Noxious Weed Survey
And
Integrated Noxious Weed Management Plan

Schriever Air Force Base

May 2017

COLORADO NATURAL HERITAGE PROGRAM

CNHP's mission is to advance the conservation of Colorado's native species and ecosystems through science, planning, and education for the benefit of current and future generations.

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Front Cover: Landscapes at Schriever Air Force Base in 2016. Photos courtesy of the Colorado Natural Heritage Program ©

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Noxious Weed Survey and Integrated Noxious Weed Management Plan

Schriever Air Force Base

El Paso County, CO

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Executive Summary

Schriever Air Force Base (AFB) includes approximately 3,840 acres east of Colorado Springs in El Paso County, Colorado. In 2016, Colorado State University and the Colorado Natural Heritage Program (CNHP) mapped eight state-listed noxious weeds known to occur, and a new species, salt cedar (*Tamarix ramosissima*), not previously known to occur, on the 3,500 acre buffer zone surrounding the administrative area in the center of the installation. In addition to weed mapping, an integrated weed management plan was created to guide noxious weed management activities in the most efficient and effective manner. This plan pertains to the "natural" portions of the base and excludes highly developed areas, such as around buildings, recreation fields, and lawns. The 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. The weed management plan includes recommendations for managing individual weed species mapped in 2016.

Of nine total species of noxious weeds mapped at Schriever AFB in 2016, the species with the largest cover include Canada thistle (>11 acres), knapweeds (> 6 acres) and field bindweed. Russian olive was found at 29 sites and puncturevine was found at one site, both of these species with about half an acre of coverage. Salt cedar and musk thistle were only found from one site each with very low cover and there were no individuals of bull thistle observed in 2016. The most difficult noxious weeds to manage on base are likely Canada thistle (*Cirsium arvense*) and the knapweeds which include diffuse knapweed, spotted knapweed (*Centaurea diffusa, C. stoebe*) and their hybrid. The methods used to map weeds in 2016 are described in detail in Appendix A.

Elements of Conservation Concern

The Schriever AFB supports at least two elements of conservation concern, one of which is a very rare plant community: the Western Wheatgrass – Spikerush Mixedgrass Prairie – a playa grassland (*Pascopyrum smithii – Eleocharis* spp. Herbaceous Vegetation) which is considered to be critically imperiled both on a state and global level (G1/S1). This community was first documented in 2000 at Schriever AFB. A rare plant species, the plains ragweed (*Ambrosia linearis*), is considered to be both globally and state vulnerable (G3/S3). There are two locations of each of these elements of conservation concern in undeveloped areas on the base. The locations of these rare plants and plant communities were included in the weed mapping effort because they need to be considered in future developments and in current management efforts.

Summary of Weed Mapping Results (arrows indicate change since 2012)

Status	Scientific Name	Common Name	Comment
	*Carduus nutans*	Musk thistle	Twenty plants mapped at one site and treatments have been initiated by resource management. Follow-up monitoring is recommended for 3-5 years.
	*Cirsium arvense*	Canada thistle	178 sites mapped in 2016, ranging from one plant to >22,000 individuals. Thirty-one locations had more than 1,000 plants with six of those having 10,000 or more.
	*Cirsium vulgare*	Bull thistle	Previously known from one location and was not found in 2016.
?	*Convolvulus arvensis*	Field bindweed	Opportunistically mapped in 2016. Many occurrences are near roads and in prairie dog towns. This species is typically in disturbed habitats and treatment may not be worthwhile.
 	*Centaurea diffusa, Centaurea stoebe* (*C. maculosa*) & hybrid	Diffuse and spotted knapweeds, plus hybrid	Diffuse was the most common knapweed species and included a hybrid with very little spotted knapweed. There were 46 knapweed locations ranging in size from one plant to an estimated 2,500 individuals. Site plans should be created for each area where treatments will occur.
	*Elaeagnus angustifolia*	Russian olive	Most of the 29 mapped locations are found along roads and near the installation boundary. Monitor for spread and treat young sprouts. Treating large trees is optional to prevent spread of seeds.
	*Tamarix ramosissima*	Salt cedar	**New species** not previously mapped; a single large shrub was mapped in 2016 that was likely present in 2012.
	*Tribulus terrestris*	Puncturevine	Mapped at one location in a severely disturbed habitat. Mechanical removal or hand-pulling with follow-up monitoring should eliminate this species from the base.

Summary of Management Recommendations

Prevention measures are widely considered to be the most cost effective and efficient tool for weed control (Colorado Dept. of Agriculture 2017, Sher et al. 2010, Tu et al. 2001, Zouhar 2001). This is accomplished by following Best Management Practices (BMPs) that minimize the entry of new noxious weed species to Schriever AFB. These BMPs include making sure equipment is cleaned before soils are disturbed and protecting areas from unnecessary disturbances, as well as concerted efforts for locating and eliminating new, small occurrences of noxious weeds before they can become established. Many weed treatment measures are not successful once populations are established and sometimes containment and suppression are very difficult. Results from multiple studies have shown that weed management strategies that only target the removal of weeds are not effective and may lead to increases in disturbance and ultimately more weed cover. For this reason, creating a site plan for each area to be treated is recommended, as well as for areas where treatments have been initiated.

- Creating a site plan for all weed infestations is recommended. Refer to the Assessment Worksheet for Weed Management Site Plan in Appendix B.
- Primary focus should be on the protection of intact landscapes from disturbances.
- When disturbances occur during construction and maintenance activities, these newly disturbed landscapes should be surveyed for noxious weeds as soon as possible (within a year). See BMPs to Prevent Noxious Weeds during Forest, Range and Residential Projects in Appendix C.
- Russian olive should no longer be used as a landscaping tree.
- For established populations of Canada thistle and knapweeds, use the 2016 weed mapping data to monitor the populations to determine if they are contained or spreading, especially previously treated areas.
- Any treatment should start as a small workable area. Many treatments for Canada thistle, knapweeds, Russian olive and salt cedar have the potential to make the weeds increase.
- Locations of rare plants and rare plant communities as well as intact systems should be considered prior to developing the natural areas at Schriever or before weed treatments are initiated. See BMPs for Managing Noxious Weeds on Sites with Rare Plants in Appendix D.
- Success should be defined for each treatment site and should not be a system dominated by non-native species, or a solid cover of grasses with little or no broad-leaved species, or landscapes that are less biodiverse than the treated system.
- Consider the establishment of permanent monitoring plots, especially for knapweeds and Canada thistle, to help detect if increases or decreases are occurring and to measure changes over time for both treated and untreated sites.

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Introduction

Schriever Air Force Base (AFB) includes about 3,840 acres and is located 10 miles east of Colorado Springs in El Paso County, Colorado (Figure 1). In 2016, Colorado State University and the Colorado Natural Heritage Program (CNHP) mapped state-listed noxious weeds known to occur in the 3, 500 acre buffer zone surrounding the administrative area in the center of the installation (Figure 2). The goal is to develop an updated weed map and noxious weed management plan to assist natural resource managers in preparing successful treatment plans to control weed infestations. This information is needed to comply with noxious weed regulations. In addition to noxious weeds, the area surrounding the installation also contains occurrences of a very rare plant community and rare plant species (discussed in more detail below) which will need to be considered in weed management and development activities.

It is important to understand that the term "weed" is not a scientific term and neither is the term "native". These are cultural terms and their meanings are subjective. For the purposes of most noxious weed surveys, a weed is a legally defined entity. Native plant species (sometimes defined as plants established in the U.S. before Europeans came to North America) can also be weedy – that is, they move into disturbed areas and can dominate. Disturbance is a natural and necessary part of native systems which change over time. In natural systems, dominance of weeds will often fade with time as the system recovers from disturbance. Systems disturbed by humans tend to be very different; the degree of disturbances are wide-ranging, they may be constant, and tend to be much more destructive to soils. In modern times, disturbances are not always obvious, like temperature fluctuations and warming caused by climate change which impacts insect and plant phenologies, or air and water pollution which adds nutrients that change soils and soil chemistry allowing a different set of plants and organisms an advantage. This may be a cause for the failure of weed treatments that have been observed across the country and Colorado. The abundance of native and agricultural grazers can also cause direct soil damage that changes the native plant cover.

Weed science has changed since the first weed laws were introduced. More information and management experiences are available in published literature on the impacts of not only the noxious weeds themselves but on treatments. Some removal techniques have been found to be damaging and create more habitat for either the same weed or other weed species. Some of the treatments have also been found to have the same impact on areas as the weed itself. How a treatment is carried out is very site-specific and site plans are now considered to be one of the best ways to approach weed management in a system where other natural resources need protection (versus a monoculture agricultural field). Protection of wildlife, wildlife habitat, rare plants and water quality are very important when considering treatments to target weeds. Treatments may cause adverse impacts and must be part of the analysis in determining for each site what the final goal will be. In addition, no treatments are recommended without site plans that include a follow-up monitoring schedule, as many species will need multiple visits and/or treatments to prevent spread and to accurately interpret the success of treatments.

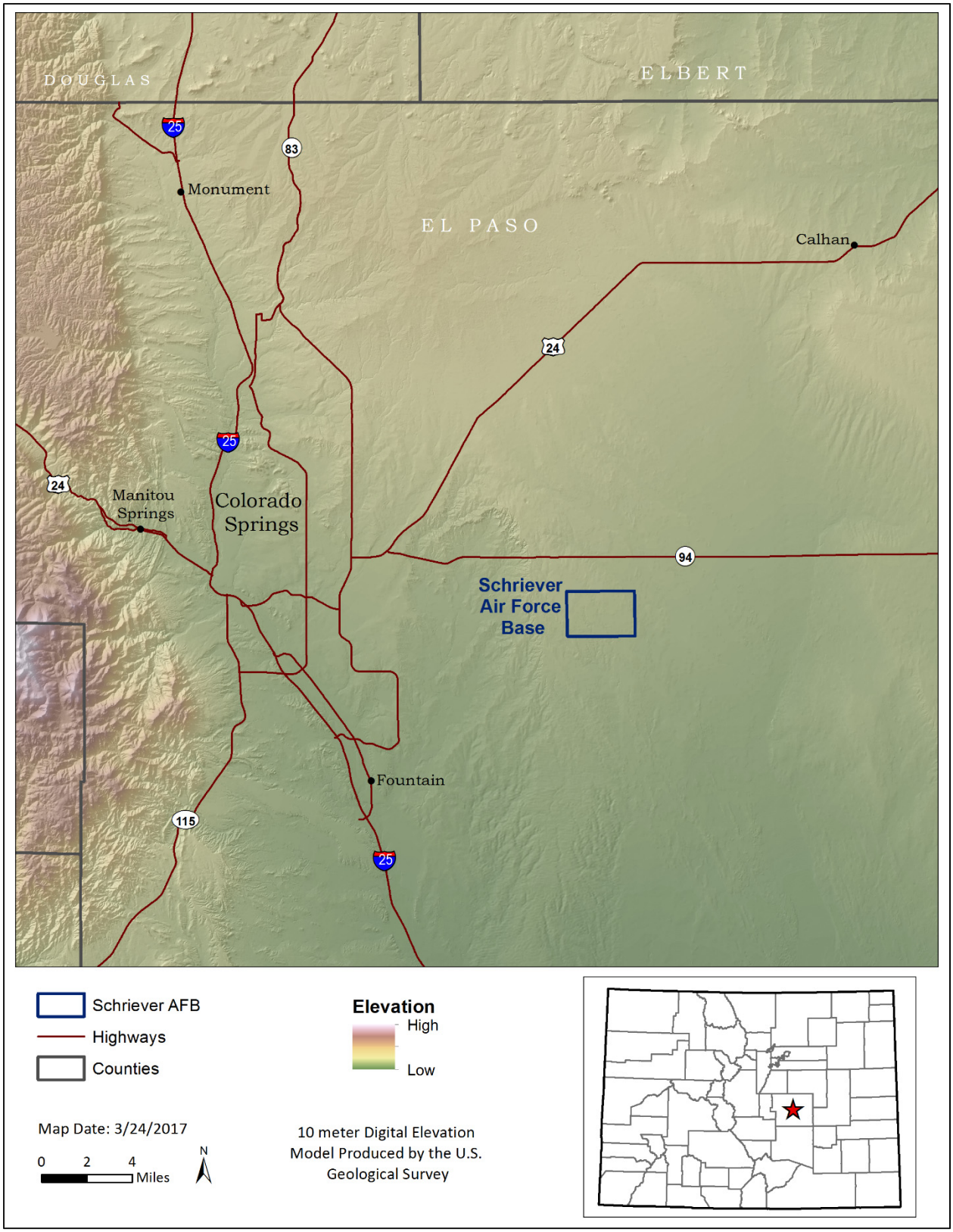


Figure 1. Vicinity map for Schriever AFB.

Figure 2. The Administrative Area at Schriever AFB.

Good planning is cited as the most critical and most overlooked aspect of weed treatments and is often cited as a major reason that weed treatments and restorations fail. Because planning requires collecting a variety of information it leads to a greater understanding of site requirements (Interagency Workgroup 2016). Plans that include detailed site evaluations are recommended in Best Management Plans (BMPs) for weed treatment in areas with ecological value by numerous agencies, books on the subject and scientific articles including: UC Davis Weed Research and Information Center (2013) for "Weed Control in Natural Areas in the Western US", USFS Fire Effects Information System control and management of tamarisk (Zouhar 2003), CSU Extension (2016), and The Nature Conservancy Weed Control Methods Handbook (Tu et al. 2001). In addition, Best Management Practices (BMPs) written specifically for managing tamarisk (Colorado State University 2010, Sher et al. 2010) state that the preparation of a detailed site plan before treatment actions occur is critical. An effective weed management plan for Schriever AFB will synthesize all of the previous applicable work that has been conducted to develop a clear plan for resource managers, with defined management units, objectives, and goals. The field surveys conducted in 2016 quantified weed cover and included qualitative assessments on the current condition.

Information from previous mapping efforts are included in the descriptions below and are used to look at trends.

The Colorado 2014 Weed List provides prioritized management goals for the listed weeds (List A, B, and C - Table 1), 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 1). Management plans/rules prepared by the State for the List B species, mandates whether eradication, suppression, or containment will be required depending on location.

Table 1. 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. 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.

The El Paso County noxious weeds website can be found at the following address:
http://adm.elpasoco.com/Environmental%20Division/Forestry%20and%20Noxious%20Weeds/Pages/default.aspx

Past and on-going weed management at Schriever AFB

The base was surveyed for weeds in 2004 and in 2012 (North Wind 2005, 2012). A total of eight species of noxious weeds were identified. In 2016, a new noxious weed, salt cedar or tamarisk (*Tamarix ramosissima*), was documented bringing the total number of noxious weeds to nine. Seven species are on the state noxious weed list B and two on list C (Table 2).

Table 2. List of noxious weeds mapped at Schriever AFB in 2016.

Common Name	Scientific Name
LIST B	
Musk thistle	*Carduus nutans*
Canada thistle	*Cirsium arvense*
Bull thistle	*Cirsium vulgare*
Diffuse knapweed	*Centaurea diffusa*
Spotted knapweed	*Centaurea stoebe (C. maculosa)*
Russian olive	*Elaeagnus angustifolia*
Salt cedar (Tamarisk)	*Tamarix ramosissima*
LIST C	
Field bindweed	*Convolvulus arvensis*
Puncturevine	*Tribulus terrestris*

Weed treatments for some species have been ongoing at Schriever since 2014. Mowing treatments have been carried out on stands of Canada thistle as well as knapweeds. In 2015, a late season herbicide application (Milestone TM) was applied to a bolted population of Canada thistle northeast of the perimeter road (Pers. Comm. Max Canestorp, March 03, 2017).

Survey Method

Weeds were surveyed using a census survey method where weeds were documented as found by walking the property using GPS and GIS technology. Infestations were mapped as points, lines, or polygons, depending on the size and shape of each occurrence. Points and lines were buffered to estimate actual size. GIS data were mapped using a Yuma rugged tablet with a built-in GPS receiver and ArcPad version 10.2 (ESRI 1995-2015), a portable version of GIS software that allows the field botanist to create and edit spatial data remotely using a tablet computer. Qualitative notes and actual counts and estimates for populations were made at each mapping site. Areas already known to contain weeds were targeted and then surveys were conducted in natural areas surrounding the installation to locate new infestations and encroachment into natural areas. Photographs were taken of some of the areas with weeds and elements of conservation concern. Field surveys were conducted in August and September of 2016. A description of the mapping protocol is provided in Appendix A.

Weed Management Plan

The following integrated weed management plan for Schriever AFB follows approaches utilized by North Wind (2004, 2012), management plans for Schriever AFB, Carpenter and Perce (2004), and Smith et al. (2015). In addition, information for weed management was designed for Schriever based on other research on weed management in areas that contain natural resources (Mui and Panjabi 2016, Person and Ortega 2009, and Tu et al. 2001). New information on weed control methods was also 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 and the U.S. Forest Service Fire Effects Information Service (FEIS 2017).

Weed treatment actions for the most difficult species to control often only temporarily suppress the noxious weed cover and have simultaneously exacerbated other noxious weed species within the treatment areas (Pearson et al. 2016). Treatments that focus solely on the removal of a target species with no follow-up actions or that have no defined treatment goals are often met with failure (Interagency Workgroup 2016, CSU 2010, Sher et al. 2010). In addition, it is important to keep in mind that the current infestation level of noxious weeds may have taken many years to develop. Understanding the reasons why noxious weeds are in an area is key to their control. Simply removing targeted weed species from an area without addressing the underlying reasons for infestations and considering the impacts from the management activity itself, is a common problem leading to unsuccessful weed management. Treating weeds in areas where natural resources need to be protected is much more complex than it is on a roadside or in a farm field. Very different approaches and measurements for success apply. New studies have demonstrated that many weed treatments are as damaging to the ecosystem as the species they are trying to remove (FEIS 2017, Pritekel et al. 2006).

The El Paso County 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. These ideas have all been incorporated in the weed management plan.

Results

The results for the 2016 survey for nine noxious weed species at Schriever AFB show that at least three species of noxious weeds, Canada thistle, knapweeds and Russian olive, have expanded since the last weed monitoring surveys were conducted (North Wind 2005, 2012). Only a single population of puncturevine and musk thistle were mapped in 2016 along with a single individual of salt cedar and no bull thistle was observed (Table 3).

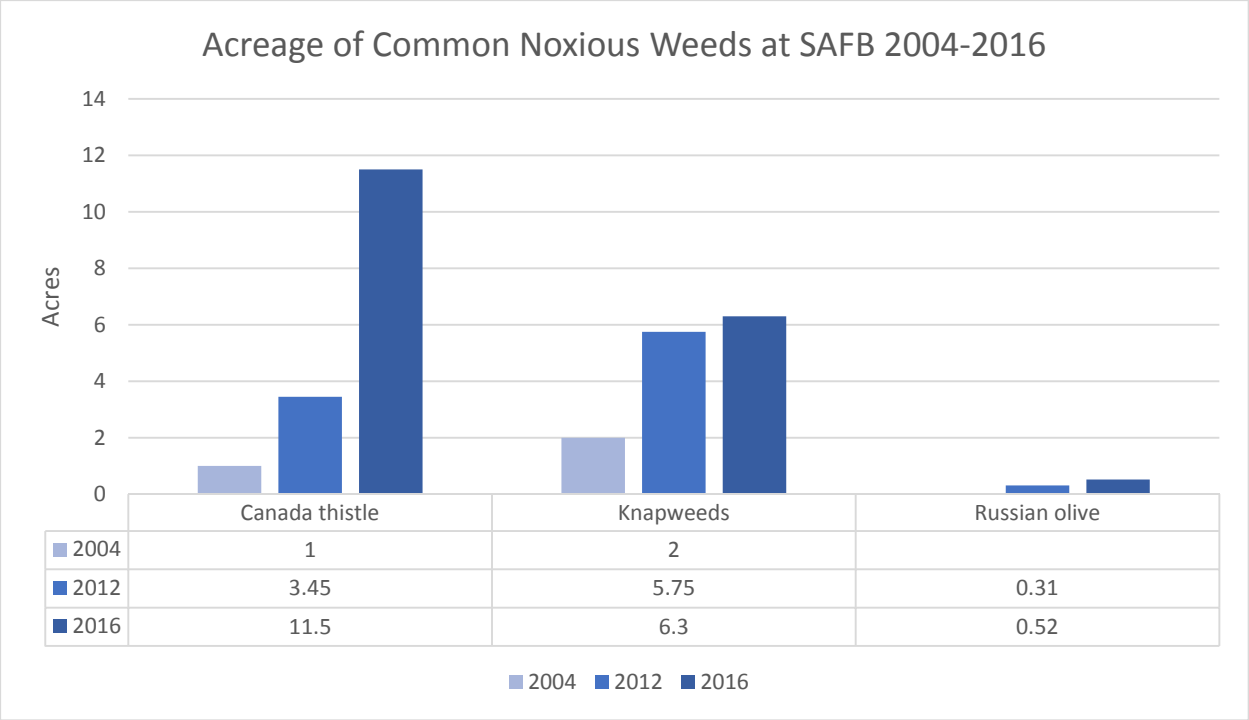
Canada thistle and the knapweeds account for most of the weed cover at Schriever AFB (Figure 3). The locations of noxious weed species at Schriever AFB are strongly correlated to areas disturbed by anthropogenic developments. Noxious weeds are common near roads and other disturbances and less disturbed areas have far fewer weeds (Figure 4).

For the 2016 weed mapping survey, diffuse and spotted knapweeds and their hybrid were mapped together (knapweeds). The knapweeds are very difficult to control once they become established and their total cover over a landscape exceeds 2.5 acres (~1 hectare) (Zimmerman et al. 2011). Canada thistle coverage was mapped at 11.5 acres and just over six acres for knapweeds. Both of these species are on the Colorado State List B. Plants with less than an acre coverage have a chance for control or even elimination. At Schriever AFB, musk thistle, puncturevine and salt cedar (tamarisk) have the potential to be eliminated because of their low cover. Russian olive was planted as an ornamental and has been present for many years. It is a List B noxious weed that is known to be difficult to control once it becomes established and it escapes to riparian areas. There were young trees observed indicating the plant is spreading. Field bindweed was the only other species that exceeded an acre in coverage across the base. It is a List C species that is found largely along ditches, roadsides, and in prairie dog towns. This species was not mapped in its entirety because of the widespread nature of the plant. Populations of field bindweed that were not found in the 2012 mapping effort were mapped and many of the previously mapped areas were visited and confirmed extant. However, all sites were not ground-truthed due to financial constraints so no definitive statements can be made on trends for field bindweed. The data would be useful as a guide to the locations and not a quantitative measure.

Table 3. Results of the noxious weed survey conducted at Schriever AFB in 2016.

Common Name	Scientific Name	2004 North Wind	2012 North Wind	2016 CNHP Occupied Acres	2016 CNHP Mapped Locations
LIST B					
Musk thistle	*Carduus nutans*	<0.25 acres	0.02 acres	0.02 acres	1
Canada thistle	*Cirsium arvense*	1 acre	3.45 acres	11.5 acres	181
Bull thistle	*Cirsium vulgare*	---	1 plant	0 acres	0
Knapweeds	*Centaurea diffusa; C. stoebe, hybrid*	<2 acres	<5.75 acres	6.3 acres	46
Russian olive	*Elaeagnus angustifolia*	(Present)	0.31 acres	0.52 acres	29
Salt cedar (Tamarisk)	*Tamarix ramosissima*	---	---	< 0.01 acres	1
LIST C					
Field bindweed	*Convolvulus arvensis*	19 acres	22.52 acres	13.4 acres*	79
Puncturevine	*Tribulus terrestris*	(Present)	0	0.45 acres	1

*Estimated



	Canada thistle	Knapweeds	Russian olive
2004	1	2	
2012	3.45	5.75	0.31
2016	11.5	6.3	0.52

Figure 3. Acreage of 3 common noxious weeds at Schriever AFB from 2004-2016.

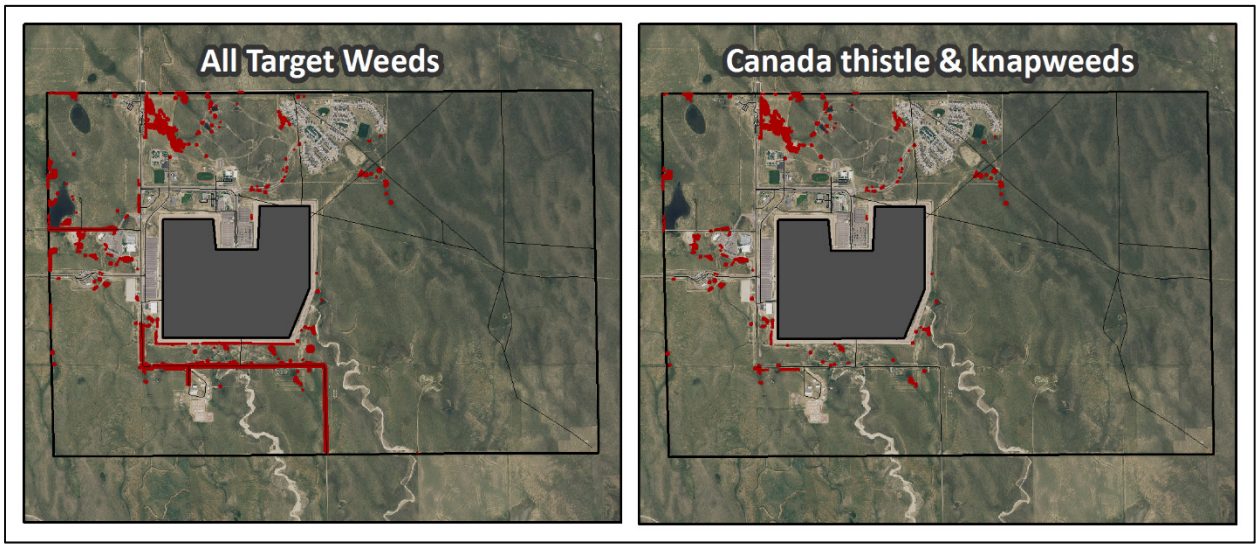


Figure 4. All noxious weeds at Schriever AFB compared to Canada thistle and knapweed occurrences.

Elements of Conservation Concern

At Schriever AFB, the more highly disturbed areas near buildings, houses, ditches, culverts and roads have noxious weeds. Areas around the installation without these developments not only have much fewer weeds but contain intact prairie as well as elements of conservation concern at both a state and global level. The Schriever AFB supports at least two different elements of conservation concern including a very rare plant community: the Western wheatgrass – Spikerush Mixedgrass Prairie – a playa grassland (*Pascopyrum smithii – Eleocharis* spp. Herbaceous Vegetation) which is considered to be critically imperiled both on a state and global level (G1/S1). This community was first documented in 2000 at Schriever AFB and has remained in good condition over the past 16 years (Photo 1). The rare plant, plains ragweed (*Ambrosia linearis*), considered to be both globally and state vulnerable (G3/S3), occurs near intermittent streams, pond margins and playas on moist sand or sandy clay soils at low elevations on the plains (Photo 2). There are two locations of each of these elements of conservation concern in undeveloped areas of the base which need to be considered in future developments and weed management efforts.

Photo 1. Critically globally imperiled Western wheatgrass – Spikerush Mixedgrass Prairie playa grassland at Schriever AFB in 2016.

Photo 2. Plains ragweed *(Ambrosia linearis*), a rare plant species at Schriever AFB, August 15, 2016 P. Smith

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 or roadside. Weed management in natural areas must consider the management of the entire community and not just removal of individual weeds to be successful. The areas that support elements of conservation concern will benefit from special management approaches in weed treatment strategies. The ecosystem services that will be provided to the base should also be considered before natural areas are developed. Water quality protection, wetland protection, flood protection, wildlife, air quality and aesthetics are important aspects often overlooked in landscape planning. To assist in weed management efforts at Schriever, we have provided a map with areas delineated for natural areas and sensitive natural areas (Figure 5.).

Natural areas include landscapes where weed management techniques should follow a natural areas approach for weed management (discussed in more detail below). Sensitive natural areas include landscapes where rare plants and rare plant communities are known to occur. These areas are where Best Management Practices for treating noxious weeds in the vicinity of rare plants would apply (Mui and Panjabi 2016, Appendix D). Unfortunately, many of the guidelines for controlling noxious weeds are out of date and may also include information from herbicide label instructions which are often based on agricultural landscapes that are not designed for natural areas. There is an important distinction between these two land uses, especially for ecological resource management.

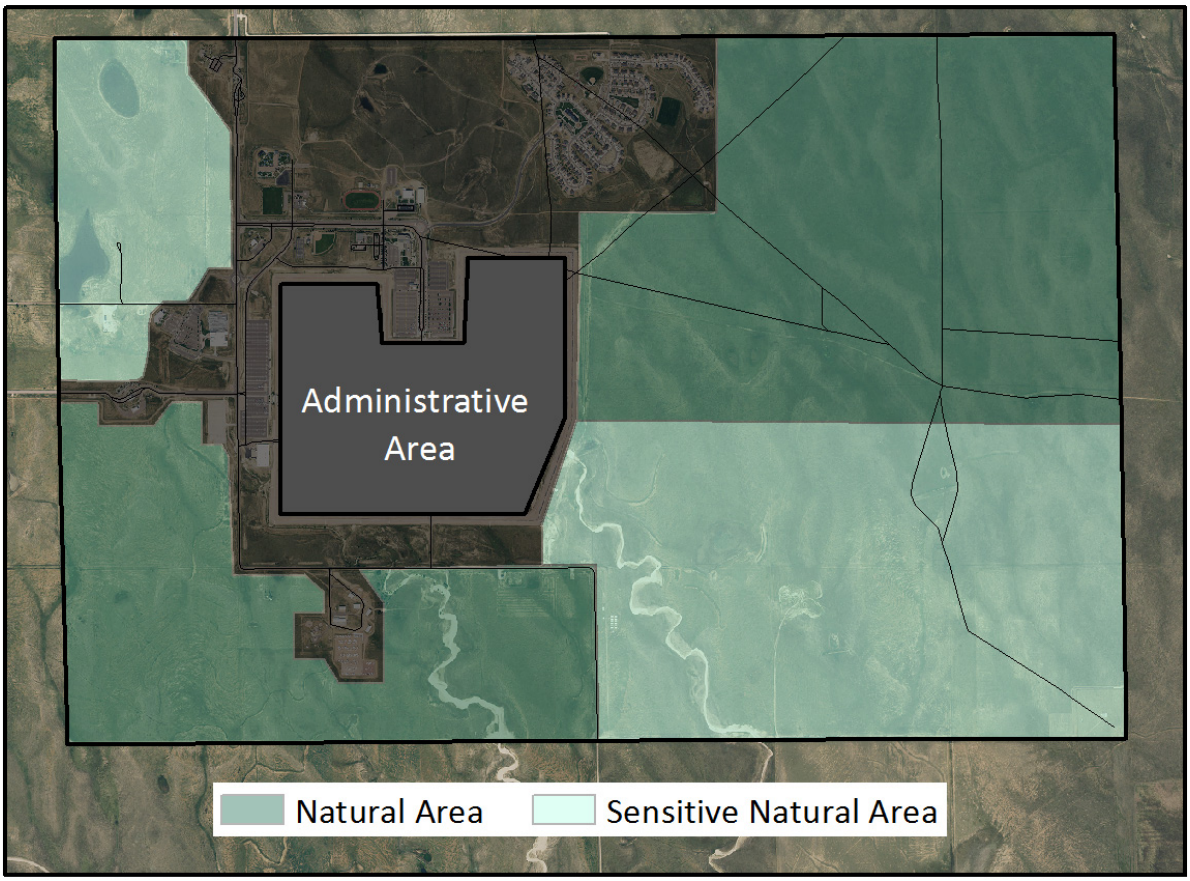


Figure 5. Natural Areas and Sensitive Natural Areas at Schriever AFB delineated for weed and landscape management.

The majority of the weeds mapped at Schriever AFB are found in areas that are highly disturbed, near roadways, construction sites, storm water retention basins and areas where the soil has been turned over. Some of the areas where weeds were documented include the natural and sensitive natural areas where there are natural resources that could be negatively impacted by standard weed treatments (Figure 6). Planned developments and new construction in or near these areas should be monitored aggressively to remove weeds in their earliest growth stages before they develop the deep root systems that make them difficult to control.

There are two species that were mapped at Schriever AFB in 2016 that had more than an acre of coverage and appear to be expanding, Canada thistle and the knapweeds. These two species pose the largest management challenges. There is no easy way to control either one of these species especially in natural settings. The key is to control the disturbances that create the landscape for weeds and to try and encourage the landscapes that are more welcoming to native species. The biggest hurdle for these species is to not harm the system you are trying to save. Weed management is relatively new compared to many other sciences. In addition, much information has been published in the past that is subjective and was presented as if it were based on scientific findings and many recommendations were based on subjective ideas rather than fact-based research. Since weed regulations were first promulgated much more has been learned about the biology of the weeds in addition to years of experimenting with different treatments. The following

sections provide details for each of the weed species at Schriever and offer recommendations for management based on the newest scientific information available.

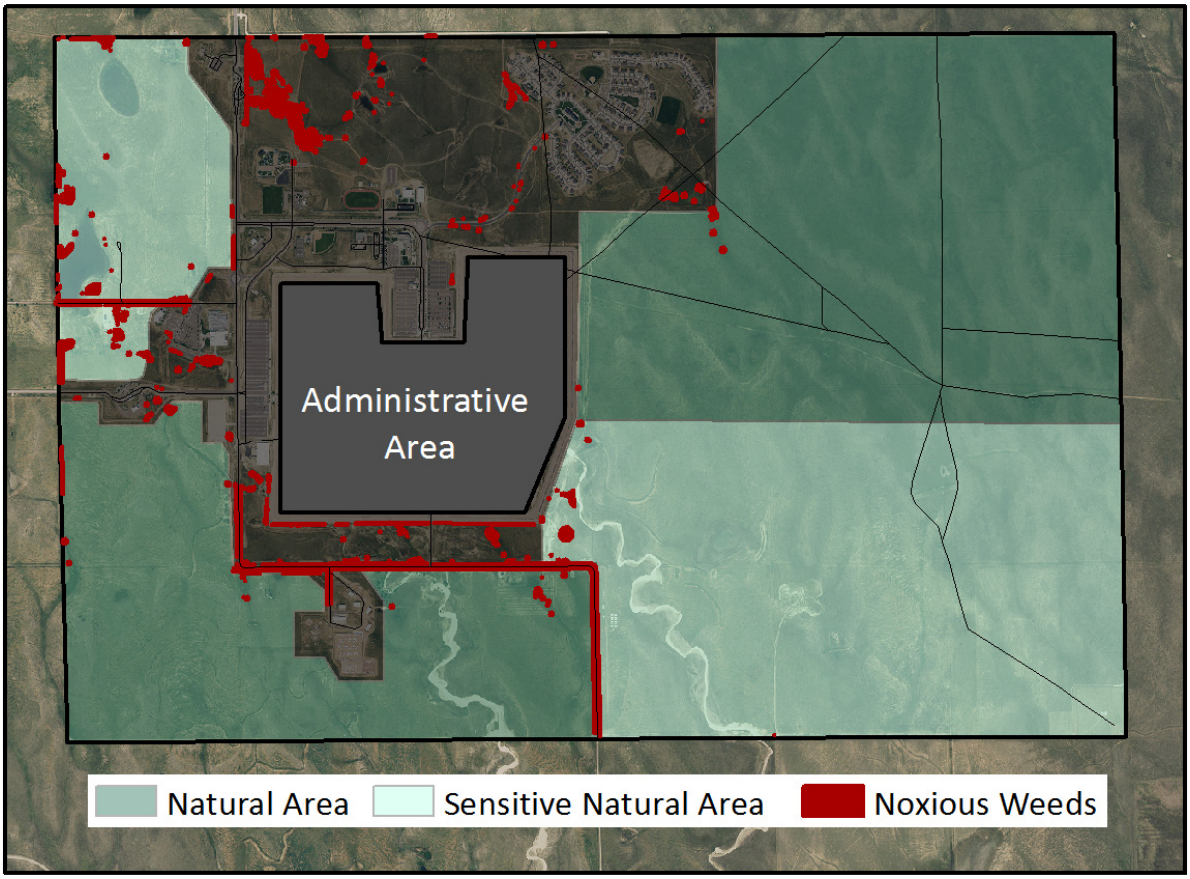


Figure 6. Location of noxious weed occurrences at Schriever AFB in relation to Natural Areas and Sensitive Natural Areas delineated in 2016.

Site Plan for Weed Management

The biggest reasons weed management has been unsuccessful, especially for problematic species like Canada thistle and knapweeds, are:

1) The underlying reasons that weeds occupy an area is not addressed;
2) Weed science has changed since the first weed laws were introduced and managers may be accustomed to outdated strategies;
3) Disturbances created during weed treatments are not considered;
4) The perceived harm weeds are causing is not weighted against the harm caused by weed treatments and
5) Considering a variety of weed treatments and evaluating actions with the highest potential to work is not done on a site specific basis.

This is the reason much of the new information on weed management is emphasizing the creation of a site plan before weed treatments, or even after actions have been initiated on any weed species. A site assessment worksheet that will guide the preparation of a site plan is provided in Appendix B. This form will assist in the documentation of current conditions, the goal and plan of action that will take into account site characteristics and provide a place to schedule and update follow-up activities that may occur. This will make it much easier to determine and document the success of an action or to determine if actions are even necessary. Adaptive management, or the ability to change the original plan if results warrant, will be facilitated as there will be information documenting what has been done, results at the site and a comparison to the last survey.

Musk thistle (*Carduus nutans*)

Decreasing: Only found in one location in 2016.

State List B

Photo by Michelle Washebek

- Biennial (winter annual) with a taproot
- Reproduction only by seed
- Rosettes form early spring, bolts in March to May
- Plants die after seed set
- Plants are impacted by drought
- Seed longevity: 10 years (CCR 2014)

Photo musk thistle rosettes. CSU Extension website 2017.

Mapping Results

Musk thistle was mapped at one location in 2016 near a residential area in the north central part of Schriever AFB (Figure 7). There were 20 individuals covering 0.02 acres that were mapped in 2016 (Table 4). In 2012, a weed survey located about seven occurrences near the same residential development covering 0.02 acres (North Wind 2012). The resource manager at Schriever is already aware of the population reported in 2016 and has initiated rapid response activities for this population.

Table 4. Results of the noxious weed survey conducted at Schriever AFB in 2016 for musk thistle.

	2004 North Wind	2012 North Wind	2016 CNHP
Occupied Acres	<0.25	0.02	0.02
Estimated Number of Shoots	--	--	20
Number of Mapped Features	--	--	1

Plant Biology

Musk thistle is a biennial forb that reproduces solely by seed and produces rosettes in the first year. Removal of the seed source is the best management objective because the bolted plants will die after they go to seed. Seeds remain viable for 10 years (Code of Colorado Regulations (CCR) 2014). Biocontrol is available in Colorado. However, the population at Schriever does not warrant insect introduction and one of the biocontrol insects is thought to harm native thistles (Michels et al. 2014).

Management Recommendations

The recommendation for musk thistle, which currently has a low threat level at Schriever AFB, is to continue to survey for rosettes and bolted plants, especially in the vicinity of known locations near residential development and new construction sites, and remove plants as they are encountered in rosette stage. New construction sites should be a priority for rapid response. Digging rosettes or severing below the root crown before the plants bolt and set seed, is the most cost effective method. Monitoring for new sprouts and rosettes is recommended for at least 10 years because of the seed longevity.

A musk thistle fact sheet can be downloaded at
https://www.colorado.gov/pacific/agconservation/musk-thistle

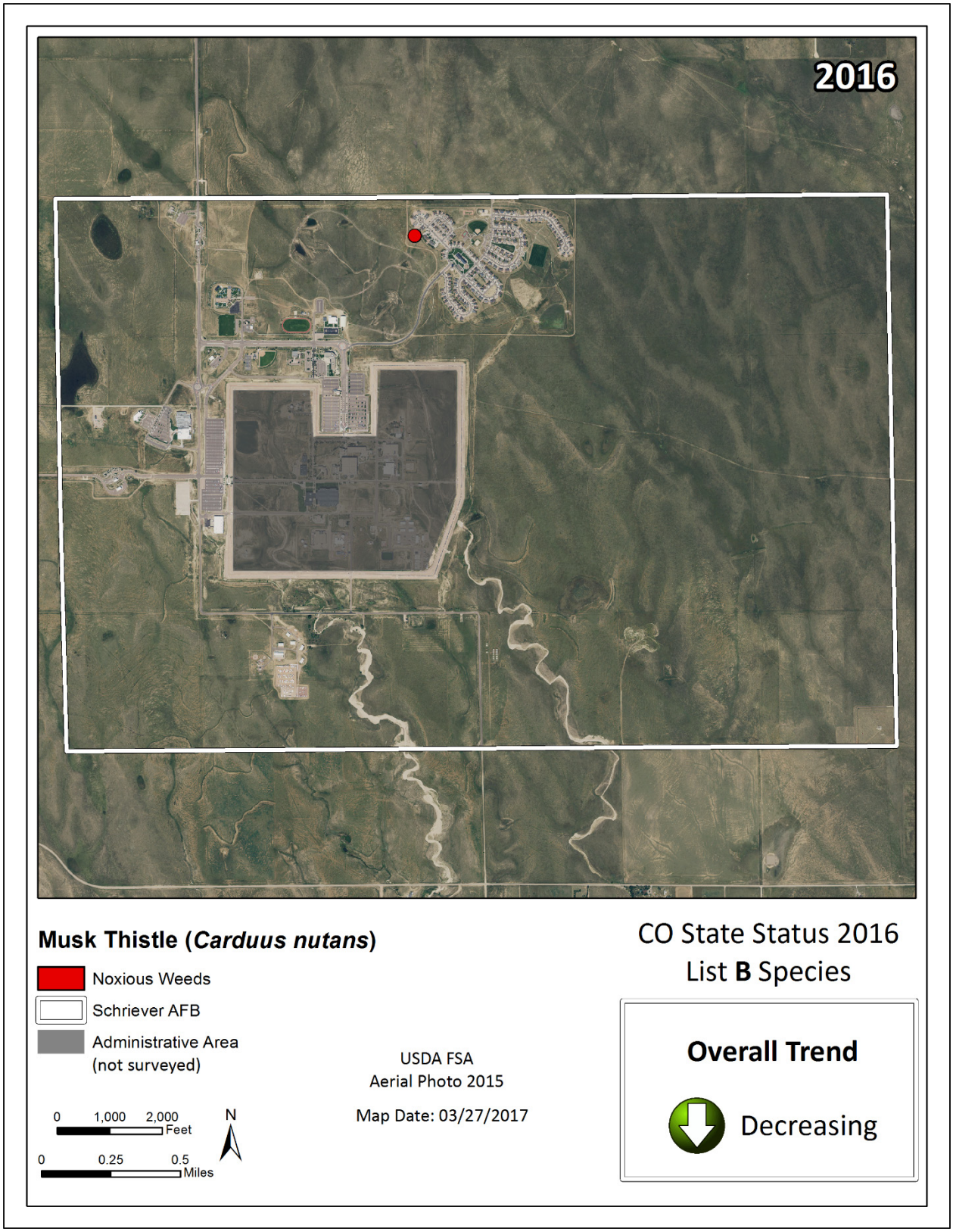


Figure 7. Distribution of musk thistle mapped at Schriever AFB in 2016.

Canada thistle (*Cirsium arvense*)

Increasing: Over 11 acres mapped in 2016.

State List B

Canada thistle rosettes, Oregon State University.

Canada thistle in flower, CSU Extension.

Dense stand of mature Canada thistle with prairie vegetation upslope at Schriever AFB, August 16, 2016.

- Perennial
- Dioecious (male and female plants separate)
- Horizontal and vertical root systems >10' deep
- Reproduction from root buds and seeds
- Seed longevity 22 years with deep burial promoting longevity
- Susceptible to shading and inundation
- **ALL FORMS OF TREATMENT ARE KNOWN TO STIMULATE SPREAD**

Mapping Results

Canada thistle was noted as one of the three most problematic invasive species for the Schriever AFB (North Wind 2012). The other two species are knapweeds (*Centaurea stoebe, C. diffusa*) which are found overlapping some of the mapped Canada thistle sites at Schriever AFB. When the base was surveyed in 2004, the cover for Canada thistle was estimated to be about one acre in scattered populations north of the installation and along the fence. One acre is typically the size when most invasive species become hard to eliminate from a system. The weed survey eight years later showed the coverage had increased by more than three times to 3.45 acres (North Wind 2012). In 2016, the coverage of Canada thistle has increased another threefold to 11.5 acres. All occurrences are correlated with disturbances such as roads, ditches, culverts and runoff. There were a total of 181 mapped Canada thistle sites (Figure 8) that ranged in counts from 1-22,000 plants (Table 5). Thirty-one sites had more than 1,000 plants (6 locations with 10,000+ plants).

Table 5. Results of the noxious weed survey conducted at Schriever AFB in 2016 for Canada thistle.

	2004 North Wind	2012 North Wind	2016 CNHP
Occupied Acres	1	3.45	11.5
Estimated Number of Shoots	--	--	183,665
Number of Mapped Features	--	--	181

On-going Weed Management Activities

Some areas with dense Canada thistle stands have been treated by mowing with motorized machinery where accessible; weed whips were used in drainages and ditch lines for smaller stands. Future plans are to continue mowing especially the large population near the north entrance. Some herbicide applications (2015 Milestone section 23W) have been applied to some of the un-mowed populations in late season (post bloom).

Plant Biology

Canada thistle has been in the U.S. for at least 400 years and is thought to have come from southeast Europe, others sources include Canada as its native range (Zouhar 2001a). Canada thistle is a deep-rooted perennial that has the ability to reproduce by seed and by underground root buds. This characteristic makes the plant extremely difficult to treat. Any activity that removes above ground portions can stimulate underground root buds to grow. These activities include, but are not limited to cutting, grazing, mowing, fire and chemical applications. Seeds are viable for up to 22 years once mature (CSU 2013b) and become viable on the plants within 7-10 days of flowering. Canada thistle does not tolerate shade and is often found in a variety of dry to moist disturbed areas along roadsides, fields, meadows, moist depressions, stream sides, drainages, burned areas, wetlands and flooded areas especially those with fluctuating water levels. Canada thistle also does not tolerate high levels of inundation. Overgrazed areas, in burn scars and any areas where soil is subject to disturbance that is open to sunlight with some moisture content, will be a potential site for Canada thistle. It differs from other thistle species in the fact that it is dioecious, the male and female plants

are separate, and entire areas may consist of only male or female plants. Sheep and cattle avoid eating Canada thistle and thus it is often selected for in range lands.

There are some beneficial aspects of Canada thistle. It has been documented providing cover for animals, including endangered species. It is pollinated primarily by honey bees. Canada thistle is credited with many medicinal properties (Zouhar 2001a).

Discussion and Recommendations

For Schriever AFB, the coverage of this plant is too large to consider eradication. *The primary focus for resource managers should be protecting existing intact landscapes from invasion.* Invasion is not really an appropriate term, it is more like "invitation" as Canada thistle and other noxious weeds typically inhabit areas that have been previously disturbed. Canada thistle plants appear to be invading but are really taking up a newly created niche that invites them in and favors them over native species. The sprouting margins of dense stands may invade intact areas along the margins. This is essential to consider when treating because removing the weed will likely not result in native species returning to a previously disturbed site and could increase footprint of the colony. Planning, monitoring, seeding and forethought will be required if treatments are undertaken.

Any weed treatment program should put prevention as the top priority. This has the most benefit to cost ratio and the most successful outcome. In addition to making sure heavy equipment or any equipment used to disturb soils is cleaned to remove potential seed sources (follow prevention BMPs provided in Appendix C), surveys for new populations of very young Canada thistle plants that can be pulled should be a top priority for sites that are newly disturbed. Young sprouts will not have developed the very deep rhizomatous roots of established Canada thistle populations and can be successfully removed. Visiting areas where new disturbances have occurred should be a high priority to survey for new Canada thistle shoots, including construction activities for roads or buildings, flooding or any activity that may impact soils and open up potential habitat for Canada thistle.

Well-established populations are very difficult to treat as most forms of treatment cause the underground biomass to expand and have the potential to increase the footprint of the population. There is no single treatment that will remove Canada thistle from an infested site. Treatments require multiple types, careful assessment, follow-up and planting of native plants in natural (non-agricultural) areas. Depleting the underground reserves is the goal by utilizing multiple types of treatments at multiple times over periods of years (5-10+ years). Even under the best of circumstances, the final result is almost always not a native cover. Typically a non-native rhizomatous grass (especially if herbicide treatments are used) or another noxious weed are the end result (Pearson and Ortega 2009, Zouhar 2001a). Native plantings may make it more successful, but they have to be done by people with experience. Knowing the seeding rate (which is often much higher than most people want to pay for), the best available seed mixes (to avoid contaminants of non-native seed and non-native genotypes) and the residence time for chemical treatments must be included in the design. Milestone, for example, which is often used to treat

Canada thistle, has a one year residence time in the soil, which could influence establishment of broad-leaved species.

Site Assessment for Weed Treatment

A site assessment for weed management and the creation of a site plan ideally should be conducted before established populations of Canada thistle are treated. The number one reason many treatments fail is because there was no plan (Interagency Workgroup 2016, CSU 2010, Sher et al. 2010). By creating a plan, many factors will come to light that may lead to a successful result. For example, if there is no money or resources for follow-up monitoring, it may be better to avoid treatment. Treatment could exacerbate the growth of Canada thistle if results of treatments are not monitored and follow-up actions are not administered. In areas where natural landscapes exist, the first goal is to protect them. By looking at the site in detail, it will become clear which resources may need protection from treatments or the weed. Determining whether the weed population is spreading or at full containment is imperative and may take a couple of seasons. It is also extremely important to know all of the plants and animals in the treatment area.

All types of weed management (mowing, burning, pulling, herbicide applications) for Canada thistle can stimulate the underground parts to grow. A site plan is extremely important to have in place before action is taken to treat Canada thistle. One of the main reasons treatments fail for deep-rooted perennial species like Canada thistle, is that the removal efforts are themselves a type of disturbance that needs to be considered. Disturbance is often the underlying cause for weed presence. Understanding the current conditions at a proposed treatment site is critical to determining the result that may be expected from a given treatment. At Schriever AFB, many areas where Canada thistle dominates appear to be subject to an array of disturbance including frequent runoff and perhaps even high volume runoff, in some areas. These areas are being continually disturbed not only by water flows but pollution, salts and nutrients which are being added to these sites. Chances for successful control are likely very low, even with follow-up planting efforts. Some treatments have been initiated on populations at Schriever AFB; the creation of a site plan for these areas should be given higher priority to document results of the activities. Most recommendations state that treatment area size should be small so you can determine if the activity is beneficial before conducting it across a larger area.

There must be careful thought about what the area to be treated looks like currently (is it mixed with native herbs and grasses) and what the expectations are for the area post-treatment. The disturbance regime at a particular site is important to consider. Canada thistle populations at Schriever are subject to storm water runoff from culverts and roadways in addition to direct soil disturbances (Photo 3). Unnatural flows (those that don't match natural hydroperiod), and the addition of pollutants, including nutrients and salts, provide a continuous source of disturbance. Under these conditions, native plants do not thrive and treatments for weeds will likely be unsuccessful and lead to either a different weed or the same weed moving into treated sites. An Assessment Worksheet for Weed Management Site Plan is included in Appendix B.

Photo 3. View of mowed area of Canada thistle with culvert, roadway and disturbed soils are evident.

Herbicides

Herbicides are complicated to use and may also contribute to spreading weeds in a disturbed system. Results will vary based on the differential susceptibilities of ecotypes and tolerant varieties, growth stages, application method, application rate, accuracy of the delivery application device (they get clogged), solutions may not mix, the carriers selected to deliver the pesticide, weather, and the types of plants present in the surrounding area and in the seed bank. If the physiological, morphological and phenological stage of the plants and the environmental conditions under which the plants are growing are not optimal, herbicides will be ineffective and control will not be satisfactory (Zouhar 2001a, CSU 2013b). Translocation to the roots does not happen in dry times.

Wildlife considerations are also important especially in natural areas. The location of Canada thistle in areas that have a connection to ground water or flow to areas that connect to ground water may contaminate groundwater. Many of the Canada thistle plants are in areas with connectivity to ground water even if they may not be considered a wetland. Picloram (Tordon) is often recommended for Canada thistle control. However, this restricted herbicide should not be used in wet areas or areas that are frequently flooded (which may not be readily apparent at all times of the year to applicators). This herbicide is known to contaminate groundwater and have significant impact to woody vegetation (see herbicide label data).

A consideration must be made to determine what may replace Canada thistle in this environment of a continuous disturbance regime. Typically, it will be more weeds. Also, the herbicide resistance that has developed in many species being continuously subjected to herbicides, residence time in the soil, and impacts to soil biota and animals, needs serious consideration. Herbicides are being used widely across landscapes and are having impacts on invertebrates and water quality (Gilliom 2007, Gan et al. 2003, Silver and Riley 2001). Not only the herbicide is a concern but the chemicals used as carriers (adjuvants like methylated oils and soaps that are not tested) that stick the chemical to the plants can also be harmful. Naturally occurring insects and fungi are being observed in Colorado that may weaken Canada thistle. Herbicides may be impacting these organisms that may offer the best hope for getting Canada thistle into some sort of equilibrium across landscapes.

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 (Colorado State University Extension 2016, Zouhar 2001a). 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 2013b).

As with other treatment methods, herbicides also stimulate growth of the underground root buds allowing for a potential for Canada thistle to spread even more than if it had not been treated. BMPs for natural area management of Canada thistle recommends herbicide use only in a spot spray technique. The protection of native vegetation is paramount to protecting the system. Band sprays have too much non-target damage and may lead to increases in disturbance and cover of Canada thistle or other weeds. In addition, the herbicides typically used for Canada thistle tend to shift the community to a grassland (often a non-native species).

<u>Mowing</u>

Mowing is not recommended without a site plan. Mowing is thought to have potential to control Canada thistle by stressing the underground parts by starving them of nutrients and reducing the spread of seeds. However, it must be done with some forethought because this activity has the potential for spreading the plant. The best time to cut is before the plants flower and set seed. The optimal time is thought to be the very early bud stage when food reserves are at their lowest point, and cutting must be repeated until the starch reserves in the roots are exhausted. Droughts are the best time to cut. When the primary stem of Canada thistle is removed, root buds are stimulated to produce new shoots that are otherwise suppressed (Zouhar 2001a). Cutting and mowing

stimulates significant underground growth from root buds that can cause Canada thistle to spread. It is thought that if you leave about eight inches of stem with 9 leaves/stem that may help keep buds from sprouting. However, that is not thought to work if the humidity is high and cut plants have the potential to produce twice the length and weight of new shoots in seven days (Zouhar 2001a).

Mowing may cause the population to expand and increase the footprint of Canada thistle and allow it to move in to areas that are not disturbed. In addition, the action of mowing plants does not change the disturbed status or the reason the plants are likely in the area. Many restoration activities do not result in a native landscape but rather a non-native grass dominated patch that is less biodiverse than the system that was being restored. Restoration activities may be helpful, but they require multiple years of monitoring and follow-up actions in order to support restoration of a dense stand of Canada thistle (pers. Comm. March 9, 2017, C. Strouse Restoration Botanist, City of Fort Collins).

Monitor and control satellite populations

The most effective way to begin controlling Canada thistle at Schriever is to determine if patches are actively expanding. In 2016, many of the areas with Canada thistle were mapped. Some of the patches were mowed and some were not subject to treatments. Monitoring these areas to determine if any of the mapped polygons are sprouting around the perimeter would be beneficial. Some of the recommendations include monitoring established populations and treating only for new satellite populations. For Canada thistle, sprouts need to be removed before the roots begin to dig deep into the ground. (However, sprouts that are coming up from underground roots versus from newly sprouting seeds, will not be easy to remove.) Within the first few weeks of sprouting the entire plant can be effectively removed by pulling. These are the areas that can be immediately replanted or depending on the surrounding vegetation allowed to fill in with native species. Preventing the spread is the goal of this type of treatment and it is not as costly and does not have the same potential to actually increase the spread of Canada thistle or other weed species. Monitoring would need to be carried out throughout the growing season. Monitoring does not require much equipment; a trained technician with a GPS can look for changes in size and for new sprouts that can be easily removed.

Active management, or changing management actions based on observed results, is a necessity for beneficial treatments; each situation needs to be evaluated often to see what is, and is not working in a local situation. A site assessment plan created before any action provides important baseline information that is essential for a successful treatment and allows for informed active management so adjustments can be made when it is observed that a potential treatment may be harming an area or may show a treatment that appears to be having the desired management goal.

Biocontrol

Biocontrol agents and vectors naturally present potentially offer the best long term management tool for Canada thistle. A number of biocontrol agents have been introduced over the last two decades. Ongoing monitoring for these organisms shows the agents are dispersed in areas of the state and appear to be effective (Michels et al. 2014). Natural disease vectors, insects and fungi may

potentially offer natural controls. Gall forming insects appear to have dramatically increased in Canada thistle populations at the U.S. Air Force Academy over a three year period (Smith and Greenwell 2017 IN PREP). A 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 present and helping to control Canada thistle. In addition, the rust is available for distribution in the State of Colorado (El Paso County 2014).

Summary of Recommendations

It should be noted when considering future treatments of Canada thistle that a study in Rocky Mountain National Park demonstrated that weed management practices including both chemical and mechanical treatments resulted in impacts to soils, soil biota and native plant species that were as damaging as the impacts from the Canada thistle (Pearson et al. 2016, Pritekel et al. 2006). This calls into question the use of treatments that damage soils in systems where the protection of native vegetation, wildlife and natural resources is important. Future monitoring will continue to shed light on the possibility that Canada thistle plants may decrease due to natural causes if the sites are not in a continual state of disturbance keeping the successional stage where weeds dominate. Money and time might be better spent on monitoring, removal of new sprouts and site plans that monitor expansion, than conducting treatments that could actually exacerbate the spread of Canada thistle in patches that may not be actively spreading.

1) The **protection of existing intact landscapes** should be the first priority by limiting disturbances where possible, especially in undisturbed habitats and near rare plant and plant communities.
2) Use Canada thistle weed mapping data from 2016 to begin to **monitor existing populations for expansion.**
3) **Monitoring new disturbances for Canada thistle sprouts that can be effectively removed should be a top priority**. This monitoring should be conducted several times throughout the growing season, targeting new disturbances and perimeters of established populations. (Seedlings will be easy to remove but not root sprouts.)
4) **Create a SITE PLAN before a treatment** is conducted, **or for sites where treatments have already been initiated** at Schriever AFB. (Assessment Worksheet for Weed Management Site Plan is included in Appendix B.)
5) The **control of newly established satellite populations** (those near existing populations) before they become established is likely going to be the most efficient and cost-effective approach at Schriever to attempt to control Canada thistle.
6) **Monitor post-treatment** to determine success of any treatment and whether or not to continue. This is key because all treatments have the potential to stimulate the growth of Canada thistle and results may vary from site to site.
7) The size of the **treatment area should be small and workable** – site plan.
8) The **potential impacts of treatment should be ascertained** ahead of time – site plan.
9) It may be prudent **not to treat** if a site plan is not feasible and there is no way to support a monitoring plan for a population. This can be justified based on published treatment data.
10) Consider **establishing photo monitoring plots** that can be used to compare sites from year to year. These are cheaper and easier to set up than quantitative plots and still yield valuable information. If funding and staff are available setting up quantitative plots is also beneficial.

11) **Herbicides** should be used only with a site plan in place and **are not recommended**, especially if spot application is not used in delineated Natural Areas and Sensitive Natural areas at Schriever AFB.

A Canada thistle fact sheet can downloaded at http://extension.colostate.edu/topic-areas/natural-resources/canada-thistle-3-108/

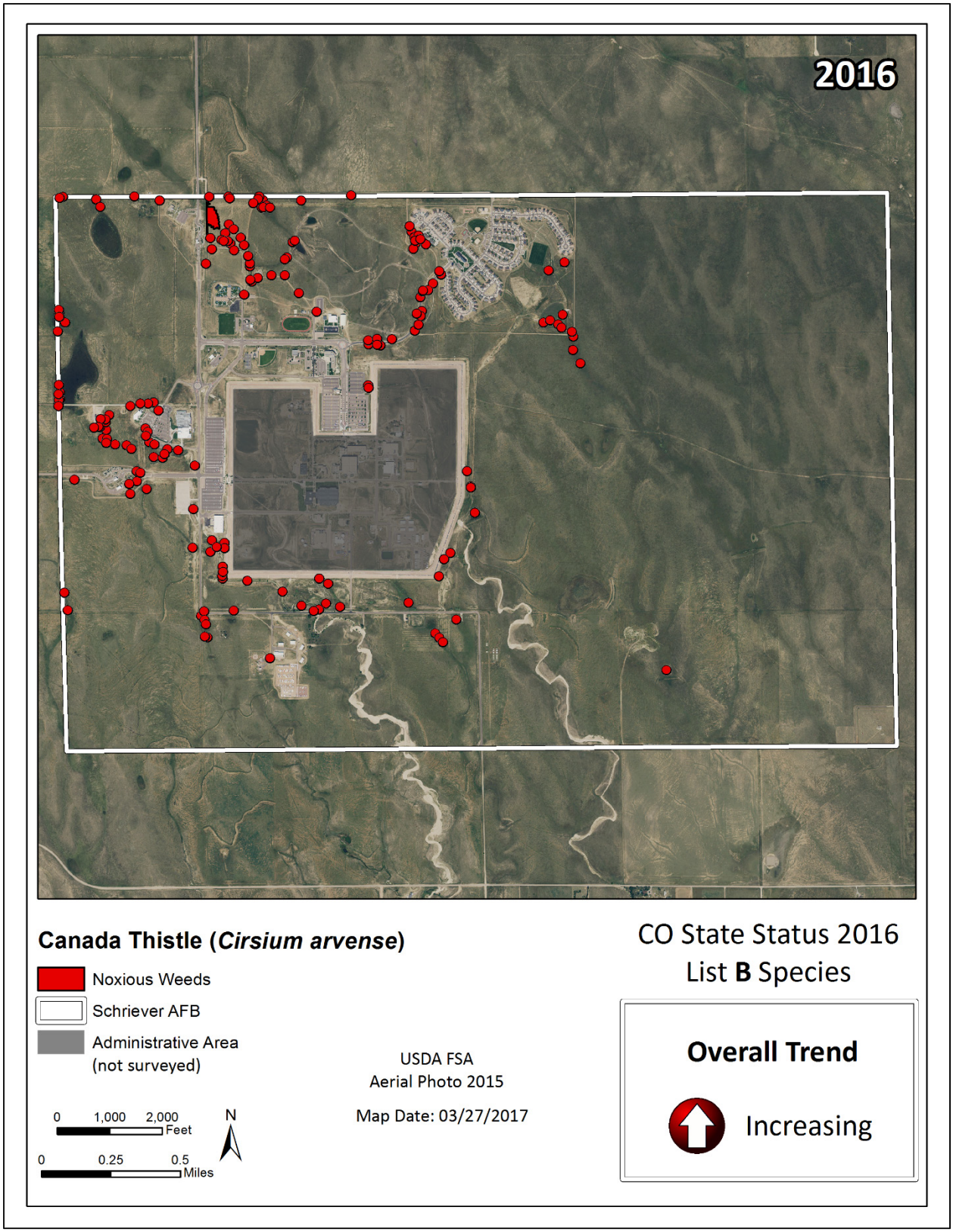


Figure 8. Distribution of Canada thistle mapped at Schriever AFB in 2016.

Bull thistle (*Cirsium vulgare*)

Not Present: Only native thistles located in former bull thistle site.

State List B

- Biennial forb
- Reproduction ONLY BY SEED
- No rhizomes
- Seed longevity: 3 years
- Transitory species

Photo: Bull thistle in flower http://www.kingcounty.gov/environment/animalsAndPlants/noxious-weeds/weed-identification/bull-thistle.aspx

Mapping Results

Bull thistle was not found during the 2016 survey at a site reported by North Wind in 2012 (Table 6, Figure 9). The actions taken to remove bull thistle appear to have been successful. Therefore, the threat level is considered very low at this time. At the site reported for bull thistle by North Wind (2012), we identified wavy leaf thistle (*Cirsium undulatum*), a common native prairie species at Schriever AFB.

Table 6. Results of the noxious weed survey conducted at Schriever AFB in 2016 for bull thistle.

	2004 North Wind	2012 North Wind	2016 CNHP
Occupied Acres	--	--	0
Estimated Number of Shoots	--	1	0
Number of Mapped Features	--	1	0

Plant Biology

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). Native thistles were seen at the old bull thistle site. Thistles can be difficult to distinguish from one another, correct identification is important especially when native species grow near occurrences of weeds.

Native Yellowspine thistle (*Cirsium ochrocentrum*) Patrick J. Alexander, hosted by USDA-NRCS PLANTS Database

Photo: Native wavy leaf thistle (*Cirsium undulatum*) JW Stockert - Public Domain, https://commons.wikimedia.orgwindex.phpcurid=4024218

Management Recommendations

Since bull thistle is an annual or biennial species, it has likely been removed by rapid response actions. The seed longevity is relatively short and this species may not return. However, follow-up visits to the site to survey for new occurrences is highly recommended.

Continue follow-up monitoring at the known bull thistle site for at least 3-5 more years. Seeds can live up to 3 years (King County 2015, Zohar 2002) and longer if buried in deep soil.

1) Staff should be trained to recognize and distinguish bull thistle rosettes from native thistles that could be found at Schriever AFB (see photos below).
2) If bull thistle plants are found, 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 because the plant is an annual or biennial. Seed longevity is short, with 95% sprouting in the first year.

A bull thistle fact sheet is located at http://www.cwma.org/BullThistle.html

Rosettes of bull thistle (Top photo: NPS.gov; Bottom photo University of Missouri.)

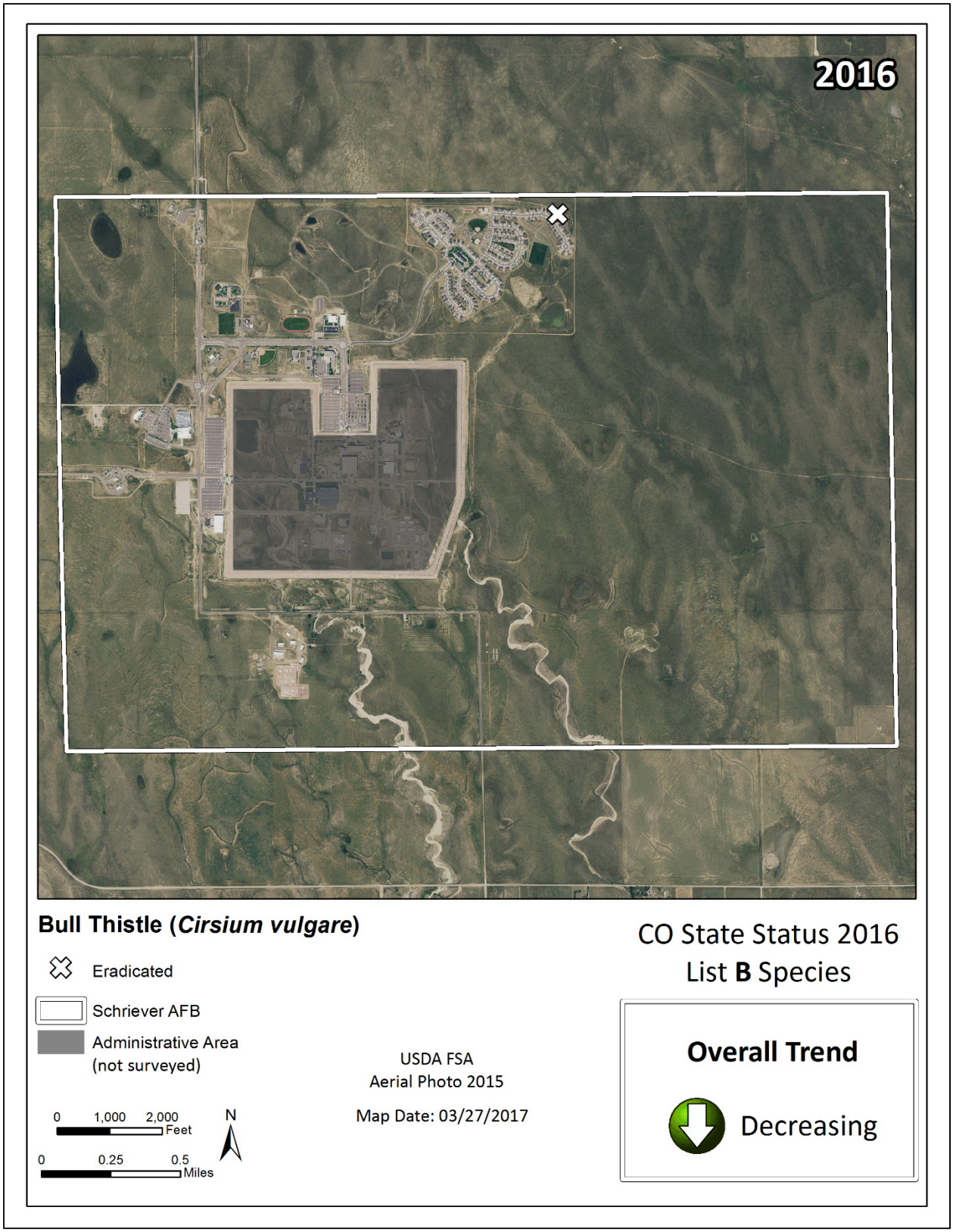


Figure 9. Distribution of bull thistle mapped at Schriever AFB in 2016.

Field Bindweed (*Convolvulus arvensis*)

?

Unknown: Most 2012 sites are still extant and only a few new locations were mapped in 2016.

State List C

Field bindweed in flower.

https://en.wikipedia.org/wiki/Convolvulus_arvensis

- Perennial vine arising from deep, persistent spreading roots (tap root and spreading roots to 10 + feet deep)
- Reproduction by seed and vegetatively by root buds
- Seeds viable for 20 - 50 years
- Flowers last one day, insect pollinated (bees, moths)
- Seed dispersal not far from plant unless carried by water or animals including in digestive tracts
- Contaminant in seed mixes
- Dry to moderately moist disturbed soils
- Early successional species that establishes on bare ground in open conditions

Mapping Results

Field bindweed (*Convolvulus arvensis*) was not comprehensively mapped at Schriever AFB in 2016 due to its widespread abundance. Known populations were spot-checked for bindweed and found to be extant so it is assumed that bindweed occurrences mapped by North Wind in 2012 are still present. New locations in previously uninfested areas were mapped and combined with 2012 locations to represent our best estimate of field bindweed distribution at Schriever AFB (Table 7, Figure 10). The number of individuals was not documented.

Table 7. Results of the noxious weed survey conducted at Schriever AFB in 2016 for field bindweed.

	2004 North Wind	2012 North Wind	2016 CNHP*
Occupied Acres	19	22.52	13.4
Estimated Number of Shoots	--	--	--
Number of Mapped Features	--	--	79

*Too widespread to comprehensively map in 2016. Historic sites were spot checked and found to be extant. Only new locations not previously documented were mapped in 2016.

Plant Biology

Field bindweed will invade bare ground and often areas that are highly disturbed (Photo 4). It is an early successional species that has the potential to decrease on its own over time. It is very difficult to treat once it becomes established because it forms deep root systems that includes both a tap root and lateral roots. It can reproduce by seed as well as by root buds. The eradication of an established population of field bindweed is considered a rare event and control efforts do not offer consistent results. Interestingly, populations of mule deer have been documented eating field bindweed (Zouhar 2004).

Management Recommendations

Field bindweed is a list C noxious weed in Colorado and treatment may not be required.

1) Because field bindweed is always associated with disturbances, prevention is considered the most efficient and effective method to prevent spread. Avoid management activities that encourage invasion and be prepared to eradicate small infestations that may follow such disturbances.
2) For established populations a site plan should be prepared (sample site assessment worksheet is provided in Appendix B) to determine the necessity of treatment and the goals.
3) Continued monitoring may be the best activity at this time as natural sources may be depleting the underground reserves.

A field bindweed fact sheet can be downloaded at
https://www.colorado.gov/pacific/agconservation/field-bindweed

Photo 4. Field bindweed population along a roadside at Schriever AFB in 2016.

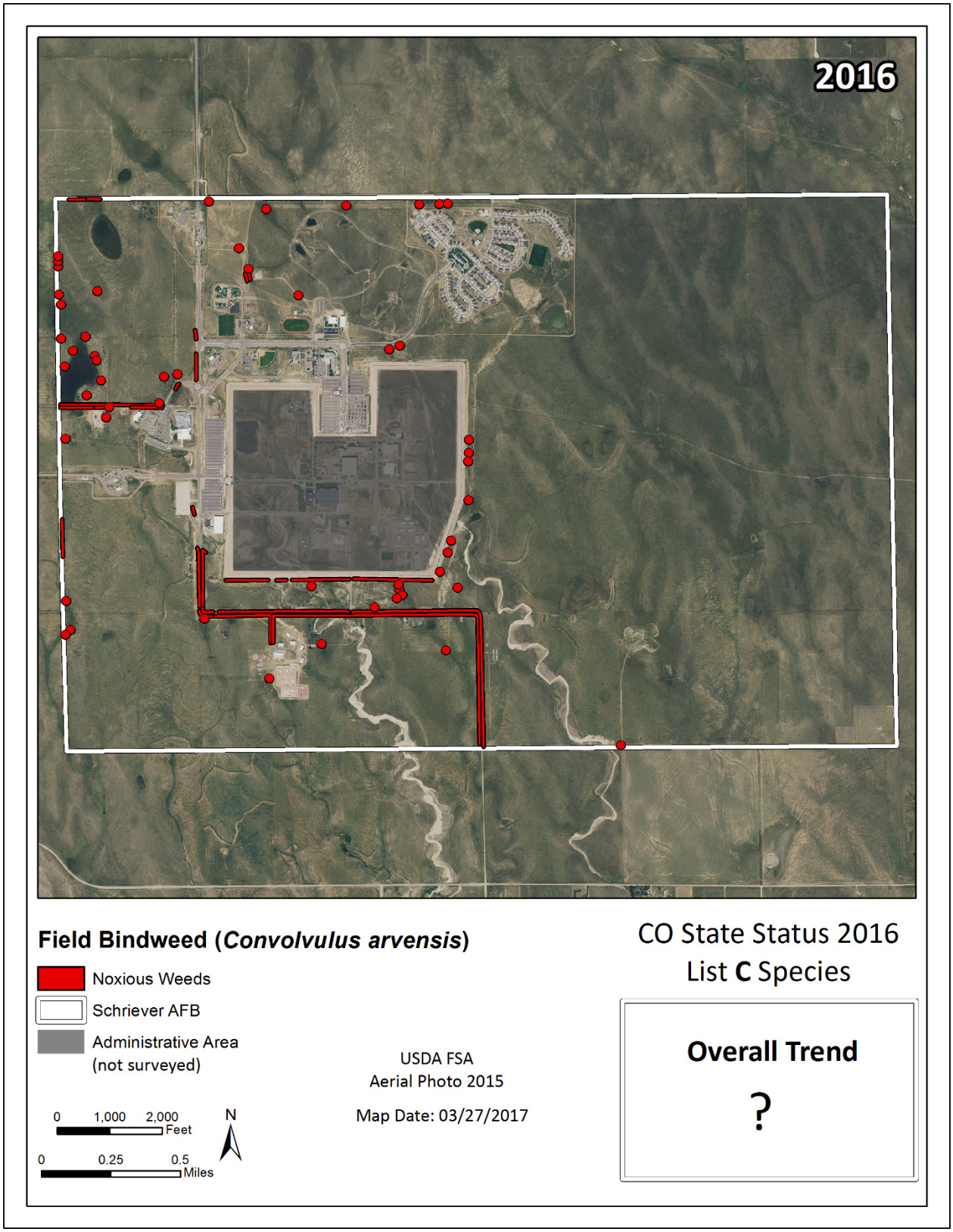


Figure 10. Distribution of field bindweed mapped at Schriever AFB in 2016.

Diffuse and Spotted Knapweeds (*Centaurea diffusa*, *C. stoebe* and hybrids)

Increasing/Stable: Increase 2004-2012, stable cover, increase # sites 2012-2016.

State List B

Left photo: Diffuse Knapweed, Michelle Washebek, right photo: Spotted Knapweed (*Centaurea (stoebe) maculosa*) Wiki Commons 2015.

- Short-lived non-creeping perennial, biennial, occasionally annual that spreads only by seeds
- Seeds germinate in the spring or fall and anytime during the growing season with disturbance
- Environmental disturbance promotes invasion; Photo 5
- Seed longevity: 8-10 years (CCR 2014) – wind dispersed
- Provides nectar and pollen for honeybees
- Presence of knapweed is an indicator of disturbance
- Highly competitive, rapid growth rate, long growing season and prolific seed production
- Allelopathy is disputed as soil residuals too low to cause mortality of plants
- Plant has tumbleweed mobility
- It forms rosettes in its early growth stage (1-2 years)
- Diffuse knapweed can sprout from the root crown after top-kill (Zouhar 2001b)

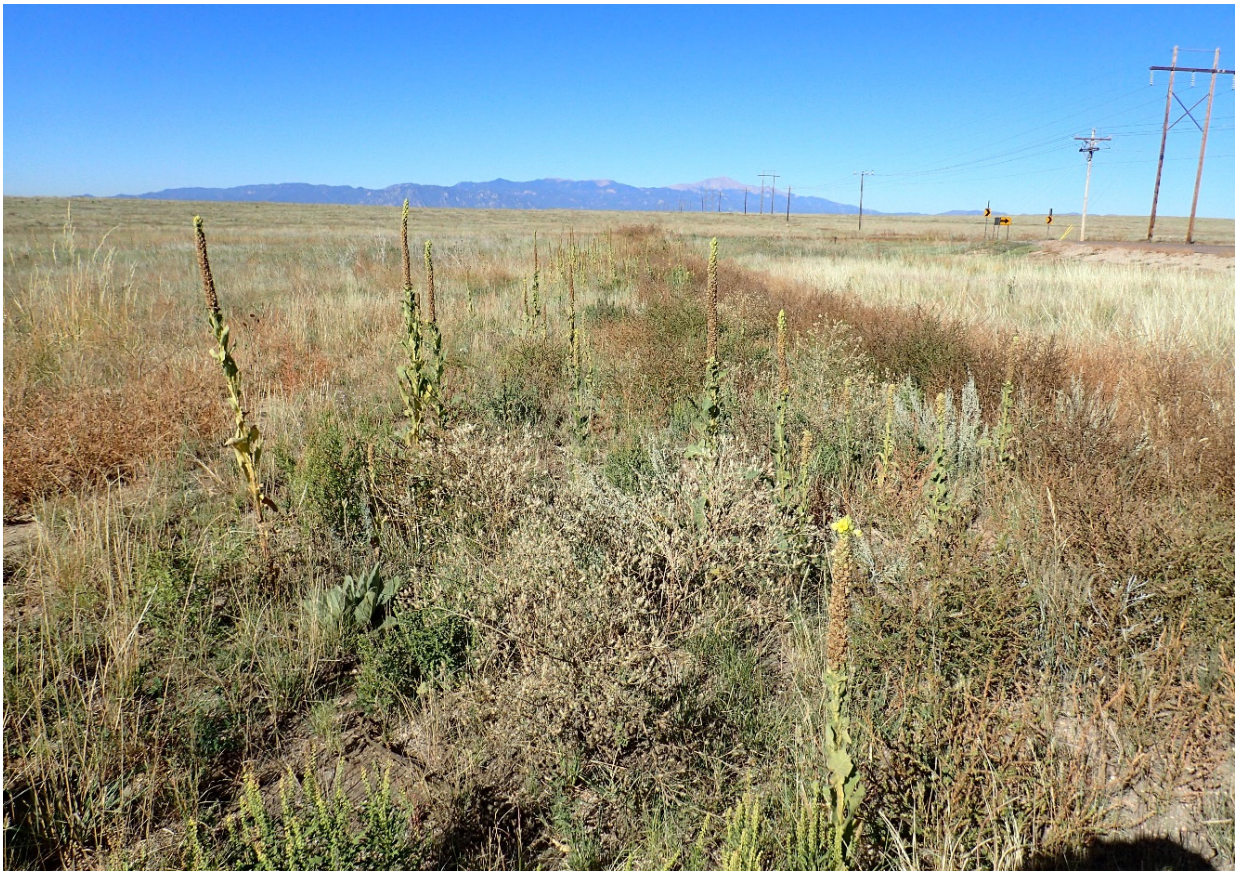


Photo 5. Diffuse knapweed located in disturbed area at Schriever AFB with common mullein a List C noxious weed. Note intact grasslands in the background and evident disturbance of soils (mounds) with weeds.

Mapping Results

There were 46 mapped locations for knapweeds in 2016 (Figure 11) ranging in size from 1-2,500 individuals (Table 8). The total coverage of the mapped knapweed occurrences was 6.3 acres in 2016. In 2004, the knapweeds were mapped with less than two acres of coverage; in 2012, knapweeds were mapped with greater than 5.75 acres of coverage at Schriever AFB (North Wind 2005, 2012). Based on the similar acreage of mapped area between 2012 and 2016, the population may be stabilizing. However, the number of sites may have increased as the locations are more widespread than in 2012. The current threat level for knapweeds is somewhat stable to potentially increasing. In addition, some of the knapweed areas were mowed before the field surveys and there is potential to have missed areas because the plants aren't as visible.

Table 8. Results of the noxious weed survey conducted at Schriever AFB in 2016 for all knapweeds.

	2004 North Wind	2012 North Wind	2016 CNHP
Occupied Acres	< 2	< 5.75	6.3
Estimated Number of Shoots	--	--	6,340
Number of Mapped Features	--	--	46

The knapweeds are considered together for this survey because spotted and diffuse knapweeds are hybridizing at Schriever and at many areas in Colorado (Rondeau and Lavender 2013). The plants at Schriever AFB were reported to consist largely of diffuse knapweed and the hybrid with almost no spotted knapweed. The survey for knapweeds was initiated in mid-August at which point the majority of the plants had been subjected to mowing and the flowering tops were removed. This made mapping less accurate because the plants were harder to see. First year rosettes were observed in some of the mowed areas. In September, the mowed sites were beginning to grow back. The knapweeds tended to be associated with fences; likely due to the dried flowering tops that break off and become caught in fences.

Plant Biology

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 (CCR 2014). Long-term studies have shown treatments for spotted knapweed (*Centaurea maculosa* = C. *stoebe*) have actually encouraged future knapweed invasions as they mimic the same suppression effects the weeds have on native forbs (Pearson and Ortega 2009).

Mowing and Mechanical Removal

Mowing may help remove the seed sources and weaken reserves stored in the roots. It is important that this is carried out before the plants flower and go to seed. Because this activity may cause weed infestations to spread it is important that treatments start small and are evaluated for success before it is used across the base. Digging has been shown to be effective if the taproot is severed below ground while the plants are in the rosette stage (CCR 2014). The severing needs to be several inches below ground to be lethal (Zouhar 2001b). To be most effective, treatments must not affect nearby native species or cause soil disturbances. Digging would only work for small infestations.

Chemical

Herbicides can cause soil disturbance by increasing bare ground, changing the pH and the balance of soil organisms, and impacting nearby native forbs and woody species. 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 (Photo 6), to maximize effectiveness. Treatments should be conducted with great care as some types of treatments including herbicides appear to have increased populations of knapweeds, reduced woody plant cover and increased cover of smooth brome, a non-native rhizomatous grass (Rondeau and Lavender 2013). Consideration of the previous disturbances and on-going disturbances are important as any treatment may not be effective if the soil is disturbed.

Photo 6. Diffuse knapweed rosette (University of Oregon).

Biocontrol

Biocontrol agents include the lesser knapweed flower weevil (*Larinus minutus*) and gall flies (*Urophora* sp.) which are introduced and have shown success in Colorado (Cranshaw 2009).

Management Recommendations

As with most weeds, lasting control of knapweeds is achieved through proper land management to maintain desired vegetation. Since it is important to define the land use objective before going ahead with management plans, a site plan is recommended. It is also important to keep in mind that control is thought to be most effective during the first season of growth and that a plan to prevent seed production can contain existing infestations (Zouhar 2001b).

1) The **protection of existing intact landscapes** should be the first priority by limiting disturbances where possible, especially in undisturbed habitats and near rare plant and plant communities.
2) Use knapweed mapping data from 2016 to begin to **monitor existing populations** for expansion.
3) **Monitoring new disturbances** for sprouts is worthwhile as this is when they can be effectively removed and should be a top priority. This monitoring should be conducted several times throughout the growing season and target new disturbances on the base.
4) Create a **site plan** before a treatment is conducted, or for sites where treatments have already been initiated at Schriever AFB. (Assessment Worksheet for Weed Management Site Plan is included in Appendix B.)
5) The **control of newly established satellite populations** (those near existing populations) before they become established will likely be the most efficient and cost-effective approach at Schriever to attempt to control knapweeds.
6) **Monitor post-treatment** to determine success of any treatment and whether or not to continue. This is key because of the likelihood of high levels of knapweed seeds in the seed bank.
7) The **size of any treatment area should be small** and workable – site plan.
8) The **potential impacts of treatment should be ascertained** ahead of time – site plan.

9) It may be prudent **not to treat if a site plan is not feasible** and there is no way to support a monitoring plan for a population. This can be justified based on published treatment data.
10) Consider **establishing photo monitoring** plots that can be used to compare sites from year to year. These are cheaper and easier to set up than quantitative plots and still yield valuable information.
11) **Herbicides** should be used only with a plan in place and **are not recommended**, especially if spot application is not used.
12) Mowing may help reduce the seed bank and weaken the underground parts. Do not mow once the plants have flowered. This will effectively disperse and replant the seeds. The action of mowing with a tractor mower may contribute to disturbing the area and allow more area to contain weeds. This action should be carefully considered in the site plan.
13) Replanting with native species was not successful in many instances (Zouhar 2001b). This may be the result of existing disturbance conditions that favor non-native species and/or herbicide residual in the soil. Site specific seed sources may need to be prescribed.

A knapweed fact sheet can be downloaded at http://extension.colostate.edu/topic-areas/natural-resources/diffuse-and-spotted-knapweed-3-110/

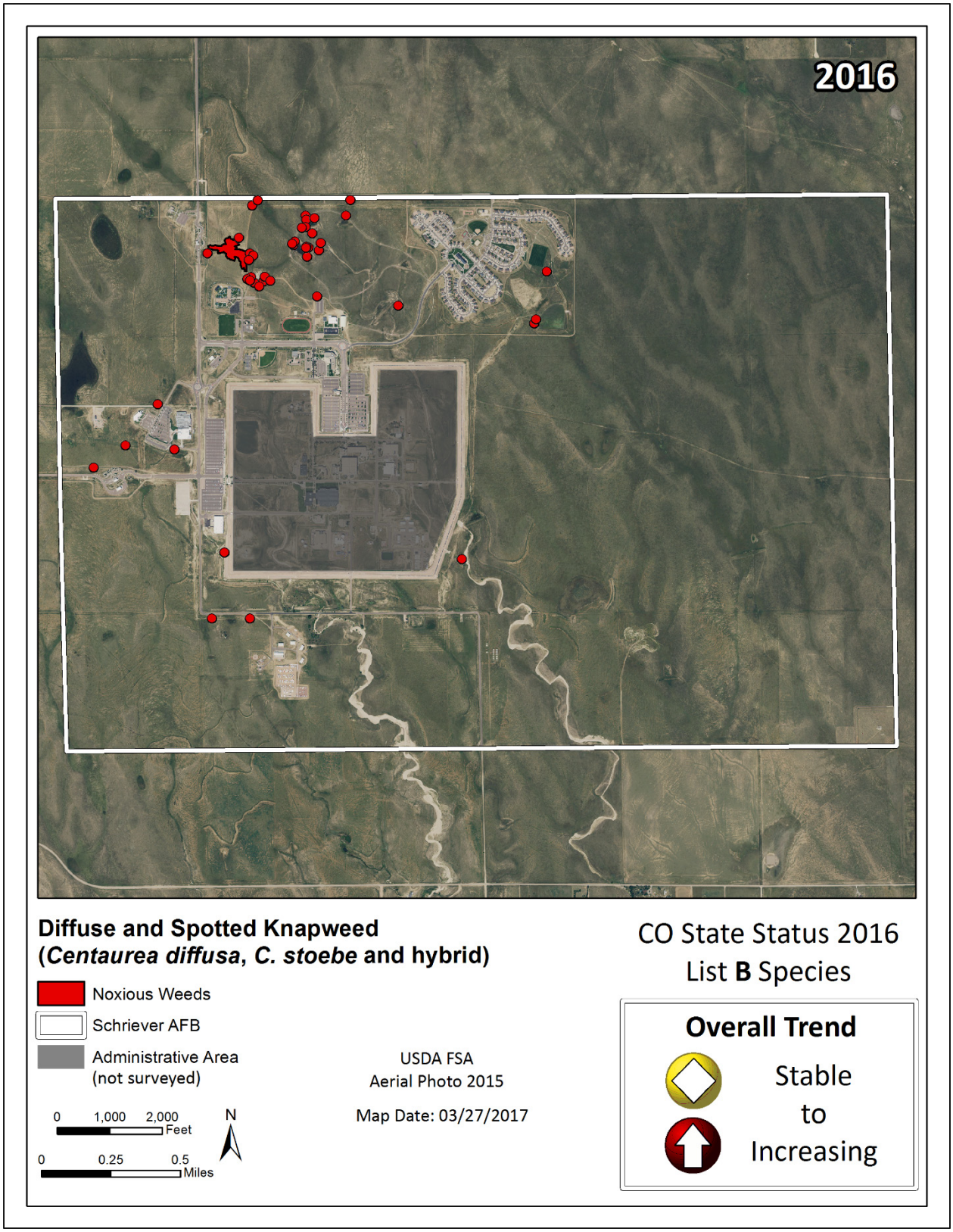


Figure 11. Distribution of knapweeds mapped at Schriever AFB in 2016.

Russian olive (*Elaeagnus angustifolia*)

Increasing: Increase in drainages near roads.

State List B

Photo (left) Russian olive branch, Wikipedia Commons, (right) Mature Russian Olive at Schriever AFB 2016.

- Planted as an ornamental at Schriever AFB
- Nitrogen-fixing capabilities
- It may or may not rapidly spread depending on site characteristics
- Injured trees sprout
- Seeds are largely dispersed by mammals
- Can enhance wildlife in disturbed areas where native species have been removed
- Difficult to control once it is established

Mapping Results

Russian olive was planted as an ornamental tree in developed areas at Schriever AFB and was noted as present in 2004 (North Wind 2012). In 2012, there were 22 mapped locations (North Wind 2012). All sites were located on the south side of the installation. In 2012, the population was considered stable and under control. There were 29 locations mapped in 2016 covering 0.52 acres (Table 9, Figure 12). The trees were located on the south and southwest side of the installation. The numbers at each occurrence ranged from one to eight individuals and included a range in sizes from under two meters to about 10 meters. The new locations for Russian olive

reported in 2016 on the west side of the installation boundary, which included small saplings, may indicate Russian olive is expanding on its own at the base. It did not appear that the small trees on the west side of the installation were intentionally planted.

Table 9. Results of the noxious weed survey conducted at Schriever AFB in 2016 for Russian olive.

	2004 North Wind	2012 North Wind	2016 CNHP
Occupied Acres	(Present)	0.31	0.52
Estimated Number of Shoots	--	--	70
Number of Mapped Features	--	22	29

Plant Biology

Russian olive is a fast-growing, small tree that reproduces by roots and seeds. This species tends to be most invasive in riparian areas impacted by human disturbances. The impact this species may pose to wildlife is site specific and debated and thought to be beneficial in degraded natural settings. The plant will sprout if it is injured. Some types of treatment will mimic injury and it can spread. It is considered to be difficult to control especially in areas where seeds can spread to nearby disturbed natural areas. Seeds are carried by birds and other wildlife. Runoff from precipitation can also transport seeds.

Biological Control

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.

Management Recommendations

There is very limited published research addressing effective techniques to control or remove Russian olive from invaded sites. Awareness and prevention are considered to be the most effective tools. Site plans will be essential to determine which areas need action. Because this species will react to treatments, a plan may be crucial for success.

1) Do not plant Russian olive anywhere on the base, even in residential areas.
2) Create a site plan for all known locations of Russian olive on the base. (Mature trees in developed areas may just need to be monitored for sprouts.)
3) Russian olive trees sprout when they are injured, thus, it is recommended that cutting the stump or girdling methods should be used along with an herbicide treatment. However, herbicides that are recommended by the Colorado Department of Agriculture are only for range and pasture lands, and not natural areas. Cutting is most effective in the fall; and it is important to remove foliage with viable seeds (Carpenter and Perce 2004).
4) Nearby drainages should be targeted to survey for small and sprouting Russian olive plants.
5) Young trees on the west side of the base should be prioritized to be evaluated for treatment.

A Russian olive fact sheet can be downloaded at
https://www.colorado.gov/pacific/agconservation/russian-olive

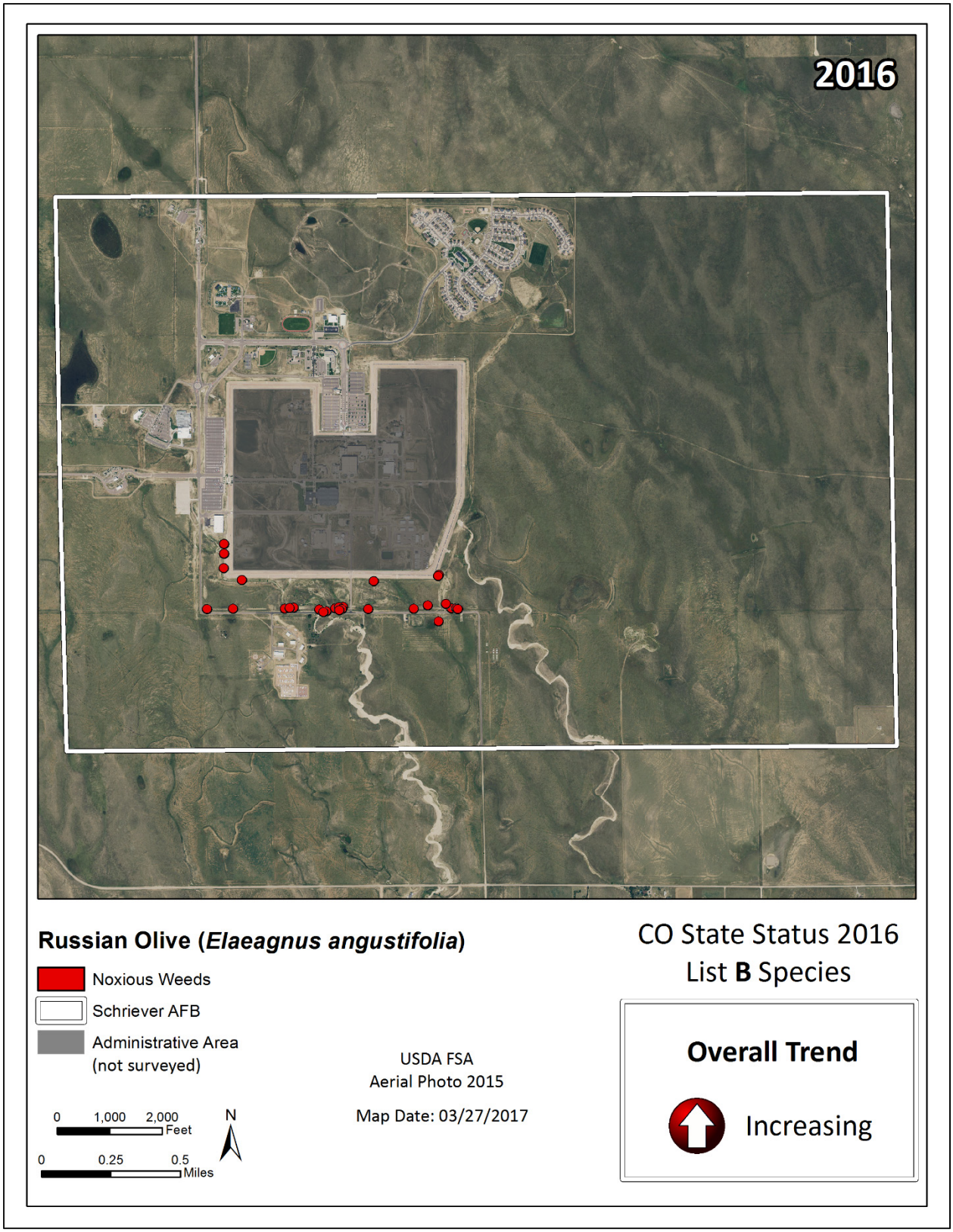


Figure 12. Distribution of Russian olive mapped at Schriever AFB in 2016.

Salt cedar (*Tamarix ramosissima*)

Stable: One mature plant found in 2016.

State List B

- Reproduction by roots, submerged stems and seeds
- Seed longevity <1 year
- Impact to wildlife is debated
- Treatments may cause plants to sprout from the crown

Photos: Salt cedar (tamarisk) at Schriever AFB, CNHP (left), Salt cedar flowers from Calphotos.berkely.edu (right)

Mapping Results

Salt cedar was not reported by North Wind in previous surveys at Schriever AFB in 2004 and 2012. A single individual was noted in the 2016 survey; it is a medium sized shrub that has likely been in that location for a number of years (Table 10, Figure 13), and likely at Schriever AFB in 2012.

Plant Biology

Salt cedar has one of the shortest seed longevities compared to many plant species of less than one year. However, treating salt cedar once it has become established is difficult because it will sprout if it is injured and growth can be stimulated in the roots and underground portions of the stem in addition to seeds.

Table 10. Results of the noxious weed survey conducted at Schriever AFB in 2016 for salt cedar.

	2004 North Wind	2012 North Wind	2016 CNHP*
Occupied Acres	--	--	< 0.01 (12.6 m^2)
Estimated Number of Shoots	--	--	1
Number of Mapped Features	--	--	1

Biocontrol

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

Management Recommendations

Even though there was only a single plant documented, a site plan is still highly recommended because of the location and the tenacity of this species. If no action is taken on the plant itself, at a minimum, frequent monitoring should occur for sprouts in the vicinity of the plant. Monitoring for sprouts should start as soon as possible. However, if treatment is to be conducted, a plan should be created with a schedule of monitoring and should include potential types of actions that will be taken along with a description of the current conditions at the site. If it is determined in the site plan that the tree should be removed, the following protocol using both mechanical and chemical methods at the same time is recommended. However, please note that if actions are initiated and not carried out as described (i.e. applying the herbicide in the fall and within a minute of cutting the tree) there is a high potential the shrub will sprout.

The herbicides triclopyr or imazapyr can be very effective when used to treat cut stumps. 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, and applying herbicide **within one minute of cutting**, to the perimeter of the cut stems. This needs to occur because the trunk will begin healing quickly which can impede translocation of the chemicals. Follow-up monitoring must occur for resprouts in the 4 to 12 months following initial treatment. If herbicides cannot be used right away as described, cutting the tree is not recommended.

Summary of Recommendations

Cutting the stem in the fall and applying herbicide treatment immediately can be effective.

1) Create a site plan to evaluate a need for action.
2) Monitoring the site and nearby drainages for young sprouts should be done yearly.

A salt cedar fact sheet can be downloaded at
https://www.colorado.gov/pacific/agconservation/salt-cedar-tamarisk

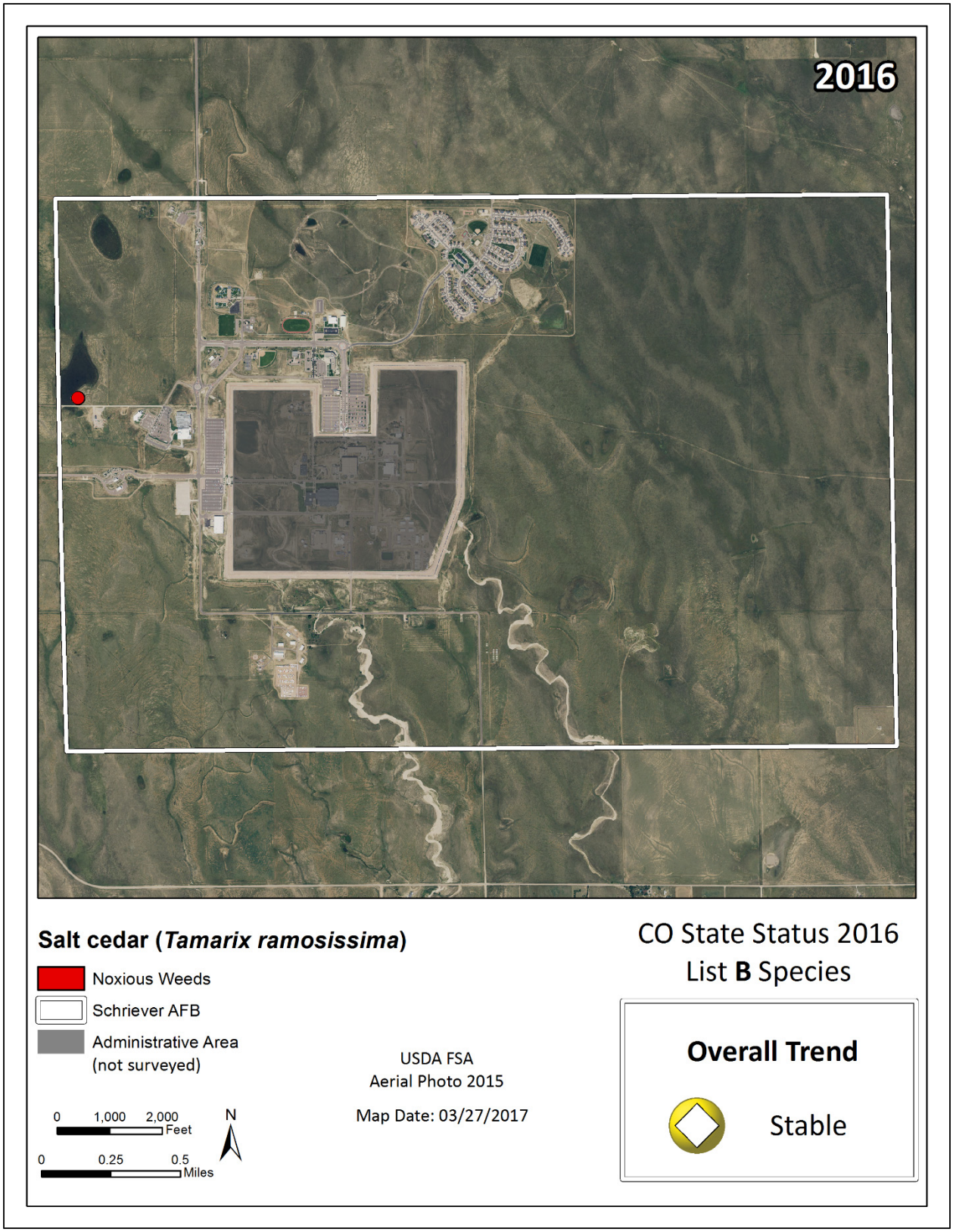


Figure 13. Distribution of salt cedar mapped at Schriever AFB in 2016.

Puncturevine (*Tribulus terrestris*)

Increasing: One location with 60 individuals.

State List C

Photos: Leaves of puncturevine with spiny "goathead" shaped fruits P. Smith (left and bottom right), fruits and flowers from invasives.org (top center and top right)

- Low growing mat-forming summer annual
- Seeds are contained within a very spiny fruit that can stick to animals, tires, etc.
- Reproduction is only by seed
- Seeds viable for 4-5 years (Douglas County NV) http://www.douglascountynv.gov/466/Puncturevine-Goathead
- Can be easily removed by digging and removing seeds

Mapping Results

Puncturevine was found in only one location at Schriever AFB in 2016. The plants were found at a half acre site where the area had been scraped to mineral soil near the north end of Hahn Avenue (Table 11, Figure 14). It was reported in 2004 near "buildings south of the cantonment fence and west of the fitness course" and puncturevine was not found in 2012 (North Wind 2012). The Noxious Weed List for Colorado currently recognizes this plant as a List C noxious weed. The threat level is considered low for Schriever AFB because there is only one location in a developed area. The population is small and puncturevine is considered relatively easy to control.

Table 11. Results of the noxious weed survey conducted at Schriever AFB in 2016.

	2004 North Wind	2012 North Wind	2016 CNHP
Occupied Acres	(Present)	0	0.45
Estimated Number of Shoots	--	--	60
Number of Mapped Features	--	--	1

Plant Biology

Puncturevine is a summer annual that grows close to the ground and produces bright yellow flowers and distinctive leaves that are easy to recognize. Since it is an annual it has a shallow root system that is easy to remove completely and is considered relatively easy to control. Reproduction is only from seeds which are contained within a spiny fruit that sticks to machinery, animal fur, and tires. The seed longevity is thought to be around five years. It is typically only found in disturbed areas.

Management Recommendations

Mechanical removal is recommended because the root system is shallow and this method is effective. The invaded site at Schriever AFB is at a single contained area making complete removal practical. Treatments should occur before the plants flower and produce seeds. The seeds are inside spiny fruits and seed removal is by far the most important aspect of treatment as the vegetative part dies in one growing season. After plants are pulled, finding and removing the dropped fruits (patting the ground with a piece of carpet works well) is important for successful control (UC Davis IPM website: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74128.html). As with any soil disturbance, a follow-up planting is advised or more weeds will likely replace the puncturevine. Post-treatment follow-up monitoring to see if plants are returning should be continued for at least five years based on seed longevity. Dispose of the seeds carefully to prevent growth in another area.

A puncturevine fact sheet can be downloaded at
https://www.colorado.gov/pacific/agconservation/puncturevine

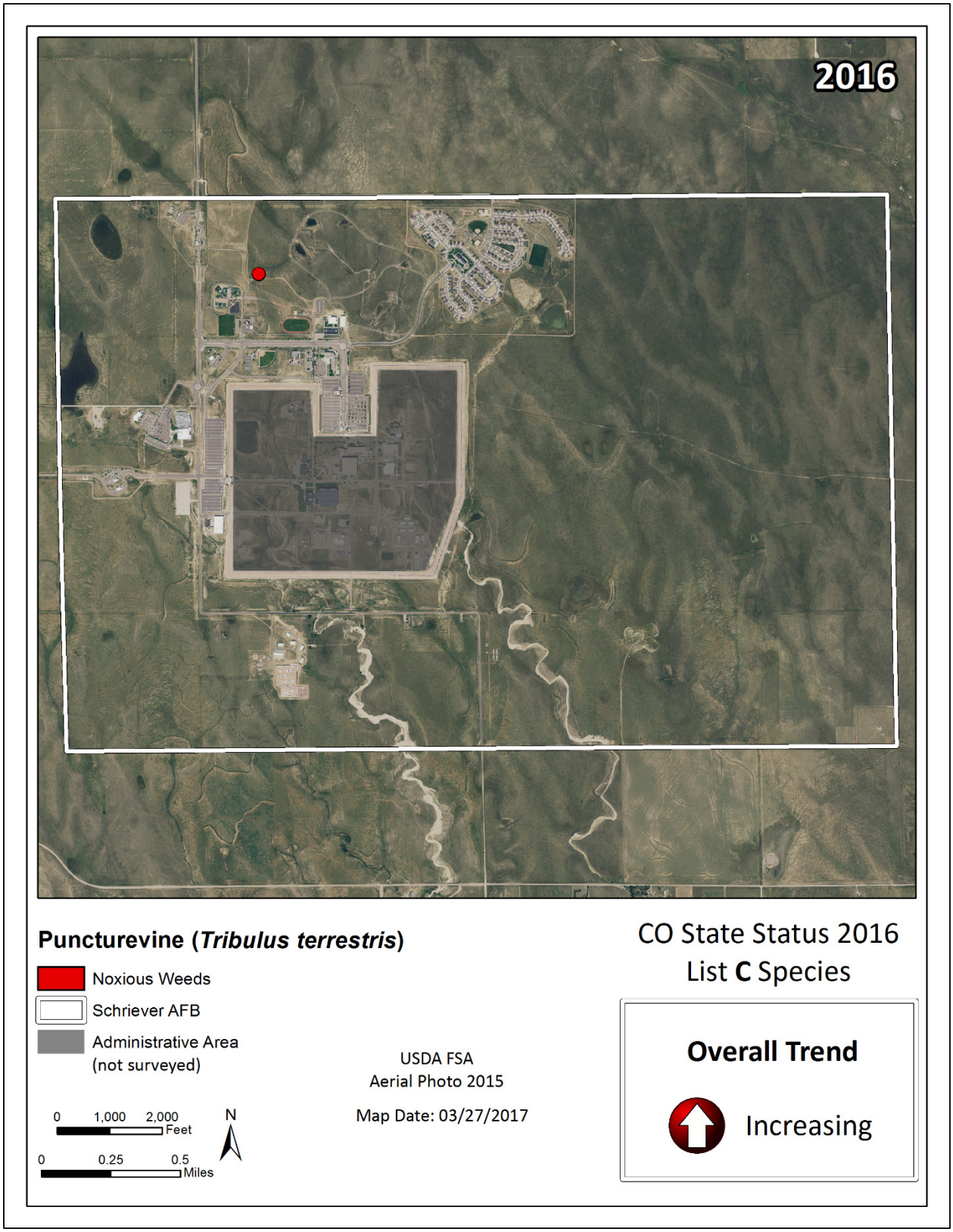


Figure 14. Distribution of puncturevine mapped at Schriever AFB in 2016.

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Appendix A. Mapping Protocol

All weed infestations were mapped in the field using ArcPad, a portable version of GIS software developed by the Environmental Systems Research Institute (ESRI) that allows the field technician to create and edit spatial data remotely using a tablet computer. ArcPad was installed on a Trimble Yuma rugged tablet with a Windows 7 operating system and a built-in GPS receiver module. According to Trimble specifications the GPS is generally accurate to within 2-5m using SBAS (Satellite-Based Augmentation System). To ensure data accuracy during the collection process, SBAS was activated and warning systems were enabled in ArcPad to notify the user when the PDOP (Positional Dilution of Precision) exceeded 6 and the EPE (Estimated Probable Error) exceeded 8. Twenty points were averaged at each location, and 10 vertices were averaged for lines and polygons.

Weeds were mapped as points, lines or polygons, depending on the size and configuration of the occurrence. Linear features were mapped as lines and assigned a buffer width to estimate area. Irregularly shaped features greater than approximately 30 meters in either direction were mapped as polygons. All other features were mapped as points and assigned a radius. Raw data points and lines were buffered and combined with polygons to produce a final weed map depicting our best estimate of the area covered by targeted weeds.

Since weeds are mobile from year to year, and the GPS has inherent inaccuracies, infestations within 5 meters of each other were mapped as one feature. If previously mapped infestations were not located, they were marked as eradicated, as opposed to deleted, in order to keep track of the soil seed bank and ensure future visits to historically infested areas. All features were collected using the GPS unless otherwise noted in the attribute table. Features that were inaccessible due to natural barriers or exclosures were digitized “heads-up” using the 2015 NAIP digital orthophoto quad for reference.

Attributes were collected using customized field forms, designed to minimize user error by maximizing domain tables and field auto-population techniques. One free text field was maintained to document any observations deemed important, such as nearby significant species or difficulties incurred in a specific area (e.g., dense oak thickets affecting the ability to map features or estimate individuals). The field technician had the option to document number of individuals or density as number of individuals per square meter. If density was noted, the number of individuals was calculated in the office based on the assigned density and the size of the infestation.

Weed data are stored in a file geodatabase in ArcGIS, a robust GIS software platform also developed by ESRI. The following attributes were captured:

COLLECTDAT – Collection date

PLANSCODE – USDA plants code

SPECIES – Scientific name

COMMONNAME - Common name

NUMINDIV – Number of individuals

DENSITY – Density per square meter

BUFFDIST - Radius for point features; buffer width for line features; not applicable to polygon features

COVERCLASS – 0-1%, Trace; 1-5%, Low; 5-25%, Moderate; 25-75%, High; 75-100%, Very High

PATTERN – Continuous, Patchy, NA (for eradicated infestations)

COMMENT – Free text field

DATUM – Datum

FEATTYPE – Point, line or polygon

USOWNER – Federal land ownership

LOCALOWNER – Local land ownership

US_STATE – U.S. state

COUNTRY - Country

EXAMINER –Field observer

MAPAGENCY – Mapping agency

STATUS – Extant, Eradicated, Dead Standing, Sprouting, Other

Appendix B. Assessment Worksheet for Weed Management Site Plan

Site ID:_____

Weed Management Site Plan Worksheet

1. Site location:_____

2. Size of area with target species:_____

3. Target species of concern at site:_____

   a. Describe the biological characteristics that will be important for management:
      □ Annual with a shallow root system (puncturevine)
      □ Biennial species that dies after it flowers (musk thistle, knapweeds, bull thistle)
      □ Perennial broad-leaved plant with deep root system (Canada thistle, field bindweed)
      □ Woody plant (salt cedar, Russian olive)
      □ Other _____

   b. Seed longevity:_____(how long to monitor site)

   c. Length of time species of concern has been present at site: _____

   d. % cover of target species at site: _____

   e. % cover native species: _____

   Describe other species present: _____

   _____

   _____

4. Site Description (include wildlife use):
   _____
   _____
   _____

   a. How is the target species distributed?
      a. □ solid stand
      b. □ patchy
      c. □ linear
      d. □ in a depression
      e. □ other_____

   b. Is the area a wetland? (herbicides should be wetland approved)
      a. □ wet or moist soil year round
      b. □ periodically flooded
      c. □ upland inclusions
      d. □ wetland adjacent or part of site

   c. Has the site been previously treated? YES/NO. If yes,
      how?_____when?_____

d. Are there ongoing disturbances to the site? (natural and anthropogenic)
   a. □ near a road
   b. □ trails
   c. □ culverts, drains
   d. □ grazing (native or livestock)
   e. □ off road use by tractors, mowers, four wheelers
   f. □ soil disturbed by berm building, digging, ditching
   g. □ other _____

5. Surrounding land use description: _____
   _____
   _____

6. Are there rare plants or rare plant communities either adjacent to or in the site? YES/NO.
   If yes, do you know where they are located and how to identify them? _____
   Is the site within a delineated natural area or sensitive natural area? YES/NO If so, follow BMPs for treating weeds in the vicinity of Rare Plants (Appendix D Weed Mgmt Plan 2017 or website: https://www.colorado.gov/
   Is the site located near (<10 m) of a rare plant or within a rare plant community? YES/NO

7. Describe actions that are being considered for this site*:_____
   _____
   _____
8. What are the expected results of proposed action(s)? _____
   _____
   _____

9. What are the potential negative impacts of proposed actions? _____
   _____
   _____
10. Describe the goal for the proposed action(s):
    □ **Eradication** (only for small populations; puncturevine, bull thistle, tamarisk)
    □ **Control or suppression** targeting satellite populations (Canada thistle, knapweed) (this is typically used if a restoration is planned in the future or the area will be developed and removal of seed source is the goal).
    □ **Monitor** – get baseline to see if population is expanding – set up permanent monitoring plots

11. Describe the damage being caused by the presence of the target weed? (Is it clear the population is expanding? Should you monitor first? _____
    _____
    _____

12. Will removal of the target species damage the system? And will that damage have the potential to make the system more disturbed than the existing situation (i.e. produce bare soil, impacts from equipment, herbicide residue, introduction of outside seeds, change drainage pattern, etc)?

13. Will the removal of the target species have a high likelihood of being successful?
    a. Is there potential for re-establishment of nearby native species? YES/NO
    b. Is there on-going disturbances that may make removal of targets result in secondary invasion by non-native species? YES/NO (Is smooth brome present?, herbicide residue time)
    c. Can monitoring and follow-up activities occur after treatment? YES/NO)
    d. Is the size of the treatment area workable and easily monitored for sprouts and effectiveness of treatments?
    e. Proposed schedule for follow-up monitoring (within a year) _____
    f. Funding available for multiple follow-up YES – NO (if no follow-up consider no treatment)
    g. Describe how you will document success? _____

_____

_____

14. Set up photo plot or photo monitoring plot:

INITIAL BASELINE PHOTO PLOT: (set rebar and take photo that captures the site, try to return to photograph at least once a year at or near the same date (or spring and fall).

PLOT ID:_____ UTM:_____

DATE OF PHOTO:_____TIME_____

DATE PLOT INITIATED:_____# of individuals_____est. cover %_____

ASPECT/COMPASS HEADING FOR PHOTO:_____

***HERBICIDE**: Recommended only for salt cedar.

If herbicides are planned for Canada thistle in areas with other plant species, a spot application technique for satellite populations may be appropriate. Follow-up monitoring and detailed information on the area treated with follow-up visits are necessary to observe whether treatments are working and plants are not spreading. Most populations experience some sort of runoff or flooding, and many herbicides are not appropriate for natural areas (even if Canada thistle is listed on the label!). Replanting may be required. If smooth brome is in the area, there is a very high probability the area will fill in with this non-native grass and reduce forb cover. Herbicide application for knapweeds is tricky and almost always results in a situation as disturbed as the one being treated.

***MOWING**: Frequent follow-up monitoring, especially for Canada thistle, field bindweed or knapweeds (which are stimulated by mowing above ground parts), will be essential. Start with small areas and don't mow outside treatment area. Protect native landscape from mowing machinery. Will likely need to mow multiple times in a growing season. Do not mow knapweed after it has set seed.

Site ID:_____

Follow-up Monitoring

Year 2 _____

PLOT ID: _____ UTM:_____

DATE OF PHOTO: _____TIME: _____

DATE PLOT INITIATED: _____# of individuals: _____ est. cover %:_____

ASPECT/COMPASS HEADING FOR PHOTO: _____

List actions taken in year 1 with observations:

□ monitor only_____

□ satellite treatment only_____

□ full site treatment _____

Describe in detail results (population increasing/decreasing). (photo comparison – size of polygon)

Are additional treatments necessary?

Change in treatment plan for year 2?

Next scheduled monitoring date: _____

Appendix C. Best Management Practices to Prevent Noxious Weeds during Forest, Range and Residential Projects

The following are best management practices for preventing noxious weed germination, establishment and spread for projects conducted in the field. These practices are ideal for fire hazard mitigation work around homes and structures, new housing construction or remodel, installation or maintenance of infrastructure such as roads, ditches, and utilities, disaster recovery work and agricultural production operations. These actions may cost time at the beginning of the project, but they will save lots of money and headaches after the project is done and the contractors or workers are long gone.

Before starting a project:

1. Do a complete inventory noxious weed occurrences, using a GPS whenever possible; note what weed species are present, where they are located, how big the infestation is and how developed the plant is (green up, bolting, flowering, going to seed, past seed, decaying).
2. Share the weed inventory data with the local County Weed Manager for entry in the State's online noxious weed database, or provide List A data directly to Patty York and List B noxious weed data directly to Lara Duran.
3. Designate an area on-site where equipment, tools and clothing can be cleaned and mark these on the ground.
4. Designate an area on-site where equipment, vehicles, tools etc. can be staged when not in use and mark these on the ground; whenever possible pick locations that are already compacted (e.g. road turnouts, driveways, etc.).
5. Identify areas that are weed-free that may be ingress/egress paths and mark these on the ground.
6. Create a map with areas to avoid; also include locations of staging areas, stock piling areas, and areas where travel is permitted.
7. Share the maps with contractors and project employees and make sure all know where the avoidance, staging, stock piling and travel areas are located on the ground.
8. Treat known weed infestations in a manner that ensures seeds will not mature and germinate on the ground.
9. Treat all areas where equipment, materials, tools, vehicles, travel corridors and operations are expected including ingress/egress paths from the roadside to the project site.

At the start of the project

1. Clean all equipment prior to arriving or entering a new site that is located off of a roadway; cleaning means removing all soil, mud, plant parts, seeds, vegetative matter, or other debris that could contain or hold seeds.
2. Workers need to inspect, remove, and properly dispose of weed seed and plant parts found on their clothing and tool; this means removing all soil, mud, plant parts, seeds, vegetative matter, or other debris that could contain or hold seeds.
3. Flowers and seeds need to be collected, bagged and thrown into the trash or incinerated; composting does not produce enough heat to kill most noxious weed seeds and flowers left on the ground will often mature and disperse despite the dead stalk.
4. Plant leaves, stems and roots should be collected, bagged and thrown whenever possible; some noxious weeds reproduce from stems, roots or leaf fragments alone.
5. Inspect equipment and tools that is arriving on site to ensure contractors, drivers and workers washed the equipment and tools properly.

During the project:

1. Implement in a manner that minimizes soil disturbance.
2. Avoid travelling/driving/operating through or using equipment in weed infested areas.
3. Avoid piling debris and wood to be burned on top of noxious weeds; many weeds germinate after fire, or actively increase the frequency of fire: e.g. cheatgrass (*Bromus tectorum*).
4. Avoid piling or staging equipment, tools and materials on top of noxious weeds.
5. Avoid scraping or dragging equipment, tools and materials or debris on the surface of the ground.
6. When possible, chip and masticate woody debris on site instead of skidding/dragging/yarding it over ground; feller-buncher that pick up individual trees and load them into a landing are also preferred over skidding/dragging/yarding.
7. When possible, leave native plants, rocks, dead and down wood and other ground cover intact; many noxious weeds prefer to germinate in bare mineral soil and disturbed ground.
8. Stock pile materials and debris on ground that is already compacted whenever possible (e.g. road turnouts, driveways, etc.).

At the end of the project:

1. Clean all equipment, before leaving the project site, if operating in areas infested with weeds; cleaning means removing all soil, mud, plant parts, seeds, vegetative matter, or other debris that could contain or hold seeds.
2. Seeds and plant parts need to be collected and bagged or incinerated whenever possible.

After the project:

1. Do a complete inventory and GPS the project area for noxious weed occurrences for annually for three consecutive years after the project is completed.
2. Treat noxious weeds that are detected during post-project inventories.
3. Revegetate disturbed soil whenever possible with locally adapted native plants that are characteristic of that environment; make sure that the seed mix does not contain noxious weeds.

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Photo Credit: US Forest Service

For detailed information about noxious weed management in Colorado, be sure to visit our website at: https://www.colorado.gov/pacific/agconservation/noxiousweeds

Appendix D. Best Management Practices for Managing Noxious Weeds on Sites with Rare Plants

Recommended Best Management Practices for Managing Noxious Weeds on Sites with Rare Plants

Cecily HY Mui, Noxious Weed Specialist, Colorado Department of Agriculture-Noxious Weed Program[1]
Susan Spackman Panjabi, Senior Botanist, Colorado Natural Heritage Program

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This document provides natural resource professionals, land managers, and land use decision makers with guidelines and a set of questions to consider surrounding decisions related to noxious weed management in the vicinity of rare plants. These guidelines will help establish and refine a species-specific best management practices (BMPs) that can be customized for each unique project area.

Colorado hookless cactus (*Sclerocactus glaucus*, G2G3) with noxious weeds downy brome (*Bromus tectorum*) and halogeton (*Halogeton glomeratus*). Photo: Delia Malone, CNHP.

The goal of noxious weed management is to improve the value of the land, protect natural resources, and to enhance desired land uses through effective weed control. Therefore, while efforts are directed towards stopping the displacement of rare plants by noxious weeds, precautions are required to minimize unintended harm that can occur during weed management activities, such as trampling, herbicide contact, pollination disruption, and significantly altering the rare plant's habitat. Guidelines are needed to assist landowners and managers to protect rare plants at risk of local or global extinction.

One of the biggest conservation issues facing rare plants is the lack of awareness of their existence and their status. In Colorado, the non-profit Colorado Natural Heritage Program (CNHP) tracks over 500 rare plant species. A species' abundance is ranked 1 to 5, with 1 being critically imperiled and 5 being widespread and abundant. Initial conservation priority for the recommended BMPs herein will focus on Plants of Greatest Conservation Need as defined in the Colorado Wildlife Action Plan (Colorado Parks and Wildlife 2015). These are species ranked G1 (critically imperiled with 5 or fewer occurrences or populations globally) and G2 (imperiled with 6 - 20 occurrences globally). In 2015, there were 121 rare, native plant species (G1 and G2) threatened with extinction in Colorado. They are known to occur within 47 of the 64 Colorado counties. This list of rare plants includes species identified on the federal threatened and endangered species list. Most of Colorado's imperiled plants are naturally rare because they are restricted to very specific,

[1] Cecily Mui was employed with the Colorado Department of Agriculture's Noxious Weed Program from January 2013 to March 2016. There she developed the state's List B Noxious Weed program. In March 2016, she began working for the St. Vrain Creek Coalition on flood recovery as Watershed Coordinator/Executive Director.

narrowly distributed habitat. Unfortunately, many of these sites are vulnerable to human activities that can lead to habitat degradation and the loss of rare plants. As we work to improve the land through noxious weed control, it is important that we simultaneously strive to minimize the unintended impacts of our actions through careful, collaborative planning.

The desired outcomes of these recommended best management practices are to create greater awareness for rare plants among all who utilize the land and make decisions regarding land use, and to reduce the impacts of noxious weed control activities on rare plants on public and private lands. The guidelines and provided questions, which assist in the development of site and species-specific BMPs, are grouped into three major categories: 1) Site Assessment, 2) Harm Avoidance, and 3) Weed Management Techniques. These listed BMPs are general guidelines that should be more carefully detailed and customized for each specific rare plant species and project site with considerations for regulatory jurisdictions. These comprehensive recommendations may not be feasible for some private landowners, but experts (such as, NRCS and local county weed managers) are available to assist and advise, and these BMPs can be adapted for implementation at a smaller scale. All weed control activities should be evaluated and monitored iteratively to assess for benefits or impacts on rare plants on the project site. Based upon those assessments, adaptive management should be utilized to promote successful rare plant protection and weed control.

Recommended Best Management Practices

A list of recommended best management practices is provided for site assessment, harm avoidance, and weed management techniques. Some recommendations include a set of questions that assists with decision making.

<u>Site Assessment</u>

The goal of the "Site Assessment" section is to determine the locations of rare plants and noxious weeds within the defined project area and to define the desired land uses and noxious weed management goals that form the guiding principles for weed management on the site.

1. Define and map the boundaries of the project area.

2. Develop a list and map of rare plants ranked G1 and G2 that are known or suspected to occur within the project boundaries.

    - Gather information from the Colorado Natural Heritage Program, U.S. Fish and Wildlife Service (USFWS), or other known sources of rare plant spatial data.
    - If the project is on public lands, contact the land management agency whether it is federal, state, or local because they may have a unique list of species of concern, permitting, and regulatory requirements that must be met before weed control activities can proceed (e.g., Bureau of Land Management (BLM) Sensitive Species List and U.S. Forest Service (USFS) Regional Forester's Sensitive Species List).
    - The list of rare plant species should be updated annually, since new information is constantly being collected and species status can change.

- Sources of rare plant information:
  - Colorado Natural Heritage Program – Rare Plants List and general location maps: http://www.cnhp.colostate.edu/download/gis.asp, http://www.cnhp.colostate.edu/download/projects/rareplants/list_location.aspx?GeoScaleID=3
  - USFWS Threatened and Endangered Species List: http://ecos.fws.gov/tess_public/reports/species-listed-by-state-report?state=CO
  - BLM Sensitive Species List: http://www.blm.gov/co/st/en/BLM_Programs/botany.html
  - USFS Regional Forester's Sensitive Species List: http://www.fs.usda.gov/detail/r2/landmanagement/?cid=stelprdb5390116
  - Southwest Environmental Information Network (SEINet) – Plant species location information: http://swbiodiversity.org/seinet/
  - University of Colorado Herbarium – Plant species location information: https://cumuseum.colorado.edu/research/botany/databases
  - Rocky Mountain Herbarium – Plant species location information and species search within a drawn polygon: http://www.rmh.uwyo.edu/

3. Develop a list and map of all species of noxious weeds that will be treated within the project boundaries.

   - The Colorado Department of Agriculture – Noxious Weed Program has county noxious weed lists and statewide maps of noxious weed distribution:
     - Colorado noxious weed list https://www.colorado.gov/pacific/agconservation/noxious-weed-species
     - Noxious weeds sightings by counties https://www.colorado.gov/pacific/agconservation/county-weed-programs
     - Noxious weed distribution maps https://www.colorado.gov/pacific/agconservation/quarterquad-maps
   - If other undesired plant species will also be treated simultaneously with Colorado regulated noxious weeds, list and map these species as well.

4. If rare plants are suspected in the project vicinity and the project boundary includes the rare plant's habitat, consult botanical experts to obtain a confirmation. If the project is on USFS or BLM lands, contact the agency. If rare plants are confirmed within the project boundary, carefully consider and implement recommended BMPs. Consult and collaborate with rare plant and noxious weed specialists to obtain scientifically-based information and to explore treatment options.

   - A botanist may need to be hired to survey and confirm rare plants, especially when working on public lands. Surveys should be conducted during phenologically appropriate times for species confirmation.
   - Occasionally, assistance can be obtained from the CNHP, Denver Botanic Garden, or Colorado Natural Areas Program. The Colorado Native Plant Society may be able to assist

with a Rapid Response Team or the NRCS with a Technical Service Provider (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical/tsp/). Some services may include a fee.

- Some federal (USFWS - http://www.fws.gov/endangered/), state, and local land management agencies have complementary policy and regulatory guidelines to minimize adverse impact of activities on rare plants; along with these recommended BMPs, one will need to comply with those regulatory requirements.

5. Develop a project team with these primary roles: project manager, noxious weed specialist, rare plant specialist, regulatory partners, landowner/manager, and contractor manager.

    - Set up meetings and communication protocols to assist with information sharing.
    - If establishing a project team is not feasible, at a minimum, consult with a noxious weed specialist and rare plant specialist to obtain recommendations to minimize harm to rare plants and to select appropriate weed treatment options.

6. Carefully assess and define the desired land uses and noxious weeds management goals.

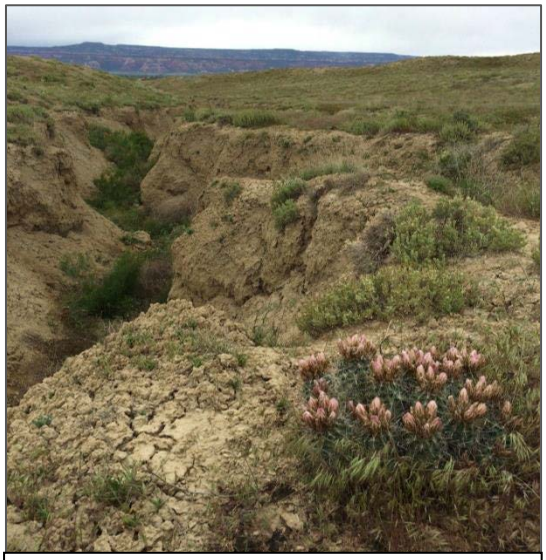
    - Define desired land uses and how existing noxious weeds affect the desired use.
    - Define the desired noxious weed management goals.
        - Are the goals for elimination and eventual eradication of a particular targeted weed species?
        - How aggressive a resource competitor is the weed?
        - Is some level of long term noxious weed existence acceptable?
        - What caused and perpetuated the weed infestation as the site and can that situation be managed to minimize the spread of noxious weeds and prevent future re-infestation?
        - What is the timeline for achieving the desired goals?
    - Assess how noxious weed are affecting rare plants on the site.
        - Do the weeds and rare plants occupy the same habitat?
        - Have noxious weeds been observed in the same habitat as rare plants?
        - If the plants occupy the same habitat, does there appear to be a stable population balance between the rare plant and noxious weed on those sites?
        - Is there a threat of potential rare plant displacement in the future?
    - Assess how might noxious weed management activities impact rare plants on the site.
        - What is the likelihood of misidentifying the rare plant for a targeted noxious weed?
        - When weeds are being treated on the site, what is the growth phase of the rare plant?
        - Will management activities affect rare plant pollination and reproduction? Consider the pollinator species, where they live, and weed control activities that can impact them.
        - What are potential unintended impacts on the rare plant due to weed treatment activities: trampling by foot or vehicle, herbicide contact, herbicide residual activity in the soil, significant changes in microhabitat such as canopy cover reduction, shifts in plant community with secondary invaders, etc.?

- Are there known secondary invaders in the area that may pose a greater threat, if the niche freed up by the removal of the targeted weed is not replaced by a desirable plant?

Harm Avoidance

The goal of the "Harm Avoidance" section is to define overarching approaches and techniques that focus on minimizing harm to rare plants in each unique project situation. Some recommendations include a set of questions that assists with decision making.

1. Assess the risks and benefits of weed management on rare plants within the project site.



Colorado hookless cactus (*Sclerocactus glaucus*, G2G3, Federally Listed Threatened) surrounded by downy brome (*Bromus tectorum*). Photo: Delia Malone, CNHP.

   - Can weed treatment risks be minimized or mitigated by selecting low impact treatment techniques suggested in the "Weed Management Techniques" section of the BMP?
   - If treatment risks can't be avoided or minimized, and the targeted noxious weed is not an aggressive competitor, is it essential to eliminate the targeted noxious weed from the project site?
   - What is an acceptable percentage of loss in the number of individuals of the rare plant's population within the overall goal of preventing species extinction?
   - Can "no current weed control action" and monitoring rare plants and noxious weed populations be the management option for relatively stable systems where noxious weeds don't appear to be threatening rare plants and the weed populations aren't expanding?
   - If monitoring shows potential harm to rare plants and desired land use, will there be resources to treat weeds in the future?
   - If the dominant weed is controlled, is there a secondary weed in the area that can potentially expand in the altered system and can pose a greater impact on the rare plant? An example of this is the removal of Russian-olives from the canopy and thus creating an environment that favors Russian knapweed and cheatgrass, which may have a greater impact on native understory plants.
   - Is it important to manage secondary weeds if plant communities and structure will be significantly altered?

2. Designate "Special Management Areas (SMAs)" based on known locations of rare plants and their habitat. The treatment of noxious weeds within the SMAs needs to be carefully conducted and follow BMPs recommended in the Weed Management Techniques section of this document.

- Map and/or physically mark the SMA within the project boundary. The SMA needs to include a buffering distance to minimize the impacts of planned activities on rare plants and their dynamic population changes on the landscape. This distance varies with the specific characteristic of the rare plants and the local environment.
  - Distances should be determined based on activities in the project area and the selectivity of the weed treatment techniques (e.g., vehicular traffic may require greater buffering distances and may need to be further adjusted based on the drift potential of the selected herbicide).
- Share SMA boundaries (hard-copy and/or digital maps) with all project staff and partners. Update maps and SMA boundaries as new rare plant locations are found.
- Consider temporarily fencing SMAs when activities on the sites are high.
  - If the site has public access, use care so that fencing does not draw unwanted attention that can pose harm to the rare plant.

3. Focus on weed prevention and containment of infestations to keep weeds from spreading, and invading Special Management Areas.

   - If weeds don't currently occur within project SMAs, focus on prevention to keep them out.
     - Require visual inspections of all vehicles, staff clothing, and equipment to be clean of seeds and vegetative material prior to entering the project boundary and again at SMAs.
     - Minimize activities that can cause soil disturbance.
     - Make it a high priority to treat weeds outside of the SMA boundaries, thus minimizing the future need to treat weeds immediately adjacent to rare plants. One might want to define that distance of defendable space outside of the SMA for technicians working on the site.
     - If the targeted noxious weed spreads by windborne seeds, widen the treatment area on the side with the prevailing winds. Similarly for weeds that spread along streams, target weeds upstream of the SMA.

4. If the noxious weed treatment timeline is long and flexible, consider setting up study plots within a small portion of the project area to assess which techniques best serve the given situation and minimize impacts of treatment on rare plants. Study results can be used to aid in selecting a noxious weed control technique that can then be applied over the greater project area.

   - Prior to implementing a study, find out if there is existing information on the proposed treatment, the targeted weed, and rare plant species
   - Consider monitoring and collecting data on rare plant and noxious weed populations within the project area throughout the course of treatments to determine their effects.

- At a minimum, collect baseline population data of rare plants and noxious weeds. Management techniques can then be adapted to minimize impacts and to assess if goals are being met.

5. If weed treatment techniques will result in abrupt alternations in the structure and functions of the ecosystem and affect the rare plant, consider applying the treatment in phases, thus allowing treated patches recovery time and assessment of treatment results before proceeding to the next set of treatment sites.

6. Minimize the number of entries into Special Management Areas through careful event coordination.

   - Designate a project manager who will catalog, review, coordinate, and monitor all project activities occurring within the SMAs.

7. Ensure that all project staff and contractors working on the site can correctly identify all rare plants and noxious weeds in their various stages of growth.

   - Consult with the CNHP or a professional botanist to confirm rare plant sightings.
     - Photos and GPS locations should be taken of potential sightings; only trained professionals with collecting permits should pull or remove any part of a rare plant.
   - Provide annual training to staff and contractors to discuss plant identification, documentation protocols, project activities, monitoring results, and treatment updates.

<u>Weed Management Techniques</u>

The goal of the "Weed Management Techniques" section is to provide guidance on weed management technique selection and cautious application of the selected techniques to minimize impacts on rare plants within the treatment area.

1. Carefully assess the suite of integrated weed management tools (mechanical, chemical, biological, and cultural) available for natural areas management.

   - Select and rank options that: are selective, have a low impact on altering the soils, does not impede the growth and reproduction of the rare plants, are proven to be effective on the targeted weeds, etc.

2. Chart the implementation timing of each treatment option and compare that with the growth phase of the rare plant populations at the site.

   - Whenever possible, time the treatment to occur when rare plants are dormant (not in a flowering, reproductive, or seedling phase) or have the ability to recover from potential damage.

3. Utilize herbicide applicators and noxious weed technicians who are highly skilled in plant identification.

    - Anyone treating noxious weeds on sites with rare plants needs to be able to identify the targeted noxious weed in all its growth phases and other noxious weeds known to be in the region. Additionally, that person should be able to identify rare plants on the site in all its growth phases, common native plants, and to distinguish native plants that are often confused with the targeted noxious weed.

4. Utilize mechanical control techniques with minimal soil disturbance.

    - Seedlings, annual, biennial, and short-lived perennial weeds can be pulled or severed 2-3 inches below the plant's crown, which is where the plant's stem meet the roots.
        - Minimize soil disturbance when pulling or severing below the crown.
        - One technique is to insert a shovel into the soil close to the crown, sever the root 2-3 inches below the soil, and then pull out the shovel carefully without turning over the soil or the plant. This technique reduces soil disturbance and the potential for planting undesired seeds.
    - Treat annuals, biennial, and short-lived perennial weeds before they produce flowers.
        - Otherwise, clip, bag, and dispose into the landfill flowers and seed heads from weeds within the SMA and adjacent buffer; seeds many continue to develop on severed plants.
        - Determine the weed seed's longevity in the soil; this is will determine the number of growing seasons the monitoring and treatment will be needed for the project area.
        - Weed seed longevity information can be found on the Colorado Noxious Weed Program's website: https://www.colorado.gov/pacific/agconservation/noxious-weed-species
    - Mowing should not be implemented within SMAs, unless it is required for safety reasons such as on rights of way.
        - Avoid mowing when plants are actively growing; use the best available information for rare plants on the site.
        - Mowing with a 6-inch (15 cm) or higher cut could take place in SMAs before the rare plant's growing season or after it has produced seeds or is dormant.
        - Mower tires should not be driven over or parked on top of the rare plants.
    - Some mechanical techniques, such as cutting, pulling, or mowing, can invigorate weed growth if applied at the wrong time, on a rhizomatous plant, or one that reproduces vegetatively. Carefully assess the technique and its application timing.
    - Avoid walking or driving on rare plants.

5. Select chemical control techniques that are known to: be effective on the targeted weeds, have minimal impacts on the rare plant, are selective, and can be applied with precision.

    - Rhizomatous perennial noxious weeds should be treated with carefully selected herbicides because other control methods are not effective or cause significant soil disturbance.

- Consult several herbicide experts to thoroughly understand the characteristics, effectiveness, timing of application, and application rates of potential herbicides, as well as, the impacts of the herbicides on the site's native plant community.
- If possible, select herbicides that are effective on the targeted weed and have low impacts on the plant family of the rare plant.
- Work with rare plant and herbicide specialists to select an application timing that will have minimal impacts on the rare plant.
- Read and follow information on the herbicide label, especially the "Environmental Hazards" section and if available, any information under the "Endangered Species Protection Requirements" section.
  - Some herbicide manufacturers have websites with additional information for good product stewardship. This is an example of one that is specific to the protection of threatened and endangered plants: http://www.monsanto.com/products/pages/glyphosate-endangered-species-initiative.aspx
- Carefully assess the impacts of the herbicide's soil residual on the rare plant.
  - Determine if the herbicide residual significantly affect the rare plant's growth and reproduction.
- Minimize potential drift of herbicide droplets or migration through the soil or water table by using carefully selected herbicides and method of application.
  - If a weed and rare plant are in close proximity, use a shield, like cardboard, to prevent drift onto the rare plant.
  - Wick and swiper applicators can also be considered.
  - If there is contact between the weed and rare plants, trim the weed to remove contact before conducting a shielded spray.

Treating Russian-olives with a cut-stump and shielded spray technique. Photo: Brian Elliott.

- Within the SMA, utilizing herbicide application techniques that have high precision, such as backpack sprayers.
  - Boom sprayers can be considered for sites within the project boundaries that are outside of the SMA and where the target noxious weed populations are high and dense.
  - Evaluate how the selected herbicide may alter the plant community, especially natives, within the rare plant's greater habitat; avoid harming native plants important to the overall plant community and causing a loss in biodiversity.
- Aerial application should only be considered for sites within the project area that are inaccessible and can put the safety of the applicator at risk.
  - Careful evaluation must be taken to consider the costs and benefits of an aerial application on the rare plant population.

    - Questions to consider include:
        - What percentage of the rare plant's population within the area fall into the proposed aerial treatment sites?
        - Is the cost of losing a few individual rare plants within the population during weed treatment worth the benefit of protecting the remainder of the population?
    - Measure the accuracy of the selected pilot and equipment on similar treatment terrain and environmental conditions, and adjust for optimal accuracy prior to treating the SMAs.
- Avoid walking or driving on rare plants.

6. Biological control can be considered for noxious weeds with large, regional infestations in the project area.

    - Biocontrol should not be used if the targeted weed populations are small outside of the SMAs, or within SMAs where weeds will be managed with an elimination objective.
    - Biocontrol is a potential option on large infestations only if the biocontrol agent is available and documented to be effective on the targeted noxious weed.
        - Contact the Colorado Department of Agriculture – Biological Control Program for more information: https://www.colorado.gov/pacific/agconservation/biocontrol
    - Biocontrol can be used when the noxious weed management goals do not require complete elimination and some level of noxious weed existence is acceptable.
    - Biocontrol can also be used to help reduce a large population to a point where it becomes manageable for elimination.
    - Carefully assess if the biocontrol agent may incidentally feed on rare plants, especially if the target weed and rare plant are in the same plant family.

7. Cultural techniques, such as revegetation, need to be done with careful consideration for materials and technique selection.

    - Assess past site alterations and uses that may have led to the invasion of noxious weeds.
        - Determine if:
            - The impact can be removed or repaired to prevent future re-infestation?
            - The restoration process, such as repairing hydrology, can naturally remove noxious weeds or will it favor the weeds and require treatment prior to restoration?
    - Determine if the rare plant's natural habitat consists of bare ground; if so, do not re-seed or alter the soil.
        - Many rare plants are adapted to live on specific substrates that may not resemble topsoil (e.g. shale barrens with very course and rocky substrate).
        - Some rare plants may not compete well on more developed topsoils; the retention of original surface substrates is important.
    - Use nearby occupied rare plant habitat as reference sites for the revegetation of disturbed habitat.

    - The revegetated native vegetation cover, composition, and structure should be similar to the reference site.
- If native vegetation does not show signs of re-establishment within a year after noxious weeds treatment, revegetate with native seeds, preferably collected from native plants in the area and using a mix that maintains the biodiversity of the site.
    - Commercial seed mixes should not contain any non-native species or native species not part of the reference plant community.
    - Request for high seed purity in the mix.
- Use wood straw (http://www.fs.fed.us/eng/pubs/html/04231302/04231302.html) or certified weed-free straw or hay, if mulch or erosion control is required.
- If tilling is necessary, avoid burying rare plants or putting large amounts of dust on them.
- Do not transplant rare plants, except when significant disturbance such as, development is unavoidable on the site.
- Do not utilize fire as a weed management tool in SMAs, unless a controlled burn is known to promote the rare plant's growth and population.
- Do not graze within the SMA, unless it is known to be beneficial for the rare plants on the site.

8. Test the selected weed management techniques to determine which have the least impact on the rare plant.

9. Monitor rare plant populations. If impacts are noted, change management techniques.

Conclusion

These recommended BMPs are intended to serve as a guideline designed to assist natural resource professionals, land managers, and land use decision makers. The BMPs are utilized most effectively as a template for customizing a species-specific plan for a targeted project area. The recommended BMPs can also be used to enhance weed management in natural areas that have a focus on native plants. Suggested future work that can further minimize unintended harm to rare plants include: a website and fact sheets to provide additional information; the development of regional lists of commercial herbicide applicators who are proficient at working in rare plant environments; a shared database of Special Management Areas for rare plants that is accessible online; and demonstration projects showing successful management of noxious weeds while enhancing rare plant populations. Collaborative planning; inputs from rare plant, noxious weed, and herbicide experts; coordination; and information sharing are required for the implementation of weed control activities on sites with valuable rare plant resources, where negative impacts can contribute to a species' extinction.

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