Noxious Weed Survey of Francis E. Warren Air Force Base 2018

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2018

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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: Dalmatian toadflax with a perched grasshopper sparrow at Francis E. Warren Air Force Base in 2018. Photo by Georgia Doyle (CNHP).

EXECUTIVE SUMMARY

In the summer of 2018, the Colorado Natural Heritage Program (CNHP) mapped noxious weeds at Francis E. Warren Air Force Base (FEWAFB) located just west of Cheyenne, Wyoming. The mapping was undertaken to provide another year of data on noxious weeds at the base for comparison to two prior years of weed mapping data (2004 and 2014). The information is also provided to comply with the FEWAFB 2018 Integrated Natural Resources Management Plan (INRMP 2018) that outlines the goals for mapping invasive species to track effectiveness of FEWAFB noxious weed control efforts. The methodology CNHP utilized to conduct this survey was based on similar weed surveys conducted at the U.S. Air Force Academy, Peterson Air Force Base, Cheyenne Mountain Air Force Station, and Pueblo Chemical Depot.

The use of repeatable data is important to facilitate comparisons of weed populations over time. This report will provide a useful tool to continue to develop and inform adaptive weed control strategies and to comply with noxious weed regulations. Due to discrepancies in mapping techniques, exact comparisons between all years (2004, 2014, and 2018) are not possible, but trends suggested by the data are worth exploring and are discussed when pertinent.

Areas on FEWAFB that provide habitat and ecological needs for the federally Threatened Colorado butterfly plant (*Oenothera coloradensis*) and Preble's meadow jumping mouse (*Zapus hudsonius preblei*) contain noxious weeds. Changes in stream flows and ground water hydrology may encourage weed encroachment (INRMP 2018). Information gathered from this survey helps inform ongoing noxious weed management decisions critical to the survival of these threatened species.

Summary of Findings

CNHP identified 15 noxious weed species at FEWAFB and all were mapped in 2018 except Dalmatian toadflax (*Linaria dalmatica*). Dalmatian toadflax covers more than 65% of the base (SWCA 2014) making it impractical to map; however, a new understanding of the biocontrol organisms may allow for more effective treatment. Canada thistle (*Cirsium arvense*) is the next most widespread weed (603.1 acres) followed by leafy spurge (*Euphorbia esula*) (143.4 acres) and houndstongue (*Cynoglossum officinale*) (99.3 acres); all of which continue to present complex management challenges especially in the wet meadows and riparian areas. Field bindweed (*Convolvulus arvensis*) and hoary cress (*Cardaria draba*) were mapped with more than eight acres of cover, making eradication unlikely. Russian olive (*Elaeagnus angustifolia*) coverage is 1.5 acres of mostly mature trees and depending on FEWAFB management decisions, either containment or eradication is possible. Common teasel (*Dipsacus fullonum*) coverage is just over an acre making eventual eradication possible. Common burdock (*Arctium minus*) and the newly discovered diffuse knapweed (*Centaurea diffusa*) cover less than ½ acre and are likely candidates for eradication. Musk thistle (*Carduus nutans*), baby's breath (*Gypsophila paniculata*), purple loosestrife (*Lythrum salicaria*), and Scotch thistle (*Onopordum acanthium*) each cover less than 0.1 acre and bull thistle (*Cirsium vulgare*) had only one individual. All five species are candidates for successful eradication. A summary of findings is provided in Table 1.

Table 1. Summary of findings for noxious weed species at F. E. Warren AFB in 2018 in order of highest to lowest cover. As ranks shift from low to very high, the likelihood of eradication increases.

Management Urgency Ranks: low, medium, high, very high (eradication possible)			
Urgency	Scientific Name	Common Name	Comment
	Linaria dalmatica	Dalmatian toadflax	Widespread - not mapped in 2018 – low potential for eradication. Biological control with *Mecinus janthiniformis* has potential to reduce populations.
	Cirsium arvense	Canada thistle	603.1 acres mapped – eradication not likely. Confirm potential for stable or declining populations with continued monitoring. Investigate use of Canada thistle rust.
	Euphorbia esula	Leafy spurge	143.4 acres mapped – low potential for eradication. Good candidate for biocontrol. Potential for weed treatments to be more detrimental than the presence of leafy spurge. Site plans highly recommended before any treatments occur.
	Cynoglossum officinale	Houndstongue	99.3 acres mapped – Low potential for eradication due to location in drainages with dense vegetation.
	Convolvulus arvensis	Field bindweed	8.9 acres mapped opportunistically – full extent is not known -widespread. Eradication not likely, natural declines could be confirmed with monitoring.
	Cardaria draba	Hoary cress (whitetop)	8.2 acres mapped. Potential natural decreases observed. Confirm natural decrease with continued monitoring.
	Elaeagnus angustifolia	Russian olive	1.5 acres mapped – moderate to high potential for control/eradication. Monitor and treat young sprouts. Treating large trees is optional to prevent spread of seeds with a restoration plan including replanting and monitoring.
	Dipsacus fullonum	Common teasel	1.4 acres mapped - moderate to high potential for control. Mechanical treatment occurred in 2018.
	Centaurea diffusa	Diffuse knapweed	0.46 acres mapped – potential for eradication. Identified for the first time at FEWAFB.
	Arctium minus	Common burdock	0.37 acres mapped – good potential for eradication.
	Carduus nutans	Musk thistle	<0.1 acre mapped - 7 populations, 59 total individuals. Good potential for eradication.
	Gypsophila paniculata	Baby's breath	<0.1 acre mapped – high potential for eradication. Found on noxious weed list in Montana and on Colorado's watch list.
	Lythrum salicaria	Purple loosestrife	<0.1 acre mapped with 62 individuals – very high potential for eradication with immediate mechanical removal and follow-up monitoring.
	Onopordum acanthium	Scotch thistle	<0.1 acre mapped – very high likelihood of eradication with immediate mechanical removal and follow-up monitoring.
	Cirsium vulgare	Bull thistle	1 individual - eradication very likely. Colorado noxious weed.

Summary of Recommendations

- Regularly monitor weed-free areas on FEWAFB for noxious weeds or disturbances. Protection of undisturbed sites is the best measure to prevent the spread of noxious weeds. Native species provide weed competition in addition to ecosystem services like pollinator habitat, soil stability, habitat structure, diversity, etc.
- The types of weed treatments (mechanical, biological or chemical) should be considered on a site by site basis with a site plan that includes the goal to be achieved, the size of the treatment, and consideration for the biology of the target weed (i.e. annual, biennial or perennial with underground root buds that may be stimulated by above ground actions). Methods and detailed timelines used for control, a record of treatments, and plans for follow-up monitoring should also be included in the plan to ensure a successful outcome. See worksheet in Appendix A.
- Create site plans for natural areas being experimentally grazed for weed control (Appendix A).
- Herbicides should not be the first or only choice for noxious weed treatments in natural areas due to potential impacts to soil, surface and ground water quality, and non-target impacts.
- Implement or continue rapid response activities using mechanical treatments for diffuse knapweed (*Centaurea diffusa*), common burdock (*Arctium minus*), musk thistle (*Carduus nutans*), baby's breath (*Gypsophila paniculata*), purple loosestrife (*Lythrum salicaria*), Scotch thistle (*Onopordum acanthium*) and bull thistle (*Cirsium vulgare*), with follow-up monitoring post treatment.
- Common teasel (*Dipsacus fullonum*) was mapped with over an acre cover and is approaching a level that may be difficult to eradicate. A site plan that includes a timeline for treatments and follow-up monitoring to make sure treatments are effective is essential for success. Many treatments may increase sprouting or soil damage post treatment and encourage a new set of weeds to move in.
- Educate FEWAFB staff to be on the lookout for new occurrences of noxious weeds and learn to recognize native plants that resemble noxious weeds.
- Use details in the following sections of this report as additions to material in (SWCA 2014) in the FEWAFB Integrated Natural Resources Management Plan (INRMP 2018 – Appendix K) and for supplementary information on plant biology and treatment strategies.
- Be prepared to revisit, alter or even cease methods of treating weed species where the follow-up monitoring show treatments are not reducing weeds – adaptive management.
- If weed control resumes in natural areas that are near or include the Colorado butterfly plant and Preble's meadow jumping mouse, create site plans. Be certain to include a site description with a species list, the proposed method of treatment(s) and a description of the follow-up monitoring. Treatments without site plans are not recommended.
- Host workshops as necessary for updates and improved communication for contractors and staff. Information can be discussed to create site plans for proposed treatment areas with natural resources. Identification of native species and the Colorado butterfly plant on the base as well as target weeds in different growth stages can be reviewed.

- Recognize the extensive occurrences of native thistles at FEWAFB and distinguish them from the four weedy thistles, especially Canada thistle, to prevent the native thistles from becoming accidental targets for control.
- The impacts of any proposed treatment should always be considered. All weed treatments have the potential to cause harm to soils, wildlife and native plant species.
- Investigate the use of *Mecinus janthiniformis* for biocontrol of Dalmatian toadflax.
- Whenever biocontrol organisms are deployed, any other treatments need to be assessed and potentially terminated as they can impair the success of the biocontrol organisms.

Acknowledgements

The help and generosity of many experts is gratefully acknowledged. Alex Schubert (USFWS) was our primary contact at FEWAFB and his assistance with project logistics was extremely valuable as was his time orienting CNHP personnel in 2018. Alex was also very helpful in providing pertinent FEWAFB natural resource documents which greatly expanded the background information necessary to complete this report.

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INTRODUCTION

Francis E. Warren Air Force Base (FEWAFB) is located in southeastern Wyoming, west of Cheyenne in Laramie County (Figure 1). The base includes approximately 5,866 acres of which 3,660 acres are considered unimproved with most development in the southern portion of the property. In the summer of 2018, the Colorado Natural Heritage Program (CNHP) targeted ten state-listed noxious weeds known to occur on the base for mapping. Four additional weed species were observed and mapped in 2018. Base-wide weed maps were updated to continue to assist natural resource managers in understanding, controlling and monitoring weed infestations. At least three previous weed surveys (Heidel and Laursen 2002, North Wind 2005, and SWCA 2014) have included weed mapping on the base. CNHP's involvement is the result of an ongoing effort by FEWAFB to continually update their maps and knowledge of the base's noxious weeds.

Current noxious weed mapping efforts are necessary to comply with federal noxious weed laws and Executive Order 13112 (U.S. Department of Agriculture [USDA] 1999). This executive order also clearly defines a species as invasive if it is not native to the ecosystem under consideration and is likely to cause environmental, economic or human harm. The Wyoming Weed and Pest Council (2018) stresses the importance of a program of Early Detection and Rapid Response as key to mitigating new infestations of invasive weeds, as do most reputable state weed programs.

At FEWAFB, occurrences of the federally listed Colorado butterfly plant (*Oenothera coloradensis*) and Preble's meadow jumping mouse (*Zapus hudsonius preblei*) are found in riparian areas that include wetland and intermittent drainages where many of the noxious weeds occur (Heidel et al. 2018, SWCA 2014). The 2018 Integrated Natural Resources Management Plan (INRMP) for FEWAFB affirms the conundrum that "weed control and a failure to control weeds each pose potential adverse impacts to Preble's meadow jumping mouse and the Colorado butterfly plant" referencing the dangers posed by both endeavors to control noxious weeds in riparian habitats.

The understanding that weed infestations are typically the result of previous soil disturbances and not the weed species itself, is helpful in defining a successful treatment and prevention strategy. Disturbances within natural systems can be natural or anthropogenic. Removal of vegetation and soil disturbances, excessive grazing by native or domestic animals, impacts to hydrology including changes in flooding regimes by impoundments, wells, surface developments and impacts of rising average temperatures and changes in precipitation patterns influence cover and introductions of noxious weeds. Weed treatments, including herbicide applications, mechanical and cultural controls can create localized disturbances that can lead to larger weed footprints or new introductions in natural areas (Smith et al. 2018). Unintended consequences from well-intentioned weed management actions can be avoided by having a clear set of goals and a strategy for weed treatments that are species specific and include follow-up monitoring.

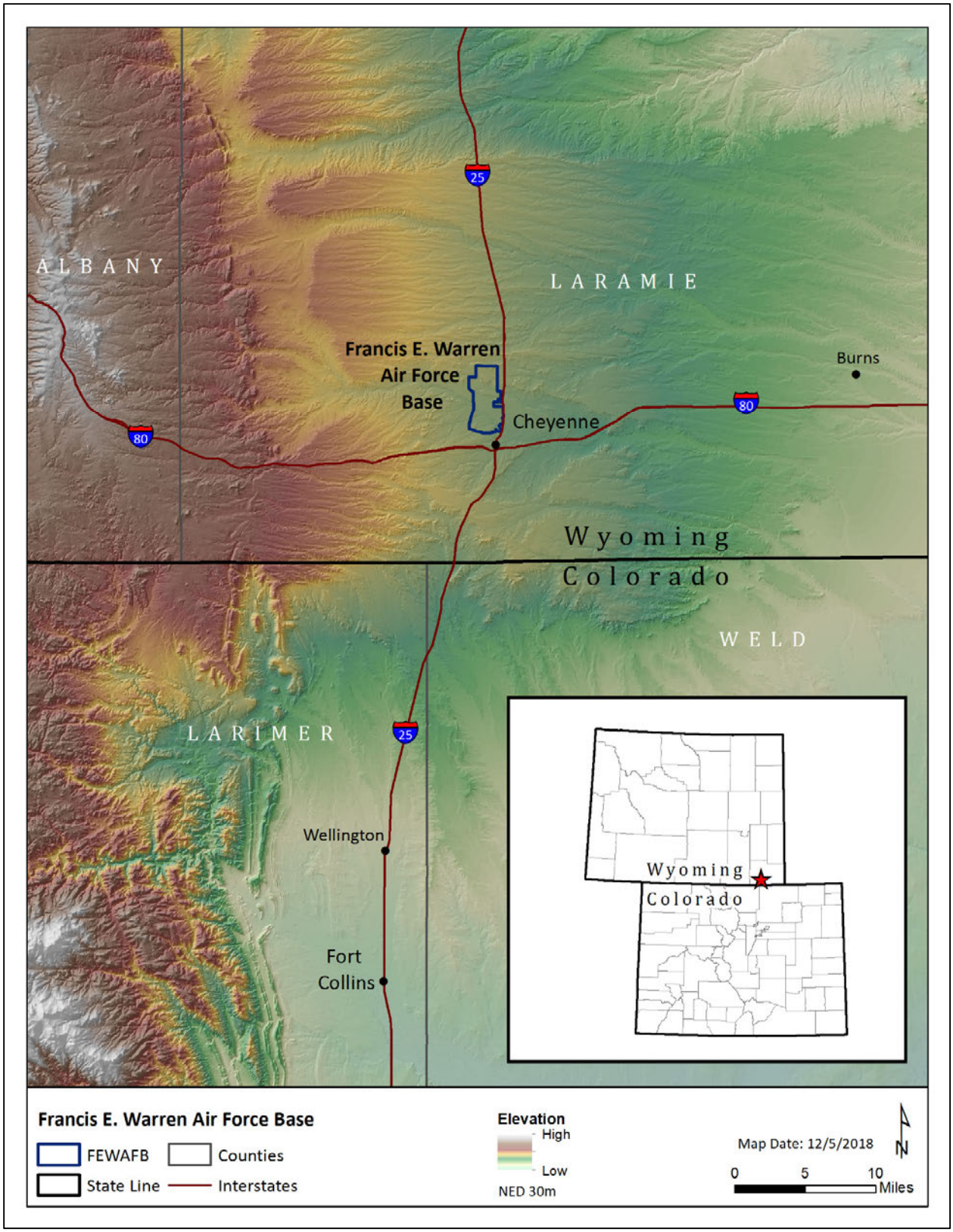


Figure 1. Location of F. E. Warren Air Force Base in Wyoming.

A number of organizations that manage natural areas recommend the preparation of a site plan before noxious weed treatments are undertaken (USFS 2016, Interagency Workgroup 2016, Pearson et al. 2016, Mui and Spackman Panjabi 2016, CPW 2013, UC Davis Weed Research and Information Center 2013, Sher et al. 2010, The Nature Conservancy 2011, and Tu et al. 2001). Site plans are especially helpful where other natural resources need protection as at FEWAFB (versus agricultural fields or rangelands). Clearly stated written goals for the protection and ecological management of a site is imperative for successful invasive plant removal. Management resources are usually limited relative to the scope of invasive species threats. Plans should include a reasonable set of goals that will be created by considering the current condition of the community to be managed with the desired site condition, clear timelines for management actions, and a realistic method for monitoring results. Site plans include measuring the size and scope of the noxious weed cover, assessing the habitat being invaded for quality, presence of rare plants and animals, considering species in the area that have the potential to replace the targeted noxious weed once it is treated**,** estimating resources needed to meet the management goals, and knowing when not to undertake an invasive species removal project (The Nature Conservancy 2011). Information that is useful to consider in developing a site plan is included in a CNHP assessment worksheet for weed management provided in Appendix A.

CNHP recommends that site plans be initiated in FEWAFB's natural areas in addition to the goals already outlined in the Integrated Natural Resources Management Plan (INRMP) for the base's known weed infestations. The INRMP for FEWAFB includes *The Invasive Species Control Plan* (INRMP 2018, Appendix K) which has extensive species-specific management information and a system of prioritization for the ten previously documented noxious weeds on the base (SWCA 2014). Newly discovered weeds, supplementary information on plant biology, and new treatment strategies are detailed in the following sections of this report as additions or updates to material in Appendix K of FEWAFB's Integrated Natural Resources Management Plant (INRMP 2018, SWCA 2014).

Site Description

The topography of FEWAFB includes approximately nine square miles of broad plateaus. The highest elevation of the base is 6,405 feet in the northern area to its lowest point 6,118 feet where Crow Creek exits the property in the southeast corner. Most of the northern portion of the base is modified shortgrass prairie. Riparian corridors and major drainages run through the southern portion of the base where most of the developed areas occur. The densest weed infestations are primarily in these southern riparian corridors and drainages.

METHODS

Noxious weed species mapped during previous weed surveys in 2014 (SWCA Environmental Consultants) and 2004 (North Wind) were targeted for this survey with the exception of Dalmatian toadflax. Dalmatian toadflax is ubiquitous, especially in the northern part of the base. Therefore, mapping is cost prohibitive with little to gain since eradication or significant control is not likely. All weeds mapped in 2004 and 2014 were found at FEWAFB in 2018. In addition, CNHP targeted all species on the Wyoming State Designated Weed and Pest List (Appendix B) and the State of Colorado noxious weed list. As a result, four additional species of noxious weeds, diffuse knapweed, bull thistle, baby's breath, and common teasel, were also mapped in 2018. In total, 14 noxious weeds were mapped out of 15 known noxious weeds on FEWAFB (Table 2).

Approximately four weeks of field work were completed by two field botanists throughout the summer of 2018. The base was visited in June to capture early species like hoary cress, and then later in mid-July and mid-August. Weeds were surveyed using a census survey method where weeds were documented 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. Irregularly shaped features greater than approximately 30 meters in any direction were mapped as polygons. Data were mapped using a Trimble Yuma rugged tablet with a built-in GPS receiver (accuracy between 2-5m) and ArcPad (ESRI 1995-2018), a portable version of GIS software.

Qualitative notes and actual counts and estimates for populations were made at each mapping site. Field botanists had an option to estimate a total number of individuals or density as number of individuals per square meter. If density was estimated, occurrence size and density were used to calculate an estimated number of individuals. It is important to note that riparian areas along Crow Creek and Diamond Creek proved difficult to map. Vegetation was dense, with weed species frequently co-occurring. It was often impossible to penetrate thick stands of weeds and willows to search the interior of the riparian areas. In these dense areas, co-occurring weeds were mapped together and split into separate features as density changed. In cases where one polygon mapped in the field represented many species, polygons for each species were generated in the office. This scenario occurred most frequently with Canada thistle, leafy spurge, and houndstongue. When weeds were visible but exact locations were inaccessible, offsets were applied to the GPS or features were digitized heads-up using the 2015 NAIP aerial photo for reference. Notes were taken to document non-standard, "on the fly" mapping techniques. Standing dead weeds were mapped as extant since they were alive during a recent growing season and likely produced seeds or could sprout in the next growing season.

For each noxious weed species, the size of the area with weeds, number of mapped features, and estimated number of individuals are tabulated in Results and Recommendations. All mapped features, attributes and notes are found in the geodatabase accompanying this report. A more detailed description of the mapping protocol is provided in Appendix C.

Table 2. Noxious weeds known from F. E. Warren AFB and mapping activities.						
Scientific Name	Common Name	Wyoming Weed & Pest List	Mapped in 2004 (North Wind)	Mapped in 2014 (SWCA)	Mapped in 2018 (CNHP)	Comment
Arctium minus	Common burdock	Yes	---	X	X	
Cardaria draba	Hoary cress	Yes	X	X	X	
Carduus nutans	Musk thistle	Yes	X	---	X	
Cirsium arvense	Canada thistle	Yes	X	X	X	
Cirsium vulgare	Bull thistle	---	---	---	X	On Colorado's Noxious Weed List
Centaurea diffusa	Diffuse knapweed	Yes	---	---	X	Newly discovered in 2018
Convolvulus arvensis	Field bindweed	Yes	X	X	X	
Cynoglossum officinale	Houndstongue	Yes	X	X	X	
Dipsacus fullonum	Common teasel	---	---	---	X	On Colorado's Noxious Weed List
Elaeagnus angustifolia	Russian olive	Yes	---	X	X	
Euphorbia esula	Leafy spurge	Yes	X	X	X	
Gypsophila paniculata	Baby's breath	---	---	---	X	On Colorado's watch list
Linaria dalmatica	Dalmatian toadflax	Yes	X	X	---	Present in 2018 but too widespread to map
Lythrum salicaria	Purple loosestrife	Yes	---	X	X	First documented in 1998, next seen 2014
Onopordum acanthium	Scotch thistle	Yes	---	X	X	

Collection of weed data was subject to limitations imposed by human resources, time, and safety. Seasonal precipitation and weather patterns can influence results. Most of the base was surveyed by foot or vehicle. Residential areas with manicured landscapes and the area immediately north of Diamond Creek and east of Missile Drive with ongoing active military exercises, were not surveyed. In 2014, a small population of Canada thistle, two smaller populations of houndstongue, and a linear roadside occurrence of field bindweed were mapped in disturbed areas near buildings (SWCA 2014). These could be re-visited in future mapping exercises. Discrepancies in mapping methods and survey effort from previous years likely exist.

RESULTS AND RECOMMENDATIONS

There are 15 noxious weeds currently known from FEWAFB. These species were mapped during the summer of 2018 except for Dalmatian toadflax which is so widespread it is impractical to map and to eradicate (Table 2). Overall, more than 1,200 weed occurrences covering 640 acres were mapped (Figure 2). Over 220 of the 640 total acres have significant infestations of multiple noxious weed species. Canada thistle, leafy spurge, and houndstongue most frequently co-occur in riparian areas.

Figure 2. Distribution of known weed infestations at FEWAFB in 2018 excluding Dalmatian toadflax.

Many species have the potential for eradication with appropriate treatment and follow-up monitoring (Table 3). The three biennial thistles mapped, Scotch, musk, and bull thistle, along with common burdock, baby's breath, purple loosestrife and diffuse knapweed are candidates for eventual eradication. Occurrences of these species are low enough that carefully planned control efforts with follow-up monitoring utilizing prepared site plans could reduce or potentially eliminate these species from the base.

While Canada thistle continues to have a large coverage in the riparian areas and drainages alongside the Colorado butterfly plant, there continues to be some new hope for future control efforts using a rust. The Canada thistle rust is already present in most U.S. infestations, but artificially increasing its presence may be a viable future control strategy with good results. This has shown promise in Colorado and is being studied and distributed by the USDA Palisades Insectary in Colorado (Price 2018). A stem-mining weevil for Dalmatian toadflax has shown impressive efficacy in impacting populations in several recent studies. With such a large population of Dalmatian toadflax residing on FEWAFB, almost 4,000 acres in 2014, it is a strong candidate for more biocontrol releases. Leafy spurge, houndstongue and hoary cress will continue to challenge land managers at FEWAFB because of their size and impacts as well as the difficulty in accessing them for control efforts without harming desirable species.

Noxious weeds with potentially increasing cover that are not likely to be eradicated include Dalmatian toadflax, leafy spurge and houndstongue, In addition, Canada thistle, which appears to be neither increasing or decreasing (stable), and hoary cress (potentially declining), are also both

unlikely candidates for eradication. Russian olive may be eradicated or contained and is decreasing in cover. Common teasel is on the edge of being a candidate for eradication with a cover exceeding an acre.

Table 3. Noxious weed acreages at F. E. Warren AFB reported from 2004, 2014, and 2018 in order of highest to lowest cover.

Change in Known Population Size	Scientific Name	Common Name	2004	2014	2018	Eradication
Unknown*	*Linaria dalmatica*	Dalmatian toadflax	1,915	3,913	---	Not likely
Stable	*Cirsium arvense*	Canada thistle	660.6	533.1	603.1	Not likely
Increasing	*Euphorbia esula*	Leafy spurge	28.4	134	143.4	Not likely
Increasing	*Cynoglossum officinale*	Houndstongue	50.2	165.8	99.3	Not likely
Unknown*	*Convolvulus arvensis*	Field bindweed	95	6.6	8.9	Not likely
Decreasing	*Cardaria draba*	Hoary cress	23.7	0.4	8.2	Not likely
Decreasing	*Elaeagnus angustifolia*	Russian olive	---	4.2	1.5	Possible (long-term)
Increasing*	*Dipsacus fullonum*	Common teasel	---	---	1.4	Possible (long-term)
Increasing	*Centaurea diffusa*	Diffuse knapweed	---	---	0.46	Possible
Increasing	*Arctium minus*	Common burdock	---	0.2	0.37	Possible
Unknown*	*Carduus nutans*	Musk thistle	?	---	<0.1	Possible
Increasing	*Gypsophila paniculata*	Baby's breath	---	---	<0.1	Possible
Stable	*Lythrum salicaria*	Purple loosestrife	---	0.1	<0.1	Possible
Decreasing	*Onopordum acanthium*	Scotch thistle	---	5.1	<0.1	Possible
Increasing	*Cirsium vulgare*	Bull thistle	---	---	<0.1	Possible

*Comprehensive mapping not completed in 2018 for Dalmatian toadflax and field bindweed. Common teasel estimates provided by FEWAFB Natural Resources Managers. Musk thistle acreage not reported in 2004.

Acreages from previous weed surveys are taken from the 2014 Invasive Species Control Plan (SWCA 2014). It is important to highlight that 2018 had higher spring and summer precipitation and higher average temperatures than 2004 and 2014 which could correlate with the increases noted in leafy spurge and houndstongue (Figure 3 and Figure 4). It is harder to draw correlations

with other species with so few data points across some years and potential discrepancies in mapping techniques.

Precipitation and Temperature

Higher precipitation, especially in winter and spring, can often mean higher weed densities for some species (Smith et al. 2018). The closest climate station to FEWAFB is a NOAA (National Oceanic and Atmospheric Administration-Region 8, Station 481675) data center, located to the northeast at the Cheyenne Municipal Airport which is 4.3 km (2.7 miles) away at a similar elevation (WRCC 2018). Climatic data, for combined spring and summer precipitation and maximum temperature averages, have been collected annually since 1936. Annual maximum temperature averages have ranged from ~55 ºF in 1951 to ~63 ºF in 2012, with an overall upward trend. Average annual precipitation has ranged from less than 6" in 1960, 1964, 2002 and 2012 to greater than 16" in 1957 and 1983 and shows an overall downward trend (Heidel et al. 2018) (Figure 3).

The recent season of mapping in 2018 at FEWAFB had above average precipitation for spring and summer (1.67" above average). Precipitation was slightly above average in 2014 and 2018, while 2004 had below average precipitation (Figure 4). Some increases observed for houndstongue and leafy spurge may be related to above average precipitation.

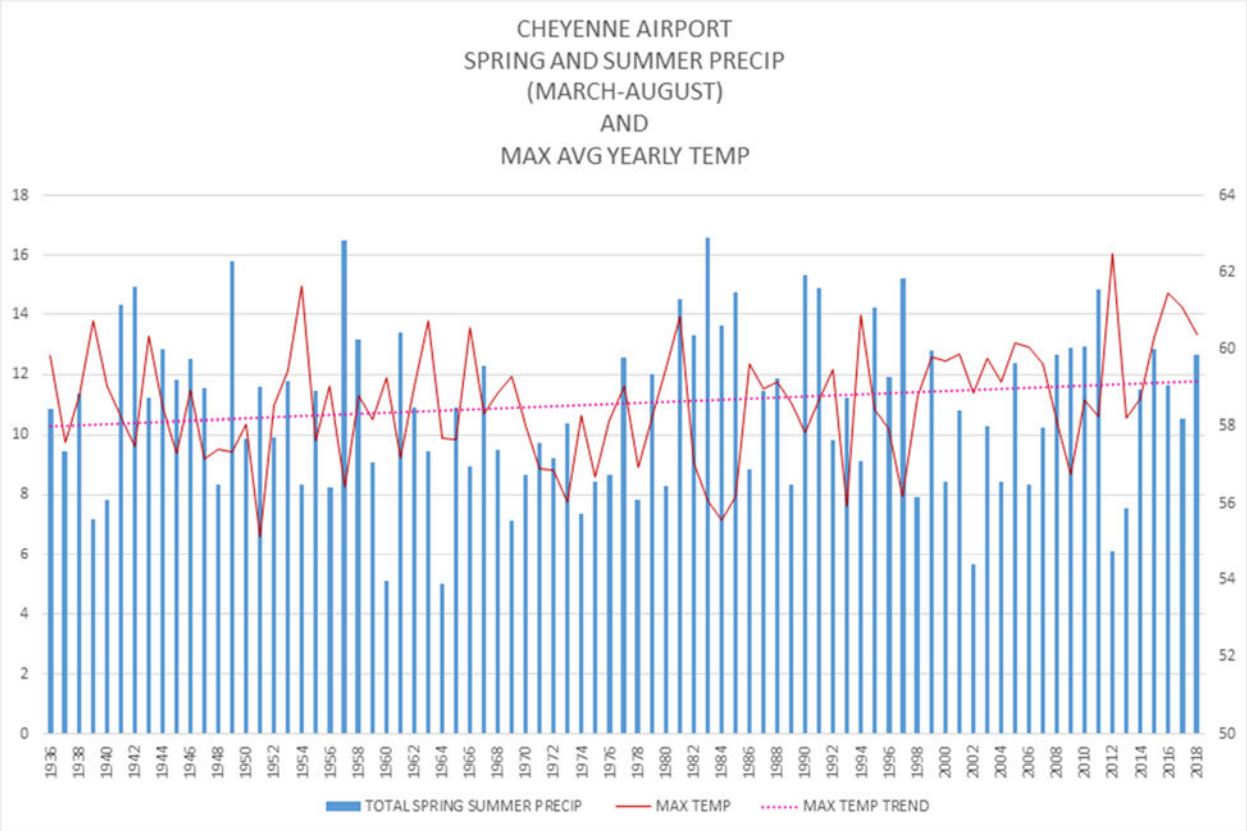


Figure 3. 1936-2018 yearly average combined spring and summer precipitation (in inches): Spring = March-May, Summer = June-August. Red Line: yearly average temps (degrees F). Dotted pink line: yearly average temperature trend since 1936 (WRCC 2018).

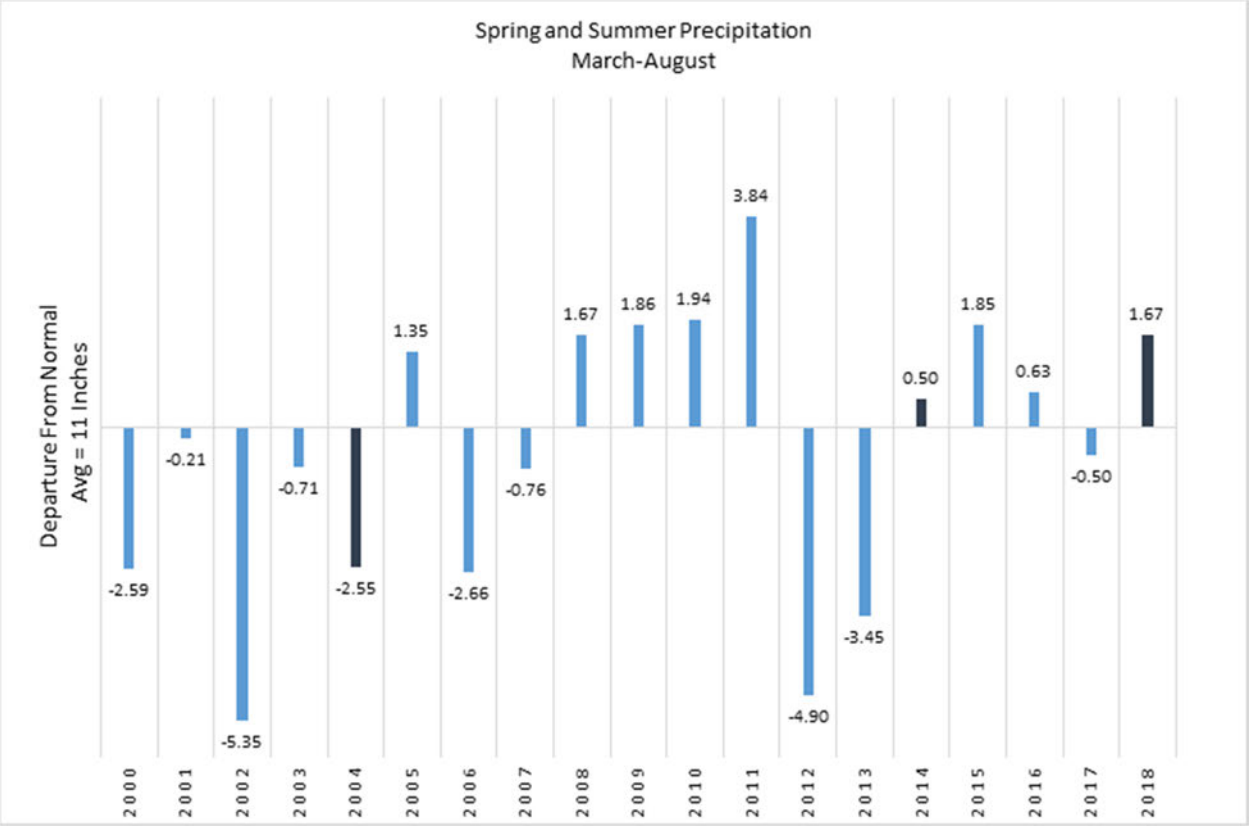


Figure 4. Departure from average (11 inches of precipitation) for yearly combined spring and summer precipitation since 2000 (Cheyenne Airport). Darker bars for 2004, 2014 and 2018 are the years weeds were mapped at FEWAFB.

Elements of Conservation Concern

Photo: Colorado butterfly plant at FEWAFB, Lisa Tasker (CNHP)

Noxious weed species, as well as elements of conservation concern that include two Federally Threatened species, the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) and the Colorado butterfly plant (*Oenothera coloradensis*), occur at F. E. Warren Air Force Base. The Colorado butterfly plant has been well documented on the base and has been censused since 1986 (Heidel et al. 2018). The Colorado butterfly plant population at FEWAFB is one of the largest populations of the species known leaving its viability on the property as key to the species overall conservation (Heidel et al. 2018). Colorado butterfly plant numbers appear to be stable across FEWAFB, with numbers increasing on Diamond Creek and the unnamed drainage basin and decreasing on Crow Creek (Heidel et al. 2018). Crow Creek riparian areas support Preble's meadow jumping mouse which is limited in distribution to very few documented sites in Colorado and Wyoming.

According to the FEWAFB Integrated Natural Resources Management Plan (INRMP 2018, SWCA 2014), there has been a cessation of mowing and herbicide use for weed control within the Colorado butterfly habitat since 1989. The Crow Creek populations have been declining over the 30-year census period while experiencing impacts to the historic stream flows and ground water hydrology which can influence the cover of noxious weeds. If or when weeds are targeted for management in the Colorado butterfly plant habitats at FEWAFB, a site plan (Appendix A) should be created with careful attention to best management practices (BMP's) established for sites where noxious weeds are managed alongside rare plants (Mui and Spackman Panjabi 2016). The City of Fort Collins in Colorado has been conducting treatments within Colorado butterfly populations on their property on the Wyoming border. They may be able to provide some information on their noxious weed treatment results.

Common Burdock (*Arctium minus*)

Management Urgency: Very High

Management Goals: Eradication

Photos: Left: Mature common burdock, ©2018 Glen Mittelhauser

Right: Flowering heads, photo © John Hilty 2002-2017

Photos: Left: First year rosette, Mary Ellen Harte, Invasive.org

Right: The inspiration for Velcro©, photo © 2018 Glen Mittelhauser

- Biennial, living up to four years (ISCB 2018).
- Reproduces only from seeds.
- First year growth is a basal rosette of thickly hairy leaves; second year is a multi-branched, erect stem 3 to 10 feet tall.
- Base of each flower has many hooked spines that, when dry, become easily dispersed burs.
- Burs gave rise to the idea of Velcro (ISCB 2018).
- Growth is from a fleshy brown taproot.
- A known nitrate accumulator (CSU 2011).

2018 Mapping

Common burdock was mapped for the first time at FEWAFB in 2014 (SWCA 2014). In 2018, the cover increased from 0.2 to 0.37 acres and its range expanded to the north (Table 4, Figure 5). Over 80% of the known individuals are documented from one occurrence along Crow Creek. Because of the fairly small size of the populations, the biennial life cycle and reasonably small number of occurrences, successful management and eventual eradication may be attainable. For these reasons, common burdock is given a rating of high urgency for management.

Table 4. Common burdock noxious weed survey results.

	2004	2014	2018
Occupied Acres	---	0.2	0.37
Estimated Number of Shoots	---	?	1,348
Number of Mapped Features	---	?	13

Recommendations

Actions that minimize soil disturbance while protecting intact native vegetation are recommended. Cutting common burdock plants below the root crown will kill the plant with minimal soil disturbance. Pulling up entire plants works in wet soils but creates a soil disturbance. Any plants with flowers or seeds should be bagged and removed from the site as common burdock is a prolific seed producer. Removing top growth is effective and fulfills the goal of keeping soils from being disturbed (USFS-USDA 2005, CDA 2009). Seeding of desirable native species on disturbed soils after common burdock is removed is recommended if areas of bare soil result from treatment where weeds could establish. Seeding efforts are a way to provide competition to common burdock seedlings that may germinate from the soil seedbank. Due to the small numbers, herbicides are not recommended. If herbicides are used, only targeted spot spraying of newly emerged seedlings in the fall, after the larger efforts of physical removal is recommended. If seeding is done after herbicide application, consider the residual effects of the herbicides used.

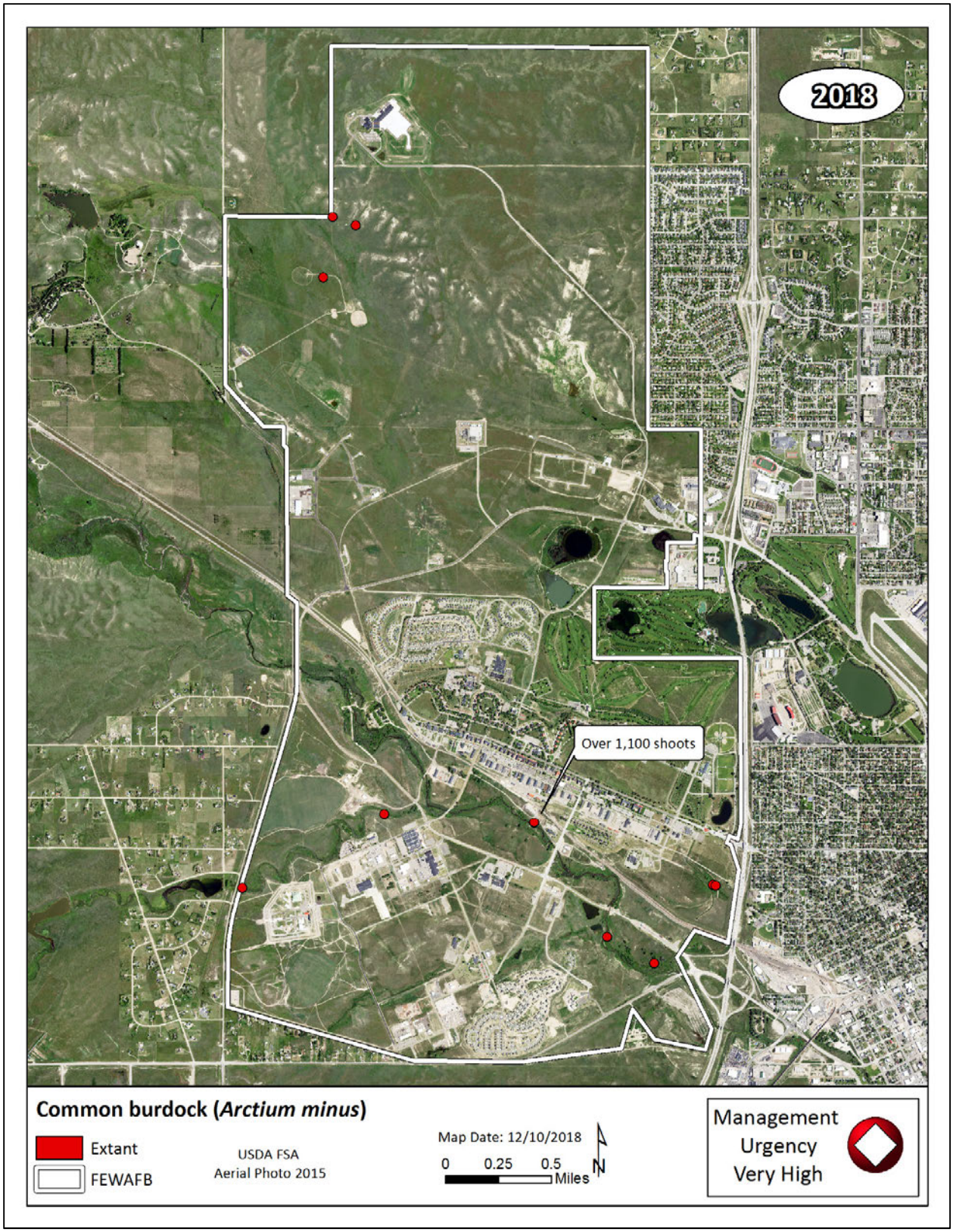


Figure 5. Distribution of common burdock at F. E. Warren Air Force Base in 2018.

Hoary Cress (*Cardaria draba*)

Management Urgency: Medium

Management Goals: Containment; protect uninfested areas from invasion and eliminate satellite populations

Photo: Hoary cress in flower at F. E. Warren Air Force Base, Georgia Doyle (CNHP)

Photo: Michelle Washebek (CNHP)

- Perennial that reproduces by seeds and lateral roots.
- Flowers May-June with seed set by mid-summer.
- Grows to 2 feet tall with root depths to 32 inches.
- Seed capsules heart-shaped.
- Does well on moist and alkaline soils.
- Numerous 4-petaled, fragrant, white flowers.
- Seed longevity is only 3 years (CCR 2014).

2018 Mapping

At FEWAFB, hoary cress (or whitetop) was mapped in upper Crow Creek in and adjacent to riparian areas and wet meadows preferred by the Colorado butterfly plant (Figure 6). Weed mapping in 2014 may have missed the full extent of hoary cress at FEWAFB due to the timing of fieldwork and may account for the smaller cover reported. In 2018, mapping was done during peak flowering times allowing for more accurate location of infestations. The mapped acreage of hoary cress declined by almost 35% from 2004 to 2018 (Table 5). Monitoring prior to changing any current, ongoing management activities should be prioritized to see if there is a natural cause for the decrease. After becoming well-established, natural decreases have been observed in hoary cress populations at the U.S. Air Force Academy in Colorado Springs, Colorado (Smith et al. 2018).

Table 5. Hoary cress noxious weed survey results.

	2004	2014	2018
Occupied Acres	23.7	0.4	8.2
Estimated Number of Shoots	?	?	305,980
Number of Mapped Features	?	?	111

Recommendations

Deep-rooted perennial species like hoary cress are difficult if not impossible to control once established and containment becomes the management strategy. Natural declines are the best possible outcome so monitoring to confirm declines should be a priority. Many sources recommend targeting treatments to new infestations or satellite populations that occur around the outside of existing populations. The creation of a site management plan (template in Appendix A) is recommended before any actions take place to make sure they are warranted and appropriate.

The Integrated Natural Resources Management Plan for FEWAFB states that mowing and spraying of riparian zones ceased in 1989 due to concerns about potential impacts to the Colorado butterfly plant (INRMP 2018). If hoary cress management occurs in other places or if herbicide applications resume near Upper Crow Creek, populations of hoary cress should be targeted using a backpack hand held sprayer or wick method both of which are recommended for natural areas (USFS-USDA 2014b). Plans should be in place for follow-up monitoring or treatments should not be undertaken.

Mowing is not recommended for natural areas and currently there are no known biocontrol organisms for hoary cress. It is important to note that if the timing of mowing or herbicide treatments is inappropriate, it can increase densities via spreading seeds and stimulating new shoots from underground root buds (USFS-USDA 2014b).

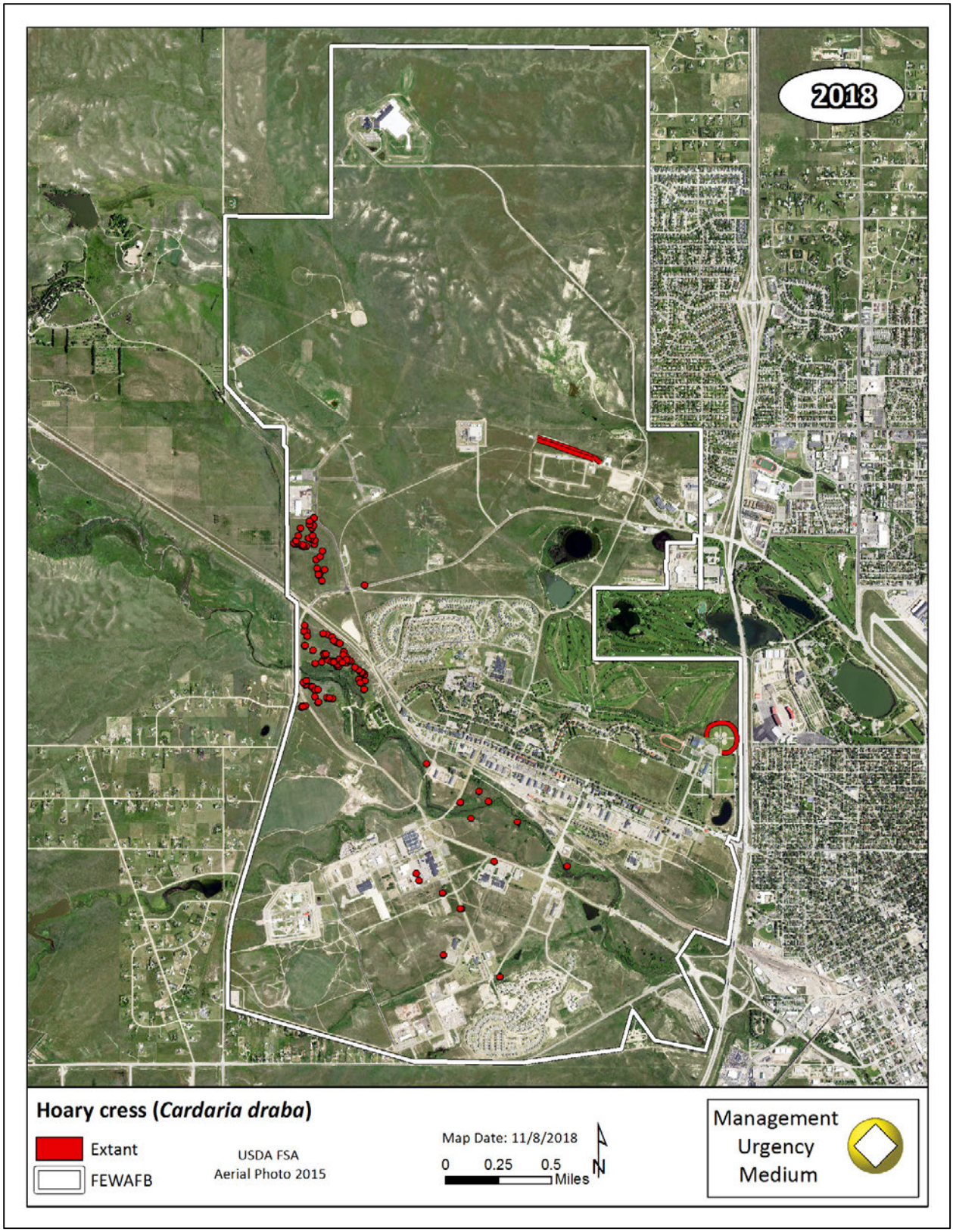


Figure 6. Distribution of hoary cress at F. E. Warren Air Force Base in 2018.

Musk Thistle (*Carduus nutans*)

Management Urgency: Very High

Management Goals: Eradication

Photo: Left: Musk thistle flowers, Michelle Washebek (CNHP) Right: Musk thistle plant, Wikimedia

- Biennial (winter annual) with a taproot.
- Reproduction only by seed.
- Rosettes form early spring, bolts in March to May.
- Plants die after seed set (CSU 2013b).
- Plants are impacted by drought.
- Seed longevity of 10 years (CCR 2014).

2018 Mapping

Musk thistle is present in very low numbers at FEWAFB covering less than a tenth of an acre in total. It was mapped at seven sites and in low densities. It went undetected during 2014 mapping efforts but a few plants were observed in 2004 (Table 6, Figure 7). A very high management urgency rank is assigned because plant numbers are so low that rapid response efforts have a high probability for successful eradication.

Table 6. Musk thistle noxious weed survey results.

	2004	2014	2018
Occupied Acres	?	---	< 0.1
Estimated Number of Shoots	?	---	59
Number of Mapped Features	?	---	7

Recommendations

Now is the time to eliminate musk thistle from the base as plant numbers are manageable and therefore eradication is a realistic goal. The best strategy for tackling musk thistle is through proactive actions which include monitoring for new occurrences and preventing unnecessary soil disturbance. Biennial species reproduce solely by seed production and are more easily controlled than deep-rooted perennial species with vegetative reproduction.

At FEWAFB, the small number of plants can be eradicated successfully using mechanical methods. Severing plants below the root crown before the plants bolt and set seed is a successful control method (CSU 2013b). It is important that flowers and seeds be removed if present and follow-up monitoring should be conducted. Digging up roots will cause localized disturbance to soil around the plants and can bring new weed seeds to the surface where they may germinate. With so few occurrences, herbicides are not recommended. However, if an herbicide is used, only targeted spot spraying of plants in the rosette stage is recommended with continued annual monitoring. Timing of herbicide applications and limiting overspray are key to a successful result. Overspray should always be avoided to limit impacts to desirable nearby plants that provide important competition. Limiting soil disturbance in efforts to remove musk thistle is important. Monitoring for up to ten years may be necessary because of seed longevity.

Figure 7. Distribution of musk thistle at F. E. Warren Air Force Base in 2018.

Canada Thistle (*Cirsium arvense*)

Management Urgency: Low

Management Goals: Monitor for new occurrences; suppression through mechanical, chemical and/or biological treatments could occur based on site plans.

Photos: Left: mature Canada thistle plant, NDSU. Upper right: Canada thistle rosettes, Oregon State University. Lower right: Canada thistle in seed by Jill Handwerk (CNHP), 2014.

- Perennial.
- Small, marble-sized flowering heads; male and female plants separate.
- Horizontal and vertical roots > 10 feet deep; stimulated by above ground treatments.
- Reproduction from root buds and seeds.
- 15,000 seeds per stem (Price 2018).
- Seed longevity 22 years with deep burial promoting longevity (CSU 2013a).
- Susceptible to shading and inundation.

Photo: Canada thistle on the north side of Upper Crow Creek August 2018, Lisa Tasker (CNHP)

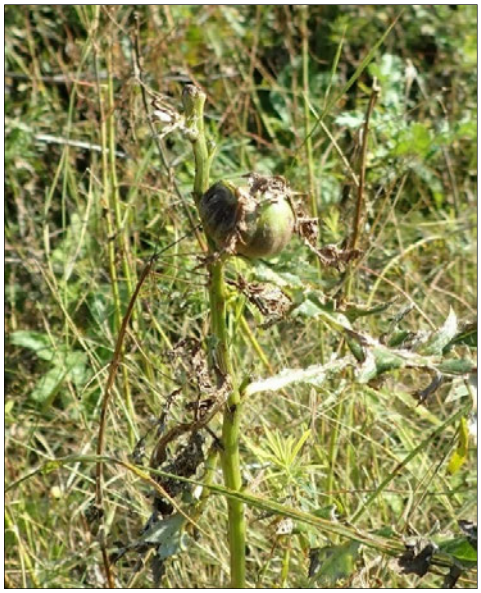
2018 Mapping

In 2018, greater than 10% (603 acres) of the landscape at FEWAFB was covered by Canada thistle. Occurrences have stayed between 9% and 11% cover for 14 years (Table 7). Of the noxious weeds on the base, only Dalmatian toadflax surpasses Canada thistle in distribution. The largest and densest populations are associated with water sources and natural areas, especially streams and drainages (Figure 8).

Table 7. Canada thistle noxious weed survey results.

	2004	2014	2018
Occupied Acres	660.6	533.1	603.1
Estimated Number of Shoots	?	?	9,753,243
Number of Mapped Features	?	?	583

Recommendations



FEWAFB 2018: Gall on Canada thistle likely caused by the gall fly *Urophora cardui*. Photo by Lisa Tasker (CNHP).

Coverage of Canada thistle is so extensive at FEWAFB that it is considered a low priority for eradication. The stability noted since 2004 may indicate Canada thistle has maximized its potential niche. Management of this species should focus on continued monitoring to determine if any increases are occurring or new populations are establishing. Creating a site plan to manage areas where treatments are being considered is highly recommended. This species is extremely difficult to control and can increase its footprint when the top growth is removed by mechanical or chemical methods. A promising biological control, the Canada thistle rust fungus (*Puccinia punctiformis*), is being distributed and researched in Colorado and is getting closer to being an option for managers to explore in the near future. This may offer promise even in the sensitive habitats or Conservation Zones (INRMP 2018) on FEWAFB. While the host-specific Canada thistle rust fungus has likely been around for a long time and found in every state, only recent research has outlined a way to utilize it as an effective biocontrol (CDA 2018).

The biocontrols *Urophora cardui*, a gall fly (see photo above), and *Hadroplontus litura*, a stem-mining weevil, have been around for over 40 years and are thought to be ineffective on a population level (CDA 2018).

Within the larger discussion for Canada thistle, there is no single treatment that will remove it from an infested site. Well-established populations react to most forms of treatment by increasing underground biomass. Typically, the treatment strategy for Canada thistle is to deplete underground reserves by utilizing multiple types of treatments over periods of years (5-10+ years). Even under the best of circumstances the result is almost always non-native plant cover. Often a non-native rhizomatous grass (especially if herbicides are used) or other noxious weeds colonize instead of native species (Pearson and Ortega 2009). For large dense stands where treatments are needed, a restoration plan is likely the best course of action.

Because of the tenacity of this species, close monitoring and the creation of site assessment plans before beginning any management actions are the best first steps to take before embarking on Canada thistle control activities (Assessment Worksheet for Weed Management Site Plan is in Appendix A). The most immediate recommended course of action is monitoring only to confirm continued stability in cover.

Use of herbicides in the natural areas at FEWAFB should only happen if careful spot applications are employed on Canada thistle and then only with a detailed site plan in place and a clear end goal.

Currently a common practice is to keep the size of treatment areas small and workable, ascertain potential impacts of your treatment and prepare not to treat if necessary. Then monitor the site post-treatment to decide whether to continue with previous control attempts and even expand them. Consider establishing photo monitoring plots to compare sites from year to year. The herbicide Milestone which is often used on Canada thistle, has a one-year soil residence time which could impact the establishment of desirable broad-leaved species. Most of the typical strategies and herbicides recommended for Canada thistle control are not designed for natural areas and wetlands.

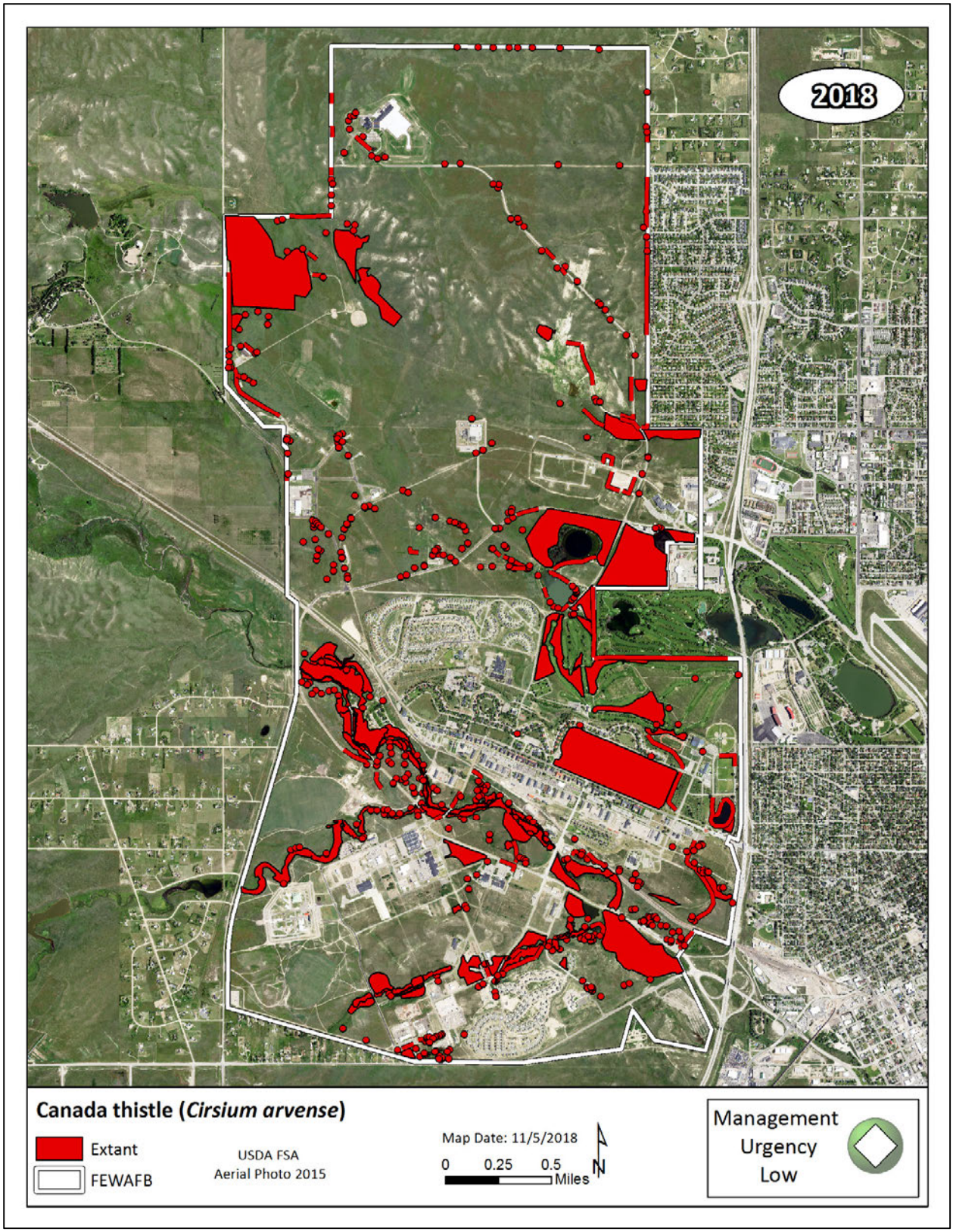


Figure 8. Distribution of Canada thistle at F. E. Warren Air Force Base in 2018.

Bull Thistle (*Cirsium vulgare*)

Management Urgency: Very High

Management Goals: Eradication. Monitor for new occurrences.

Photo: mature bull thistle in flower, kingcounty.gov

Photo: Top: bull thistle first year rosette, kingcounty.gov; Bottom: bull thistle flower with notable spines, wikimedia.org

- Branching, biennial forb.
- Sharp spines on leaf edges and stems.
- Reproduction only by seed.
- Seed longevity of 3 years with up to 4,000 seeds per plant.
- Short fleshy taproot with many primary roots.
- No rhizomes.

2018 Mapping

Although not on the Wyoming State Designated Weed and Pest list, bull thistle is on the Colorado noxious weed list. A single plant was found on the northeastern part of the base in 2018 (Table 8, Figure 9). This is the first time bull thistle has been documented at FEWAFB.

Table 8. Bull thistle noxious weed survey results.

	2004	2014	2018
Occupied Acres	---	---	< 0.1
Estimated Number of Shoots	---	---	1
Number of Mapped Features	---	---	1

Recommendations

Managers and contractors should become familiar with bull thistle to recognize new occurrences. The single occurrence found in 2018 should be eradicated as soon as possible. As with many biennial thistles, severing plants below the root crown before the plants bolt and set seed kills the plant. Extreme care should be taken not to disturb surrounding soils as much as possible. Monitoring the area for three years after management is advised due to seed longevity.

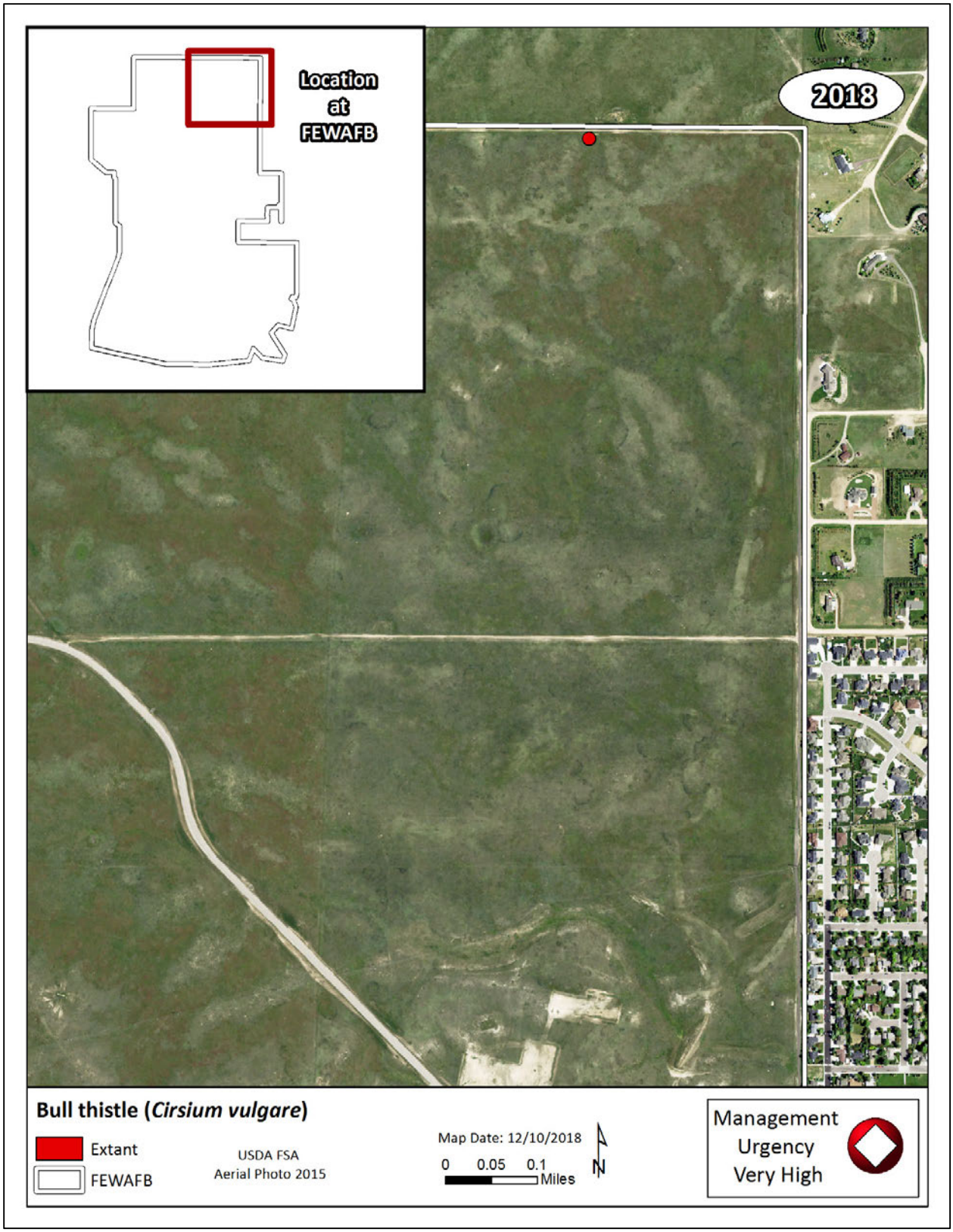


Figure 9. Distribution of bull thistle at F. E. Warren Air Force Base in 2018.

Diffuse Knapweed (*Centaurea diffusa*)

Management Urgency: Very High

Management Goals: Eradication. Monitor for new occurrences.

Photos: Top left: diffuse knapweed plant. Top right: diffuse knapweed mature flower. Flowers can be white or pink. Photos wikimedia.

Bottom left: rosette of diffuse knapweed. Photo North Dakota State University 2018.

- 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.
- Seed longevity of 8-10 years (CCR 2014) – wind dispersed.
- Provides nectar and pollen for honeybees.
- Highly competitive, rapid growth rate, long growing season and prolific seed production.

- Allelopathy is disputed as soil residuals are too low to cause mortality of plants.
- Plant has tumbleweed mobility.
- It forms rosettes in its early growth stage (1-2 years).
- Can sprout from the root crown after top-kill (Zouhar 2001).

2018 Mapping

Diffuse knapweed was found for the first time at FEWAFB during the 2018 survey. The total acreage of all 17 occurrences is less than a half-acre, the number of shoots is estimated to be over 2,000 (Table 9). Over 80% of shoots are clustered in the same area (Figure 10). Eradication is still possible at this stage.

Table 9. Diffuse knapweed noxious weed survey results.

	2004	2014	2018
Occupied Acres	---	---	0.46
Estimated Number of Shoots	---	---	2,404
Number of Mapped Features	---	---	17

Recommendations

Knapweeds become very difficult to control once they become established and when their total cover exceeds 2.5 acres (Zimmerman et al. 2011). Since the diffuse knapweed occurrence at FEWAFB is under a half acre, eradication is a reasonable goal. The key to effectively controlling knapweed is by preventing plants from flowering and going to seed during the growing season and by preventing ground disturbance from overspray or manual removal.

Lasting control of knapweeds is achieved with proper land management to maintain desired vegetation and limit disturbance. The mapped occurrences at FEWAFB are in the northwest portion of the base in the areas of modified shortgrass prairie where native species can provide cover after treatments. Control of diffuse knapweed is most effective in the first season of growth (Zouhar 2001).

Create a site plan before treatments are initiated that includes follow-up monitoring, timelines for activities, records of treatments, locations, photo plots for monitoring and adaptive management strategies (Appendix A). Knapweeds can increase if treatments are not carried out with a good plan and follow-up monitoring protocol (Pearson and Ortega 2009). Pulling plants is effective for small populations (Jefferson County 2019). If using herbicides, apply before the mature plants set seed, or to rosettes in the fall to maximize effectiveness. Herbicides can be applied using a backpack sprayer or a wick application for small areas to minimize damage to non-target plants providing competition to knapweed. Herbicides can create unintended soil disturbances by increasing bare ground, changing soil pH and the balance of soil organisms, and negatively impacting surrounding native plants.

Figure 10. Distribution of diffuse knapweed at F. E. Warren Air Force Base in 2018.

Field Bindweed (*Convolvulus arvensis*)

Management Urgency: Low

Management Goals: Reduce disturbances that may encourage spread. Watch for new occurrences for rapid response.


Photos: Left: Field bindweed in flower, wikimedia.org Right: Prostrate, twining stems, NDSU online

- Perennial vine arising from deep, persistent spreading roots (tap root and rhizomatous 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.
- Dry to moderately moist disturbed soils.
- Early successional species that establishes on bare ground in open conditions.

Field bindweed will opportunistically invade bare ground and often areas with continually high rates of disturbance (photo below). It is considered an early successional species that may decrease on its own over time. Field bindweed is difficult to treat once it becomes established because of deep root systems that include both a tap root and lateral roots. Eradication at FEWAFB is considered unlikely due to widespread cover and the management urgency is considered to be low. Reproduction is by seed and root buds. Of interest is mule deer populations have been documented eating field bindweed (Zouhar 2004).

2018 Mapping

Field bindweed is found across the base and typically in highly disturbed areas near roads, parking lots and buildings. Because of the ubiquitous magnitude of field bindweed, mapping was done opportunistically compared to the mapping of all other weed occurrences in 2018, so the full extent of field bindweed is likely higher than the 8.9 acres captured (Table 10, Figure 11).

Photo: Field bindweed is often found in the highly disturbed areas along roads, CNHP.

Table 10. Field bindweed noxious weed survey results.			
	2004	2014	2018
Occupied Acres	95	6.6	8.9
Estimated Number of Shoots	?	?	174,840
Number of Mapped Features	?	?	131

Recommendations

For established populations of field bindweed, a site plan is highly recommended to determine the necessity of treatment and the goals (Appendix A). Because field bindweed is always associated with disturbances, prevention is the most efficient and effective method to prevent spread. Avoid management activities that encourage invasion and be prepared to eradicate small, new infestations that may follow any disturbances. Monitoring may be the best activity at this time with resources better spent on managing other noxious weeds at FEWAFB.

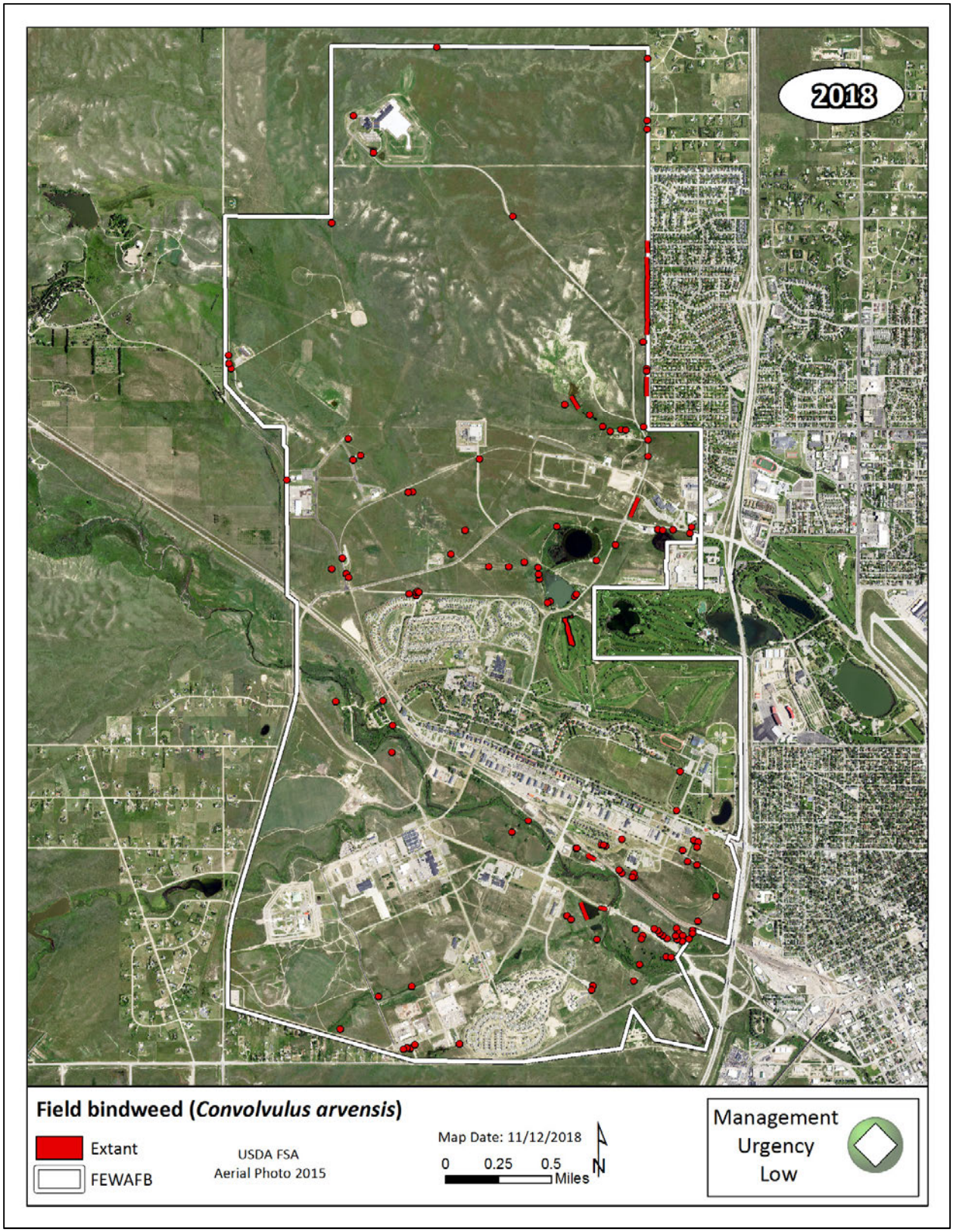


Figure 11. Distribution of field bindweed at F. E. Warren Air Force Base in 2018.

Houndstongue (*Cynoglossum officinale*)

Management Urgency: Low

Management Goals: Containment

Photos: Top left: Houndstongue in fruit and flower, Georgia Doyle (CNHP) Top right: Houndstongue rosette, wikimedia.org

Bottom photo: FEWAFB houndstongue occurrence 2018, Georgia Doyle (CNHP)

- Biennial.
- Reproduction only by seed.
- Flowers May-July.
- Thick, black, woody taproot.
- Forms rosette first year.
- Seeds fall close to plant but Velcro©-like seeds allow transport by animals.
- Seed longevity of 3-5 years (CCR 2014).

2018 Mapping

As the fourth most common noxious weed at FEWAFB (just shy of 100 acres in 2018), houndstongue is widely distributed, primarily on wetter landscapes on the base. The majority of occurrences were mapped in the drainages and natural areas on the southern end of the property. Houndstongue was often found co-occurring with Canada thistle and leafy spurge on wetter sites. Populations were commonly recorded growing together with leafy spurge under the willows and woody riparian vegetation on Crow Creek and in many areas supporting the Colorado butterfly plant. Eradication is not a reasonable goal with widespread coverage and over 99 acres mapped (Table 11 and Figure 12).

Table 11. Houndstongue noxious weed survey results.

	2004	2014	2018
Occupied Acres	50.2	165.8	99.3
Estimated Number of Shoots	?	?	261,453
Number of Mapped Features	?	?	250

Recommendations

Site plans should be created before future treatments are initiated to effectively keep track of goals, unintended impacts and to follow any trends that unfold for houndstongue populations (Appendix A). Currently there is complete curtailment of any weed control in Colorado butterfly habitat (SWCA 2014), but if weed control strategies are revisited, creation of a site plan would be a critical first step (Appendix A). Potentially hosting weed pulling events for houndstongue is mentioned in the 2018 INRMP for the base and creating a site plan prior to these activities is highly recommended due to the potential to create soil disturbances that could exacerbate weed cover. Without proper training on how to remove the plants with minimal soil disturbance, flower and seed removal and plans for follow-up monitoring post treatments, houndstongue could expand.

Assessments of the disturbance regimes in the areas supporting houndstongue, Canada thistle and leafy spurge should be completed. If ongoing or periodic disturbances such as unnatural hydrologic perturbations cannot be manipulated or altered favorably, then weed treatment activities may actually not make sense. The unnatural levels of disturbance may be supporting weed expansions and invasions. The flow regime on Crow Creek, a perennial stream, is impacted from its use as a municipal water source upstream. Additionally, its flows are greatly curtailed in years of water shortage (INRMP 2018). These impacts to natural flows, the addition of nutrients from pollution, along with the presence of relatively coarse soils may cause dry years to be exaggerated (Heidel et al. 2018) whereby native vegetation becomes stressed opening up opportunities for weed expansion. The upper reaches of Crow Creek are managed for the Colorado butterfly plant as are sections of the unnamed creek and all of Diamond Creek at FEWAFB (INRMP 2018). The majority of houndstongue management decisions will be entirely dependent upon plans for Colorado butterfly plant populations at these sites.

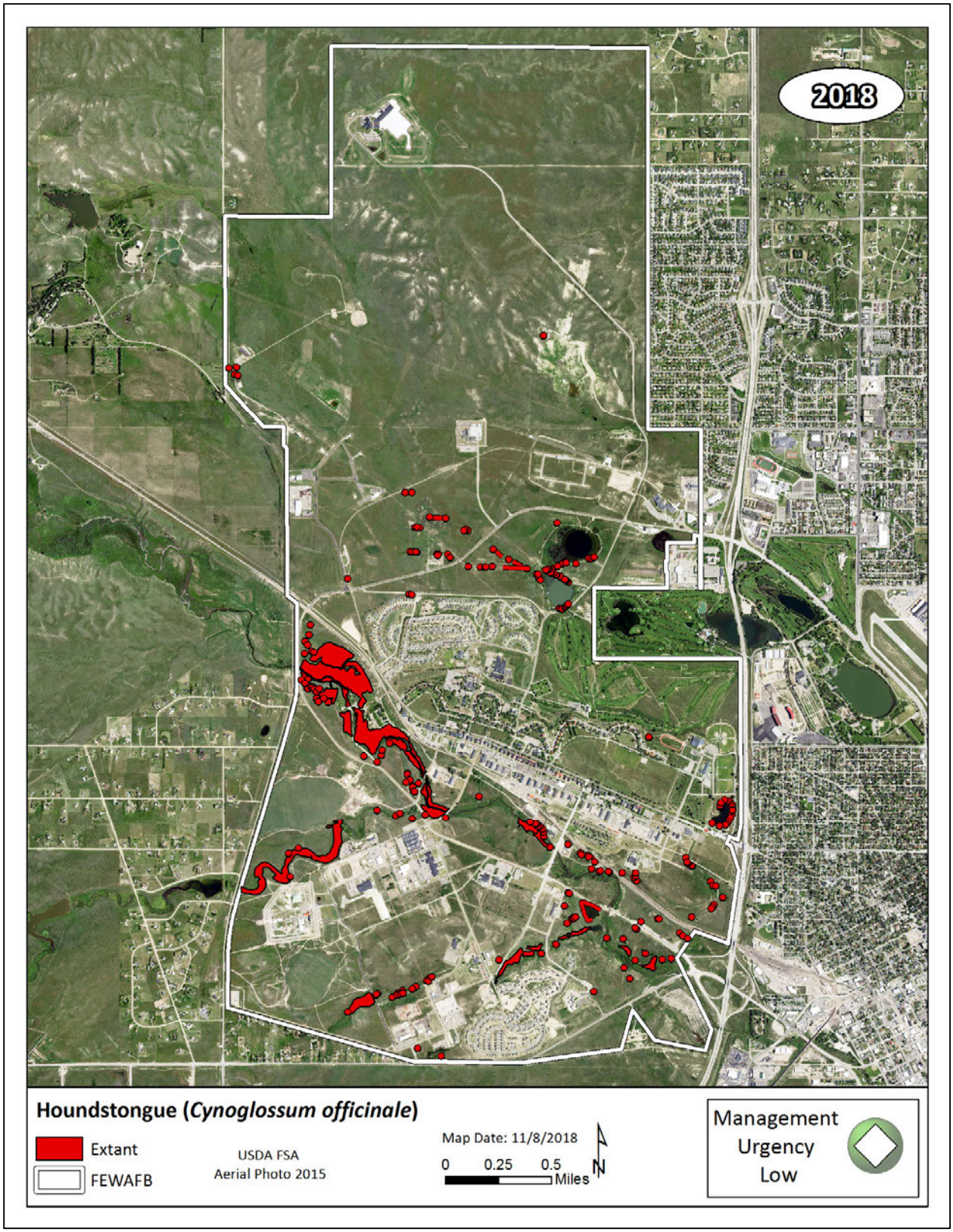


Figure 12. Distribution of houndstongue at F. E. Warren Air Force Base in 2018.

Common Teasel (*Dipsacus fullonum*)

Management Urgency: High

Management Goals: Contain and keep from going to seed; eradication may be possible

Above photo: mature common teasel, wikimedia.org

Above photos, wikimedia.org: top left: flowering head; top right: first year rosette; bottom photo: mature common teasel stands can become very dense, kingcounty.gov

- Biennial, sometimes monocarpic perennial forb.
- Only reproduces from seed.
- Up to 34,000 seeds per plant (King County 2018).
- Basal foliage is prickly, especially the distinct, white midrib on the leaf's underside.
- Individual lilac colored flowers bloom in a spiral around the egg-shaped, spiny heads.
- Can grow taller than 6 feet.
- Seeds fall near the plant but often moved by water, mowers, soil movement and animals.
- Deep taproot up to 2 feet long.

Common teasel has distinctive spiny seed heads that are popular in floral arrangements. It now occurs from coast to coast in the U.S. after first being introduced in the 1700's (King County 2018). Common teasel is most often found on roadsides, waste areas, agricultural fields, swales, and pastures which are often areas with significantly wetter conditions than surrounding uplands.

Plants grow as rosettes for one or more years (monocarpic perennials) until resources are built up enough to flower and set seeds. Reproduction is entirely from seed. Plants can have between 1 and 40 flowering heads with each head producing on average 850 seeds or up to 34,000 seeds per plant. Seed viability is 14 years. Most seeds fall near the parent plant but can be moved to new locations by mowing, water, soil movement and animals. Plants grow from deep taproots up to 2 feet long and an inch wide at the crown (King County 2018).

2018 Mapping

Common teasel was mapped on 1.4 acres on the southeast part of FEWAFB (Table 12 and Figure 13). This 2018 season was the first year common teasel was mapped, although Natural Resources Managers have known of its presence since 2016 and are mechanically treating it with follow-up monitoring (Pers. comm. Alex Schubert USFWS). Most plants were removed prior to mapping and 2018 estimates were provided to CNHP by Natural Resources Managers.

Table 12. Common teasel noxious weed survey results.

	2004	2014	2018*
Occupied Acres	---	---	1.4
Estimated Number of Shoots	---	---	2,138
Number of Mapped Features	---	---	4

*Estimates provided by FEWAFB Natural Resources Managers.

Recommendations

Resource managers at FEWAFB are hand digging small populations of common teasel (Pers. comm. Alex Schubert USFWS). Pulling the entire plant for small sprouts is acceptable. There are other mechanical methods to consider that cause less soil disturbance for established plants. The protection of any intact vegetation is the first goal and best protection against increasing this or other weeds. Severing the root crown of the plant (section below the soil surface) with a sharp knife or digging tool at various stages of growth will kill plants (Duncan 2018). For follow-up monitoring after treatments when small sprouts are present, the entire plant can be pulled. For dense infestations where removal would cause a large area of open soil, cutting bolting or flowering stems has also been shown to significantly reduce seed viability and production. In experiments it was found that teasel stems cut before flowering would regrow but with significantly fewer flowerheads than uncut plants and stems cut during or after flowering produced no new flowerheads. In addition, the seeds in flowerheads of plants cut during or immediately after flowering failed to germinate (Cheesman 1998). Therefore, significant seed reduction is possible with correctly timed stem cutting.

A site plan should be created for teasel treatments as soon as possible. Creating a clear plan for treatments and follow-up monitoring are essential to control. Sizing up the entire infestation, visualizing the desired result, timelines for follow-up monitoring from actions and knowing what species are likely to replace the invader as well as estimating the resources needed to be successful is extremely important at this stage. The coverage of teasel is significant and approaching a level where eradication is not going to be likely, even though it is localized, if it is not treated appropriately. Conduct follow-up monitoring post-treatment to see results and take necessary action because the possibility for not gaining control or even causing increases are high.

There are riparian and wetland appropriate herbicides available for the treatment of common teasel, but if success can be achieved with mechanical treatments at FEWAFB, then chemical control options can be put on hold. Herbicides can create a new set of problems, such as destroying soil microbes, prohibiting germination of other desirable plants, and increasing the mortality of surrounding desirable vegetation. Using herbicides in wetlands is even more problematic. The location of surface water, depth to groundwater and sensitivity of the site to trampling when applications occur as well as timing can determine outcomes. Impacts to water quality and local fauna are also important to consider as is off target damage to other plant species (The Nature Conservancy 2010). Replanting can also be an issue.

Monitoring of treatment sites may need to occur for up to 14 years after successfully controlling infestations. There are currently no biological controls available for common teasel.

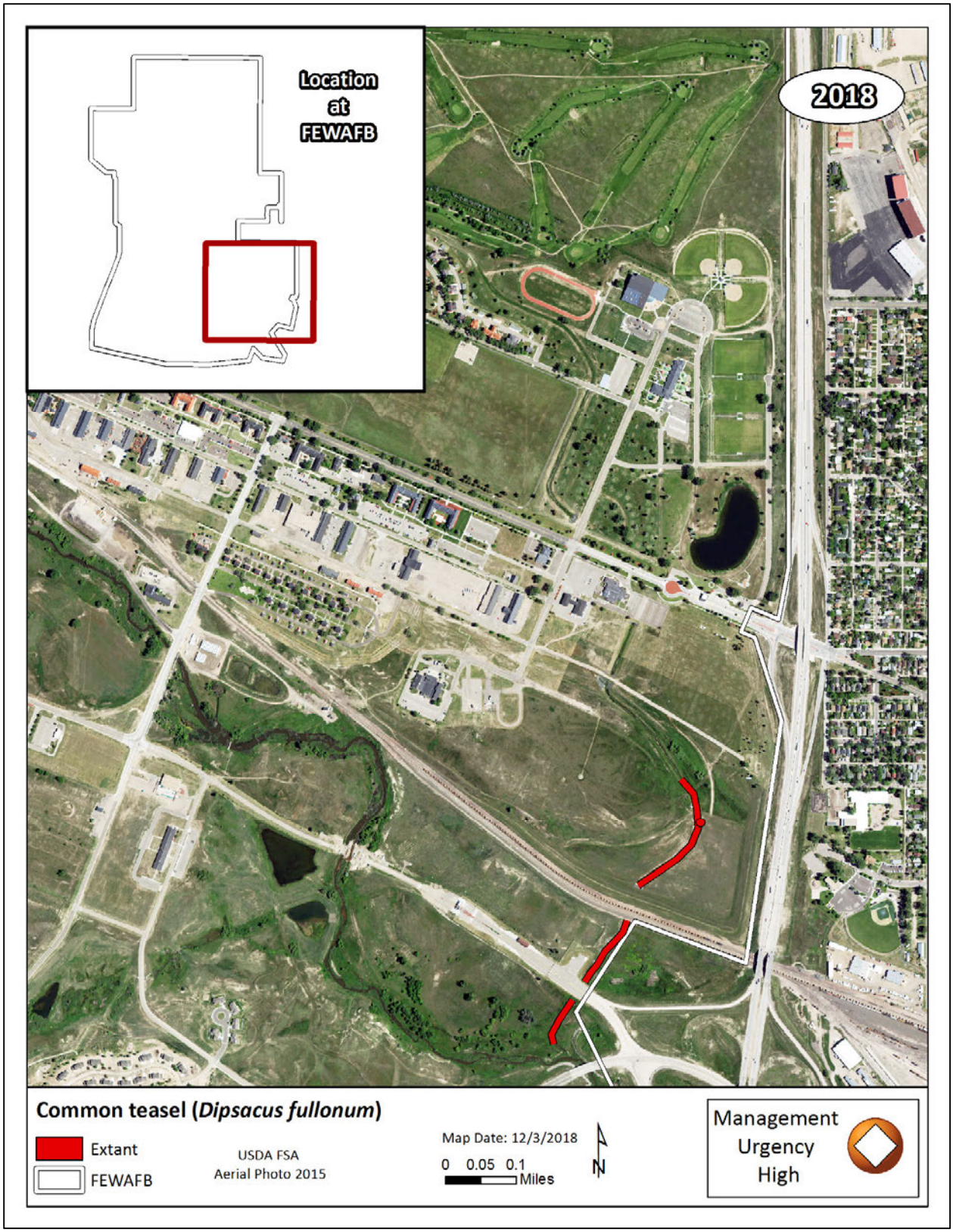


Figure 13. Distribution of common teasel at F. E. Warren Air Force Base in 2018.

Russian Olive (*Elaeagnus angustifolia*)

Management Urgency: High

Management Goals: Containment

Photo: mature Russian olive, Wikimedia.org

Photo: fruits of Russian olive, Wikimedia.org

- Ability to establish in the absence of disturbance (Montana Audubon 2010).
- Seeds are largely dispersed by birds and mammals.
- Can enhance wildlife in disturbed environments where native species have been removed.
- May or may not rapidly spread depending on site characteristics.
- Injured trees sprout.
- Difficult to control once established.
- Nitrogen-fixing capabilities.
- Intentional planting in the U.S. since the early 1900's until recently.

2018 Mapping

Many of the Russian olives at FEWAFB are mature trees that were intentionally planted at one time in the developed areas of the base. The numbers of trees are at a level where elimination is possible and the management urgency is ranked as high. There were 42 mapped features with a total of 87 individuals located at the western and southern edges of the golf course (Table 13 and Figure 14). There was evidence of control treatments along Crow Creek.

Table 13. Russian olive noxious weed survey results.

	2004	2014	2018
Occupied Acres	---	4.2	1.5
Estimated Number of Shoots	---	?	87
Number of Mapped Features	---	?	42

Recommendations

The first priority for Russian olive should be containment. Crow Creek, Diamond Creek and the unnamed drainage should continue to be prioritized for the removal of any new sprouts as they are discovered. In natural areas, sprouts and seedlings can be removed by hand-pulling. As the plants get larger but still less than 3.5 inches in diameter trees can still be removed with a hoe or other tool. Once the plants get larger than 3.5 inches in diameter, you need to combine herbicide with physical methods at the appropriate time of year. A basal bark treatment method can be used in early spring or late winter when the plants will take up herbicide. Consult a knowledgeable applicator who will treat trees individually with the appropriate herbicide (USDA 2017a).

In areas where large trees are established it is very difficult to control Russian olive without habitat disruptions. If removal of large areas of overstory Russian olive trees is desired, a site plan should be created. Mature trees have been present for years and birds and other animals likely use them for breeding, food and nest construction. Quick removals will resemble a clear cut, opening up areas and soils to light and disturbances which could lead to increases in other weeds or the spread of non-native rhizomatous grasses like smooth brome (*Bromus inermis*) that can form monocultures in riparian areas. It is also important to remember that cutting, girdling, and even stump removal can lead to resprouting. Treating fresh cut stumps or girdling scars with an appropriate herbicide can eliminate this problem.

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

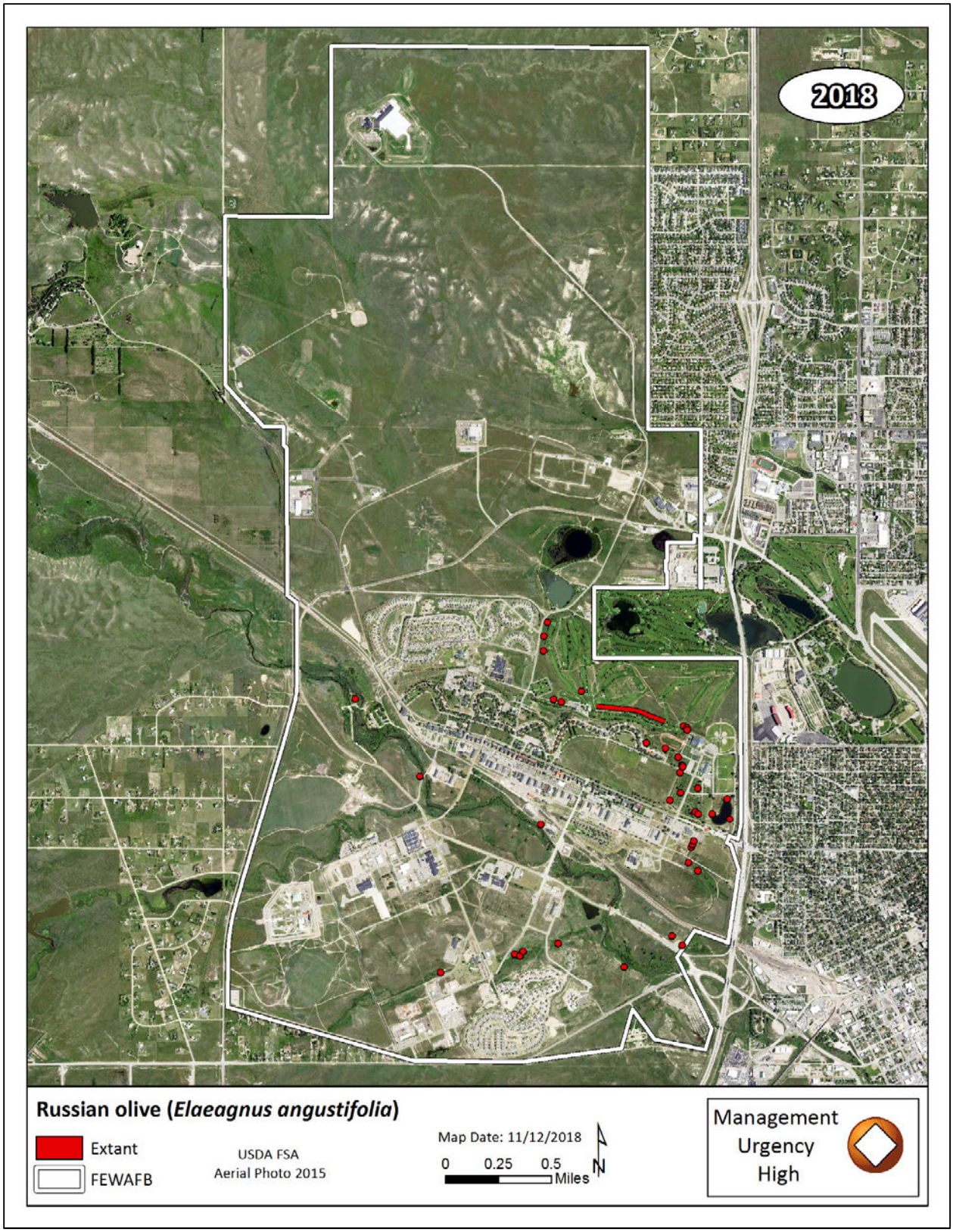


Figure 14. Distribution of Russian olive at F. E. Warren Air Force Base in 2018.

Leafy Spurge (*Euphorbia esula*)

Management Urgency: Low

Management Goals: Monitor existing populations for biocontrol. Monitor and control new occurrences.

Photo: leafy spurge plant, no flowers, Lisa Tasker (CNHP)

Top photo: leafy spurge flowers. Bottom photo: milky latex. Lisa Tasker (CNHP)

- Perennial with extensive root system that can reach 15 feet in depth.
- Reproduction from seed and root buds, seeds ejected up to 15 feet from plant.
- Plant has white milky sap.
- Seed longevity 8+ years, peak production in May.
- Young plants easily mistaken for yellow toadflax.
- Grows very early in the spring.
- Extremely difficult to control (CWMA 2017).

2018 Mapping

Leafy spurge was mapped across 143.4 acres primarily in the creek and drainage areas on FEWAFB (Table 14 and Figure 15). It was commonly found co-occurring with Canada thistle and houndstongue. No occurrences were mapped in the northern undeveloped areas of the base in the modified shortgrass prairie.

Table 14. Leafy spurge noxious weed survey results.

	2004	2014	2018
Occupied Acres	28.4	134.0	143.4
Estimated Number of Shoots	?	?	5,621,166
Number of Mapped Features	?	?	101

Recommendations

The leafy spurge populations are well-established and cover large areas of FEWAFB. Due to copious seed production and extensive root systems, large occurrences of leafy spurge are extremely difficult to successfully manage. Eradication is not likely. Biocontrol organisms are available and may be the best hope for impacting large infestations. If any biocontrol agents have been released, monitoring for their continued presence before taking any next steps should be pursued along with creating site plans (Appendix A).

Photo: A large field of flowering leafy spurge at lower Crow Creek FEWAFB, Georgia Doyle (CNHP).

If grazing is used to try to lower seed production, the first step is creating a site plan. A site plan is critical to understanding how to respond to effects from management decisions. Sheep and goats will readily graze young leafy spurge plants and are not as susceptible to poisoning as other livestock. Sheep can graze leafy spurge closely and have been widely used because of this. However, timing and duration are critical to depleting seed production and keeping grazing from unfavorably impacting desirable vegetation already providing competition to leafy spurge plants. Some information suggests that light grazing has been shown to trigger a shift in a plant community to less dominance by leafy spurge as a result of tannins produced in response to being clipped and these in turn trigger spurge plants to reduce energy spent on new growth (USFS-USDA 2014c).

In a study in Rocky Mountain National Park in Colorado (Pritekel et al. 2006) both chemical and mechanical treatments resulted in impacts to soils, soil biota and native plant species that were equally as problematic as the presence of leafy spurge. This calls into question the efficacy of treating these plants in habitats where native vegetation needs protection. Other studies have proven that disturbance of soils will encourage the growth of leafy spurge or other non-native species and this can happen through both chemical and mechanical treatments targeted for leafy spurge plants (Nicholas et al. 2008). Impacts to native plant cover and to soil chemistry from disturbance (including herbicides) should be top considerations in order to protect soils and prevent leaving bare soil areas where other undesirable species can move in. In addition, natural declines have been documented after 10 years of no treatments in areas where the disturbance pressure is removed in a natural area setting (Smith et al. 2018). Creating and maintaining site plans (Appendix A) prior to any treatment decisions is critical to being successful and understanding management impacts of this difficult to manage species.

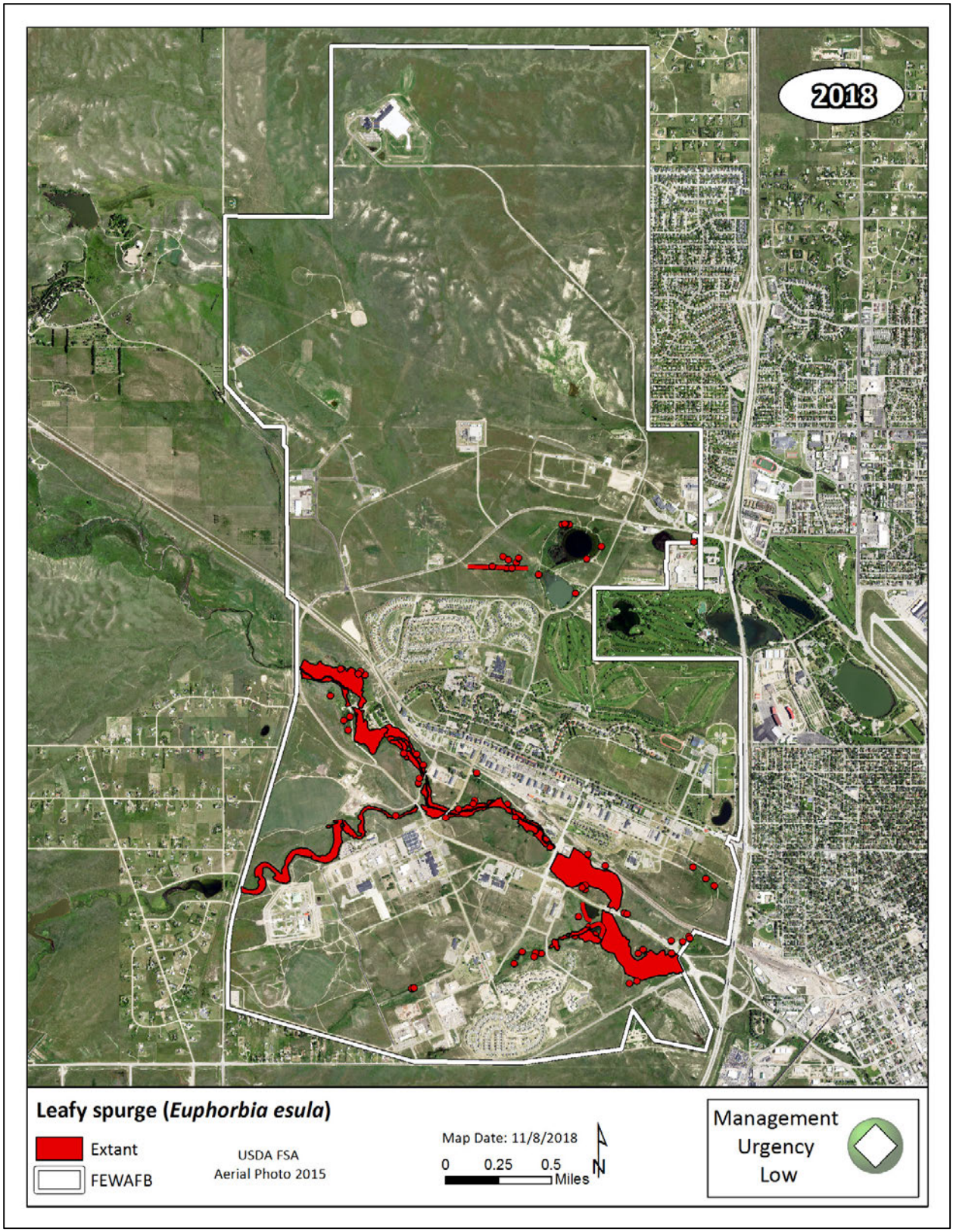


Figure 15. Distribution of leafy spurge at F. E. Warren Air Force Base in 2018.

Baby's Breath (*Gypsophila paniculata*)

Management Urgency: Very High

Management Goals: Eradicate and continue monitoring.

Left: mature common baby's breath, wikimedia.org

Right: Common baby's breath flowers, wikimedia.org

- Inflorescence open and panicle-like with numerous, small white flowers.
- Plants break off at ground level and tumble with the wind.
- Leaves opposite and stems swollen at the nodes.
- Reproduction from seed with up to 14,000 seeds per plant (DiTomaso et al. 2013).
- Seeds survive 1 or 2 years and require little to no dormancy period (DiTomaso et al. 2013).
- Regrows after mowing.

Baby's breath is an escaped ornamental that infests rangeland and pastures in several areas of the western U.S. It is a perennial with branching stems that, when dry, can break off and move in the wind like a "tumbleweed" similar to Russian thistle (*Salsola iberica*) and tumble mustard (*Sisymbrium altissimum*). Baby's breath has a large, deep taproot that allows it to survive well in dry soil conditions. Roots can penetrate soils to depths of 13 feet (DiTomaso et al. 2013). Seeds are small and black resembling black pepper, and can germinate in 10 to 15 days. Plants are difficult to remove once established and can produce millions of seeds in a small area.

2018 Mapping

Baby's breath was mapped for the first time at FEWAFB in 2018. A total of nine features were collected for a combined total of less than 1/10th of an acre (Table 15 and Figure 16). Plants were observed in the northern modified shortgrass prairie close to roads or fence lines. The potential for eradication is high due to the low coverage and number of individuals.

Table 15. Baby's breath noxious weed survey results.

	2004	2014	2018
Occupied Acres	---	---	< 0.1
Estimated Number of Shoots	---	---	76
Number of Mapped Features	---	---	9

Recommendations

Preventing seed production and suppressing the root system is the best goal for mature, well-established plants. The recommended mechanical method for removal by the Nature Conservancy is to use a flat-nosed spade placed close to the base of each baby's breath plant and pushed into the soil at a sharp downward angle so that the tap root is severed as far below ground as possible. The goal is to sever the tap root below the caudex (the point where the root becomes the stem) with the least soil disturbance. If severed below the caudex the plant cannot resprout; if severed above the caudex, the plant has the chance to resprout (https://wiki.bugwood.org/Gypsophila_paniculata).

Mowing has not resulted in noticeable decreases in populations in northeastern California (DiTomaso et al. 2013).

A number of herbicides are labeled for the control of baby's breath. However, due to the small size of the population and the fact there is an effective mechanical control, herbicides are not recommended in natural areas but could be considered for roadsides. Timing for applications for most are post-emergence to spring growth or spring rosettes and even bolting plants with green basal leaves. If herbicides are used, a site plan should be in place first for natural areas. Herbicides can be applied using a backpack sprayer or a wick application for small areas to minimize damage to non-target plants providing competition nearby. Herbicides can create unintended soil disturbances by increasing bare ground, changing soil pH and the balance of soil organisms, and negatively impacting surrounding native plants. Therefore, herbicide treatments should be conducted with great care and careful monitoring in order to alter management strategies if applications begin causing more problems than they are solving.

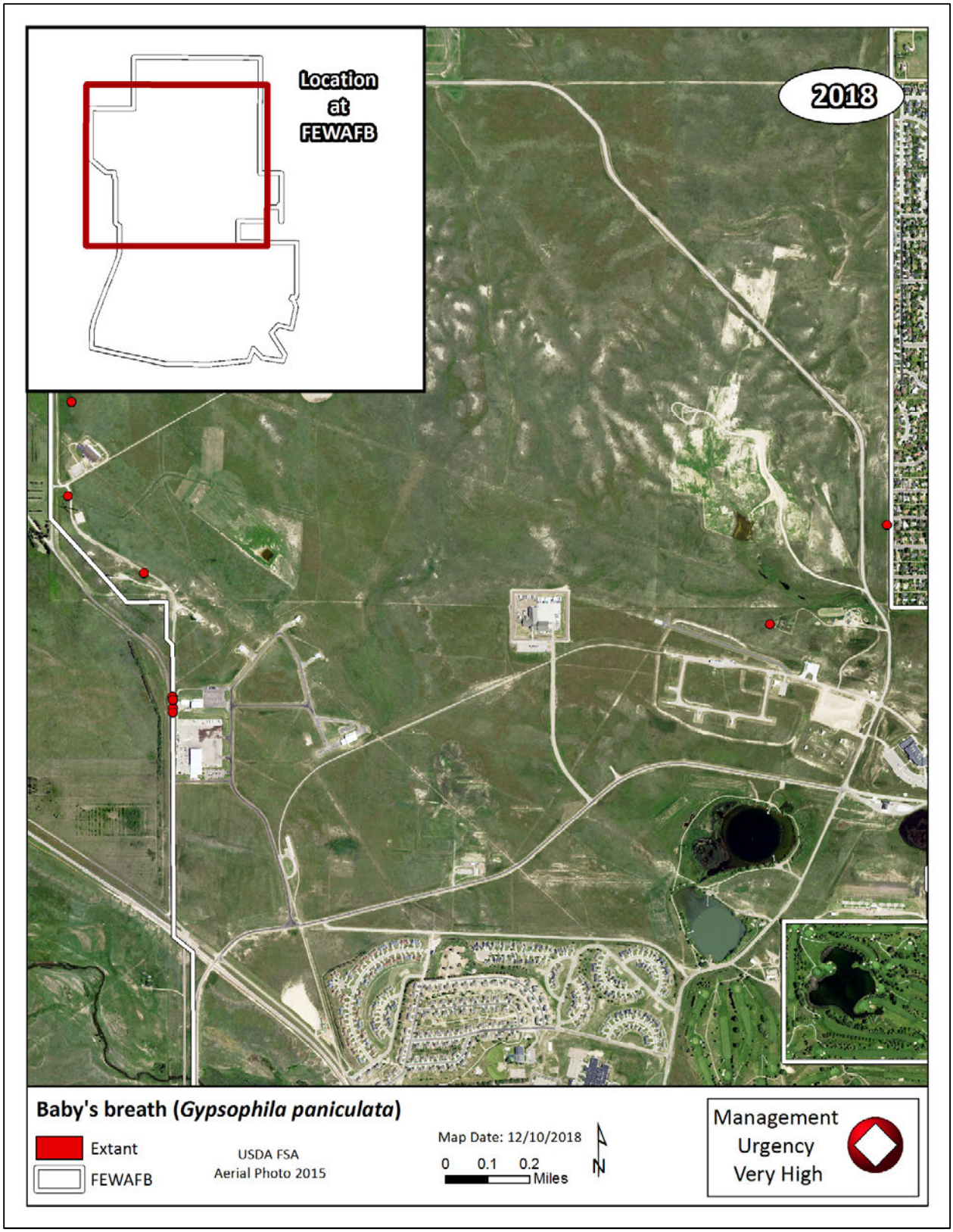


Figure 16. Distribution of baby's breath at F. E. Warren Air Force Base in 2018.

Dalmatian Toadflax (*Linaria dalmatica*)

Management Urgency: Low

Management Goals: Utilize existing biocontrols. Establish long-term monitoring plots.

Left photo: Dalmatian toadflax flowers, kingcounty.gov Right: mature plants, CSU Stephen Asmus

- Perennial forb.
- Prefers disturbed areas.
- Escaped garden plant that flowers May to June.
- A single plant can produce 500,000 seeds with viability up to 10 years.
- Reproduction by seeds and root buds.
- Extensive root systems in established populations can spread quickly.
- Difficult to control (USFS-USDA 2014a).
- Plants commonly only live up to 3 years (Weed and Schwarzlander 2014).

2018 Mapping

Dalmatian toadflax is the only noxious weed on FEWAFB that was not mapped in 2018 due to the wide distribution, especially in the northern part of the base, with 3,913 acres mapped in 2014 (Table 16). Attempting to map Dalmatian toadflax is cost prohibitive across ~6,000 acres and eradication is not likely at this stage of infestation. The plants occur in patches and often with low cover. The base has used the biocontrol *Mecinus janthinus* as recently as 2012, as well as herbicide applications in the past to decrease the footprint of Dalmatian toadflax (Alex Schubert 2018 personal communication).

Table 16. Dalmatian toadflax noxious weed survey results.

	2004	2014	2018
Occupied Acres	50.2	3,913	---
Estimated Number of Shoots	?	?	---
Number of Mapped Features	?	?	---

According to Alex Schubert:

> *Biocontrol agent releases started in 2004, with* Mecinus janthinus*, and follow-up releases occurred periodically until 2012. In addition,* Brachypterolus pulicarius *has been documented on the base, but not released by the base. There is also an experimental project where University of Wyoming researchers are evaluating the potential effects of sheep grazing to reduce the need for chemical control of Dalmatian toadflax.*

<u>Biocontrol Discussion</u>

In 2012, it was discovered that *Mecinus janthinus* (stem-mining weevil) is not effective for Dalmatian toadflax control (Sing et al. 2015). In the newsletter (Bean 2012) produced by the Colorado Department of Agriculture Palisade Insectary, an article discusses the discovery that *Mecinus janthinus* actually only has an appetite for yellow toadflax (*Linaria vulgaris*). *M. janthinus* is now officially called the "yellow toadflax stem-mining weevil" and the discovery was made that another weevil unidentified at the time, *Mecinus janthiniformis* was typically among the releases that were thought to only be *M. janthinus* (Sing et al. 2015). *M. janthiniformis* is now referred to as the "Dalmatian toadflax stem-mining/boring weevil" as it only has an appetite for Dalmatian toadflax. The original releases of *Mecinus janthinus* are suspected to have included both insects even though they were thought to only be *Mecinus janthinus* because both insects now have widespread establishment. Morphologically they look very similar and that's the reason why *M. janthiniformus* went undiscovered for many years.

Unfortunately, both of these insects were often not in meaningful numbers needed for plant impacts in those releases (Sing et al. 2015, Parker and Gassman 2016). The Palisade Insectary explicitly received the newly identified *M. janthiniformis* for the first time in 2012 from Montana. So if earlier releases of *M. janthinus* for Dalmatian toadflax by chance did not have meaningful

numbers of *M. janthiniformis*, impacts to selected sites would have been very poor. The discovery of two species of weevil was a breakthrough for better understanding the use of these stem-mining weevils (Sing et al. 2015).

In Canada, *M. janthiniformis* has been reported to be the most successful biocontrol released for Dalmatian toadflax (Parker and Gassman 2016). Some sites have had better control than others and differences in severe winter temperatures, rainfall, and Dalmatian toadflax density dependent processes are thought to be important factors (Weed and Schwarzlander 2014). Because adults overwinter in the stems, they are thought to be particularly susceptible to losses at sites subject to large fluctuations in winter temperatures and also influenced by inadequate insulating snowpack depths (Sing et al. 2015). Besides many successes in Canada, some of the more disappointing results may also be due to the wrong *Mecinus* species being released.

A study in Idaho across 17 counties and across nine ecoregions was conducted through the University of Idaho where it was found that ramet (number of stems from a single individual) densities of Dalmatian toadflax were strongly influenced by both precipitation and the abundance of *M. janthiniformis* (Weed and Schwarzlander 2014). Sites were selected for monitoring vegetation changes following the release of weevils and monitored up to 11 years afterwards. Higher weevil abundance was correlated with decreased ramet densities and toadflax growth rates. The study also found that ramet densities were also influenced by precipitation with increases in ramet densities following increased winter precipitation. Other studies have also found regional declines in Dalmatian toadflax patch density, cover, and height have been credited to the release of *M. janthiniformis* (Weed and Schwarzlander 2014, Sing et al. 2015).

An annual program of counting the adult stem-mining weevils has proven to be a cost-effective method for gauging expected impacts from biocontrol releases (Weed and Schwarzlander 2014). Because of the influence of precipitation, land managers are also encouraged to annually record winter precipitation in conjunction with annual weevil abundance assessments in order to analyze and distinguish precipitation effects on a biological control program. In the Idaho study, toadflax ramet densities declined at all sites where *M. janthiniformis* had been present for greater than six years. The sites with the lowest ramet densities had resident weevil populations for at least nine years. Long-term monitoring appears to pay off as sites during the first four years of the study tended to be highly variable in the magnitude and direction of impacts, revealing longer term monitoring was key to understanding biocontrol trends were actually more promising.

Key findings:

1.) *M. janthiniformis* is having an impact on *L. dalmatica* growth rates in numerous cases.
2.) Annually counting weevils is a cost-effective exercise that land managers can do to gauge expected biocontrol impacts.
3.) Keeping track of winter precipitation along with other monitoring activities will help to understand how changes in precipitation also effect plant densities and cover and impact long-term management goals using a biocontrol program.

Brachypterolua pullicarius (toadflax flower-feeding beetle) was not intentionally released as a biological control agent, but was instead adventively introduced pre-1919 from Europe (USDA 2017b). It was first reported in New York and then spread naturally through redistributions throughout North America on both yellow and Dalmatian toadflax (Sing et al. 2015). A recent study found that it performs better on yellow toadflax, even for individuals collected on Dalmatian toadflax. It can still be found on Dalmatian toadflax and in high densities can cause increased branching and stunt stem height, but its overall impact on flowering and seed production is considered minimal (Sing et al. 2015). Even on yellow toadflax populations where it performs much better, the population level impacts are considered negligible even though the beetle can cause high reductions in seed numbers (USDA 2017b). Because of its poor performance, *B. pulicarius* is not considered to be a high priority for redistribution. It will continue to be found in many stands of toadflax, but control from this flower-feeding beetle is considered to be rather ineffective.

Rhinusa antirrhini was another accidental introduction to the U.S. This weevil is widespread, but considered to be ineffective for meaningful control of even yellow toadflax where it is most often found. It is only found sporadically on Dalmatian toadflax. Satisfactory control has not been achieved (Sing et al. 2015).

Calophasia lunula, the toadflax defoliating moth, was released as an approved biocontrol agent, but is susceptible to high levels of bird and insect predation and thought to be vulnerable to pathogenic attack when under certain environmental conditions the moth populations build to high densities (USDA 2017b). There are calls for great caution too because *C. lunula* is known to feed on desirable snapdragon species, so it poses a risk to non-target plants (Sing et al. 2015).

Eteobalea intermediella, the Dalmatian toadflax root-boring moth, has no reports that it has established on Dalmatian toadflax in North America as of 2016 despite multiple introductions (Sing et al. 2015).

Recommendations

Biocontrol

An IPM (Integrated Pest Management) or more specifically an IWM (Integrated Weed Management) program continues to make the most sense for addressing the Dalmatian toadflax populations at FEWAFB. Biocontrol programs with populations that have experienced repeated, yearly attacks by both the adults and larvae of *Mecinus janthiniformis* have shown striking reductions in Dalmatian toadflax densities. Even with IWM as a goal, just the single strategy of utilizing biocontrols has been documented to be successful on some sites.

Sampling should be done to determine if *M. janthiniformis* is already present and if so at what densities. If these weevils are absent or in low numbers, then FEWAFB should consider pursuing new releases with a careful monitoring program that includes a site assessment plan (Appendix A). There have also been petitions for the introduction of other Dalmatian toadflax biocontrols in the U.S. that are pending and worth following, like the stem-galling weevil *Rhinus rara* (Tosevski et al 2015). The adults of these *Rhinus* species overwinter in the soil or leaf litter which may mean better survival rates then *M. janthiniformis* which overwinters in the more vulnerable dead stems of

toadflax. Additionally, none of the life stages of *R. rara* would compete for resources with *M. janthiniformis* so they could both co-exist and be additive impacts to Dalmatian toadflax (USDA 2017b). Other biocontrols should be investigated as more research comes forward.

Cultural

Continuing to pursue a grazing program with sheep should be coupled with site assessment and treatment plans. Combining grazing and biocontrol should be examined to see if biological control organisms could persist under any level of grazing pressure. Grazing programs with rare plant species present would also need to be evaluated to prevent unintended impacts.

Purple Loosestrife (*Lythrum salicaria*)

Management Urgency: Very High

Management Goals: Rapid Response Eradication and continued monitoring

Photos: Purple loosestrife, kingcounty.gov **Showy flowers of purple loosestrife, wikimedia.org**

- Long-lived, wetland perennial that can completely dominate a site.
- Tall, showy magenta flower spikes.
- One plant can produce > 2 million seeds the size of ground pepper (King County 2018).
- Seeds viable up to 20 years (CDA 2015).
- Reproduces by rhizomatous roots, seeds and broken stems.
- Simple smooth-edged leaves grow opposite or whorled from stiff, 4-6 sided stems.
- Flowers in spikes at the top of 6-10 feet stems from July to September.

Purple loosestrife is a rhizomatous perennial that can live up to 20 years. Seeds can build-up in soils over years going unnoticed until conditions are favorable and a widespread infestation can suddenly appear. The tiny seeds easily float on water and stick to animals expanding dispersal. Reproduction is by seed, roots, or vegetative growth, even pieces of stems. It is most often found on freshwater wetlands, ponds, lakes, ditches, and waterways as well as brackish wetlands (King County 2018). The showy magenta flowers are easily spotted in many western landscapes when the plant is in bloom.

2018 Mapping

Purple loosestrife is found in two small areas on FEWAFB, relatively close to the base entrance and on the edge of a ditch. As of 2014, it was not reported in Laramie County, but was documented in low acreages (<100) in 5 other counties mostly in northern Wyoming and in eastern Wyoming in Niobrara County. Because of the low cover and potential for expansion in disturbed wetlands, it is of high management and rapid response urgency.

Table 17. Purple loosestrife noxious weed survey results.

	2004	2014	2018
Occupied Acres	---	0.1	< 0.1
Estimated Number of Shoots	---	?	62
Number of Mapped Features	---	?	4

Recommendations

Purple loosestrife occurrences are small and eradication is possible with immediate rapid response actions that include repeated annual removal of all plant parts including the roots before the plants set seed. Plant parts should all be bagged and disposed of as trash. If plants are in flower or setting seed, care should be taken not to disperse the tiny, ground black pepper-sized seeds or root fragments. Efforts to brush off clothes and shoes before leaving an infested site helps prevent spread. If infestations increase in size and treatments actions are not working, other methods of control will need to be investigated. Biocontrol is not an option for purple loosestrife control at FEWAFB due to the small coverage and lack of availability of a biocontrol organism. Purple loosestrife prefers areas with unnatural hydrologic regimes and it can tolerate water pollution (Thompson et al. 1987, Rawinski 1982). Areas that include frequent flooding with repeated soil disturbances such as irrigation ditches and wetlands with open, moist and bare soil should be investigated routinely for the presence of purple loosestrife.

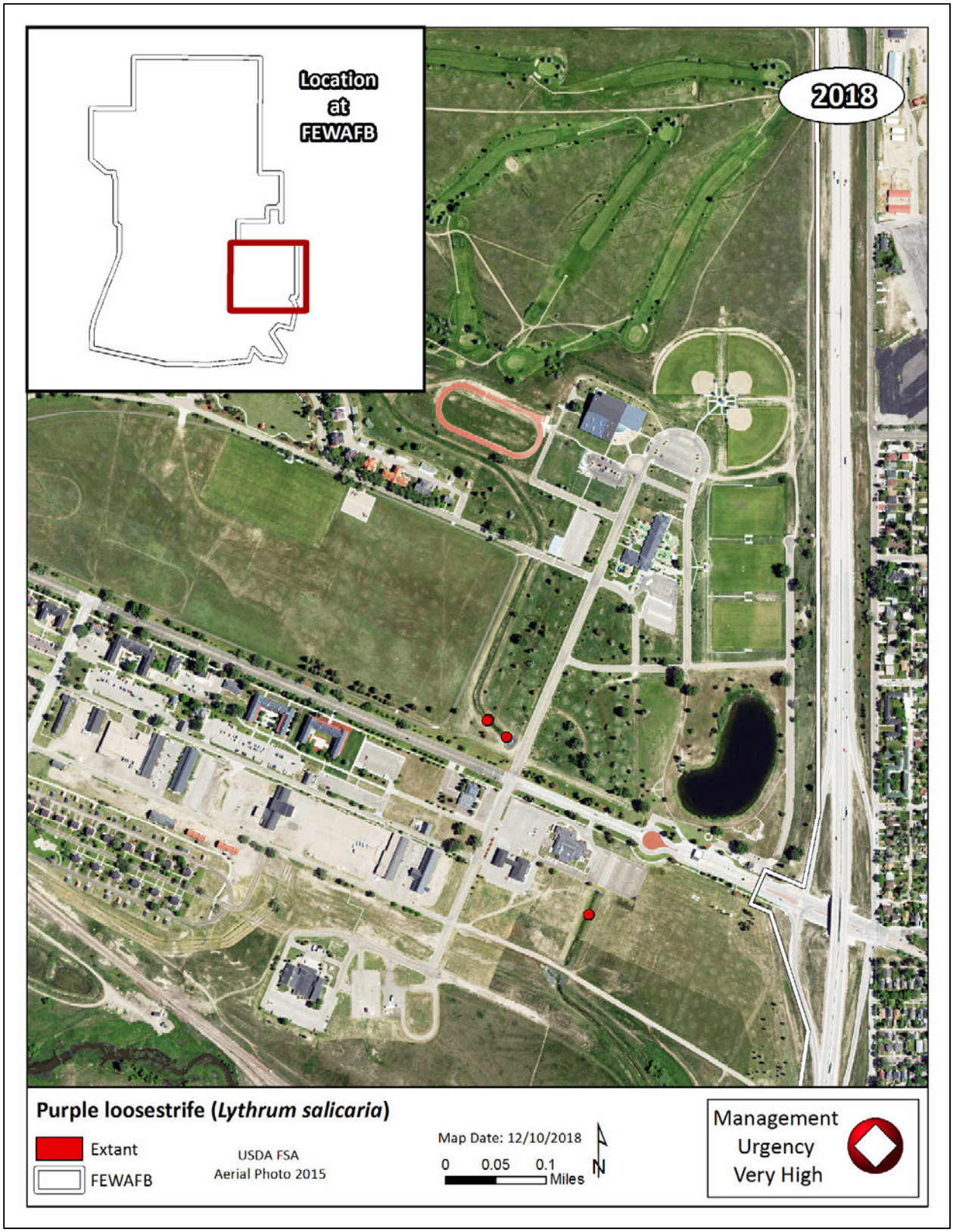


Figure 17. Distribution of purple loosestrife at F. E. Warren Air Force Base in 2018.

Scotch Thistle (*Onopordum acanthium*)

Management Urgency: Very High

Management Goals: Mechanical treatments and post treatment monitoring.

Photo: mature Scotch thistle, Lisa Tasker (CNHP)

Top: Scotch thistle flower, wikimedia.org
Bottom: rosette beginning to bolt, wikimedia.org

- Biennial with a taproot that grows to 30 cm.
- Reproduction is only by seed.
- Seed longevity is 7-20 years. (CDA 2016).
- Germination anytime in the growing season (NV 2002).
- Rosettes form first year.
- Temperature and moisture content of soil are more important than soil nutrients.
- Drought resistant and grows up to 12 feet tall.

2018 Mapping

Less than a tenth of an acre of Scotch thistle was mapped in 2018 compared to just over five acres in 2014. Scotch thistle wasn't found at the base in 2004 (Table 18). The seven occurrences at FEWAFB are all relatively small in size, but spread out across the base (Figure 19).

Table 18. Scotch thistle noxious weed survey results.

	2004	2014	2018
Occupied Acres	---	5.1	< 0.1
Estimated Number of Shoots	---	?	78
Number of Mapped Features	---	?	7

Recommendations

Scotch thistle is a biennial which reproduces from seeds. Therefore, preventing seed production is an important goal. Physically removing the plants and being careful to sever the tap root below the root crown before the plants bolt will effectively kill them. Targeted manual digging when the plants are still in the rosette stage is ideal because no seeds are available to accidentally spread during removal efforts. Extreme care should be taken not to disturb surrounding soils as much as possible. Monitoring for new plants needs to occur for many years as the seeds remain viable for over 20 years.

With so few occurrences, herbicides are not the first choice. Carefully targeted spot spraying of plants in the rosette stage with continued annual monitoring could show good results. Timing of herbicide applications and limiting overspray are also key to a successful program. Overspray should always be avoided so as to limit impacts to desirable nearby plants that provide important competition. Any treatments that leave behind bare soils should be avoided. Follow-up after treatments for new sprouts is important for successful results.

Figure 18. Distribution of Scotch thistle at F. E. Warren Air Force Base in 2018.

Summary of Recommendations

Dalmatian toadflax, Canada thistle, leafy spurge, houndstongue, and hoary cress are all widespread at FEWAFB. Biological controls look promising for Dalmatian toadflax (weevil), leafy spurge, and Canada thistle (rust). Houndstongue and hoary cress populations are especially challenging due to their cover and prevalence in riparian areas and within TES habitat.

Scotch thistle, musk thistle, bull thistle, common burdock, purple loosestrife, baby's breath, and diffuse knapweed are all candidates for eradication. Occurrences are low enough that persistent treatment with monitoring could eliminate them from FEWAFB. Keep in mind that native thistles do exist at FEWAFB (see photo). Common teasel and Russian olive can likely be contained and are potential targets for eventual eradication. Containment of field bindweed is most realistic since eradication along roadsides and other disturbed, developed areas is unlikely.

Photo: *Cirsium flodmanii*, a native thistle at FEWAFB, Lisa Tasker (CNHP)

Recommendations include a new approach for weed treatment in addition to traditional strategies especially on the FEWAFB's natural areas. This new approach includes creating site plans. The Site Assessment Worksheet in Appendix A can be used to create localized plans for weed treatments not only to document treatment activities, but to assess success and adapt to failure. A significant portion of the landscapes impacted by noxious weeds at FEWAFB fall into the "natural areas" category and include important riparian and wetland features that harbor two federally threatened species. Natural areas in general can be defined as non-crop areas that support native vegetation where management includes the protection of these areas as well as the generation of ecosystem services (Pearson and Ortega 2009). Successfully managing weeds in natural areas is much more complex than managing them in ecologically simplified agricultural areas. The Site Assessment Worksheet is designed to help develop adaptive management strategies to reduce the use of herbicides and ineffective or harmful treatments, and document the success of effective weed control strategies at FEWAFB. Many weed species may experience natural declines and some management activities could actually cause weed footprints to expand, especially perennial species that have underground root buds that are stimulated by above ground treatment activities (e.g. Canada thistle and hoary cress). This is where monitoring becomes the most important action. In recent years, natural declines are being observed (Canada thistle, leafy spurge and field bindweed). These natural declines can be far more effective than many treatments that harm or impact soils and water quality. Many weedy species reduce in number naturally given

enough time as part of the successional pattern in areas where the disturbance regime is reduced or removed.

One of the most important activities involved with weed management is to record treatments and monitor post treatment for success. This cannot be emphasized enough. The Site Assessment Worksheet helps immensely with this exercise and informs time-saving, cost-saving, and course corrections (Appendix A).

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APPENDIX A. ASSESSMENT WORKSHEET FOR WEED MANAGEMENT SITE PLAN

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, teasel, Scotch thistle, houndstongue)
   □ Perennial broad-leaved plant with deep root system (hoary cress, Canada thistle, field bindweed, knapweeds, bouncingbet, St. Johnswort, Dame's rocket, scentless chamomile, toadflaxes)
   □ Woody plant (salt cedar, Russian olive, honeysuckle)
   □ 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 (https://cnhp.colostate.edu/download/documents/2016/BMP_Noxious_Weeds_on_Sites_with_Rare_Plants_CMui_SPanjabi_May_2016.pdf)
   Is the site located near (<10 m) 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, salt cedar)
    □ **Control or suppression** targeting satellite populations (Canada thistle, knapweed) (this is typically used if 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 and Datum:_____

DATE OF PHOTO: _____TIME_____

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

ASPECT/COMPASS HEADING FOR PHOTO: _____

***HERBICIDE**:

If herbicides are planned for natural areas, 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 the species 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.

***MOWING**: Protect native landscape from mowing machinery. Mowing will likely need to occur multiple times in a growing season. Mowing is best during droughts.

Follow-up Monitoring

Year 2 _____

PLOT ID: _____UTM and Datum:_____

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 B. WYOMING STATE DESIGNATED WEEDS

2018 Wyoming Weed & Pest Control Act State Designated Noxious Weeds W.S. 11-5-102 (a)(xi)

(1) Field bindweed (*Convolvulus arvensis* L.)
(2) Canada thistle (*Cirsium arvense* L.)
(3) Leafy spurge (*Euphorbia esula* L.)
(4) Perennial sowthistle (*Sonchus arvens*is L.)
(5) Quackgrass (*Agropyron repens* (L.) Beauv.)
(6) Hoary cress (whitetop) (*Cardaria draba* and *Cardaria pubescens* (L.) Desv.)
(7) Perennial pepperweed (giant whitetop) (*Lepidium latifolium* L.)
(8) Ox-eye daisy (*Chrysanthemum leucanthemum* L.)
(9) Skeletonleaf bursage (*Franseria discolor* Nutt.)
(10) Russian knapweed (*Centaurea repens* L.)
(11) Yellow toadflax (*Linaria vulgaris* L.)
(12) Dalmatian toadflax (*Linaria dalmatica* (L.) Mill.)
(13) Scotch thistle (*Onopordum acanthium* L.)
(14) Musk thistle (*Carduus nutans* L.)
(15) Common burdock (*Arctium minus* (Hill) Bernh.)
(16) Plumeless thistle (*Carduus acanthoides* L.)
(17) Dyers woad (*Isatis tinctoria* L.)
(18) Houndstongue (*Cynoglossum officinale* L.)
(19) Spotted knapweed (*Centaurea maculosa* Lam.)
(20) Diffuse knapweed (*Centaurea diffusa* Lam.)
(21) Purple loosestrife (*Lythrum salicaria* L.)
(22) Saltcedar (*Tamarix* spp.)
(23) Common St. Johnswort (*Hypericum perforatum*)
(24) Common tansy (*Tanacetum vulgare*)
(25) Russian olive (*Elaeagnus angustifolia*)
(26) Black henbane (*Hyoscyamus niger* L.)
(27) Common mullein (*Verbascum thapsus* L.)
(28) Yellow starthistle (*Centaurea solstitialis* L.)
(29) Ventenata (*Ventenata dubia* (Leers) Coss.)
(30) Medusahead rye (*Taeniatherum caput-medusae* (L.) Nevski)

APPENDIX C. MAPPING PROTOCOL

Noxious weed occurrences were mapped in the field using ArcPad version 10.2 R5 (ESRI 1995-2018), a portable version of GIS software that allows users to efficiently create and attribute 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. The Yuma tablet has improved display capabilities, a rugged exterior to withstand adverse weather conditions, a stable operating system and hard drive, and a large screen to help with navigation and data collection. According to Trimble specifications, the GPS is 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 any direction were mapped as polygons. All other features were mapped as points and assigned a radius. Since weeds are mobile from year to year, and the GPS has inherent inaccuracies, weeds of the same species within 5 meters of each other were mapped as one feature.

Riparian areas at F. E. WAFB were thick with co-occurring weed species and willows. In order to make efficient use of field time in these dense areas, only one polygon was mapped in the field and species and densities were described in notes. In the office, notes were used to create polygons for each weed and assign densities. Density and size were then used to estimate number of individuals

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 look-up tables and field auto-population techniques. One free text field was maintained to document any observations deemed important, such as nearby significant species (e.g. rare plants, native thistles) or difficulties incurred using the GPS in a specific area (e.g. “on the fly” mapping). The botany 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 by multiplying density by the size of the infestation in square meters.

Weed data were stored in an ESRI file geodatabase and 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%, Medium; 25-75%, High; 75-100%, Very High
PATTERN – Continuous or Patchy
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

Points and lines were buffered and combined with polygons to generate a final weed map depicting our best representation of the distribution of noxious weeds on the base. See buffering examples below.