as well. It is typically found from 6,000 to 8,500 feet, but can be found up to 10,000 feet.

Historical: Yellow toadflax was introduced from Eurasia as an ornamental.

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 selfincompatible 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).

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. ai/acre, or glyphosate at 1.5 lb. ai/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. ai/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, miminum-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.

References

Lajeunesse, S. 1990. Dalmatian and yellow toadflax. In R.L. Sheley and J.K. Petroff, eds. *Biology and Management of Noxious Rangeland Weeds*. Oregon State University Press, Corvallis, OR.

McClay, A.S. 1992. Effects of *Brachypterolus pulicarius* (L.) (Coleoptera: Nitidulidae) on flowering and seed production of common toadflax. *The Canadian Entomologist* 124: 631-636.

Morishita, D.W. 1991. Dalmatian toadflax, yellow toadflax, black henbane, and tansy mustard: importance, distribution, and control. In L.F James, J.O. Evans, M.H. Ralphs and R.D. Child, eds. *Noxious Range Weeds*. Westview Press, Boulder, CO.

Robocker, W.C. 1974. Life history, ecology, and control of Dalmatian toadflax. Tech. Bull No. 79. Washington Agricultural Experiment Station. Pullman, WA.

Rutledge, C. R. and T. McLendon. No Year. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97pp. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrdata/Explant/explant.htm [Version 15 Dec 98].

Saner, M.A., D.R. Clements, M.R. Hall, D.J. Doohan, and C.W. Crompton. 1995. The biology of Canadian weeds. 105. *Linaria vulgaris* Mill. *Canadian Journal of Plant Science* 75: 525-537.

Sebastian, J.R. and K.G. Beck. 1999. The influence of picloram or picloram plus 2,4-D applied for 1, 2, or 3 years on cover, density and control of yellow toadflax on Colorado rangeland. Res. Prog. Rep. Wes. Soc. Weed Sci. p. 36-37.

Zimmerman, J.A.C. 1996. Ecology and distribution of *Linaria vulgaris* (L.) Miller, Scrophulariaceae. USGS Colorado Plateau Field Station, Southwest Exotic Plant Mapping Project. http://www.usgs.nau.edu/swemp/Info_pages/plants/Linaria/linariatitle.html [14 Jan 98].

Sulfur cinquefoil (Information from the CWMA website: www.cwma.org)
Potentilla recta L.

USDA Code: PORE5

Legal Status: Colorado Noxious Weed List B

Lifecycle: Perennial

Growth form: Forb

Flower: Flowers are light-yellow with 5 petals

Seeds/Fruit: Each flower produces numerous small seeds (.05 in long) that are slightly flattened

Leaves: Leaves are alternate, palmately compound with 5-7 toothed leaflets on each leaf. Leafstalks have conspicuous perpendicular hairs, and leaves appear green on the underside

Stems: Mature plants are 1-1.5 feet tall with one to several stems growing from well-developed rootstocks (Whitson et al. 1996)

Roots: Fibrous roots and lateral rhizomes

Agricultural Impacts: Sulfur cinquefoil is unpalatable to grazing animals, therefore it reduces forage for livestock and wildlife where it is abundant (Rice 1999)

Ecological Impacts: Sulfur cinquefoil is a competitive early successional weed that persists until a woody cover is present. It can dominate a site after within 2-3 years of first appearance (FEIS 1998). Sulfur cinquefoil has a long lifespan, and twenty year old plants are not uncommon (FEIS 1998). Sulfur cinquefoil has been known to invade bluebunch wheatgrass rangeland in good condition (FEIS 1998). In Montana, it is actually out-competing spotted knapweed on some sites (FEIS 1998). Some species that are commonly associated with sulfur cinquefoil include smooth brome (Bromus inermis), Canada bluegrass (Poa compressa), quackgrass (Elytrigia repens), timothy (Phleum pratense), annual ragweed (Ambrosia artemisiifolia), yellow toadflax (Linaria vulgaris), and spotted knapweed (Centaurea maculosa) (FEIS 1998).

General requirements: Although colonies of sulfur cinquefoil can be found in undisturbed sites, it is commonly found in disturbed grasslands, shrubby areas, and old fields. Sulfur cinquefoil grows on dry sandy, gravelly, and rocky soils, and prefers climates that receive from 13-50 inches of mean annual precipitation.

Distribution: Naturalized throughout much of North America. It is typically found in low to middle elevations in the Intermountain west

Historical: Sulfur cinquefoil is a native of Eurasia that was first introduced into North America before 1900 (FEIS 1998)

Life cycle: Seeds of sulfur cinquefoil may germinate at any time during the growing season provided soil moisture is adequate. However, seeds don't germinate when temperatures are high (usually during July and August). Growth begins early in spring. Sulfur cinquefoil flowers from May to July with peak flowering generally occurring in late June.

Mode of reproduction: Sulfur cinquefoil has an unusual means of vegetative reproduction. Annual regrowth each spring eventually causes individual plants to become several closely-spaced independent plants. Also, plants that are knocked to the ground can produce roots at the nodes.

Seed bank: Seeds may remain viable in the soil for more than four years

Integrated Management Summary

Sulfur cinquefoil is a competitive weed that uses its early emergence to establish itself and push out desirable vegetation. It has even been observed to out-compete other noxious weed species. It is not a serious problem in cropland because it does not tolerate frequent plowing. This species is not yet widespread in Colorado, and should be a priority for immediate eradication if found. Small infestations can be controlled by hand pulling, but larger stands are commonly controlled with herbicide. Management programs for sulfur cinquefoil should focus on improving the competitiveness of other more desirable species, and preventing the spread of this weed.

References

Duncan, C.L. 1993. Chemical control of sulfur cinquefoil on range and pasture. In: Proceedings of the Montana Weed Control Association Clanay, MT. pg. 11-13.

FEIS - Fire Effects Information System [Online] (1996, September). Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. Available: www.fs.fed.us/database/feis/ [1998,March 12]

Rice, P. 1999. Sulfur cinquefoil. In R.L. Sheley and J.K. Petroff (eds.) Biology and management of noxious rangeland weeds. Oregon State University Press, Corvallis. pg. 382-388.

Whitson, T.D.(ed.), L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, R. Parker. 1996. Sulfur cinquefoil. Weeds of the West. Western Society of Weed Science, in cooperation with the Western United States Land Grant Universities Cooperative Extension Services, Newark CA. pg. 536.

Diffuse Knapweed (Information from the CWMA website: www.cwma.org)
Centaurea diffusa Lam.

Family: Asteraceae (Sunflower)

Other Names: spreading knapweed, tumble knapweed

USDA Code: CEDI3

Legal Status: Colorado Noxious Weed List B

IDENTIFICATION

Growth form: Biennial or short-lived perennial forb.

Flower: Flower heads are broadly urn-shaped, 0.6-0.8 inches tall, solitary or in clusters of 2-3 at the ends of the branches. Floral bracts are yellowish with a brownish margin, sometimes spotted, fringed on the sides, and terminating in a slender bristle or spine. The heads contain two types of flowers, ray flowers around the edges surrounding tubular disk flowers. The ray flowers are white, rose-purple, to lavender.

Seeds/Fruit: Seeds are light brown to black.

Leaves: Basal leaves are stalked and divided into narrow, hairy segments. Stem leaves are smaller, alternate, less divided, stalkless, and become bract-like near the flower clusters.

Stems: Stems are upright, 4-24 inches tall, highly branched, angled, with short, stiff hairs on the angles.

Roots: Taproot.

Seedling: Seedlings have finely divided leaves that are covered with short hair.

SIMILAR SPECIES

Exotics: Diffuse knapweed may be distinguished from other knapweeds by the terminal spine on the floral bract.

Natives: None.

IMPACTS

Agricultural: Diffuse knapweed reduces the productivity of rangeland by displacing desirable forage species.

Ecological: Diffuse knapweed is a pioneer species that can quickly invade disturbed and undisturbed grassland, shrubland, and riparian communities. Once established, diffuse knapweed outcompetes and reduces the quantity of desirable native species

such as perennial grasses. Diffuse knapweed contains allelopathic chemicals, which can suppress competitive plant growth and create single species stands (Watson and Renney 1974). The densities of these stands can range from 1-500 plants/m^2. The replacement of native grassland with diffuse knapweed can reduce biological activity and increase soil erosion (Sheley et al. 1997).

Human: Some people develop a rash when handling the plants.

HABITAT AND DISTRIBUTION

General requirements: Diffuse knapweed is found on plains, rangelands, and forested benchlands. It is generally found on light, dry, porous soils. Diffuse knapweed has been observed in elevations up to 7,000 feet (Zimmerman 1997). It prefers open habitats to shaded areas (Watson and Renney 1974). Diffuse knapweed is not common on cultivated lands or irrigated pasture because it cannot tolerate cultivation or excessive moisture (Watson and Renney 1974).

Distribution: Diffuse knapweed is now common in the Front Range counties, and has been reported in scattered infestations from both the east and west slope of Colorado.

Historical: Native to Eurasia.

BIOLOGY/ECOLOGY

Life cycle: Diffuse knapweed plants first form low rosettes and may remain in this form for one to several years depending on environmental conditions. Diffuse knapweed plants that complete their juvenile growth by the fall overwinter as rosettes and bolt in early spring (Watson and Renney 1974). Diffuse knapweed plants that have not finished the juvenile stage by the end of fall remain as rosettes through the second year and bolt during the third year. Flower buds are formed in early June and flowering occurs in July and August (Watson and Renney 1974). Mature seeds are formed by mid-August (Watson and Renney 1974).

Mode of reproduction: Reproduces by seeds.

Seed production: A single diffuse knapweed plant can produce up to 18,000 seeds (Harris and Cranston 1979) and a stand of diffuse knapweed can produce up to 40,000 seeds per square meter (Watson and Renney 1974).

Seed bank: Seeds may remain dormant for several years.

Dispersal: Seed dispersal for diffuse knapweed is mainly by wind (Watson and Renney 1974). When the seed capsule sways in the breeze or is disturbed, the seeds fall from the small opening in top of the flower head and are distributed around the parent plant (Watson and Renney 1974). However, most of the involucres remain closed until the plant dries up, breaks off at ground level and effectively becomes a tumbleweed, allowing seeds to be individually dispersed over long distances (Zimmerman 1997). Diffuse knapweed stalks readily lodge under vehicles, expanding their long distance dispersal.

REFERENCES

Beck, G. K. 1997. Natural resources series, diffuse knapweed. Colorado State University Cooperative Extension. Internet 05/05/98. Available: http://ozma.jefferson.co.us/dpt/openspac/weed/dfknapwd.htm

Fletcher, R.A., and A.J. Renney. 1963. A growth inhibitor found in *Centaurea* spp. Canadian Journal of Plant Science 43:475-481.

Harris, P., and R. Cranston. 1979. An economic evaluation of control methods for diffuse and spotted knapweed in western Canada. Canadian Journal of Plant Science 59:375-382.

Niefoff, J. E-mail message-broadcast. Sent 9-12-97, 9:29 AM.

Roché, B.E. and C.T. Roché. 1999. Diffuse knapweed. In: R.L. Sheley and J.K. Petroff (eds.) Biology and management of noxious rangeland weeds. Oregon State University Press, Corvallis, pg. 217-230.

Schirman, R. 1981. Seed production and spring seedling establishment of diffuse and spotted knapweed. Journal of Range Management 34:45-47.

Sheley, R.L., B.E. Olson, and L.L. Larson. 1997. Effect of weed seed rate and grass defoliation level on diffuse knapweed. Journal of Range Management 50: 39-43.

Watson, A.K., and A.J. Renney. 1974. The biology of Canadian weeds *Centaurea diffusa* and *C. maculosa*. Canadian Journal of Plant Science 54:687-701.

Youtie, B. 1997. Weed control as the first step in protecting and restoring native plant communities on northeast Oregon natural areas. Conservation and Management of Native Plants and Fungi. Native Plant Society of Oregon, Corvallis, Oregon. pages 78-82.

Youtie, B. and J. Soll. 1994. Non-chemical control of diffuse knapweed (*Centaurea diffusa*). Knapweed Newsletter 8(3):2-3. Washington State University Cooperative Extension, Pullman WA.

Zimmerman, J.A.C. 1997. Ecology and distribution of *Centaurea diffusa* Lam., Asteraceae. USGS Biological Resources Division , Colorado Plateau Field Station-Flagstaff, Arizona. Internet 02/16/98. Available: http://www.nbs.nau.edu/FNF/Vegetation/Exotics/diffusa/ diffusa.html