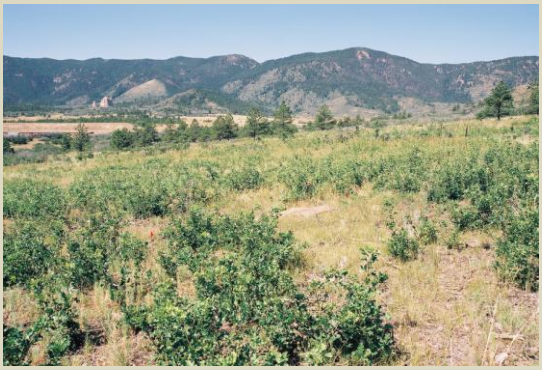

Integrated Noxious Weed Management Plan

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
Warner College of Natural Resources

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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.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

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.

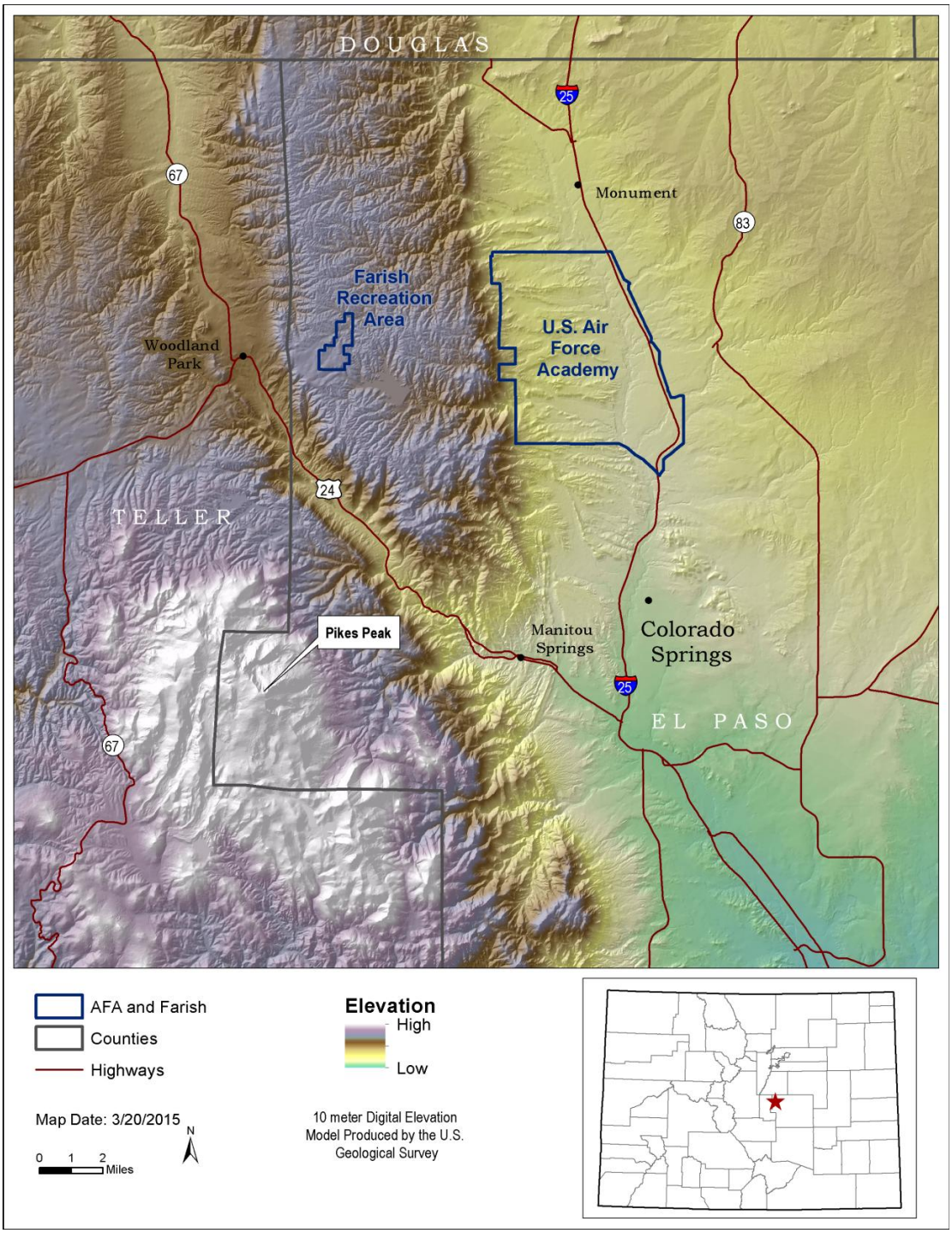

Figure 1. Location of the Air Force Academy and Farish Recreation Area in El Paso County, Colorado.

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).

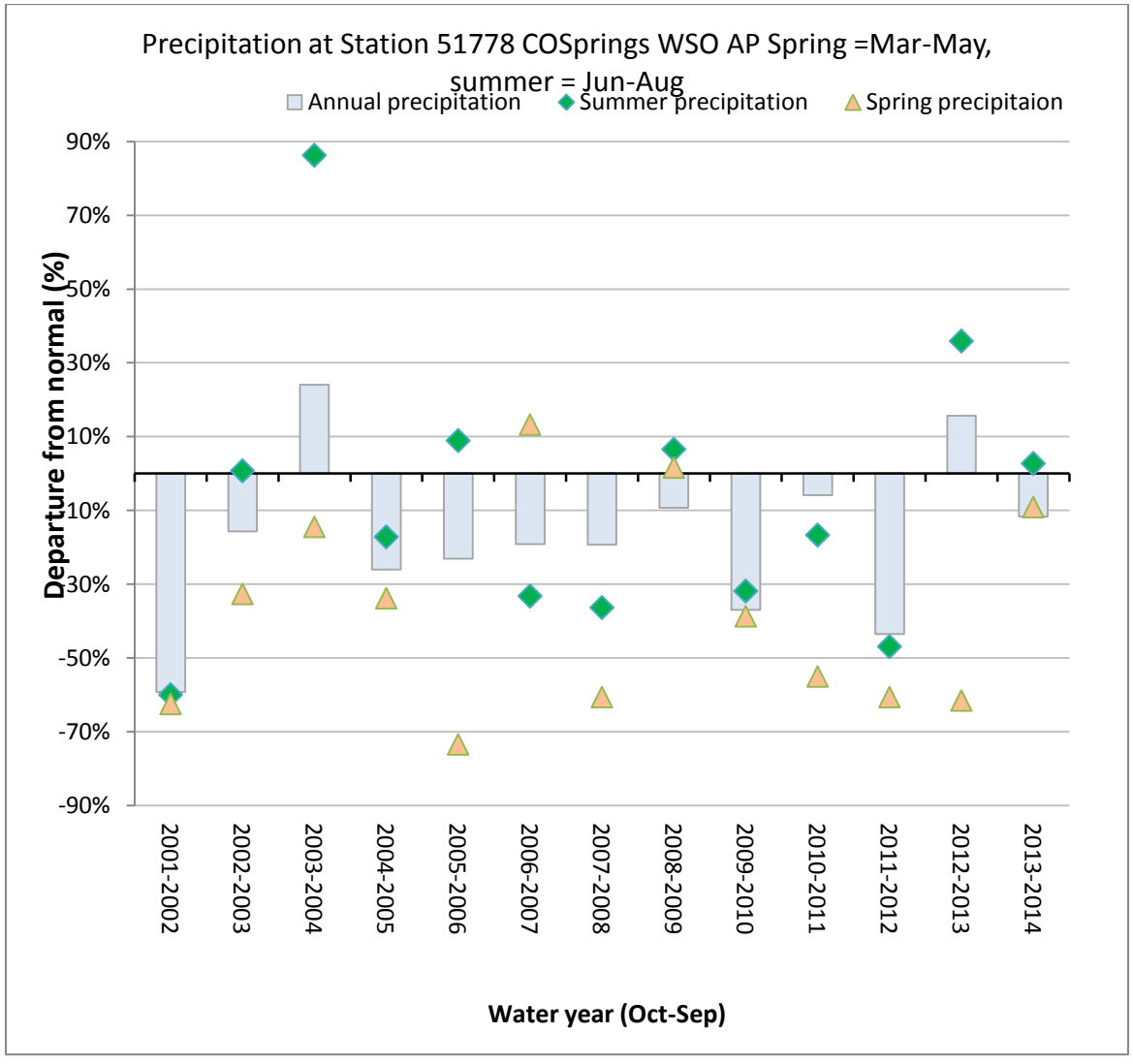

Figure 2. Summary data for annual precipitation by water year (October-September) at Colorado Springs, Colorado from 2002 through 2014 (Western Regional Climate Center 2014). **Average annual precipitation (1961-1990) is 16.3 inches. Spring = March-May, Summer = June-August**

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*).

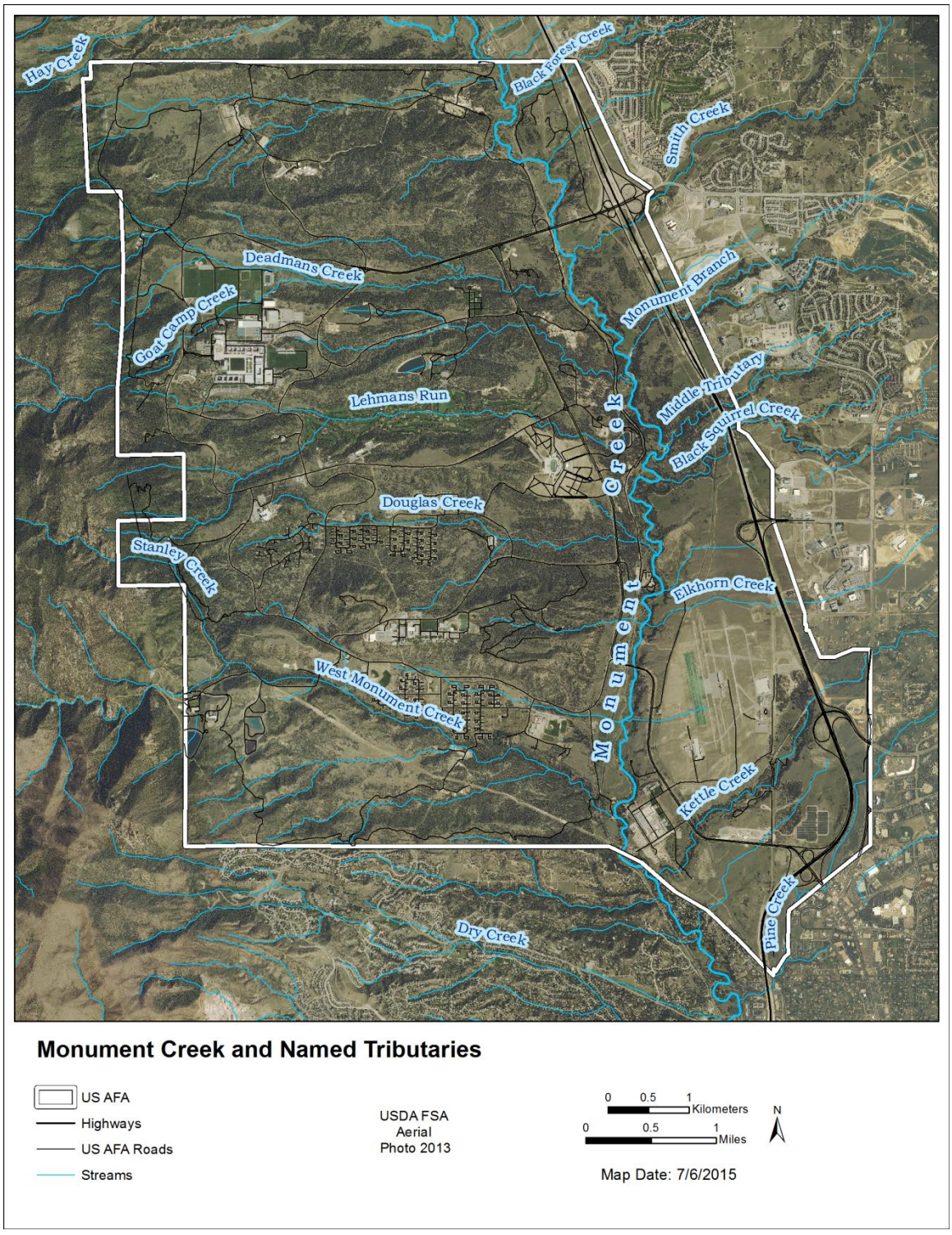

Figure 3: Monument Creek and Named Tributaries

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).

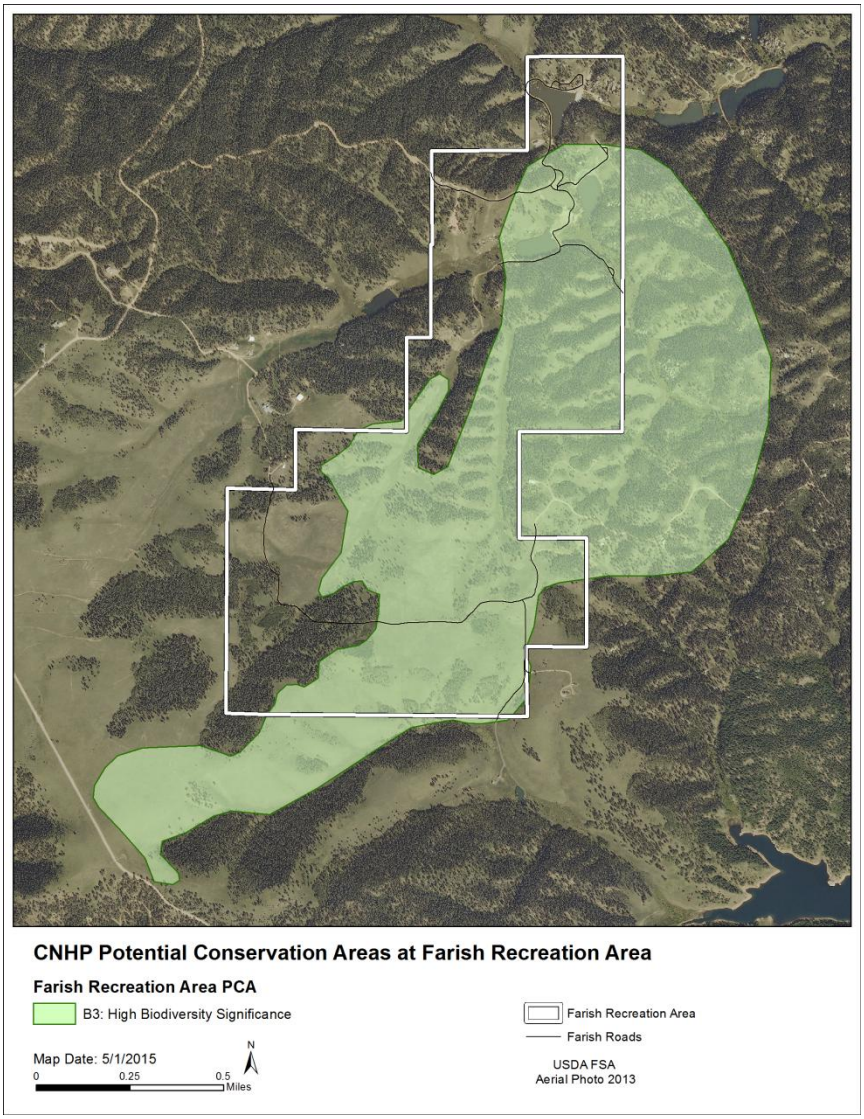

Figure 4. Potential Conservation Areas (PCAs) at Farish Recreation Area.

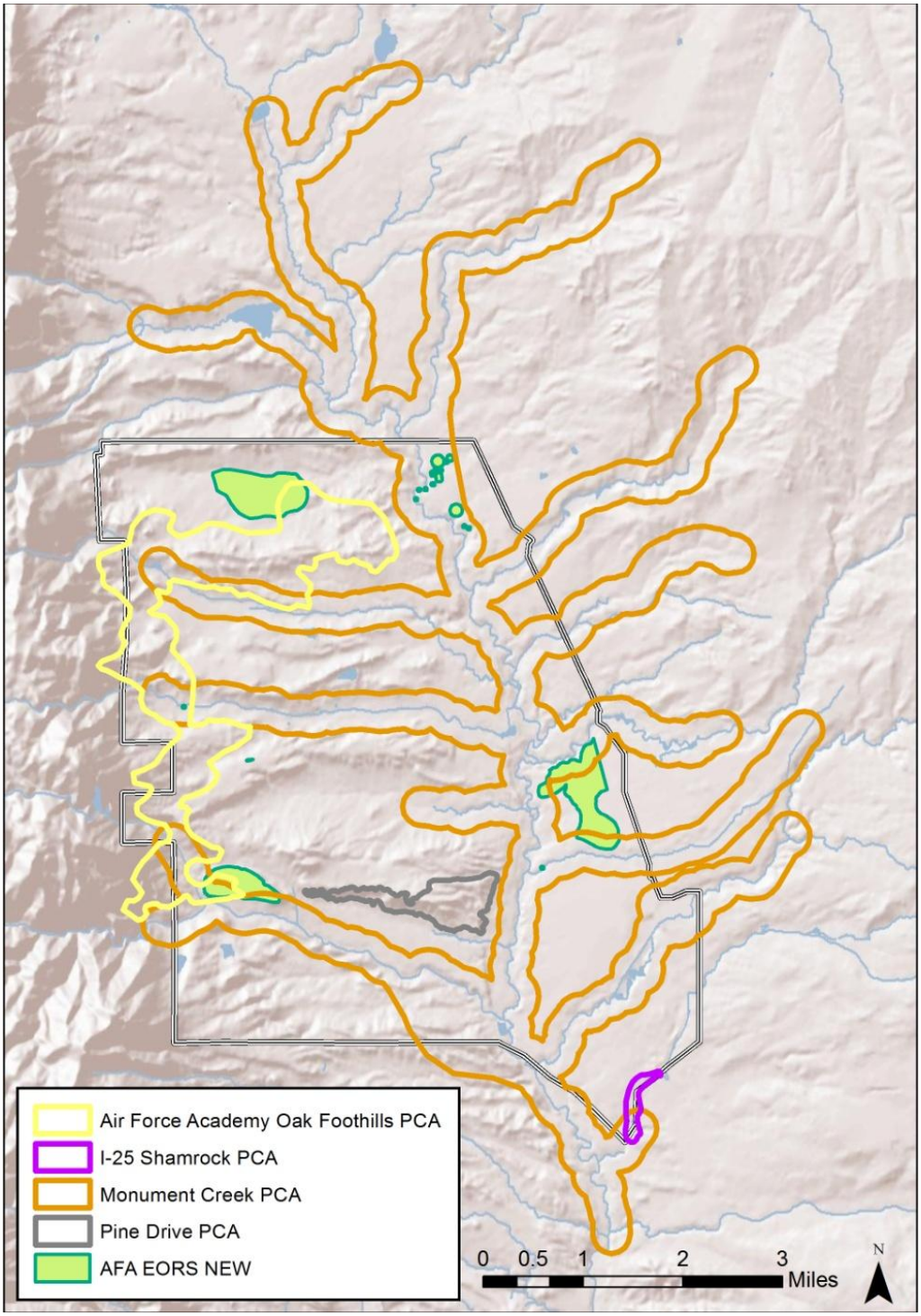

Figure 5. Location of Five Potential Conservation Areas (PCAs) and New Element Occurrences (EORs) at the Air Force Academy in 2015

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.

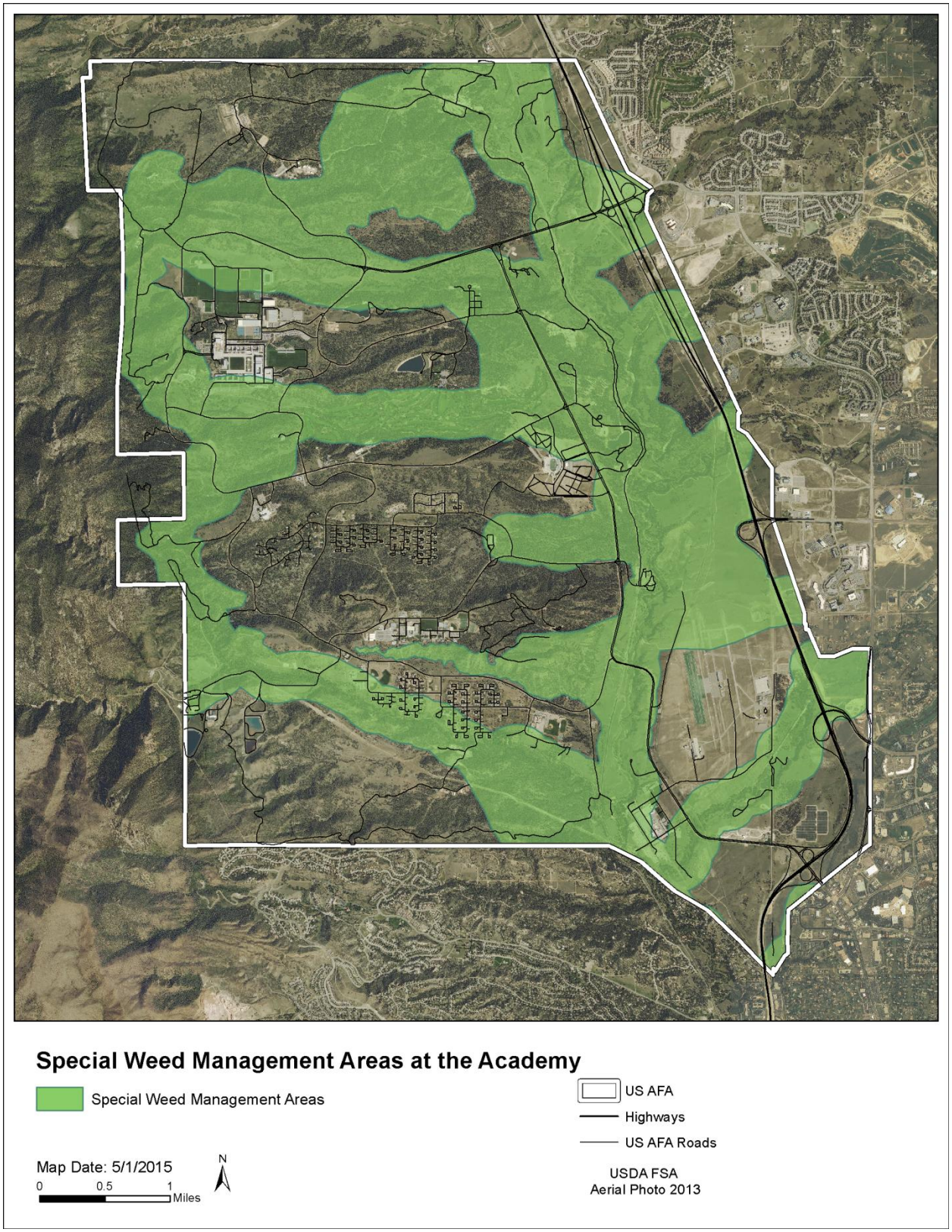

Figure 6. Special Weed Management Areas at the U.S. Air Force Academy. All of Farish Recreation Area is considered to be a Special Weed Management Area.

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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