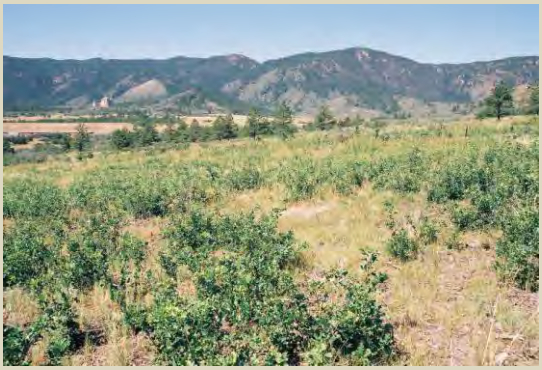

Integrated Noxious Weed Management Plan

US Air Force Academy and Farish Recreation Area

NATURAL HERITAGE PROGRAM
COLORADO

August 2015

CNHP's mission is to preserve the natural diversity of life by contributing the essential scientific foundation that leads to lasting conservation of Colorado's biological wealth.

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Department of Natural Resources

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Front Cover: Documenting weeds at the US Air Force Academy.
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Integrated Noxious Weed Management Plan

US Air Force Academy and Farish Recreation Area

El Paso County, CO

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Colorado Natural Heritage Program
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WARNER COLLEGE OF
Natural Resources
Colorado State University

August 2015

EXECUTIVE SUMMARY

Various federal, state, and local laws, ordinances, orders, and policies require land managers to control noxious weeds**.** The purpose of this plan is to provide **a guide to manage, in the most efficient and effective manner, the noxious weeds on the US Air Force Academy (Academy) and Farish Recreation Area (Farish) over the next 10 years (through 2025),** in accordance with their respective integrated natural resources management plans**.** This plan pertains to the "natural" portions of the Academy and excludes highly developed areas, such as around buildings, recreation fields, and lawns. This plan covers the entire Farish site, including the developed areas. For clarification purposes, throughout this report, the word "we" refers to the authors of this report, Colorado Natural Heritage Program (Smith et al. 2015).

An integrated weed management plan employs a combination of weed control strategies in an effort to protect and/or achieve lasting restoration of native plant communities and the natural processes that support them. This plan follows approaches utilized by Carpenter and Perce (2004) who wrote the previous management plan as well as various other management plans that are designed for weed management in areas that contain natural resources that need protection (Person and Ortega 2009, Spackman Panjabi and Decker 2007, Tu et al. 2001 and Randal 2001). In addition, new information on weed control methods was gleaned from contemporary scientific literature, a Colorado State University Extension Course (Exploring Herbicide Use in Natural Areas, G. Beck 2015), CSU Extension Fact Sheets, and management recommendations from El Paso County (2014) and the US Forest Service Fire Effects Information Service (FEIS 2015) which have been incorporated into this plan.

A key element of a management plan is to compile a complete list and map of the noxious weeds known from the management area. A noxious weed survey of the Academy and Farish was conducted by the Colorado Natural Heritage Program during 2002, 2007, and 2012 with a subset of species mapped on an annual basis (Anderson et al. 2003, Anderson and Lavender 2006, 2007, 2008, Anderson, Lavender and Neid 2009, Anderson et al. 2010, Rondeau et al 2011, 2014, Rondeau and Lavender 2012, 2013). These studies documented 8,308 locations of at least 25 (Colorado State List A,B,C) noxious weed species. While many of these infestations have been treated over the years and the noxious weed targets have changed, all mapped weed locations were used in the development of this strategy, given the assumption that treated infestations have the potential to re-surface over time. Such a large number of weed locations necessitated a prioritization process to reduce the number of occurrences to be controlled to a manageable number. **The noxious weed species were prioritized for control based on three factors: 1) the extent of the infestation; 2) the feasibility of successful control and 3) the proximity to areas with natural values** (i.e. proximity to a rare plant or animal habitat or location within a rare plant community). To assist in determining whether a location was in a natural area or an area with natural value(s) we have designated areas referred to as Special Weed Management Areas (SWMAs). This results in a total of approximately 6,189 noxious weed occurrences for which we recommend a "natural areas" management approach, which is about 74% of the total number of mapped occurrences. Currently, 4,654 of the 6,189 occurrences are extant (pers. comm. A. Greenwell 2015).

Weed management objectives have been established for the 20 most significant weed species at the Academy within designated SWMAs. Six species (myrtle spurge, bouncingbet, Dalmatian toadflax, dame's rocket, Russian knapweed, and salt cedar) are slated for eradication. Three species previously considered candidates for eradication across the Academy, houndstongue, Scotch thistle and St. Johnswort, are slated for eradication and/or control because these species have reached coverage approaching or exceeding one acre and are widespread in distribution at the Academy and eradication may no longer be a realistic goal. All other species are slated for suppression or containment. However, in some cases, any one of the 20 weed species may need to be slated for elimination at a local level, especially at the intersection with important natural resources (SWMAs).

There are five viable broad categories of weed management techniques that could be employed at the Academy and Farish. These include prevention, manual, biological, chemical, and prescribed burning. A most effective/lasting approach will integrate a combination of several techniques. An integrated weed management plan that includes revegetation with native plants, and selects multiple control techniques that ideally interact to provide effective and feasible control for each target weed species will result in the most successful restoration results. More detailed restoration plans are needed for treating infestations in some locations of the Special Weed Management Areas, particularly areas that support habitat for the Listed Threatened Preble's meadow jumping mouse and other biological elements of concern that are mapped at the Academy. To that end we have recommended specific weed management techniques for each of the 20 target weed species known on the Academy and Farish and have provided digital polygons for the locations of the natural resources and Special Weed Management Areas that can be used by contractors and Academy staff.

Prevention measures are by far the most effective tool for weed control; it is essential to minimize the entry of new noxious weed species to the Academy and Farish, as well as to locate and eliminate new, small occurrences before they can become established. Several policies and actions that we believe will greatly reduce the entry of new weeds to the Academy and Farish and reduce the likelihood of inadvertently spreading weeds within these properties are utilized by the Academy. These include requiring heavy equipment used for construction, forest management, and firefighting to be cleaned before entering the Academy or moving between construction sites within the Academy; working with the base stables to improve the condition of ranges where the government-owned horses graze; prohibiting noxious weeds and certain other invasive plants species from being planted at the Academy and Farish; and promptly revegetating with native plant species all disturbances created by construction, logging, and firefighting. Further, periodic weed surveys are also recommended for early detection and rapid response of new infestations.

The success of any treatment program needs to be evaluated. We have proposed the continuation of a monitoring program to evaluate the effectiveness of weed management actions. Broadly speaking, monitoring will follow Rondeau and Greenwell (2014), and involve collecting photographs and vegetation data in permanent plots in selected weed occurrences that are being actively managed. It is also important to properly interpret results and to record actions taken by the Academy (location of type of treatments each year).

The Air Force Academy supports at least 31 different elements of conservation concern, including a Federally Listed Threatened species (Preble's meadow jumping mouse). We also recommend monitoring the elements of conservation concern which include rare plants, animals, and high quality plant communities (CNHP 2015), to ensure these areas do not become degraded by noxious weeds. In general, weed control efforts, albeit well meaning, can be detrimental to these natural resources, and should be approached with consideration for the long term viability of the communities and local processes that support these natural values. In areas that support rare species and/or high quality plant communities, a "natural area" approach is recommended for all weed management activities/efforts.

A list of actions that can be undertaken immediately to begin to implement this plan include:

1) Continue to monitor and map 20 target noxious weed species using established protocols (Lavender et al. 2015).
2) Continue successful Rapid Response Early Detection (RRED) efforts for Russian knapweed, Dalmatian toadflax, myrtle spurge and salt cedar.
3) Utilize and monitor biocontrol agents present at the Academy.
4) Utilize a "natural areas" approach for noxious weeds located in the mapped Special Weed Management Areas.
5) Conduct follow-up monitoring on treated areas and evaluate success.
6) Maintain records on treatments and treatment areas, and make them available to field workers and for data analysis.
7) Reduce herbicide use by using manual methods when appropriate.
8) Protect wetlands and groundwater by avoiding herbicide use in drainages, lakeshores, riparian areas and floodplains.
9) Monitor rare species and plant communities in proximity to noxious weed species.
10) Review the literature for current updates on successful weed treatments. Incorporate new scientific information and results from monitoring data into treatment strategies.
11) Provide a yearly workshop or annual meeting with the Academy staff, Colorado Natural Heritage Program and weed contractors to share observations and ideas.
12) Look for natural biological controls that may be present on Canada thistle and Russian olive.
13) Be aware of, and know how to identify List A species that have the potential spread to landscapes at the Academy.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Dr. Brian Mihlbachler, Natural Resource Manager and Fish and Wildlife Biologist with the U.S. Fish & Wildlife Service, who is stationed at the Academy and has been instrumental in guiding weed management activates at the Academy and Farish over the past 15 years. Renee Rondeau and Amy Greenwell provided important data on weed locations and monitoring results, and well as guidance regarding the conceptual approaches used in this strategy. Alan Carpenter and Steven Perce's work on the 2004 plan gave us a great start and framework for this updated strategy.

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1.0 INTRODUCTION

Weed management plans are intended to help weed managers make the best use of available time and funding by determining which invasive species, and which specific infestations of those species should be the primary focus of weed control and restoration efforts. Based on weed mapping and monitoring efforts that have been conducted at the Academy between 2001- 2015, it is clear that managing all noxious weeds found on the property is not possible. This is typical of almost all landscapes in developed areas along the Front Range of Colorado. An Integrated Noxious Weed Plan for the Academy was completed in 2004 (Carpenter and Perce 2004) to establish a plan to prioritize weed species for control; this report provides an update to that plan.

A number of critical biological resources including rare plants, animals and plant communities have been identified at the Academy and Farish over the years (CNHP 2012). Weed management plans for areas that harbor critical biological elements need to assess the potential harm from weeds and as well as potential harm from weed treatments. It is much more complicated to manage weeds in a natural system than it is to manage weeds in an agricultural setting. A complex system of wetlands and drainages also occur at the Academy which pose additional challenges for successful weed management. Weed management in natural areas concepts are incorporated into this management plan by not only identifying and prioritizing weed species for control but by also delineating areas with significant natural resources. Consideration of the impacts of removal of target weed species should be evaluated by weighing potential harm and/or gains for each site, particularly those with significant natural features.

1.1 Purpose and Need

The purpose of this integrated noxious weed management plan is to provide a guide to manage, in the most efficient and effective manner, the noxious weeds on the Air Force Academy and the Farish Recreation Area over the next 10 years (through 2025) in accordance with their respective integrated natural resources management plans. A periodically updated Integrated Noxious Weed Management Plan that includes a monitoring component for pre- and post-treatment efforts is the most effective tool for managing weed populations. Since the previous management plan was written, more information has become available from the ongoing studies at the Academy, as well as new scientific data. This new information has been used to update the existing management plan to target management needs for weed infestations that are a priority for control efforts at the Academy and Farish.

1.2 Management Area

The Academy is located in Colorado Springs, El Paso County, Colorado (Figure 1) and includes 18,445 acres of land. The Farish Recreation Area includes 655 acres of forest and grassland, as well as three man-made lakes. Extensive areas at the Academy include lands with dense vegetation. Therefore, it is important to note that locating all of the noxious weeds, despite frequent weed

mapping efforts, is likely not possible. New species and occurrences have been, and will continue to be found at the Academy. This is one of the primary reasons for revising weed management plans. The 2015 Weed Management plan pertains to the "natural" portions of the Air Force Academy and excludes highly developed areas, such as around buildings, recreation fields, and lawns. In addition, this plan covers the entire Farish Recreation Area site, including the limited developed areas.

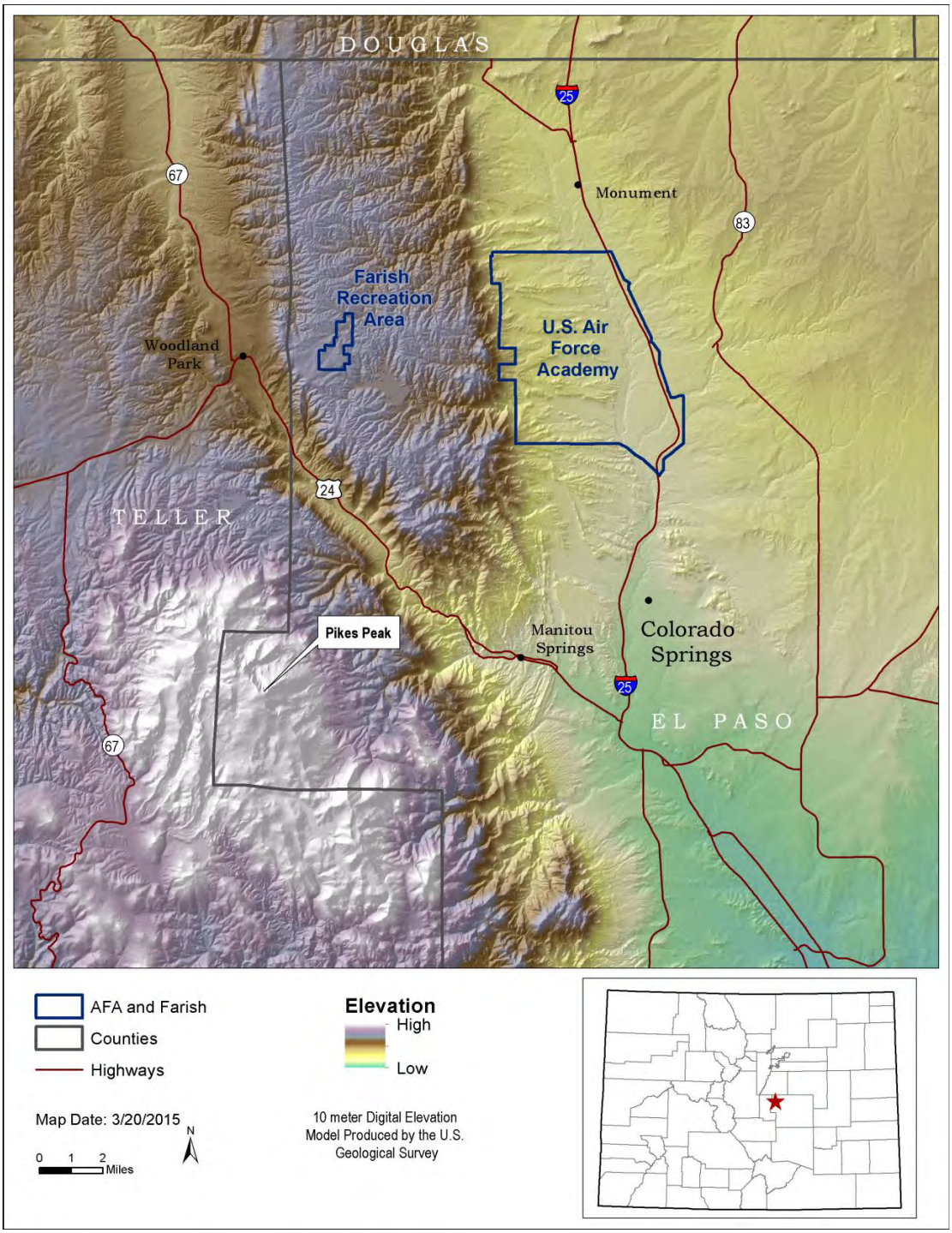

Figure 1. Location of the Air Force Academy and Farish Recreation Area in El Paso County, Colorado.

Climate

Climate is important in understanding many aspects of plant growth and is considered in weed population trends and in the interpretation of monitoring results.

The Academy is located in a semi-arid area. The local weather station received an average annual precipitation of 15.4 inches from 1979 – 1991 (ESCO Associates, Inc. 1992) and 16.4 inches from 1992 – 2003 (unpublished data from USAFA airfield). Wetlands and riparian areas are often much wetter than the average annual precipitation would indicate because they receive supplemental moisture from storm water and effluent discharges, surface flow and/or groundwater. However, precipitation in the greater Colorado Springs area has been below normal 11 of the past 15 years (Figure 2).

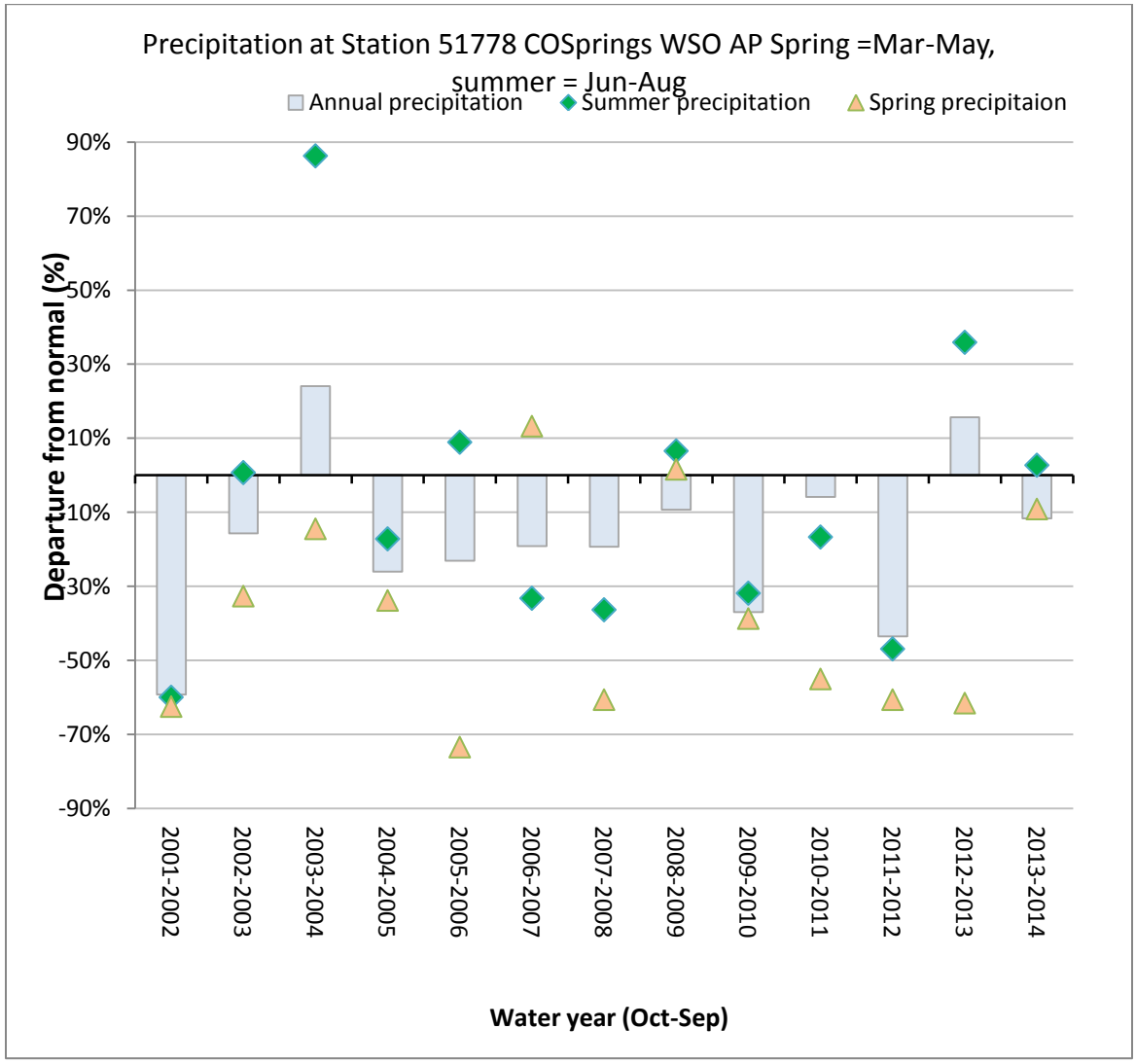

Figure 2. Summary data for annual precipitation by water year (October-September) at Colorado Springs, Colorado from 2002 through 2014 (Western Regional Climate Center 2014). **Average annual precipitation (1961-1990) is 16.3 inches. Spring = March-May, Summer = June-August**

Physiography and Geology

The primary physical feature of the Academy is a series of east-west trending ridges that are comprised of arkosic sandstones (Ripley 1994). The ridges create south- and north-facing slopes. Generally, the south-facing slopes are relatively hot and dry, while the north-facing slopes are cooler and moister. These north-facing slope environments are preferred by different species of noxious weeds. The elevation of the Academy ranges from 6,376 feet along Monument Creek to 7,899 feet at Stanley Canyon.

The Farish Recreation Area is located west of the Academy in the Rampart Range, which consists mostly of Pikes Peak granite. The elevation of Farish ranges from 9,048 feet along Beaver Creek to 9,315 feet south of Schubarth Road.

Soils

Soils at the Academy are primarily derived from granitic parent material. Soils on the sides of ridges are typically coarse and thin, especially in the natural portions of the Academy. Somewhat deeper and finer-textured soils occur at the bases of the ridges. Deeper, more productive soils are found in the floodplain of Monument Creek.

Surface water, wetlands, drainages and riparian areas

The major surface water feature of the Academy is Monument Creek. It rises on the eastern flanks of the Rampart Range about 6 miles northwest of the Academy and flows northeast to the Town of Palmer Lake, after which it flows south through the Academy on its way to Fountain Creek. There are significant wetlands and riparian areas along Monument Creek, as well as along the other tributary creeks. Wetlands and riparian areas typically occur in floodplains and drainages, which are nearly all classified as "natural" in the Comprehensive Plan for the Academy. Wetlands and riparian areas are considered high-value resource areas.

The area between Palmer Lake and the Academy is rapidly developing. Within the Academy, Goat Camp Creek, Deadmans Creek, Lehman Run, Douglas Creek, West Monument Creek, and Stanley Creek flow from west to east and join Monument Creek. Hay Creek joins Monument Creek immediately north of the Academy boundary. Jackson, Black Forest, Smith, Monument Branch, Middle Tributary, Black Squirrel, Elkhorn, Kettle, and Pine Creek flow from east to west and joins Monument Creek (Figure 3).

Farish contains three man-made lakes and the Academy has five man-made lakes that are heavily used for recreation, mainly fishing. The Farish Recreation Area contains a small fen, which is a type of wetland supported by ground water seepage, and where peat accumulates. The fen harbors the lowest-elevation and eastern-most occurrence in Colorado of a globally rare plant, the Porter feathergrass (*Ptilagrostis porteri*).

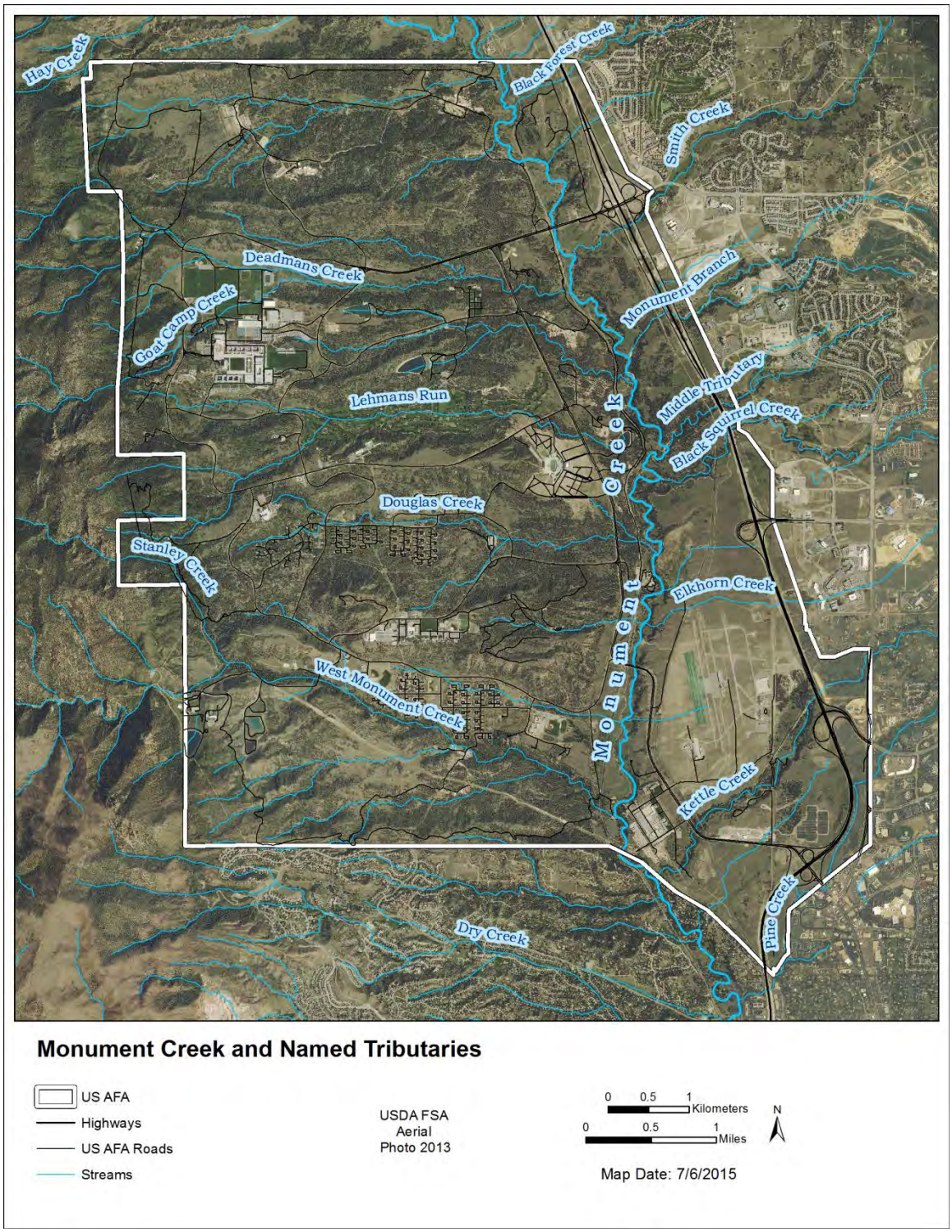

Figure 3: Monument Creek and Named Tributaries

Plant Communities

The variety of elevation, slope aspect, soils, and soil moisture creates different environments that harbor different plant communities. ESCO Associates Inc. (1992) mapped the plant communities of the Academy. The upland forest vegetation type includes white fir, Douglas-fir, ponderosa pine, Colorado blue spruce, and aspen communities. The upland shrubland vegetation type includes Gambel's oak, wax current, skunkbrush, snowberry, and mountain mahogany. The upland grassland vegetation type includes mountain muhly, Parry oatgrass, big and little bluestem, blue grama, western wheatgrass, prairie sandreed, and needle-and-thread communities.

Wildlife

The forest, woodland, shrubland, and grassland habitats at lower and higher elevations support a large diversity of animals including Mule deer, White-tailed deer, American elk, Coyote, and Black bear. The Academy hosts many migratory and non-migratory bird species. Bats, prairie dogs, mice, squirrels, rabbits and a variety of smaller mammals are present at the Academy and Farish.

Rare Plants, Animals, and Significant Plant Communities

The Colorado Natural Heritage Program (2015) has documented 31 species that are considered significant elements at the Academy (Table 1). One species of amphibian, one bird, four insects, two mammals, 10 plant communities and 14 species of rare plants have been documented at the Academy and Farish Recreation Area (CNHP 2015). There are a number of these elements that are globally vulnerable and imperiled species (G2, G3, T2, T3) and 10 elements that include populations considered to be excellent or very good quality (A or B ranked) occurrences based on population size, quality of surroundings and potential for longevity (Table 1, see Appendix 1 for an explanation of CNHP Element Occurrence Rankings). There are multiple occurrences of these plants, animals and plant communities scattered throughout the natural areas at the Academy and Farish. The Preble's meadow jumping mouse is the only species that is Listed Threatened under the Federal Endangered Species Act. Siemers et al. (2012) conducted a biological inventory that provides detailed locations, photographs and descriptive information for most of the significant elements at the Academy.

Table 1. Rare animals, significant plant communities, and rare plants documented at the Air Force Academy and Farish Recreation Area (CNHP 2015). Species are listed by major group, and then according to global and state ranks. (For rank and status definitions please see Appendix 1.)

Common Name	Scientific Name	Global Rank	State Rank	Federal Status	State Status
Amphibians					
Northern Leopard Frog	*Lithobates pipiens*	G5	S3	BLM/USFS	SC
Birds					
Ovenbird[B]	*Seiurus aurocapilla*	G5	S2B		
Insects					
Hops Feeding Azure	*Celastrina humulus*	G2G3	S2		
Cross-line Skipper	*Polites origenes*	G4G5	S3		
A Buckmoth	*Hemileuca grotei diana*	G4T3T4	S2		
Moss's Elfin[B]	*Callophrys mossii schryveri*	G4T4	S2S3		
Mammals					
Preble's Meadow Jumping Mouse Subspecies[A]	*Zapus hudsonius preblei*	G5T2	S1	LT	ST
Gunnison's Prairie Dog - Montane Population	*Cynomys gunnisoni* pop. 1	G5T2	S2	C, BLM	
Plant communities					
Montane Riparian Shrubland	*Alnus incana* / Mesic Graminoids Shrubland	G3	S2		
Great Plains Mixed Grass Prairies (Sandstone/Gravel Breaks)	*Schizachyrium scoparium - Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation	G3	S2		
Montane Grasslands[B]	*Danthonia parryi* Herbaceous Vegetation	G3	S3		
Mixed Mountain Shrublands[B]	*Quercus gambelii - Cercocarpus montanus / (Carex geyeri)* Shrubland	G3	S3		
Thinleaf Alder-Red-osier Dogwood Riparian Shrubland	*Alnus incana / Cornus sericea* Shrubland	G3G4	S3		
Narrowleaf Cottonwood Riparian Forests	*Populus angustifolia / Salix exigua* Woodland	G4	S4		
Snowberry Shrubland	*Symphoricarpos occidentalis* Shrubland	G4G5	S3		
Foothills Ponderosa Pine Scrub Woodlands	*Pinus ponderosa / Quercus gambelii* Woodland	G5	S4		
Coyote Willow/Mesic Graminoid[B]	*Salix exigua* / Mesic Graminoids Shrubland	G5	S5		
Mixed Mountain Shrublands[B]	*Cercocarpus montanus / Muhlenbergia montana* Shrubland	GU	S2		
Vascular plants					
a sedge[B]	*Carex oreocharis*	G3	S2		
Porter's feathergrass[B]	*Ptilagrostis porteri*	G2	S2	USFS	
Southern Rocky Mountain cinquefoil[B]	*Potentilla ambigens*	G3	S2		

Common Name	Scientific Name	Global Rank	State Rank	Federal Status	State Status
Rocky Mountain phacelia	*Phacelia denticulata*	G3	S3		
New Mexico cliff fern	*Woodsia neomexicana*	G4?	S2		
Frostweed	*Crocanthemum bicknellii*	G5	S1		
Richardson alum-root	*Heuchera richardsonii*	G5	S1		
Yellow stargrass	*Hypoxis hirsuta*	G5	S1		
New England aster	*Virgulus novae-angliae*	G5	S1		
Dwarf wild indigo	*Amorpha nana*	G5	S2		
American currant	*Ribes americanum*	G5	S2		
Prairie violet	*Viola pedatifida*	G5	S2		
Vernonia (Plains ironweed)	*Vernonia marginata*	G5?	S1		
Gay-feather	*Liatris ligulistylis*	G5?	S2		

[A] = At least one A ranked occurrence, [B] = at least one B ranked occurrence

Conservation Areas

There have been a number of studies to identify the significant natural areas of the Academy (ESCO Associates Inc. 1992, Ripley 1994, CNHP 1995, Ellingson et al. 1996) and most recently a biological inventory conducted by CNHP in 2012 (Siemers et al. 2012). About 40 counties in Colorado have been surveyed by the Colorado Natural Heritage Program for critical biological resources (CNHP 2015), and El Paso County was surveyed in 2001 (Doyle et al. 2001). Locations with Natural Heritage significance (where significant elements of biodiversity have been documented) are presented in survey results as Potential Conservation Areas (PCAs). The goal of delineating PCAs is to identify a land area that can provide the habitat and ecological needs upon which a particular element or suite of elements (rare plants, animals and plant communities) depends upon for their continued existence. PCAs are ranked according to their biodiversity significance or B ranks (Table 2).

Table 2. Biodiversity Ranks and Definitions

B1 Outstanding Significance (irreplaceable)
B2 Very High Significance
B3 High Significance
B4 Moderate Significance
B5 General or State-wide Biological Diversity Significance

The Colorado Natural Heritage Program (CNHP 2015) has identified five Potential Conservation Areas or PCA planning areas for the protection of the rare plant and animal species and high quality plant communities at the Academy and Farish (Table 3, Figures 4 & 5). Detailed profiles for each of these PCAs can be found in Appendix 2. Since the last weed management plan was updated and since the 2012 biological resources inventory (Siemers et al. 2012), new Element Occurrence Records (EORs) have been documented and a new PCA was described (Figure 4).

Table 3. List of Potential Conservation Areas at the Academy and Farish

PCA Name	Biodiversity Rank
Monument Creek	B2
Farish Recreation Area	B3
Air Force Academy Oak Foothills	B3
I-25 Shamrock*	B5
Pine Drive	B4

*PCA added since 2012 Inventory (Siemers 2012).

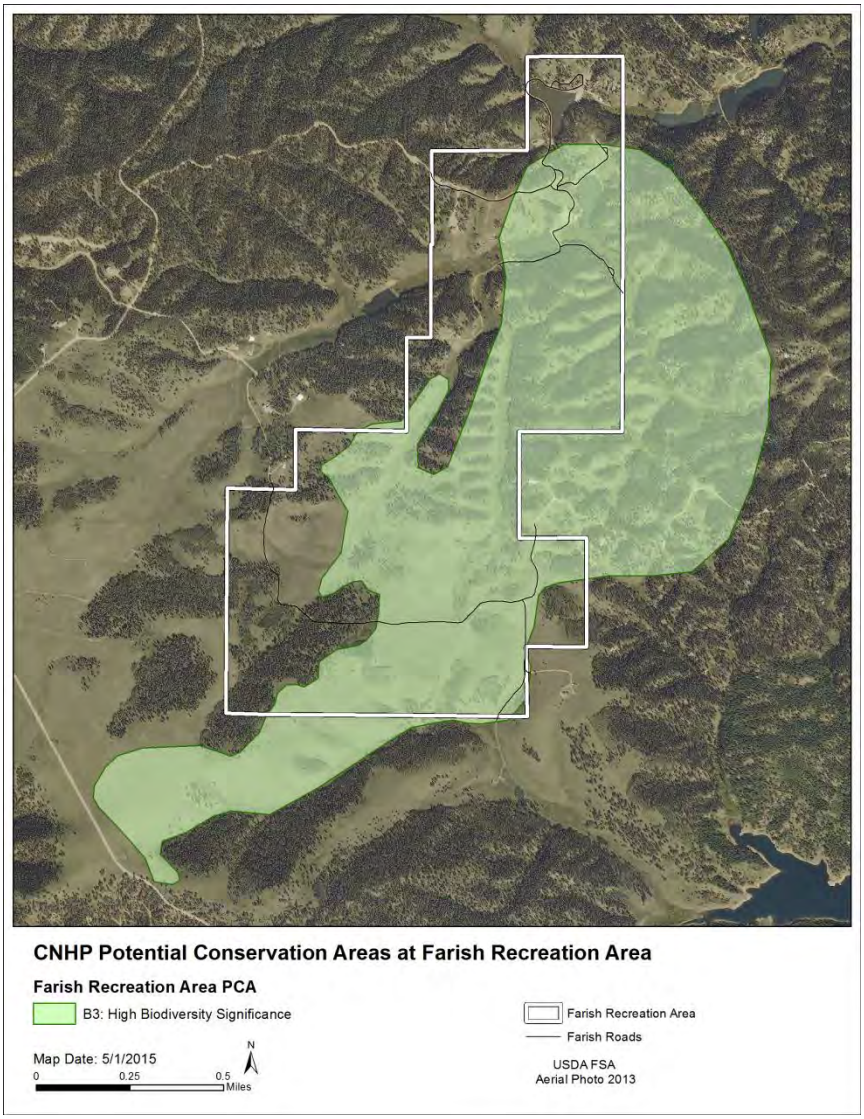

Figure 4. Potential Conservation Areas (PCAs) at Farish Recreation Area.

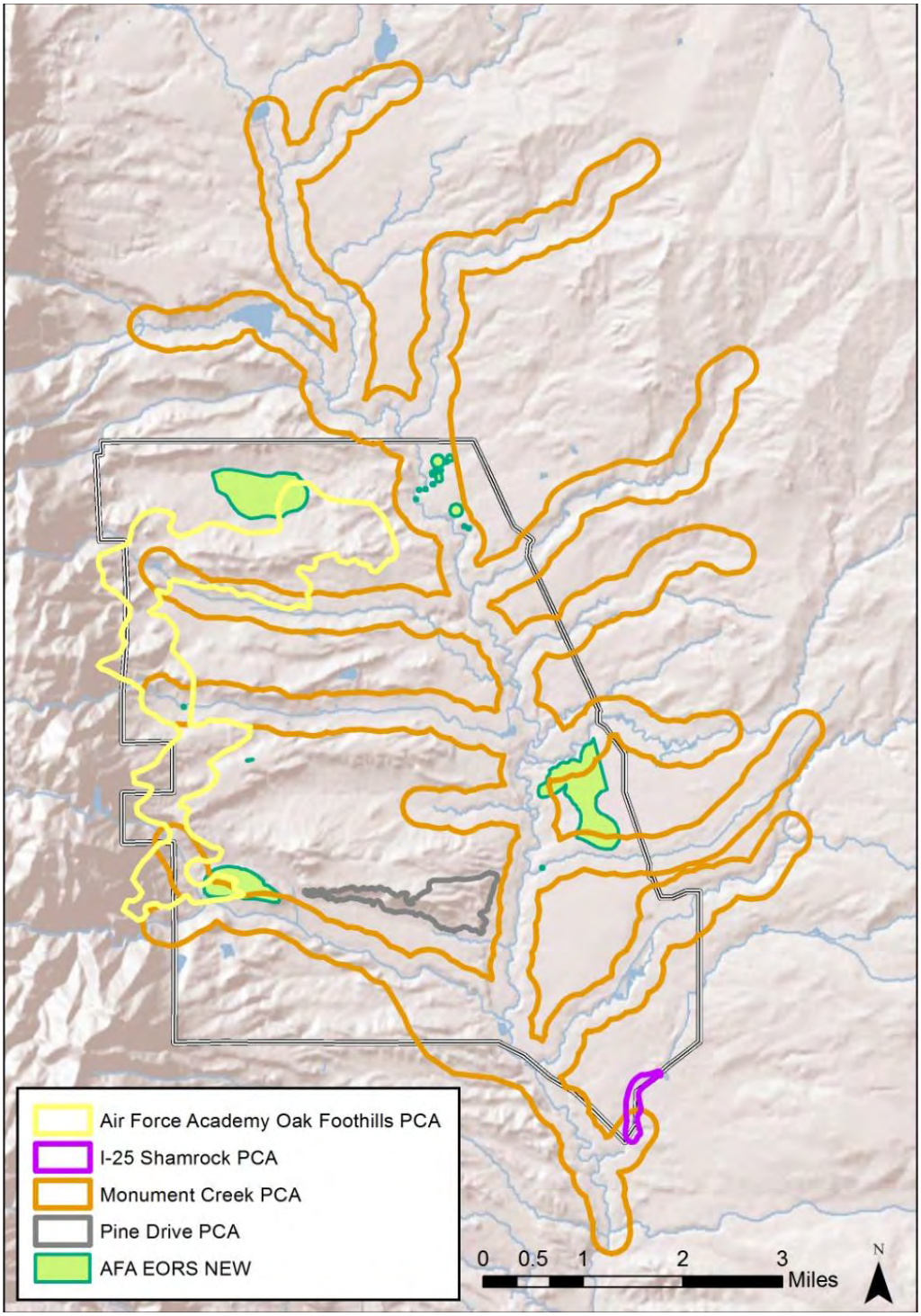

Figure 5. Location of Five Potential Conservation Areas (PCAs) and New Element Occurrences (EORs) at the Air Force Academy in 2015

1.3 Noxious Weed Legislation

There are a variety of federal, state, and local laws or regulations regarding noxious weed control that pertain to the US Air Force Academy in Colorado. These are listed below along with a brief description of the U.S. Air Force Academy and Farish Recreation Area Natural Resource Management Plans.

Sikes Act

The Sikes Act (16 USC 670a-670o, 74 Stat. 1052, Public Law 86-797 as amended) of 1960 provides for cooperation by the Departments of the Interior and Defense with appropriate State agencies "to promote effectual planning, development, maintenance, and coordination of wildlife, fish, and game conservation and rehabilitation in military reservations." The emphasis on conservation of natural resources on military reservations lays the framework for Department of Defense management of noxious weeds, in context with subsequent legislation.

Federal Noxious Weed Act

The Federal Noxious Weed Act of 1975 (Public Law 93-629 7 U.S.C. 2801 et seq.; 88 Stat. 2148) established a Federal program to control the spread of noxious weeds. Section 1453 of the 1990 Farm Bill (Public Law 101-624) added Section 15 to the Act establishing provisions for the management of undesirable plants on Federal lands. Undesirable plant species are defined as "plant species that are classified as undesirable, noxious, harmful, exotic, injurious, or poisonous pursuant to State or Federal law." Undesirable species cannot include federally listed threatened or endangered species or species indigenous to the area in question.

Where state or private programs for the control of noxious weeds exist, federal land-managing agencies are required to:

1. Designate an office or person adequately trained in managing undesirable plant species to develop and coordinate a program to control such plants on the agency's land;
2. Establish and adequately fund the undesirable plant management program through the agency's budget process.
3. Complete and implement cooperative agreements with the States regarding the management of undesirable plants on agency land. These agreements shall prioritize and target the undesirable plant species to be controlled or contained, describe the **integrated management** system to be used in control or containment, define the means of implementation, define the duties of the respective agencies, and establish a timeline for completion of the plan.
4. Establish **integrated management** systems to control or contain undesirable plants targeted under the cooperative agreements. Such integrated management systems shall use an interdisciplinary approach that includes participation by experienced federal or state agency personnel and consideration of the most efficient and effective method of containing or controlling the undesirable plant species, scientific evidence and current technology, the physiology and habitat of a plant species, and the economic, social, and ecological consequences of implementing the program.

Executive Order 13112

Executive Order 13112, signed in February 1999, directed Federal agencies to identify agency actions that may affect the status of invasive species, and, as applicable, to:

1. **prevent** introduction of invasive species;
2. detect and respond rapidly to and **control** populations of such species in a cost-effective and environmentally sound manner;
3. **monitor** invasive species populations accurately and reliably;
4. provide for **restoration** of native species and habitat conditions in ecosystems that have been invaded;
5. conduct **research** on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species; and
6. promote public **education** on invasive species and the means to address them.

Federal agencies are further forbidden to authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless the agency has determined and made public its determination that the **benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions**. The Executive Order also created an Invasive Species Council and an Invasive Species Advisory Committee to provide national leadership on invasive species issues and to develop a nation-wide Invasive Species Management Plan.

U.S. Air Force Regulatory Requirements

Air Force Instruction 32-7064 (Integrated Natural Resource Management) requires the control of noxious, exotic, and invasive species**.** Air Force agricultural outgrant programs must comply with the requirements of the Federal Noxious Weed Control Act. Outgrant programs will, to the extent practicable and within the limits of available funds, support state and federal programs for the control of noxious, exotic, and invasive plant species. Installations may enter into cooperative agreements with local area government entities that establish integrated pest management principles for the control of undesirable plant species. Expenditure of agricultural program funds to control noxious, exotic and invasive species will be consistent with the level of effort exhibited on similar federal, state or private agriculture and grazing lands in the vicinity of the installation.

Colorado Noxious Weed Act

In 1990, the Colorado General Assembly passed House Bill 90-1175, adding article 5.5 (Undesirable Plant Management) to Title 35 of the Colorado Revised Statutes. Originally known as the "Colorado Weed Management Act," this legislation defined the duty and authority of county and municipal governments to control noxious weeds, and required the adoption of management plans for undesirable plants for all such governing bodies. The Act authorizes local governing bodies of all counties and municipalities in Colorado to enter into cooperative agreements with federal and state agencies for the integrated management of noxious weeds within their respective territorial jurisdictions. In 1996 House Bill 96-1008 renamed and amended this Article as the "Colorado Noxious Weed Act," to establish and fund an office of state weed coordinator, and to institute the

designation by rule of state and local noxious weed lists. Rules pertaining to the administration and enforcement of the Act, including the list of designated noxious weeds are published under the Code of Colorado Regulations (8 CCR 1206-2). The Act was further amended in 2003, codifying the classification of designated weeds. The commissioner of the Colorado Department of Agriculture is directed to develop and implement by rule state noxious weed management plans, including management objectives for noxious weed species classified as list A or list B species.

The Colorado 2014 Weed List provides prioritized management goals for the listed weeds (List A, B, and C - Table 4), per rules promulgated by the Colorado Department of Agriculture and applicable as of December 30, 2014, pursuant to revisions of the Colorado Weed Management Act enacted in 2003.

The Colorado Noxious Weed Act (2003), specifies that certain noxious weeds must be eradicated (List A species), while others (List C species) will no longer be mandated for control by the State (Table 4). Management plans/rules prepared by the State for the List B species (which includes all of the worst noxious weeds mapped at the Academy and Farish, except for field bindweed), mandates whether eradication, suppression, or containment will be required depending on location.

Table 4. List A, B, C and Watch List Definitions (Colorado Noxious Weed Act, 35-5.5-104.5 to 35.5-118)

List A species are invasive weeds that are either not known to occur in Colorado or are of very limited distribution and are required to be eradicated (completely eliminated). **List B** species are invasive weeds with populations of varying distribution and densities within the state. The level of mandated control is based on local conditions. These weeds may require eradication within certain areas of the state. **List C** species are widespread and common within the state. They may pose a risk to agricultural lands and may be required to be controlled. **Watch List** species that are not known but that are expected to be found in Colorado and should be reported when found.

El Paso County Weed Management Program

El Paso County updated their Noxious Weed Management Plan in 2014:
http://car.elpasoco.com/clerktotheboard/Documents/14-097.pdf

The County has adopted an ordinance that regulates the management of undesirable plants on private and public lands within the County. The ordinance requires certain plant species that are listed as "undesirable" to be managed within the unincorporated portions of the County. The undesirable plants include leafy spurge, diffuse knapweed, Russian knapweed, spotted knapweed, Canada thistle, and purple loosestrife. In addition, musk thistle and yellow toadflax are designated as potentially undesirable. All of these species are known to occur on the Academy, except for purple loosestrife. The commissioners' call for 1) preventing noxious weeds from entering non-

infested sites, 2) developing and maintaining a noxious weed inventory and monitoring to assess progress, 3) educating the public and 4) researching weed management control strategies.

Website for County Noxious Weeds
http://adm.elpasoco.com/Environmental%20Division/Forestry%20and%20Noxious%20Weeds/Pages/default.aspx

1.4 Past and on-going weed management at the U.S. Air Force Academy

Noxious weed surveys and species-specific noxious weed monitoring has been conducted by the Colorado Natural Heritage Program at Colorado State University over the past 15 years (Rondeau and Lavender 2012, Rondeau et al. 2015). Noxious weed control actions employed at the Academy have included the broad use of biocontrol insects and herbicide applications, with localized hand-pulling and digging.

Biocontrol

Dr. Jerry Michels, formerly a researcher with the Texas Agricultural Experiment Station (Texas AgriLife) in Bushland, Texas, oversaw a research biocontrol project at several federal installations in Colorado, including the Academy (Michels at al. 2003 - 2014). This project began in 2000 at the Academy and continued through 2014. Biocontrol agents have shown some success in controlling diffuse and spotted knapweeds, and leafy spurge at the Academy. Biocontrol insects have been introduced to control St. Johnswort (which has been very successful elsewhere and at the Academy) and Canada thistle (which has not been particularly successful elsewhere). In addition, musk thistle is probably being controlled to some degree by a weevil that has been widely introduced in Colorado and is now essentially naturalized. Surveys performed in 2014 for biocontrol agents occurring outside their original release site indicated that most insects have naturally dispersed throughout the Academy to other dense populations of the target weeds.

Herbicides

Herbicides have been widely used at the Academy to control a variety of noxious weeds, especially leafy spurge, diffuse and spotted knapweeds, Russian knapweed, St. Johnswort, teasel, Scotch thistle, musk thistle, Canada thistle, bouncingbet, Russian olive, yellow spring bedstraw, and others. The Academy annually contracts for herbicide application for up to 450 acres of noxious weed infested rangeland and forest. Frequently used herbicide active ingredient includes aminopyralid, 2-4-D amine salt, imazapic, metsulfuron, and triclopyr.

Mechanical Removal

Hand pulling and cutting has been done for a variety of species at the Academy that have a very low cover. Dalmatian toadflax, myrtle spurge, salt cedar (tamarisk), houndstongue, bouncingbet and Scotch thistle plants have been treated with some success by pulling or cutting plants. This method has been an excellent early detection rapid response technique that has been used for years at the Academy to help control these species.

2.0 TARGET WEED SPECIES 2015

The 20 weed species targeted for this plan are based on the Colorado Department of Agriculture Noxious Weed List (Code of Colorado Regulations 2014), the 2004 U.S. Air Force Academy and Farish Recreation Area Integrated Noxious Weed Management Plan (Carpenter and Perce 2004), weed mapping conducted by CNHP (Rondeau and Lavender 2012) and communications with the Academy (pers. comm. Brian Mihlbachler 2014). The target list includes 17 species on the Colorado State Noxious Weed List (1 List A, 15 List B and 1 List C) and three species of garden escapes or planted ornamentals that are not on the State Weed List, but are actively managed, or being considered for active management at the Academy due to their potential to be invasive (Table 5). Some species are managed opportunistically, that is, they are treated as they are encountered by Academy staff. Cheatgrass and common mullein were targeted in the 2004 plan but are not a focus in the 2015 management plan due to the widespread nature of these species (Table 5). Field bindweed, chicory and common burdock are all state List C noxious weeds that were not included in the 2004 management plan. These species will again not be included in 2015 due to the widespread distribution and relatively low potential for impacts compared to other species (Table 5). Field bindweed was surveyed and biocontrol agents were introduced, however, the results did not appear to show successful treatment (Michaels et al. 2014).

Since the 2004 weed management plan (Carpenter and Perce 2004) was written, the Colorado State Noxious weed list was updated (CCR 2014) with the following new changes:

- **Hairy willowherb (*Epilobium hirsutum*)** was moved to List A from Watch List status and **garden yellow loosestrife (*Lysmachia vulgaris*)** was added to List A. Although neither of these species has been documented at the Academy, there is potential habitat especially along the creeks. We recommend the staff learn to identify, understand the plant biology and be prepared for effective early detection and rapid response actions for these species.
- Two List B species that also are not currently known from the Academy, spurred anoda (*Anoda cristata*), and Venice mallow (*Hibiscus trionum*), were removed from the State Noxious Weed List. No action is required on the part of the Academy for this change.
- **Quackgrass (*Elymus repens*)** is known from the Academy, and has moved from List B to List C. This also will not require any action on the part of the Academy, which was not currently targeting this species for management.

A change was made by CNHP to combine diffuse and spotted knapweeds (*Centaurea diffusa, C. maculosa*) and a hybrid of these two species for monitoring and mapping purposes. This was necessary because of rampant hybridization at the Academy (Rondeau and Lavender 2012). These knapweeds will also be considered as a single management group for this plan (note: this group does not include Russian knapweed (*Acroptilon repens*).

Table 5. List of Noxious Weeds documented at the Academy and Farish as of 2014 (Rondeau and Lavender-Greenwell 2014). The list also includes three additional weed species that are not on the State Weed List, but are actively managed or being considered for active management. Shaded and bolded species are the focus of this management plan.

Common Name	*Latin Name*	*2014 Colorado Weed List*	*Current Management*
Myrtle spurge	***Euphorbia myrsinites***	**A**	**Rapid response**
Bouncingbet	***Saponaria officinalis***	**B**	**Rapid response**
Bull thistle*	***Cirsium vulgare***	**B**	**Active management**
Canada thistle*	***Cirsium arvense***	**B**	**Active management**
Common teasel*	***Dipsacus fullonum***	**B**	**Opportunistic management**
Dalmatian toadflax	***Linaria dalmatica***	**B**	**Rapid response**
Dame's rocket	***Hesperis matronalis***	**B**	**Rapid response**
Hoary cress (Whitetop)*	***Cardaria draba***	**B**	**Active management**
Houndstongue	***Cynoglossum officinale***	**B**	**Rapid response**
Knapweeds (spotted, diffuse and hybrid)*	***Centaurea* spp.**	**B**	**Active management**
Leafy spurge*	***Euphorbia esula***	**B**	**Active management**
Musk thistle*	***Carduus nutans***	**B**	**Active management**
Russian knapweed*	***Acroptilon repens***	**B**	**Active management**
Russian olive*	***Elaeagnus angustifolia***	**B**	**Active management**
Scotch thistle*	***Onopordum acanthium***	**B**	**Active management**
Yellow toadflax*	***Linaria vulgaris***	**B**	**Opportunistic management**
Salt cedar (Tamarisk)	***Tamarix ramosissma***	**B**	**Rapid response**
Chicory	*Chichorium intybus*	C	Not managed
Common burdock	*Arctium minus*	C	Not managed
Common mullein*	*Verbascum thapsus*	C	Not managed
Common St. Johnswort*	***Hypericum perforatum***	**C**	**Active management**
Downy brome (cheatgrass)*	*Bromus tectorum*	C	Not managed
Field bindweed	*Convolvulus arvensis*	C	Not managed
Poison hemlock	*Conium maculatum*	C	Not managed
Quackgrass	*Elymus repens*	C	Not managed
Wild proso millet	*Panicum miliaceum*	C	Not managed
Siberian peashrub	***Caragana arborescens***	**NA**	**Considering for management**
Tatarian honeysuckle	***Lonicera tatarica***	**NA**	**Opportunistic management**
Yellow spring bedstraw	*Gallium verum*	NA	Rapid response

***Weed species included in the 2004 Weed Management Plan.**

2.1 Priorities for Weed Management

The Colorado Natural Heritage Program weed survey (Rondeau and Lavender 2012) mapped 8,308 occurrences of seventeen noxious weed species, and two additional weed species of concern. Controlling this number of weed occurrences is not practical and additional weed locations at the Academy and Farish are likely present that have not yet been detected. Thus, it is imperative to prioritize specific plant species and specific areas for control. Sources used to prioritize weeds and weed management areas include the 2004 Weed Management Plan (Carpenter and Perce 2004), weed mapping and weed monitoring information (Anderson et al. 2003, 2009, Anderson and Lavender 2006, 2007, 2008a, 2008b, Rondeau et al. 2010, 2011, 2015, Rondeau and Lavender, 2012, 2013, 2014), Heibert and Stubbendieck (1993), the Biodiversity Tracking and Conservation System (BIOTICS) database (CNHP 2015), and Invasive Species Impact Ranks (I ranks) of Morse et al. (2004). The Invasive Species Assessment Protocol (Morse et al. 2004, NatureServe 2015) has been used to provide up-to-date information about ecological impacts, distribution, trends, and management issues for noxious weeds throughout the U.S.

Priority Species

The primary factors considered for 20 weed species targeted in this plan (Table 5) were: 1) the extent of the infestation, and 2) the feasibility of successful control and 3) the location or proximity to conservation elements.

1. The extent of an infestation is reported in terms of the occupied acres that have been mapped at the Academy (Rondeau and Greenwell 2012), as well as communication with Brian Mihlbachler. Because acreage alone does not fully portray the problem posed by weed infestations, density of the plants in the infestations is considered when available.
2. The feasibility or likelihood of successful control, or how hard the noxious weeds are to control, is based on extent of the infestation, biology of the weed species, and specific observations and information provided by previous studies at the Academy and new research from weed managers and scientific literature.
3. The Academy and Farish have 31 elements of conservation concern, each with one to many occurrences across the properties. These have been mapped using CNHP methodology incorporating delineated Potential Conservation Areas. Using these data, Special Weed Management Areas have been created to assist with identifying areas where weeds and elements of concern overlap and require a specific management strategy.

Generally, the high-priority species targeted for management are those that are locally uncommon, have high impact, high rates of spread, and are not too difficult to control. There is convincing evidence that the most cost-effective approach to controlling noxious weeds is to focus management attention on small occurrences of locally uncommon weed species (Moody and Mack 1988, Smith at al. 1999).

Weed Management Objectives

For the purposes of this management plan we define the following terms based on the Colorado State Noxious Weed Act and in consultation with Brian Mihlbachler, Air Force Academy Natural Resource Manager.

A management objective is a specific, desired result of integrated management efforts and includes:

Eradication: Reduce the reproductive success of a noxious weed species or specified noxious weed population in largely uninfested regions to zero and permanently eliminating the species or population within a specified period of time. Once all specified weed populations are eliminated or prevented from reproducing, intensive efforts continue until the existing seed bank is exhausted.

Containment: Maintain a buffer zone that separates infested regions, where suppression activities prevail, from largely uninfested regions, where eradication activities prevail.

Suppression: Reduce the vigor of noxious weed populations within an infested region, by decreasing the propensity of noxious weed species to spread to surrounding lands, and mitigating the negative effects of noxious weed populations on infested lands. Suppression efforts may employ a wide variety of integrated management techniques.

Monitoring: This can be used as a single objective that does not include treatments. Observe and check the invasiveness of potentially problematic species, or monitor the progress or results from treatments over a period of time; e.g., review to evaluate results to determine if the vegetation or community desired in place of the weeds is moving toward the objective(s).

Weed management objectives for the Academy and Farish are presented in the Integrated Weed Management section below. Note that eradication is reserved for only the least abundant noxious weeds due to the difficulty of completely eliminating a well-established noxious weed species from an area the size of the Academy. It should be noted that evaluating the success of achieving the weed management objectives via the recommended management actions will require a monitoring program, as outlined in a subsequent section of this plan.

The high-priority weed species for management include species where eradication from the Academy is still possible and include: myrtle spurge, bouncingbet, Dalmatian toadflax, dame's rocket, Russian knapweed, and salt cedar (Table 6). St. Johnswort, Scotch thistle and houndstongue have previously been targeted for eradication at the Academy. However, due to the the extent of the current infestations at the Academy, suppression may be a more realistic goal. This is discussed in more detail in Section 4.0. Bull thistle, common teasel, and musk thistle have a cover of an acre or more at the Academy making it less likely that these plants can be eradicated and opportunistic management to suppress these plants is the goal. The woody invasive plant species at the Academy include Tatarian honeysuckle, Russian olive, salt cedar, and the Siberian peashrub. Tatarian honeysuckle has the smallest mapped acreage and does not appear to be aggressively spreading. Many of these honeysuckles have been in the same area for a number of years without producing obvious sprouts. Russian olive and the Siberian peashrub cover much larger areas up to 10-11 acres. They can form a dense canopy cover in some areas. Removal of these species must be considered carefully before any action is taken. A site specific management plan should be in place that includes the goal for what the area would be like after any proposed treatment activity. Focusing initially on new sprouts and avoiding damage to the surrounding vegetation should be a

priority and not complete removal of established shrubs and trees in a single effort. Salt cedar is known from only a few locations on the Academy, and all plants (mostly single individuals) are hand-dug or treated with herbicide as soon as they are identified.

2.2 Special Weed Management Areas (SWMAs)

The location of noxious weeds is also an important factor to consider for prioritizing weed species management at the Academy and Farish in addition to the priority status for each weed (Table 6). For example, a lower priority weed might have the potential to spread to a new area based on its location along a waterway, or a weed might be located in an area that might threaten a rare species. A noxious weed that might have a low priority for treatment across the property may have a high priority for control if it is located so that it has the potential to negatively impact an area with natural values.

The Biodiversity Tracking and Conservation System (BIOTICS) database (CNHP 2015) was used to search for locations of rare species and high quality plant communities found at the Academy. A Geographic Information System (GIS) analysis (Rondeau and Greenwell 2012) was conducted to determine which mapped locations of noxious weeds fell within 1/8 mile (about 200 meters) of the mapped locations of rare plants, animals and high quality plant communities. We consulted with several experts, and subjectively chose 1/8 mile as an appropriate distance for the analysis to get some idea about which weeds might threaten the occurrences (pers. comm. Rondeau, Greenwell, Anderson 2015). We recognize, however, that this distance may not be appropriate for all noxious weed species reported here. Some weeds may not threaten the natural resources from this distance, and others may pose a threat from much greater distances. Using this information, we developed a map of Special Weed Management Areas (SWMAs) at the Academy (Figure 6). All of the Farish Recreation Area is considered a SWMA for this plan**.**

Table 6. Factors that influence priorities for management for noxious weed species at the Air Force Academy and the Farish Recreation Area. **Species highlighted in Blue are targeted for Early Detection Rapid Response at the Academy.**

Weed Species Common Name	*Weed Management Objective*	*Priority for Treatment*	*Extent (Acres)*	*Feasibility of control*	*Estimated %Occurrences in Special Weed Management Areas*
Myrtle spurge	**Eradicate**	**High**	**~1**	**High**	**>30%**
Bouncingbet	**Eradicate**	**High**	**<1**	**High**	**30%**
Bull thistle	Suppress	Medium	1	Medium	>50%
Canada thistle	Suppress	Medium	91	Low	>80%
Common teasel	Suppress	Medium	9	Low	>50%
Dalmatian toadflax	**Eradicate**	**High**	**<1**	**High**	**>10%**
Dame's rocket	**Eradicate**	**High**	**<1**	**High**	**>30%**
Hoary cress (Whitetop)	Contain	Medium	14	Low	>80%
Houndstongue	**Eradicate/ Suppress**	**High**	**<1**	**High/ Medium**	**100%**
Knapweeds (spotted, diffuse and hybrid)*	Suppress	Low	106	Low	>50
Leafy spurge	Contain	Low	11	Low	>25%
Musk thistle	Suppress	Medium	15	Low	>50%
Russian knapweed	**Eradicate**	**High**	**<1**	**High**	**>50%**
Russian olive	Contain	Medium	11	Medium	>50%
Salt cedar (Tamarisk)	**Eradicate**	**High**	**<1**	**High**	**>50%**
Scotch thistle	**Contain**	**High**	**<1**	**Medium**	**>50%**
Yellow toadflax	Monitor/Suppress	Low	Widespread	Low	>50%
St. Johnswort	**Contain**	**Medium**	**1**	**Medium**	**100%**
Siberian peashrub	Monitor	Unknown	10	Unknown	>50%
Tatarian honeysuckle	Contain	Medium	<1	High/ Medium	100%

*Because of the large number of hybrids of diffuse and spotted knapweed they were combined for monitoring in 2012 into one group.

Figure 6. Special Weed Management Areas at the U.S. Air Force Academy. All of Farish Recreation Area is considered to be a Special Weed Management Area.

Special Weed Management Areas contain sensitive natural resources. Therefore, we recommend a "natural areas" approach for all weed management activities in these areas because they support occurrences of significant plants, animals and plant communities. In these areas, the protection of natural habitat conditions and processes will greatly facilitate the control of weeds. There are 6,189 mapped weed occurrences within the SWMAs of the 20 species targeted in this plan. (These sensitive areas are provided as electronic shape files in formats that will be accessible to the Air Force Academy and contractors treating weeds.)

For some weed species, all of the occurrences will have the same priority, e.g., all salt cedar locations will be high priorities for control. This reflects its relative rarity at the Academy, its high adverse impact on native plant communities, its rapid rate of spread, and the great potential of control. However, only some occurrences of Canada thistle and spotted and diffuse knapweeds will be high priorities for control, i.e., those occurrences that fall within Special Weed Management Areas. This reflects the fact that Canada thistle and diffuse knapweeds are among the most abundant noxious weed species at the Academy.

All the SWMAs are high-value resource areas, meaning that they merit more careful noxious weed management attention than they otherwise would. We recommend that site specific monitoring occur and management/restoration plans be developed for these areas before treatment occurs that will create soil disturbances that include patches of bare soil. Weed control methods should be pursued only in cases where the control method will not cause an infestation to increase or the treatment could have more adverse impacts than either no action or monitoring. The staff and contractors at the Academy should be aware and educated about the rare plants and plant communities. In addition, the impacts of proposed weed treatments on animals of concern, including the Federally Listed Threatened Preble's meadow jumping mouse need to be considered in management activities (e.g., herbicide impacts on potential food sources – Weedar 64 used at the Academy is toxic to aquatic macroinvertibrates (Weedar 64 per label information).

2.3 Weed Management in Natural Areas

Natural areas are defined as non-crop areas that contain native vegetation where the management includes the protection of these areas to generate ecosystem services (Pearson and Ortega 2009). Successfully managing weeds in natural areas that contain a great variety of species is much more complex than in an agricultural area. Weed management in natural areas must consider the management of the entire community and not just removal of individual weeds to be successful. A large extent of the landscape at the Academy would fall into the "natural areas" category which also includes important wetland features and lands that support native plants, animals, plant communities and a population of the Federally Listed, Threatened Preble's meadow jumping mouse and SWMAs. The areas that support these elements will benefit from special management approaches in weed treatment strategies.

Many of the guidelines for controlling noxious weeds include herbicide label instructions which are often based on agricultural landscapes and not natural areas. There is an important distinction between these two land uses, especially for ecological resource management.

3.0 Integrated Weed Management

The purpose of this section of the plan is to identify specific, integrated weed management actions that are thought to be effective for each of the 20 targeted weed species. The concept is to apply multiple management actions that ideally interact to provide maximum control for each noxious weed species. (For an extensive compilation of potential weed control methods see DiTomaso et al. 2013). It is impractical to control all noxious weed species on the Air Force Academy and the Farish Recreation Area. Thus, it is critical to use limited resources wisely so control efforts are focused where they do the most good. Traditional management for weeds has been to simply remove the target weed. New research indicates that removal of the target weed often results in a secondary invasion by other non-native exotic species as well as the simplification (reduced biodiversity) of the site. This occurs because of the complexity of weed invasions and our lack of understanding of how and why these invasions are occurring (FEIS 2015, Pearson and Ortega 2009).

3.1 Preventative

Prevention is the most cost-effective way to manage noxious weeds, i.e., keeps them from becoming established. The method described in the 2004 management plan (Carpenter and Perce 2004) included working with the appropriate officials at the Academy to develop a policy that requires that all heavy equipment (e.g., logging trucks, bulldozers) that enter the Academy and operate in the natural areas must be cleaned prior to being used and before they are moved to different natural areas around the base.

Periodic weed surveys are conducted at the Academy that target new weed infestations. Targeting common places for weed entry are part of these surveys and they include looking at developed lands adjacent to the Academy, railroads, roads, trails and areas that experience periodic flooding and other disturbances that remove plants or soil from natural areas. The staff at the Academy has successfully prevented noxious weed entry by utilizing an Early Detection Rapid Response method for a number of weeds including yellow spring bedstraw, Russian knapweed, myrtle spurge, salt cedar and Dalmatian toadflax.

3.2 Cultural

Protecting the soil surface from degradation is a cornerstone of natural resource management**.** Soil that is covered with vigorous, desirable plant species will resist erosion, maintain its productive capacity, and will resist noxious weed colonization. Current Academy policy requires the use of Best Management Practices and compliance with the Erosion Control, Revegetation, and Tree Care Standards to minimize soil disturbance and to control erosion to the extent practicable during construction and major maintenance projects.

We strongly recommend revegetating all disturbed areas promptly with appropriate native plant species in the Special Weed Management Area portions of the Academy and Farish that are caused by construction, logging, and fire suppression. The Academy already requires that only certified weed-free straw and hay (in accordance with State requirements) be used for erosion control. After the revegetation is complete, follow-up is important to confirm that seeding was successful, and if not, to rectify the situation and to look for noxious weeds that may have become established.

Certain noxious weed and invasive plant species are used in the horticultural trade. These include Russian olive, dame's rocket, oxeye daisy, and purple loosestrife. It is clearly counterproductive for these species to be deliberately introduced to the Academy. We recommend working with the appropriate officials at the Academy to develop and adopt a policy that prohibits noxious weed and invasive plant species from being planted. We also recommend that an appropriate Academy natural resources staff review all landscaping, reclamation, and revegetation plans to check for noxious weed species (e.g., Russian olive, purple loosestrife) or other invasive plant species (e.g., honeysuckle) that may have be included in planting lists.

3.3 Mechanical

Hand Pulling

This technique is appropriate for shallow-rooted weed species that are present in small amounts or for newly established deep-rooted perennial species. Bolted stems of the biennial weeds, including bull, musk, Scotch thistle and common teasel, can be pulled if the soil is fairly course and/or moist. For rhizomatous and deep-rooted weed species such as Canada thistle, hoary cress, leafy spurge, Russian knapweed, St. Johnswort, and yellow toadflax, pulling is usually only effective for new

growth in satellite populations that spring up around established populations where it is still possible to remove the entire root.

Mowing and Cutting

Mowing is not appropriate for many natural areas at the Academy and Farish. It is important to remember that mowers can spread weed seeds. Therefore, a mower should be washed prior to moving it from one location to another if it is used to mow weeds when seeds are present.

Cutting is appropriate for small infestations of biennial weeds, including bull, musk, and Scotch thistle and common teasel that reproduce solely from seeds. Scotch thistle can be killed by severing the root below the soil surface. If seed production can be eliminated, a weed occurrence will decline over time. The seed stalks must be cut prior to seed dispersal, with the cut stalks being disposed of in a dumpster. Leaving the cut stalks in the field is not appropriate as the seeds of many weed species will ripen on cut stalks and continue to perpetuate the infestation.

Prescribed Burning

Prescribed burning is used in situations where the target weed species is more susceptible to the effects of fire than associated desirable plant species. However, most of the noxious weeds at the Academy are either stimulated (directly or indirectly) or are unaffected by fire. Burning can be used to reduce biomass, particularly dead material, to facilitate the effectiveness of follow-up herbicide application. Burning can also invigorate plant communities that have evolved with fire, such as ponderosa pine and prairie communities, thereby reducing their susceptibility to noxious weed colonization. A prescribed burn plan must be prepared to satisfy Federal, State, and local regulations. In addition, a qualified burn boss must supervise any prescribed burn, with a crew of qualified and credentialed individuals. We do not anticipate that prescribed burning will be used at the Academy for the sole purpose of controlling noxious weeds.

3.4 Biological Control

Biological control agents include insects, other arthropods (such as mites), and pathogens that attack noxious weeds, and ideally, do not damage non-target plant species. Biological control will not eradicate a noxious weed occurrence, but it can be effective at suppressing a weed occurrence and bringing it into a balance with other species. Biological control agents are most appropriate in situations where a weed species is firmly established and hard to control. At the Academy, yellow toadflax, field bindweed, diffuse and spotted knapweeds, Canada thistle and St. Johnswort are candidates for biological control due to their great abundance and impracticality of control using conventional methods. A list of the biocontrol agents that have been released or documented at the Academy between 2000 and 2014 are included in Table 7.

Biological controls that are potentially available naturally are being recognized in Colorado. For example, there is a rust fungus that can be detrimental to Canada thistle that is now becoming quite widespread and is also available for introduction. A bark disease has been found in nature that affects Russian olives.

Table 7. List of Biocontrol Agents that have been released or documented at the U.S. Air Force Academy 2000-2014 (Michels et al. 2001, 2011, 2014). Red font =Also impacts native species.

Latin Name	Target Plant(s)	Name	Introduced 2000-2013	Biocontrol Present in 2014
Field bindweed				
Aceria malherbae	Field bindweed	Bindweed gall mite	√	---
Canada thistle				
Cassida rubiginosa	Canada, musk thistles	Thistle-feeding shield beetle	√	√
Ceutorhynchus litura	Canada thistle	Stem-mining weevil		√
Larinus planus	Canada thistle	Bud weevil	√	√
Urophora cardui	Canada thistle	Thistle stem gall fly	√	√
Leafy Spurge				
Aphthona nigriscutis	Leafy spurge	Black dot leafy spurge flea beetle	√	√
Apthona lacertosa	Leafy spurge	Brown-legged leafy spurge flea beetle		√
Apthona czwalinae	Leafy spurge	Black leafy spurge flea beetle	√	√
Oberea erythrocephala	Leafy spurge	Leafy spurge stem-boring beetle	√	√
Spurgia esulae	Leafy spurge	Gall midge	√	---
Common mullein				
Gymnetron tetrum	Common mullein	Seed feeding weevil	√	---
Musk thistle				
Cassida rubiginosa	Canada, musk thistles	Thistle-feeding shield beetle	√	√
Rhinocyllus conicus	Musk thistle	Thistle-head weevil	√	√
Trichosirocalus horridus	Musk thistle	Rosette weevil	√	√
Diffuse and Spotted knapweeds				
Cyphocleonus achates	Knapweeds	Root knapweed weevil	√	---
Larinus minutus	Knapweeds	Lesser knapweed flower weevil	√	√
Metzneria paucipunctella	Knapweeds	Spotted knapweed seed head moth		
Urophora affinis	Knapweeds	Seed head fly	√	√
Urophora quadrifasciata	Knapweeds	Seed head fly	√	√
St. Johnswort				
Chrysolina quadrigemma *C. hyperici*	St. Johnswort	Klamath weed beetles	√	---
Toadflax				
Mecinus janthinus	Yellow toadflax	Stem boring weevil	√	√
Brachypterolus pulicarius	Yellow toadflax	Toadflax flower-feeding beetle		√
Calophasia lunula	Yellow toadflax	Toadflax moth	√	---
Gymnetron antirrhini	Yellow toadflax	Toadflax capsule weevil	√	√

3.5 Chemical

In areas with highly valued species and communities, it must be clear that the risks of using an herbicide are outweighed by the potential benefits of controlling the weed. This is not always a straight forward determination. For example, based on years of herbicide use data, there is a significant risk that once a targeted pest is eliminated another often replaces it. This occurs because the infestation is a symptom of a more fundamental problem (Randal et al. 2001, FEIS 2015). The "first do no harm" approach needs to be considered in light of the fact that herbicides, like other control methods, are themselves a type of disturbance. Many of the replacement species tend to be rhizomatous non-native grasses (Kentucky bluegrass and smooth brome) that often present a less desirable end result from an ecological perspective (Pearson & Ortega 2009, FEIS 2015). Long-term use of herbicides at some areas at the Academy have shown that not only do the rhizomatous grasses replace dicot herbs but result in a decrease of native shrubs (Rondeau and Lavender 2012,) because the chemicals used for herbaceous plants often also harm woody species. Therefore when chemical herbicides are used in natural areas a "precise spot application" is the recommended method. Backpack sprayers or tongs with sponges are used to contact the intended plant (Randal 2001). Inappropriate use of herbicides is also a common problem, overspray, calibration errors, mixtures, application times, clogged values, operator error, mis-identification and inappropriate weather conditions can all contribute to an undesirable and potentially more harmful result. Herbicide resistance is also a serious problem for frequently sprayed sites where areas or individual plants are partially treated.

The Department of Defense (DoD) has adopted a policy to reduce the use of herbicides at DoD installations. The target is to reduce pesticide use (including herbicides) to below 50% of the level of active ingredient used by the base in 1993. At that time, there was very little herbicide used at the Academy, so any significant increase in the use of herbicides will negatively affect the base's ability to meet this target. With herbicides, the label is the law. Any person who applies herbicide for a fee in Colorado must be certified by the State Department of Agriculture. Furthermore, Air Force Instruction 32-1053 (Pest Management Program) requires all herbicide applicators at Department of Defense installations to be certified as specified in *DoD Plan for Certification of Pesticide Applicators*.

Typically the goal for weed management should be to use less chemical control. It is well-known that herbicides can have non-target effects on plants, but in natural areas it is very important to consider they may also have strong indirect effects on other trophic levels, particularly pollinators. Native bee populations have suffered extreme declines in recent years, and though the cause of these declines remains unclear, exposure to chemicals and habitat alteration are two likely drivers. Because many plant species require an animal pollinator for reproduction, reductions in the abundance of pollinators could greatly disrupt the viability of plant populations. This is because herbicides are increasingly used in natural areas to suppress invasive plants despite the fact that the consequences of herbicide use in the communities in which they are applied are largely unknown (Palladini 2013, Aktar 2015).

The widespread use of chemicals applied to landscapes and lawns to kill weeds and insects has resulted in the contamination of the majority of urban waters in the U.S. (Gan et al. 2003a, Gilliom 2007, USGS 1998). Chemicals may have secondary unintended effects and in addition, large amounts of applied chemicals (>99%) do not even reach the intended targets and are released into the environment (Silver and Riley 2001, Gan et al. 2003b). Herbicide use can have many hidden costs because the resulting contamination poses risks to soil microorganisms, insects, plants, fish, birds and humans (Gilliom 2007). Contrary to common misconceptions, herbicides are even more problematic because of the large volumes in which they are now being applied (Silver and Riley 2001). Improper use of herbicides can compound potential harmful effects; for example, spraying at the wrong time or life stage (Photo 1), herbicide resistance (Photo 2), groundwater contamination (Photo 3) and removal of a native species due to mis-identification (Photo 4).

Photo 1. Example of inappropriate application time spraying bolted Scotch thistle plants with seed heads. Also, overspray killing adjacent plants showing over application and excessive disturbance and wasted resources. Rosettes are most appropriate target for herbicide application (CSU Extension 2015, Carpenter and Perce 2004). Photo: P. Smith 2014.

Photo 2. An example of partial treatments that leave partially treated plants of Scotch thistle which can create herbicide resistance. Photo: P. Smith 2014.

Photo 3. Ground water contamination can occur when restricted use herbicides are used in areas that may appear to be upland but can be inundated during a rain event. St. Johnswort is an example of a plant that is found in both wet and dry habitats at the Academy. Photo: P. Smith 2014.

Photo 4. Mis-identification leads to double disturbance in this wetland that contains rare plants by not only impacting native species but increasing the chance for weed infestations from the disturbance to the soils caused by the herbicide and the application process. The dead plants (herbicide treatment) in this wetland are all native species. The target appears to be Lanceleaf figwort (*Scrophularia lanceolata*) which is a native species. Other native grasses and rushes appear to be overspray impacts.

Accurate Plant Identification

For successful management, it is important that the applicators of herbicides are familiar with, and can recognize wetland habitats, rare plants and a variety of noxious weed species, many of which need to be recognized when they are in early growth stages. Spraying native species can magnify negative impacts from weeds by causing disturbances that encourage more weed growth.

Timing

Understanding the life cycle of the targeted weed is essential to successful treatment (CSU Extension 2013). For many of the plants that are targeted, it is imperative to reduce seed production. Many of these species are biennials that form a rosette, bolt and produce a flowering head that goes to seed and then dies. Treating bolted stems with developed seed heads may be inappropriate because the plant is already dying and the seeds can still be viable. Treatment for biennial plant species (bull thistle, dame's rocket, houndstongue, musk thistle, Scotch thistle and common teasel) is only recommended for the rosette stage or the early bolting stage.

Timing is important so that biocontrol agents that have been introduced at the Academy are not harmed. This adds another complication to herbicide treatments (Michels et al. 2014).

The weather at the time of application or within a window of treatment can also impact the efficacy of the herbicide. Too much wind or lack of wind, and air temperatures at the time of the applications can all impact a treatment. Precipitation at the time or soon after treatment can reduce efficacy and move herbicide to drainages. For example herbicide drift to non-target species occurs in wet and windy conditions and some herbicides like 2.4 D evaporate quickly in hot temperatures.

Drought or other stress conditions in plants can also make chemical treatments less effective because stressed plants don't translocate the active ingredients (Tu et al. 2001).

Persistence

Herbicides have different degrees of persistence in soils and this must be considered in treatment plans so that over application does not occur. Research on deep-rooted perennial weed species are demonstrating that chemicals appear to eradicate weeds but are really only temporarily controlling them and will require another form of treatment to actually control the plants (Tu et al. 2001, FEIS 2015).

Toxicity to non-target plants and animals

Today, herbicides constitute a major addition to natural communities. Most impacts to ecological communities (especially aquatic communities) are gleaned from testing on single species under laboratory conditions. Although this is an economical way to identify impacts of pesticides on organisms, it does not reflect direct and indirect pesticide effects on organisms in their natural ecological contexts. New research is suggesting that some herbicides thought to have no toxicity to animals are actually toxic when the studies are conducted under ecologically relevant conditions (mesocosms). For example, Roundup© (glyphosate) which is designed to kill plants, was found to cause unexpected direct toxicity to amphibians. Herbicide and pesticide applications on landscapes are thought to be one of the factors contributing to the decline of amphibians across the country. It is very hard to know how all of these chemicals react in complex natural systems (Relyea 2005).

Sprayer Calibration

Sprayer calibration is one of the most important aspects of chemical treatment (pers. comm. Beck March 2015). If the dose is too low or too high the consequences will reduce chances of successful control. Clogged sprayers and inappropriate mixes can cause additional problems. Some mixes need to be repeatedly mixed or the ingredients settle. Adjuvants also make the proper application of herbicides more complicated (Tu et al. 2001).

Pesticide Resistance

Pesticide resistance is a problem that comes with repeated use of herbicides and partial treatments of individual infestations. It is almost impossible not to miss individuals, especially in natural areas and this is one of the drawbacks to chemical applications that need to be considered.

Biocontrol agents

Herbicides can have lethal or negative side effects to the biocontrol organisms that have been introduced to control noxious weeds (Michels et al. 2014).

Adjuvants

Adjuvants are additives to herbicides that may be in the form of soaps or oils. These additives allow herbicides to stick to plants and are often recommended. However, it is important for managers of natural areas to understand that the side effects and potential impacts of these substances are typically much less well understood than the main herbicide ingredients. Sometimes adjuvants are already included in herbicide formulations and sometimes they are added separately by the applicator. The U.S. Environmental Protection Agency (EPA) does not test and regulate manufacture and use of adjuvents as is done for herbicides. In addition, there is little information on the effects of adjuvants (Tu et al. 2001). There is a potential to do harm, often cheap or low quality products or unnecessary use and even the order in which the adjuvant is added to an applicators tank can impact the outcome. Therefore it is important to take into consideration how an adjuvant and herbicide will affect populations of native plants and other organisms in treatment areas. Will the adjuvant increase damage to desirable plants to unacceptable levels?

Safety for Field Personnel/Exposure

Exposure to applicators and staff or contractors who work in treatment areas needs to be addressed when chemicals are selected for use. Applicators typically have the proper knowledge and access to protective gear. However, other workers or visitors to areas at the Academy need to be aware when areas are treated with herbicides to avoid contact for themselves and pets. Many chemicals take hours or days before they are safe to contact.

Recommendations for Record Keeping and Evaluation

Record keeping includes: procedures used and dates applied; weather conditions; growth stage; condition of weeds; and condition of desirable plants. This information is essential to evaluate success or failure. Evaluate and monitor sites after applications. Assessments one to three years after control applications are most accurate and are especially critical for perennial weeds (Beck, 2013).

4.0 Species Specific Weed Management Recommendations

Based on monitoring and management information from the previous studies conducted at the Academy, conversations with Academy staff and Colorado Natural Heritage Program scientists, recommendations from El Paso County (2014), the 2004 Weed Management Report (Carpenter and Perce 2004), CPW 2013, CSU Extension, Texas A&M biocontrol and information from the USFS Fire Effects Information System (FEIS 2015), we have included a list of species specific weed management recommendations. Table 8 provides information for each species on the level of infestation (an estimate based on conversations with CNHP and Academy staff), the life form of the

plant and general recommendations for control. More details are provided in the paragraphs that follow regarding recommended treatments for the Academy and Farish SWMAs.

The size of the Academy and the widespread coverage of some weed species may preclude effective management. There is a point where it becomes impractical to impossible to control or eradicate a species. Many weed species are located in wetlands or near sensitive elements (plants, animals or plant communities of conservation value) at the Academy. The recommendations provided below apply to these areas and not to roadsides or heavily developed areas.

Detailed Species Specific Recommendations

Integrated management includes preventative, mechanical, chemical and biocontrol methods. Preventative measures that call for the protection of existing healthy systems is always the first choice where feasible. For the species below, the biology, degree of infestation and location at the Academy (in wetlands or near elements of concern) is addressed for mechanical, chemical and biocontrol management tools. The practicality of some of the treatments must also be considered for large infestations and for those which there is no practical form of treatment available, especially the deep-rooted perennials: leafy spurge, diffuse and spotted knapweeds, St. Johnswort and yellow toadflax which are particularly problematic for all land managers. This section is to be used as a guide for the resource manager who will ultimately decide the best course of action. A summary is provided in Table 8 (p.41)

LIST A

Myrtle spurge (*Euphorbia myrsinites*)
This tap-rooted perennial plant has been treated somewhat effectively at the Academy though early detection rapid response actions by Academy staff.

Mechanical removal works well for this species especially before plants set seed and roots develop extensively (CPW 2013). However, at the Academy resprouts are common after mechanical removal, as seeds sprout throughout the season and can be hard to detect and require multiple visits to a site in a single growing season. Seed longevity is about 8 years. The sap of this plant irritates skin and eyes, so persons digging the plants need to exercise caution.

There are approved chemicals that can be used to treat myrtle spurge (2014 El Paso County). However, following CSU Extension guidelines, it should be noted that chemical applications are considered appropriate for range and pasture lands and not for areas with natural resources (CSU FACT SHEET https://www.colorado.gov/pacific/agconservation/myrtle-spurge .)

No biological controls are currently approved by El Paso County (2014).

LIST B

Bouncingbet (*Saponaria officinalis*)
This perennial forb grows in moist well-drained soils and prefers full sun. Seed longevity is not known. Bouncingbet is a showy species that escapes from gardens and spreads rapidly in the wild. It is difficult to control once established and is often found growing in dense patches.

Mechanical treatments are only recommended for new single plants and not established populations because bouncingbet reproduces clonally from the root system.

Herbicide application of Telar©(Chlorsulfuron) applied at the bolting to bud stage in late spring – mid-summer is recommended for range and pasture lands (CSU 2013 see Appendix 3). Identification of pre-flowering plants is important for successful treatment. At the Academy, many of the bouncingbet plants survive under oaks or other heavy shrub growth and are difficult to reach with chemical treatments. Currently, it appears that the coverage at the Academy is low. Some of the populations are located in or near wetlands at the Academy. The treatment goal is to deplete nutrient reserves in the roots, and prevent seed production.

Biocontrol is not available at this time for bouncingbet (El Paso County 2014).

Bull thistle (*Cirsium vulgare*)

Bull thistle is a biennial forb that does not tolerate shade and does not thrive in areas with tall grasses and forbs. It is typically a transitory species that does not tend to persist unless the area is continually disturbed. http://invasives.wsu.edu/biological/urophorastylata.htm

Mechanical control is effective to eliminate small populations or for plants in late growth stage. Bolted stems can be cut before seed dispersal in summer. Seed longevity is short, with 95% sprouting in the first year. Seeds can live up to 3 years (FEIS 2015, King County 2015).

Chemical treatments are most effective on the rosette stage in spring or fall (CWMA http://www.cwma.org/BullThistle.html).
Biocontrol agents include the bull thistle seed head gall fly (*Urophora stylata)*, which has been shown to reduce seed production by 60% in Washington State. It is probably not appropriate for use at the Academy due to the scattered nature of bull thistle and the fact this fly can also impact native thistle species (*Cirsium* spp.). (http://invasives.wsu.edu/biological/urophorastylata.htm)

Canada thistle (*Cirsium arvense*)

Canada thistle is a deep-rooted perennial that is often in wetlands and is widespread at the Academy. Spread is by rhizomes and seed production. Seeds are viable for up to 22 years (CSU 2013 b). Effective treatment is difficult to achieve especially in natural areas. All types of treatments have the potential to stimulate growth because anything that removes above ground portions can cause more root growth. Depleting the underground reserves is the goal utilizing multiple treatments.

Mechanical treatments are not recommended for dense populations and can stimulate growth of underground portions of the plant. Cutting stems followed by spot herbicide treatments can work for small infestations. It should be noted that the growth of these plants can be stimulated by many types of treatments to the above ground portions of the plant.

Herbicides can be applied to re-sprouts in the pre-flower bud stage (avoid chemicals that are not approved for wetland applications and timing that might impede biocontrol organisms). It should be noted that most of the reports and studies of herbicide use for the reduction of Canada thistle apply to agricultural areas and are not directly applicable for use in natural areas. This is because of the potential harm to non-target plant and animal species, including soil organisms, aquatic species, humans, and other vertebrates and the potential to contaminate water resources and set back the

succession of natural communities. In addition, herbicides require repeated applications to achieve moderate control and their continual use may lead to herbicide resistance, soil sterilization and erosion (FEIS 2015; Colorado State University Extension - Appendix 3). Identification and treatments of pre-flowering plants are important for successful treatments. All treatments may need to be repeated and should be combined with other treatment methods (see CSU 2013).

Biocontrol agents potentially may offer a long term management tool for Canada thistle but nothing is considered particularly effective at this time. A number of biocontrol agents have been introduced to the Academy over the last two decades (see Table 7) and are an important resource. Ongoing monitoring for these organisms shows the agents are dispersed and somewhat effective (Michals 2014). Many of the Canada thistle infestations at the Academy are too small for effective biocontrol. However, maintaining populations of the biocontrol agents may prove beneficial for populations in the future (Michals 2014). Another potential natural control (a pathogenic rust – *Puccinia punctiformis*) has been identified that has been controlling Canada thistle in other parts of Colorado. Monitoring for the rust can help resource managers determine if it is impacting Canada thistle. The rust is available for distribution in the State of Colorado (El Paso 2014).

Common teasel (*Dipsacus fullonum*)
Common teasel is a large biennial forb that reproduces only by seed. Seeds are viable for at least 5 years (CABI 2015). Seed reduction is the most important aspect of treatment for this species.

Mechanical control is effective and includes digging rosettes or cutting bolted stems before seed dispersal in summer (Carpenter and Perce 2004).

Chemical herbicides can be used but this plant is typically found in wetlands and applications need to be made on pre-flowering stage, so proper identification and precise spot spraying are important to minimize ground water contamination and for successful control and only wetland approved herbicides are recommended. CSU Extension (Appendix 3) recommends chemical control only for weeds in range and pasturelands and not for natural areas.

Biocontrol is not available at this time for bouncingbet (El Paso County 2014).

Dalmatian toadflax (*Linaria dalmatica*)
Dalmatian toadflax is a perennial forb that reproduces by seed and creeping root rhizomes. Growth of this plant can be stimulated by removing the above ground parts and it is thought that much of the major reproduction of this plant is from root growth as opposed to seeds. At the Academy eradication is still possible because the infestation is currently small. Early detection and rapid response efforts utilizing both mechanical and chemical controls is being utilized at the Academy. Once established this plant is difficult to control.

Biological controls are available but the density of plants at the Academy is currently low. However, some of the biological control agents for Dalmatian toadflax have been observed on yellow toadflax (*Linaria vulgaris*; Michals 2014 -Table 7). Yellow toadflax is widespread at the Academy.

Dame's Rocket (*Hesperis matronalis*)
Dame's rocket is a biennial to short-lived perennial forb that reproduces only by seed. Seed longevity is unknown but is thought to be many years. These plants are located in wet areas and drainages at the Academy.

Mechanical removal has been shown to be effective when the soil is moist and all roots can be removed. The populations at the Academy currently have low coverage and are patchy in distribution. Removal of just the seed heads is also acceptable since the plants reproduce solely by seed.

Chemical applications are occurring at the Academy. Non-target application of herbicides has been observed. CSU Extension recommends chemical control for range and pasture lands but not natural areas (Appendix 3).

Biocontrol is not available at this time for dame's rocket (El Paso County 2014, CSU 2013).

Hoary cress (Whitetop) (*Cardaria draba*)
Hoary cress is a perennial forb reproducing by seeds and creeping rhizomes. Frequent monitoring and evaluation is important for this species as many management techniques can stimulate growth. Seeds remain viable for three years. This plant is difficult if not impossible to control once it has become established (USFS 2014). Few treatments have been effective for sites like the ones present at the Academy. It is thought that targeting satellite populations that are newly established might be more effective and the dense populations should be monitored.

"Hand digging or grubbing may be feasible for small, isolated populations or for plants located in sensitive areas such as riparian corridors. Ideally, the entire root system should be dug out before seed forms. Debris should be disposed of by burning piled plants or by bagging and then depositing the bags in a landfill" (USFS 2014).

For chemical applications the USFS (2014) recommends a variety of potential treatments (see Appendix 3). A backpack or hand-held sprayer or wick method are recommended for natural areas.

Biocontrol is not available at this time for whitetop (El Paso County 2014, CSU 2013, USFS 2014).

Houndstongue (*Cynoglossum officinale*)
Houndstongue is a biennial to short-lived perennial that spreads by seeds only. Seed longevity is 3 years (Colorado Code of Regulations, 2014). Because the seed viability time is short compared to many other weed species, preventing seed production from year to year is crucial.

Manual digging of rosettes to remove is effective for small infestations. Pulling plants in damp soil or cutting bolted seed stalks before seed set are both accepted control methods. The root crown must be removed to effectively control the plants (El Paso County 2014, CSU Extension Appendix 3).

Herbicide application is recommended only in the spring to rosette stages using precise spot applications (CSU Extension 2013). Since most of these plants are found in wetland drainage areas, certain recommended herbicides cannot be used (Appendix 3).

Knapweeds (*Centaurea maculosa, C. diffusa* and hybrids)
Spotted and diffuse knapweeds are hybridizing at the Academy. These species are treated as a group because so many of the populations contain hybrids (Rondeau et al. 2012). The diffuse and spotted knapweeds are short-lived perennials to biennials and even occasionally annuals that spread only by seed. Seeds are viable for 8-10 years (Code of Colorado Regulations 2014). Long-term studies have shown treatments for spotted knapweed (*Centaurea maculosa*) have actually encouraged future knapweed invasions as they mimic the same suppression effects the weeds have

on native forbs (Pearson and Ortega 2009). This is supported by Beck (2013) who states chemical treatments have been found to suppress knapweeds which often return. Due to the widespread nature of this species and the lack of any reliable treatments, the recommendations are only for small areas.

Digging has been shown to be effective if the taproot is severed below ground while the plants are in the rosette stage (El Paso County 2014).

Herbicides can be applied using a backpack sprayer or a wick application for small areas to minimize damage to non-target plants. Herbicides should either be applied before the mature plants set seed, or to rosettes in the fall, to maximize effectiveness (See Appendix 3 Diffuse Knapweed for BMPs and recommendations).

Biocontrol agents include the lesser knapweed flower weevil (*Larinus minutus*) and gall flies (*Urophora* sp.) which have shown success in Colorado (Cranshaw 2009). Biocontrol agents that are effective against knapweed are present at the Academy (Table 7).

Leafy spurge (*Euphorbia esula*)
Leafy spurge is a long-lived perennial with deep roots that spreads both by underground roots and by seed. Studies on seed longevity suggest the seeds sprout mostly within two years but have been found to be viable up to 5 years (FEIS 2015). Seeds are spread when mature capsules expel them up to 15 feet from the plant. This species is found scattered in many areas at the Academy. Gambel oak is often in the overstory and the plants are extremely difficult to find and treat in this habitat. Once established this species is difficult to control and can recover from any control effort because of strong root reserves (Beck 2013).

Mechanical and chemical removal of aboveground parts can weaken the deep roots; however, established populations are almost impossible to treat (FEIS 2015). Treating newly established plants is recommended, while making sure control efforts do not impede biological control of the weed species. Partial treatment with chemicals can cause resistance in the future. Treatment should be focused on newly established populations with younger plants. Repetitive treatments are required to weaken the extensive root system. See Appendix 3 for details on herbicide use.

Flea beetles in the genus *Aphthona* have been the most successful biocontrol agents released against leafy spurge in North America (https://dnr.state.il.us/stewardship/cd/biocontrol/14leafyspurge.html). Monitoring of established populations for biocontrol impacts can provide important management information for the Academy. These beetles are present at the Academy and may be an important control agent.

Musk thistle (*Carduus nutans*)
Musk thistle is a biennial forb that reproduces solely by seed. Removal of the seed source is the best management objective. Seeds remain viable for 10 years. (Code of Colorado Regulations 2014).

Severing the root crown while plants are in the rosette stage or cutting bolted stems and removing seed heads has been shown to be effective (Carpenter and Perce 2004, El Paso County 2014). Musk thistle is easily removed by severing the root below ground with a shovel (Beck 2013).

Herbicides must be applied early in the spring or fall and are recommended for the rosette stage only (Beck 2013). Care must be taken so the rosettes are not confused with the native thistle species present at the Academy.

The biocontrol agent for this species is present at the Academy (Table 7).

Russian knapweed (*Acroptilon repens*)
Russian knapweed is a deep-rooted creeping perennial that reproduces largely from root buds and from seed. Seed longevity is 5 years (Code of Colorado Regulations 2014). Russian knapweed is another one of the species that is extremely difficult to control once it becomes established. However, this has not yet happened at the Academy where early detection and rapid response activities of Academy personnel have kept the population very low. Re-visiting sites where the plants have been treated either mechanically and or chemically should be a high priority to prevent establishment. Encouraging native grasses to grow in areas where Russian knapweed has been treated is a recommended cultural control (Beck 2013).

Newly established plants can be removed mechanically.

Russian knapweed is found to be very susceptible to fall-applied herbicides (Beck 2013).

Biological control is not yet available for Russian knapweed.

Russian olive (*Elaeagnus angustifolia*)
Russian olive is a fast-growing, small tree that reproduces by roots and seeds. Academy staff have been treating the trees with success.

Saplings can be mechanically removed or cut with brush cutters and are sensitive to mechanical treatment (https://www.colorado.gov/pacific/agconservation/russian-olive).

The recommended method for tree removal is to cut the stumps or girdle the basal bark and apply herbicide. The herbicides that are recommended by Colorado Department of Agriculture are only for range and pasture lands (see Appendix 3 Russian Olive).The trees will sprout if herbicide is not used on cut stumps. Cutting is most effective in the fall; remove foliage with viable seeds (Carpenter and Perce 2004).

Biological control occurs naturally in some populations from *Tubercularia* canker and can be lethal to the trees. Monitoring for the presence of the canker can assist in future management decisions.

Scotch thistle (*Onopordum acanthium*)
Scotch thistle is a very large (up to 12 feet) biennial forb that reproduces solely by seed. The most crucial key to controlling Scotch thistle is seed reduction (Carpenter and Perce 2004, CSU 2013, El Paso County 2014). The goal is not to let Scotch thistle flowers appear (Appendix 3 – Scotch thistle).

Severing the root section below the soil surface is sufficient to kill the plant (El Paso County 2014). Any plants that have bolted need to be disposed of so that the seeds to not enter the system as they can still mature on cut plants.

Recommended chemical applications are for rosettes in the spring or fall or early bolted stems. The recommended herbicides are only for range and pasturelands (Appendix 3 – Scotch thistle). People

who conduct treatments must recognize and correctly identify the rosettes. The populations at the Academy are increasing and they are approaching the level where mechanical control is more difficult. The reason current treatments may be ineffective is because bolted plants are being treated leaving seed heads intact and the rosettes are left untreated (Photo 1, Section 3.5). In addition, overspray causes excessive disturbance surrounding the treated plants that can provide habitat for missed rosettes and newly sprouting seeds.

Yellow toadflax (*Linaria vulgaris*)
This plant is difficult to control by most methods once the deep root system is established. Unlike Dalmatian toadflax where seeds are an important reproductive mechanism for the plant in addition to vegetative root growth, yellow toadflax seeds have a low viability so spread is largely vegetative (USDA 2014). Yellow toadflax is thought to be harder to control than Dalmatian toadflax (Appendix 3 – toadflaxes). The most vulnerable stage is the seedling stage. Smaller infestations in healthy sites are recommended for control. This species is widespread at the Academy. It is often found dispersed within plant communities making it difficult to control without impacting surrounding species. This species is managed opportunistically at the Academy. Each treatment site needs to be evaluated for density, current land use, accessibility, flora or fauna present, cost and years to achieve control. Yellow toadflax treatment sites have been reported to require 10+ years of treatments (Appendix 3 – Field Guide for Managing Toadflaxes in Southwest Colorado).

Biocontrol may eventually be the best method for control because this plant is so widespread at the Academy. However, biocontrol insects currently appear to be ineffective at the Academy and data are not available to document effects at other locations in the State (Appendix 3 – toadflaxes).

Salt cedar (*Tamarix ramosissima*)
Salt cedar was known from five separate sites between 2002 and 2014. Continued rapid response efforts at the Academy have eliminated the individuals as they were found. The seed longevity is short, less than a year. The Academy has used a combination of mechanical and herbicide treatments.

The herbicides triclopyr and imazapyr can be very effective when used to treat cut stumps. The stumps need to be cut as close to the ground as possible and the herbicides need to be applied immediately after cutting to the perimeter of the cut stem. Healing occurs quickly and can impede translocation of the chemicals (Appendix 3 Tamarisk). Herbicide treatments can 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 (CPW 2013).

Biocontrol agents are available but populations of salt cedar at the Academy are not large enough to pursue this treatment method at this time.

LIST C

St. Johnswort (*Hypericum perforatum*)
St. Johnswort is a perennial forb with deep root systems and produces seeds that are viable for 20 or more years. Control of this species is extremely difficult in established populations. Because of this, the most effective method is considered to be the prevention of the establishment of new populations. Also, due to the nature of the plant, many treatments may actually stimulate growth if not done consistently and without a plan for re-establishing native species and reducing disturbance from treatments. “Single stresses, even if severe, are usually insufficient as St.

Johnswort root reserves respond with increased rates of sprouting from damaged roots and root crowns" (FEIS 2015). At the Academy, several large occurrences have been destroyed by recent flooding events which were observed during a weed survey in 2015 (pers. comm. P. Smith).

Repeated pulling, digging and application of herbicides can be used to contain St. Johnswort (Appendix 3 – St. Johnswort). Hand pulling can be effective for small populations that have not yet established deep root systems. Because the plants can re-sprout if fragments are left behind, plants might need to be pulled consistently for a number of years. Chemical treatments can be used to control small infestations. The timing of the applications is exceedingly important to be effective (see Appendix 3 St. Johnswort). Some of the effective chemicals are not recommended (Picloram) for the populations at the Academy because of the locations of these plants in frequently flooded sandy soils, wetlands and in drainages.

St. Johnswort seedlings are highly susceptible to competition and the presence of competitive plant species is thought to be very important in the reduction of periodic peaks in the populations. Therefore, treatments that don't harm non-target wetland species are preferred.

The biocontrol agents for this species are present at the Academy (Table 7). Biological control agents have been successful in the past and might be important in the future at the Academy, if and when St. Johnswort infestations approach densities that support the agents.

INVASIVE PLANTED SPECIES NOT ON STATE WEED LIST

Siberian peashrub (*Caragana arborescens*)

Siberian peashrub is a small fast-growing small tree that can reach 19 feet. Siberian peashrub is widely planted and escapes from cultivation and was intentionally planted at the Academy (pers. comm. Brian Mihlbachler 2014). Sprouting occurs when trees are cut or burned. The trees can also reproduce by seed, which ripen in mid-summer. These trees have an extensive root system and fix nitrogen. This species prefers full sun but can tolerate some shade and easily adapts to low quality sites. The Siberian peashrub has been found to be invasive in woodland edge environments, riparian areas and disturbed grasslands (USDA, NRCS 2015, and WDNR 2015). At the Academy, it has been found to be invading riparian areas (pers. comm. Brian Mihlbachler 2015).

At the Academy, site-specific treatment plans can be beneficial for Siberian peashrub management, as removal of areas of dense growth have the potential to create habitat for more invasive species without follow-up restoration. If treatments are undertaken for this species, small patches will be treated initially and will likely involve cutting trees and applying herbicides that are safe for riparian areas.

Tatarian honeysuckle (*Lonicera tatarica*)

Tatarian honeysuckle is a large shrub or small tree that is commonly planted and often escapes to natural areas. There are many cultivars that are sold for landscaping. It is often found near wetlands and in riparian habitats at the Academy. One of the known locations includes a state rare plant species (American currant) imbedded in the population of Tatarian honeysuckle. It is not required to be treated by the State of Colorado, although it is recognized as an invasive species across the United States.

Control for small to medium sized shrubs can include digging or pulling.

Chemical control includes cut stump or basal bark treatments (see Appendix 3). (http://dnr.wi.gov/topic/Invasives/fact/TatarianHoneysuckle.html)

Table 8. Approximate level of infestation, life form, and recommendations for treatment of 20 target weed species at the Academy and Farish that are located within Special Weed Management Areas (SWMAs). Level of infestation follows El Paso County (2014): Low=scattered, less than 10 meters in diameter with few plants; Light=small patches less than one acre; Moderate=1-10 acres; High=dense infestation greater than 10 acres. **Highly recommended actions are bolded.** Shade indicates plants found in wetlands or riparian areas.

Weed Common Name	*Level of Infestation*	*Plant Life Form*	*Biological Control*	*Manual Control*	*Chemical (precise spot application)*
Myrtle spurge	*Low-Light*	Perennial forb	NA*	Hand pull with follow-up monitoring**	Not recommended in SWMAs*** although it has been used in areas at the Academy.
Bouncingbet	*Low*	Perennial forb	NA*	Hand pulling only for new plants where roots can also be extracted.	Chlorsulfuron only at bolting stage, late spring –mid summer.*
Bull thistle	Light	Biennial forb	*Urophora stylata (fly)**	Sever root below below soil surface*	Rosette stage only in spring or fall. *
Canada thistle	*Light*	Deep-rooted Perennial forb	Monitor for biocontrol agents including naturally occurring rust.	Must return to the same area multiple times over the season – can potentially stimulate growth.	Precise rosette and re-sprout applications for SWMAs. If not done well can potentially stimulate growth.
Common (Fuller's) teasel	*Low*	Biennial or monocarpic perennial	NA*	Dig rosettes or remove seed heads before they mature.	Apply in rosette or bolting stage.*
Dalmatian toadflax	*Low*	Perennial forb	Available but small populations at Academy	Hand pulling for new infestations*	Precise spot applications are preferred in SWMAs.
Dame's rocket	Low	Biennial, short-lived perennial forb	NA*	Pull when moist, remove all roots.*	Rosette, bolting or late flower depending on chemical.*
Hoary cress (Whitetop)	*Light*	Perennial forb	NA*	Repeated removal of above ground plant parts weakens roots.* Hand pulling for plants where underground parts can be removed (USDA 2014).	Target satellite populations and monitor other established populations. Chemical control options in Appendix 3 (USDA 2014).
Houndstongue	Low	Biennial, short-lived perennial forb	NA*	Remove root crown in rosette stage.	Apply in rosette stage in spring only*

Weed Common Name	*Level of Infestation*	*Plant Life Form*	*Biological Control*	*Manual Control*	*Chemical (precise spot application)*
Knapweeds (spotted, diffuse and hybrid)	Light	Short-lived perennial forb that reproduces only by seed.	Available, populations of control insects have been observed.	Hand pull moist soil, especially while in rosette stage, removal of above ground parts stresses roots.*	Note: herbicides mimic damage done by knapweed in natural systems and encourages secondary invasions of knapweed or other noxious species (Pearson & Ortega 2009).
Leafy spurge	*Light*	Long-lived perennial	Available, populations of control insects have been observed.	Newly established plants can be pulled.	Newly established plants can be treated. Must avoid partial treatment of plants and high priority to protect intact surrounding landscape. Only treat in spring or fall, timing is critical.*
Musk thistle	*Light*	Biennial	Available but also damages native thistles	Sever below rood crown*	Only in spring and only for rosette to early bolting stages. Fall treatments for rosettes only.*
Russian knapweed	*Low*	Perennial forb with very deep roots	NA *	Remove above ground parts. *	Small populations, timing is complex.
Russian olive	Light	Small tree	Monitor for Tubercularia canker – could be naturally present *	Cutting stumps, or girdling basal bark.	Apply to cambial layer of tree immediately after stump is cut or basal bark girdled (Triclopyr or Imazapyr*)
Scotch thistle	*Light*	Very large biennial forb	*Urophora stylata* (fly)*	Severing section below root crown, removal of bolted stems before seed set.*	Only in spring and only rosette stages.
Yellow toadflax	*Moderate*	Perennial forb with extensive root system.	Available, but not demonstrated to be effective at the Academy	Hand pulling for newly established plants.	Plant is difficult to control once the deep root system is established. All treatments should target new plants fall application*

Weed Common Name	*Level of Infestation*	*Plant Life Form*	*Biological Control*	*Manual Control*	*Chemical (precise spot application)*
Salt cedar (Tamarisk)	*Low*	Small shrub or tree	*Diorhabda elongata* (Leaf beetle) - available not warranted at this time.	Cutting or digging plants and monitor for re-sprouts.	Herbicide can be applied to freshly cut stumps Triclopyr or Glyphosate*. Imazapyr timing to avoid not for heavy sap flow)*
Common St. Johnswort	*Low-Light*	Perennial forb	Organisms are present and have controlled areas with large populations in the past.	Cut seed stalks.	All sites within SWMA, many in wetland areas. Avoid non-target plant damage as this will encourage more weed growth.
Siberian peashrub	*Low-Light*	Small shrub or tree	NA	Resprouts after cut. Does not tolerate shade.	
Tatarian honeysuckle	*Low*	Small shrub or tree	NA	Small saplings can be pulled.	Cut stumps should be treated immediately and monitored for resprouts.

*El Paso County 2014 ** CPW 2013***CSU 2013

The most effective method for managing all weed species is preventing establishment and spread. Containment of local populations, minimizing soil disturbances, detecting and eliminating new growth and seed dispersal and establishing and encouraging desirable competitive plants are key. Integrated management requires more than just the removal of above ground parts. Monitoring, evaluation and persistence are important. The establishment of desirable species while maintaining weed-free systems over the long-term are essential to control all of the species listed above.

5.0 Follow-up Monitoring and Evaluation

It is important to develop a practical monitoring program to evaluate the effectiveness of weed management actions. The term "monitoring" is used in different ways by different people. As used in this plan, monitoring refers to the structured and repeated collection and analysis of information that enables an evaluation of the progress toward a management objective. Thus, the purpose of monitoring is to provide feedback, without which, managers cannot learn and improve their control of noxious weeds.

Recommended monitoring actions for all 20 target noxious weed species are listed in Table 9. They are designed to be simple yet practical measures that will provide sufficient information to evaluate effectiveness of weed management actions in relation to the respective weed management objectives and activities that have been ongoing at the Academy. We recommend conducting monitoring annually for at least the first three years after plants have been removed from a site (this timeframe may be longer based on seed longevity). Seed longevity is a means to determine a timeframe to help establish when a targeted species has been potentially eliminated from a site.

We also recommend the Academy continue the basewide weed surveys and GIS mapping that has been taking place every five years as part of the ongoing monitoring program. This, along with observations of Academy staff, is an excellent means of identifying new weed species and populations for early detection and rapid response (EDRR) actions.

Table 9. Recommended monitoring of targeted noxious weed species at the Air Force Academy or Farish Recreation Area.

Noxious Weed Species	*Monitoring Action(s) and Seed Longevity*
LIST A	
Myrtle spurge	Continue to monitor known locations, count plants annually and map new locations as they are found. Make observations on any treatments. Seed viability is 8 years.
LIST B	
Bouncingbet	Continue to monitor known locations, count plants and map new locations as they are found. Make observations on any treatments. Seed viability is unknown.
Bull thistle	Follow-up monitoring after opportunistic management activities to make sure plants have been removed. Seed longevity is 1-3 years.

Noxious Weed Species	*Monitoring Action(s) and Seed Longevity*
Canada thistle	Continue to monitor 10 permanent plots in randomly selected occurrences; look for the presence of biocontrol agents and for the rust organism that has the potential to provide control for this species. Seed viability is 22 years (CSU 2013b).
Common teasel	Continue to monitor known locations, count plants and map new locations as they are found. Make observations on any treatments. Seed viability is 5 years.
Dalmatian toadflax	Continue RRED, and to monitor and map locations where plants have been removed. Collect data on any observed treatments. Seed viability is 10 years (USDA 2014).
Dame's Rocket	Continue to monitor known locations, count plants and map new locations as they are found. Make observations on any treatments. Seed viability is thought to be many years.
Houndstongue	Continue to monitor known locations, count plants and map new locations as they are found. Make observations on any treatments. Seed viability is 3 years.
Hoary cress	Continue to monitor 7 permanent plots and add 3 new randomly selected occurrences to bring the permanent plot number to 10; collect data on treatments and observations on insect and animal browse. Seed viability is 3 years.
Knapweeds:	
Diffuse & Spotted	Continue to monitor 10 permanent plots in randomly selected occurrences; collect data on any treatments that might have occurred in the plots and continue to collect plant and insect data at permanent biocontrol plots. Seed viability is 8-10 years.
Leafy spurge	Continue to monitor 10 permanent plots in randomly selected occurrences; collect data on any treatments that might have occurred in the plots and continue to collect plant and insect data at permanent biocontrol plots. Seed viability is thought to be between 2-5 years.
Musk thistle	Continue to monitor10 permanent photo plots; collect data on the presence of biocontrol agents and make observations on treatments. Seed viability is 10 years.
Russian knapweed	Monitor sites where the plant was treated in the past and continue to look for new occurrences. Seed viability is 5 years.

Noxious Weed Species	*Monitoring Action(s) and Seed Longevity*
Russian olive	Monitor treated areas for secondary invasions and resprouts.
Salt Cedar	Monitor sites where the plant was treated in the past and continue to look for new occurrences. Seed viability is less than 1 year.
Scotch thistle	Continue to map all occurrences and count plants. Make observations on treated areas and evaluate treatment success. Seed viability is 7-20 years.
Yellow toadflax	Opportunistic management should be followed-up by monitoring treatments. Seed longevity is not known. Seed viability is low.
LIST C	
St. Johnswort	Continue to monitor known locations, count the plants and map new locations as they are found. Collect data on any observed treatments. Seed longevity is 20+ years.
INVASIVE SPECIES NOT ON NOXIOUS WEED LIST	
Tatarian honeysuckle	Continue to monitor known locations, count plants and map new locations as they are found. Collect data on any observed treatments.
Siberian peashrub	Continue to monitor known locations and collect data on any treated areas.

Adjusting Weed Management Actions

The point of monitoring is to provide a rational basis for determining if weed management actions are effective in moving toward weed management goals. Annual weed monitoring conducted at the Academy has provided important information on treatment activities and the extent of weed coverage. The analysis of the monitoring data each year is also key, and to meet with concerned parties to discuss the monitoring results, ideally early in the calendar year. Thereafter, weed management actions for the forthcoming year can be changed, as needed, if indicated by the results of the monitoring. It may also become apparent that the initial approach to monitoring for a certain weed species is not effective or efficient. If so, the monitoring methodology can be adjusted, as needed. After the first three years of monitoring, the data may show that less frequent or less intensive monitoring is acceptable for certain weed species.

Communication between Academy staff and contractors regarding field observations and needs would greatly enhance the success of weed control at the Academy. Due to the complex nature of treating weeds in a natural landscape, the presence of important natural resources, wetlands and rare biological elements, the presence of biocontrol agents, and the ongoing treatment and monitoring activities, it is imperative that the different groups are able to communicate with the Natural Resources staff at the Academy and with each other in a timely manner. For example, if a

weed applicator notices a new occurrence of a weed, or a biologist finds a new rare plant species, or a biocontrol plot is treated (photo 5), a means needs to exist for the groups to communicate. A weed applicator may need a biologist to identify a plant (photo 6) or plant community, etc. Thus, a yearly meeting or workshop is recommended for updates and as a means to facilitate communication between these groups during the field season.

Photo 5. Ice Lake Road 2 site was sprayed with herbicide after "Do Not Disturb" signs were posted in 2001 (Michels et al. 2001).

Photo 6. A native thistle (flagged for future monitoring) targeted herbicides (Michels 2001).

Future/On-going Weed Survey Needs

Other noxious weed species will undoubtedly appear at the Academy in the future or may occur there now, having been overlooked in the previous inventories. We encourage natural resources staff at the Academy to be alert for the following species and to control them aggressively if they are discovered. Given the climate and soil conditions at the Academy, all of these species could flourish on the base. All locations of the species listed below should be considered high-priority for management due to their (presumed) local rarity, high impact, and high rates of spread.

- **Purple loosestrife (*Lythrum salicaria*)** is a List A noxious weed species in Colorado that grows in wetlands and riparian areas. It is a showy species that has been widely planted in gardens. It re-sprouts readily from its extensive root system, making it very difficult to control once it becomes established. It is able to outcompete native species especially where water levels are controlled and do not match natural flood regimes.
- **Garlic mustard (*Alliaria petiolata*)** is a Watch List noxious weed species in Colorado that has been documented from El Paso and Jefferson counties (USDA 2015, SEINet 2015) and is found in similar habitats to those found at the Academy. It is a biennial herbaceous plant found in shaded, moist to dry areas. It has allelopathic properties, is self-fertile, and is known to invade healthy habitats.
- **Hairy Willowherb (*Epilobium hirsutum*)** is a List A noxious weed species in Colorado that has been found in cattail marshes, ditches and rivers in Adams, Denver and Jefferson counties.
- **Mediterranean sage (*Salvia aethiopsis*)** is a List A weed species in Colorado. It is a showy species that escapes from gardens and spreads rapidly in the wild. It is a biennial that is readily controlled by digging.
- **Tall whitetop (*Lepidium latifolium = Cardaria latifolia*)** is a List B weed species that typically grows in moist habitats such as riparian areas, ditch banks, and wetlands. It spreads rapidly in favorable environments and is difficult to control once established. It is known from many counties in Colorado and includes nearby Denver, Jefferson, Otero and Rio Grande counties.

In addition, another invasive plant species not currently classified as noxious by the State of Colorado, but which could appear at the Academy in the future is **common buckthorn (*Rhamnus cathartica*).** This plant is found along riparian areas along the South Platte River in the Denver metropolitan area, some of it was evidently planted (Smith and Kuhn 2015). It is also known from Boulder, Jefferson and Larimer counties. This species has the potential to colonize riparian areas along Monument Creek and its tributaries.

SUMMARY OF RECOMMENDATIONS

1) Continue to monitor and map 20 target noxious weed species using protocols utilized over the last decade including permanent plots for hard to control species (Lavender et al. 2015).
2) Continue successful rapid response early detection efforts for Russian knapweed, Dalmatian toadflax, myrtle spurge and salt cedar.
3) Utilize and monitor biocontrol agents for leafy spurge, Canada thistle, St. Johnswort and knapweeds for control where possible. Avoid chemical treatments in biocontrol monitoring plots.

4) Utilize a "natural areas" approach for noxious weeds located in the mapped Special Weed Management Areas. Provide shapefiles to applicators and Academy staff with the locations of SWMAs and Element Occurrences.
5) Conduct follow-up monitoring on treated areas and evaluate success.
6) Maintain records on treatments and treatment areas, and make them available to field workers and for data analysis and interpretation.
7) Reduce herbicide use and prevent non-target damage by utilizing "precise spot applications" and using manual methods when possible.
8) Protect wetlands and groundwater from contamination by avoiding herbicide use in sandy soils of drainages, lakeshores, riparian areas and floodplains. If herbicide is deemed the only viable method, a precision application with tongs or backpack sprayer with a non-restricted herbicide appropriate for wetlands (Jefferson County 2002) should be applied in SWMAs.
9) Monitor rare species and plant communities. Look for new occurrences and proximity to noxious weed species.
10) Review the literature for current updates on successful weed treatments and integrate findings into management protocols.
11) Provide a yearly workshop or annual meeting with the Academy staff, Colorado Natural Heritage Program, and weed spraying contractor to share ideas, learn to recognize rare species, and to look for potential new noxious weeds and rare species that could be present.
12) Look for natural biological controls that may be present on Canada thistle and Russian olive.
13) Be aware of and know how to identify List A species that have the potential spread to landscapes at the Academy: Purple loosestrife, garlic mustard, hairy willowherb, Mediterranean sage, tall whitetop and common buckthorn.

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APPENDIX 1
Understanding Natural Heritage Program Conservation Status

Understanding Natural Heritage Conservation Status

Introduction
Determining which plants and animals are thriving and which are rare or declining is crucial for targeting conservation towards those species and habitats in greatest need. As a member of the international Natural Heritage Network governed by NatureServe, the Colorado Natural Heritage Program (CNHP) employs a standardized method for evaluating the relative imperilment of both species and ecological communities. These assessments lead to the designation of a conservation status rank. For plant and animal species these ranks provide an estimate of extinction risk, while for ecological communities they provide an estimate of the risk of elimination. There are currently no conservation status ranks determined for Ecological Systems.

Conservation status ranks are based on a one to five scale, ranging from critically imperiled (G1) to demonstrably secure (G5). Status is assessed and documented at three distinct geographic scalesglobal (G), national (N), and state/province (S). These status assessments are based on the best available information, and consider a variety of factors such as abundance, distribution, population trends, and threats.

Interpreting NatureServe Conservation Status Ranks
The conservation status of a species or community is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global), N = National, and S = Subnational). The numbers have the following meaning:

1 = critically imperiled
2 = imperiled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.

For example, G1 would indicate that a species is critically imperiled across its entire range (i.e., globally). In this sense the species as a whole is regarded as being at very high risk of extinction. A rank of S3 would indicate the species is vulnerable and at moderate risk within a particular state or province, even though it may be more secure elsewhere.
Extinct or missing species and ecological communities are designated with either an "X" (presumed extinct or extirpated) if there is no expectation that they still survive, or an "H" (possibly extinct or extirpated) if they are known only from historical records but there is a chance they may still exist. Other variants and qualifiers are used to add information or indicate any range of uncertainty. See the following conservation status rank definitions for complete descriptions of ranks and qualifiers.

Global, National, and Subnational Assessments
The overall status of a species or ecological community is regarded as its "global" status; this rangewide assessment of condition is referred to as its global conservation status rank (G-rank). Because the G-rank refers to the species or community as a whole, each species or community can have just a single global conservation status rank. The condition of a species or community can vary from one country to another, and national conservation status ranks (N-rank) document its condition in a particular country. A species or community can have as many N-ranks as countries in which it occurs.

Similarly, status can vary by state or province, and thus subnational conservation status ranks (Srank) document the condition of the species or community within a particular state or province.

Again, there may be as many subnational conservation status ranks as the number of states or provinces in which the species or community occurs.

National and subnational status ranks must always be equal to or lower than the global rank for a particular species or community (in this sense a "lower" number indicates greater risk). On the other hand, it is possible for a species or community to be more imperiled in a given nation or state/province than it is range-wide. As an example, a species may be common and secure globally (G5), vulnerable in the United States as a whole (N3), yet critically imperiled in Florida (S1). In the United States and Canada, the combination of global and subnational ranks (e.g., G3S1) are widely used to place local priorities within a broader conservation context.

Global conservation status assessments generally are carried out by NatureServe scientists with input from relevant natural heritage member programs and experts on particular taxonomic groups. NatureServe scientists similarly take the lead on national-level status assessments in the United States and Canada, while state and provincial member programs assess the subnational conservation status for species found in their respective jurisdictions.

Status assessments ideally should reflect current conditions and understanding, and CNHP, NatureServe, and other member programs of the Natural Heritage Network strive to update these assessments with new information from field surveys, monitoring activities, consultation, and scientific publications. Persons with significant new or additional information are encouraged to contact CNHP.

To ensure that CNHP and other Natural Heritage Network programs databases represent the most current knowledge throughout the network, data exchanges are carried out each year between each individual program and NatureServe. The national and global conservation status ranks (G-ranks and N-Ranks) presented in CNHP data are therefore only as current as the last data exchange with NatureServe. Although most global and national conservation status ranks do not change frequently, the most current G-ranks and N-Ranks can be obtained directly from NatureServe.

Status Assessment Criteria

Use of standard criteria and rank definitions makes CNHP and NatureServe conservation status ranks comparable across organism types and political boundaries. Thus, G1 has the same basic meaning whether applied to a salamander, a moss species, or a forest community. Similarly, an S1 has the same meaning whether applied to a species or community in Manitoba, Minnesota, or Mississippi.

This standardization in turn allows NatureServe scientists to use the subnational ranks assigned by local natural heritage programs to help determine and refine global conservation status ranks. Status assessments are based on a combination of quantitative and qualitative information. Criteria for assigning ranks serve as guidelines, however, rather than arithmetic rules. The assessor's overall knowledge of the species or community allows them to weigh each factor in relation to the others, and to consider all pertinent information. The general factors considered in assessing species and ecological communities are similar, but the relative weight given to each factor differs.

For species, the following factors are considered in assessing conservation status:

- total number and condition of occurrences (e.g., populations)
- population size
- range extent and area of occupancy
- short- and long-term trends in the above factors

- scope, severity, and immediacy of threats
- number of protected and managed occurrences
- intrinsic vulnerability
- environmental specificity

For ecological communities, the association level generally is the classification unit assessed and ranked (see Classification of Ecological Communities for an explanation of the classification hierarchy). Only global conservation status ranks are currently available for ecological communities on *NatureServe Explorer*. The primary factors for assessing community status are:

Species known in an area only from historical records are ranked as either H (possibly extirpated/possibly extinct) or X (presumed extirpated/presumed extinct). Other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate uncertainty. See the lists of conservation status rank definitions for complete descriptions of ranks and qualifiers.

- total number of occurrences (e.g., forest stands)
- total acreage occupied by the community.

Secondary factors include the geographic range over which the community occurs, threats, and integrity of the occurrences. Because detailed information on these factors may not be available, especially for poorly understood or inventoried communities, preliminary assessments are often based on the following:

- geographic range over which the community occurs
- long-term trends across this range
- short-term trend (i.e., threats)
- degree of site/environmental specificity exhibited by the community
- imperilment or rarity across the range as indicated by subnational ranks assigned by local natural heritage programs.

Relationship to Other Status Designations

CNHP and NatureServe conservation status ranks are a valuable complement to legal status designations assigned by government agencies such as the U.S. Fish and Wildlife Service and the National Marine Fisheries Service in administering the U.S. Endangered Species Act (ESA), and the Canadian Wildlife Service in administering the Species at Risk Act (SARA). CNHP and NatureServe status ranks, and the documentation that support them, are often used by such agencies in making official determinations, particularly in the identification of candidates for legal protection. Because the Natural Heritage Network assessment procedures-and subsequent lists of imperiled and vulnerable species-have different criteria, evidence requirements, purposes, and taxonomic coverage than official lists of endangered and threatened species, they do not necessarily coincide.

The IUCN Red List of threatened species is similar in concept to NatureServe's global conservation status assessments. Due to the independent development of these two systems, however, minor differences exist in their respective criteria and implementation. Recent studies indicate that when applied by experienced assessors using comparable information, the outputs from the two systems are generally concordant. NatureServe is an active participant in the IUCN Red List Programme, and in the region covered by *NatureServe Explorer*, NatureServe status ranks and their underlying documentation often form a basis for Red List threat assessments.

Global Conservation Status Definitions
Listed below are definitions for interpreting NatureServe global conservation status ranks (G-ranks). These ranks reflect an assessment of the condition of the species or ecological community across its entire range. Where indicated, definitions differ for species and ecological communities.

NatureServe Global Conservation Status Ranks

Rank	Definition
GX	**Presumed Extinct** (species)— Not located despite intensive searches and virtually no likelihood of rediscovery. **Eliminated** (ecological communities)—Eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.
GH	**Possibly Extinct** (species)— Missing; known from only historical occurrences but still some hope of rediscovery. **Presumed Eliminated**— (Historic, ecological communities)-Presumed eliminated throughout its range, with no or virtually no likelihood that it will be rediscovered, but with the potential for restoration, for example, American Chestnut Forest.
G1	**Critically Imperiled**—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
G2	**Imperiled**—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
G3	**Vulnerable**—At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
G4	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
G5	**Secure**—Common; widespread and abundant.

Variant Ranks

Rank	Definition
G#G#	**Range Rank**—A numeric range rank (e.g., G2G3) is used to indicate the range of uncertainty in the status of a species or community. Ranges cannot skip more than one rank (e.g., GU should be used rather than G1G4).
GU	**Unrankable**—-Currently unrankable due to lack of information or due to substantially conflicting information about status or trends. Whenever possible, the most likely rank is assigned and the question mark qualifier is added (e.g., G2?) to express uncertainty, or a range rank (e.g., G2G3) is used to delineate the limits (range) of uncertainty.
GNR	**Unranked**—Global rank not yet assessed.
GNA	**Not Applicable**—A conservation status rank is not applicable because the species is not a suitable target for conservation activities.

Rank Qualifiers

Rank	Definition
?	**Inexact Numeric Rank**—Denotes inexact numeric rank (e.g., G2?)
Q	**Questionable taxonomy**—Taxonomic distinctiveness of this entity at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or the inclusion of this taxon in another taxon, with the resulting taxon having a lowerpriority conservation priority.
C	**Captive or Cultivated Only**—At present extant only in captivity or cultivation, or as a reintroduced population not yet established.

Infraspecific Taxon Conservation Status Ranks

Infraspecific taxa refer to subspecies, varieties and other designations below the level of the species. Infraspecific taxon status ranks (T-ranks) apply to plants and animal species only; these T-ranks do not apply to ecological communities.

Rank	Definition
T#	**Infraspecific Taxon** (trinomial)—The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T-ranks follow the same principles outlined above for global conservation status ranks. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1. A T-rank cannot imply the subspecies or variety is more abundant than the species as a whole-for example, a G1T2 cannot occur. A vertebrate animal population, such as those listed as distinct population segments under under the U.S. Endangered Species Act, may be considered an infraspecific taxon and assigned a T-rank; in such cases a Q is used after the T rank to denote the taxon's informal taxonomic status. At this time, the T rank is not used for ecological communities.

National and Subnational Conservation Status Definitions

Listed below are definitions for interpreting CNHP and NatureServe conservation status ranks at the national (N-rank) and subnational (S-rank) levels. The term "subnational" refers to state or provincelevel jurisdictions (e.g., Colorado, Ontario). Assigning national and subnational conservation status ranks for species and ecological communities follows the same general principles as used in assigning global status ranks. A subnational rank, however, cannot imply that the species or community is more secure at the state/province level than it is nationally or globally (i.e., a rank of G1S3 cannot occur), and similarly, a national rank cannot exceed the global rank. Subnational ranks are assigned and maintained by CNHP.

National (N) and Subnational (S) Conservation Status Ranks

Status	Definition
NX SX	**Presumed Extirpated**—Species or community is believed to be extirpated from the nation or state/province. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
NH SH	**Possibly Extirpated** (Historical)—Species or community occurred historically in the nation or state/province, and there is some possibility that it may be rediscovered. Its presence may not have been verified in the past 20-40 years. A species or community could become NH or SH without such a 20-40 year delay if the only known occurrences in a nation or state/province were destroyed or if it had been extensively and unsuccessfully looked for. The NH or SH rank is reserved for species or communities for which some effort has been made to relocate occurrences, rather than simply using this status for all elements not known from verified extant

	occurrences.
N1 S1	**Critically Imperiled**—Critically imperiled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
N2 S2	**Imperiled**—Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
N3 S3	**Vulnerable**—Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
N4 S4	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
N5 S5	**Secure**—Common, widespread, and abundant in the nation or state/province.
NNR SNR	**Unranked**—Nation or state/province conservation status not yet assessed.
NU SU	**Unrankable**—Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
NNA SNA	**Not Applicable** —A conservation status rank is not applicable because the species is not a suitable target for conservation activities.
N#N# S#S#	**Range Rank** —A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species or community. Ranges cannot skip more than one rank (e.g., SU is used rather than S1S4).
Not Provided	Species is known to occur in this nation or state/province. Contact the relevant natural heritage program for assigned conservation status

Breeding Status Qualifiers

Qualifier	**Definition**
B	**Breeding**—Conservation status refers to the breeding population of the species in the nation
or state/province.	**N**
Nonbreeding—Conservation status refers to the non-breeding population of the species in	the nation or state/province.
M	**Migrant**—Migrant species occurring regularly on migration at particular staging areas or concentration spots where the species might warrant conservation attention. Conservation status refers to the aggregating transient population of the species in the nation or state/province.

Note: A breeding status is only used for species that have distinct breeding and/or non-breeding populations in the nation or state/province. A breeding-status S-rank can be coupled with its complementary non-breeding-status S-rank if the species also winters in the nation or state/province, and/or a migrant-status S-rank if the species occurs regularly on migration at particular staging areas or concentration spots where the species might warrant conservation attention. The two (or rarely, three) status ranks are separated by a comma (e.g., "S2B,S3N" or "SHN,S4B,S1M").

Other Qualifiers

Rank	Definition
?	**Inexact or Uncertain**—Denotes inexact or uncertain numeric rank. (The ? qualifies the character immediately preceding it in the S-rank.)

Reference

The information on this page is a slightly modified version of the NatureServe Conservation Status page found on the NatureServe Explorer website at:
http://www.natureserve.org/explorer/ranking.htm .

Introduction to Potential Conservation Areas (PCAs)

In order to successfully protect populations or occurrences, it is necessary to delineate conservation areas. These potential conservation areas focus on capturing the ecological processes that are necessary to support the continued existence of a particular element of natural heritage significance. Potential conservation areas may include a single occurrence of a rare element or a suite of rare elements or significant features.

The goal of the process is to identify a land area that can provide the habitat and ecological processes upon which a particular element or suite of elements depends for their continued existence. The best available knowledge of each species' life history is used in conjunction with information about topographic, geomorphic, and hydrologic features, vegetative cover, as well as current and potential land uses. The proposed boundary does not automatically exclude all activity. It is hypothesized that some activities will cause degradation to the element or the process on which they depend, while others will not. Consideration of specific activities or land use changes proposed within or adjacent to the preliminary conservation planning boundary should be carefully considered and evaluated for their consequences to the element on which the conservation unit is based.

Element Occurrence

An Element Occurrence (EO) is defined as a specific example of an Element at a geographic location characterized by a habitat capable of sustaining or contributing to the survival of the species, or by a landscape that supports the ecological integrity of the community.

Element

A biodiversity unit of conservation attention and action for which a Heritage Conservation Status Rank is assigned.

Elements may be recognized at any taxonomic level (although typically are only recognized at the species level and below for organisms, and the Ecological System, Alliance, and Association levels for communities).

Elements may also be recognized for biodiversity units for which there is no systematic hierarchy (e.g., animal assemblages, community Complexes).

Elements may be native or exotic at a particular location and collectively represent the full array of biological and ecological diversity for the geographic area covered. Elements may serve as the targets of Heritage inventory. Typically, these targets include native, regularly occurring vulnerable species (including infraspecific taxa and populations) and exemplary ecological communities.

APPENDIX 2
Potential Conservation Area Reports

Level 1 Potential Conservation Area (PCA) Report

Name Monument Creek **Site Code** S.USCOHP5*201

IDENTIFIERS

Site ID 501 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

Site Relations Overlaps Monument Southeast (S.USCOHP*22206), Air Force Academy Oak Foothills (S.USCOHP*28428) and I-25 Shamrock (S.USCOHP*7875).

LOCATORS

Nation United States **Latitude** 390038N

State Colorado **Longitude** 1044959W

Quad Code	Quad Name
39104-A7	Monument
38104-H7	Pikeview
38104-H8	Cascade
39104-A8	Palmer Lake

County

El Paso (CO)

Watershed Code	Watershed Name
11020003	Fountain

Site Directions

This site is located approximately 12 miles north of the city of Colorado Springs, extending from the town of Monument to the northern border of Colorado Springs. It encompasses the length of Monument Creek plus all eastern tributaries and most western tributaries including Beaver Creek, Deadmans Creek, Lehmans Run and West Monument Creek.

SITE DESCRIPTION

Minimum Elevation	6,220.00	**Feet**	1,895.86	**Meters**
Maximum Elevation	7,500.00	**Feet**	2,286.00	**Meters**

Site Description

Monument Creek flows southward from the Monument Divide through the U.S. Air Force Academy (Academy) and into the city of Colorado Springs. The site begins at the town of Monument and extends to the northern edge of the city of Colorado Springs. It is centered around Monument Creek and includes the tributaries of Beaver Creek, Deadmans Creek, Lehman Run and West Monument Creek to the west and Dirty Woman Creek, Jackson Creek, Smith Creek, Monument Branch, Black Squirrel Creek, and Kettle Creek to the east. The floodplain is composed of gravel and silt and is defined by steep, eroding sandstone cliffs and gentle terraces. Monument Creek meanders broadly through some stretches, particularly the Academy where periodic flooding events have created substantial deposits of silt and debris. The riparian vegetation is dominated by coyote willow (*Salix exigua*), peachleaf willow (*Salix amygdaloides*), and crack willow (*Salix fragilis*) with scattered stands of narrowleaf cottonwood (*Populus angustifolia*). Also found in these mesic habitats are snowberry (*Symphoricarpos occidentalis*), wild plum (*Prunus americana*), and Russian olive (*Elaeagnus angustifolia*). Stream banks retain native graminoid vegetation in the form of sedges (*Carex* spp.) and rushes (*Juncus* spp.). Surrounding uplands are generally midgrass prairie that is composed of smooth brome (*Bromopsis inermis*), cheatgrass (*Bromus tectorum*), big bluestem (*Andropogon gerardii*), needle-and-threadgrass (*Hesperostipa comata*), and little blue stem (*Shizachyrium scoparium*). Ponderosa pine (*Pinus ponderosa*) and Gambel's oak (*Quercus gambelii*) occur in patches on either side of Monument Creek and its tributaries. Prior to the establishment of the U.S. Air Force Academy, the area was used for logging and ranching operations since settlement in the 1860s (Ripley 1994). Within the Academy, logging has not occurred since 1915 and cattle grazing has not occurred since the purchase of the area by the Air Force in 1954 (Ripley 1994). Cattle grazing and smaller ranching operations still exist north of the Academy. South and east of the Academy the system is quickly being encroached by residential and commercial development.

Key Environmental Factors

No Data

Level 1 Potential Conservation Area (PCA) Report

Name Monument Creek **Site Code** S.USCOHP5*201

Climate Description

No Data

Land Use History

Prior to the establishment of the Air Force Academy Reservation, the site was used for logging and ranching operations since settlement in the 1860's (Ripley 1994). Logging has not occurred since 1915 (Ripley 1994). Cattle grazing has not occurred since the purchase of the area by the Air Force Academy in the 1950's (Ripley 1994). This has allowed herbaceous and woody riparian vegetation to remain dense. In the absence of grazing, the streambed integrity is likely greater than a grazed site would be, as well. In any case, a lack of grazing may be related to the present occurrence of Preble's meadow jumping mice over their historic range (F. Harrington, pers. comm.).

Cultural Features

No Data

SITE DESIGN

Site Map Y - Yes **Mapped Date** 06/01/2001

Designer Schorr, R.A.

Boundary Justification

The boundaries are based on the presence of Preble's meadow jumping mice throughout the system. Since 1997, sampling for Preble's meadow jumping mice has occurred within the U.S. Air Force Academy. Outside of the Academy, jumping mice have been documented in Beaver Creek, Kettle Creek, Deadmans Creek, Jackson Creek, Smith Creek and Dirty Woman Creek. The boundary includes 300 meters on either side of the associated creek. This is designed to include the riparian vegetation and associated upland grass communities that have been documented as part of Preble's meadow jumping mouse habitat (Schorr 2001). The distance of 300 meters was intended to be conservative, likely including a greater amount of upland community than most mice will utilize, but sufficient in all circumstances to ensure persistence of jumping mice. A better approximation of this potential conservation area would be the area that includes the 100-year floodplain and an additional 100 meters of adjacent upland habitat. Until these data layers are available for all areas within the conservation area, this conservation boundary should provide the persistence of the subspecies in this area.

Primary Area 13,142.47 **Acres** 5,318.59 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B2: Very High Biodiversity Significance

Biodiversity Significance Comments

The Monument Creek site supports an excellent (A-ranked) occurrence of the globally and state imperiled (G5T2/S2) Preble's meadow jumping mouse (*Zapus hudsonius preblei*), a species designated as sensitive (Forest Service), as federally threatened (US Endangered Species Act), and as a species of special concern (State of Colorado). This occurrence is one of the most outstanding occurrences rangewide.

Other Values Rank No Data

Other Values Comments

No Data

Protection Urgency Rank P1: Immediately Threatened/Outstanding Opportunity

Protection Urgency Comments

Likely the biggest threat is the encroachment of urban impacts. Although the impacts of development are unclear, Preble's meadow jumping mice are not found in great numbers or simply do not occur, near urban settings. This site is well protected within the U.S. Air Force Academy, but may be subject to a host of potential impacts outside of the Academy boundaries. Since the likelihood of increased urbanization east and north of the Academy is high, it is important to use these conservation area boundaries to plan for the long-term conservation of this significant Preble's meadow jumping mouse population. Since much of the Monument Creek site is housed within the U.S. Air Force Academy much of the area will be protected as long as the Academy maintains the present habitat management strategy. However, much of it is located on private and local government land. Depending on the management strategies in place on these properties, it may be more difficult to ensure long-term persistence off Academy lands. Within the Academy the riparian communities and associated uplands are some of the healthiest along the Front Range. Although the presence of exotic, invasive plant species may compromise the value, it currently does not impact the persistence of Preble's meadow jumping mice. Further investigations are necessary to determine the conservation impact weedy

plants have on jumping mouse biology. Outside the Academy current habitat management strategies may complicate the conservation value of this area. In particular, the increase in development adjacent to riparian systems in the eastern and northern sections of this conservation area may jeopardize the persistence of jumping mouse populations. To date, there have not been studies associating increased development and jumping mouse declines, but anecdotal evidence (Compton and Hugie 1993, Ryon 1995) suggests that they may be incompatible. In some areas along the northern section of Monument Creek and the associated tributaries current management may not jeopardize jumping mouse populations, but also may not allow populations to expand considerably. For the most part, the tributaries in this area are surrounded by small to medium ranches that may house a few head of livestock. It is believed that jumping mice and livestock grazing are compatible, but depending on the level of impact to riparian systems these ranches may preclude expansion of jumping mouse populations.

Management Urgency Rank M2: Essential within 5 Years to Prevent Loss

Management Urgency Comments

Current management within the Academy restricts human access to Monument Creek and some of the associated tributaries. This management strategy likely contributes to the high-quality habitat that persists today. North and south of the Academy, the level of grazing and ranching may not jeopardize the population, but also may restrict the degree to which it can expand. Grazing and ranching can restrict the expanse of riparian shrub communities and thus, restrict the ability for Preble's meadow jumping mice to utilize the area. However, mild grazing pressure may not affect the population. Of the utmost importance to ensuring the persistence of the jumping mouse populations is the continued management of habitats within the U.S. Air Force Academy. The current management strategy, which limits activities within riparian corridors, has provided habitat for one of the healthiest populations of Preble's meadow jumping mouse known. Outside of the Academy, it is essential to ensure that development in and around riparian corridors provide both riparian and upland habitat for jumping mice. Jumping mice have been documented using upland habitats and it is possible that habitats that only include riparian communities will not be sufficient for jumping mouse persistence. Current management strategies on ranches may be sufficient to maintain jumping mouse populations at their current level; however, restricting impacts such as excessive grazing and compaction of soils near riparian systems will likely increase jumping mouse populations.

LAND MANAGEMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

Noxious weeds at the site include bull thistle, Canada thistle, common St Johnswort, dames rocket, diffuse knapweed, spotted knapweed, Fuller's teasel, leafy spurge, musk thistle, myrtle spurge, Russian knapweed, Russian olive, Scotch thistle, whitetop, yellow spring bedstraw and yellow toadflax.

Offsite

No Data

Information Needs

We have established a primary site boundary for this occurrence using a 100m buffer. However, we do not know the precise role of the buffer nor the size and type of buffer that is sufficient to protect the site. Further information is needed on hydrologic processes in the Monument Creek drainage and on the effects of various kinds of adjacent land uses on populations of jumping mice, in order to be able to provide an adequate buffer for the site. The role of beavers in maintaining and buffering the system, and their status on the site, needs to be determined. Evidence in other western riparian stream systems suggest that beavers played a major role in the evolution of riparian natural communities and stream hydrology (Knight 1994). One of the most important questions that we must begin to answer is the process(es) responsible for the large year-to-year fluctuations in captures of this species, a pattern observed not only by us, but also by others (B. Wunder, pers. comm.) The USAFA offers a unique opportunity for the long term population studies of the species which are necessary for understanding ecological trends (Pimm 1991). We do not know where the single jumping mouse captured below Reservoir No. 2 came from or whether a larger population occurs near the point of capture in areas other than those surveyed thus far. Because this portion of the site is of limited quality as far as we now know, no management steps are warranted at this time. The most prudent action would be a more complete trapping survey of the area to determine the true conservation significance. The riparian habitats around Reservoir No.

2 should be examined as well as natural or man-made (from golf course runoff, for example) seeps in the area of the capture to attempt to identify a source population. We repeat that, given our existing state of knowledge, the single capture of a jumping mouse at the site is atypical.

Management Needs

Maintaining the habitats that support jumping mice and other important elements on this site will require maintenance of ecological processes on the site. Protection and management should incorporate steps to maintain natural hydrologic integrity (hydroperiod, water quality, etc.), control exotic plant species, and reduce predation by domestic pets. Preble's jumping mice use areas dominated by a variety of exotic plant and animal species, but we do not know whether they are intolerant of any specific invader or would thrive better with the reduction in one or more invader species. While control of some of the exotic invaders is desirable, and in some cases required by law, the type and timing of control measures should be considered in light of jumping mouse activity and behavior. It is possible that application of general broad-leaf herbicides could cause direct loss of habitat and mice from vehicular traffic during application. Additionally, a general herbicide could reduce the seeds which may be the main food of jumping mice, particularly during prehibernation fattening. Loss of herbaceous cover in areas without a dense woody shrub canopy could increase predation on this species, and/or preclude the mice from using affected areas. The diets and habitat use patterns of this species need to be determined in order to make specific recommendations regarding the best level of control of exotics that should be used, as well as the timing and use of pesticides. Hydrology is a concern not only in establishing an appropriate buffer, but also in identifying off-site and Zone B alterations to the system that may reduce the integrity of this site. Study of the natural hydrological processes of the area are needed to understand the system. Consideration should be given to reducing erosion into the stream and reducing degradation of the streambed in other ways, by identifying areas of problem runoffs and controlling them. The secondary boundary is recommended to protect the riparian area from use by domestic cats. Cats will not cross roadways, but can readily avoid the them by going under them through culverts (J. Coleman, pers. comm.) Chain-link fencing is known to be an effective barrier to their passage and some type of culvert fencing should be implemented if the secondary boundary as now recommended is to be effective. Managing cats already present in Zone B may be possible by educating residents about the effects of cats on wildlife, and encouraging them to control the reproductive output of their pets (Coleman and Temple 1993).

Managed Area Relations

No Data

Protection Comments

Because the academy is protected as a military educational institute, its defensibility is good. Monument Creek, its tributaries, and the adjacent uplands have not been impacted by livestock grazing for decades. Lack of heavy use of the riparian area by recreationists likely improves streamside vegetation and reduces stream degradation. Adjacent uplands, although with altered plant composition, are protected from development. This reduces impacts on the hydrologic regime and on the mouse community more directly by reducing access to the riparian area by domestic dogs and cats (C. Meaney, pers. comm.). The hydrologic integrity of the tributaries of Monument Creek and Monument Creek itself is poor in places. A healthy riparian ecosystem reflects native hydrological regimes, with natural ebbs and flows of water inputs, and good water retention and storage capacity of the soil. Livestock grazing along riparian areas reduces the water-holding capacity of the soil and removes streamside vegetation that could buffer the system from physical alteration during peak flows. Water diversion for irrigation and alteration of natural water flows depletes the water table, allowing the invasion of upland vegetation into the riparian community, and drying out streamside soils. Dry soils are easily erodible; combined with unnatural, large flushes of water, entrenching of the streambed and further lowering the water table occur. Increased urbanization also results in increased peak flows and reduced water retention. Erosion of banks on tributaries both east and west of Monument Creek, and on portions of Monument Creek itself, suggests that this is weakly functioning riparian system, likely still recovering from the decades of grazing and farming that occurred on this site prior to the establishment of the AFA Reservation. Maintenance of natural flows of water and protection from off-site development will be critical for the continued recovery of this site. For the flow below the non-operational sewage disposal site, our concern is whether water will persist in the future. For all areas, our concern is the periodic, unbuffered influx of water that could cause erosion and degrade the streambed further. A high EO rank is suggested from trapping results on Monument Creek, but consideration must be made of several factors that would tend to lower the rank of the site from a broader ecological perspective. Considering the quality of the site solely in terms of plant community quality, the riparian area would not be rated highly. The riparian vegetation of the USAFA is highly modified from a pristine condition, with herbaceous plant species composition dominated by exotic species of grasses and forbs throughout the area. Invasion by exotic mammal species was documented, as well, with the

capture of house mice on a transect near Ice Lake where jumping mice were also captured. Adjacent landowner cooperation in managing water issues and protecting the connectivity corridors to the north will likely be required to preserve the areas' value to jumping mice.

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
24976	*Alnus incana* / Mesic Graminoids Shrubland	Montane Riparian Shrubland	G3	S2	N
24976	*Alnus incana* / Mesic Graminoids Shrubland	Montane Riparian Shrubland	G3	S2	N
19320	*Symphoricarpos occidentalis* Shrubland	Snowberry Shrubland	G4G5	S3	N
19320	*Symphoricarpos occidentalis* Shrubland	Snowberry Shrubland	G4G5	S3	N
24773	*Alnus incana / Cornus sericea* Shrubland	Thinleaf Alder-Red-osier Dogwood Riparian Shrubland	G3G4	S3	N
24872	*Salix exigua* / Mesic Graminoids Shrubland	Coyote Willow/Mesic Graminoid	G5	S5	N
21289	*Zapus hudsonius preblei*	Meadow Jumping Mouse Subsp	G5T2	S1	Y
24872	*Salix exigua* / Mesic Graminoids Shrubland	Coyote Willow/Mesic Graminoid	G5	S5	N
24872	*Salix exigua* / Mesic Graminoids Shrubland	Coyote Willow/Mesic Graminoid	G5	S5	N
24872	*Salix exigua* / Mesic Graminoids Shrubland	Coyote Willow/Mesic Graminoid	G5	S5	N
24738	*Populus angustifolia / Salix exigua* Woodland	Narrowleaf Cottonwood Riparian Forests	G4	S4	N
20146	*Celastrina humulus*	Hops Feeding Azure	G2G3	S2	N

REFERENCES

Reference ID	Full Citation
161701	Compton, Stephen A. and Roy D. Hugie. 1993. Status Report on Zapus hudsonius preblei, a Candidate Endangered Subspecies. Prepared by Pioneer Environmental consulting Services, Inc. under contract to the U.S. Fish and Wildlife Service.
166286	Ripley, J. Douglas. 1994. Vegetation of the U.S. Air Force Academy and the Adjacent Regions of the Pike National Forest, El Paso County, Colorado.
160660	Ryon, T. 1995. Evaluation of historical capture sites of the Preble's meadow jumping mouse in Colorado. M.S. Thesis. University of Colorado. 39 pages + figures.
194495	Schorr, R. 2001. Field Survey for Preble's meadow jumping mouse at the U.S. Air Force Academy.
200512	Siemers, J., D.G. Anderson, R. Schorr, and R. Rondeau. 2012. Final Report: United States Air Force Academy Biological Inventory. Colorado Natural Heritage Program, Fort Collins, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

VERSION

Version Date 06/01/2001

Version Author Schorr, R.A.

Level 1 Potential Conservation Area (PCA) Report

Name Farish Recreation Area **Site Code** S.USCOHP*7835

IDENTIFIERS

Site ID 561 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

Site Relations No Data

LOCATORS

Nation United States **Latitude** 385947N

State Colorado **Longitude** 1050004W

Quad Code	Quad Name
38105-H1	Woodland Park
38104-H8	Cascade
39104-A8	Palmer Lake
39105-A1	Mount Deception

County

El Paso (CO)

Watershed Code	Watershed Name
11020003	Fountain

Site Directions

The Farish Recreation Area is located in El Paso County, northeast of the town of Woodland Park.

SITE DESCRIPTION

Minimum Elevation	9,050.00	**Feet**	2,758.00	**Meters**
Maximum Elevation	9,440.00	**Feet**	2,877.00	**Meters**

Site Description

This site includes much of the Farish Memorial Recreation Area. The landscape is diverse, with the steep rugged topography typical of the Rampart Range. The steep slopes are studded with countless large, rounded granite boulders, giving the slopes a striking lumpy appearance. These uplands support subalpine forests dominated by Engelmann spruce (*Picea engelmannii*) and quaking aspen (*Populus tremuloides*). Among the steep ridges and slopes are mesic meadows, streams, and willow carrs. Several streams have been dammed in the recreation area to create Sapphire Lake, Leo Lake, and Grace Lake. During the summer, afternoon rain showers occur almost daily. West-facing slopes are drier that other slopes. The area is used heavily by elk in the fall and winter. This site contains the only known occurrence of Porter's feathergrass (*Ptilagrostis porteri*) in El Paso County. This species is a Colorado endemic, known currently from only three counties (Park, El Paso, and Summit). The occurrence is located south of Leo Lake in the Farish Memorial Recreation Area. The plants are found in a limited area in deep, peaty soils in a willow carr / sedge meadow peatland. The plants are growing in clumps in a hummocky area, with tufts of the grass growing on top of the hummocks. The dominant species are willows, including planeleaf willow (*Salix planifolia*), shortfruit willow (*S. brachycarpa*), and possibly mountain willow (*S.* cf*. monticola*). Shrubby cinquefoil (*Pentaphylloides floribunda*) is also common with the Porter's feathergrass. Other associated taxa include sedges (*Carex utriculata, C. aquatilis, C. simulata, C. lanuginosa*), hairgrass (*Deschampsia caespitosa*), Canadian reedgrass (*Calamagrostis canadensis*), foxtail grass (*Alopecurus aequalis*), and rosecrown (*Clementsia rhodantha*). The montane grassland community in the southern portion of the site occupies one of the largest openings in the Rampart Range. The grassland community is Parry's oatgrass (*Danthonia parryi*) with Idaho fescue (*Festuca idahoensis*), fringed sage (*Artemisia frigida*), three-nerved fleabane (*Erigeron subtrinervis*), and hairy aster (*Heterotheca villosa*). A rare dryland sedge (*Carex oreocharis*) occurs within the Parry's oatgrass meadow.

Key Environmental Factors

No Data

Climate Description

No Data

Land Use History

No Data

Level 1 Potential Conservation Area (PCA) Report

Name Farish Recreation Area **Site Code** S.USCOHP*7835

Cultural Features

No Data

SITE DESIGN

Site Map Y - Yes **Mapped Date** 03/07/2012

Designer Rondeau, R.J.

Boundary Justification

The boundary encompasses the occurrences and adjacent similar habitat that is not known to be impacted at this time. Open meadows to the north of the Parry's oatgrass montane grassland have been planted with smooth brome and Kentucky bluegrass, while meadows to the south have several roads or trails within them. Both areas have been excluded from the site. The site itself would not include all necessary processes (especially fire) for survival of the montane grassland occurrence, but they could be simulated at a smaller scale. The watershed of the creek that supports the occurrence of Porter's feathergrass was included to ensure the persistence of the proper hydrologic regime for this species.

Primary Area 801.43 **Acres** 324.33 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

This site contains a fair (C-ranked) occurrence of the globally imperiled (G2/S2) Porter feathergrass (*Ptilagrostis porteri*), a good (B-ranked) occurrence of the globally vulnerable (G3/S2) sedge, *Carex oreocharis*, and a good (B-ranked) occurrence of the globally vulnerable (G3/S3) *Danthonia parryi* montane grassland.

Other Values Rank No Data

Other Values Comments

No Data

Protection Urgency Rank P4: No Threat or Special Opportunity

Protection Urgency Comments

Most of the site is currently owned by the Air Force Academy and operated as Farish Recreation Area. The site extends onto Pike National Forest.

Management Urgency Rank M3: Needed within 5 Years to Maintain Quality

Management Urgency Comments

Management to control exotic species may be needed within five years to maintain the current quality. Recreation activities could potentially impact the site. A road/campground runs along the boundary of the willow carr / sedge meadow potentially serving as a conduit for non-native species.

LAND MANAGEMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*) and yellow toadflax (*Linaria vulgaris*) have all been documented within the site during weed surveys performed by CNHP.

Offsite

No Data

Information Needs

No Data

Management Needs

No Data

Managed Area Relations

No Data

Level 1 Potential Conservation Area (PCA) Report

Name Farish Recreation Area **Site Code** S.USCOHP*7835

Protection Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
19228	*Danthonia parryi* Herbaceous Vegetation	Montane Grasslands	G3	S3	Y
20528	*Carex oreocharis*	a sedge	G3	S2	Y
19684	*Ptilagrostis porteri*	Porter feathergrass	G2	S2	Y

REFERENCES

Reference ID	Full Citation
200512	Siemers, J., D.G. Anderson, R. Schorr, and R. Rondeau. 2012. Final Report: United States Air Force Academy Biological Inventory. Colorado Natural Heritage Program, Fort Collins, CO.

ADDITIONAL TOPICS

Additional Topics

Original site design by Anderson, D.G. 2001-06-15.

VERSION

Version Date 03/07/2012

Version Author Rondeau, R.J.

Level 1 Potential Conservation Area (PCA) Report

Name I-25 Shamrock **Site Code** S.USCOHP*7875

IDENTIFIERS

Site ID 1204 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

Site Relations Overlaps Monument Creek (S.USCOHP5*201).

LOCATORS

Nation United States **Latitude** 385643N

State Colorado **Longitude** 1044829W

Quad Code	Quad Name
38104-H7	Pikeview

County

El Paso (CO)

Watershed Code	Watershed Name
11020003	Fountain

Site Directions

No Data

SITE DESCRIPTION

Minimum Elevation 6,325.00 **Feet** 1,927.86 **Meters**

Maximum Elevation 6,445.00 **Feet** 1,964.44 **Meters**

Site Description

The site is a riparian area dominated by narrowleaf willow (*Salix exigua*).

Key Environmental Factors

No Data

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

SITE DESIGN

Site Map P - Partial **Mapped Date** 03/26/1997

Designer Spackman, S.C.

Boundary Justification

Boundary is drawn to protect the element from direct impacts. A much larger area should be considered to protect the hydrological setting necessary for the long-term viability of the rare plant at this site.

Primary Area 87.36 **Acres** 35.35 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B5: General Biodiversity Interest

Biodiversity Significance Comments

This site includes a fair (C-ranked) occurrence of a state rare (G5/S2) plant species. The American currant (*Ribes americanum*) is known from riparian areas on the Front Range of Colorado. The Front Range is facing high development pressures and riparian areas are being modified and degraded at an alarming rate.

Other Values Rank No Data

Other Values Comments

No Data

Protection Urgency Rank P2: Threat/Opportunity within 5 Years

Level 1 Potential Conservation Area (PCA) Report

Name I-25 Shamrock **Site Code** S.USCOHP*7875

Protection Urgency Comments

Protect from activities associated with I-25, interchange, and local businesses.

Management Urgency Rank M2: Essential within 5 Years to Prevent Loss

Management Urgency Comments

Site is very degraded and surrounded by roads, parking lots, and other developments. Local hydrology must be protected to ensure viability of the occurrence.

LAND MANAGEMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

Noxious weeds at the site include Canada thistle, diffuse knapweed, Fuller's teasel, leafy spurge, musk thistle, Russian olive, Tatarian honeysuckle and yellow toadflax.

Offsite

No Data

Information Needs

No Data

Management Needs

No Data

Managed Area Relations

No Data

Protection Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
16957	*Ribes americanum*	American currant	G5	S2	Y

REFERENCES

Reference ID	Full Citation
-	No Data

ADDITIONAL TOPICS

Additional Topics

No Data

VERSION

Version Date 03/26/1997

Version Author Spackman, S.C.

Level 1 Potential Conservation Area (PCA) Report

Name Pine Drive **Site Code** S.USCOHP*28427

IDENTIFIERS

Site ID 2792 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

Site Relations No Data

LOCATORS

Nation United States **Latitude** 385830N

State Colorado **Longitude** 1045114W

Quad Code	Quad Name
38104-H7	Pikeview

County

El Paso (CO)

Watershed Code	Watershed Name
11020003	Fountain

Site Directions

The site is within the US Air Force Academy in Colorado Springs. To access from the south gate, follow Southgate Blvd and turn left at Pine Dr. The site is north of Pine Dr, bounded by Community Center Dr to the north and Stadium Blvd to the east.

SITE DESCRIPTION

Minimum Elevation	6,480.00	**Feet**	1,975.10	**Meters**
Maximum Elevation	6,920.00	**Feet**	2,109.22	**Meters**

Site Description

This area is an east-west running ridge and associated slopes at the base of the Southern Rocky Mountains where it meets the Central Shortgrass Prairie. The rocky slopes and mesa are dominated by a mountain mahogany (*Cercocarpus montanus*) shrubland with scattered ponderosa pine (*Pinus ponderosa*) and junipers (*Juniperus scopulorum*). Gambel's oak (*Quercus gambelii*) may also be present but is seldom the dominant shrub. Mountain mahogany ranges from 3-15% cover. The understory is dominated by mountain muhly grass (*Muhlenbergia montana*), 20-50% and blue grama (*Bouteloua gracilis*), 5-25%. Yucca and prickly pear are frequent yet the cover is less than 3%. Weeds are mostly non-existent. There are some small patches of smooth brome (*Bromus inermis*) are in the area however the overall cover is less than 1% although some patches reach 4%. These Front Range foothill communities are often heavily disturbed and prone to weed invasion thus this area stands out due to its lack of disturbance and nearly weed free nature. Part of an archery range is within this area.

Key Environmental Factors

Geology, soil depth, drought, grazing, fires, and slopes play a critical role in determining the vegetation species composition. Fires kill or severely damage mountain mahogany, yucca, prickly pear and junipers therefore a fire will increase grass productivity until shrubs return. Mountain mahogany can stump sprout after a fire however it can be 10-20 years before the shrubs regain their density and cover. Mountain mahogany is a preferred browsing shrub for mule deer. Slopes are generally less vegetated than the mesa tops.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

SITE DESIGN

Site Map Y - Yes **Mapped Date** 03/07/2012

Designer Rondeau, R.J.

Level 1 Potential Conservation Area (PCA) Report

Name Pine Drive **Site Code** S.USCOHP*28427

Boundary Justification

The boundary is drawn to include the known occurrence, additional potential habitat, and the local mosaic of plant communities. The boundary was digitized while referencing a one meter digital color orthophoto quad, and a 1:24,000 digital quad.

Primary Area 289.05 **Acres** 116.98 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B4: Moderate Biodiversity Significance

Biodiversity Significance Comments

The site supports a good (B-ranked) occurrence of a state rare (GU/S2) *Cercocarpus montanus / Muhlenbergia montana* mountain shrubland. The global rank for this community type is unknown.

Other Values Rank No Data

Other Values Comments

No Data

Protection Urgency Rank P4: No Threat or Special Opportunity

Protection Urgency Comments

This site is within the Air Force Academy.

Management Urgency Rank M3: Needed within 5 Years to Maintain Quality

Management Urgency Comments

Most of the site has little human activity except for some trails associated with the archery range. Pine Drive and Stadium Blvd are adjacent to the site on the east and southern boundaries and the Community Center borders the northwest side. Deer utilize the site but do not appear to have much of an influence. The area is primarily used by Air Force Academy for archery practice and trail running.

LAND MANAGEMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

Noxious weeds at the site include musk thistle, myrtle spurge, Russian olive, smooth brome, and yellow toadflax.

Offsite

No Data

Information Needs

No Data

Management Needs

No Data

Managed Area Relations

No Data

Protection Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
40632	*Cercocarpus montanus / Muhlenbergia montana* Shrubland	Mixed Mountain Shrublands	GU	S2	Y

REFERENCES

Reference ID	Full Citation
200512	Siemers, J., D.G. Anderson, R. Schorr, and R. Rondeau. 2012. Final Report: United States Air Force Academy Biological Inventory. Colorado Natural Heritage Program, Fort Collins, CO.

Level 1 Potential Conservation Area (PCA) Report

Name Pine Drive **Site Code** S.USCOHP*28427

ADDITIONAL TOPICS

Additional Topics

No Data

VERSION

Version Date 03/07/2012

Version Author Rondeau, R.J.

Level 1 Potential Conservation Area (PCA) Report

Name Air Force Academy Oak Foothills **Site Code** S.USCOHP*28428

IDENTIFIERS

Site ID 2793 **Site Class** PCA

Site Alias None

Network of Conservation Areas (NCA)

NCA Site ID	NCA Site Code	NCA Site Name
-		No Data

Site Relations Overlaps Monument Creek (S.USCOHP5*201).

LOCATORS

Nation United States **Latitude** 390015N

State Colorado **Longitude** 1045353W

Quad Code	Quad Name
39104-A8	Palmer Lake
39104-A7	Monument
38104-H8	Cascade

County

El Paso (CO)

Watershed Code	Watershed Name
11020003	Fountain

Site Directions

The site is within the US Air Force Academy in Colorado Springs. To access from the north gate, follow Northgate Blvd until you reach Parade Loop. Boundary edge is at this intersection. To access from the south gate, follow Southgate Blvd and turn left at Pine Dr. Pass Interior Dr. Site starts at dirt road on the left, just past Interior Dr.

SITE DESCRIPTION

Minimum Elevation 6,220.00 **Feet** 1,895.86 **Meters**

Maximum Elevation 7,500.00 **Feet** 2,286.00 **Meters**

Site Description

The Front Range foothills near Colorado Springs are dominated by a shrubland/grassland mosaic with large patches of oak or mountain mahogany, interspersed with grasslands. Ponderosa pine are widely scattered throughout much of the area with occasional areas where it dominates. The grasslands are variable and range from mountain muhly, needle-and-thread, and blue grama to the occasional patches of Parry's oatgrass. The buckmoth (*Hemileuca grotei diana*) documented within this area utilizes the Gambel's oak as its host plant. The rare ovenbird is primarily an eastern deciduous bird that reaches its southwest extension along the Front Range. The ovenbird is a ground nester, primarily under the oak shrubland, and utilizes the ponderosa pine as singing perches to establish their territories and attract mates. Two rare plants have been documented within this site and include frostweed and Rocky Mountain phacelia. The phacelia is located amongst the mountain mahogany stands on flat areas while the frostweed is located near the oak/grassland areas.

Key Environmental Factors

Geology, soil depth, drought, grazing, fires, and slopes play a critical role in determining the vegetation species composition. Intense fires will top kill oaks however they will stump sprout. Droughts can severely prune oaks as can late spring frosts. Oak and mountain mahogany are very important food plants for wildlife.

Climate Description

No Data

Land Use History

No Data

Cultural Features

No Data

SITE DESIGN

Site Map Y - Yes **Mapped Date** 03/07/2012

Designer Rondeau, R.J.

Level 1 Potential Conservation Area (PCA) Report

Name Air Force Academy Oak Foothills **Site Code** S.USCOHP*28428

Boundary Justification

The boundary is drawn to include the known occurrences, additional potential habitat, and the local mosaic of plant communities. The boundary was digitized while referencing a one meter digital color orthophoto quad, and a 1:24,000 digital quad.

Primary Area 2,397.78 **Acres** 970.35 **Hectares**

SITE SIGNIFICANCE

Biodiversity Significance Rank B3: High Biodiversity Significance

Biodiversity Significance Comments

The site supports a good (B-ranked) occurrence of the globally vulnerable (G3/S3) *Danthonia parryi* montane grassland and a good (B-ranked) occurrence of the globally vulnerable (G3/S3) *Quercus gambelii - Cercocarpus montanus* / (*Carex geyeri*) shrubland. There is also a good (B-ranked) occurrence of the state rare (GU/S2) *Cercocarpus montanus / Muhlenbergia montana* shrubland, whose global rank is unknown, an extant occurrence of the state rare (G5/S2B) Ovenbird (*Seiurus aurocapilla*), a fair (C-ranked) occurrence of the globally vulnerable (G3/SU) Rocky Mountain phacelia (*Phacelia denticulata*), and a good to fair (BC-ranked) occurrence of the state rare (G5/S1) frostweed (*Crocanthemum bicknellii*).

Other Values Rank No Data

Other Values Comments

No Data

Protection Urgency Rank P4: No Threat or Special Opportunity

Protection Urgency Comments

This site falls on the U.S. Air Force Academy and USFS lands.

Management Urgency Rank M3: Needed within 5 Years to Maintain Quality

Management Urgency Comments

Most of the site has some use by Air Force Academy however it is largely intact. Deer, elk, wild turkey, black bear, and mountain lion are known to utilize the area.

LAND MANAGEMENT ISSUES

Land Use Comments

No Data

Natural Hazard Comments

No Data

Exotics Comments

Noxious weeds at the site include bull thistle, Canada thistle, diffuse knapweed, leafy spurge, musk thistle, Russian olive, Scotch thistle, spotted knapweed and yellow toadflax.

Offsite

No Data

Information Needs

No Data

Management Needs

No Data

Managed Area Relations

No Data

Protection Comments

No Data

ASSOCIATED ELEMENTS OF BIODIVERSITY

Element State ID	State Scientific Name	State Common Name	Global Rank	State Rank	Driving Site Rank
18196	*Phacelia denticulata*	Rocky Mountain phacelia	G3	SU	N
19228	*Danthonia parryi* Herbaceous Vegetation	Montane Grasslands	G3	S3	Y
21235	*Crocanthemum bicknellii*	frostweed	G5	S1	N
20309	*Seiurus aurocapilla*	Ovenbird	G5	S2B	N

Level 1 Potential Conservation Area (PCA) Report

Name Air Force Academy Oak Foothills **Site Code** S.USCOHP*28428

24685	*Quercus gambelii - Cercocarpus montanus / (Carex geyeri)* Shrubland	Mixed Mountain Shrublands	G3	S3	Y
40632	*Cercocarpus montanus / Muhlenbergia montana* Shrubland	Mixed Mountain Shrublands	GU	S2	N

REFERENCES

Reference ID	Full Citation
200512	Siemers, J., D.G. Anderson, R. Schorr, and R. Rondeau. 2012. Final Report: United States Air Force Academy Biological Inventory. Colorado Natural Heritage Program, Fort Collins, CO.

ADDITIONAL TOPICS

Additional Topics

No Data

VERSION

Version Date 03/07/2012

Version Author Rondeau, R.J.

APPENDIX 3
Weed Fact Sheets

Myrtle spurge

Colorado Department of Agriculture

305 Interlocken Pkwy
Broomfield, CO 80021

(303) 869-9030
weeds@state.co.us

Myrtle spurge Identification and Management

Identification and Impacts

Myrtle spurge *(Euphorbia myrsinites)* is a low growing perennial with trailing fleshy stems. The leaves are fleshy, blue-green and alternate. Flowers are inconspicuous with yellow-green, petal-like bracts that appear from March to May. Myrtle spurge spreads by seed and plants are capable of projecting seeds up to 15 feet. The plant grows from a taproot, with new stems emerging in early spring and dying back in the winter. Plants can grow up to 8-12 inches high and 12-18 inches in width.

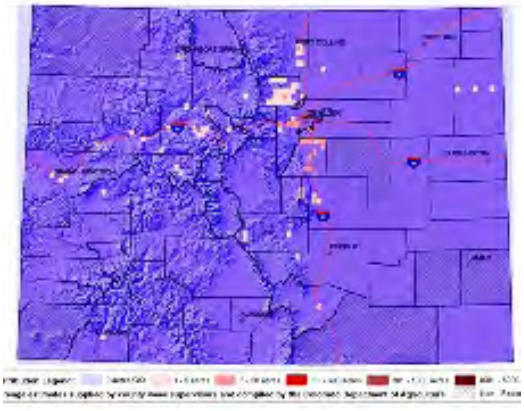
Myrtle spurge contains a toxic, milky sap which can cause severe skin irritations, including blistering. This plant is poisonous if ingested; causing nausea, vomiting and diarrhea. Wearing gloves, long sleeves, shoes, and eye protection is highly recommended when in contact with myrtle spurge, as all plant parts are considered poisonous.

Myrtle spurge is an invasive ornamental that is native to Eurasia. It is popular with xeriscapes and rock gardens, preferring sunny to partly sunny areas and well drained soils. Myrtle spurge rapidly escapes gardens and invades sensitive ecosystems, out competing native vegetation and reducing wildlife forage. Alternatives to planting myrtle spurge include native plants such as sulphur flower (*Erigonum umbellatum*), Kinnikinnick *(artcostaphylos uvursi*), or creeping mahonia (*Mahonia repens*). The soil seed reserve of myrtle spurge is estimated to be eight years. The site must be monitored for at least nine years after the last flowering adult plants have been eliminated and treatments repeated when necessary.

The key to effective control of myrtle spurge is to remove plants prior to seed set and to detect and remove new populations in natural areas early on. Small areas can be easily removed by mechanical means but should be done early to prevent triggering seed launching. Details on the back of this sheet can help to create a management plan compatible with your site ecology.

Myrtle spurge is designated as a "List A" species in the Colorado Noxious Weed Act. It is designated for statewide eradication. For more information visit www.colorado.gov/ag/weeds and click on the Noxious Weed Management Program. Or call the State Weed Coordinator at the Colorado Department of Agriculture, Conservation Services Division, 303-239-4100.

Map of myrtle spurge infestation.



Key ID Points

1. Low growing plant with blue-green, waxy leaves.
2. Flowers are yellow-green petal like bracts that appear from March to May.

Updated on: 7/2015

Euphorbia myrsinites

Photos © Kelly Uhing, Colorado Department of Agriculture and (above) Crystal Andrews, Colorado Department of Agriculture.

Management Recommendations

CULTURAL
Keeping desirable vegetation healthy and thick will help keep invaders out. Prevent the establishment of new infestations by minimizing disturbance and seed dispersal. Survey your land regularly to detect new invaders and eradicate any new populations quickly.

BIOLOGICAL
Biocontrol is not an approved method of contol for State List A species. Eradication as the management objective for all List A species. For more information on insect biocontrol in Colorado, please contact the Palisade Insectary of the Colorado Department of Agriculture at 970-464-7916

MECHANICAL
Hand pull or dig when soil is moist. Make certain to pull all the roots and wear rubber gloves and eye protection to protect yourself from the toxic milky sap. Treatment follow up is important to check root fragment resprouts that will occure when the tap root is severed too shallow.

Integrated Weed Management:

Since Myrtle spurge spreads mainly by seed, it is very important to prevent seed production and deplete the seed bank. Remove mature plants prior to setting seed and seedlings whenever present.

Populations can be managed mechanically and by spot treatment of herbicides. It is important to be persistent with follow up treatments for many years.

Myrtle spurge

HERBICIDES

NOTE: The following are recommendations for herbicides that can be applied to range and pasturelands. Rates are approximate and based on equipment with an output of 30 gal/acre. Please read label for exact rates. **Always read, understand, and follow the label directions. The herbicide label is the LAW!**

Herbicide	Rate	Application Timing
2,4-D ester	2 qt./acre + 1% v/v methylated seed oil	Use a 2,4-D ester formulation that has a 4.0 lbs. active ingredient/acre. Apply during spring or during fall regrowth.
Dicamba + 2,4-D	1 pint/acre dicamba + 2-3 pints/acre 2,4-D (amine or ester)	Use a 2,4-D formulation that has a 4 lbs. active ingredient/gallon. Apply during spring or during fall regrowth.
Picloram (Tordon/Picloram 22K - Restricted use pesticide) + 2,4-D	20 oz./acre + 2-3 pints/acre 2,4-D (amine or ester)	Apply at flowering growth stage during spring or to fall regrowth. DO NOT use near trees, desirable shrubs, water, or high water table.
Additional herbicide recommendations for other species can be found at: www.colorado.gov/agconservation/CSUHerbicideRecommendations.pdf		

Top to bottom photos © Unknown, A. Murray, Univ. of Florida; USDA ARS Archive; and unknown.

Bouncingbet

Colorado Department of Agriculture

305 Interlocken Pkwy
Broomfield, CO 80021

(303) 869-9030
weeds@state.co.us

Bouncingbet Identification and Management

Identification and Impacts

Bouncingbet *(Saponaria officinalis)* is a perennial forb. The flowers are crowded at the ends of branches, and have five petals that are generally light pink to white and slightly notched at the apex. Flowering begins in July and continues until September. The fruits are many-seeded capsules and seeds are dull-black and roundish or kidney-shaped. Bouncingbet reproduces by seed and spreads by rhizomatous swollen nodes. Leaves are opposite, smooth, narrow, 2 to 4 inches long and have three distinct veins from the base. The stems are erect, sparingly branched, smooth, and forming. Mature plants grow up to three feet tall.

Bouncingbet can be poisonous to livestock and humans. It is generally considered unpalatable to livestock. The plant contains sapogenic glycosides that cause gastrointestinal irritation and can destroy red blood cells when absorbed in the blood streams of grazing animals.

The habitat of Bouncingbet is often found in large dense patches on hillsides, along rivers, roadsides, meadows, and waste areas. It prefers moist, well-drained soil, and full sun to partial shade and is currently found primarily in municipal areas and nearby wildlands. Bouncingbet spreads rapidly, replacing more valuable species (e.g. perennial grasses). Bouncingbet is increasingly common in Colorado, particularly in residential areas and local open spaces where it has escaped as an ornamental species. Bouncingbet was originally introduced from Europe as a garden ornamental.

The key to effective control of Bouncingbet is early detection and prevention of new infestations, since it is not yet widespread in Colorado. If infestations are discovered, they should be controlled immediately, and all seed production prevented. Since Bouncingbet usually grows in dense patches it is relatively easy to spot and treat. Be aware that this species is often found in wet areas, which may restrict the use of certain herbicides. As with all perennial weeds that have extensive root systems, the key to controlling Bouncingbet, is to eliminate seed production while depleting the nutrient reserves in the roots. Details on the back of this sheet can help to create a management plan compatible with your site ecology.

Bouncingbet is designated as a "List B" species in the Colorado Noxious Weed Act. It is required to be either eradicated, contained, or suppressed depending on the local infestations. For more information visit www.colorado.gov/ag/csd and click on the Noxious Weed Management Program. Or call the State Weed Coordinator at the Colorado Department of Agriculture, Conservation Services Division, 303-239-4100.

Photos © Lower left by: Ohio State Weed Lab Archive, Ohio State University, Bugwood.org; Richard Old, XID Services, Inc., Bugwood.org; All others by Kelly Uhing, Colorado Department of Agriculture.

Key ID Points

1. Leaves are opposite, smooth, narrow, and 2-4 inches long.
2. Flowers have five petals and are generally light pink to white.

Updated on: 08/08

Saponaria officinalis

Management Recommendations

CULTURAL
Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities. Contact your local Natural Resources Conservation Service for seed mix recommendations. Maintain healthy pastures and prevent bare spots caused by overgrazing.

BIOLOGICAL
There is no biological control available for Bouncingbet. Since biological control agents take years to research, develop and release, no releases are expected in the foreseeable future. For more information, contact the Palisade Insectary of the Colorado Department of Agriculture at 970-464-7916.

MECHANICAL
Physical or mechanical control of Bouncingbet is NOT recommended because the plant reproduces clonally from its root system. Handpull or dig only single plants/new infestations when soil is moist to make certain entire root system is excavated.

Integrated Weed Management:

Since Bouncingbet usually grows in dense patches it is relatively easy to spot and treat. Be aware that this species is often found in wet areas, which may restrict the use of certain herbicides. As with all perennial weeds that have extensive root systems, the key to controlling Bouncingbet is to eliminate seed production while depleting the nutrient reserves in the roots.

Bouncingbet

HERBICIDES

NOTE: The following are recommendations for herbicides that can be applied to range and pasturelands. Rates are approximate and based on equipment with an output of 30 gal/acre. Please read label for exact rates. **Always read, understand, and follow the label directions. The herbicide label is the LAW!**

HERBICIDE	RATE	APPLICATION TIMING
Chlorsulfuron (Telar)	1 oz product/A + 0.25% v/v	Apply at bolting to bud growth stage. (Late Spring to Mid Summer)

Bull thistle

Cirsium vulgare (Savi) Tenore

Keys to Identification

- Leaves are prickly-hairy above and cottony below
- Has stiff pointy spines on leaf tips

This information courtesy of the Colorado Natural Areas Program

Family: Asteraceae (Composite)

Other Names: common thistle, spear thistle, fuller's thistle

USDA Code: CIVU

Legal Status: Colorado Noxious Weed List B

Identification

Lifecycle: Biennial

Growth form: forb/herb

Flower: Flowers are 1.5-2 in wide and clustered at the ends of branches. The flower bracts are somewhat tapered and covered with spines (Whitson et al. 1996). Flowers are pinkish to dark purple.

Seeds/Fruit: Seeds are capped with a circle of plume-like white hairs.

Leaves: Leaves are alternate. Bull thistle is the only thistle in Colorado that are prickly hairy on the top surface of the leaves and cottony-hairy on the undersides.

Stems: In mature plants the leaves extend down, clasping the stem and are divided into

segments (i.e. strongly decurrent).

Roots: Has a short, fleshy taproot with several primary roots extending from the root crown. Each bears a number of smaller lateral roots.

Seedling: Seed leaves (cotyledons) are round to spatulate (spoon shaped), and smooth. First true leaves are oval to spatulate with spines and a rough, bumpy surface (Carey et al. 1993). First year plants form a rosette with leaves easily distinguished from other thistles by the above leaf characteristics.

Similar Species

Exotics: Could be confused with musk thistle.

Natives: There are many native *Cirsium* species, some common *(Cirsium undulatum)* some rare *(Cirsium perplexans)*. The natives generally do not have leaves clasping the stem all the way from node to node (strongly decurrent leaves), and many have hairy upper and lower leaf surfaces and are blue-green or gray.

Impacts

Agricultural: Heavy infestations can exclude livestock from areas. Additionally, the presence of bull thistle in hay decreases the forage value and lowers the market price (Zimmerman 1997). It is an aggressive weed, but it will not survive where cultivation has cut back its stem and destroyed its root system (FEIS 1998).

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)

Human: Bull thistle has been reported to cause hay fever in some individuals (FEIS 1998).

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 1998). Potential habitats include pastures, overgrazed rangeland, roadsides, and logged areas.

Distribution: Within Colorado bull thistle infestations have been reported to occur in nearly all counties west of the continental divide, this plant has also been observed in the Upper Arkansas Watershed and in pockets on the plains. 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: Biennial

Mode of reproduction: Seed

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 1998). 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 in may remain viable for up to 3 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).

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 preventative measure against bull thistle. Chemical control is most effective when rosettes are targeted (fall or spring depending on population density and the plant's stage of growth). Mechanical controls can be used to eliminate small populations or plants in a later growth stage. To be effective plants with buds or flowers should be collected and immediately either landfilled or destroyed in a method that eliminates seeds.

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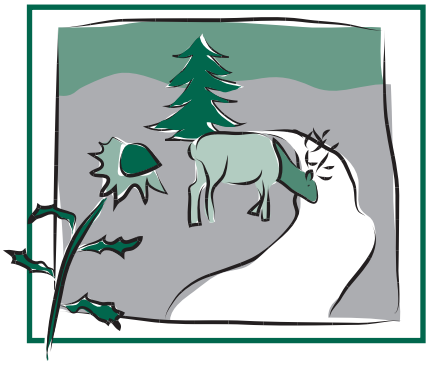
Extension



Canada Thistle

Fact Sheet No. **3.108** Natural Resources Series | **Range**

by K.G. Beck*

Canada thistle (*Cirsium arvense*) is an aggressive, creeping perennial weed that infests crops, pastures, rangeland, roadsides and noncrop areas. Generally, infestations start on disturbed ground, including ditch banks, overgrazed pastures, tilled fields or abandoned sites. Canada thistle reduces forage consumption in pastures and rangeland because cattle typically will not graze near infestations. In 2002, the Colorado Department of Agriculture surveyed counties and while incomplete, the results showed more than 100,000 acres infested with Canada thistle (Figure 1).

One plant can colonize an area 3 to 6 feet in diameter in one or two years. Canada thistle grows in a variety of soils and can tolerate up to 2 percent salt content. It is most competitive in deep, well-aerated, productive, cool soils. It usually occurs in 17- to 35-inch annual precipitation zones or where soil moisture is adequate. It is less common in light, dry soils. A survey conducted in 1998 showed Colorado has about 400,000 acres infested with Canada thistle.

Phenology

Emergence. Canada thistle develops from seed or vegetative buds in its root system. Horizontal roots may extend 15 feet or more and vertical roots may grow 6 to 15 feet deep. Canada thistle emerges from its root system in mid- to late spring (late April through May) and forms rosettes (Figure 2).

The greatest flush of root-derived plants occurs in spring, but another flush occurs in fall. A flush can occur anytime during the growing season when soil moisture is adequate. This is particularly a problem when Canada thistle growth is disturbed by tillage or herbicides. This feature can be manipulated to the land manager's advantage.

Plants that germinate from seed do so at about the same time as root-derived shoots. Seedlings grow slowly and are sensitive to competition, particularly if shaded. Canada thistle seedlings develop a perennial habit (the ability to reproduce from their root systems) about seven to eight weeks after germination.

Reproduction and spread. Canada thistle begins to flower in late spring to early summer in response to 14- to 16-hour days (Figures 3, 4 and 5). Plants are male or female (dioecious) and grow in circular patches that often are one clone and sex. Female flowers produce a sweet odor and insects readily pollinate different sexed patches up to 200 feet apart.

Canada thistle develops seed sparingly. It may produce 1,000 to 1,500 seeds per flowering shoot. Generally, vegetative reproduction from its root system contributes to local spread and seed to long distance dispersal. Seed may be transported long distances by water, or attached to animals, clothing, farm equipment and other vehicles, and in contaminated crop seed. Also, wind may help disperse seed, but most often, the feathery pappus breaks off, leaving the seed attached to the parent plant to be dispersed by other means. Seed can remain viable in soil up to 22 years, and deep burial promotes survival longevity.

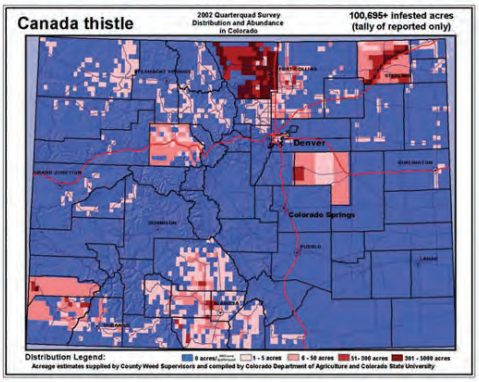


Figure 1: 2002 distribution of Canada thistle in Colorado.

Quick Facts

- Canada thistle is a creeping perennial that reproduces from vegetative buds in its root system and from seed.
- It is difficult to control because its extensive root system allows it to recover from control attempts.
- Combining control methods is the best form of Canada thistle management.
- Persistence is imperative so the weed is continually stressed, forcing it to exhaust root nutrient stores and eventually die.

www.ext.colostate.edu

*Colorado State University Extension weed science specialist and professor, bioagricultural sciences and pest management. 11/2013

Figure 2: Emerged Canada thistle rosettes from roots in early spring.

Figure 3: Canada thistle bolting growth stage in spring.

Canada thistle allocates most of its reproductive energy into vegetative propagation. New shoots and roots can form almost anywhere along the root system of established plants (Figure 6). Tillage segments roots and stimulates new plants to develop. Shoots emerge from root and shoot pieces about 15 days after disturbance by tillage. Small root pieces, 0.25 inch long by 0.125 inch in diameter, have enough stored energy to develop new plants. Also, these small roots can survive at least 100 days without nutrient replenishment from photosynthesis.

Management

The key principle to Canada thistle control is to stress the plant and force it to use stored root nutrients. Canada thistle can recover from almost any stress, including control attempts, because of root nutrient stores. Therefore, returning infested land to a productive state occurs only over time. Success requires a sound management plan implemented over several years.

Cultural control. Grasses and alfalfa can compete effectively with Canada thistle if their growth is favored by good management. Maintain fertility and, if possible, moisture at optimum levels to favor grass or alfalfa growth. Soil analysis can easily determine fertility needs. Be cautious with nitrogen fertilizers, because excess available soil nitrogen may favor weed growth.

These are essential management steps to ensure optimum desirable plant growth and competition. However, competition alone seldom is effective against Canada thistle.

Chemical control. Read the label, follow directions and use precautions. Research at Colorado State University shows that Tordon 22K (picloram), Milestone (aminopyralid), Transline (clopyralid), Perspective (aminocyclopyrachlor + chlorsulfuron), Banvel/ Vanquish/Clarity (dicamba), and Telar (chlorsulfuron) are effective against Canada thistle in pastures, rangeland, natural areas, and noncrop settings. Canada thistle is difficult to control and re-treatment for one to three or more years after the initial application is common. Refer to Table 1 for use rates and application timing and always read the herbicide label before using the product. These herbicides are most effective when combined with cultural and/or mechanical control.

Colorado State University data also indicates that Banvel/Vanquish/Clarity or Telar are effective when combined with 2,4-D as a split-season application.

Apply 2,4-D, 2 quarts per acre (A), in spring when Canada thistle is 10 to 15 inches tall, in pre-bud to early bud growth stages. Re-treat in fall with Banvel/ Vanquish/Clarity (2 quarts/A) or Telar (1 ounce/A) to re-growth. Use a surfactant (0.25 percent to 0.5 percent v/v; equivalent to 1 to 2 quarts of surfactant per 100 gallons of spray solution) with Telar for adequate control. Perspective should be applied in spring from the rosette to flower bud growth stages or in fall. CSU research shows that aminocyclopyrachlor (one of the Perspective components) and aminopyralid (Milestone) are absorbed primarily by the root system.

Curtail is clopyralid plus 2,4-D and is effective on Canada thistle but control tends to be less than from Transline. Research at Colorado State University shows that the performance of Curtail to control Canada thistle can be improved when preceded by two or three mow¬ings. When Canada thistle infestations occur in situations where root growth would be restricted, such as habitats with high water tables, begin mowing when it is 12 to 15

Table 1. Herbicide to control Canada thistle in pastures, rangeland, natural, and noncrop areas.

Herbicide	Rate (Product/A)	Application timing	Comments
Tordon	1 quart	Anytime when weeds are rapidly growing	Fall applications consistent results; may need re-treatment 1 to 2 years
Milestone	5 to 7 fl oz	Spring at pre-flower-bud growth stage; or fall	Use higher rate for older or dense stands; Milestone may be used to edge of ponds or streams; may need re-treatment 1 to 2 years
Transline	0.67 to 1.33 pints	Spring after all shoots have emerged, rosette to early bud growth stages; or fall	Apply 1 pint/A or more in fall; may need re-treatment 1 to 3 years
Perspective	5.5 oz	Spring rosette to flower bud growth stage; or fall	Use with a non-ionic surfactant at 0.25% v/v
Telar	1 oz	Spring bolting to bud growth stages; or fall	Fall applications most consistent results; essential to use non-ionic surfactant at 0.25% v/v; may need retreatment 1 to 2 years
Banvel, Vanquish, or Clarity (dicamba)	2 quarts	Spring rosette growth stage; or fall	Fall applications most consistent results; may need re-treatment 2 to 4 years

Figure 4: Canada thistle in the late bud growth stage.

Figure 5: Canada thistle in flowering growth stage.

Figure 6: Canada thistle root system after 14 months growth from 25 vegetative shoot cuttings.

inches tall. Repeat mowings at about one month inter-vals. Apply Curtail at 2 to 3 quarts/A in October or about one month after the third mowing. Follow this regimen for two consecutive years.

Mechanical control. Mowing hay meadows can be an effective tool if combined with herbicide treatments. Mowing alone is not effective unless conducted at one-month intervals over several growing seasons. Always combine mowing with cultural and chemical control. Mowing at hay cutting stimulates new Canada thistle shoots to develop from its root system.

In irrigated grass hay meadows, fall herbicide treatments that follow mowing can be an effective management system because more Canada thistle foliage is present after cutting to intercept herbicide. Additionally, root nutrient stores decrease after mowing because the plant draws on them to develop new shoots.

If a Canada thistle infestation exists in a field that will be rotated to alfalfa, control the weed before seeding alfalfa. Alfalfa is an effective competitor only after it is established. It will not adequately establish in a well-developed Canada thistle infestation. A Canada thistle management system can start with crop or grass competition combined with herbicides, with the field rotated to alfalfa when the management plan ends.

Biological control. *Ceutorhyncus litura* is a weevil currently used as a biocontrol agent in Colorado. The female lays eggs on the underneath side of Canada thistle leaves in early spring. Larvae bore into the main leaf vein, then down into the plant's crown area. If the population is high enough, plant death can occur, otherwise Canada thistle is stressed and less vigorous.

Ceutorhyncus alone will not effectively control Canada thistle. It must be combined with other methods to be successful. Combine the weevil with cultural techniques that allow for maximum desirable plant competition. Research to combine *Ceutorhyncus* with herbicides or mowing has not been conducted. Research has shown that biological and chemical controls are compatible for musk thistle. This is most likely true for Canada thistle as well. *Ceutorhyncus litura* is available from the Colorado Department of Agriculture.

Urophora cardui is another biocontrol insect available from the Colorado Department of Agriculture. Females lay eggs on apical meristems of developing shoots. Larvae burrow into shoots. Their feeding triggers huge galls to form that stress the plant, sometimes killing it. Galls that form near the terminal meristems (e.g., where flowers develop) keep the weed from flowering and reduce seed set.

Canada Thistle Identification and Management

List B

Canada thistle (*Cirsium arvense*) is a non-native, deep-rooted perennial that spreads by seeds and aggressive creeping, horizontal roots called rhizomes. Canada thistle can grow 2 to 4 feet in height. The leaves are oblong, spiny, bright green, and slightly hairy on the undersurface. Unlike other noxious biennial thistles which have a solitary flower at the end of each stem, Canada thistle flowers occur in small clusters of 1 to 5 flowers. They are about 1 cm in diameter, tubular shaped, and vary from white to purple in color.

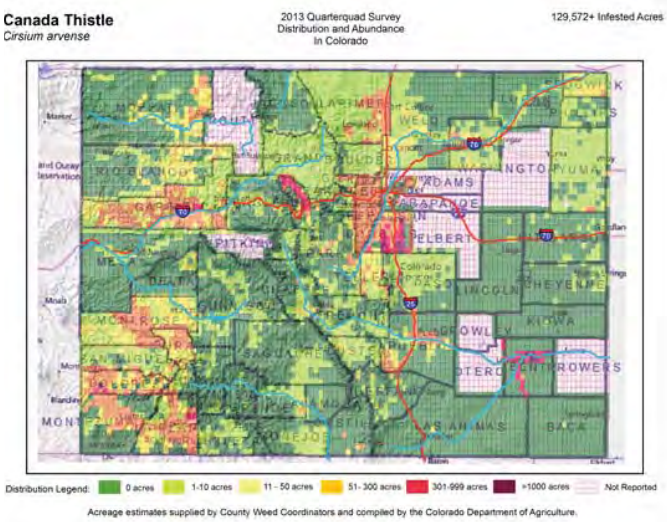
Canada thistle emerges from its root system from late April through May. It flowers in late spring and throughout the summer. It produces about 1,000 to 1,500 seeds per plant that can be wind dispersed. Seeds survive in the soil for up to 20 years. Additionally, Canada thistle reproduces vegetatively through its root system, and quickly form dense stands. Each fragmented piece of root, 0.25 inch or larger, is capable of forming new plants. The key to controlling Canada thistle is to eliminate seed production and to reduce the plant's nutrient reserves in its root system through persistent, long-term management.

Canada thistle is one of the most troublesome noxious weeds in the U.S. It can infest diverse land types, ranging from roadsides, ditch banks, riparian zones, meadows, pastures, irrigated cropland, to the most productive dryland cropland. Large infestations significantly reduce crop and cattle forage production and native plant species. It is a host plant to several agricultural pests and diseases. Canada thistle prefers moist soils, but it can be found in a variety of soil types. It has been found at elevations up to 12,000 feet.

Effective Canada thistle control requires a combination of methods. Prevention is the most important strategy. Maintain healthy pastures and rangelands, and continually monitor your property for new infestations. Established plants need to be continually stressed. Management options become limited once plants begin to produce seeds. Details on the back of this sheet can help to create a management plan compatible with your site ecology.

Canada thistle is designated as a "List B" species as described in the Colorado Noxious Weed Act. It is required to be either eliminated, contained, or suppressed depending on the local infestations. For more information visit www.colorado.gov/ag/weeds and click on the Noxious Weed Program link or call the State Weed Coordinator at the Colorado Department of Agriculture, Conservation Services Division, (303) 869-9030.

2013 Quarter Quad Survey



Key ID Points

1. Cluster of 1-5 white to purple flowers on a stem.
2. Floral bracts are spineless.
3. Small flowers that are 1 cm in diameter.
4. Perennial, rhizomatous plant with spiny, oblong, green leaves.

Canada thistle

Cirsium arvense

List B

Integrated Weed Management Recommendations

Canada thistle

Cirsium arvense

Integrated weed management is imperative for effective Canada thistle control. This weed needs to be continually stressed, forcing it to exhaust root nutrient stores, and eventually die. Mowing or grazing can be followed up with herbicide application. Avoid hand-pulling and tilling which can stimulate the growth of new plants.

CULTURAL

Prevention is the best control strategy. Maintain healthy pastures , riparian areas, and rangelands. Prevent bare ground caused by overgrazing, and continually monitor your property for new infestations. Establishment of select grasses can be an effective control.

BIOLOGICAL

Cattle, goats, and sheep will graze on Canada thistle when plants are young and succulent in the spring. Follow up grazing with a fall herbicide application. Insects are available, and provide limited control. Currently, collection and distribution methods for Canada thistle rust (*Puccinia punctiformis*) are being refined. For more information on Canada thistle biocontrol, contact the Colorado Department of Agriculture - Palisade Insectary at (970) 464-7916.

MECHANICAL

Due to Canada thistle's extensive root system, hand-pulling and tilling create root fragments and stimulate the growth of new plants. Mowing can be effective if done every 10 to 21 days throughout the growing season. Combining mowing with herbicides will further enhance Canada thistle control.

CHEMICAL

The table below includes recommendations for herbicides that can be applied to rangeland and some pastures. Treatments may be necessary for an additional 1 to 3 years because of root nutrient stores. Always read, understand, and follow the label directions.

HERBICIDE	RATE	APPLICATION TIMING
Aminopyralid (Milestone)	5-7 oz/acre or 1 teaspoon/gal water	Apply in spring until flowering and/or to fall regrowth. Add 0.25% v/v non-ionic surfactant (equivalent to 0.32oz/ gal water or 1 qt/100 gal water). Can also add chlorsulfuron (Telar) at 1 oz/acre to the mix.
Aminoclopyrachlor + chlorsulfuron (Perspective)	5.5 oz product/acre + 0.25% v/v non-ionic surfactant	Apply in spring from rosette to flower bud stage and/or fall regrowth. Important: Applications greater than 5.5 oz product/acre exceeds the threshold for selectivity. DO NOT treat in the root zone of desirable trees and shrubs. Not permitted for use in the San Luis Valley.
Clopyralid + triclopyr (Prescott; others)	3 pints product/acre or 1.25 oz/gal water	Apply in spring until flowering and/or fall regrowth. Add 0.25% v/v non-ionic surfactant.

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Rev. 10/14

Figure 2: Emerged Canada thistle rosettes from roots in early spring.

Figure 3: Canada thistle bolting growth stage in spring.

Canada thistle allocates most of its reproductive energy into vegetative propagation. New shoots and roots can form almost anywhere along the root system of established plants (Figure 6). Tillage segments roots and stimulates new plants to develop. Shoots emerge from root and shoot pieces about 15 days after disturbance by tillage. Small root pieces, 0.25 inch long by 0.125 inch in diameter, have enough stored energy to develop new plants. Also, these small roots can survive at least 100 days without nutrient replenishment from photosynthesis.

Management

The key principle to Canada thistle control is to stress the plant and force it to use stored root nutrients. Canada thistle can recover from almost any stress, including control attempts, because of root nutrient stores. Therefore, returning infested land to a productive state occurs only over time. Success requires a sound management plan implemented over several years.

Cultural control. Grasses and alfalfa can compete effectively with Canada thistle if their growth is favored by good management. Maintain fertility and, if possible, moisture at optimum levels to favor grass or alfalfa growth. Soil analysis can easily determine fertility needs. Be cautious with nitrogen fertilizers, because excess available soil nitrogen may favor weed growth.

These are essential management steps to ensure optimum desirable plant growth and competition. However, competition alone seldom is effective against Canada thistle.

Chemical control. Read the label, follow directions and use precautions. Research at Colorado State University shows that Tordon 22K (picloram), Milestone (aminopyralid), Transline (clopyralid), Perspective (aminocyclopyrachlor + chlorsulfuron), Banvel/ Vanquish/Clarity (dicamba), and Telar (chlorsulfuron) are effective against Canada thistle in pastures, rangeland, natural areas, and noncrop settings. Canada thistle is difficult to control and re-treatment for one to three or more years after the initial application is common. Refer to Table 1 for use rates and application timing and always read the herbicide label before using the product. These herbicides are most effective when combined with cultural and/or mechanical control.

Colorado State University data also indicates that Banvel/Vanquish/Clarity or Telar are effective when combined with 2,4-D as a split-season application.

Apply 2,4-D, 2 quarts per acre (A), in spring when Canada thistle is 10 to 15 inches tall, in pre-bud to early bud growth stages. Re-treat in fall with Banvel/ Vanquish/Clarity (2 quarts/A) or Telar (1 ounce/A) to re-growth. Use a surfactant (0.25 percent to 0.5 percent v/v; equivalent to 1 to 2 quarts of surfactant per 100 gallons of spray solution) with Telar for adequate control. Perspective should be applied in spring from the rosette to flower bud growth stages or in fall. CSU research shows that aminocyclopyrachlor (one of the Perspective components) and aminopyralid (Milestone) are absorbed primarily by the root system.

Curtail is clopyralid plus 2,4-D and is effective on Canada thistle but control tends to be less than from Transline. Research at Colorado State University shows that the performance of Curtail to control Canada thistle can be improved when preceded by two or three mow¬ings. When Canada thistle infestations occur in situations where root growth would be restricted, such as habitats with high water tables, begin mowing when it is 12 to 15

Table 1. Herbicide to control Canada thistle in pastures, rangeland, natural, and noncrop areas.

Herbicide	Rate (Product/A)	Application timing	Comments
Tordon	1 quart	Anytime when weeds are rapidly growing	Fall applications consistent results; may need re-treatment 1 to 2 years
Milestone	5 to 7 fl oz	Spring at pre-flower-bud growth stage; or fall	Use higher rate for older or dense stands; Milestone may be used to edge of ponds or streams; may need re-treatment 1 to 2 years
Transline	0.67 to 1.33 pints	Spring after all shoots have emerged, rosette to early bud growth stages; or fall	Apply 1 pint/A or more in fall; may need re-treatment 1 to 3 years
Perspective	5.5 oz	Spring rosette to flower bud growth stage; or fall	Use with a non-ionic surfactant at 0.25% v/v
Telar	1 oz	Spring bolting to bud growth stages; or fall	Fall applications most consistent results; essential to use non-ionic surfactant at 0.25% v/v; may need retreatment 1 to 2 years
Banvel, Vanquish, or Clarity (dicamba)	2 quarts	Spring rosette growth stage; or fall	Fall applications most consistent results; may need re-treatment 2 to 4 years

Figure 4: Canada thistle in the late bud growth stage.

Figure 5: Canada thistle in flowering growth stage.

Figure 6: Canada thistle root system after 14 months growth from 25 vegetative shoot cuttings.

inches tall. Repeat mowings at about one month inter-vals. Apply Curtail at 2 to 3 quarts/A in October or about one month after the third mowing. Follow this regimen for two consecutive years.

Mechanical control. Mowing hay meadows can be an effective tool if combined with herbicide treatments. Mowing alone is not effective unless conducted at one-month intervals over several growing seasons. Always combine mowing with cultural and chemical control. Mowing at hay cutting stimulates new Canada thistle shoots to develop from its root system.

In irrigated grass hay meadows, fall herbicide treatments that follow mowing can be an effective management system because more Canada thistle foliage is present after cutting to intercept herbicide. Additionally, root nutrient stores decrease after mowing because the plant draws on them to develop new shoots.

If a Canada thistle infestation exists in a field that will be rotated to alfalfa, control the weed before seeding alfalfa. Alfalfa is an effective competitor only after it is established. It will not adequately establish in a well-developed Canada thistle infestation. A Canada thistle management system can start with crop or grass competition combined with herbicides, with the field rotated to alfalfa when the management plan ends.

Biological control. *Ceutorhyncus litura* is a weevil currently used as a biocontrol agent in Colorado. The female lays eggs on the underneath side of Canada thistle leaves in early spring. Larvae bore into the main leaf vein, then down into the plant's crown area. If the population is high enough, plant death can occur, otherwise Canada thistle is stressed and less vigorous.

Ceutorhyncus alone will not effectively control Canada thistle. It must be combined with other methods to be successful. Combine the weevil with cultural techniques that allow for maximum desirable plant competition. Research to combine *Ceutorhyncus* with herbicides or mowing has not been conducted. Research has shown that biological and chemical controls are compatible for musk thistle. This is most likely true for Canada thistle as well. *Ceutorhyncus litura* is available from the Colorado Department of Agriculture.

Urophora cardui is another biocontrol insect available from the Colorado Department of Agriculture. Females lay eggs on apical meristems of developing shoots. Larvae burrow into shoots. Their feeding triggers huge galls to form that stress the plant, sometimes killing it. Galls that form near the terminal meristems (e.g., where flowers develop) keep the weed from flowering and reduce seed set.

Common

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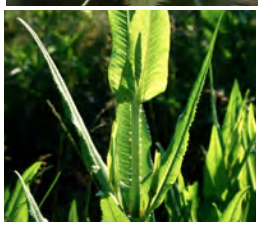
Common teasel Identification and Management



Key ID Points

1. Grows over 6 feet tall.
2. Leaves at the base are dark green and appear rippled.
3. Flowers are purple or white.

Identification and Impacts

Common teasel *(Dipsacus spp.)* is a biennial or sometimes monocarpic perennial forb. The fruits are a four-angled achene, each containing a single seed. Common teasel can produce more than 2,000 seeds per plant. The flowers are purple or white with spiny, awned bracts at the base. The flower head is generally egg-shaped, with a square base. The floral bracts at the base of the head are generally longer than the head. Rosette leaves are conspicuously veined, with stiff prickles on the lower midrib and appear to be wrinkled. Stem leaves are simple, opposite, net-veined, stalkless, and clasp the stem. Mature plants can grow up to or over six feet tall. The taprooted stem is rigid with several rows of downward turned prickles. Plants die after production of seed has occurred.

Habitats for Common teasel include open, sunny habitats that range from wet to dry levels. It is generally found along irrigation ditches, rivers, abandoned fields, pastures, waste places, and forests. Common teasel is spreading rapidly in America, particularly in the Pacific Northwest. In Colorado, teasel is usually found in relatively moist, disturbed situations but is moving into drier areas. Seeds can stay viable for at least 2 years. Seeds don't generally disperse far form the parent plant. Plants can regenerate fairly easily, due to the bare ground where the basal leaves were. Common teasel is native to Europe where it historically had many uses.

The key to effective control of Common teasel is prevention. Eliminate seed production to decrease the spread of this forb, and continue to deplete the seed bank for four to six years. Reseeding areas with perennial grasses for several years will reduce an infestation. Mechanical and chemical control methods are effective when dealing with Common teasel. Details on the back of this sheet can help to create a management plan compatible with your site ecology.

Common teasel is designated as a "List B" species in the Colorado Noxious Weed Act. It is required to be either eradicated, contained, or suppressed depending on the local infestations. For more information visit www.colorado.gov/ag/weeds and click on the Noxious Weed Management Program. Or call the State Weed Coordinator at the Colorado Department of Agriculture, Conservation Services

Photos © Kelly Uhing, Colorado Department of Agriculture.

Dipsacus spp.

Updated on: 08/08

Management Recommendations

http://www.colorado.gov/ag/weeds

Common teasel

CULTURAL
Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities. Contact your local Natural Resources Conservation Service for seed mix recommendations. Maintain healthy pastures and prevent bare spots caused by overgrazing.

BIOLOGICAL
There is no biological control available for Common teasel. Since biological control agents take years to research, develop and release, no releases are expected in the foreseeable future. For more information, contact the Palisade Insectary of the Colorado Department of Agriculture at 970-464-7916.

MECHANICAL
Treatments such as digging and cutting can be effective in certain situations. Digging at the rosette and bolting stage, making sure that the majority of the root comes up, can be effective. Cutting plants when near the flowering stage is also effective. When using either of these methods, revisiting the site frequently is recommended to ensure regrowth does not occur.

Integrated Weed Management:

The key to controlling Common teasel is to eliminate seed production and exhaust the seed bank in the soil. Common teasel does not reproduce vegetatively and dies after seed production.

Mechanical and chemical control methods can be effective.

HERBICIDES

NOTE: The following are recommendations for herbicides that can be applied to range and pasturelands. Rates are approximate and based on equipment with an output of 30 gal/acre. Please read label for exact rates. **Always read, understand, and follow the label directions. The herbicide label is the LAW!**

HERBICIDE	RATE	APPLICATION TIMING
Metsulfuron (Escort XP)	1 oz. of product/ac. + 0.25% v/v non-ionic surfactant	Apply when in rosette or bolting growth stage. (Spring or Fall rosettes or Early summer bolting)
Aminopyralid (Milestone)	4 to 7 fl. oz./ac. (start with 7 fl. oz.) + 0.25% v/v non-ionice surfactant	Apply when in rosette or bolting growth stage. Best choice of herbicide to use in riparian areas. (Spring or Fall rosettes or Early summer bolting)
Imazapic (Plateau)	8 to 12 fl. oz./ac. + 2 pt/ac. methylated seed oil	Apply when in rosette or bolting growth stage. Good choice of herbicide to use in riparian areas. (Spring or Fall rosettes or Early summer bolting)

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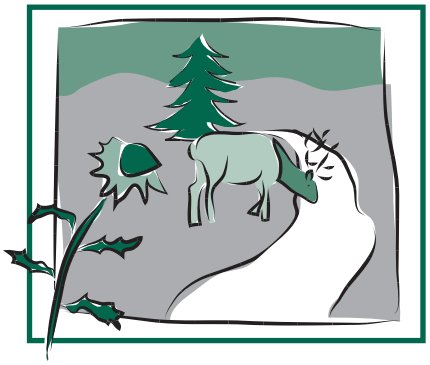
Biology and Management of the Toadflaxes

Fact Sheet No. **3.114** Natural Resources Series | **Range**



by K.G. Beck*

Yellow toadflax (*Linaria vulgaris*) and the Dalmatian toadflaxes (*Linaria dalmatica* and *Linaria genistifolia*) are invasive, perennial weeds that are noxious in Colorado and many other western states. Toadflax invasion is favored by disturbance and they invade degraded areas such as roadsides, abandoned lots and fields, gravel pits, clearings, and overgrazed rangeland. In Colorado, these weed species are found at elevations from 5,000 feet to over 10,000 feet. Yellow toadflax in particular has spread into high mountain valleys and parks. Yellow toadflax infests 40,800 acres in Colorado and Dalmatian toadflax infests 34,200 acres. Infestations of both species are expanding.

Origin and History

The toadflaxes have a storied past and a long relationship with humans. Dalmatian toadflax is native to the Mediterranean region. Broad-leaved Dalmatian toadflax (*L. dalmatica*) has been cultivated as an ornamental for at least 400 years. It was introduced into the western U.S. as an ornamental in 1874. The majority of Dalmatian toadflax infestations in the west are broad-leaved Dalmatian toadflax; however in its native Eurasian habitat, narrow-leaved Dalmatian toadflax (*L. genistifolia*) is more widespread, indicating its potential to also invade and become widely dispersed in the U.S. Narrow-leaved Dalmatian toadflax currently infests several areas in western Oregon, northwestern Washington, British Columbia, and possibly in Colorado.

Yellow toadflax is native to south-central Eurasia where it was used for fabric dyes and for medicinal purposes. It was imported into North America in the late 1600s as an ornamental and for folk remedies. It was widely distributed in North America by the mid 20th century. Unfortunately in states where yellow toadflax is not noxious, it still is sold by some nurseries as "butter and eggs" or as "wild snapdragons."

Figure 1: A second year Dalmatian toadflax plant; note prostrate shoots that survived the winter and new shoots that emerged from roots.

Biology

Germination and Emergence

Seeds of yellow toadflax germinate and emerge in early to mid-May while Dalmatian toadflax seeds may germinate and emerge earlier especially on south or southeast facing slopes. In Washington, Dalmatian toadflax seedlings on south facing slopes usually emerge in early to mid-March. First year Dalmatian toadflax plants often produce prostrate shoots in fall that survive into the following spring (Figure 1). Mature Dalmatian toadflax may produce prostrate shoots, but to a lesser extent, and these typically die before winter and shoots emerge the following spring from roots (Figure 2). Yellow and Dalmatian toadflax shoots that

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Quick Facts

- Yellow toadflax (*Linaria vulgaris*) and the Dalmatian toadflaxes (*Linaria dalmatica* and *Linaria genistifolia*) are invasive, perennial weeds that are noxious in Colorado and other western states.
- Seeds of yellow toadflax germinate and emerge in early to mid-May while Dalmatian toadflax seeds may germinate and emerge earlier, especially on south or southeast facing slopes.
- Toadflax invasion is favored by disturbance and they invade degraded areas such as roadsides, abandoned lots and fields, gravel pits, clearings, and overgrazed rangeland.

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Figure 2: Mature Dalmatian toadflax shoot emergence in early spring; note well-developed deep taproot and lateral roots that were broken off during excavation.

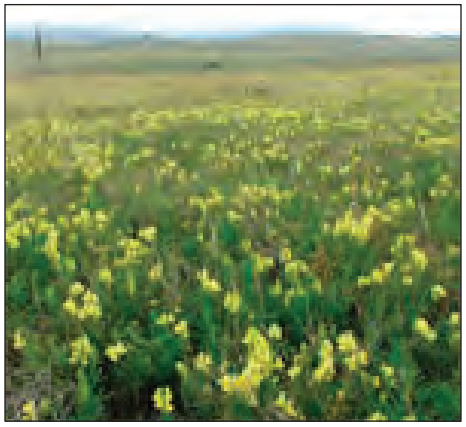

Figure 3: Yellow toadflax usually is 1 to 3 feet tall and often dominates Colorado rangeland.

grow from roots emerge as early as mid-March along the Front Range in Colorado, but vegetative shoot emergence may not begin until mid- to late June at 9,000 feet to 10,000 feet. In Canada, vegetative shoots begin to emerge when soil temperatures range from 42F to 50F.

Yellow toadflax shoots are usually 1 to 3 feet tall (Figures 3 and 4) and leaves are narrow, linear, somewhat pointed at both ends, and 1 to 2 inches or more in length (Figure 5). Dalmatian toadflax shoots typically are 2 to 3 feet tall (Figure 6) and leaves are waxy, broad, spade-shaped and bases tend to wrap around shoots (Figure 7). However, Dalmatian toadflax leaves also can be much narrower and lance shaped. Similar to yellow toadflax, Dalmatian toadflax can dominate plant communities after it invades (Figure 8).

Root growth

Seedling root development is slow and represents a life stage vulnerable to control attempts and plant competition. Disturbance promotes toadflax invasion and may be necessary for establishment to occur. However once established, toadflaxes readily spread into adjacent non-disturbed areas. Much of this spread is by vegetative means, reflecting a vigorously-growing root system. Dalmatian toadflax roots may grow 20 inches deep or more nine weeks after seedlings have emerged and have vegetative buds that give rise to new shoots. Patch expansion can be dramatic. In Colorado, Dalmatian toadflax shoot density increased over 1,200 percent in six years at one location and 190 percent over three years at another. Yellow toadflax seedlings produce vegetative shoots from root buds two to three weeks after germination. Mature toadflax have well-developed and extensive root systems. Dalmatian toadflax roots may penetrate the soil 4 feet to 10 feet and lateral roots may extend 10 feet from the parent plant; while yellow toadflax roots grow 3 feet deep or more with lateral roots that may extend several yards.

Flowering

Dalmatian toadflax typically flowers beginning in late May or June in Colorado and may continue until fall, particularly if moisture is not limiting. Yellow toadflax begins to flower when shoots are from 16 to 24 inches tall, mid- to late May along the Front Range in Colorado, although at higher elevations (9,000 feet or more), flowering may not begin until late July. Yellow toadflax may not flower until fall under drought conditions. Flowers of both species are indeterminate, grow at the bases of upper leaves, are bright yellow with orange centers (not always in Dalmatian toadflax), and have a spur that is about as long as the rest of the flower (Figures 9 and 10). Yellow toadflax shoot phenology in any given patch may range from vegetative to flowering to seed set, depending on the time of season and environmental conditions (particularly moisture). This contributes to management difficulties.

Figure 4: Mature yellow toadflax.

Figure 5: Yellow toadflax shoots and leaves; note narrow, linear leaf shape.

Management

All toadflax species are difficult to control and management plans should integrate as many strategies as possible to increase potential for success. Assess the condition and composition of the existing plant community in an infested area, then

determine the approximate composition of the desired plant community needed to achieve land management goals and objectives. Create a management plan that combines various control strategies to foster development of the desired plant community.

Chemical and Cultural Management of Dalmatian Toadflax

Dalmatian toadflax may be controlled with Tordon 22K at 2 pt/A sprayed at flowering or in fall. In Colorado, rates of 2, 4, and 8 pt/A of Tordon were compared and control longevity was greatest from the 2 pt rate, apparently because competition from crested wheatgrass was maintained. Researchers in Wyoming treated Dalmatian toadflax in early September, 1994, with Tordon at 2 pt/A, then seeded the following year in April or August with 'Hycrest' crested wheatgrass, 'Luna' pubescent wheatgrass, 'Critana' thickspike wheatgrass, 'Bozoisky' Russian wildrye, or 'Sodar' streambank wheatgrass. The combination of spraying and seeding competitive grasses controlled Dalmatian toadflax better than spraying alone. Three years after treatments were started, control of Dalmatian toadflax ranged from 61 percent to 86 percent where grasses were seeded in April and from 76 percent to 95 percent from the August seeding, compared to no control from spraying alone.

Telar also controls Dalmatian toadflax when applied in fall but relatively high rates (2 oz product/A) are required. Other research in Colorado shows that addition of a silicone/methylated seed oil surfactant at 1 percent (equivalent to 1 gallon per 100 gallons of spray solution) improves control from Telar.

Chemical Control of Yellow Toadflax

Yellow toadflax appears to be more difficult to manage than Dalmatian toadflax. In Colorado, control from Tordon 22K applied at flowering has been most consistent and typically, 4 pt/A is recommended. Yellow toadflax usually recovers from a single application. For example, Tordon applied at 4 or 8 pt/A controlled 13 percent and 69 percent of yellow toadflax three years after treatments were applied. Other research conducted in Colorado suggests that yellow toadflax control may be improved if Tordon is applied over three consecutive years,

Figure 6: Mature Dalmatian toadflax.

but control varied with location. In one experiment conducted at high elevation (Camp Hale; elevation approximately 10,000 feet), 4 pt/A of Tordon applied at flowering for three consecutive years decreased shoot density to zero. However, the same treatment applied for three years at two other locations (White River drainage, elevation approximately 8,500 feet) controlled 69 percent and 35 percent of yellow toadflax.

Telar also may be used to control yellow toadflax. In an experiment conducted in Middle Park near Parshall, Telar at 1.25 oz/A applied during flowering or in fall controlled 84 percent of yellow toadflax one year later. Telar, however, should be applied at 1.5 oz/A and a non-ionic surfactant (NIS) should be included at 0.25 percent v/v (equivalent to 1 quart per 100 gallons of spray solution). Control of yellow toadflax from Telar can be improved if a methylated seed oil at 1 percent v/v is used instead of a NIS, but injury to native forbs and shrubs may increase.

Recent CSU research showed that yellow toadflax control was improved when Tordon was mixed with Overdrive. Treatments were applied on August 29, 2007 when yellow toadflax was in the flowering growth stage (not all shoots were flowering) and vegetative root buds 0.5 to 0.75 inches long were present on about

Table 1. Herbicides used to control Dalmatian Toadflax.

Herbicide	Rate (Product/A)	Application Timing	Comments
Tordon 22K	2 pt	Flowering or fall	Best control when applied at full bloom or fall.
Telar	2 oz	Fall	Improved control achieved with 1 % v/v silicone/methylated seed oil surfactant; NIS at 0.25% v/v can be used if collateral injury to native forbs and shrubs at risk but control will decrease.
Plateau	12 oz	Fall	Apply when 25% of plant is necrotic, usually after a hard frost. Use a methylated seed oil at 1 qt/A. Cool-season grass injury often occurs from high rates of Plateau applied in fall.

Table 2: Chemical control of Yellow Toadflax.

Herbicide	Rate (Product/A)	Application Timing	Comments
Tordon 22K	2 to 4 pt	Late flowering to seed capsule/seed set in fall	Control best at seed capsule growth stage. Use high rate for old, dense stands. Treatment may be required for more than one year.
Tordon 22K + Overdrive	2 pt + 8 oz	Late flowering to seed capsule/seed set in fall	Control best at seed capsule growth stage. Treatment may be required more than one year.
Telar	1.33 to 2 oz	Late flowering to seed capsule/seed set in fall	Control best at seed capsule growth stage. Add crop oil concentrate or methylated seed oil.

Figure 7: Dalmatian toadflax leaves usually are waxy, spade-shaped, and wrap around shoots.

Figure 8: Dalmatian toadflax often dominates rangeland after invasion.

70 percent of crowns examined. Tordon applied alone at 2 or 4 pt/A controlled 53 percent and 70 percent of yellow toadflax, respectively, about one year after treatments were applied; however, when these rates were mixed with Overdrive at 6 oz product/A control improved to 97 percent and 94 percent, respectively. This experiment is being repeated to determine if improved control is consistent.

Other recent research showed that best control was achieved when herbicides were applied when at least 75% of shoots had flowered and were entering the seed capsule growth stage in fall. This yellow toadflax stand condition likely can be most easily observed when less than 25% of shoots at the time of application remain in the vegetative growth stage – all other shoots would be in the late-flower to seed capsule growth stage. CSU research also shows that adventitious root bud development increases rapidly after shoots flower suggesting that these growing tissues may act as a sink for herbicide translocation and this may provide a mechanism to explain the field observations immediately above.

Escort, 2,4-D amine, Banvel, and Paramount controlled from 5 percent to 24 percent of yellow toadflax one year after single treatments were applied at flowering. Plateau showed some potential to control yellow toadflax in another Colorado experiment where 8 oz/A applied once in fall controlled 59 percent of yellow toadflax one year later. While this level of control is unsatisfactory, sequential treatments may increase control but experiments must be conducted to test this hypothesis.

Mechanical and Chemical Control of Yellow Toadflax

Mowing combined with spraying Tordon did not improve control in an experiment conducted near Hesperus, Colorado. Yellow toadflax was mowed three times per year then treated with Tordon at 4 pt/A in fall for two consecutive years and compared to Tordon applied at 4 pt/A at flowering also for two consecutive years. Yellow toadflax control was the same (85 percent) whether Tordon treatments were combined with mowing or not.

Biological Control of Toadflaxes

Several classical biocontrol agents are available to use against toadflaxes. However, the success of these agents remains largely unknown. A defoliating moth (*Calophasia lunula)*, an ovary-feeding beetle *(Brachypterolus pulicarius),* and two-seed capsule-feeding weevils *(Gymnaetron antirrhini* and *G. netum*) have been released in the U.S. and Canada to control all toadflax species. Particularly the flowering and seed feeding insects should help decrease seed production.

A stem-boring weevil *(Mecinus janthinus)* and a root-boring moth (*Eteobalea intermediella*) also were released in Canada and the U.S. to control all species of toadflax. These species may help to control shoots and seed production as well as decrease root vigor, but data are unavailable to document their effects. Several of these classical biocontrol agents are available from the Colorado Department of Agriculture Insectary in Palisade. Very few published studies are available to determine whether grazing by livestock will effect any control of Dalmatian or yellow toadflax.

Figure 9: Dalmatian toadflax flowers.

Figure 10: Yellow toadflax flowers.

USDA

United States Department of Agriculture

Field Guide for Managing Dalmatian and Yellow Toadflaxes in the Southwest

Forest Service

Southwestern Region

TP-R3-16-06

September 2014

Cover Photos

Top left: Dalmatian toadflax; Utah State University Archive, Utah State University, Bugwood.org
Top right: Dalmatian toadflax flower; Bob Nowierski, Montana State University, Bugwood.org
Bottom left: Yellow toadflax, David Powell, U.S. Forest Service, Bugwood.org
Bottom right: Yellow toadflax flower; Wendy Van Dyk Evans, Bugwood.org

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Dalmatian toadflax (*Linaria dalmatica* (L.) Mill. ssp. *dalmatica*)
Yellow toadflax (*Linaria vulgaris* Mill.)

Figwort family (Scrophulariaceae)

Dalmatian toadflax and yellow toadflax are invasive plants that have been introduced into the southwestern United States. Both species are listed in New Mexico as noxious weeds; however, only Dalmatian toadflax is listed in Arizona.

This field guide serves as the U.S. Forest Service's recommendations for management of Dalmatian and yellow toadflaxes in forests, woodlands, and rangelands associated with its Southwestern Region. The Southwestern Region covers Arizona and New Mexico, which together have 11 national forests. The Region also includes four national grasslands located in northeastern New Mexico, western Oklahoma, and the Texas panhandle.

Description

Dalmatian toadflax (synonyms: broad-leaved toadflax, wild snapdragon) and yellow toadflax (synonyms: butter-and-eggs, common toadflax, toadflax, Jacob's ladder, common linaria, wild snapdragon) were brought from the Mediterranean region to the western U.S. as ornamentals and have since escaped to become widely growing invasive plants. Currently, large infestations occur in California, Colorado, Washington, Oregon, Idaho, Montana, Nevada, Utah, and Wyoming. These short-lived perennials produce new plants from adventitious buds on a resprouting root system that is both extensive and deep. Flowers of both plants are snapdragon-like. While similar in appearance, Dalmatian toadflax grows taller and produces new plants mainly from seed whereas yellow toadflax spreads mostly from root buds. Table 1 lists growth characteristics of both toadflax species.

Ecology

Impacts/threats

These aggressive weeds are highly adaptable and can out-compete winter annuals or shallow rooted perennials for soil moisture. A high density of toadflax reduces the availability of quality forage and diversity of flora and fauna species. Dalmatian and yellow toadflaxes contain glucoside compounds that are poisonous, especially to cattle; however, these plants are typically not grazed by animals.

Table 1. Growth characteristics

Species	Life Span	Growth and Root Habit	Vegetative Appearance	Flower Appearance	Reproductive Method and Seed Appearance
Dalmatian toadflax	Short-lived perennial (generally < 5 years)	Averages 3 feet tall; up to 25 stems per crown during first year of growth; taproot and creeping lateral roots.	Waxy, blue-green oval to heart-shaped; leaves clasp upper stem; rough, woody stem at base that becomes smooth, waxy and herbaceous near the top.	0.75 to 1.5 inches long yellow, two-lipped flowers with an orange bearded throat and a long spur; flowers in leaf axils. Fruit 2 celled and irregular shaped.	Reproduces mainly by seed and partly by adventitious root buds. Black, sharply angled seeds that are slightly winged. Produces 500,000 seeds per plant.
Yellow toadflax	Same as above.	1.5 to 3 feet tall; has taproot and extensive system of vertical roots with creeping laterals. Grows in tight clumps.	Pale green, soft linear lanceolate leaves that are sessile and do not clasp stem; Upright, unbranched stem that is woody at the base and smooth at the tip.	1-inch long yellow flowers with 5 fused petals (2 upper lobes and 3 lower), an orange bearded throat, and a yellow spur; flowers in leaf axils. Fruit 2 celled and globe shaped.	Reproduces primarily by adventitious buds on lateral roots. Seeds are dark brown to black, long, flattened, and winged. Produces 30,000 seeds per plant.

Location

Disturbance favors toadflax establishment. Both species thrive in degraded areas such as roadsides, cleared lots and fields, gravel pits, heavily grazed rangeland, and riparian zones. These weeds often establish in naturally occurring openings within sagebrush, ponderosa pine, and other woodland or parkland plant communities at higher elevations. Dalmatian toadflax favors cool, semiarid climates and coarse, dry soils with a neutral pH. Yellow toadflax favors moist soils and can tolerate subarctic conditions. In New Mexico, Dalmatian toadflax is typically found at elevations between 5,000 and 6,000 feet, whereas yellow toadflax occurs at higher elevations between 6,000 and 9,500 feet. Infestations of both species are expanding in Arizona and New Mexico.

Spread

Yellow toadflax produces shoots from underground stems as early as March from which new, independent plants can form later during the growing season. Seed viability in yellow toadflax is quite low; therefore, the spread and persistence of plants in the field are due mainly to vegetative reproduction. Unlike yellow toadflax, Dalmatian toadflax spreads vegetatively and by seed with shoots emerging from these two sources in early April through May. Seed viability for Dalmatian toadflax is high with germination rates near 75 percent.

Invasive Features

Yellow toadflax can grow new shoots on lateral roots as far as 10 feet away from the parent plant. A single Dalmatian toadflax plant can produce 500,000 seeds from July through October depending on location, aspect, and availability of water. Seeds are viable in the soil for up to 10 years, and roots are easily spread by machinery.

Management

Early detection and preventing a population from expanding is the first priority for managing Dalmatian and yellow toadflaxes. The seedling stage is most vulnerable, and seedlings should be removed upon discovery. Once the root system is established, these plants are extremely competitive for water and resources; and they are difficult to control/eradicate. Management of established plants should focus first on smaller infestations in otherwise healthy sites, and measures should be taken to prevent seed formation and vegetative spread. Larger infestations are very difficult to manage and cannot be effectively controlled within a single year or by using only one method. Complete control will likely require 10 to 15 years of repeated treatment and followup management. The following actions should be considered when planning a management approach:

- Maintain healthy plant communities to reduce or limit toadflax infestations. This may involve using improved grazing management strategies to prevent overgrazing.
- Check hay and straw for presence of toadflax seed. Only certified weed-free hay and pellets should be fed to horses used in back-country areas.
- Detect, report, and eradicate new populations of toadflax as early as possible.
- Map known infestations. Keep annual records of reported infestations.
- Combine mechanical, cultural, biological, and chemical methods for most effective toadflax control.
- Implement monitoring and a followup treatment plan for missed plants and seedlings.

Table 2 summarizes management options for controlling Dalmatian or yellow toadflax under various situations. Choice of individual control method(s) for these toadflaxes depends on the degree and density of infestation, current land use, and site conditions (accessibility, terrain, microclimate, other flora and fauna present, etc.). Other important considerations include treatment effectiveness, overall cost, and the number of years needed to achieve control. More than one control method may be needed for a particular site.

Table 2. Management Options*

Site	Physical Methods	Cultural Methods	Biological Methods	Chemical Methods
Roadsides and noncrop areas	In level terrain, use repeated cultivation with disk or sweep-type cultivators about 8 to 10 times the first year followed by 4 to 5 times the second year. Follow up with chemical control.	Educate road crews to identify and report infestations along roads; implement requirements for vehicle operations.	Use beetles, moths, or weevils as classical biological control agents (see table 3). Effectiveness of biological control agents may be limited when disturbance from road operations interrupts an agent's life cycle.	Apply in fall during late flowering stages. Use truck or ATV-mounted spraying equipment. Wash under vehicle after application to prevent spread.
Rangelands	In level terrain, use repeated cultivation with disk or sweep-type cultivators about 8 to 10 times the first year followed by 4 to 5 times the second year. Follow up with chemical control.	Use certified weed-free hay. Check animals, clothing, and vehicles for seeds. Corral sheep for 11 days before moving to uninfested areas. Reseed treated areas if necessary to make desirable plants more competitive. Fertilization and/or irrigation may help establishment of desirable plants. Plant certified seed.	Use beetles, moths, or weevils as classical biological control agents (see table 3). Closely manage grazing to prevent overuse.	For extensive and dense infestations, use ground or aerial broadcast spraying. For less dense infestations, consider individual plant treatment with crews using backpack sprayers.
Wilderness and other natural areas	Repeated hand-pulling, digging, or hoeing for seedlings and regrowth. Anticipate need to repeat treatments and monitor for ~10 years.	Use certified weed-free hay. Check animals, clothing, and vehicles for seeds. Corral sheep for 11 days before moving to uninfested areas. Post signs warning visitors to inspect and remove seed from clothing, animals, and vehicles. Reseed treated areas if necessary to make desirable plants more competitive. Fertilization and/or irrigation may help establishment of desirable plants. Plant certified seed.	Same as above	Use backpack or hand-held sprayers. Broadcast spraying by aerial or ground methods may be used on thicker stands if allowed.

* Choice of a particular management option must be in compliance with existing regulations for land resource.

Physical Control

Physical methods to control toadflax should focus on destroying the root system. Surface treatments (such as cutting or mowing) used to reduce flowering and seed production can suppress toadflax populations but will not kill the plants.

Manual Methods

Hand pulling, digging, or hoeing can be effective for seedlings or small infestations of toadflax. These methods are easier if done in sandy or moist soils. Removal of the root is very difficult but is necessary for maximum effectiveness. These treatments should be repeated several times per growing season, and the site should be revisited

for many years to assure new plants have not grown from dormant seed. Proper disposal of debris is important to reduce further spread. If flowers or seed are present, they will continue to mature. Therefore, debris should be destroyed by burning or else bagged and removed from the site. If flowers or seed are not present, plants may be pulled and left onsite.

Mechanical Methods

Mowing, chopping, or cutting plants can suppress toadflax; but these practices are not generally recommended since new shoots can resprout rapidly from adventitious root buds in response. Repeated cultivation with a disk or a sweep-type cultivator can be effective if done for 2 or more consecutive years. However, mechanical control with these two implements is typically limited to agronomic settings since the terrain must be suitable for their use. Starting in May or June, cultivation should be done through the growing season as often as required to eliminate green growth. Do not allow new growth to be visible for longer than 7 to 10 days before repeating cultivation. Generally, 8 to 10 cultivations are required during the first season and at least 4 to 5 times in the second year. Consider reseeding the next spring or fall with a variety of desirable perennial forage species of varying root depths and growth habits. It will probably be necessary to use a followup chemical treatment to control new toadflax seedlings and resprouting of roots. Plan to periodically monitor the treated site for as many as 10 years, and then spot treat or hand pull plants as they emerge.

Prescribed Fire

Wildfire or controlled burns can destroy toadflax canopies, but plants taller than 2 inches tend to have well-developed roots and are usually not killed by heat from fire. Typically, there is prolific sprouting from Dalmatian and yellow toadflaxes after fire; therefore, burning is not recommended. However, burning Dalmatian toadflax seedlings less than 2 inches high with a propane torch has been used with some success in Oregon and eastern Washington.

Cultural Control

Early detection and plant removal are critical in preventing establishment of Dalmatian and yellow toadflaxes. Land managers, the local public, and road crews should be educated in identifying these species (especially in the seedling stage) so they can help report all suspected infestations. Farm, rangeland, and outdoor recreation equipment can transport seeds; care should be taken to clean the equipment thoroughly before moving from infested areas to uninfested areas. If possible, weed screens should be used on irrigation water intakes in infested areas to prevent seed transportation in ditches or canals. Reseeding of treated areas may help establish desirable competitive plants if native plants are not already present. However, native grasses generally increase rapidly in the season following herbicide treatment.

Biological Control

Grazing

Toadflaxes contain glucosides that are poisonous to livestock when consumed in high quantity, but animals typically avoid eating these species. Care should be taken not to overgraze infested areas since overgrazing allows toadflax plants to become more competitive and abundant than desirable grazed species. Short-term, intensive grazing by sheep during spring and late season can suppress Dalmatian toadflax and limit seed production as shown by field trials in Montana. However, followup herbicide treatments were still needed to control toadflax further.

Classical Biological Control

Several insect species have been investigated and permitted for release in the United States as biocontrol agents for both Dalmatian and yellow toadflaxes. Table 3 lists agents recently released in southwestern states; however, the long-term success of these agents is largely unknown. For further information on biological control of Dalmatian and yellow toadflaxes, see Wilson et al. (2005) in the “References and Further Information” section of this field guide.

Table 3. Classical biological control agents

Species	Type of Agent	Site of Attack	Impact	Use/Considerations for Release
Brachypterolus pulicarius	beetle	shoot and flower	Adults feed on shoot tips and axillary buds; lays eggs in buds; larvae feed on immature seeds. Can reduce seed set by 74 percent.	Well established in the Northwest. Impacts both toadflaxes.
Calophasia lunula	moth	leaves	Active in larval stage; defoliates leaves, thereby reducing seed production and root carbohydrate levels.	Established in Idaho, Montana, and Washington. Impacts both toadflaxes. More effective if used in combination with stem boring weevils.
Eteobalea intermediella	moth	root	Adults lay eggs in lower leaf axils at base of yellow toadflax and on nonflowering Dalmatian toadflax stems. Larvae bore into stem or root.	Impacts both toadflaxes.
Rhinusa antirrhini (formerly *Gymnaetron*)	weevil	seed capsule	Adults eat leaf buds, young leaves, and young shoot tips. After bloom, adults eat floral tissue and lay eggs in floral ovaries; larvae eat seeds.	Well established in the Northwest. Impacts both toadflaxes.
Rhinusa netum (formerly *Gymnaetron*)	weevil	seed capsule	Similar to *R. antirrhini*. Both species impact seed production and may reduce toadflax by 85 to 90 percent.	Impacts both toadflaxes.
Rhinusa linariae (formerly *Gymnaetron*)	weevil	root	Adults feed on stem tissue and sap, lay eggs in root crown near soil surface; larvae form galls and feed on root.	Impacts both toadflaxes.

Agents used for biological control in southwestern states should be adaptable to arid environments and local conditions. Public, tribal, and private land managers may obtain biological control agents for release directly from local offices of the USDA Animal and Plant Health Inspection Service (APHIS) when the agents are available. Other sources for biocontrol agents include private companies or locally developed insectaries. A permit must be obtained from APHIS before biological control agents can be transported across state boundaries. Regulations and permit applications (PPQ 526 permit forms) pertaining to interstate shipment of biological control agents can be found at http://www.aphis.usda.gov/ppq/permits/. Although biological control agents may be collected and released within a given state without a permit from APHIS, the state's Department of Agriculture or Agricultural Extension Service should be consulted for any regulations relating to movement of these agents inside the state.

Chemical Control

Herbicide spraying can be an important component for restoring rangeland infested with Dalmatian and yellow toadflax. Before spraying, evaluate each area closely to determine if seeding may be necessary or if the plant community will return naturally. Seeding is not typically needed when native grasses are common beneath toadflax as grasses will increase rapidly in the following season after spraying (i.e., spray release). If seeding is needed following a spray treatment, then additional herbicide treatment can be used to complement seeding of desirable competitive species.

Most herbicide treatments are recommended for application during the flowering or postflowering stage in fall. Yellow toadflax is usually more difficult to control with herbicide spraying than Dalmatian toadflax, although repeated treatments over several years are often needed to control either species. Followup monitoring and spot treatment of toadflax regrowth and seedlings should be anticipated for at least 3 to 4 years and possibly longer if complete eradication of toadflax is desired.

All herbicides recommended in table 4 will control or suppress both toadflax species when properly applied, although these herbicides may also impact nontarget species such as forbs, shrubs, or trees. Control results will vary due to weather variables and the plant's growth stage, so special care should be taken to follow label directions closely. Each herbicide product will have different and unique requirements and restrictions according to the herbicide label. Read and understand the label prior to any application. Consult the registrant if you have questions or need further details.

Table 4. Herbicide recommendations

Common Chemical Name (active ingredient)	Product Example[1]	Product Example Rate per Acre (broadcast)	Backpack Sprayer Treatment Using Product Example[2]	Time of Application	Remarks
Picloram [3]	Tordon 22K	1–2 quarts	0.5–1%	Late flower to post-bloom stage in the fall.	Persistent, selective herbicide. Re-treatment for several years may be required. Labeled for rangeland use.
Dicamba	Banvel, Clarity, Vanquish	1–2 quarts	3–5%	Same as above.	Same as above
Chlorsulfuron	Telar XP	2–2.6 ounces	Consult label	Same as above.	Apply as a high volume foliar spray using a minimum of 24 gallons of water per acre.
Aminocyclopyrachlor + chlorsulfuron	Perspective	7.5–8 ounces	Add 5–9 grams of dry flowable powder to 1 gallon of water. Consult label for directions.	Apply to fall rosettes for best control.	Persistent; selective; may cause temporary injury to some grass species. Labeled for noncrop use.
Imazapic	Plateau	8–12 fluid ounces Plateau + 1 quart methylated seed oil (MSO)	0.25–1.5%	Same as above.	Persistent, selective herbicide. Re-treatment for several years may be required. Use lower rate when cool season grasses are present.

[1] Trade names for products are provided for example purposes only, and other products with the same active ingredient(s) may be available. Individual product labels should be examined for specific information and appropriate use with toadflax.

[2] Herbicide/water ratio - As an example, a gallon of spray water with a 3 percent mixture is made by adding a sufficient volume of water to 4 ounces of liquid herbicide until a volume of 1 gallon is reached (4 oz ÷ 128 oz/gal = 0.03 or 3 percent). For dry formulations, particulates should be added to sufficient water as specified by the label until the required concentration or volume of spray water is reached.

[3] Picloram is a restricted use pesticide. A certified applicator's license is required for purchase and use.

The best performing herbicides for toadflax control are chlorsulfuron (e.g., Telar XP) and picloram (e.g., Tordon 22K) either alone or in combination. Other herbicides listed in table 4 will control toadflax, but plants often recover from a single treatment so anticipate that spraying may need to be repeated. Herbicide control experiments with Dalmatian toadflax in northern Colorado and southern .Wyoming showed Telar XP at 2 oz/a gave excellent control over 5 years while Tordon 22K at 2 pt/a gave good control. Treatments made on yellow toadflax were somewhat site dependent and required higher rates of Telar XP (2.5 to 3 oz/a) or Tordon 22K (2 to 4 pt/a) to be effective. When mixing Telar XP, use a quality nonionic surfactant (NIS) or silicone-based adjuvant at the labeled rate. According to the Colorado-Wyoming study, control of yellow toadflax with Telar XP can be improved by using methylated seed oil at 1 percent v/v instead of a NIS, but injury to native forbs and shrubs may increase.

Herbicides shown in table 4 may be applied by backpack sprayers, ATV or UTV sprayers, or conventional boom sprayers that are pulled or attached to a tractor or truck. For individual plant treatment (IPT), wet the foliage and stems thoroughly with a single nozzle, hand held or backpack sprayer. Consult the herbicide label for mixing directions.

Control Strategies

Because treatment situations can vary, management of either Dalmatian or yellow toadflax on a particular site must involve detailed planning. A management plan should be developed that considers the condition and composition of native plants together with a combination of methods necessary for toadflax control. Initial treatments should attempt to eliminate live toadflax plants and disrupt seed and/or root production as much as possible. Later treatments should strive to enhance establishment and competition of native plants to further reduce toadflax populations. Failure to perform followup monitoring and management may result in recolonization and return to pretreatment levels of invasion.

Adaptive Management

Toadflax species are difficult to control, and it should be anticipated that ongoing management will be required for many years. Therefore, realistic goals and objectives should be established to manage toadflax infestations occurring extensively throughout a given landscape. To improve long-term success, consider using an adaptive management strategy with the overall goal of restoring desirable plant communities. The stepwise process for adaptive management involves:

1. Assessment of the overall weed problem,
2. Establishing management goals and objectives,
3. Implementation of control strategies,
4. Monitoring the effectiveness of management actions,
5. Evaluating actual outcomes in relation to expected results, and
6. Adjusting practices as necessary.

Steps of this process should be repeated in sequence as part of a continuous learning cycle that improves management planning and strategy by learning from the outcomes of previous management actions. In general, an adaptive management strategy may be considered to be successful if:

1. Stakeholders are actively involved and remain committed to the process,
2. Monitoring and assessment are used to adjust and improve management decisions, and
3. Management goals and/or objectives for the resource are being achieved.

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Suggested Web Sites

Herbicide labels online:

http://www.cdms.net/labels/msds/lmdefault.aspx

Encycloweedia Datasheets by California Department of Food and Agriculture:

http://www.cdfa.ca.gov/phpps/ipc/weedinfo/linaria.htm

For more information or other field guides, contact:

USDA Forest Service
Southwestern Region
Forest Health
333 Broadway Blvd., SE
Albuquerque, NM 87102

Or visit:

http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies

Dame's rocket

Colorado Department of Agriculture

305 Interlocken Pkwy
Broomfield, CO 80021

(303) 869-9030
weeds@state.co.us

Dame's rocket
Identification and Management

Key ID Points

1. Flowers are white or purple in color with four petals.
2. Leaves are lanced shaped with toothed margins and 2-4" long.

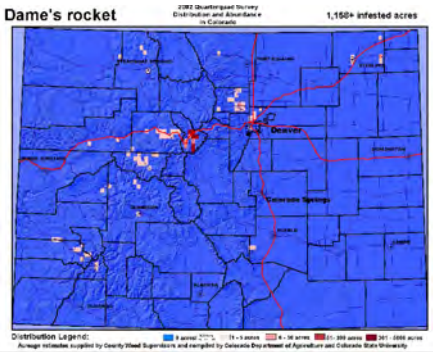
Identification and Impacts

Dame's rocket *(Hesperis matronalis)* is a native Eurasia and is a biennial or short lived perennial forb belonging to the mustard family. The flowers are white to purple with four petals and are clustered in loose terminal stalks. Flowers appear from May to August and the plant can produce seeds and flowers on any flower cluster at the same time. The fruits are long, narrow and cylindrically shaped that contains many seeds. The seeds are small, angular, grooved and dark reddish brown. The seed pods are about 1 ½ inches long and very narrow. Leaves are slightly hairy, alternate, and 2 to 4 inches long. The leaves are lance shaped with toothed margins. A mature plant ranges from 4 inches to 3 feet in height. Dame's rocket has a shallow fibrous root system.

Habitats for Dame's rocket include: gardens, partly shaded woodlands, ditches, roadsides, pastures, rangelands, thickets, open woods, disturbed sites, and other areas that have moist well drained soils and full sun to light shade. Many people think that it is a native wildflower and is planted as a garden ornamental, however; the plant quickly escapes cultivation due to its prolific seed production. It is often sold in "native wildflower" mixes, so please be sure to check the contents of "native wildflower" seed mixes and do not plant those that carry Dame's rocket.

The key to effective control of Dame's rocket is prevention. Locate and remove plants immediately before plants set seed to prevent the spread of Dame's rocket. Since the plant reproduces solely by seed, integrated management efforts must include the elimination of seed production and depletion of seed bank. Combing control methods of herbicide and mechanical can be effective. Mechanical methods include removal of rosettes, and removal of seed heads from any plants that have bolted to prevent seed dispersal. Details on the back of this sheet can help to create a management plan compatible with your site ecology.

Dame's rocket is designated as a "List B" species in the Colorado Noxious Weed Act. It is required to be either eradicated, contained, or suppressed depending on the local infestations. For more information visit www.colorado.gov/ag/csd and click on the Noxious Weed Management Program. Or call the State Weed Coordinator at the Colorado Department of Agriculture, Conservation Services Division, 303-239-4100.



Photos © Clockwise from lower left: Richard Old, XID Services Inc., Bugwood.org; dnr.state.wi.us; Tom Heutte, USDA Forest Service, Bugwood.org; Kelly Uhing, Colorado Department of Agriculture; and map above by Crystal Andrews, Colorado Department of Agriculture.

Updated on:
08/08

Hesperis matronalis

Management Recommendations

Dame's rocket

CULTURAL
Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities. Contact your local Natural Resources Conservation Service for seed mix recommendations.

BIOLOGICAL
There is no biological control available for Dame's rocket. Since biological control agents take years to research, develop and release, no releases are expected in the foreseeable future. For more information, contact the Palisade Insectary of the Colorado Department of Agriculture at 970-464-7916.

MECHANICAL
Hand pull or dig when soil is moist, making sure to get the roots to prevent resprouting. Removing flowers before the plant sets seed will also be effective. Be sure to bag specimens carefully so the spread of seeds does not occur.

Integrated Weed Management:

Locate and remove plants immediately before plants set seed to prevent the spread of Dame's rocket. Since the plant reproduces solely by seed, integrated management efforts must include the elimination of seed production and depletion of seed bank. Combing control methods such as herbicide and mechanical can be effective.

HERBICIDES

NOTE: The following are recommendations for herbicides that can be applied to range and pasturelands. Rates are approximate and based on equipment with an output of 30 gal/acre. Please read label for exact rates. **Always read, understand, and follow the label directions. The herbicide label is the LAW!**

HERBICIDE	RATE	APPLICATION TIMING
NO INFORMATION AVAILABLE: Colorado State University is conducting experiments to provide data and recommendations. Recommedations should control, but waiting official data.		
Metsulfuron (Escort XP)	1 oz product/ac. + 0.25% non-ionic surfactant	Apply when plant is in rosette or bolting growth stage. (Early Spring)
Chlorsulfuron (Telar)	1 oz product/ac. + 0.25% non-ionic surfactant	Apply when plant is in rosette or bolting growth stage. (Early Spring)
Imazypic (Plateau)	9 to 10 fl oz/ac. + 2 pt/ac. methylated seed oil	Apply when plant is in late flower growth stages. (Late Spring to Fall)

USDA

United States Department of Agriculture

Field Guide for Managing Whitetop in the Southwest

Forest Service

Southwestern Region

TP-R3-16-20

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Cover Photos

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Lower right: Chris Evans, River to River CWMA, Bugwood.org

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Whitetop (*Cardaria draba (*L.) Desv., formerly known as *Lepidium draba*)

Mustard family (Brassicaceae)

Whitetop is listed as a noxious weed in Arizona and New Mexico. This field guide serves as the U.S. Forest Service's recommendations for management of whitetop in forests, woodlands, and rangelands associated with its Southwestern Region. The Southwestern Region covers Arizona and New Mexico, which together have 11 national forests. The Region also includes four national grasslands located in northeastern New Mexico, western Oklahoma, and the Texas panhandle.

Description

Whitetop (synonyms: heart-podded hoary cress, whiteweed, peppergrass, hoary cardaria) is an introduced, creeping, broadleaved, perennial plant that grows up to 2 feet tall. It is similar in appearance to two closely related *Cardaria* species: *C. chalepensis* (lens-podded hoary cress) and *C. pubescens* (globe-podded hoary cress). These three exotics are members of the mustard family (Brassicaceae) and are often grouped together because they invade similar sites and are equally difficult to control. The primary distinguishing characteristic between these species is the type and shape of the fruit, which is an indehiscent (remaining closed at maturity) pod called a silicle. *C. draba* has heart-shaped pods that become flattened with prominent veins as they dry. *C. chalepensis* has oval or lens-shaped pods that do not become flattened and veins are not prominent. *C. pubescens* has globose, hairy purplish pods that remain inflated when dry.

Growth Characteristics

- Perennial herbaceous plant; typically grows 16 to 20 inches tall.
- Deep, long-lived taproots that store carbohydrates; extensive creeping root system.
- Plants have a gray-green, soft-hairy appearance; grayish stems grow upright or along ground without rooting at the nodes (procumbent); lower portion of plant tends to be hairier and have more leaves; branching occurs primarily in upper portion of plant.
- Leaves alternate; rosette leaves and basal leaves of mature plants taper to a petiole. When mature, lower leaves are long and slender; upper leaves are obovate with smooth to slightly toothed margins; arrowhead-like lobes of leaves clasp the stem; leaves covered with short, white hairs.
- Many white, 4-petalled flowers occur in a flat-topped inflorescence (corymb of racemes); flowers have 6 stamens; 1 pistil; sepals are green; petals are spoon shaped.
- Indehiscent fruits are heart-shaped, 2-chambered silicles with a distinct beak (a persistent style) on the end opposite the notch; one ovoid, reddish-brown seed per chamber.

Ecology

Impacts/threats

Whitetop produces low quality forage, and dense infestations can crowd out desirable plants and reduce animal diversity. The foliage contains glucosinolates, which are toxic to cattle and decompose into allelopathic compounds that can impede germination and growth of desirable plants.

Location

Whitetop favors unshaded, disturbed areas with moderately moist, alkaline soils. It is widely distributed across the western U.S. and can be found along roadsides or irrigation ditches, and in rangeland meadows, subirrigated pastures, and hay fields. Whitetop grows on a wide range of soil types, from those that are moderately saline to acidic soils with low moisture.

Spread

A single plant produces up to 4,800 seeds that are viable for up to 3 years in the soil. In warmer climates, whitetop may produce several seed crops during a growing season. Seed is dispersed by water, wind, and animals; seed may move great distances as a contaminant in other types of seed. New shoots are commonly grown from root fragments, which can be spread long distances as a contaminant in displaced soil,

hay bales used for erosion control, or alfalfa hay. Seed or root fragments may adhere to surfaces and undercarriages of vehicles and road maintenance equipment.

Invasive Features

Whitetop has a deep taproot and a creeping lateral root system. Extensive carbohydrate reserves are stored within the roots, which enable shoots to emerge early and grow rapidly in the spring. Root fragments less than 1-inch long may resprout to form new shoots. Because whitetop is adaptable to a wide range of habitats, invasions of whitetop often occur in sensitive areas, which can limit control options.

Management

Early detection and removal of new infestations soon after discovery is the most effective weed management strategy for whitetop control. Because of its extensive creeping rootstock, large populations are a challenge to eradicate if not an impossibility once established. Small or isolated infestations on otherwise healthy sites should be given high priority for treatment, followed by treatment of whitetop in corridors with a high likelihood for spread, such as waterways and irrigation structures. In areas where whitetop has become well established, containment should become a management priority. Containment can be achieved by managing the outside perimeter to prevent further spread. Whatever the approach, whitetop management will likely require several consecutive years of treatment with an integrated approach to reduce its impact to the plant community. The following actions should be considered when planning an overall management approach:

- Maintain healthy plant communities to limit whitetop infestations. This may involve using improved grazing management to prevent excessive grazing and reseeding areas with desirable grasses and forbs after disturbance.
- Detect, report, and map known infestations. Keep annual records of reported infestations.
- Practice prevention and eradicate new populations of whitetop as early as possible.
- Periodically check areas where hay bales are used to control erosion or where soils have been imported for presence of whitetop.
- Use certified weed-free hay; use pellets to feed horses in back-country areas.
- Implement annual monitoring and a followup treatment plan for missed plants and seedlings.
- Combine mechanical, cultural, biological, and chemical methods for the most effective whitetop control.

Table 1 summarizes some management options for controlling whitetop under various situations. Choice of individual control method(s) for whitetop depends on many factors including the current land use and site condition; accessibility, terrain, and climate; density and degree of whitetop infestations; and nontarget flora and fauna present. Other considerations include treatment effectiveness, cost, and the number of years needed to achieve control. More than one control method may be needed for a particular site.

Physical Control

Although labor intensive and costly, physical methods that are consistently and repeatedly used can be effective at controlling whitetop. Effectiveness of physical methods is usually improved when combined with herbicide control.

Manual Methods

Hand removal – Hand digging or grubbing may be feasible for small, isolated populations or for plants located in sensitive areas such as riparian corridors. Ideally, the entire root system should be dug out before seed forms. Debris should be disposed of by burning piled plants or by bagging and then depositing the bags in a landfill.

Mechanical Methods

When using machinery to manage whitetop, equipment should be cleaned after use to prevent movement of seeds or root fragments into uninfested areas.

Table 1. Management options*

Site	Physical Methods	Cultural Methods	Biiological Methods	Chemical Methods
Roadsides, fence lines, or noncrop areas	Mow at late bud to early flower stage; apply herbicide to resprouts. Remove small patches by hand pulling.	Clean machinery following activity in infested areas. Train road crews and the public to identify and report infestations; map reported populations.	Biological control agents are currently unavailable.	Spray at bud to early flower stage. For ground application, use truck-mounted or tractor-pulled spraying equipment. Wash under vehicle after application to prevent spread.
Rangelands, pastures, or riparian corridors	For seedlings, use initial deep cultivation followed by repeat cultivation at a 4- to 5-inch depth every 5 to 10 days during the growth season; repeat for 2 to 4 consecutive years. Prescribed burning is NOT recommended.	Use certified weed-free seed and hay. Monitor areas where soil was imported or hay bales were used for erosion control. Reseed with competitive, desirable plants.	Prescribed grazing with sheep or goats may be considered in combination with other methods; slightly toxic to cattle. Closely manage grazing to prevent overuse of desirable species. Biological control agents are currently unavailable.	For extensive and dense infestations, use ground or aerial broadcast spraying. For sparse infestations, use backpack or hand-held sprayer.
Wilderness, other natural areas, and/ or small infestations	Hand dig or grub small patches; remove as much of the root as possible; bag and dispose of debris appropriately.	Educate the public to identify and report infestations. After passing through infested areas, inspect and remove any seed or root fragments from animals, clothing, and vehicles.	Same as above.	Use backpack or hand-held sprayers or use wick method for IPT. Broadcast spraying may be used on thicker stands, if allowed.

* Choice of a particular management option must be in compliance with existing regulations for land resource.

Mowing – By itself, mowing is not recommended as it can contribute to further spread and increased densities of whitetop. In agronomic lands or areas with level ground where mowing is practical, cutting the weed in combination with later well-timed herbicide applications will improve control effectiveness. Mow whitetop early in the growth season when it is at flower bud stage. Allow the shoots to resprout and then apply herbicide when plants again reach flower bud stage. Mowing causes the plant to produce larger leaves that are perpendicular to the ground which allows better access of herbicide into the lower third of leaves. An alternative is to spray plants in late summer/early fall and then mow in the spring. New shoots will likely be produced, and repeat spraying is usually necessary for further control.

Tillage – Cultivation is effective with seedlings and in areas where the population is not yet well established. Till plants below the depth of lateral and vertical roots, and plan to repeat cultivation shortly after new shoots emerge. This may require tillage that is needed every 10 to 15 days for 6 to 8 weeks during the growing season which may be followed by less frequent tillage. Speed of eradication depends upon timing and frequency of cultivation, and this practice usually has to be repeated for at least 2 consecutive years. Even infrequent cultivation before seed set can reduce whitetop infestation. Combining tillage with well-timed herbicide use can further improve effectiveness.

Prescribed Fire

Since 75 percent of whitetop's total biomass is below ground, populations rebound rapidly following fire. Therefore, this practice is not recommended as a control method. Burning is an acceptable means to dispose of plant debris.

Flooding

When feasible, flooding an area with 6 to 8 inches of water for 2 months can be an effective control method.

Cultural Control

Prevention is key to controlling whitetop, and early detection and plant removal are critical for reducing its spread. Educating land managers, the local public, and others to identify nonnative noxious species is important so they can help report all suspected infestations. Weed screens for irrigation ditches should be considered as a means of preventing seed dispersal via waterways. Reseeding with desirable shrub and perennial grass species that are competitive with whitetop should be considered for areas not recovering naturally following suppression efforts.

Biological Control

Grazing

Although palatability is low, goats and sheep will graze whitetop from rosette until the early flowering stage. Whitetop reportedly is toxic to cattle if consumed in great enough quantity, but livestock generally make very little use of this weed.

Table 2. Herbicide recommendations

Common Chemical Name (active ingredient)	Product Example[1]	Product Example Rate per Acre (broadcast)	Backpack Sprayer Treatment Using Product Example[2]	Time of Application	Remarks
Chlorsulfuron	TelarXP	1 ounce	1–2%	Bud to early bloom.	Selective; safe for labeled grasses; provides 1–2 years control. Not for use near waterbodies. Use 0.25% v/v NIS[3]. If area is mowed before herbicide applied, lower rate is effective.
Metsulfuron methyl	Escort, Ally	0.75–1 ounce	1%	Same as above.	Selective; safe for most perennial grasses. Not for use near irrigation water. Add 0.25% v/v NIS[3]. May apply in fall if part of plant is still green.
Chlorsulfuron + metsulfuron	Cimmaron Plus	1.25 ounces	1%	Same as above.	Broad spectrum; most broadleaved plants and certain grasses are susceptible; absorbed through foliage and roots; preemergent and postemergent activity. Add 1/16% – 1/18% v/v NIS[3]; a 1 to 2 inches of rainfall is required after application to move herbicide into root zone.
Aminopyralid + metsulfuron	Chaparral	2.5–3.33 ounces	1%	Spring (rosette to bolt) or fall (seedling to rosette).	Broad spectrum; most broadleaved plants (including legumes and woody plants) and certain grasses are susceptible. Not for use near surface water. Tank mix with 2,4-D for bolt to early flower stages. Add 0.25% v/v NIS[3].
Glyphosate	Rodeo, RoundUp Pro, others	3 quarts Rodeo 4 quarts RoundUp Pro	Rodeo: 0.75–2% + NIS3 RoundUp Pro: 2%	Flower bud stage.	Nonselective. Rodeo is labeled for use in or near aquatic areas. If infestation is dense, mow and then apply glyphosate when regrowth reaches flower bud stage.

Table 2. Herbicide recommendations (continued)

Common Chemical Name (active ingredient)	Product Example[1]	Product Example Rate per Acre (broadcast)	Backpack Sprayer Treatment Using Product Example[2]	Time of Application	Remarks
2,4-D ester or amine4	several products available	2 quarts	1–5%	Before bud stage.	Selective; acceptable for use in/near aquatic areas. Apply annually for 2 years or more to control established stands. If infestation is dense, mow first and then spray regrowth.
Imazapyr	Arsenal, Habitat, others	2–3 pints	0.5–5%	Flower bud to flowering stage; apply to actively growing plant parts.	Nonselective; preemergent and postemergent; broad-spectrum control. Habitat is labeled for use near water. In addition to overspray, nontarget plants may be killed or injured by root transfer of imazapyr between intertwined root systems. Add 0.25% v/v NIS for postemergent use.
Imazapic	Plateau	12 fluid ounces	5%	Same as above.	Selective herbicide but may retard growth of some grasses. This herbicide is the preferred alternative to imazapyr if protection of desirable plants is needed.

[1] Trade names for products are provided for example purposes only, and other products with the same active ingredient(s) may be available. Individual product labels should be examined for specific information and appropriate use with whitetop.

[2] Herbicide/water ratio - As an example, a gallon of spray water with a 3 percent mixture is made by adding a sufficient volume of water to 4 ounces of liquid herbicide until a volume of 1 gallon is reached (4 oz ÷ 128 oz/gal = 0.03 or 3 percent).

[3] NIS is an abbreviation for nonionic surfactant which is an additive commonly recommended by herbicide labels for postemergent foliar application of herbicides.

[4] 2,4-D is a restricted use pesticide in New Mexico only. A certified applicator's license is required for purchase and use.

Classical Biological Control

Biological control research is underway; however, there are currently no classical biological control agents approved by USDA for management of whitetop. The following species are being studied for whitetop control: *Ceutorhynchus cardariae* (a gall-forming weevil), *C. turbatus* (a seed-feeding weevil), *Melanobaris semistriata* (a root-mining weevil), and *Psylliodes wrasei* (a shoot-mining flea beetle).

Chemical Control

Whitetop grows in many different crop and rangeland situations, which complicates the choice for best chemical control. Herbicides commonly used to control mustards generally work well on whitetop; but these chemicals often control a wide range of other broadleaf plants as well, some of which may be desirable. For example, legumes such as alfalfa are sensitive to most herbicides that are effective with whitetop and could be lost if sprayed. All herbicides recommended in table 2 will effectively control whitetop when properly applied. Chlorsulfuron or metsulfuron methyl provide effective whitetop control in noncropland areas, but timing is important. Spraying should be done in early spring or preferably in the fall before winter dormancy. 2,4-D (ester or amine) can provide fair to good control or provide suppression when sprayed in early spring. Glyphosate, imazapic, or imazapyr formulations are acceptable for use in areas near water. Monitoring and followup applications at a minimum of several years are recommended to attain long-term control. Herbicide applications should be made during

the flower bud to early flowering stage when carbohydrate root reserves are lowest.

Each herbicide product will have different requirements and restrictions according to the label. Read and understand prior to any application. To prevent development of resistance in whitetop from repeated treatments, the label should be consulted for guidelines on rotating herbicide active ingredients. Consult the registrant if you have questions or need further detail.

Herbicides may be applied in several ways including backpack, ATV or UTV sprayers, or conventional boom sprayers that are pulled or attached to a tractor or truck. For sparse populations, one person or a small team can spray or wick whitetop in an area using the individual plant treatment (IPT) method. Spray plants directly by wetting the foliage and stems to the point of dripping while using an adjustable spray nozzle attached to a hand-held or backpack sprayer. To suppress whitetop in riparian areas while allowing desirable plant species to reestablish, wick individual plants with 100 percent solution of 2,4-D for several consecutive years. Where water is not present year-round, chlorsulfuron may be used as long as the herbicide has time to degrade in the soil before water returns.

Control Strategies

Because each treatment situation is unique, the strategy adopted for whitetop control must involve careful planning and a long-term commitment to management actions. Combining methods, as outlined in this guide, should always be considered in a long-term approach to control whitetop. As an example, combining physical methods with chemical control can be an effective option.

Regardless of the strategy used, components of a successful whitetop control program should include repeated treatments, monitoring of treated areas, and measures taken to control missed plants, resprouts, and newly emerged seedlings. Monitoring should be conducted in early spring and late summer to find rosettes that form the leading edge of expanding infestations. To enhance long-term control, efforts should be made to encourage return of desirable plants such as shrubs and perennial grasses that will compete with whitetop for water, nutrients, and space.

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Suggested Web Sites

CABI database:

http://www.cabi.org/?page=1017&pid=2257&site=170

For information on invasive species:

http://www.invasivespeciesinfo.gov/

http://www.invasive.org/weedus/index.html

For information about calibrating spray equipment:

NMSU Cooperative Extension Service Guide A-613 Sprayer Calibration at http://aces.nmsu.edu/pubs/_a/A-613.pdf

Herbicide labels online:

http://www.cdms.net/LabelsMsds/LMDefault.aspx

For more information or other field guides, contact:

USDA Forest Service
Southwestern Region
Forest Health
333 Broadway Blvd., SE
Albuquerque, NM 87102

Or visit:

http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies

A Self-Learning Resource From MSU Extension

MONTANA STATE UNIVERSITY EXTENSION

MontGuide

Houndstongue: Identification, Biology and Integrated Management

by Susan Kedzie-Webb[1] and Roger L. Sheley[2]
revised by Jane Mangold[3] and Melissa Brown[4]

This weed is non-native and poisonous and infests pastures, fields and disturbed areas. This publication describes growth and dispersal and suggests control strategies.

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HOUNDSTONGUE (*CYNOGLOSSUM OFFICINALE* L.) is known by a number of common names – beggar's lice, dog's tongue, sheep bur, dog bur, sheep lice, glovewort, and woolmat – which suggest the problematic nature of its barbed seeds that stick to fur, fleece, and clothing. In addition to being a general nuisance, houndstongue impacts livestock fitness, marketing costs, and fleece quality. Houndstongue foliage has the potential to poison livestock and wildlife. Dense infestations can reduce pasture and range for grazing animals. Although this plant is commonly associated with disturbed sites, houndstongue is also a problem on grasslands, pastures, shrublands, forestlands, croplands, and riparian areas. Correctly identifying houndstongue and understanding its life cycle and growth requirements are important for selecting management strategies that effectively suppress houndstongue populations and promote healthy, desired vegetation.

Origin and distribution

Houndstongue, native to Asia and Europe, was probably introduced to North America as a contaminant of cereal seed. The first occurrences of houndstongue in the United States were recorded in Oregon in 1893, and then in Montana (Sweetgrass County) in 1900.

Over the next 50 years, fewer than 10 counties reported houndstongue in Montana. After the mid-1950s, the number of Montana counties reporting houndstongue increased sharply. As of 2009, houndstongue was reported in at least 35 counties (Figure 1). Houndstongue occurs in most states of the U.S. and is included on noxious weed lists for six western states: Colorado, Nevada, Oregon, Washington, Wyoming, and Montana.

Houndstongue is often associated with disturbed areas such as trails, roadsides, logging areas, or abandoned cropland, but plants are also effective competitors in rangelands, pastures, riparian areas, and borders or openings of wooded areas. Houndstongue is shade-tolerant, and survives well in wetter grasslands and moist draws on drier sites. This weed is found on soils ranging from well-drained relatively coarse material, to clay subsoils in open forests.

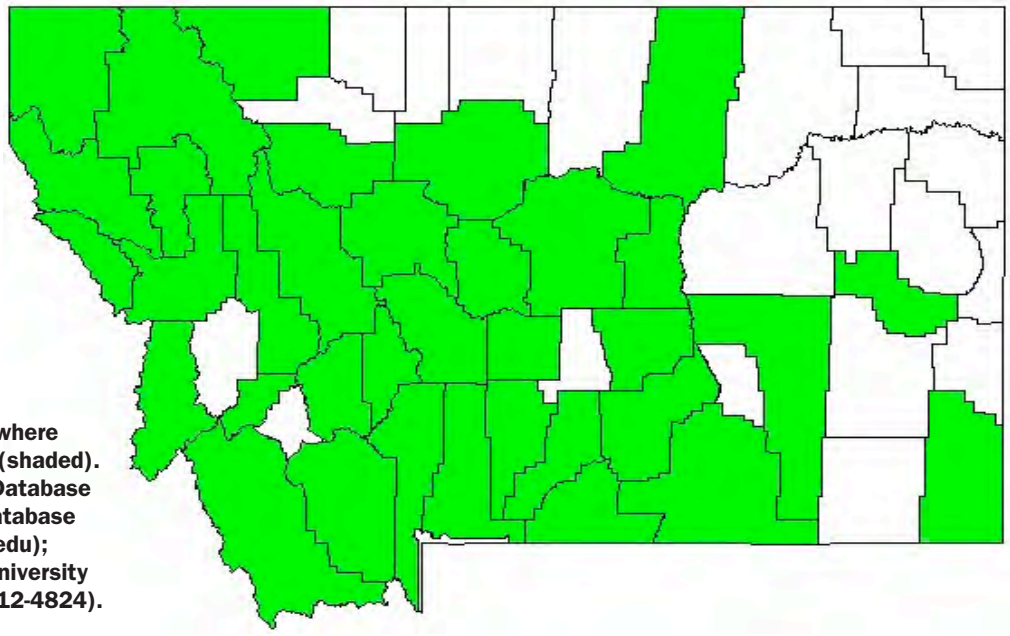

FIGURE 1. Counties in Montana where houndstongue has been reported (shaded). Information taken from Invaders Database System (Rice, P.M. INVADERS Database System (http://invader.dbs.umt.edu); Division of Biological Sciences, University of Montana, Missoula, Mont. 59812-4824).

[1] former MSU graduate Research Assistant, [2] former Extension Weed Specialist, [3] MSU Extension Invasive Plant Specialist, [4] Center for Invasive Plant Management Communications Coordinator

FIGURE 2. Houndstongue plant with nutlets (A) and root (B). (USDA-NRCS Plants Database/Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions.* Vol. 2: 533.)

Identification and biology

Houndstongue is a member of the Boraginaceae (Borage) family. Leaves are oblong with numerous soft white hairs on both surfaces. They have prominent veins and are said to look like a dog's tongue (Figure 2). During the second year of growth, plants produce a flowering stalk 8 to 30 inches tall. Flowers range in color from dull red to burgundy. Each flower develops seed clusters containing three to four nutlets roughly ¼ inch long. Fruits are flat, teardrop-shaped, and have a hard spiny husk with barbs. Protruding barbs adhere to fur or fleece of wildlife and livestock, and human clothing. Research suggests that cattle are major dispersers of houndstongue, picking up about 65 percent of bur stalks in grazed paddocks.

How does houndstongue grow?

Houndstongue is a biennial or short-lived perennial plant that reproduces by seed. Seedlings emerge in the spring and early summer and form a rosette and a thick, black, branching taproot that can grow to depths greater than three feet in the first year. The taproots store nutrients sufficient for seed production in the second year even when second-year rosette leaves are removed. In early summer of the second year, plants bolt and form a flowering stalk. If environmental conditions are unfavorable, flowering may be delayed past the second year. Flowering occurs from May through July, and seeds mature from July through August. In Montana, a single houndstongue plant typically produces 300 to 675 seeds per year, but exceptionally robust plants may produce up to 2000 seeds. Seeds either fall nearby to the ground or remain on the parent plant where they are positioned to attach to a passing animal or person. Seeds may be carried long distances this way. Seeds on the soil surface often dry out and fail to germinate, whereas seeds buried about an inch under the soil may remain viable for two to three years. Houndstongue seeds do not form large or persistent seeds banks in the soil, and germination generally requires some form of scarification or softening of the seed coat.

Impacts

Houndstongue readily displaces desirable species and can establish monocultures and degrade forage quality and grazing capacity. Nutlets entangled in the wool or hair of livestock may create marketing problems for ranchers because of the extra time and money required to remove burs. They can also become lodged in the eyelashes of livestock causing potentially severe eye damage. Another concern is the threat of livestock poisoning from houndstongue (see below). Although in most cases the fresh plant is considered unpalatable and is generally avoided, livestock may eat plants when they are cut and dried with harvested hay, or when animals are confined to a small area lacking desirable forage. Herbicides may also increase palatability of houndstongue foliage.

Houndstongue Poisoning

Poisoning occurs when animals consume sufficient quantities of houndstongue with high pyrrolizidine alkaloid (PA) concentrations. PA levels are generally highest in immature plants (1.5 to 2 percent dry weight) and decrease with maturation. The acute or chronic nature of poisoning depends on the PA concentration, amount eaten and rate of ingestion.

Signs of houndstongue poisoning in cattle:

- Slight disinterest in food
- Stands off by itself, reluctant to move
- Stands with head lowered for much of the day
- Kicking at belly
- Gradual weight loss, slow to gain weight
- Diarrhea or constipation; severe straining
- Nervousness, convulsions, photosensitivity, jaundice, coma

To prevent poisoning, do not confine animals in a pasture that is densely infested with houndstongue and lacking other forage. Avoid harvesting houndstongue in hay crops. Should poisoning occur, owners must remove the animal from pasture as soon as possible and consult a veterinarian.

Integrated management

The most effective method of houndstongue management is preventing its spread and establishment. Limiting weed seed dispersal, containing current infestations, minimizing soil disturbances, detecting and eradicating new plants, maintaining competitive desirable plants, and grazing properly will help reduce the establishment and spread of houndstongue. Once houndstongue is established, persistent management using a combination of techniques will give the best control. Because houndstongue seeds do not usually remain viable in the seedbank for more than a few years, preventing seed production from year to year is critical. Small-scale infestations may be controlled using hand removal or herbicide spot treatments. Larger infestations may require combinations of techniques such as prescribed grazing to maintain competitive perennial grasses and judicious application of herbicides.

Hand pulling and grubbing may be practical for small populations of houndstongue. To effectively control houndstongue, the root crown must be removed.

Tilling and cultivation - Houndstongue is rarely found on cropland, therefore repeated cultivation may be an effective control measure as long as cultivation practices sever the root one to two inches below the surface.

Cutting, mowing, and other forms of defoliation are not effective in controlling houndstongue. Although one study found that seed production was reduced in plants that were cut zero to three inches from the soil surface, taproots often store enough nutrients to support normal flowering and seed production following mowing.

Prescribed burning in the late summer or early fall may destroy seeds and prevent spread because the nutlets on the plant are exposed to high temperatures. Near the soil surface, however, temperatures may not be hot enough to destroy houndstongue seeds. Instead, fire may stimulate germination and provide optimal conditions for houndstongue establishment by creating a disturbance and exposing bare mineral soil.

Biological control agents have not been approved for release in the United States because of concerns for negative effects on rare native plant species that are in the same family as houndstongue. However, researchers have identified five biological control insects as potential agents for houndstongue. One in particular – the houndstongue root-mining weevil (*Mogulones cruciger*) – has persistently reduced houndstongue populations in British Columbia and Alberta, Canada.

Grazing is more likely to contribute to the spread than the control of houndstongue because of the plant's association with disturbance, resistance to defoliation and herbivory, and tendency of seeds to stick in fur and fleece. Furthermore, houndstongue has the potential to poison livestock and wildlife that might graze it. Prescribed grazing management that maintains competitive grasses and desirable forage can help reduce the risk of houndstongue invasion and some instances of poisoning. In areas susceptible to invasion, proper livestock grazing should include altering timing, frequency and level of defoliation to allow a full recovery of desirable grass species. Cattle and other livestock may carry houndstongue seeds in their fur or fleece, so it is important to avoid spreading seeds from infested sites to uninfested sites.

Chemical methods can be used to manage houndstongue on range, wildland, and pasture sites. Several herbicides, including 2,4-D, metsulfuron and chlorsulfuron can provide effective houndstongue control. Application rates and timing of application for various herbicides are shown in Table 1. Herbicide choice and rates are influenced primarily by growth stage at time of application. In general, spring applications provide consistently better control of houndstongue than fall treatments. First-year and second-year plants can be controlled using 2,4-D amine when applied at rosette growth stage. Metsulfuron is recommended for use in rangeland, pastures and disturbed areas. Metsulfuron should be applied mid-June when plants are actively growing. Because of the hairy nature of houndstongue leaves, it is important to always add a recommended non-ionic surfactant to the spray solution. Annual herbicide application may be needed for several years until seed is no longer viable in soil. Label information

TABLE 1. Examples of herbicides that can be used to manage houndstongue. Consult herbicide labels for additional rate, application, and safety information. Additional information can be found at http://www.greenbook.net.

Herbicide Active Ingredient Trade Name	Product per acre	Timing
2,4-D Amine Many trade names	1 to 2 quarts	First or second year rosettes
*Metsulfuron** Escort/Cimarron	0.5 to 1 ounce	Actively growing plants, early flower
*Chlorsulfuron** Telar	0.5 to 1 ounce	Actively growing plants

*requires non-ionic surfactant

for all herbicides should be carefully followed not only for application restrictions but also for restrictions that apply to grazing and harvest of forage after application. Herbicide application may increase the palatability of houndstongue foliage, so grazing too soon after treatment could increase the risk of livestock poisoning.

Glossary

Biennial – a plant that normally requires two seasons to complete its life cycle, the first season's growth being strictly vegetative

Bolt – growth of an elongated stalk with flowers grown from within the main stem of a plant

Perennial – a plant that lives for more than two years

Rosette – circular arrangement of leaves, with all the leaves at a single height

Scarification – process involving breaching the natural seed coat by mechanical, thermal, or microbial methods

Note: Information in this document is provided for educational purposes only. Reference to commercial products or trade names does not imply endorsement by MSU Extension. Common chemical and trade names are used in this publication for clarity. Inclusion of a common chemical or trade name does not imply endorsement of that particular product or brand of herbicide and exclusion does not imply non-approval. This publication is not intended to replace the product label.

Houndstongue Uses and Lore

Houndstongue has a long history of use for a variety of magical, medicinal, and practical purposes.

- The name houndstongue comes from the belief that a leaf worn in the shoe could ward off dog attacks.
- Extracts of roots and leaves of houndstongue have been used in folk remedies for various ailments including fever, eczema, acne vulgaris, and hemorrhoids.
- Houndstongue ointment is said to cure baldness.
- The red pigments of the outer root surface are anti-bacterial and reportedly have wound-healing properties.
- Roots and leaves have been used as pesticides and leaves have been used to repel moles in gardens and rodents from stored foods.

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File under: Agriculture and Natural Resources (Weeds)
Revised August 2009 2000-809SA

Houndstongue

Colorado Department of Agriculture

305 Interlocken Pkwy
Broomfield, CO 80021

(303) 869-9030
weeds@state.co.us

Houndstongue Identification and Management

Key ID Points

1. Panicles of reddish-purple flowers with 5 petals and 5 soft, hairy sepals.
2. Velcro-like seeds with 4 nutlets.

Identification and Impacts

Houndstongue (*Cynoglossum officianale)* is a short lived perennial or biennial forb. It produces rosettes in the first year, and bolts a stout, erect stem that is 1 to 4 feet tall, by mid-summer of the second year. Then it flowers and produces fruit. Flowers are reddish-purple (occasionally white) and droop slightly from densely clustered panicles. The five rounded petals are cupped by five sepals covered with long, soft white hairs. Flowering occurs May to July. The simple leaves are lance or oblong shaped, with a smooth edge and no teeth or lobes. Leaves are alternate, 1 to 12 inches long and 1 to 3 inches wide. The leaf tip is sharply pointed, like a hound's tongue, yet are covered with long-soft white hairs. Leaves often appear dusty and insect-ridden. A thick, dark, woody taproot can reach 3 to 4 feet deep.

Reproduction is solely by seeds. Seeds are 4 prickly teardrop-shaped nutlets, which are packed in a pyramid-shaped receptacle. Most seeds fall close to the parent plant, but the seeds can travel great distances. The seeds have barbs like Velcro, with a hooked tip that clings to animals, clothing and machinery. A mature plant can produce 2,000 seeds. Seed viability is 1 to 3 years. Houndstongue is poisonous. Toxic pyrrolizidine alkaloids in Houndstongue stop liver cells from reproducing. Livestock and wildlife may live up to six months after ingesting a lethal dose. Though the plant has a distinctive odor that repels animals, it is more palatable when dried. Animals rarely eat it unless it is dried and mixed with hay. Houndstongue's toxicity effects horses and cattle more severely, sheep seem more resistant. Burs will reduce the value of sheep wool if present.

Habitats for Houndstongue are open to shady, moist, disturbed areas, along trails, roadsides, fields, pasture, rangeland, along the edge of forests, sand dunes and ditch banks. Houndstongue prefers moist areas, but often grows on sandy or gravelly alkaline soil up to 9,000 feet elevation. Areas with more than 10% bare ground are particularly vulnerable to Houndstongue invasions.

The key to effective control of Houndstongue is preventing establishment and to prevent seed production. Planting competing and desirable grasses and forbs can be effective. Helping with reestablishment of disturbed sites. An integrated weed management approach can also be successful. Chemical, mechanical, and biological controls can be effective when dealing with Houndstongue. Details on the back of this sheet can help to create a management plan compatible with your site ecology.

Houndstongue is designated as a "List B" species in the Colorado Noxious Weed Act. It is required to be either eradicated, contained, or suppressed depending on the local infestations. For more information visit www.colorado.gov/ag/csd and click on the Noxious Weed Management Program. Or call the State Weed Coordinator at the Colorado Department of Agriculture, Conservation Services Division, 303-239-4100.

Photos: top left Aspen County, CO; all other Kelly Uhing , Colorado Department of Agriculture.

Updated on:
08/08

Cynoglossum officianale

Management Recommendations

Houndstongue

CULTURAL
Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities. Contact your local Natural Resources Conservation Service for seed mix recommendations. Maintain healthy pastures and prevent bare spots caused by overgrazing.

BIOLOGICAL
A root weevil, *Mogulones cruciger*, has been successful in Canada and introduced in Montana, but has not yet been approved for use in Colorado. For more information, contact the Palisade Insectary of the Colorado Department of Agriculture at 970-464-7916.

MECHANICAL
Cut or pull plants, and remove entire root crown when plants are in the rosette stage. Remove dense litter layer (up to 4 inches) to stimulate germination of desired plants. To reduce seed production, mow or cut flowering stems before seed nutlets develop, this can significantly reduce seed production.

Integrated Weed Management:

Prevention is the best option when dealing with Houndstongue. Use only certified weed-free hay. If an infestations does occur, reducing the seed production is key in controlling Houndstongue. Chemical, mechanical and the developing biological controls can also be effective management techniques.

HERBICIDES

NOTE: The following are recommendations for herbicides that can be applied to specific areas. Rates are approximate and based on equipment with an output of 30 gal./acre. **Always read, understand, and follow the label directions. The herbicide label is the LAW!**

HERBICIDE	RATE	APPLICATION TIMING
Metsulfuron Methyl + Chlorsulfuron (Cimarron X-tra)	2.0 oz. product/acre + 0.25% v/v non-ionic surfactant	Apply in spring rosette to early bud growth stages.
Picloram + 2,4-D (Grazon P+D)	4 pints/acre + 0.25% v/v non-ionic surfactant	Apply in spring rosette stage.

Top photo, © Kelly Uhing, Colorado Department of Agriculture. *Mogulones cruciger* photo ©H. Goulet. Mechanical management by Kelly Uhing.

Colorado State Parks

COLORADO STATE PARKS
BEST MANAGEMENT PRACTICES
WEED PROFILE

Date Created: April 25, 2003
Revised: April 1, 2005
Author: Various
Parks Affected: Many

Diffuse knapweed

Centaurea diffusa **Lam.;**

Acosta diffusa **(Lam.) Sojak**

BMPs

Family: *Asteraceae* (Sunflower)
Other Names: spreading knapweed, tumble knapweed
USDA Code: CEDI3
Legal Status: Colorado Noxious List B (top ten worst)

Keys to Identification:

- The floral bracts have yellow spines with teeth appearing as a comb along the spine margins.
- Flowers are usually white, but may be rose-purple to lavender in appearance.
- Seedlings have finely divided leaves that are covered with short hairs.

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, or 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 hairs.

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 has been reported to contain 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 diversity and increase soil erosion (Sheley et al. 1997).
Human: No information available.

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 at elevations up to 8,500 feet (K.G. Beck, pers. comm.). It grows in open habitats as well as 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 is a semelparous perennial; it grows as a rosette unitl it reaches a critical size, then bolts, flowers and usually dies (Thompson and Stout 1991). 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). Along the Colorado Front Range, seed production of 500-1500 seeds pre plant is more typical (Beck et al. 1998).

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 dispersed over long distances (Zimmerman 1997). Diffuse knapweed stalks readily lodge under vehicles, expanding their long distance dispersal.

Hybridization: No information available.

Keys to Control:

- Eliminate seed production.
- Stress the plants nutrient reserves as well as the soil seed bank through persistent management.
- Re-seed infested area with desirable species and manage them to produce a vigorous stand of plants.

Control

Biocontrol: Currently, biological control agents are available but the extent to which they effectively control diffuse knapweed populations is unclear. 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*, *Urophora quadrifasciata*, *Agapeta zoegana*, *Sphenoptera jugoslavica*, *Cyphocleonus achates*. The seedhead weevil *Larinus minutus* may also become available for distribution.

Mechanical: Cutting or mowing the above-ground portion of the plant, before seed set may be an effective way to reduce seed production, but it will not eliminate the infestation. Mowing usually increases diffuse knapweed density, due to increased germination from the soil seed bank. Mowings should therefore be followed by a fall herbicide treatment (Sebastian and Beck 1999). When a diffuse knapweed plant has been cut, the rosette may live and re-bolt. Additionally, diffuse knapweed seeds can remain dormant for several years, requiring any cutting program to be repeated several times annually (spring, summer, and fall) to be effective. Mowing or fire can be used as a way to remove standing dead material such that subsequently applied herbicide will be more effective (Roché and Roché 1999.)

Pulling can be effective for knapweed control, but it must be repeated frequently. Youtie and Soll (1994) suggested hand-pulling knapweeds three times annually until the plant disappears. The first pulling is in spring when the soil is moist, allowing enough of the plant to be

pulled to kill it. The second pulling in June focuses on bolted plants, with the third pulling just before seed dispersal to kill any remaining plants.

Fire: In areas without abundant native perennials, burning has been shown to be an effective control of diffuse knapweed with strong grass regrowth occurring on burned sites (Zimmerman 1997). A low-severity fire may only top-kill (not kill the root) diffuse knapweed, but a severe fire will probably kill the entire plant. Dry soil conditions associated with burns may discourage diffuse knapweed re-infestation as moisture is the limiting factor for diffuse knapweed seed germination. Re-seeding desirable species after burning helps to prevent a re-infestation of diffuse knapweed or other exotic species.

Herbicides: Several herbicides are relatively effective at controlling diffuse knapweed. Picloram is the most widely recommended (Harris and Cranston 1979). Other effective herbicides include clopyralid, dicamba, 2,4-D, and glyphosate (Beck 1997, Youtie 1997, Watson and Renney 1974). 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), clopyralid (0.25 lb./acre), clopyralid+2,4-D (0.2+1.0 lb./acre) and dicamba plus 2,4-D (0.5 lb./acre + 1.0 lb./acre) all control diffuse knapweed (Beck 1997). A backpack sprayer or a wick is recommended in small areas to minimize damage to non-target plants. Herbicides should either be applied before the mature plants set seed, or to rosettes in the fall, to maximize effectiveness.

Cultural/Preventive: Prevent establishment of new infestations, and manage grazing or other land use to maintain vigorous native communities.

Integrated Management Summary

Integrated treatment of diffuse knapweed depends on each situation. Single treatments provide temporary but not long-lasting control. In grasslands where the forb component is minimal or expandable, suggested strategies include altering grazing management to promote vigorous grasses, spraying with picloram, re-seeding with competitive grass species, followed by spot treatment with picloram or hand-pulling. According to Roché and Roché (1997), the best case scenario is establishing competitive forage species that can, with the help of biological control agents and proper livestock management, maintain knapweed at low levels. The most effective method of control for diffuse knapweed is to prevent its establishment. Areas that are adjacent to known patches of diffuse knapweed 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 diffuse knapweed can be pulled or spot treated with picloram. Burning may be an effective means of controlling diffuse knapweed in areas where seasonal or occasional fires are part of the natural ecosystem (Zimmerman 1997). Seeding desirable perennial grasses is essential to prevent weed reinvasion (Beck 1997).

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Spotted Knapweed Identification and Management

List B

Spotted knapweed (*Centaurea stoebe*) is a non-native, short-lived perennial forb that reproduces mainly by seed. A prolific seed producer, spotted knapweed can grow up to 900 seeds per plant annually that are viable for up to 8 years. The key to distinguishing spotted from other knapweeds is the black-tipped, spiny, involucral bracts (phyllaries) at the base of the flower. Unlike diffuse knapweed, it does not have a long, distinct terminal spine at the tip of the bracts. Spotted knapweed can grow up to 3 feet tall on ridged stems that are openly branched on the upper half of the plant. Urn-shaped flowers are solitary on the tip of each branch. Flowers are pink to purple, and rarely white. Leaves on the stem are alternate, deeply lobed, and become smaller and simple near the tips of the stem. Basal rosette leaves are deeply lobed and up to 6 inches long.

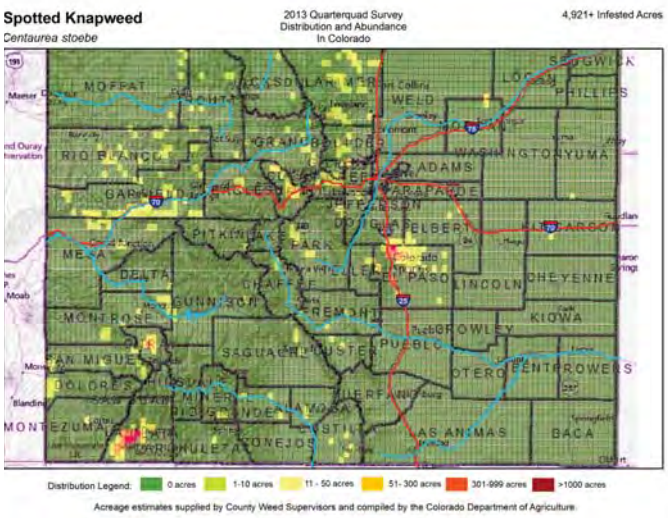
Flowers bloom from June to October and seed-set usually occurs by mid-August. Spotted knapweed can also reproduce vegetatively from lateral roots.

Spotted knapweed tends to invade disturbed, overgrazed areas. It also occurs in grasslands, pastures, foothill clearings, logged areas, roadsides, sandy soils, and floodplains. Since it can tolerate both dry conditions and moist areas it is an especially versatile invader. Spotted knapweed and diffuse knapweed infestations often occur together in Colorado and plants can hybridize. Once established, spotted knapweed reduces livestock and wildlife forage by out-competing native and desirable species.

The most effective method of control for spotted knapweed is to prevent seed production and establishment through proper land management. Maintain healthy pastures, rangeland, and forests; and continually monitor for new infestations. If spotted knapweed is already established, applying an integrated weed management approach is effective. Details on the back of this sheet can help to create a management plan compatible with your site ecology.

Spotted knapweed is designated as a "List B" species as described in the Colorado Noxious Weed Act. It is required to either be eliminated, contained, or suppressed depending on the local infestations. For more information please visit www.colorado.gov/ag/weeds and click on the Noxious Weed Program link or call the State Weed Coordinator, Colorado Department of Agriculture at 303-869-9030.

2013 Quarter Quad Survey



Key ID Points

1. Floral bracts have black tips, with comb-like spines of equal length.
2. Flowers are pink to purple, and rarely white.
3. Basal and stem leaves are deeply lobed, but become simple and oblong towards the tips of the stem.

Spotted knapweed

Centaurea stoebe

List B

Integrated Weed Management Recommendations

Spotted knapweed
Centaurea stoebe

Spotted knapweed is best controlled at the rosette stage with mechanical or chemical techniques in the spring and fall. A key goal is to prevent seed production. Management must be intense and persistent in order to deplete the seed bank in the soil.


© Patrick J. Alexander


Hybrid spotted-diffuse knapweed flower

CULTURAL
Bareground is prime habitat for weed invasions. Maintaining healthy pastures and forests, while minimizing disturbance and overgrazing, is crucial. Contact your local Natural Resources Conservation Service for seed mix recommendations.

BIOLOGICAL
Root and seed head weevils (*Cyphocleonus achates* and *Larinus minutus*) attack the roots and reduce seed production in spotted and diffuse knapweeds. This is an option for large infestations, though optimum results take 3-5 years. To obtain the insects, contact the Colorado Department of Agriculture's Insectary in Palisade, Colorado at 970-464-7916.

MECHANICAL
Dig when the soil is moist; remove the root crown, 2-4 inches of taproot, and lateral roots. Digging alone requires several years of multiple treatments within a growing season. Mowing spotted knapweed when flower buds or early flowers are present will stress the plant, but not kill it. Do not mow after seed-set because it can disperse the seeds. Annual cultivation can eliminate spotted knapweed.

CHEMICAL
The table below includes recommendations for herbicides that can be applied to rangeland and some pastures. Always read, understand, and follow the label directions. The herbicide label is the LAW!

HERBICIDE	RATE	APPLICATION TIMING
Aminopyralid (Milestone)	5-7 ounces/acre or 1 teaspsoon/gal water	Spring at rosette to early bolt stage and/or in the fall to rosettes. Add 0.25% v/v non-ionic surfactant (equivalent to 0.32oz/gal water or 1 qt/100 gal water).
Aminocyclo-pyrachlor + chlorsulfuron (Perspective)	4.75 to 8 oz product/acre	Apply in the fall when above-ground stems die back and root buds are highly susceptible; can also apply in the bud to senescence stages. Important: Applications greater than 5.5 oz product/acre exceeds the threshold for selectivity. DO NOT treat in the root zone of desirable trees and shrubs. Add 0.25% v/v non-ionic surfactant.
Clopyralid (Transline, Stinger)	2/3 to 1 pint/acre	Apply to spring/fall rosettes before flowering stalk lengthens. Add 0.25% v/v non-ionic surfactant.
Clopyralid + 2,4-D (Curtail)	2-3 qts. product/acre	Apply in spring and fall to rosettes. Add 0.25% v/v non-ionic surfactant.

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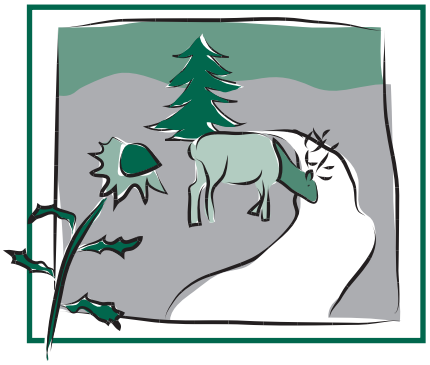

Leafy Spurge

Fact Sheet No. **3.107** Natural Resources Series | **Range**

by K.G. Beck*

Leafy spurge (*Euphorbia esula L.*) is a creeping, herbaceous perennial weed of foreign origin that reproduces from seed and vegetative root buds. It can reduce rangeland cattle carrying capacity by 50 to 75 percent. About half of this loss is from decreased grass production. Cattle won't graze in dense leafy spurge stands and these areas are a 100 percent loss to producers.

A 1990 survey found 44,000 acres in Colorado infested with leafy spurge. In 2002, the Colorado Department of Agriculture conducted a follow-up survey and found more than 73,800 infested acres of leafy spurge (Figure 1).

Leafy spurge is an erect plant that grows 1 to 3 feet tall. Leaves are bluish-green with smooth margins, 0.25 inch to 0.5 inch wide, and 1 inch to 4 inches long (Figures 2 and 3).

Umbel flowers are surrounded by heart-shaped, showy, yellow-green bracts. (An umbel looks like the stays of an umbrella if it is held upside down. Figure 4.) Flowers occur in many clusters toward the top of the plant (Figure 5). Seeds are round to oblong, about 1/12 inch long, gray or mottled brown with a dark line on one side.

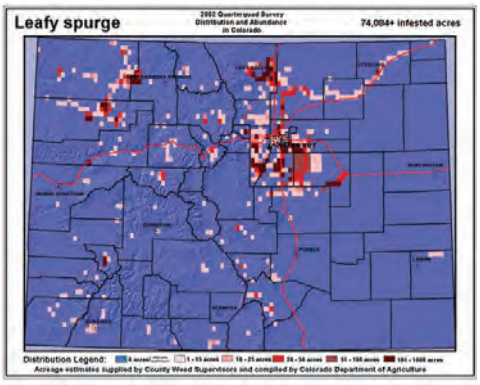

Figure 1: Leafy spurge distribution in Colorado, 2002.

Leafy spurge contains a white milky latex in all plant parts. Latex distinguishes leafy spurge from some other weeds (e.g., yellow toadflax), particularly when plants are in a vegetative growth stage.

Leafy spurge has an extensive root system that is abundant in the top foot of soil, and it may grow 15 feet deep or more. Roots contain substantial nutrient reserves that allow the weed to recover from stress, including control efforts. Many vegetative buds along roots grow into new shoots. This contributes to its persistence and spread.

Phenology

Leafy spurge shoots originate in early spring from crown tissue just below the soil surface and from sporadic buds along the root system. Leafy spurge is very competitive, one of the first plants to emerge each spring, and uses moisture and nutrients that otherwise would be available for more desirable vegetation.

Flowering occurs primarily in April and May but may occur through fall. Bracts emerge about two weeks before flowers and give leafy spurge the appearance of flowering. For optimum herbicide application timing, it is important to recognize true flower emergence.

Each flowering shoot produces an average of 140 seeds. Seeds are expelled up to 15 feet when capsules dry. They are viable up to eight years in soil. Water, birds, animals and people aid seed dispersal. Seeds readily float and waterways are good sources for new infestations.

Peak seed germination generally occurs in May (Figure 6). Seedlings quickly acquire the ability to reproduce vegetatively by developing buds on roots within 10 to 12 days after emergence. Perennial leafy spurge is more difficult to control than seedlings.

*Colorado State University Extension weed science specialist and professor, bioagricultural sciences and pest management. 11/2013

Quick Facts

- Leafy spurge (*Euphorbia esula L.*) is a creeping perennial that reproduces from seed and vegetative root buds.
- It can reduce cattle carrying capacity of rangeland or pastures by 50 to 75 percent.
- Leafy spurge is difficult to control. Its extensive root system has vast nutrient stores that let it recover from control attempts.
- Combine control methods into a system to achieve best results.

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Figure 2: Leafy spurge stems and leaves.

Figure 3: Leafy spurge in bolting growth stage; note leafy spurge seedlings.

Figure 4: Leafy spurge in the early flower stage; note the heart-shaped bracts beneath developing flowers.

Management

Leafy spurge is difficult to manage and can recover from almost any control effort. Therefore, a management scheme that combines control methods over four to five years is recommended. Even after that time, monitor infestations for recurrence and adopt a maintenance program.

Cultural control. Vigorous grass growth is an important aspect of leafy spurge control. Over-grazing stresses grasses and makes them much less competitive with weeds, leafy spurge in particular. Irrigation, where applicable, may favor grass growth and make it more competitive with leafy spurge.

Chemical control. For optimum leafy spurge control, proper timing of herbicide application is imperative. Research from North Dakota-State University indicates that Tordon 22K (picloram) 2,4-D, Banvel/Vanquish/Clarity (dicamba) are most effective when applied in spring when true flowers emerge (not just bracts). Fall application to leafy spurge regrowth also is good timing for these herbicides. Refer to Table 1 for rates and application timings and always read the herbicide label before using the product.

Tordon is one of the most effective herbicide for leafy spurge control. Treat large, readily accessible areas for three to four consecutive years. For more remote locations, Tordon can be spot sprayed at 2/quarts/A but not more than 50% of an acre can be treated in any year. Monitor infestations after treatment and retreat with 1 quart/A of Tordon when shoot control is less than 75 percent.

Tordon may be tank-mixed with 2,4-D to provide adequate control. Apply 1 to 1.5 pints of Tordon with 1 to 1.5 quarts/A of 2,4-D in spring when leafy spurge flowers. When this application is made for three to five consecutive years, leafy spurge shoot control is generally 80 to 90 percent and cattle will feed in the area again.

Plateau (imazapic) can be used to control leafy spurge in pastures, rangeland, and non-crop areas. It can be used safely around trees but may temporarily injure cool-season perennial grasses. Apply Plateau in fall while milky latex still is present in the plant. Add a methylated seed oil to the spray solution. A liquid nitrogen fertilizer solution may be added to the spray mixture to increase weed control, but it may increase cool-season perennial grass injury. Injury tends to increase with late fall applications.

Perspective control of leafy spurge is similar to Tordon. CSU research indicates that multiple years of treatment with Perspective may be necessary but not always as consecutive year applications–a single application may control leafy spurge for two growing seasons and then a repeat application may be needed.

Table 1. Herbicide rates and application timings to control leafy spurge.

Herbicide	Rate (Product/A)	Application timing	Comments
Tordon	1 quart	Spring at flowering growth stage; or fall	May need treatment 3 to 4 years
Plateau	8 to 12 fl oz	Early fall (August through October) before loss of latex	Use higher rate for older and dense stands; adds 1.5 to 2 pint/A of methylated seed oil; high rate or consecutive year treatments may injure cool season grasses
Paramount	16 oz	Spring at prebloom (yellow bract stage) or in fall	Add 1.5 pt/A of a methylated seed oil or 2 pt/A of a crop oil concentrate
Perspective	5.5 oz	Spring at flowering growth stage; or fall	Methylated seed oil or crop oil concentrate may aid leaf absorption of Perspective at 0.5 to 1% v/v; or use of a non-ionic surfactant at 0.25 to 0.5% v/v also is recommended
Banvel, Vanquish, or Clarity (dicamba)	2 quarts	Spring at flowering growth stage; or fall	Fall applications most consistent results; may need re-treatment 2 to 4 years
Roundup	1 quart each application; 2 quarts total	Apply sequentially; first application first of June and second one month later	Must be combined with grass seeding

Be certain to monitor treated sites for leafy spurge recovery and retreat when control appears to be 70% or less. A methylated seed oil or crop oil concentrate may aid leaf absorption of Perspective and often improves control. However, a non-ionic surfactant also can be used instead of the seed or crop oil.

Paramount (quinclorac) is a highly selective herbicide and can be used to control leafy spurge in pastures, rangeland and non-crop areas. CSU research indicates that Paramount caused the least injury to desirable/native forbs and shrubs. It should be used in conjunction with a methylated seed oil or crop oil concentrate.

Banvel/Vanquish/Clarity also is effective against leafy spurge. When applied in spring at flowering for three consecutive years. Often control is not very good in the first year but improves over the next two years. At that time, a maintenance schedule that uses low rates of Banvel/Vanquish/Clarity + 2,4-D (4 to 8 ounces + 0.5 to 1 quart/A), or Tordon + 2,4-D (1 pint + 1 quart/A) as needed can be used to keep infestations under control. **Note: Avoid using soil-active herbicides such as Tordon, Perspective, or Banvel/ Vanquish/Clarity near windbreak plants or other desirable woody vegetation.** Plant injury or death can occur. Also, do not allow any herbicide to drift onto desirable woody vegetation for the same reasons.

Roundup (glyphosate) is most effective when applied sequentially at one month intervals, coupled with fall grass seeding. Make the first application at the beginning of June and a second application one month later. Occasionally, leafy spurge will recover from these Roundup treatments. An application of 2,4-D (2.0 quart/A) in September can control regrowth. Sow perennial grasses in later fall as a dormant seeding (seed later enough that grass seedlings will not emerge until following spring).

Biological control. Sheep or goats can be used to help control leafy spurge. Research from Montana State University indicates sheep may consume up to 50 percent of their diet as leafy spurge. Introduce sheep to leafy spurge in early spring when the weed is succulent. Goats will consume leafy spurge at almost any time during the growing season.

Rotate pastures to prevent seed production and allow desirable forage plants to regain vigor. If livestock graze leafy spurge after seed formation, hold animals in a corral for at least seven days before moving them to an uninfested area. This reduces viable seed passage. Sheep or goats followed by fall herbicide treatment may be an effective, integrated means to use infested ground and control the weed.

The Colorado Department of Agriculture insectary has four flea beetles (*Apthona nigriscutis*, black-dot flea beetle; *A. cyparissiae*, brown-dot spurge flea beetle; *A. czwalinae*, black spurge flea beetle; and *A. flava*, copper spurge flea beetle) available for release. Their larvae feed on leafy spurge root hairs and within roots, while adults feed on foliage. Other insects may become available in the future. Most likely, a combination of insects will be necessary to adequately control leafy spurge. Insects would be most advantageous in areas where herbicide use is difficult or risky.

Recent research completed by Colorado State University showed that six to eight sheep per acre grazing for 10 days in July over a period of five years decreased leafy spurge density about 90 percent. When flea beetles grazed simultaneously in July with eight sheep per acre for 10 days over five years, leafy spurge density was decreased to zero.

Habitat requirements of the flea beetles vary. While all requirements are not well understood, it is known that *A. nigriscutis* prefers open, dry sites and coarse soils low in organic matter. *A. cyparissiae* prefers soils higher in moisture than

Figure 5: Leafy spurge nearing seed set growth stage; note three-lobed seed capsules above bracts.

Figure 6: Leafy spurge seedlings.

A. nigriscutis, but still prefers moderately coarse-textured soils such as sandy loams and open sites. *A. flava* does well in coarse soils with high water tables in open and shaded conditions. *A. czwalinae* prefers moist, clay soils.

Regardless of the management system used, a combination of methods is essential to return leafy spurge-infested ground to a productive state. The key to control leafy spurge or any creeping perennial is to exhaust the root nutrient stores, causing it to collapse. Persistence is imperative to gain control.

Leafy Spurge

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Pest Status of Weed

Nature of Damage

Leafy spurge, *Euphorbia esula* L., is an invasive, deep-rooted perennial herb that is native to Eurasia (Watson, 1985; Pemberton, 1995). The plant spreads through explosive seed release and vigorous lateral root growth, forming large, coalescing patches that can dominate rangeland, pastures, prairies and other noncrop areas in the Great Plains region of North America (see Fig. 1, a and b, and Fig. 2).

Figure 1. (a) Flowering stems of leafy spurge,*Euphorbia esula* L. and (b) dense patch of leafy spurge, *Euphorbia esula* L. (Photograph [a] courtesy of Montana State University Extension Service; and [b] by USDA, ARS.)

Figure 2. Rangeland severely infested by leafy spurge, *Euphorbia esula* L. (Photograph courtesy of USDA, ARS.)

Economic damage. Leafy spurge has infested more than one million hectares in North America since its introduction approximately 200 years ago (Alley and Messersmith, 1985), and threatens to invade more areas (Lacey *et al.*, 1985). All parts of leafy spurge produce milky latex that can cause dermatitis in humans and cattle (Lacey *et al.*, 1985), and can cause death in cattle if sufficient quantities are consumed (Kronberg *et al.*, 1993). Leafy spurge reduces forage production and wildlife habitat, and causes considerable monetary losses to the livestock industry (Messersmith and Lym, 1983;

Watson, 1985; Lacey *et al.*, 1985; Nowierski and Harvey, 1988; Bangsund, 1993; Leitch *et al.*,1994). Cattle carrying capacity in rangeland can be reduced by 50 to 70% (Alley *et al.*, 1984), and in some cases, by 100 percent (Watson, 1985) through loss of grasses from competition, and the tendency of cattle to avoid spurge-infested grass (Lacey *et al.*, 1985; Hein and Miller, 1992; Kronberg *et al.*, 1993). Direct and secondary economic losses from leafy spurge, due to lost cattle production, for the Dakotas, Montana, and Wyoming in 1994 were estimated to approach $120 million annually (Leitch *et al.*, 1994). In addition, Wallace *et al.* (1992) estimated nonagricultural losses (e.g., watershed and recreation impacts) from leafy spurge at $10 million annually over the same four-state region. Leafy spurge is much less abundant in the eastern United States, although it can be weedy enough in pastures to require control.

Ecological damage. Although leafy spurge is most commonly associated with more mesic sites, it is adapted to a broad range of habitats, ranging from xeric to riparian sites (Nowierski and Zeng, 1994; Lym 1998; Kirby *et al.*, 2000). The percent cover of grasses and forbs may be significantly reduced at medium to high densities of leafy spurge (Nowierski and Harvey, 1988). Studies by Belcher and Wilson (1989) have shown that native plant species may be severely affected by leafy spurge. Such reductions in native plant diversity also may have a negative impact on wildlife populations (Wallace *et al.*, 1992; Trammell and Butler, 1995). Population declines in a number of native grassland bird species have been documented in the Great Plains Region of North America at sites with moderate to high densities of leafy spurge (D. Johnson, pers. comm.).

Geographic Distribution

Leafy spurge is native to Eurasia and is widely distributed from Spain to Japan (Ohwi, 1965; Radcliff-Smith and Tutin, 1968; Pemberton, 1995). Since the first recording of this weed in North America at Newbury, Massachusetts in 1827 (Britton, 1921), it has become widespread in certain regions of the United States and Canada. Leafy spurge has been recorded in 35 states within the United States, but has yet to be recorded in Oklahoma, Texas, Arkansas, Louisiana, Kentucky, Tennessee, North Carolina, Mississippi, Alabama, Georgia, South Carolina, and Florida (USDA, NRCS, 2001). The most extensive infestations of the weed occur in the northern Rocky Mountain and Great Plains states (Idaho, Montana, Wyoming, North Dakota, South Dakota, Nebraska, and Minnesota), and in the Canadian provinces of British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario (USDA, APHIS, PPQ, CAPS, 1994). In the upper Mississippi River drainage, leafy spurge occurs primarily in riparian habitats (R. Hansen, pers. comm.). In the eastern United States, the plant is an occasional weed of pastures, roadsides, and riparian habitats (R. Hansen, B. Blossey, J. Wickler, and P. Wrege, pers. comm.). The weed can be locally abundant, but usually is limited to discrete patches. Fifteen New York counties were known to be infested with leafy spurge in the early 1980s (Batra 1983).

Background Information On The Pest Plant

Taxonomy

In North America, leafy spurge occurs as a complex of forms, species, and hybrids and has been most commonly referred to as *Euphorbia esula* L. (Euphorbiaceae) (Pemberton, 1985). The most problematic type appears to be *E. x pseudovirgata*, which is a hybrid of *E. esula sensu stricto* and *E. waldsteinii*(=*E. virgata*) (Dunn and Radcliffe-Smith, 1980), hereafter referred to as leafy spurge, *E. esula* L. (Harvey *et al.*, 1988). Harvey *et al.* (1988) examined the leaf morphology and triterpenoid composition of leafy spurge accessions from Montana and five related European spurge species and concluded that all the Montana leafy spurge and three of the five European species could not be distinguished from*Euphorbia esula*.

Leafy spurge populations show a high degree of genetic, chemical, and morphological variability, and as a consequence the taxonomic identity of the United States populations and their affinities to other species is unclear (Shulz-Schaeffer and Gerhardt, 1987; Watson, 1985; Harvey *et al.*, 1988; Torell *et al.*, 1989; Nissen *et al.*, 1992; Pemberton, 1995; Rowe *et al.*, 1997). This genetic variability, combined with other traits, including the plant‘s possession of both sexual and asexual reproduction, a deep underground root system, an ability to infest xeric, mesic, and even hydric sites across a wide range of soil types (Nowierski and Zeng, 1994; Nowierski *et al.*, 1996; Nowierski *et al.*, 2002), along with the existence of many native spurge species (Euphorbiaceae) in North America (Pemberton, 1985), makes both conventional management and classical biological control of this weed complex and potentially difficult (Shulz-Schaeffer and Gerhardt, 1987).

Biology

Leafy spurge is an aggressive, deep-rooted perennial herb that reproduces from seed and from numerous vegetative buds along its extensive vertical and horizontal root system (Watson, 1985). Seeds of leafy spurge are released explosively by dehiscence of the seed capsules, and may be projected up to 4.6 m from the parent shoot (Hanson and Rudd, 1933; Bakke, 1936). Seeds are dispersed by ants, birds, grazing animals, humans, and water (Hanson and Rudd, 1933; Bowes and Thomas, 1978; Messersmith *et al.*, 1985; Pemberton, 1988; Pemberton, 1995). Germination of leafy spurge seed can occur throughout the growing season whenever adequate moisture is available, but the most favorable conditions for germination occur in early spring (Bakke, 1936; Messersmith *et al.*, 1985). The roots of leafy spurge reportedly can reach a depth of 9 m (Best *et al.*, 1980).

Stems of leafy spurge are erect, tough and woody and range from 0.1 to 1.0 m in height (Lacey *et al.*, 1985). The showy yellow-green inflorescences produce an average of 140 seeds per stem. Leafy spurge leaves are highly variable in shape, ranging from broadly linear-lanceolate to ovate (Watson, 1985). Additional details on the morphology and anatomy of leafy spurge can be found in Raju (1985).

Leafy spurge is one of the first plants to emerge in the spring, and its appearance has been recorded as early as March in Iowa and Wisconsin and early April in North Dakota (Messersmith *et al.*, 1985). Vegetative development and stem elongation occurs rapidly as the temperatures increase during late April through early June. The swelling of the stem apex signals initiation of the leafy spurge inflorescence, which occurs approximately one week after stem emergence. The first yellow to yellowish-green bracts appear at the base of the terminal inflorescence from early to late May depending on environmental conditions (Messersmith *et al.*, 1985). The showy yellow bracts of the leafy spurge inflorescence are most visible from late May through June. Flowering in the terminal inflorescence ends between late June and early July. Seed development and maturation continue for approximately one month post flowering. As the plants mature, the stems and leaves often turn from a blue-green to a reddish brown, red, or yellow, either during hot, dry periods after seed production in midsummer or due to senescence in the fall (Messersmith *et al.*, 1985). Plant phenology may vary greatly within and among locations due to local microclimatic differences.

Analysis of Related Native Plants in the Eastern United States

Risks to native plant species as a result of biological control of leafy spurge were analyzed by Pemberton (1985). The analysis was limited to the genus *Euphorbia*, in the tribe Euphorbieae, subfamily Eurphorbioideae, family Euphorbiaceae (Mabberley, 1997). The genus is divided into five subgenera, four of which are represented in the native flora of the eastern United States. Of the approximately 107 native *Euphorbia* species in the continental United States and Canada, about 45 occur east of the Mississippi River. These include 23 species in the subgenus *Chamaesyce*, 13 species in the subgenus *Agaloma*, and three species in the subgenus *Poinsettia*. The remaining six species belong to the subgenus *Esula*, to which leafy spurge belongs. Of these six, four are broadly sympatric with leafy spurge. These are *E. commutata* Engelm., *E. obtusa* Pursh, *E. purpurea* (Raf.) Fern., and *E. spatulata* Lam. *Euphorbia purpurea* is the only perennial of these four, and it also is the only rare eastern species growing in the general region where leafy spurge is more common. This perennial species is under review for legally protected status by the U.S. Fish and Wildlife Service (1993). The plant occurs in both dry and moist woods (Gleason and Cronquist, 1963) in Delaware, Maryland, North Carolina, New Jersey, Ohio, Pennsylvania, Virginia, and West Virginia (Federal Register, 1993). There are four other rare species of *Euphorbia* s.l. east of the Mississippi River, but all occur in Florida (Federal Register, 1993). *Euphorbia telephioides* Chapm. is formally listed as a threatened species (U.S. Fish and Wildlife Service, 1997) and is a member of the subgenus *Esula* that is restricted to the Florida panhandle. The other three rare spurges belong to the subgenus*Chamaesyce*, within the genus *Euphorbia*. Subgenera of *Euphorbia* appear to be natural groupings and most *Euphorbia*-feeding insects that have been evaluated as biological control agents distinguish among subgenera, accepting plants within some subgenera as hosts while rejecting potential host plants found in other subgenera (Pemberton, 1985).

History of Biological Control Efforts in the Eastern United States

Area of Origin of Weed

The native range of leafy spurge is Eurasia and extends from Spain to Japan (Ohwi, 1965; Radcliff-Smith and Tutin, 1968; Watson, 1985; Pemberton, 1995). More precise geographic origins for populations invasive in the United States have not been determined. In its native range leafy spurge is typically just a scattered plant in the ecosystem. R. M. Nowierski has observed the occasional use of leafy spurge in flower arrangements in Europe.

Areas Surveyed for Natural Enemies

European surveys for natural enemies of leafy spurge began in the early 1960s by the Commonwealth Institute of Biological Control (CIBC; name subsequently changed to the International Institute of Biological Control [IIBC]; now called CABI-Bioscience), through their European Station in Delémont, Switzerland. In the 1970s, surveys were initiated by the USDA, ARS Biological Control Laboratory in Rome, Italy (which is now the USDA, ARS European Biological Control Laboratory in Montpellier, France). All of the natural enemies released in North America to date against leafy spurge were discovered during these extensive European surveys. Additional surveys for spurge natural enemies, conducted in China from 1987 to the early 1990s, identified additional promising agents, including several *Aphthona* species that are still under study (Pemberton and Wang, 1989; Fornasari and Pemberton, 1993).

Natural Enemies Found

Manojlovic and Keresi (1997) reported that 121 insect species (23 species of Homoptera, six Heteroptera spp., 37 Lepidoptera spp., four Hymenoptera spp., 14 Diptera spp., and 37 Coleoptera spp.) are able to develop on plants of *E. esula*, *Euphorbia virgata* Waldstein-Wartemberg and Kitaibel, and *E. cyparissias* L. in Europe. Additional discussion of the spurge fauna was provided by Gassmann and Schroeder (1995). Through surveys for natural enemies of leafy spurge conducted by personnel of the IIBC laboratory in Delémont, Switzerland, between 1961 and 1990, two rust species and 39 insect species were found that were thought to be specialized on leafy spurges (Gassmann, 1990). Of these, 22 insect species were screened as potential biological control agents of leafy spurge. Additional insects have been screened by personnel at the USDA, ARS Biological Control of Weeds Laboratory, Rome, Italy; the USDA, ARS Biological Control Laboratories in Albany, California, USA; the Montana State University Insect Quarantine Laboratory, Bozeman, Montana, USA (Pemberton, 1995); and more recently the USDA, ARS Laboratory in Sidney, Montana, USA.

Host Range Tests and Results

See “Host Range Tests and Results” for cypress spurge for details regarding the host range tests for natural enemies attacking both leafy spurge and cypress spurge.

Releases Made

Since 1965, 12 insect species have been released against leafy spurge or cypress spurge in the United States, and 17 species have been released in Canada. The first insect released in the United States against leafy spurge was the spurge hawkmoth, *Hyles euphorbiae* L. (Lepidoptera: Sphingidae) (Figs. 3 and 4), which was first released in Idaho, Montana, Oregon, Utah, and Washington during the mid-1960s (Julien 1987). The release material was collected from an established population on cypress spurge in Braeside, Ontario, from stocks originating from cypress spurge, *Euphorbia cyparissias* L, and*E. seguieriana* Necker, from Switzerland, France, and Germany (Harris, 1984). *Hyles euphorbiae* also was the first natural enemy of spurge to be released in the eastern United States beginning in 1978 in New York, with releases directed against both leafy and cypress spurge (Batra, 1983). Although the insect was released against leafy spurge in numerous states (California, Colorado, Idaho, Nebraska, Montana, North Dakota, Nevada, New York, Oregon, Wyoming) from 1964 to 1986, the insect only has become established in New York (Batra, 1983), in Wyoming (Coombs, 2000), and at a number of sites in Montana (R. M. Nowierski, unpub. data). Researchers have attributed the poor rates of establishment of this insect to predation by ants, carabids, and mammalian predators (Harris *et al.*, 1985; R. M. Nowierski, S. J. Harvey, and J. M. Story, unpub. data), and to the possible existence of different moth host races (Harris, 1984).

Figure 3. Adults of leafy spurge hawkmoth, *Hyles euphorbiae* L. (Photograph courtesy of USDA, ARS.)

Figure 4. Larva of the leafy spurge hawkmoth, *Hyles euphorbiae* L. (Photograph courtesy of USDA, ARS.)

The clearwing moth, *Chamaesphecia tenthrediniformis* (Denis and Schiffermüller) (Lepidoptera: Sesiidae), was released against leafy spurge in Idaho, Montana, and Oregon during 1975 to 1979. None of the releases resulted in establishment (Pemberton, 1995). This and two other species, *C. hungarica*(Tomala) (Fig. 5) and *C. crassicornis* Bartel (Fig. 6), were released against leafy spurge in the western United States in 1975, 1993, and 1994, respectively. At present, it appears that none of these releases were successful, except for one population of *C. crassicornis*, which has established on leafy spurge in Oregon (Coombs, 2000).

Figure 5. Adult of the clearwing moth,*Chamaesphecia hungarica* (Tomala). (Photograph courtesy of USDA, APHIS.)

Figure 6. Adult clearwing moth, *Chamaesphecia crassicornis* Bartel. (Photograph courtesy of USDA, APHIS.)

The first coleopteran species released against leafy spurge in the United States was the stem boring beetle, *Oberea erythrocephala* (Schrank) (Coleoptera: Cerambycidae) (Fig. 7). Releases of the beetle were made in Montana, Oregon, North Dakota, and Wyoming during 1980 to 1986. Additional releases of *O. erythrocephala* were made by APHIS, PPQ in Colorado, Iowa, Idaho, Michigan, Minnesota, Montana, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Dakota, Oregon, Rhode Island, South Dakota, Utah, Washington, Wisconsin, and Wyoming during 1988 to 1995. *Oberea erythrocephala*establishment has been documented in Montana (Rees *et al.*, 1986; Hansen *et al.*, 1997), Oregon and Wyoming (Coombs, 2000), North Dakota (Pemberton, 1995), and Colorado and South Dakota (Hansen *et al.*, 1997).

Figure 7. Adult of the stem boring beetle, *Obera erythrocephala* (Schrank). (Photograph courtesy of USDA, APHIS.)

Flea beetles in the genus *Aphthona* have been the most successful biocontrol agents released against leafy spurge in North America. *Aphthona abdominalis* Duftschmidt (Coleoptera: Chrysomelidae) (Fig. 8), *Aphthona cyparissiae* (Koch) (Fig. 9), *Aphthona czwalinae* (Weise) (Fig. 10), *Aphthona flava*Guillebeau (Fig. 11), *Aphthona lacertosa* Rosenhauer (Fig. 12), and *Aphthona nigriscutis* Foudras (Figs. 13 and 14), were first released in the United States in 1993, 1986, 1987, 1985, 1993, and 1989, respectively, and all but *A. abdominalis* have established in the United States (Pemberton, 1995; Hansen *et al.*, 1997). In 1994 and 1995 USDA, APHIS, PPQ transferred *Aphthona* beetles from established populations in the western United States to a number of eastern states (Hansen *et al.*, 1997). Releases of individual species or mixed collections of several species (*A. flava*, *A. cyparissiae*,*A. nigriscutis*, *A. lacertosa* and *A. czwalinae*) were made in Iowa, New Hampshire, Michigan, Minnesota, New York, and Wisconsin.

Figure 8. Adult flea beetle, *Aphthona abdominalis* Duftschmidt. (Photograph courtesy of USDA, APHIS.)

Figure 9. Adult flea beetle, *Aphthona cyparissiae* (Kock). (Photograph courtesy of USDA, APHIS.)

Figure 10. Adult flea beetle, *Aphthona czwalinae* Weise. (Photograph courtesy of USDA, APHIS.)

Figure 11. Adult flea beetle, *Aphthona flava* Guillebeau. (Photograph courtesy of USDA, APHIS.)

Figure 12. Adult flea beetle, *Aphthona lacertosa* Rosenhauer. (Photograph courtesy of USDA, APHIS.)

Figure 13. Adult flea beetle, *Aphthona nigriscutis* Foudras. (Photograph courtesy of USDA, APHIS.)

Figure 14. Larvae of the flea beetle, *Aphthona nigriscutis* Foudras. (Photograph courtesy of USDA, APHIS.)

Figure 15. (a)Adult of the shoot tip gall midge,*Spurgia esulae* Gagné; (b) shoot tip gall made by midge larvae (inset).(Photograph courtesy of USDA, APHIS.)

The shoot tip gall midge, *Spurgia esulae* Gagné (Diptera: Cecidomyiidae) (Figs. 15a,b), is the only fly species released against leafy spurge in the United States. Releases were made in Montana, Oregon, North Dakota, and Wyoming during 1985 to 1988, and establishment was later recorded in Montana and North Dakota from these releases (Pemberton, 1995). Additional releases were made by USDA, APHIS, PPQ in Colorado, Idaho, Iowa, Michigan, Minnesota, Montana, North Dakota, Nebraska, Nevada, New Hampshire, New Mexico, New York, Oregon, Rhode Island, South Dakota, Utah, Washington, Wisconsin, and Wyoming from 1988 to 1996 (Hansen *et al.*, 1997). As of 1997, establishment of the midge from these releases has been documented in Colorado, Montana, New York, Oregon, Rhode Island, South Dakota, and Wyoming (Hansen *et al.*, 1997). The midge also has been recorded as established on leafy spurge in Idaho (Coombs 2000).

Informal human transport of leafy spurge biological control agents from Canada to the United States and vice-versa has probably resulted in additional releases (R. Hansen, pers. comm.). In addition, some biological control agents of leafy spurge, such as the tortricid moth *Lobesia euphorbiana* (Freyer), that have been released in Canada but not in the United States, may move into the United States on their own.

Biology and Ecology of Key Natural Enemies

Hyles euphorbiae (L.) (Lepidoptera: Sphingidae)

The leafy spurge hawkmoth feeds on the leaves and flowers of *Euphorbia* species in the subgenus*Esula* (Harris, 1984). Adult females lay from 70 to 110 eggs singly or in clusters on the plant surface, and the small black larvae emerge a week or two later depending on temperature. A generation is completed in about six weeks (Pemberton, 1995). Larvae go through a series of color changes as they grow, from black as they first eclose, to greenish-yellow during the next couple of instars, to a showy combination of black, white, red, and yellow during the last two instars. The larval integument and hemolymph contains triterpenoids derived from feeding on leafy spurge (P. Mahlberg

and R. M. Nowierski, unpub. data). Larvae are believed to use these compounds for chemical protection against predators, and field studies in Montana have shown larval predation to be low (N. H. Poritz, R. M. Nowierski, and S. J. Harvey, unpub. data). In contrast, rates of predation on pupae, measured using different levels of exclusion, are high and are most likely due to field mice (*Peromyscus* spp.) and shrews (R.M. Nowierski, S. J. Harvey, N. H. Poritz, and J. M. Story, unpub. data). High pupal predation by animals may explain the extreme differences in hawkmoth populations among years, as populations of small mammalian predators typically are quite variable over time.

In Montana, hawkmoth larvae are generally present during the last week or so of June and are most abundant the first week of July. Larvae pupate in the soil in July and August and a significant proportion of pupae eclose for a second generation.

Oberea erythrocephala (Coleoptera: Cerambycidae)

The longhorn beetle, *O. erythrocephala*, is native to Eurasia where it feeds within the stems and roots of several *Euphorbia* species. Adults appear in early to mid-summer when spurges are in flower, and feed on the young leaves, flowers, and stem tissue for approximately two weeks before beginning oviposition (Pemberton, 1995; Hansen *et al.*, 1997). Adult beetles girdle the upper part of the stem, chew a hole in it just above the girdle, insert an egg and cover it with latex (Pemberton, 1995; Hansen*et al.*, 1997). Larvae take approximately one month to mine their way down the stem into the crown and roots (Pemberton, 1995). Larvae feed within crowns or roots until March or April and pupate within cells in the root crown in May.

Aphthona spp. (Coleoptera: Chrysomelidae)

The flea beetle genus *Aphthona* (Coleoptera: Chrysomelidae) contains approximately 40 species that are known to feed on leafy spurges (*Euphorbia* spp.) in Europe and Asia (Harris *et al.*, 1985; Fornasari and Pemberton, 1993; Fornasari, 1996). All of the established flea beetle species released against leafy spurge in the United States are univoltine, with some of the species showing phenological differences in adult emergence during the course of the growing season (Hansen, 1994). *Aphthona abdominalis*, which has not yet been documented as established in North America, reportedly may produce more than one generation per year (Fornasari, 1996). Early larval instars feed in/on root hairs of the host plant, while later instars feed in/on yearling roots. Larval feeding contributes to leafy spurge mortality by disrupting water and nutrient transport and may provide entry points for pathogenic soil inhabiting fungi (Hansen *et al.*, 1997). Adult flea beetles feed on leaves and flower bracts of leafy spurge. *Aphthona*species overwinter as larvae, and generally pupate within the spurge roots in late spring to early summer (Rees *et al.*, 1996).

Aphthona cyparissiae (Coleoptera: Chrysomelidae)

The native range of *A. cyparissiae* extends from southern Spain and France through central and eastern Europe to western Russia (Pemberton, 1995). In Eurasia, this species occurs at higher altitudes and in areas with cool, rainy summers (Pemberton, 1995). The species has a relatively broad ecological amplitude and has been recorded from xeric to mesic sandy loam sites in Eurasia (Müller, 1949; Maw, 1981; Fornasari, 1996; Gassmann *et al.*, 1996). However, this species has been less successful in establishing on leafy spurge in the United States than *A. nigriscutis* and *A. lacertosa*.

Aphthona czwalinae (Coleoptera: Chrysomelidae)

This blue-black flea beetle species is native to central and eastern Europe (Germany, Austria, Poland), the lower Danube region, parts of Russia, central Asia, and eastern Siberia (Gassmann, 1984). It is most commonly found at mesic sites where *Euphorbia* is intermixed with other vegetation, and is thought to have the potential to colonize sites such as stream margins, where leafy spurge is often most abundant (Pemberton, 1995). The biology and host range of *A. czwalinae* is similar to that of *A. cyparissiae* and *A. flava*, although it is limited to fewer species in the subgenus *Esula* than the other two species (Gassmann, 1984; Pemberton 1987). Because the releases of *A. czwalinae* have typically been reported as an *A. czwalinae/A. lacertosa* mix (Hansen *et al.*, 1997), the actual establishment and impact of this species on leafy spurge in various states in the United States is unclear.

Aphthona flava (Coleoptera: Chrysomelidae)

This flea beetle species is found from northern Italy east and north through the former Yugoslavia, Hungary, Czechoslovakia, Bulgaria, Romania, and Russia (Sommer and Maw, 1982). In Eurasia, this species occurs in xeric to mesic habitats in areas with drier and warmer summers (Pemberton, 1995). Like *A. cyparissiae*, this species has been less successful than *A. nigriscutis* and *A. lacertosa* in establishing on leafy spurge in North America.

Aphthona lacertosa (Coleoptera: Chrysomelidae)

This species is native to Eurasia where it is associated with loamy or loamy-clay soils, in either dry or wet habitats (Gassmann, 1990; Fornasari, 1996; Gassmann *et al.*, 1996; Nowierski *et al.*, 2002). However, Maw (1981) reported that it preferred moist sites. *Aphthona lacertosa* establishment and its impact on leafy spurge has been greatest at moderately dry to mesic sites in the United States (Rees*et al.*, 1996). Unlike *A. nigriscutis*, which appears to be restricted to drier sites, *A. lacertosa* has a broader ecological amplitude and may have greater potential for controlling leafy spurge across a broad range of habitats. *Aphthona lacertosa* can be distinguished from *A. czwalinae* by its light-colored hind femur, whereas in *A. czwalinae* the hind femur is black (A. Gassmann, pers. comm.).

Aphthona nigriscutis (Coleoptera: Chrysomelidae)

This *Aphthona* species is native to Europe and is adapted to drier sites and sandier soils. This species has been most successful in establishing and controlling leafy spurge in dry, open, sandy-loam sites in Canada and the United States (Rees *et al.*, 1996). It generally has done poorly when released in high density leafy spurge infestations occurring in heavier clay soils (R. M. Nowierski, Z. Zeng, and B. Fitzgerald, unpub. data).

Spurgia esula (Diptera: Cecidomyiidae)

This small midge causes shoot-tip galls on leafy spurge, which prevents flowering and thus seed production of the attacked shoot. *Spurgia esula* is multivoltine and produces two or three generations per year in Montana (Hansen *et al.*, 1997) and up to five generations per year in its native European range (Pecora *et al.*, 1991). This gall midge overwinters as a mature larva and the first adults appear in mid- to late spring. Adult females deposit groups of eggs on leafy spurge leaves, typically near the apical buds (Hansen *et al.*, 1997). Upon eclosion, first instar larvae migrate to leafy spurge buds and begin feeding within the meristematic tissues. Larval feeding causes hypertrophy in the bud tissues and the formation of a bud gall, within which the larvae feed. Larvae require two to four weeks to complete development, depending on environmental conditions (Hansen *et al.*, 1997). Larvae of the non-diapausing summer generation construct silken cocoons inside the bud galls, from which adult flies later emerge. Mature larvae of the diapausing generation exit the galls, drop to the ground, and overwinter in the soil. No major impacts on leafy spurge populations have been reported for this biological control agent. However, Lym (1998) reported greater suppression of leafy spurge when *S. esulae* was combined with herbicides than when either approach was used alone.

Evaluation of Project Outcomes

Establishment and Spread of Agents

The spurge hawkmoth, *H. euphorbiae*, is established on spurges in New York (Batra, 1983) and is locally common in the state (B. Blossey, pers. comm.). Coordinated natural enemy releases by the USDA, APHIS, PPQ during the mid 1990s have resulted in the establishment of many biocontrol agents of leafy spurge east of the Mississippi River. Five Aphthona species (*A. cyparissiae*, *A. czwalina*, *A. flava*, *A. lacertosa*, and *A. nigriscutis*) have established in Iowa, Michigan, Minnesota, New York, and Wisconsin (Hansen *et al.*, 1997). The gall midge, *S. esulae*, has established in New York (Hansen *et al.*, 1997), and in Michigan and Wisconsin (R. Hansen, pers. comm.). *Oberea erythrocephala* has established in Michigan (J. Winklar, pers. comm.) and in Minnesota (R. Hansen, pers. comm.). At present, it is unclear whether any of these agents have established on leafy spurge in New Hampshire. As of 1997, populations of *S. esulae* and the *Aphthona* species in New York were not sufficiently large to provide insects for redistribution (Hansen *et al.*, 1997). But more recently, populations of the *Aphthona* species have reached adequate levels for redistribution in New York (P. Wrege, pers. comm.).

Suppression of Target Weed

The effects of imported natural enemies on leafy spurge densities in the eastern United States have not been formally evaluated, but there is some evidence that the *Aphthona* beetles are having an effect. The beetles have provided control over large areas in Minnesota (R. Hansen, pers. comm.), and are significantly reducing the weed at some sites in Michigan (J. Winklar, pers. comm.) and New York (P. Wrege, pers. comm.). More information is available about the impact of these biological control agents against leafy spurge in the Northern Great Plains region.

Rees *et al.* (1996) reported that five *Aphthona* species (*A. cyparissiae*, *A. czwalinae*, *A. flava*, *A. lacertosa*, and *A. nigriscutis*) have established to varying degrees on leafy spurge in the United States and Canada, and in a number of cases have significantly reduced spurge density at the release sites (see Figs. 16 and 17). Reductions in leafy spurge stem densities have been attributed to flea beetle feeding by a number of authors (Hansen, 1993; Baker *et al.*, 1996; Lym *et al.*, 1996; Stromme *et al.*, 1996; and Kirby *et al.*, 2000). Stromme *et al.* (1996) reported that leafy spurge foliar cover decreased from 40 to 1.7%, five years after A. nigriscutis was released near Edmonton, Canada. At two sites in North Dakota, *A. nigriscutis* and *A. czwalinae/A. lacertosa* reduced foliar cover of leafy spurge from 45 to 7% over a three year period, and reduced stem densities by nearly forty-fold (Kirby *et al.*, 2000). In other areas, infestations of leafy spurge have been successfully suppressed through a combination of flea beetle herbivory and controlled grazing by sheep (J. Elliott, pers. comm.). Herbicides combined with the leafy spurge flea beetles (*A. nigriscutis* or *A. czwalinae/A. lacertosa*) or the gall midge (*S. esulae*) have controlled leafy spurge better than either method used alone (Lym, 1998).

Figure 16. Leafy spurge infestation on the N-Bar Ranch, Grass Range, Montana 1989, prior to release of the flea beetle *Aphthona nigriscutis* Foudras that same year. (Photograph courtesy of USDA, APHIS.)

Figure 17. N-Bar Ranch, Grass Range, Montana leafy spurge site in 1993, four years after release of the flea beetle *Aphthona nigriscutis* Foudras. (Photograph courtesy of USDA, APHIS.)

Effects on Native Plants

Neither the impact of introduced biocontrol agents on native, non-target plants nor the recovery of native plant communities following the decline in population levels of leafy spurge (following natural enemy impact) have been reported in the literature. Some leaf feeding by adult *A. nigriscutis* on*Euphorbia robusta* (Engelm.) Small has occurred at one leafy spurge site in Wyoming, and larvae also were found on the roots of this native euphorb (L. Baker, pers. comm.). However, the plant is increasing in abundance at the site due to the beetle's control of leafy spurge (L. Baker, pers. comm.).*Euphorbia robusta* is very closely related to leafy spurge, and prerelease laboratory studies indicated that the plant might become a host of *Aphthona* spp.

Economic Benefits

The economic benefits from the biological control of leafy spurge have not been formerly reported in the literature. However, given the fact that *A. nigriscutis* and *A. lacertosa* have reduced leafy spurge densities at numerous sites in the United States and Canada, this sort of information should be forthcoming.

Recommendations for Future Work

As discussed previously, *A. nigriscutis* and *A. lacertosa* have been the most successful biocontrol agents released against leafy spurge in North America. However, neither of these agents have had a consistent suppressive effect on leafy spurge growing in shaded areas and riparian sites. Hence, additional natural enemy surveys are needed to find specialized natural enemies of leafy spurge that are adapted to such habitats. Pemberton (1995) recommended that only narrow specialists with potential host ranges at or below the level of the subgenus *Esula* should be employed to avoid damage to native North American *Euphorbia* species.

Leafy spurge is currently found in 35 states in the United States (USDA, NRCS) and in all Canadian provinces except Newfoundland (Roslycky, 1972). The potential for further range expansion of this weed warrants the continued redistribution of established biocontrol agents throughout North America. In addition to recent biological control efforts in New Hampshire and New York, biological control programs should be initiated in all other states in the northeast and central United States that have significant infestations of leafy spurge. Before releasing biological control agents in the eastern United States, host specificity data should be obtained for each agent relative to the rare *Euphorbia purpurea*and the endangered *E. telephioides*. The abilities of these spurge natural enemies to live in the southern United States, where additional rare *Euphorbia* occur, also should be considered.

Studies evaluating the effects of natural enemies introduced for the biological control of leafy spurge should be initiated across a wide range of habitat types and geographic areas in the United States. Studies should include the assessment of economic and environmental benefits of biological control, the effect of flea beetles on plant species

richness and diversity (including native species), and the assessment of any harmful effects on threatened and endangered *Euphorbia* species. Lastly, integrated weed management strategies need to be developed and implemented on a grander scale to be able to achieve consistent and sustainable management of leafy spurge in North America in the future.

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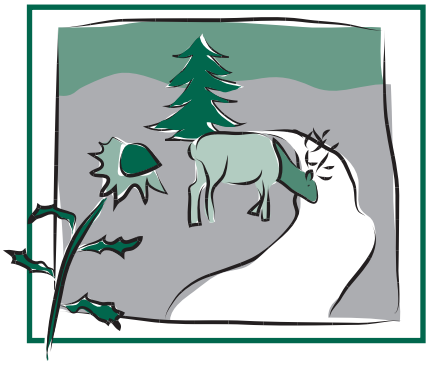

Musk Thistle

Fact Sheet No. **3.102** Natural Resources Series | **Range**

by K.G. Beck*

Musk thistle is an aggressive weed of foreign origin that occurs in pastures, rangeland, roadsides and non-crop areas (Figure 1). It is a biennial weed, although occasionally it is an annual. Because musk thistle reproduces solely from seed, the key for successful management is to prevent seed production. Over 46,000 acres are infested with musk thistle in Colorado (Figure 2).

Germination and seedling establishment are correlated with moisture and light. Thus, more seeds germinate and establish plants in open pastures and other degraded areas.

Vigorously growing grass competes with musk thistle, and fewer thistles occur in pastures where grazing is deferred. However, musk thistle also can become a problem in pasture or rangeland that is in good condition.

Phenology

Seedlings normally emerge early in spring, develop into rosettes and spend the first season in this growth stage. Seedling emergence also can occur in fall. All seedlings grow into rosettes and overwinter in that stage. Rosettes are usually large and compact with a large, corky taproot that is hollow near the crown (Figure 3). Leaves have consistent shape, sometimes expressing a frosted appearance around the leaf margins, and often have a cream-colored midrib (Figure 4).

Early in spring of the second year, overwintered rosettes resume growth. Shoots begin to elongate (bolt) in late March through May, depending on weather and elevation (Figure 5). Musk thistle flowers (Figure 6) and starts to produce seed 45 to 55 days after it bolts. Musk thistle has very large bracts beneath flowers that are armed with sharp spines and shoots beneath flowers are almost devoid of leaves.

*Colorado State University Extension weed science specialist and professor, bioagricultural sciences and pest management. 11/2013

Figure 1: Musk thistle infestation in the Colorado foothills.

Musk thistle dies after it sets seed. It spends approximately 90 percent of its life cycle in a vegetative growth stage. Musk thistle's tolerance to most herbicides increases after it bolts.

Reproduction and Spread

Musk thistle is a prolific seed producer. One plant can set up to 20,000 seeds. However, only one-third of the seeds are viable. Musk thistle produces many heads. The terminal, or tallest, shoots flower first, then lateral shoots develop in leaf axils. A robust plant may produce 100 or more flowering heads.

Musk thistle flowers over a seven- to nine-week period. It begins to disseminate seed from a head about two weeks after it first blooms. It is common to observe musk thistle with heads in several stages of floral development and senescence. Thus, musk thistle sets seed over an extended time period.

Most seed is dispersed within the immediate vicinity of the parent plant. This leads to a clumped pattern of seedling development and results in intraspecific competition and mortality. Wind and water are good dissemination methods and seeds are also spread by animals, farm machinery and other vehicles. Less than 5 percent of seed remains attached to the pappus when it breaks off the flowering head and floats away on wind currents.

Quick Facts

- Musk thistle is a biennial weed that reproduces only from seed.
- The key to successful musk thistle control is to prevent seed production.
- Apply herbicides such as Tordon, Milestone, Transline, Perspective, Vanquish/Clarity or 2,4-D to musk thistle rosettes in spring or fall. Apply Escort or Telar up to the early flower growth stage.
- Combine control methods into a management system for best results.

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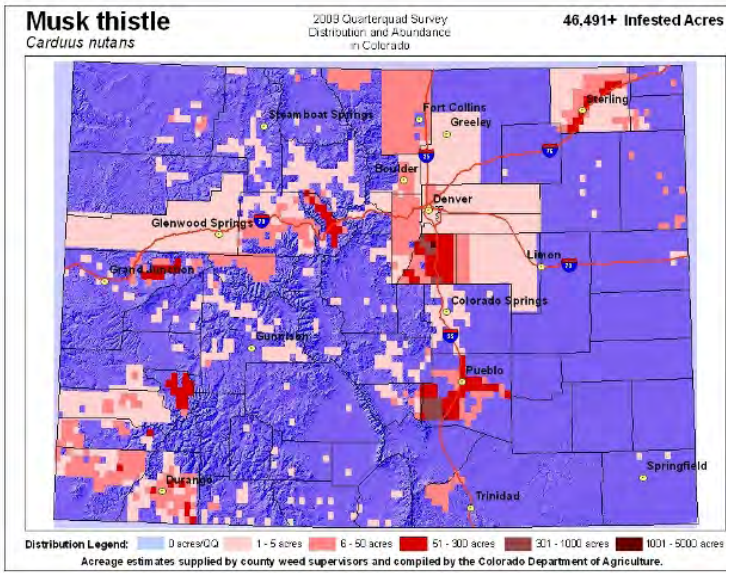

Figure 2: Musk thistle distribution in Colorado, 2009.

Figure 3: Musk thistle rosettes.

Figure 4: Musk thistle leaves; note cream-colored mid-rib and frosted appearance around leaf margins.

Figure 5: Musk thistle in bud growth stage; note large bracts below developing flower.

Management

Cultural control. Maintaining pastures and rangeland in good condition is a primary factor for musk thistle management. To favor pasture and rangeland grass growth, do not overgraze. Fertilize only when necessary and according to soil testing recommendations. To successfully manage musk thistle, prevent seed formation.

Mechanical control. Musk thistle will not tolerate tillage and can be removed easily by severing its root below ground with a shovel or hoe. Mowing can effectively reduce seed output if plants are cut when the terminal head is in the late-flowering stage. Gather and burn mowed debris to destroy any seed that has developed.

Chemical control. Several herbicides are registered in pasture, rangeland and noncrop areas to control musk thistle. Tordon 22K (picloram), Milestone (aminopyralid), Transline (clopyralid), Perspective (aminocyclopyrachlor + chlorsulfuron), Banvel/Vanquish/Clarity (dicamba), 2,4-D, or Banvel/Vanquish/Clarity plus 2,4-D are commonly used. Apply these herbicides in spring or fall to musk thistle rosettes. Refer to Table 1 for rates and application timings and always read the herbicide label before using the product. Applications during the reproductive growth stages with these herbicides (bud through flowering) will not eliminate viable seed development.

Escort (metsulfuron) or Cimarron X-tra (metsulfuron + chlorsulfuron) also can be used in pastures, rangeland, and non-crop areas. Research from Colorado State University and the University of Nebraska shows that chlorsulfuron or metsulfuron prevents or dramatically reduces viable seed formation when applied in spring, up to early flower growth stages. The latest time to apply these herbicides is when developed terminal flowers have opened up to the size of a dime. Add a good agricultural surfactant at 0.25 percent v/v to Escort or Cimarron X-tra treatments or control is inadequate (equivalent to 1 quart of surfactant per 100 gallons of spray solution).

Table 1. Herbicide rates and application timings to control musk thistle.

Herbicide	Rate (Product/A)	Application timing	Comments
Tordon	0.5 to 1 pint	Spring at rosette growth stage; or in fall	Use higher rates for older or dense stands
Milestone	3 to 5 fl oz	Spring at rosette growth stage; or in fall	Use higher rate for older or dense stands; may be used to edge ponds or streams
Transline	0.67 to 1.33 pints	Spring at rosette to early bolting growth stages; or in fall	Use higher rate for older or dense stands
Banvel, Vanquish, or Clarity (dicamba)	1 to 2 pints	Spring rosette growth stage; or in fall	Use higher rate for older or dense stands
Perspective	3 to 4.5 oz	Spring rosette growth stage; or in fall	Use higher rate for older or dense stands
Cimarrron X-tra	0.5 oz	Spring rosette to early bud growth stages; or to fall rosettes	Add non-ionic surfactant at 0.25% v/v
Escort	0.5 oz	Spring to rosette to early bud growth stages; or to fall rosettes	Add non-ionic surfactant at 0.25% v/v

Biological control. The Colorado Department of Agriculture has established a weevil, *Trichosirocalus horridus*. This weevil attacks the crown area of musk thistle rosettes and kills or weakens the plant before it bolts. This weevil is being distributed throughout Colorado by the Department of Agriculture. It tends to be more effective than the seed head weevil.

The musk thistle seed head weevil, *Rhinocyllus conicus*, can be found throughout Colorado. The female deposits her eggs on the back of developing flowers and covers them with chewed leaf tissue. After eggs hatch, larvae bore into the flower and destroy developing seed. The seed head weevil reduces seed production by 50 percent on the average. If used alone, however, it is not an effective management tool. Certain herbicides or mowing can be combined with the seed head weevil if these are used during late flowering stages. This allows the weevils to complete their life cycle and ensures their presence in subsequent growing seasons. The musk thistle seed head weevil is not being redistributed anymore because it attacks many different species of thistles, including native thistles.

Figure 6: Musk thistle flower; note large bracts and lack of leaves on shoot below flower.

Integrating Control Methods

To combine chemical and biological control methods, apply herbicides when they won't interfere with insect development. That is, allow the control insects to complete their life cycle. Or use herbicides in areas that aren't sensitive to their use and biological control in areas where herbicides are impractical or environmentally unsafe.

Cultural methods that favor desirable plant growth can be combined with chemical or biological control by superimposing proper grazing management and seeding.

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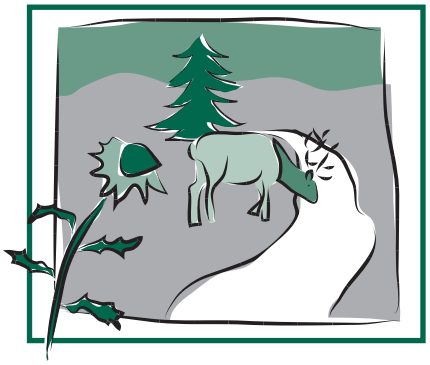

Russian Knapweed

Fact Sheet No. **3.111** Natural Resources Series | **Range**

by K.G. Beck*

Russian knapweed (*Acroptilon repens*) is a creeping, herbaceous perennial of foreign origin that reproduces from seed and vegetative root buds. Shoots, or stems, are erect, 18 to 36 inches tall, with many branches. Lower leaves are 2 to 4 inches long and deeply lobed (Figure 1). Upper leaves are smaller, generally with smooth margins, but can be slightly lobed (Figure 2). Shoots and leaves are covered with dense gray hairs. The solitary, urn-shaped flower heads occur on shoot tips and generally are 1/4 to 1/2 inch in diameter with smooth papery bracts. Flowers can be pink, lavender or white (Figure 3). Russian knapweed has vertical and horizontal roots that have a brown to black, scaly appearance, especially apparent near the crown.

Figure 1: Russian knapweed rosette emergence in early spring.

The weed forms dense, single species stands over time due to competition and allelopathy (biochemicals it produces that inhibit the growth of other plants). A 2008 survey conducted by the Colorado Department of Agriculture showed Colorado with more than 132,400 acres infested with Russian knapweed (Figure 4). Russian knapweed is toxic to horses.

*Colorado State University Extension weed specialist and professor, bioagricultural sciences and pest management. 11/2013

Figure 2: Russian knapweed shoot and leaves; note hairs and lobed leaves.

Phenology, Biology and Occurrence

Russian knapweed emerges in early spring, bolts in May to June (elevation dependent) and flowers through the summer into fall. It produces seeds sparingly, approximately 50 to 500 per shoot. Seeds are viable for two to three years in soil. Its primary method of reproduction is from vegetative propagation, with seed of secondary importance. Roots from a recently established plant expand rapidly and may cover up to 12 square yards in two growing seasons.

Russian knapweed is native to southern Ukraine, southeast Russia, Iran, Kazakhstan and Mongolia. It grows on clay, sandy or rocky prairies and sunny meadows; on saline soils; or clay, rocky or sandy shores of lakes and rivers; and on rocky and clay slopes of hills and bottomlands. It is a weed of cultivated land, dry pastures and degraded noncropland (waste places) in its native land.

Quick Facts

- Russian knapweed is a creeping perennial that reproduces from seed and vegetative root buds.
- Russian knapweed emerges in early spring, bolts in May to June, and flowers through the summer into fall.
- Russian knapweed is toxic to horses.
- The key to Russian knapweed control is to stress the weed and cause it to expend nutrient stores in its root system.
- The best management plan includes cultural controls combined with mechanical and/or chemical control techniques.

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Figure 3: Russian knapweed flower; note smooth papery bracts that lack any spines.

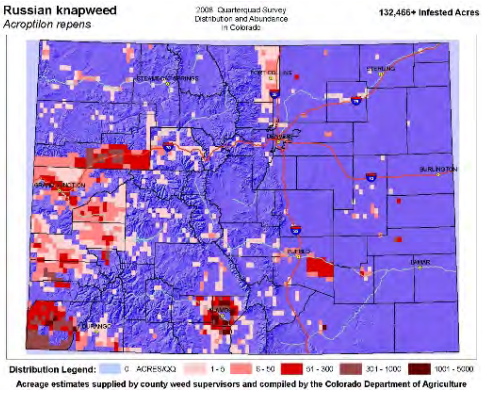


Figure 4: 2008 distribution of Russian knapweed in Colorado.

Figure 5: Russian knapweed root buds on crowns in fall; note black/brown scaly appearance to root crowns—a key identifying characteristic.

Russian knapweed grows in most western states. In Washington, it is common on heavier, often saline soils of bottomlands and grows in pastures, hayfields, grainfields and irrigation ditches. In Colorado, Russian knapweed is not restricted to certain soils and occurs in pastures, agronomic crops, roadsides, waste places and rangeland. Stands may survive 75 years or longer.

Management

Like other creeping perennials, the key to Russian knapweed control is to stress the weed and cause it to expend nutrient stores in its root system. An integrated management plan should be developed that places continual stress on the weed. Currently, the best management plan includes cultural control combined with mechanical and/or chemical control techniques. A single control strategy, such as mowing or a herbicide, usually is not sufficient.

Russian knapweed typically invades degraded areas, dominating the plant community and desirable plants (e.g. perennial grasses). Seeding competitive, perennial grass species (cultural control) after Russian knapweed has been stressed by other control measures (set-up treatments) is essential. Set-up treatments may include chemical or mechanical methods.

Cooperative research between Colorado State University and the University of Wyoming showed that chemical set-up treatments were superior to mowing. Curtail (clopyralid + 2,4-D), Escort (metsulfuron), and Roundup (glyphosate) were used to suppress Russian knapweed. Then perennial grasses were sown in late fall as a dormant seeding. Curtail (3 quarts per acre) (A) or Escort (1 ounce/A) were applied at the bud-growth stage. Roundup was applied twice at 1 quart/A, first at the bud-growth stage and again about 8 weeks later. Curtail controlled Russian knapweed best and Roundup failed to control it. None of the herbicides injured seeded grasses. Grasses established similarly among herbicide suppression treatments, even though Russian knapweed control varied. However, where Escort or Roundup was used to suppress Russian knapweed, additional herbicide treatments would be necessary to achieve acceptable control.

While two mowings eight weeks apart (first at bud growth stage), suppressed Russian knapweed during that year, the weed recovered vigorously the subsequent growing season. Perennial grasses established in the mowing treatments but much less than in herbicide treatments. Seeding desirable forbs and shrubs also may be effective to prevent Russian knapweed reinvasion, but research is necessary to test this hypothesis.. Two mowings per year for several years may control Russian knapweed better than in our experiments, but further research also is needed to test this hypothesis. Currently no biological control is available for this weed. Tillage often is necessary to overcome the residual allelopathic effects of Russian knapweed, but more recent research shows that an effective herbicide treatment that kills much of the root system also appears to ameliorate allelopathy.

When integrating chemical and cultural control, avoid using herbicide rates that injure grasses because effective competition will be reduced.

Chemical control. In most circumstances, an herbicide alone will not effectively manage Russian knapweed. However, there may be situations where desirable plants within a Russian knapweed infestation may compete effectively with the weed if it is stressed with a single weed management technique.

Russian knapweed is controlled by Tordon 22K (picloram), Milestone (aminopyralid), Transline (clopyralid), Curtail, (clopyralid + 2,4-D), Perspective (aminocyclopyrachlor + chlorsulfuron), and Telar (chlorsulfuron). Refer to Table 1 for rates and timing recommendations and always read the herbicide label before using the product. Russian knapweed is very susceptible to fall-applied herbicides. It displays a distinct cycle of root bud development. In late summer (August into

Figure 6: Russian knapweed emerged rosettes in fall.

early September) Russian knapweed begins to develop buds on its roots that will emerge to form rosettes that fall or the following spring (Figures 5 and 6). Root buds continue to grow throughout the winter but once rosettes emerge in spring, remaining root buds slough off and no buds occur on roots until this cycle begins again in late summer. This active root bud growth and development in fall through winter may be the reason that Russian knapweed is susceptible to herbicides applied in fall and winter.

Cultural control. Russian knapweed tends to form monocultures and usually eliminates other plants. Therefore, sowing desirable plant species is necessary after the weed is controlled. Smooth brome will compete with Russian knapweed. Research shows that streambank wheatgrass, thickspike wheatgrass, crested wheatgrass and Russian wildrye established after Russian knapweed was suppressed with herbicides. Sod-forming perennial grasses, like streambank or thickspike wheatgrasses, help prevent reinvasion better than bunch grasses like crested wheatgrass. More recent CSU research also shows that slender wheatgrass and western wheatgrass also compete effectively with Russian knapweed after it is suppressed.

If the Russian knapweed stand is not too old and grasses are still present, stimulating grass growth by irrigation (where possible) should increase grass competition with knapweed and keep the weed under continual stress.

Table 1. Herbicide used to control Russian knapweed.

Herbicide	Rate (Product/A)	Application timing	Comments
Tordon	2 to 4 pints	Spring at bud to mid-flowering growth stages; or late in fall	Use higher rates for older or dense stands; late treatments in fall to dormat plants very effective
Milestone	5 to 7 fl oz	Spring and summer at bud to flowering growth stages; or late in fall	Use higher rate for older stands; late treatments in fall to dormant plants very effective; Milestone may be used to edge of ponds or streams
Transline	1 to 1.33 pints	Spring after all shoot have emerged, bud to mid-flower growth stages; late in or fall	Use higher rate for older or dense; late treatments in fall to dormant plants very effective
Curtail	3 to 4 quarts	Spring after all shoots have emerged, bud to mid-flower growth stages; late in or fall	Use higher rate for older or dense; late treatments in fall to dormant plants very effective
Perspective	5.5 oz	Spring after shoots have emerged through the fall	Late fall treatments into winter when conditions are suitable for spraying is very effective
Telar	1 oz	Spring bud to flowering growth state; or late in fall	Late treatments in fall to dormant plants are very effective; temporary injury to cool season grasses may occur from fall treatments

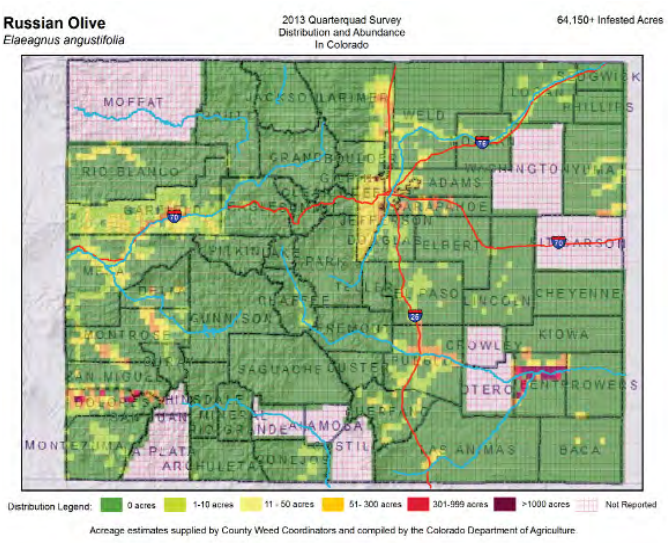
Russian Olive Identification and Management

List B

Russian olive (*Elaeagnus angustifolia*) is a perennial tree or shrub that is native in Europe and Asia. The plant has olive-shaped fruits, silver color at first then becoming yellow-red when mature. Russian olive can reproduce by seed or root suckers. Seeds are readily spread by birds and can remain viable for up to 3 years. Spring moisture and slightly alkaline soil tend to favor seedling growth. The plant's extensive root system sprouts root suckers frequently. The tree can reach up to 30 feet in height with branches that have 1 to 2 inch thorns. Leaves are 2 to 3 inches long, alternate, narrow, and have simple blades with smooth edges. The leaf's lower surface is silvery white, while the upper surface is light green in color. Flowers are 4 small sepals in light yellow clusters, fragrant, and appear May through June. Fruits mature from September to November. Russian olive twigs are flexible, reddish, and have surfaces coated with gray and scaly pubescence, becoming smooth.

Once thought to be a beneficial windbreak tree, it since has been deemed detrimental to the environment. Russian olive can grow in a variety of soil and moisture conditions, but prefers open, moist, riparian zones. It is shade tolerant and can be found along streams, floodplains, fields and open areas up to approximately 8,000 feet in elevation. Russian-olive can outcompete native plants, interfere with natural plant succession and nutrient cycling, and tax water reserves. Because Russian olive is capable of fixing nitrogen in its roots, it can grow on bare, mineral substrates and dominate riparian vegetation. Although Russian olive provides a plentiful source of edible fruits for birds, ecologists have found that bird species richness is actually higher in riparian areas dominated by native vegetation.

The key to effective control of Russian olive is preventing establishment of the trees or shrubs. If plants are already present, control options include cut-stump treatments and mechanical mowing. These treatments depend on size and location of the plant. Details on the back of this sheet can help you create a management plan compatible with your site ecology.



Russian olive is designated as a "List B" species in the Colorado Noxious Weed Act. It is required to be either eradicated, contained, or suppressed depending on the local infestations. For more information visit www.colorado.gov/ag/weeds and click on the Noxious Weed Management Program. Or call the State Weed Coordinator at the Colorado Department of Agriculture, Conservation Services Division, 303-239-4100.

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Key ID Points

1. Leaves are silvery white.
2. Branches have 1 to 2 inch thorns.
3. Yellow-red fruits on mature plants.
4. Mature trees have shedding, reddish-brown bark.

Russian olive

Elaeagnus angustifolia

List B

Integrated Weed Management Recommendations

Russian olive

Elaeagnus angustifolia

Integrated weed management offers the most effective combination of control efforts through the "cut stump" treatment. Trees are cut down with a hatchet or chainsaw, then immediately treated with an approved herbicide on the surface of the cut stump. The most effective timing is late summer/early fall for herbicide transfer into the roots.

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CULTURAL

Replace Russian olives with native trees. Prevent establishment of new trees by removing seedlings and saplings before they mature. Contact your local Natural Resources Conservation Service for recommendations of other possible trees or shrubs.

BIOLOGICAL

Tubercularia canker is an unapproved biocontrol. However, it overwinters on infected stems and spreads via rain-splash, animals, or pruning implements to open wounds in the bark. Infected tissue becomes discolored or sunken. Entire stems may be girdled and killed, and the disease can deform or kill stressed plants over time.

MECHANICAL

Saplings can be pulled with a weed-wrench or cut with brush-cutters. Trees can be girdled or cut with chainsaws. However, stump sprouting commonly occurs after cutting down the tree; and stump excavation without removing all parts of the roots can result in root sprouting. Treating cut-stumps with an herbicide can eliminate sprouting. Stump burning is practical when conditions support a long, hot fire and most effective in summer or early fall. Saplings are most sensitive to mechanical treatment.

CHEMICAL

The table below includes recommendations for herbicides that can be applied to range and pasturelands. Always read, understand, and follow the label directions. The herbicide label is the LAW!

HERBICIDE	RATE	APPLICATION TIMING
Triclopyr (Garlon 4, Remedy)	Undiluted (100% solution)	Apply to the cambial layer of the tree immediately after the cut-stump treatment.
Imazapyr + Water (Habitat + Water or Arsenal + Water)	Diluted by mixing 8 to 12 fl. oz / 1 gallon of water	Apply to the cambial layer of the tree immediately after the cut-stump treatment.
Imazapyr (Habitat or Arsenal)	4 to 6 pt./acre	Broadcast spray/spraying individual trees; low or high volume spray.

Colorado Department of Agriculture - Conservation Services
305 Interlocken Parkway
Broomfield, CO 80021
303-869-9030
www.colorado.gov/ag/weeds

Rev. 9/2013

Scotch thistle

Onopordum acanthium

Adams County
Weed Department
9755 Henderson Rd
Brighton, CO
80601
303-637-8115

Key ID Points

1. Stems have spiny wings and dense, fine hair that give it a blue-green color
2. Rosettes often have huge, broad leaves
3. Grows up to 12 feet tall

Scotch thistle Identification and Management

Scotch thistle during the flowering stage. This stage typically occurs in the early summer. Seed production will follow and effective management options will then become limited.

Identification and Impacts

Scotch thistle (Onopordum acanthium) is a non-native biennial forb that reproduces solely by seed. A biennial is a plant that completes its life-cycle within two years. During the first year of growth, Scotch thistle appears as a rosette in spring or fall. During the second year in mid to late spring – the stem bolts, flowers, sets seed, and the plant dies. A prolific seed producer, Scotch thistle can produce up to 14,000 seeds per plant. Therefore, the key to managing this plant is to prevent seed production.

Scotch thistle can grow up to 12 feet tall. Stems are numerous, branched, and have broad, spiny wings. The leaves are large, green, spiny, and covered with fine dense hair giving the leaf a woolly appearance. The flowers are violet to reddish in color, numerous (70-100/plant), and are surrounded by spine-tipped bracts. You can expect to see flowers from mid-June to September.

Scotch thistle is designated as a "B" list species on the Colorado Noxious Weed Act. It is required to be either eradicated, contained, or suppressed depending on the local infestations. For more information visit www.ag.state.co.us.

Due to the robust, spiny nature of Scotch thistle, this plant can act as a living barbed wire fence, making areas impassible for wildlife, livestock, and people. Scotch thistle invades rangeland, overgrazed pastures, roadsides, and irrigation ditches. It also prefers moist areas adjacent to creeks and rivers.

On the backside of this sheet are Scotch thistle management recommendations. If you have any questions or would like more information, please contact the Adams County Weed Department at 303-637-8115. Please visit our website www.adamscountyextension.org.

Management Recomendations

CULTURAL
Establishment of selected grasses can be an effective cultural control of Scotch thistle. Contact your local Natural Resources Conservation Service for seed mix recommendations. Maintain healthy pastures and prevent bare spots caused by overgrazing. Bareground is prime habitat for weed invasions.

BIOLOGICAL
There are no biological control insects currently available that will control Scotch thistle.

MECHANICAL
Any mechanical or physical method that severs the root below the soil surface will kill Scotch thistle. Mowing or chopping is most effective when Scotch thistle plants are at full-bloom. Be sure to properly dispose of the flowering cut plants, since seeds can mature and become viable after the plant has been cut down.

Integrated Weed Management:

Scotch thistle is best controlled in the rosette stage. For small infestations, Scotch thistle can be controlled by severing its taproot 1-2 inches below the ground. Control can be enhanced by a follow-up application of herbicides to the surviving rosettes.

It is imperative to prevent seed production. Do not allow Scotch thistle flowers to appear.

HERBICIDES
The following are recommendations for herbicides that can be applied to range and pasturelands. Always read, understand, and follow the label directions. The herbicide label is the LAW!
Rates are approximate and based on equipment with an output of 30 gallons per acre. Please read label for exact rates.

HERBICIDE	RATE	APPLICATION TIMING
Milestone	3-5 ounces/acre or 1 teaspsoon/gal water	Spring at rosette to early bolt stage and/or in the fall to rosettes. Add non-ionic surfactant @ 0.32oz/gal water or 1 qt/100 gal water.
Escort XP	1-2 ounces/acre or 0.25-0.50grams/1gal water	Apply in the spring during rosette to bloom stage or in the fall to rosettes. Add non-ionic surfactant @ 0.32oz/gal water or 1qt/100 gal water.
Redeem R&P	1.5-2 pints/acre or 0.75 oz/gal water	Apply from rosette to early bolt stage of growth and/or in the fall to rosettes. Add non-ionic surfactant @ 0.32oz/gal water or 1qt/100 gal water.
2,4-D Amine	1 qt/acre or 1.0 oz/gal water	Spring/fall rosette - before flowering stalk lengthens. DO NOT apply when outside temperatures will exceed 85 degrees F. Add a non-ionic surfactant @ 0.32oz/gal water or 1 qt/100 gal water.

Scotch thistle

Adams County Weed Department
9755 Henderson Rd
Brighton, CO 80601
303-637-8115

COLORADO STATE PARKS
BEST MANAGEMENT PRACTICES
WEED PROFILE

Date Created: April 25, 2003
Revised: April 1, 2005
Author: Various
Parks Affected: Many

Saltcedar (Tamarisk)

Tamarix ramosissima **Ledeb.**
and *Tamarix parviflora* **DC.**

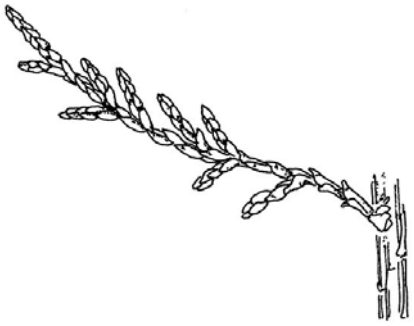
BMPs

Family: *Tamaricaceae* (Tamarisk)
Other Names: tamarisk, salt cedar
USDA Code: TARA, TAPA4
Legal Status: Colorado Noxious List A (general weeds)

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.

Identification

Growth form: Deciduous, loosely branched shrubs or small trees.
Flower: Flowers are whitish or pinkish and borne on slender racemes 2-5 cm long on the current year's branches and are grouped together in terminal panicles. Petals are usually retained on the fruit.
Seeds/Fruit: The seeds are borne in a lance-ovoid capsule.
Leaves: Leaves are minute, appressed scaly leaves, alternately arranged.
Stems: Branchlets are slender; plants may reach heights of 15 feet or more.
Roots: The primary root can grow to a depth of up to 30 meters or more (Baum 1978). Plants can develop spreading horizontal roots after reaching the water table. These can spread up to 50 meters and are capable of producing adventitious buds (DiTomaso 1996).
Seedling: No information available.



Branch

Similar Species

Exotics: None known.
Natives: None known.

Impacts

Agricultural: No information available.
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.

Close up of leaves

Habitat and Distribution

General requirements: Saltcedar grows well on moist sandy, sandy loam, loamy, and clay 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. Saltcedar commonly occurs along floodplains, riverbanks, stream courses, saltflats, 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.
Hybridization: No information available.

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.

Control

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 ocurrs 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 streambanks 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).

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A Self-Learning Resource From MSU Extension

MONTANA STATE UNIVERSITY EXTENSION

MontGuide

St. Johnswort: Identification, Biology and Integrated Management

By Jane Mangold[1], Roger Sheley[2], and Melissa Brown[3]

This MontGuide describes St. Johnswort biological and ecological characteristics. It also provides mechanical, cultural, biological and chemical options to control this plant species.

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ST. JOHNSWORT (*HYPERICUM PERFORATUM* L.), also known as goatweed and Klamath weed, is an economically important pest in temperate regions worldwide. Although used as a possible natural antidepressant, St. Johnswort causes considerable ecological and economic losses. In addition to displacing desirable plants that are important for wildlife habitat and domestic livestock forage, St. Johnswort also poses risk of poisoning grazing animals. Correctly identifying St. Johnswort and understanding the plant's life cycle and growth requirements are important for selecting management strategies that will effectively suppress St. Johnswort populations and promote healthy, desired vegetation.

Origin and distribution

St. Johnswort is native to Europe, North Africa, and parts of Asia, and has been intentionally introduced to most continents as a medicinal and ornamental plant (see Box 1). In the United States, St. Johnswort was first introduced in 1696 to Pennsylvania by a religious group who believed the plant held magical properties. Nearly 200 years later, the weed appeared on western rangelands and by 1905 was reported in Gallatin County, Montana. As of 2009, St. Johnswort is reported in at least 27 counties of Montana (Figure 1). St. Johnswort occurs in most states of the U.S. and is included on noxious weed lists in eight western states: California, Colorado, Nevada, Oregon, South Dakota, Washington, Wyoming, and Montana.

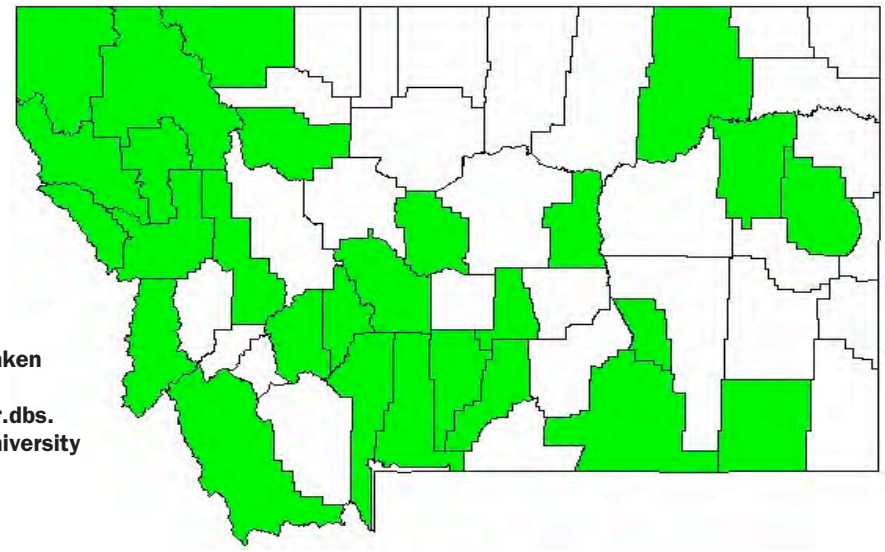

FIGURE 1. Counties in Montana where St. Johnswort has been reported. Information taken from Invaders Database System (Rice, P.M. INVADERS Database System (http://invader.dbs.umt.edu); Division of Biological Sciences, University of Montana, Missoula, MT 59812-4824).

St. Johnswort generally grows in well drained, gravelly or sandy soils and favors sunny exposures. In the western U. S., the weed occupies lower elevations where annual precipitation is between 15 and 30 inches. Because it is not a highly competitive plant, St. Johnswort persists well in disturbed areas that lack more competitive plant species. However, St. Johnswort can become established in pristine rangelands.

Identification and biology

St. Johnswort is a member of the Clusiaceae family (formerly the Hypericaceae family). Plants can grow from one to five feet tall with numerous, rust-colored branches that are woody at the base. In autumn, infestations are easy to spot by the remaining rust-colored branches. The taproot may reach depths of four to five feet. Lateral roots grow two to three inches beneath the soil surface but may reach depths of three feet. Leaves are opposite, sessile, entire, elliptic to oblong and generally not more than one inch long (Figure 2). A diagnostic characteristic of St. Johnswort is the presence of tiny, transparent perforations on the leaves,

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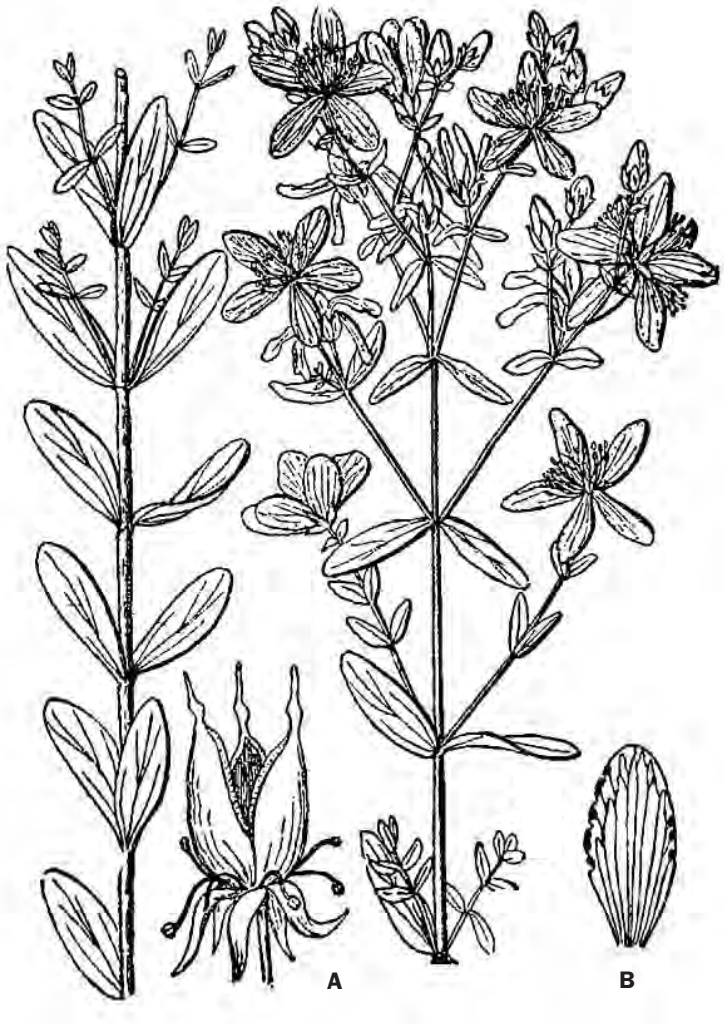

FIGURE 2. St. Johnswort plant with seed capsule (A) and seed (B).

BOX 1. St. Johnswort Uses and Lore

St. Johnswort has a long history of use for a variety of purposes, both medicinal and magical.

- Plants are believed to have great protective powers from evil spirits, witches, storms, and thunder.
- When hung in the house or carried as a charm, sprigs of the plant are claimed to bring good luck.
- When placed under a pillow, St. Johnswort sprigs may bring dreams of a future lover.
- Plants are used as an ingredient for distilling vodka, and as a source for red, yellow, purple and orange dyes.
- Native Americans used oils from American Hypericum species to heal wounds and treat consumption.
- Folk medicine practitioners in Europe use St. Johnswort to treat mania, hysteria, hypochondriasis, depression, dysentery, jaundice, and a variety of skin disorders.
- St. Johnswort is promoted as a natural anti-depressant drug and is used in herbal teas and dietary supplements.
- Recently, hypericin was found to inhibit human immunodeficiency virus.

thus the species name "perforatum". These perforations can be seen when one holds the leaf up to a light source. Flowers, which turn from east to west as the sun crosses the sky, grow in an open, flat-topped, terminal group. Flowers are bright yellow with five sepals and five petals. Petals are typically twice as long as sepals and bear black glands along the margins. Stamens are numerous and arranged in three groups. An egg-shaped, three-valved capsule (Figure 2a) bursts at maturity and releases many seeds (Figure 2b). A gelatinous coating on the seeds becomes sticky when wetted and adheres to the fur, feathers, or clothing of passing animals or humans.

How does St. Johnswort grow?

St. Johnswort is a perennial plant that reproduces by seed and rhizomes. The plant is a prolific seed producer; each flower develops into a seed capsule that may produce 400 to 500 seeds. An average-sized plant produces between 15,000 and 23,000 seeds. Seedlings emerge during the warm summer months and may require several years to reach reproductive maturity. Seedlings grow slowly and therefore compete poorly with established vegetation. During spring and fall plants sprout from lateral root buds. Vegetative growth can also be stimulated by fire, grazing or other forms of defoliation, such as cutting, mowing and pulling. Mature plants form flowers by mid-June and seeds near the end of August. Seeds can germinate at maturity, but germination rates increase with time. Longevity of viable seeds in the soil may range from six to ten years. Seeds are spread short distances by the wind, and may travel long distances by adhering to passing animals, animal ingestion and deposition in feces, water movement, and through activities of humans. High temperatures, such as those that occur during a fire, can also stimulate germination. Stems die and turn red in the late summer or early fall, when moisture is limited, or when there is a hard frost. When it rains in the fall, plants may regrow from rosettes.

Impacts

The most commonly described impacts of St. Johnswort are loss of forage production and losses associated with livestock poisoning. Dense stands of St. Johnswort can displace native and other desirable plants in pastures and rangelands, thereby reducing carrying capacity and livestock forage. Although in most cases the plant is considered unpalatable by livestock and is generally avoided, livestock may eat rosettes or the tops of plants when other forage is scarce. Livestock poisoning has been reported (see Box 2.)

Integrated management

St. Johnswort can be very difficult to control once plants become established. As with any weed management program, prevention, early detection and containment are the keys to gaining and maintaining control of St. Johnwort infestations over the long term. Most small infestations can be contained

by repeated pulling, digging, and application of herbicides. Large infestations may require a weed management program that integrates physical, chemical and biological methods. St. Johnswort seedlings are relatively poor competitors in healthy, productive plant communities. Practices that help to maintain vigorous, competitive, desirable plant communities will help to prevent St. Johnswort establishment.

Handpulling and grubbing may be effective on small, newly established populations that have not established robust lateral root systems. New stems may resprout from rhizomes and root fragments, so plants need to be completely removed, or pulled persistently over many years.

Tilling and cultivation - St. Johnswort is not a problem in cultivated crops, so repeated tilling may effectively control this plant. However, root fragments may be spread on tilling equipment, so it is important to clean equipment and spray resprouted plants with herbicide.

Mowing is typically considered ineffective as a management method for St. Johnswort because plants may resprout after defoliation. Mowing before flowers have formed can reduce St. Johnswort seed production, but it may also promote vegetative regrowth. Although repeated mowing or cutting may weaken St. Johnswort plants, these treatments may not be feasible on many sites because of inaccessible terrain and potential damage to desirable plants.

Prescribed burning may kill the above-ground portion of St. Johnswort plants, but is unlikely to damage root crowns and lateral roots. High-severity fire may stimulate germination in St. Johnswort seeds and sprouting from undamaged roots and root crowns.

Biological control agents can be a good option for suppressing large-scale infestations of St. Johnswort. Five biological control agents are available for St. Johnswort in Montana: *Chrysolina hyperici* and *C. quadrigemina*, foliage feeding beetles; *Agrilus hyperici*, a root-boring beetle; *Aplocera plagiata*, a foliage and flower feeding moth; and the gall midge, *Zeuxidiplosis giardi*. The success and populations of biocontrol agents depends on climatic differences and the seasonal fluctuations of St. Johnswort populations. Both *C. hyperici* and *C. quadrigemina* do well in mountainous, open, sunny, and warm areas, but *C. hyperici* is better suited for wet sites than *C. quadrigemina*. *Agrilis hyperici* establishes best in dry, mountainous areas. *Aplocera plagiata* does well in dry, open areas with sandy, rocky soils, and soils with limestone parent material. They do not thrive in areas receiving high rainfall. Montana's climate may not suit the gall midge *Zeuxidiplosis giardi* because populations have not

BOX 2. St. Johnswort Poisoning - Hypericism

St. Johnswort plants can be toxic to livestock if ingested in sufficient quantities. A phototoxic pigment, hypericin, is found in stems, leaves, flowers and seeds, and causes blistering and itching on light-haired or unpigmented skin exposed to intense sunlight. Horses are more susceptible to hypericin toxicity than cattle, cattle more than sheep, and sheep more than goats. All growth stages of the plant are toxic, but the greatest toxic effects are expressed during flowering.

Livestock rarely die directly from St. Johnswort ingestion; however, effects of poisoning such as blindness or swelling and soreness of the mouth may prevent affected animals from foraging and drinking, and thereby contribute to death by dehydration and/or starvation. Animals affected by hypericin toxicity lose weight, are difficult to manage and lose market value. Other signs and symptoms of hypericin toxicity are rapid pulse, fever, diarrhea, dermatitis, and excessive salivation.

To prevent poisoning, do not confine animals in a pasture lacking proper forage and avoid harvesting St. Johnswort in hay crops. Symptoms usually become detectable two to 21 days following ingestion. Should poisoning occur, owners must remove the animal from pasture as soon as possible and consult a veterinarian. Once consumption of the weed is halted, affected animals usually fully recover within three to six weeks.

TABLE 1. Examples of herbicides that can be used to manage St. Johnswort. Consult herbicide labels for additional rate, application, and safety information. Additional information can be found at http://www.greenbook.net.

Herbicide Active Ingredient **Trade Name**	**Product per acre**	**Timing**
*Metsulfuron** Escort/Cimarron	1 ounce	Actively growing plants
Aminopyralid Milestone	5 to 7 ounces	Prebloom
Picloram Tordon 22K/Picloram22	1 quart	Actively growing plants, prebloom
Glyphosate Many trade names	1 to 2 quarts	Use as part of a revegetation program
2,4-D Many trade names	1 to 2 quarts	Seedlings and prebloom

*requires non-ionic surfactant

established well. This insect prefers damp locations and does not do well in dry, continuously windy, or heavily grazed areas. When using biological control agents for long-term, large-scale management, other methods such as herbicides, should also be used to treat the infestation perimeter and satellite patches to contain infestations and prevent spread to other sites in the near term.

Grazing with livestock is not recommended in areas infested with St. Johnswort because of the potential for poisoning. However, prescribed grazing may be used to help maintain healthy competitive plant communities that may resist invasion by St. Johnswort and other unwanted plants.

Chemicals can be used to gain control of small infestations or new invasions of St. Johnswort on range, wildland and pasture sites. In general, optimum control is obtained when timing of the herbicide application is synchronized with the susceptible life stages of the weed. Several herbicides, including 2,4-D, metsulfuron, picloram, aminopyralid and glyphosate are commonly used for St. Johnswort control. Application rates and timing of application are shown in Table 1. Application of 2,4-D will control seedlings and suppress mature plants when applied at the prebloom growth stage. Ester formulations of 2,4-D are typically more effective than amine formulations. Spring application of picloram to actively growing plants before they bloom is also recommended. Metsulfuron is effective when applied to actively growing plants. Aminopyralid should be applied prebloom. Glyphosate will control St. Johnswort on cropland or where revegetation is planned.

Label information for all herbicides should be carefully followed not only for application restrictions but also for restrictions that apply to grazing and harvest of forage after application. Herbicide application may increase the palatability of St. Johnswort foliage, so grazing too soon after treatment could increase the risk of poisoning.

Glossary

Calyx – the outermost series of floral parts

Elliptic – having no divisions or subdivisions

Entire – with an unbroken or smooth margin

Perennial – a plant that lives for more than two years

Opposite – leaf arrangement where leaves occur in pairs on opposite sides of a node

Rosette – a circular arrangement of leaves, with all the leaves at a single height

Sessile – without a stalk of any kind

Sepals – one of the separate, usually green parts forming the calyx of a flower

Note: Information in this document is provided for educational purposes only. Reference to commercial products or trade names does not imply endorsement by MSU Extension. Common chemical and trade names are used in this publication for clarity. Inclusion of a common chemical or trade name does not imply endorsement of that particular product or brand of herbicide and exclusion does not imply non-approval. This publication is not intended to replace the product label.

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