Noxious Weed Mapping and Monitoring at Francis E. Warren Air Force Base 2018-2020

April 2021

COLORADO NATURAL HERITAGE PROGRAM

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WARNER COLLEGE OF NATURAL RESOURCES
COLORADO STATE UNIVERSITY

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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: Francis E. Warren Air Force Base (top), purple loosestrife with cattails (bottom) in 2020. Photos by Tom Baldvins (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. Nine species with low cover were identified for rapid response activities. In 2020, CNHP mapped and mechanically treated the rapid response species. This report includes the 2018 mapping results for widespread noxious weeds augmented to include the 2020 monitoring results and recommendations for low cover species.

Weed mapping was undertaken to provide another year of data on noxious weeds at the base for comparison to prior years of weed mapping data (2002, 2004, 2014, and 2018). 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, Buckley Air Force Base, Cheyenne Mountain Air Force Station, and Pueblo Chemical Depot. Species that are widespread in distribution with large numbers of occurrences that have a low probability for control at FEWAFB include: Canada thistle, leafy spurge, hoary cress, houndstongue, Dalmatian toadflax, and field bindweed. These species were not surveyed in 2020. However, CNHP staff manually treated species with less cover that have a high potential for control and/or eradication at FEWAFB. Multiple site visits were made to the same sites throughout the summer to map and treat plants. There were two or three follow-up visits to sites with plants present to manually treat any sprouts that had returned since the first visit treatments. The noxious weed species treated in 2020 at FEWAFB by CNHP include: common burdock, diffuse knapweed, musk thistle, bull thistle, common teasel, baby's breath, purple loosestrife and Scotch thistle. Russian olive was mapped and is being treated by FEWAFB staff.

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 between organizations, exact comparisons between all years are not possible, but trends suggested by the data are worth exploring and are discussed when pertinent.

Areas on FEWAFB support habitat and ecological needs for two rare species, a rare endemic plant, the Colorado butterfly plant (*Oenothera coloradensis*), and the federally threatened Preble's meadow jumping mouse (*Zapus hudsonius preblei*). During previous surveys, the Colorado butterfly plant was a federally threatened species but has since been delisted (11/05/2019). However, it is a rare species only known from a 60-mile area where Colorado, Nebraska and Wyoming come together. It is tracked by CNHP as a globally imperiled species (G2) that is considered critically imperiled in Nebraska (S1) and Colorado (S1) and state imperiled in Wyoming (S2). It is considered a Tier 1 State Species of Concern by the Colorado Parks & Wildlife. FEWAFB has the only known protected population of the Colorado butterfly plant (NatureServe 2021). Both of these species are found in areas that contain noxious weed species. Changes in stream flows and ground water

hydrology may encourage weed encroachment (INRMP 2018) at FEWAFB. Information gathered from this survey helps inform ongoing noxious weed management decisions critical to the survival of these threatened species.

Summary of Findings

There are 15 noxious weed species known to occur at FEWAFB. In 2020, nine noxious weed species with low cover were mapped. Of these nine species, eight were treated manually by CNHP multiple times over the same growing season. Noxious weed species with lower cover have the highest probability for eradication and seven species were assigned a "very high" urgency ranking because rapid response actions have the potential to eradicate or reduce these species at FEWAFB. These species include: bull thistle, Scotch thistle, purple loosestrife, baby's breath, common teasel, musk thistle and common burdock (Table 1). Of these seven species, baby's breath, common teasel, and purple loosestrife have the greatest potential to rapidly expand to levels that are difficult to treat, even in a single growing season, and must be prioritized for monitoring and treatment.

Russian olive trees were planted at FEWAFB many years ago before it was recognized as a noxious weed and they are currently being removed by staff. Russian olive was mapped in 2020 by CNHP but not treated. It has been assigned a high management urgency because the efforts of the FEWAFB staff have the potential to continue to reduce the cover of Russian olive.

Typically, when an invasive species reaches a cover over an acre, the potential for eradication decreases. In 2020, there were five species that were not mapped due to their high cover and widespread distribution across the property. Covers of these noxious weeds ranged from eight acres to over 600 acres in cover and include: field bindweed, houndstongue, leafy spurge, Canada thistle and Dalmatian toadflax. The management urgency for these species is considered to be low due to high cover and difficulty of treatment. Diffuse knapweed was mapped at just under half an acre in 2018, and at one and a half acres in 2020 with over 42,000 individuals. Ninety-five percent of shoots were at one large infestation. Diffuse knapweed has gone from relatively easy to eradicate as mapped in 2018, to difficult or unlikely to control/eradicate in just one or two growing seasons. The management urgency has changed from very high management urgency in 2018 to a medium urgency in 2020 due to the high cover, density and difficulty in successfully treating this species. Hoary cress was not mapped in 2018 but was mapped at over eight acres in 2018 and was assigned a medium urgency rank. All 15 species are listed in order of highest cover to lowest cover in Table 1. For species not mapped in 2020, the data from 2018 is provided.

Table 1. Summary of management urgency ranks for noxious weed species at FEWAFB in order of highest to lowest cover in 2018 or 2020.

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 or 2020 – low potential for eradication-good candidate for biocontrol
	Cirsium arvense	Canada thistle	603.1 acres mapped in 2018 – eradication unlikely. Future biocontrol possibility
	Euphorbia esula	Leafy spurge	143.4 acres mapped in 2018 – low potential for eradication. Good candidate for biocontrol
	Cynoglossum officinale	Houndstongue	99.3 acres mapped in 2018 – low potential for eradication
	Convolvulus arvensis	Field bindweed	8.9 acres mapped opportunistically in 2018– full extent is not known – widespread, eradication unlikely
	Cardaria draba	Hoary cress	8.2 acres mapped in 2018, 300,000+ individuals – medium potential for eradication
	Centaurea diffusa	**Diffuse knapweed**	1.46 acres mapped in 2020, increase cover >1 acre, 42,000+ shoots – eradication is unlikely-medium potential for eradication.
	Elaeagnus angustifolia	**Russian olive**	1.4 acres mapped in 2020 – cover is stable, # individuals increased-high potential for control/eradication
	Dipsacus fullonum	**Common teasel**	1.4 acres mapped in 2020 –decrease in # individuals – very high potential for eradication
	Arctium minus	**Common burdock**	0.23 acres mapped in 2020, cover decreased 28%, # individuals increased 13% – very high potential for eradication
	Gypsophila paniculata	**Baby's breath**	0.2 acres mapped in 2020, increase in cover, # individuals, and extant sites since 2018, very high potential for eradication
	Carduus nutans	**Musk thistle**	0.11 acres mapped 6 sites in 2020, similar to 2018, 35% increase # individuals,' very high potential for eradication
	Cirsium vulgare	**Bull thistle**	0.02 acres mapped in 2020, increase # individuals and # sites – very high potential for eradication
	Lythrum salicaria	**Purple loosestrife**	0.02 acres mapped in 2020, increase in cover, # of individuals, extant sites since 2018– very high potential for eradication
	Onopordum acanthium	**Scotch thistle**	0.01 acre mapped in 2020, cover stable, # individuals, # extant sites decreased since 2018 – very high potential for eradication

Bolded species were monitored in 2020.

Summary of Recommendations

- Continue rapid response activities starting early in the growing season, using mechanical treatments multiple times during the same season every year for the high management urgency species: common burdock (*Arctium minus*), musk thistle (*Carduus nutans*), baby's breath (*Gypsophila paniculata*), purple loosestrife (*Lythrum salicaria*), Scotch thistle (*Onopordum acanthium*), common teasel (*Dipsacus fullonum*) and bull thistle (*Cirsium vulgare*). Baby's breath, common teasel and purple loosestrife, that have the potential to expand rapidly even in a single year, should be prioritized for treatment over other species if resources are limited.
- Protection of undisturbed sites is the best measure to prevent the spread of noxious weeds. Regularly monitor weed-free areas on FEWAFB and protect them where possible from unnecessary disturbance. 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 be used as a last resort in natural areas and when all other reasonable alternatives have been ruled out due to potential impacts to soil, surface and ground water quality, and non-target impacts. Many of the treatments are designed for agricultural lands and are not the best choice for natural landscapes including wetlands.
- 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 biocontrols for diffuse knapweed, Dalmatian toadflax, leafy spurge and Canada thistle.
- 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.

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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 and 2020. 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. 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.

In the summer of 2020, the Colorado Natural Heritage Program (CNHP) targeted nine noxious weeds known to occur on the base in low cover for mapping. These species were identified during the 2018 weed survey as good candidates for rapid response and treatment activities. 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 and Tasker et al. 2019) 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 (EDRR) as key to mitigating new infestations of invasive weeds, as do most reputable state weed programs.

At FEWAFB, occurrences of a globally imperiled (G2) CNHP tracked rare plant species (formerly federally listed species until 2019), the Colorado butterfly plant (*Oenothera coloradensis*) and federally listed 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 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. A new strategy for monitoring and manually treating smaller infestations of noxious weeds that includes follow-up monitoring and treatment several times during a single growing season were incorporated to monitoring, as well as focus on rapid response species. These efforts should begin to result in reductions in weed populations at FEWAFB.

A number of organizations that manage natural areas recommend the preparation of a site plan before noxious weed treatments are undertaken (USFS 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).

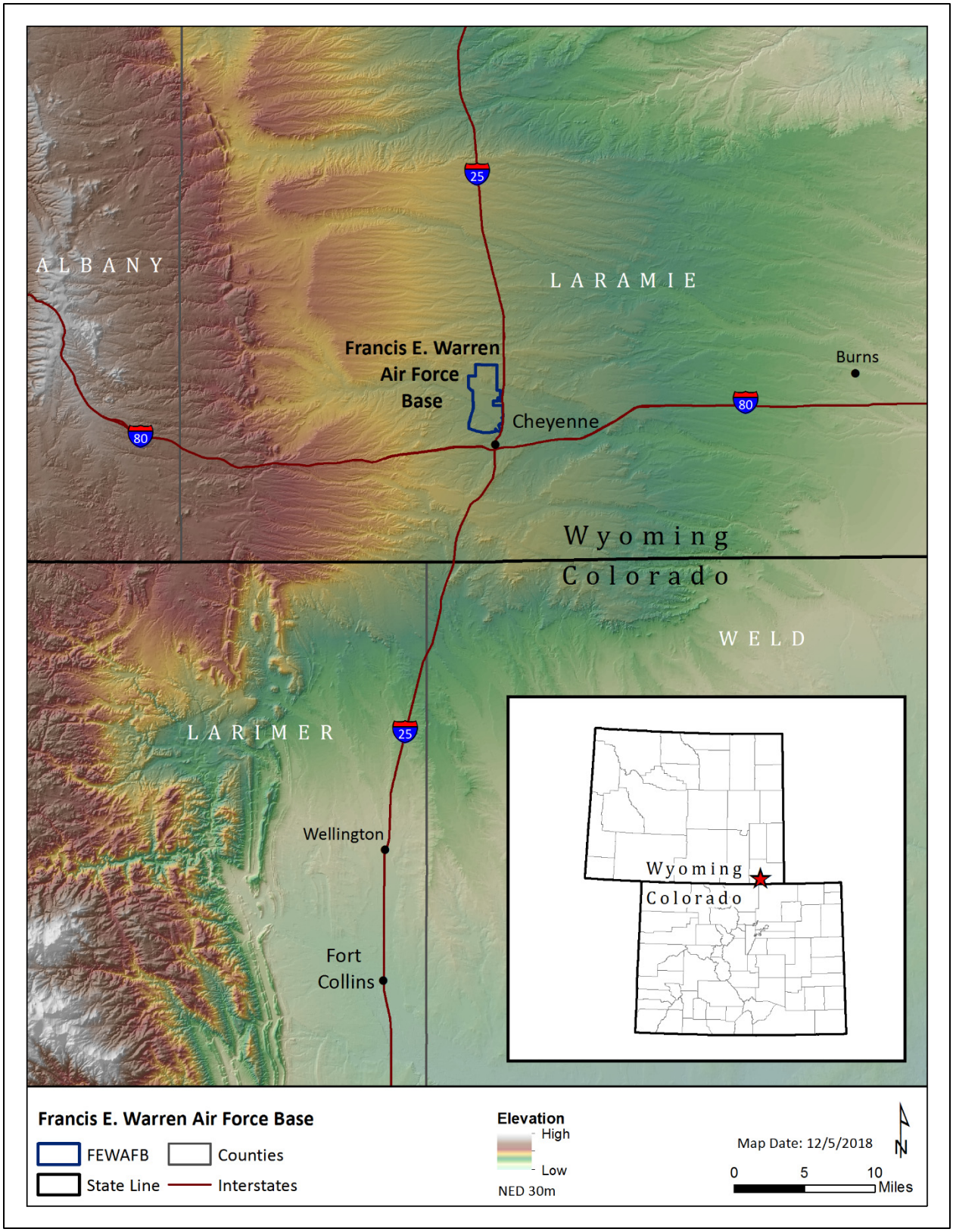


Figure 1. Location of F. E. Warren Air Force Base in Wyoming.

METHODS

Noxious weed species mapped during previous weed surveys by CNHP in 2018 (Tasker et al. 2019), 2014 (SWCA 2014) and 2004 (North Wind 2005) were targeted for this survey. These species included plants on the Wyoming State Designated Weed and Pest List (Appendix B) and the Colorado Department of Agriculture (CDA) State of Colorado Noxious Weed List (CDA 2020). A total of 15 species of noxious weeds have been mapped at FEWAFB. Of those 15 species, six have reached covers and densities that make not only mapping difficult and costly, but successful treatment unlikely. In 2020, these species included Dalmatian toadflax, hoary cress, Canada thistle, field bindweed, houndstongue and leafy spurge. These species were not mapped in 2020.

CNHP has monitored noxious weeds at FEWAFB since 2018 using two types of monitoring:

- **Basewide weed mapping** includes visiting all known occurrences and surveying for new occurrences and new noxious weed species. This is the most intensive survey and it is recommended once every five years.
- **Monitoring with treatments** was added in 2020 as a method to address potential weed increases by rapid response species. This new method combines areal mapping with mechanical treatments and includes multiple visits to occurrences throughout the growing season to remove plants and look for sprouts.

The strategy for 2020 was to focus on rapid response species where eradication or significant control is possible by monitoring with treatments. The timing of weed treatments is one of the most critical factors in effective weed control. Many of the species sprout, bloom and go to seed at different times throughout the growing season. Rapid response species were mapped early in the season and then manually treated by CNHP. This new method combines areal mapping with treatments and includes multiple visits to sites that had plants at the initial monitoring visit to look for sprouts. There were eight rapid response species treated by CNHP in 2020 using this method including: common burdock, musk thistle, bull thistle, diffuse knapweed, common teasel, baby's breath, purple loosestrife and Scotch thistle. Russian olive was mapped and treated by FEWAFB staff. Common teasel was treated during six visits made by FEWAFB staff in addition to three visits made by CNHP (Table 2).

Four weeks of field work were completed by one CNHP field botanists throughout the summer of 2020. Weeds were surveyed using a census survey method where weeds were documented by walking the property using GPS and GIS technology. Known locations were targeted for mapping and treatment and nearby locations were mapped and treated when discovered. 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 mapped feature during site visits. The surveyor recorded the number of individuals at each site visit prior to manual treatments. 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 at each site visit (called passes) are tabulated in Results and Recommendations. The first pass, before treatment, was used for comparison to the 2018 weed map. 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 FEWAFB and monitoring activities.

Scientific Name	Common Name	Wyoming Weed & Pest List	Mapped 2004 (X) (NorthWind)	Mapped 2014 (X) (SWCA)	Mapped 2018 (X) (CNHP)	Mapped (X) Treated (T) 2020 (CNHP)
Arctium minus	Common burdock	Yes	---	**X**	**X**	**X,T**
Cardaria draba	Hoary cress	Yes	**X**	**X**	**X**	---
Carduus nutans	Musk thistle	Yes	**X**	---	**X**	**X,T**
Cirsium arvense	Canada thistle	Yes	**X**	**X**	**X**	---
Cirsium vulgare	Bull thistle	Colorado List B	---	---	**X**	**X,T**
Centaurea diffusa	Diffuse knapweed	Yes	---	---	**X**	**X,T**
Convolvulus arvensis	Field bindweed	Yes	**X**	**X**	**X**	---
Cynoglossum officinale	Houndstongue	Yes	**X**	**X**	**X**	---
Dipsacus fullonum	Common teasel	Colorado List B	---	---	**X**	**X,T**
Elaeagnus angustifolia	Russian olive	Yes	---	**X**	**X**	**X**
Euphorbia esula	Leafy spurge	Yes	**X**	**X**	**X**	---
Gypsophila paniculata	Baby's breath	Colorado Watch List	---	---	**X**	**X,T**
Linaria dalmatica	Dalmatian toadflax	Yes	**X**	**X**	---	---
Lythrum salicaria	Purple loosestrife	Yes	---	**X**	**X**	**X,T**
Onopordum acanthium	Scotch thistle	Yes	---	**X**	**X**	**X,T**

Collection of weed data was subject to limitations imposed by human resources, time, and safety. Seasonal precipitation and weather patterns can influence results. In 2020, only known occurrences of rapid response species were visited. In 2018, most of the base was surveyed by foot or vehicle by CNHP. 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 by other organizations from previous years likely exist.

RESULTS AND RECOMMENDATIONS

There are 15 noxious weeds currently known from FEWAFB with an estimated cover of 868 acres excluding Dalmatian toadflax (Figure 2). Nine of these species were mapped during the summer of 2020. Five species showed increasing trends since 2018, two decreasing, and two species are stable (Table 3). Six noxious weed species are widespread across FEWAFB and were not monitored in 2020: Dalmatian toadflax, hoary cress, Canada thistle, field bindweed, houndstongue, and leafy spurge. These species have all reached coverages of eight acres to over 600 acres at FEWAFB which become difficult or impractical to treat and in some instances map. The species that have the highest potential for successful treatment were monitored and manually treated in 2020. Follow-up visits were made throughout the summer to all mapped features to conduct additional manual treatments as needed. Most sites received a total of three visits, and one species (common teasel) was treated nine separate times by both CNHP (three visits) and Natural Resources staff (six visits). Overall, almost five acres of noxious weeds were monitored multiple times and treated in 2020. Over 11,000 individuals were removed and many species were prevented from going to seed (Table 4).

Figure 2. Distribution of known weed infestations at FEWAFB, excluding Dalmatian toadflax. Locations on the map depict widespread species mapped in 2018 (863 acres) and low cover species mapped in 2020 (4.9 acres).

The nine species monitored and treated in 2020 have the potential for eradication or control with appropriate treatment and follow-up monitoring. Diffuse knapweed has the largest cover of all of the species mapped and treated in 2020 and is at levels of cover, distribution and density (1.5 acres, 42,000+ individuals) where mapping and treatment are difficult to impractical. However, containment or suppression may be achieved. The three biennial thistles (Scotch, musk, and bull thistles), along with common burdock, baby's breath, Russian olive, common teasel and purple loosestrife are candidates for eventual eradication with rapid response actions and have been assigned high to very high management urgency ranks. Diffuse knapweed was assigned a medium urgency rank because of a very large population that is reaching a point where control is more likely than eradication (Table 3).

Widespread species not mapped in 2020 include Canada thistle, Dalmatian toadflax, leafy spurge, field bindweed and hoary cress (Table 3). 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 type of a rust fungus. 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 (not mapped in 2020) 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 as is leafy spurge. Houndstongue and hoary cress will continue to challenge land managers at FEWAFB because of size and impacts as well as the difficulty in accessing them for control efforts without harming desirable species. Since natural declines may occur over time, monitoring is key to understand these trends. This is especially important to consider since extensive treatments which cost money and effort have the potential to spread weeds and some populations decline over time on their own.

Species results are reported in two ways to reflect the two different types of monitoring, basewide weed mapping and monitoring with treatments. Basewide weed mapping is the most comprehensive mapping method and covers the most ground on the base; thus, this method only allows for one pass at each mapped location. In order to compare similar data between comprehensive mapping years, only pass 1 data are compared to determine increasing, decreasing or stable trends. Monitoring with treatments targets known or nearby locations of rapid response species and includes multiple visits to each site throughout the growing season. The number of shoots documented in one growing season with multiple visits will often not match pass 1 data, as sprouts are often encountered on follow-up visits. Additionally, treatment may initially result in increased sprouts until the plant vigor or seed bank is decreased by subsequent visits within the same growing season. For these reasons, mapping results (first pass) and treatment results (multiple passes) are reported separately throughout this report.

Table 3. Summary of noxious weed mapping at FEWAFB: trends, acres, # sites, # shoots, and management urgency - highest to lowest cover in 2020.

Trend: ? unknown, Decrease Stable Moderate Increase Increase
Management Urgency: Low Medium High Very High

2018 - 2020 Trend	Common Name	2004 acres	2014 acres	2018 acres	2020 acres	2020 # Mapped Features	2020 # Shoots (Pass 1)	Mgmt Urgency
?	Dalmatian toadflax*	1,915	3,913	---	---	---	---	
?	Canada thistle	660.6	533.1	603.1	---	---	---	
?	Leafy spurge	28.4	134	143.4	---	---	---	
?	Houndstongue	50.2	165.8	99.3	---	---	---	
?	Field bindweed*	95	6.6	8.9	---	---	---	
?	Hoary cress	23.7	0.4	8.2	---	---	---	
	Diffuse knapweed	---	---	0.46	1.46	32	42,734	
	Russian olive	---	4.2	1.5	1.4	42	102	
	Common teasel**	---	---	1.4	1.4	4	1,662	
	Common Burdock	---	0.2	0.37	0.23	17	1,543	
	Baby's breath	---	---	<0.1	0.2	32	217	
	Musk thistle	?	---	<0.1	0.11	10	90	
	Bull thistle	---	---	<0.1	0.02	2	34	
	Purple loosestrife	---	0.1	<0.1	0.02	10	179	
	Scotch thistle	---	5.1	<0.1	0.01	7	35	

***Comprehensive mapping not completed in 2018 for Dalmatian toadflax and field bindweed. **Common teasel estimates provided by FEWAFB Natural Resources Managers, all passes.**

In 2020, there were a total of 323 site visits to 156 mapped noxious weed features with 52,104 individuals. Of those 52,104 shoots mapped 11,518 were manually treated in 2020 (Table 4). Diffuse knapweed had the largest cover has reached a level at which utilizing other methods including biocontrol and removal of satellite populations for containment around the perimeter could be considered.

Table 4. Summary of noxious weed treatments at FEWAFB in 2020.					
Scientific Name	**Common Name**	**# Mapped Features**	**# Site Visits**	**# Shoots Mapped**	**# Shoots Treated**
Arctium minus	Common burdock	17	51	3,910	3,910
Carduus nutans	Musk thistle	10	28	165	165
Cirsium vulgare	Bull thistle	2	5	66	66
Centaurea diffusa	Diffuse knapweed	32	83	45,271	4,685
*Dipsacus fullonum**	Common teasel	4	29	1,662	1,662
*Elaeagnus angustifolium***	Russian olive	42	42	102	---
Gypsophila paniculata	Baby's breath	32	80	516	516
Lythrum salicaria	Purple loosestrife	10	26	270	270
Onopordum acanthium	Scotch thistle	7	21	244	244
TOTALS		**156**	**323**	**52,104**	**11,518**

***Includes CNHP and FEWAFB treatments. ** FEWAFB conducts treatments for Russian olive.**

Precipitation and Temperature

In 2020, the average spring and summer rainfall was just under seven inches (WU), about four inches less than the average of 11 inches (WRCC 2018). Higher precipitation in spring and summer, can often mean higher weed densities for some species including musk thistle, houndstongue and leafy spurge (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 ^{o}F in 1951 to ~63 ^{o}F 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). Higher spring and summer precipitation could correlate with the increases noted in leafy spurge and houndstongue in 2018 (Figure 3 and Figure 4).

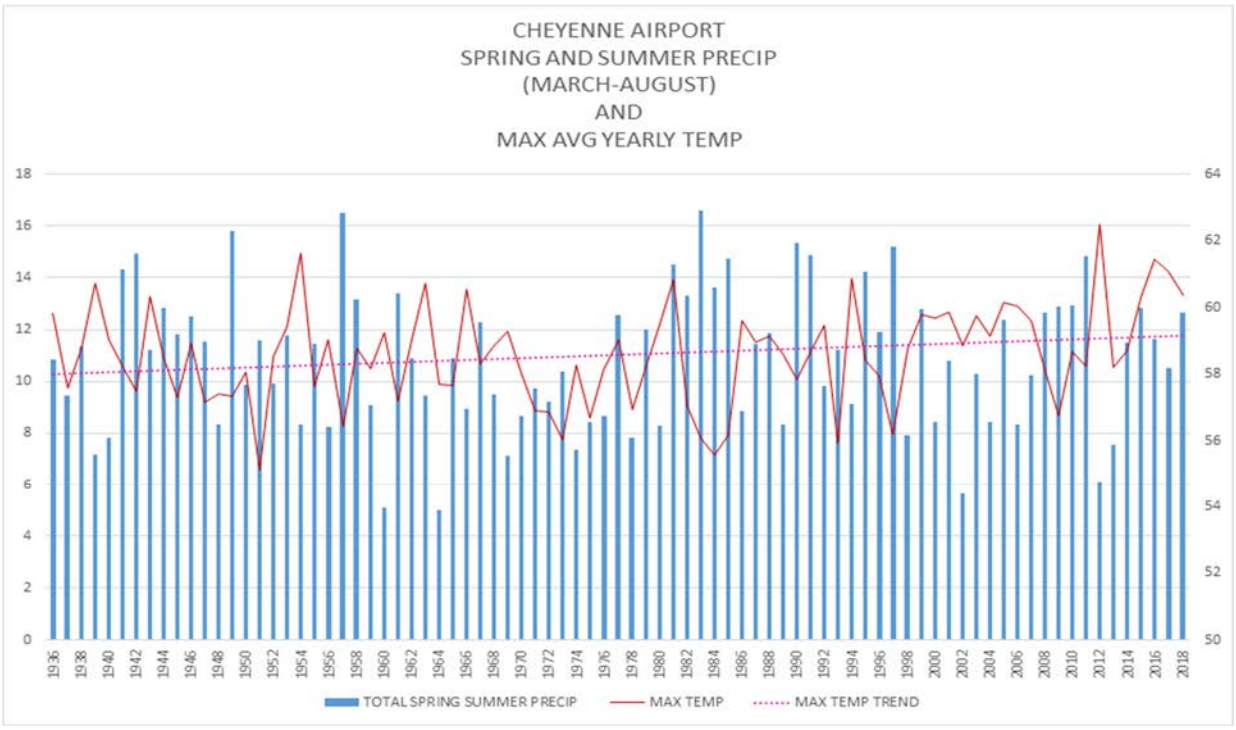


Figure 3. 1936-2018 yearly average combined spring and summer precipitation (in inches): Spring = March-May, Summer = June-August. Red Line: yearly average temps (degrees F). Dotted pink line: yearly average temperature trend since 1936 (WRCC 2018).

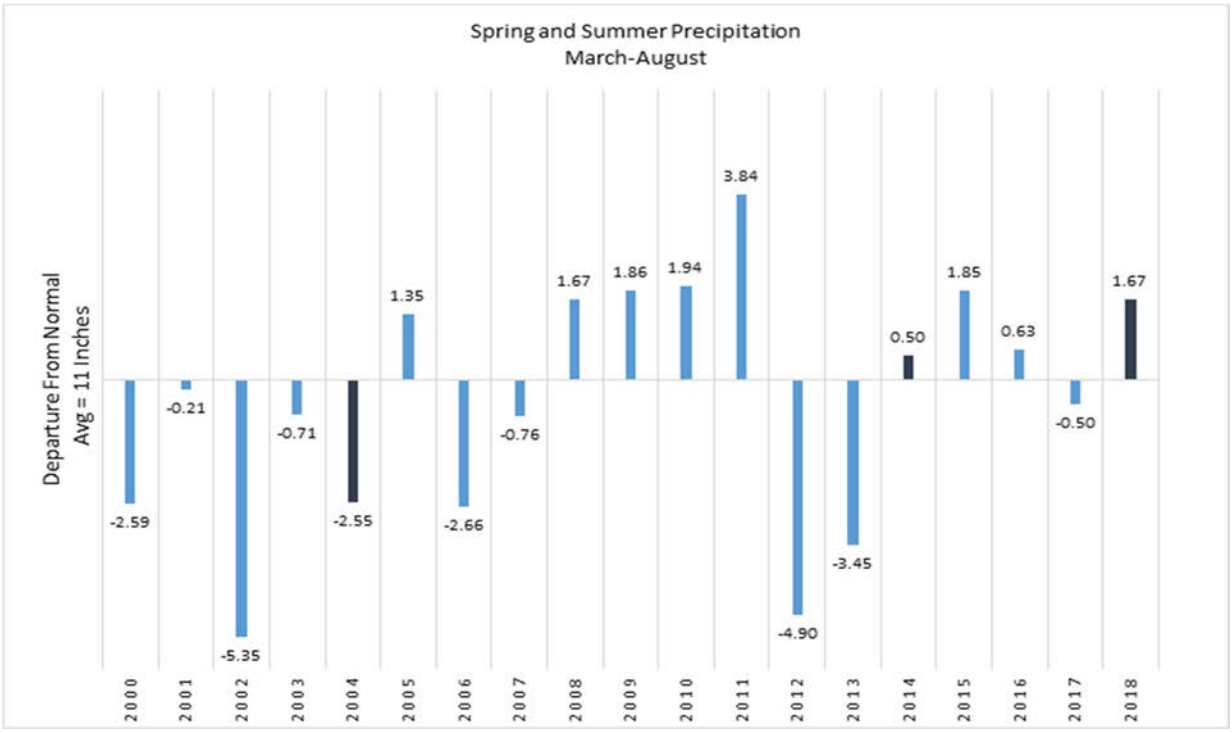


Figure 4. Departure from average (11 inches of precipitation) for yearly combined spring and summer precipitation since 2000 (Cheyenne Airport). Darker bars for 2004, 2014 and 2018 are the years weeds were mapped at FEWAFB.

Elements of Conservation Concern

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

Noxious weed species, as well as elements of conservation concern are found at FEWAFB. A Federally Threatened species, the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) is found in the wetland drainages. In addition, the Colorado butterfly plant (*Gaura neomexica* ssp. *coloradensis*/*Oenothera coloradensis*), is a rare endemic species that only occurs within a 60-mile radius where Wyoming, Colorado and Nebraska come together. It is found in the wet meadows at F. E. Warren Air Force Base. During previous surveys, the Colorado butterfly plant was a listed federally threatened species but has since been delisted (11/05/2019). It is tracked by CNHP as a globally imperiled species (G2) that is considered critically imperiled in Nebraska (S1) and Colorado (S1) and state imperiled in Wyoming (S2). It is considered a Tier 1 State Species of Concern by the Colorado U.S. Fish & Wildlife Service. FEWAFB has the only known protected population of the Colorado butterfly plant (NatureServe 2021). The Colorado butterfly plant has been studied on the base 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).

Common Burdock (*Arctium minus*) 2020 Update

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, dies after it flowers (ISCB 2018)
- Reproduces only from seeds; seed longevity 1-3 years (MSU Extension 2017)
- First year growth is a basal rosette of 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)

2020 Results

Common burdock was mapped for the first time at FEWAFB in 2014 (SWCA 2014). In 2020, the cover decreased from 0.37 to 0.23 acres while the number of individuals remained stable (Table 5, Figure 5). In 2018, over 80% of the known individuals were documented from one occurrence along Crow Creek. However, the majority of the individuals in 2020 were clustered around several structures within the firing range. Additional sites were identified from west Crow Creek and near the school building. 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 very high urgency for management.

Table 5. Mapping of common burdock at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	---	---	---	---
2014	0.2	?	?	?
2018	0.37	1,348	13	0
2020	0.23	1,543	13	4

Mapping by NW (2004), SWCA (2014), and CNHP (2018 & 2020)

2020 Treatment

There were a total of 1,543 individuals treated during the first visit in mid-June (Table 6). Of the 13 visited sites in 2018, four sites were eradicated and four new sites were observed in 2020. All plants were treated by cutting the root crown four inches below the soil surface. Plants with inflorescences or seed heads were bagged and disposed of in dumpsters. The second pass occurred in mid-July and a total of 779 individuals were treated, many of which were seedlings reestablishing themselves after the first treatment. The third trip occurred in early September, and 1,588 individuals were present across 11 sites. Many of these were seedlings with a few inflorescences present all of which were treated.

Table 6. Monitoring and treatment of common burdock sites at FEWAFB in 2020.					
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	17	1,543	1,543	13	4
Pass 2	17	779	779	10	7
Pass 3	17	1,588	1,588	11	6
TOTALS	**51**	**3,910**	**3,910**	---	---

Recommendations

Common burdock reproduces solely by seeds and it has a fairly short seed longevity estimated to be between 1-3 years (MSU Extension 2017). Therefore, the primary goal is to reduce seed production. The best way to treat common burdock is in the rosette stage when the plants are small by pulling them as they sprout throughout the growing season. The seed bank should be greatly reduced and elimination is possible with an initial large effort. Follow-up monitoring would be necessary for three to five years after plants are no longer found. Cutting the tops of larger plants may help reduce the seed bank and cutting them four inches below the root crown can keep them from bolting. Actions that minimize soil disturbance while protecting intact native vegetation are recommended because they keep native vegetation intact which prevents invasion of other weed species. Cutting common burdock plants below the root crown will kill the plant with minimal 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 seed bank.

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.

History of Sampling and Treatments:

- Common burdock was first mapped in 2014 by SWCA with a total area of 0.2 acres.
- In 2018, CNHP mapped burdock across 0.37 acres demonstrating an increase by almost double. Common burdock was mapped across 13 separate features.
- In 2020, CNHP mapped burdock across 0.23 acres at 17 features including four eradicated and four new features, with all 3,910 individuals manually treated.

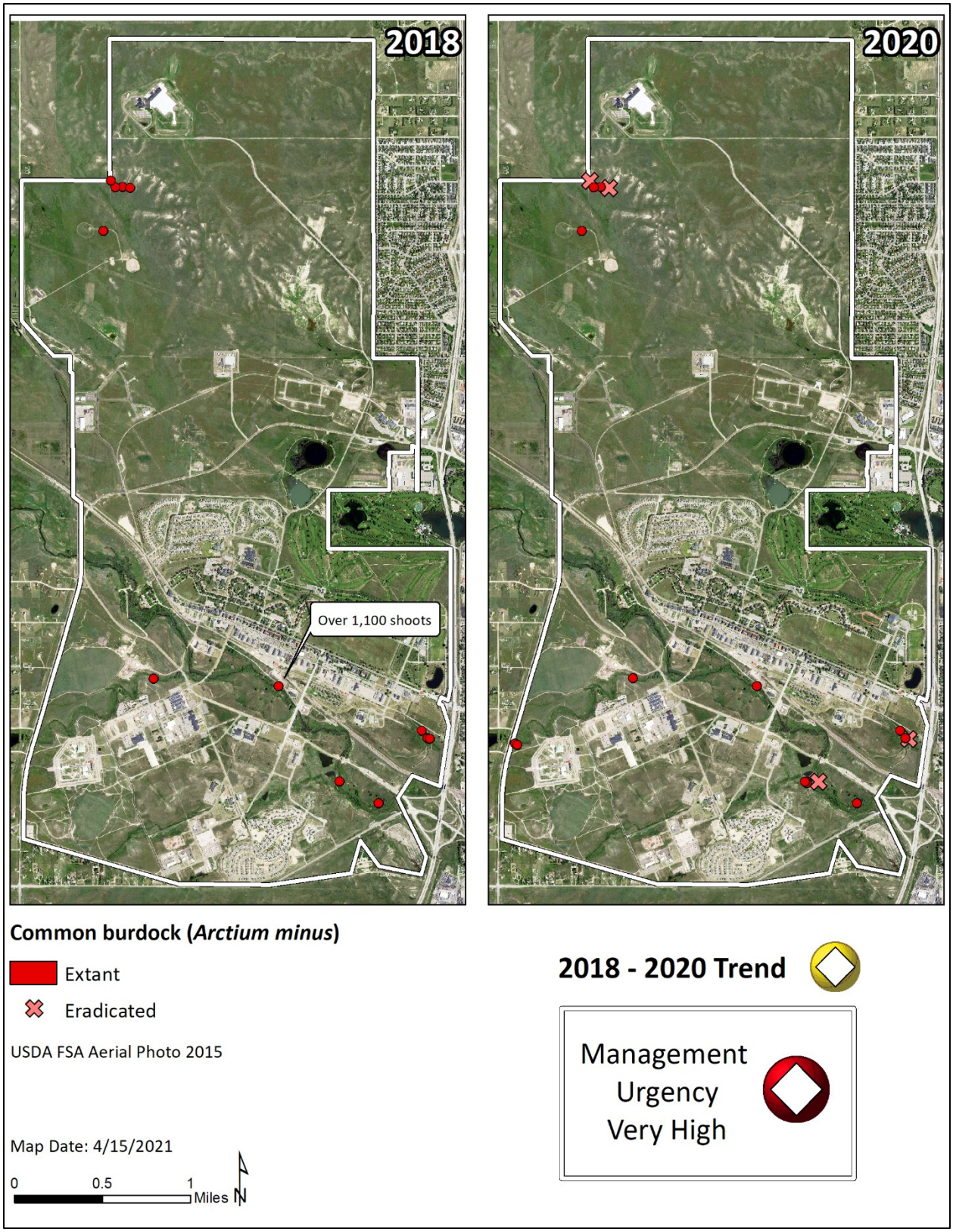


Figure 5. Distribution of common burdock at FEWAFB in 2018 and 2020.

Hoary Cress (*Cardaria draba*) 2018

Management Urgency: Medium

Management Goals: Monitor/Containment/Suppression

Photo: Hoary cress in flower at FEWAFB, 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 Results

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). In 2018, there were 111 mapped features for hoary cress at FEWAB. 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 7). Due to the large number of sites and individuals, the management urgency is considered medium. Eradication is unlikely and containment is an attainable goal.

Table 7. Mapping of hoary cress at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	23.7	?	?	?
2014	0.4	?	?	?
2018	8.2	305,980	111	---

Mapping by NW (2004), SWCA (2014), and CNHP (2018)

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 and monitoring to confirm declines or increases. Many sources recommend targeting treatments to new infestations or satellite populations that occur around the outside of existing populations. Preventing the spread to new areas and monitoring for new treatable populations before they expand should be considered. The creation of a site management plan (template in Appendix A) is recommended before any actions take place to make sure realistic treatment goals are set, appropriate time and materials for treatments and follow-up monitoring can take place. A single year top-kill effort is not a goal and can cause this species to spread. The site plan is a multi-year effort with monitored actions. 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).

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 could be targeted using a backpack hand held sprayer or wick method both of which are recommended for natural areas (USFS-USDA 2014a). 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 2014a) and result in impacts to native species.

History of Sampling and Treatments:

- Hoary cress was first mapped in 2004 with 23.7 occupied acres.
- In 2014, only 0.4 acres were mapped likely due to the timing of the survey which was conducted at a different time of the season.
- In 2018, 8.2 acres were mapped with over 300,000 individuals at 111 extant features.
- In 2020, hoary cress was not mapped.

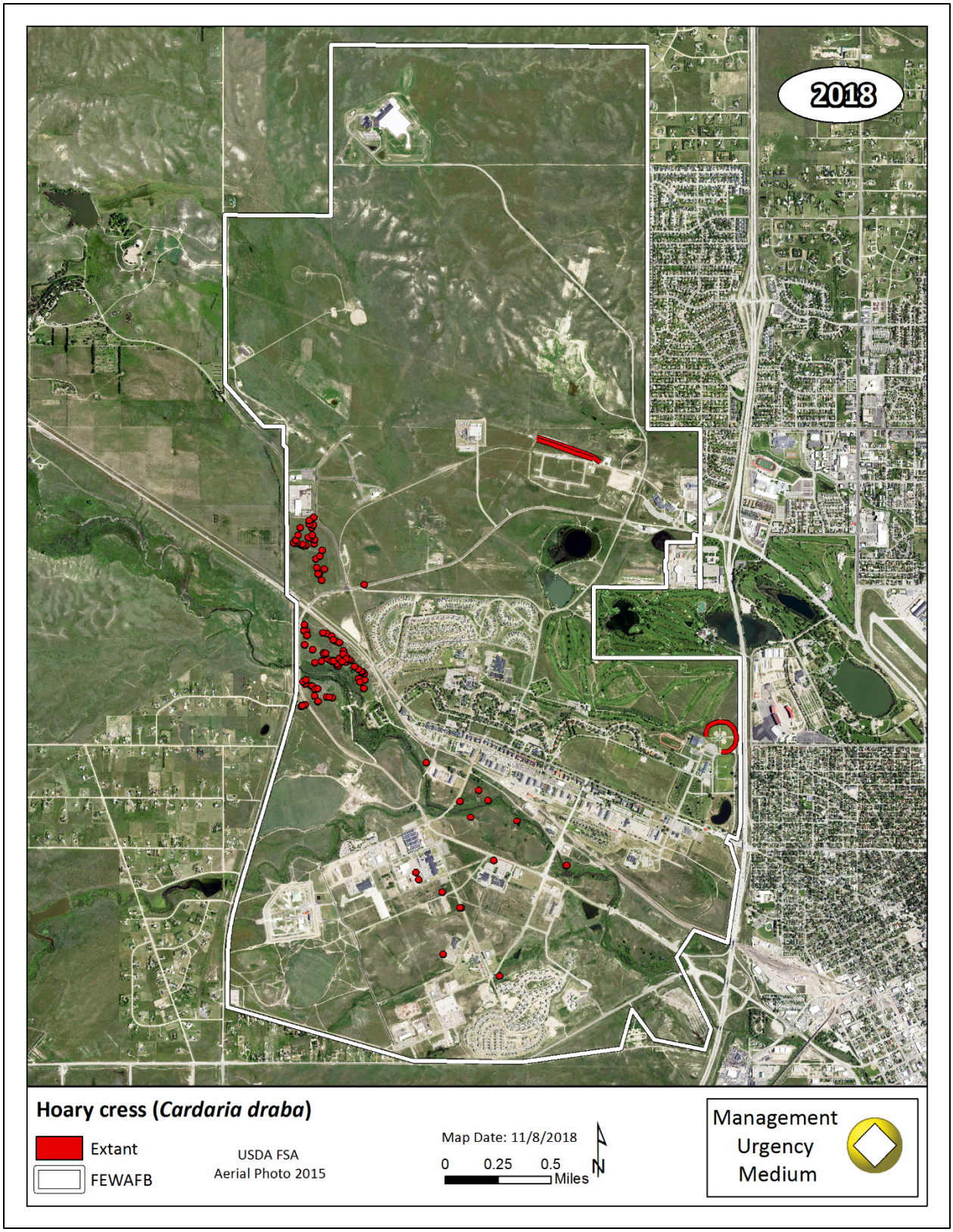


Figure 6. Distribution of hoary cress at FEWAFB in 2018.

Musk Thistle (*Carduus nutans*) 2020 Update

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 2013a)
- Plants are impacted by drought
- Seed longevity of 10 years (CCR 2014)

2020 Results

In 2020, musk thistle was mapped at six extant features with 90 individuals (shoots) and is considered to be moderately increasing since 2018. Four sites from 2018 were eradicated. Musk thistle was not found on the western side of FEWAFB, but persists on the eastern side, especially just north of the stables (Figure 7). It went undetected during 2014 mapping efforts with a few plants observed in 2004 (Table 8). A very high management urgency rank is assigned to musk thistle due to the small numbers of plants and features. In addition, this plant is comparatively easy to treat by removing the seed source and rapid response efforts have a high probability for successful eradication.

Table 8. Mapping of musk thistle at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	?	?	?	?
2014	---	---	---	---
2018	< 0.1	59	7	0
2020	0.11	90	6	4

Mapping by NW (2004), SWCA (2014), and CNHP (2018 & 2020)

2020 Treatment

In 2020, four sites from 2018 were eradicated, and three new musk thistle sites were mapped for a total of 10 features. For the first pass a total of 70 individuals were treated, 49 were treated on the second pass and 46 were removed on the third pass for a total of 165 treated shoots (Table 9). All individuals were treated by cutting the plants four inches below the root crown, and all individuals were bagged and placed in a dumpster.

Table 9. Monitoring and treatment of musk thistle sites at FEWAFB in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	10	70	70	5	5
Pass 2	10	49	49	5	5
Pass 3	8	46	46	3	5
TOTALS	**28**	**165**	**165**	---	---

Recommendations

At FEWAFB, the small number of plants can be eradicated successfully using mechanical methods. Preventing seed production is the primary goal since this is the sole way musk thistle reproduces. Severing plants below the root crown before the plants bolt and set seed is a successful control method (CSU 2013a). It is important that flowers and seeds be removed if present and follow-up monitoring should be conducted multiple times during the same growing season as sprouts come up throughout the summer and fall. 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, but severing the plant below the root crown keeps the soil disturbance to a minimum. The seed longevity is estimated to be 10 years (CCR 2014) and monitoring the known sites once no plants are found will still be important.

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.

History of Sampling and Treatments:

- Musk thistle was first mapped in 2014 by North Wind during the initial weed surveys.
- In 2018, CNHP mapped <0.1 acres of musk thistle across seven features. There were a total of 59 individuals treated.
- In 2020, CNHP visited 10 features, six features with plants and four eradicated with a total of 165 individuals treated. All individuals were treated by severing plants at least four inches below the root crown.

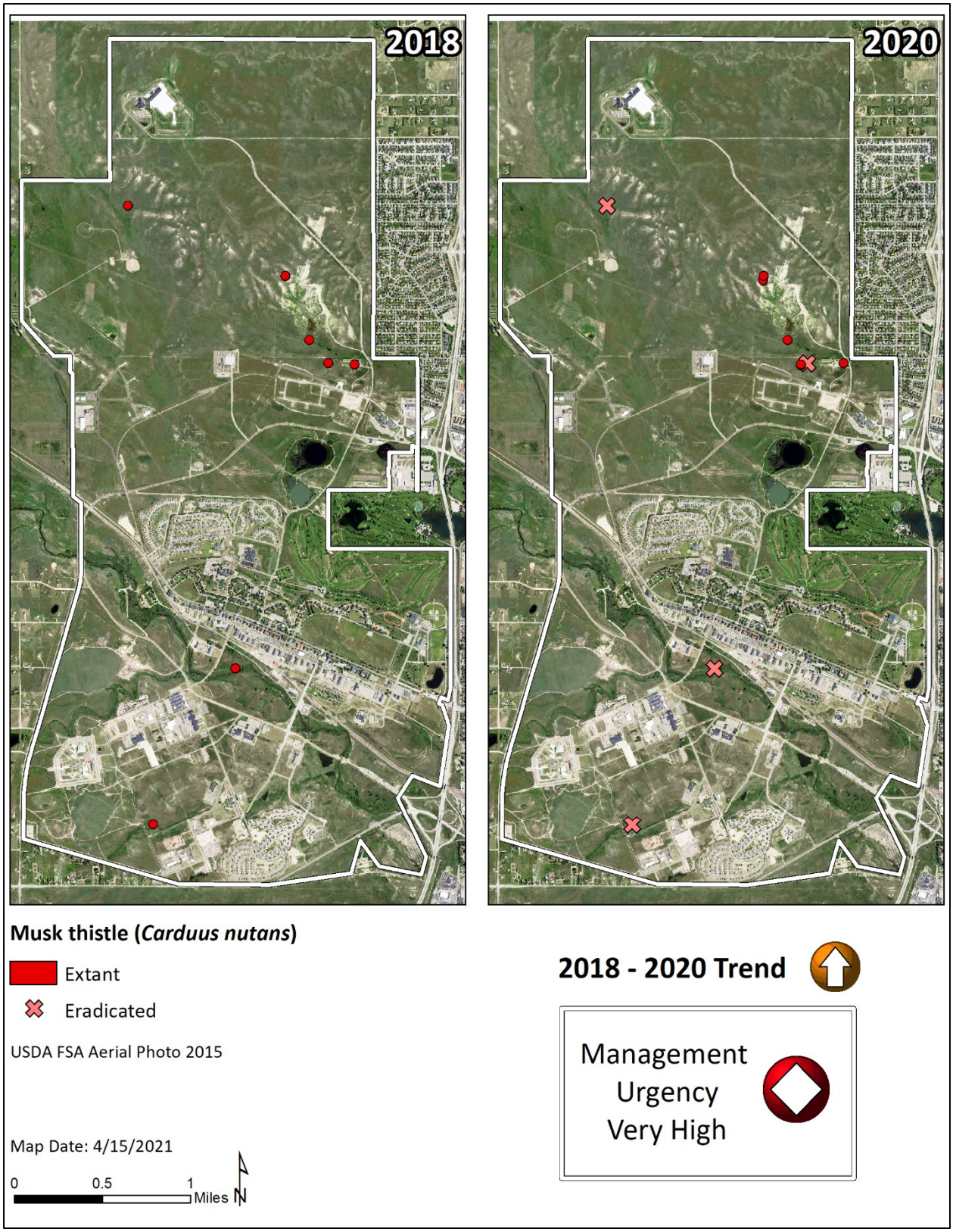


Figure 7. Distribution of musk thistle at FEWAFB in 2018 and 2020.

Canada Thistle (*Cirsium arvense*) 2018

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 2013b)
- Susceptible to shading and inundation

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

2018 Results

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 10). 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). The management urgency is considered low due the large cover and difficulty in treating this species and the fact the cover has stabilized over the years.

Table 10. Mapping of Canada thistle at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	660.6	?	?	?
2014	533.1	?	?	?
2018	603.1	9,753,243	583	---

Mapping by NW (2004), SWCA (2014), and CNHP (2018)

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.

History of Sampling and Treatments:

- Canada thistle was first mapped in 2004 with over 660 occupied acres.
- In 2014, 533 acres of Canada thistle were mapped.
- In 2018, 603 acres of Canada thistle were mapped, with an estimated 9,753,243 individuals at 583 extant sites.
- In 2020, Canada thistle was not mapped.

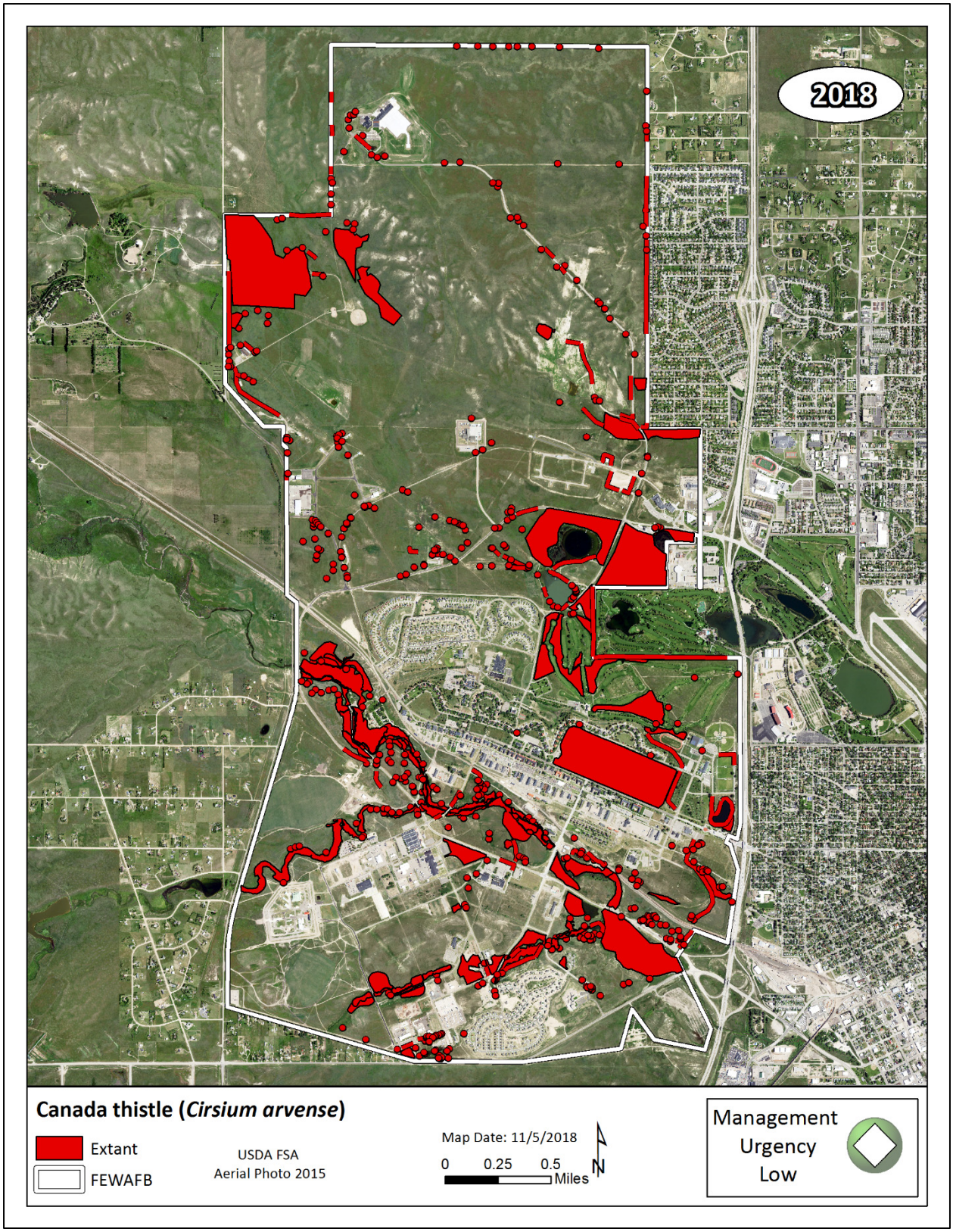


Figure 8. Distribution of Canada thistle at FEWAFB in 2018.

Bull Thistle (*Cirsium vulgare*) 2020 Update

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 (King County 2018)
- Short fleshy taproot with many primary roots
- No rhizomes

2020 Results

Bull thistle is not on the Wyoming State Designated Weed and Pest list. However, it is on the Colorado noxious weed list (List B) and is known to be problematic in some areas and has increased from a single individual to two mapped features with 34 individuals in 2020 (Figure 9, Table 11). Due to the small number of individuals, rapid response efforts have a high probability for successful eradication. This species can expand rapidly and thus bull thistle is assigned a very high management urgency.

Table 11. Mapping of bull thistle at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	---	---	---	---
2014	---	---	---	---
2018	< 0.1	1	1	0
2020	0.02	34	2	0

Mapping by NW (2004), SWCA (2014), and CNHP (2018 & 2020)

2020 Treatment

In 2020, two features were visited (one is new since 2018) during five site visits over the summer. A total of 66 individuals were treated in three site visits throughout the season (Table 12). One of the mapped features contained only two individuals. All individuals were treated by severing the plant below the root crown and bagging all the plants with flowers and/or seed heads. The bagged individuals were then deposited in a dumpster.

Table 12. Monitoring and treatment of bull thistle sites at FEWAFB in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	2	34	34	2	0
Pass 2	2	32	32	1	1
Pass 3	1	0	0	0	1
TOTALS	**5**	**66**	**66**	---	---

Recommendations

As with many biennial thistles, the key is to prevent seed production. Treating rosettes manually is the least damaging to soils but needs to be done starting in the spring and continue throughout the growing season. Severing rosettes or even bolted plants below the root crown will kill the plant. Due to the relatively short seed longevity of three years (King County 2018), the prevention of seed production is key to control. Multiple manual treatments during the same season at these two locations could result in eradication in just a few years. Managers and contractors should become familiar with bull thistle especially in the rosette stage to recognize and treat new occurrences before they go to seed.

History of Sampling and Treatments:

- Bull thistle was first mapped in 2018 by CNHP. Only 1 feature was mapped and treated.
- In 2020, CNHP visited two features and manually treated 66 individuals at multiple visits to two mapped locations.

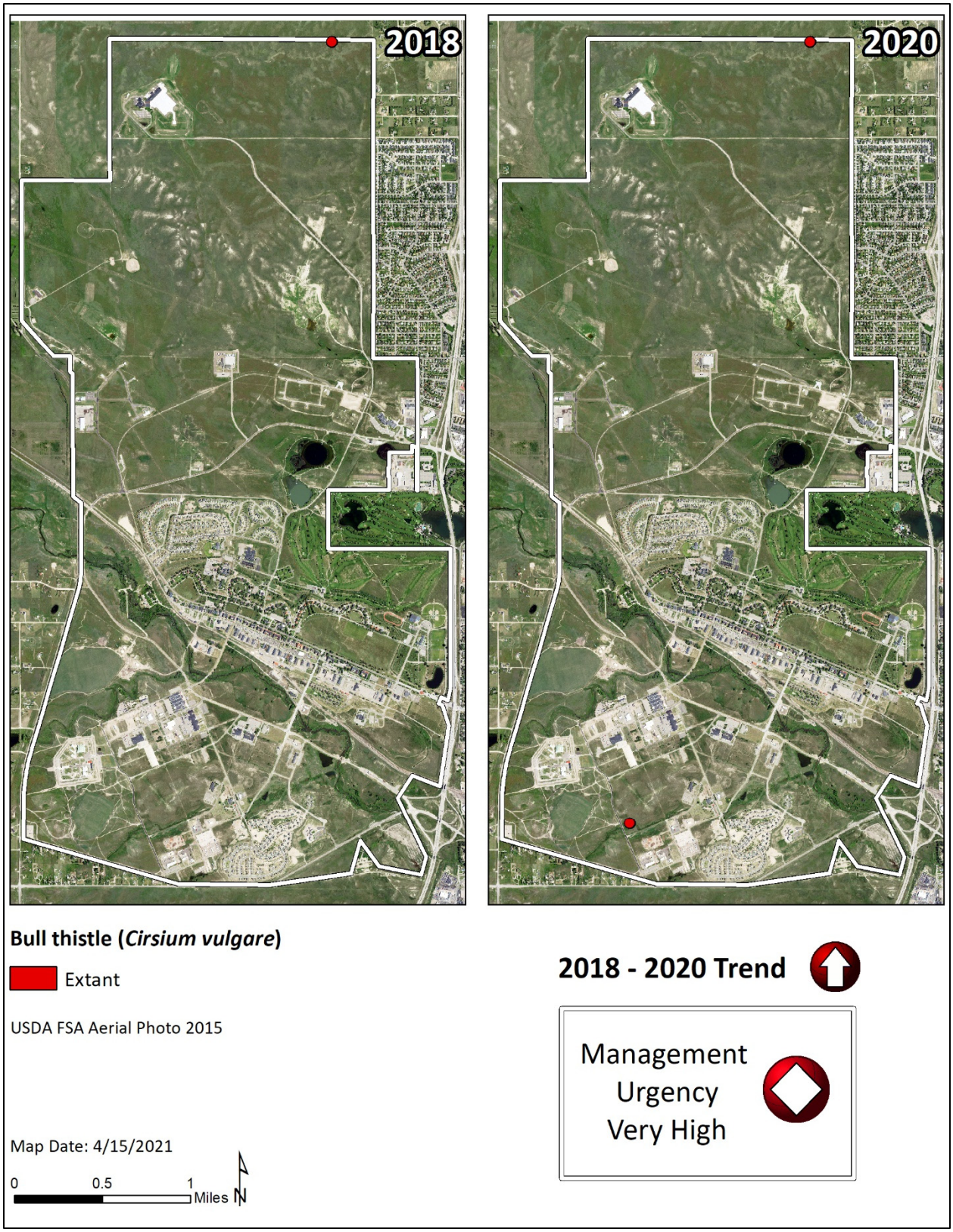


Figure 9. Distribution of bull thistle at FEWAFB in 2018 and 2020.

Diffuse Knapweed (*Centaurea diffusa*) 2020 Update

Management Urgency: Medium

Management Goals: Biocontrol

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 anytime during the growing season with disturbance
- Seed longevity of 8-10 years (CCR 2014) – wind dispersed
- Provides nectar and pollen for honeybees
- Plant has tumbleweed mobility
- Forms rosettes in its early growth stage (1-2 years)
- Can sprout from the root crown after top-kill (Zouhar 2001)

2020 Results

Diffuse knapweed is increasing at FEWAFB. In 2020 there were 15 new locations for a total of 32 mapped features with 27 extant features and five eradicated features. The total cover of diffuse knapweed is almost 1.5 acres with 42,734 individuals (Table 13). Over 80% were mapped in one area near the northeast edge of Stage Loop Road (Figure 10). The management urgency for this species is medium. One area contains the largest number of plants, over 40,000 plants. Control is possible by manually treating the outer (satellite) populations and utilizing biocontrol on the large dense area. Once diffuse knapweed becomes established across a landscape it is difficult to treat and it has a fairly long seed longevity of up to 10 years.

Table 13. Mapping of diffuse knapweed at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	---	---	---	---
2014	---	---	---	---
2018	0.46	2,404	17	0
2020	1.46	42,734	27	5

Mapping by NW (2004), SWCA (2014), and CNHP (2018 & 2020)

2020 Treatment

During the first pass in mid-June, 24 features were treated and 1,977 plants were removed. Another feature contained over 40,000 individuals and was too large to treat in this way. This area is located near the wind turbine along CATM road. Another 2,008 individuals were treated at small occurrences on the second pass and 700 individuals on the third pass (Table 14).

Table 14. Monitoring and treatment of diffuse knapweed sites at FEWAFB in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	32	42,563	1,977	25	7
Pass 2	31	2,008	2,008	22	9
Pass 3	20	700	700	12	8
TOTALS	**83**	**45,271**	**4,685**	---	---

Recommendations

Because of the increase and density in cover combined with the difficulty of treating knapweeds with commonly used control methods, we recommend introducing biocontrol organisms that feed on the flowers and roots of diffuse knapweeds. These organisms weaken the plants, reduce seed production and can help contain populations.

Knapweeds become very difficult to control once established and are most effectively controlled if treated in the first season of growth (Zouhar 2001). Diffuse knapweed was mapped at just under 1.5 acres in 2020 and has expanded tremendously since it was mapped in 2018. Typically, once an invasive species reaches over an acre in cover across a landscape, eradication is not likely. Many treatments are not successful because they damage the surrounding vegetation. Long-term studies have shown many treatments encourage knapweed invasions as they mimic suppression effects the weeds have on native forbs (Pearson and Ortega 2009). This is supported by Beck (2013) who states chemical treatments have been found to suppress knapweeds which often return to the treated sites. Seed longevity of up to 10 years (CCR 2014) is another problem because it requires at least a decade of monitoring and treatments to clear the seed bank. This may not be possible if there are knapweeds in the vicinity that could continue to blow onto disturbed soils at FEWAFB.

Biocontrols are available and likely the most economical and efficient way to suppress diffuse knapweed at FEWAFB. Although biocontrols may take three to five years to establish, they have been shown to be effective at reducing large populations of knapweeds. Some of these organisms could already be present. The area at FEWAFB is sufficiently large and dense to support biocontrol organisms. The introduction of biocontrol organisms would be the least damaging to soils and the most cost effective way to reduce knapweeds. Biocontrols can be combined with manual methods to further reduce the cover. Biocontrol agents include the lesser knapweed flower weevil (*Larinus minutus*) and gall flies (*Urophora* sp.) which have shown success in Colorado (Cranshaw 2009).

Manual treatments have been recommended for small areas and are most effective if the rosette stage is targeted. The root is not pulled but rather severed four inches below the root crown to reduce soil disturbance. This treatment must be done multiple times during the same growing season to catch all of the sprouts that can occur at any time throughout a single growing season (El Paso County 2014). Treating flowering and seeding plants is not recommended as the plants are dying at that stage and the seeds will be scattered during treatment. In addition, the soil disturbance of pulling bolted plants will create new areas for the seeds to sprout.

Herbicides alone have not been shown to be effective at eliminating knapweeds. Using herbicides with biocontrol may also not be effective. Any treatments that impact adjacent vegetation, change the soil pH, disturb the soil, increase bare ground or impact the balance of the soil organisms will be unsuccessful and can increase the cover of weeds (Pearson and Ortega 2009, Beck 2013).

The importance of proper land management in adjacent areas can't be understated. It is important to prevent disturbances where knapweed can invade. Native grasslands and properly managed lands are the best defense against invasion. Knapweeds can increase if treatments are not carried out with a site plan and success can't be documented without a follow-up monitoring protocol.

History of Sampling and Treatments:

- Diffuse knapweed was first mapped by CNHP in 2018. CNHP mapped 0.46 acres and 2,404 individuals across 17 features.
- In 2020, CNHP mapped 1.46 acres at 32 features, five were eradicated and 15 were new since 2018. A total of 4,685 shoots were treated out of 45,271 that were mapped.

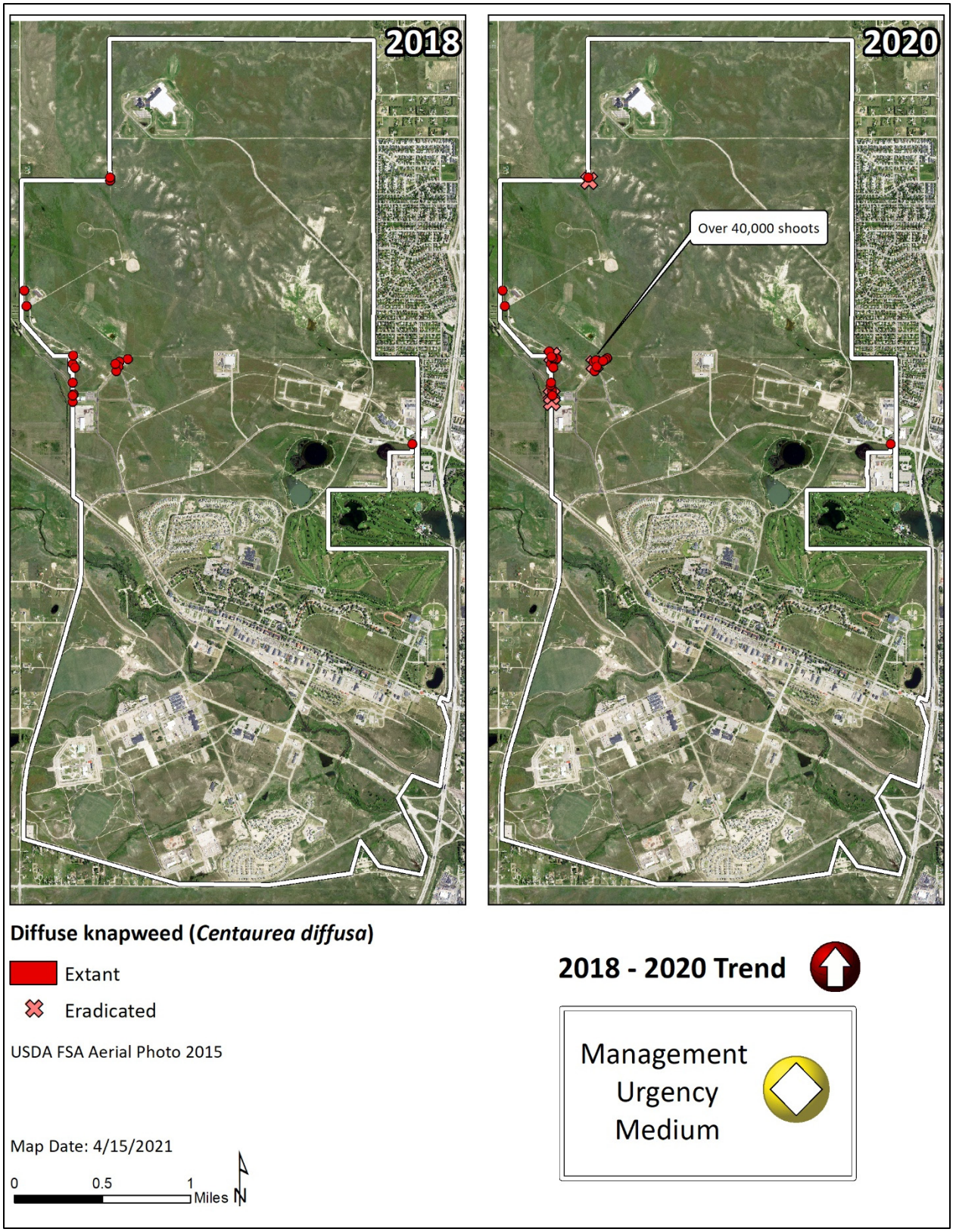


Figure 10. Distribution of diffuse knapweed at FEWAFB in 2018 and 2020.

Field Bindweed (*Convolvulus arvensis*) 2018

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 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 and often highly disturbed soils
- Early successional species that establishes on bare ground in open conditions
- Has been found to decrease over time

2018 Results

Field bindweed is found across the base and in highly disturbed areas near roads, parking lots and buildings. Because of the ubiquitous presence 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 15, Figure 11). Eradication at FEWAFB is considered unlikely due to widespread cover and the management urgency is considered to be low.

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

Table 15. Mapping of field bindweed at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	95	?	?	?
2014	6.6	?	?	?
2018	8.9	174,840	131	0

Mapping by NW (2004), SWCA (2014), and CNHP (2018)

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.

History of Sampling and Treatments:

- Field bindweed was first mapped in 2004 with 95 occupied acres.
- In 2014, 6.6 acres of field bindweed were mapped.
- In 2018, 8.9 acres of field bindweed were mapped, with an estimated 174,840 individuals at 131 extant sites.
- In 2020, field bindweed was not mapped.

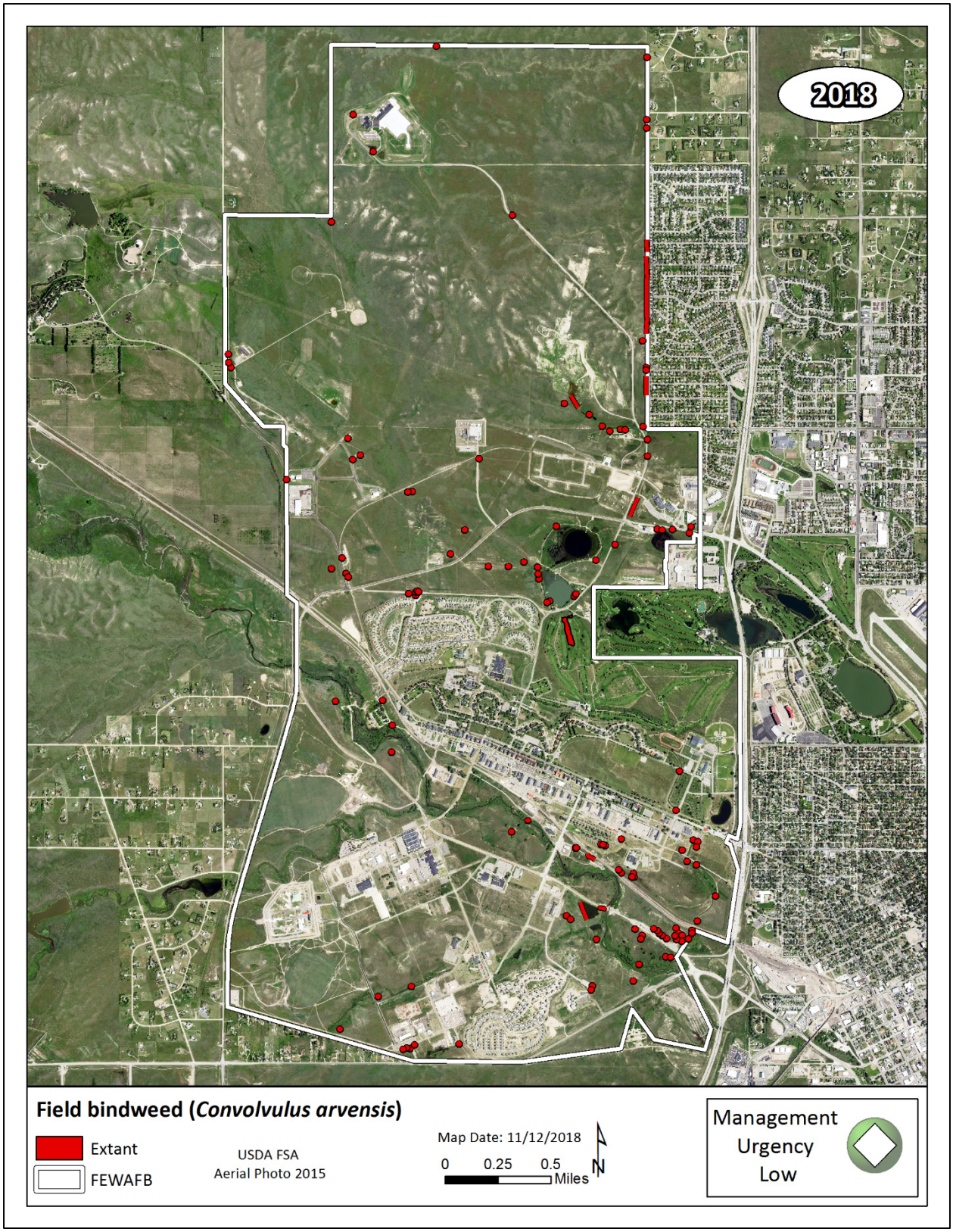


Figure 11. Distribution of field bindweed at FEWAFB in 2018.

Houndstongue (*Cynoglossum officinale*) 2018

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 Results

The management urgency for houndstongue is low due to the wide distribution across FEWAFB, the large number of mapped features (250) and large number of individuals in excess of 261,000. Houndstongue is found primarily on wetter landscapes on the base with Canada thistle and leafy spurge. The majority of occurrences were mapped in the drainages and natural areas on the southern end of the property. On Crow Creek, populations were commonly recorded under the willows and other woody riparian vegetation and in areas supporting the Colorado butterfly plant. Eradication is not a reasonable goal with widespread coverage over 99 acres and 261,453 individuals mapped (Table 16 and Figure 12).

Table 16. Mapping of houndstongue at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	50.2	?	?	?
2014	165.8	?	?	?
2018	99.3	261,453	250	0

Mapping by NW (2004), SWCA (2014), and CNHP (2018)

Recommendations

Focusing treatments on smaller sites is a possibility. Site plans should be created before treatments are initiated to effectively keep track of goals, unintended impacts and to follow any trends that unfold for houndstongue populations (Appendix A). Multiple treatments throughout a single growing season are necessary to prevent bolting and seed production as houndstongue plants can mature throughout the growing season. Targeting plants in the sprouting stage without harming nearby vegetation is the best way to control houndstongue. Protecting native vegetation is a good defense against expanding houndstongue populations.

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).

History of Sampling and Treatments:

- Houndstongue was first mapped in 2004 with 50.2 occupied acres.
- In 2014, 165.8 acres of houndstongue were mapped.
- In 2018, 99.3 acres of houndstongue were mapped, with an estimated 261,453 individuals at 250 extant sites.
- In 2020, houndstongue was not mapped.

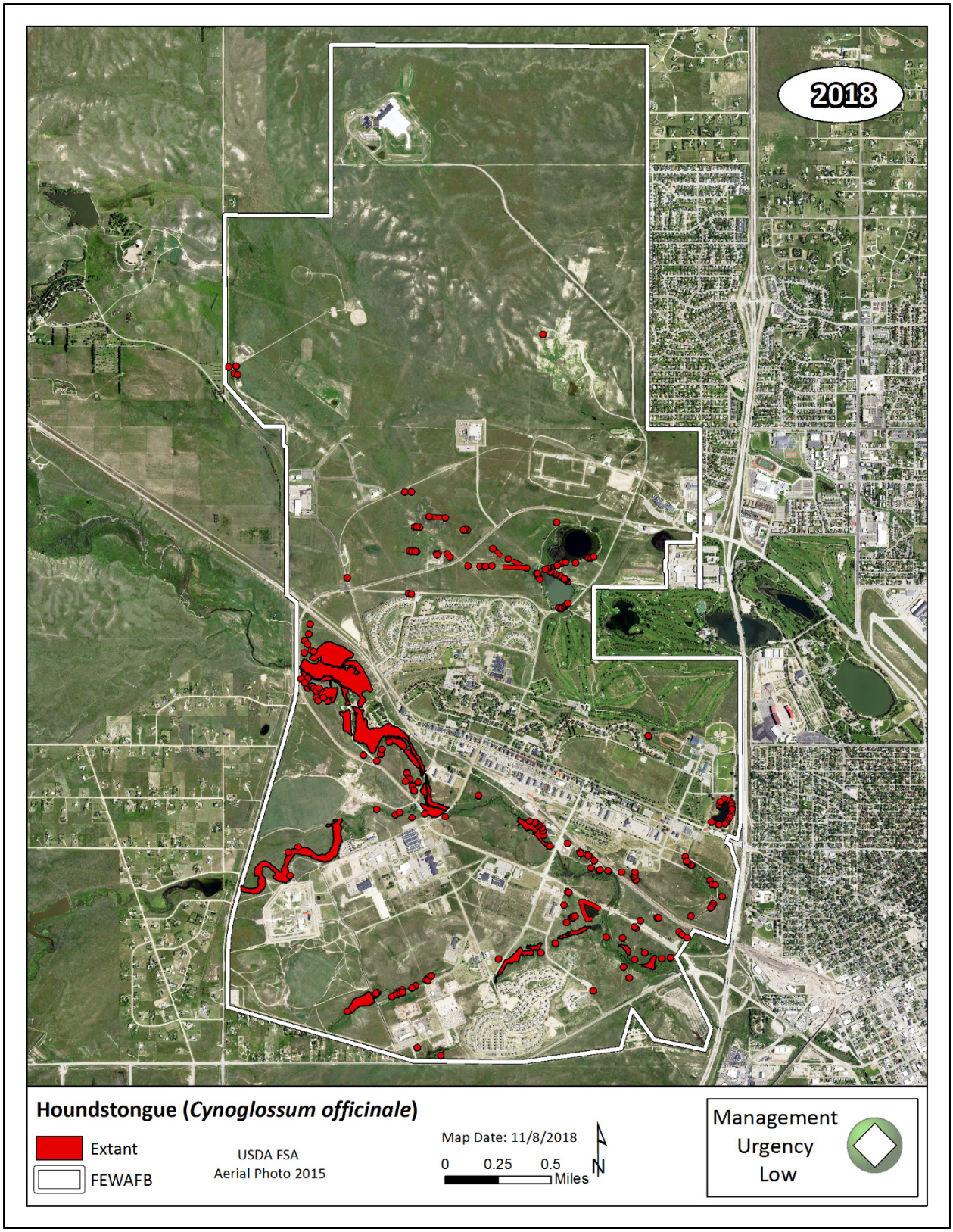


Figure 12. Distribution of houndstongue at FEWAFB in 2018.

Common Teasel (*Dipsacus fullonum*) 2020 Update

Management Urgency: Very 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 which can grow to 6 feet
- Reproduction only from seeds which are thought to be viable for up to 14 years (King County 2018)
- 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
- Seeds fall near the plant but often moved by water, mowers, soil movement and animals
- Deep taproot up to 2 feet long (King County 2018)
- Most seeds fall near the parent plant but can be moved by mowing, water and animals

2020 Results

Common teasel was mapped across 1.4 acres on the southeast part of FEWAFB in both 2018 and 2020 (Figure 13). In 2020, although the cover remained the same since 2018, the number of shoots decreased dramatically from 2,138 in 2018 to only 48 in 2020. The number of extant features has dropped from four to three (Table 17). Natural resource managers at FEWAFB have worked on mechanically treating this species before and after the 2020 weed mapping effort. As a result of the reduction in shoots compared to 2018, the management urgency is considered to be very high due to the possibility for eradication and relatively small number of mapped sites and shoots. Common teasel is very aggressive and resource managers are gaining control but continued efforts will be necessary to achieve eradication at FEWAFB.

Table 17. Mapping of common teasel at FEWAFB.

	Occupied Acres	Estimated # of Shoots (all passes)	# of Extant Features	# of Eradicated Features
2004	---	---	---	---
2014	---	---	---	---
2018	1.4	2,138	4	0
2020	1.4	1,662	3	1

Mapping by NW (2004), SWCA (2014), and CNHP/FEWAFB (2018 & 2020)

2020 Treatment

In 2020, CNHP visited the same four features mapped in 2018 and one feature was eradicated. The active involvement of the FEWAFB natural resource managers and CNHP throughout the summer of 2020 resulted in the removal of 1,662 individuals during 29 site visits to the three extant sites (Table 18). Multiple visits during the same growing season are essential to reduce the number of sprouting individuals throughout the summer. The number of sprouts were highest in the middle of the summer and reductions in the numbers of sprouts began to show up after six site visits in 2020 (Table 18). By removing the shoots, the plants are prevented from bolting and producing seeds.

Table 18. Monitoring and treatment of common teasel sites at FEWAFB in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with plants	# Sites without Plants
Pass 1	4	48	48	3	1
FEWAFB Pass 1*	3	190	190	3	0
Pass 2	4	104	104	2	2
FEWAFB Pass 2*	3	170	170	3	0
Pass 3	4	186	186	3	1
FEWAFB Pass 3*	3	434	434	3	0
FEWAFB Pass 4*	3	218	218	3	0
FEWAFB Pass 5*	3	252	252	3	0
FEWAFB Pass 6*	2	60	60	2	0
TOTALS	**29**	**1,662**	**1,662**	---	---

***** Visited by Alex Schubert, Fish and Wildlife Biologist, before and after CNHP 2020 weed mapping.

Recommendations

The frequency of treatments within the same growing season for the next few years of treatment is going to be extremely important to gain control of common teasel at FEWAFB. The protection of any intact adjacent vegetation is extremely important in managing common teasel. The numbers of sprouts recorded in all passes in 2020 demonstrates the need for multiple same-season visits. This intense work should begin to slow as the seed bank is depleted. Preventing common teasel from going to seed is the primary goal. We recommend the continued manual removal of common teasel at FEWAFB with frequent same season visits starting early in the spring. In 2020, nine visits to each site was conducted by FEWAFB staff and CNHP to remove sprouting plants. For large plants, severing the root crown of the plant at least four inches below the soil surface with a sharp knife or digging tool at various stages of growth will kill plants with much less soil disturbance than digging the roots (Duncan 2018). When small sprouts are present, the entire plant can be pulled. Targeting the sprouts throughout the growing season will be the best way to gain control of teasel. This plant sprouts vigorously during the growing season and more than nine visits a year may be required to prevent the plants from bolting and going to seed in the next few years.

If common teasel becomes dense and removal would cause a large area of open soil, cutting bolting or flowering stems may 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 flower heads of plants cut during or immediately after flowering failed to germinate (Cheesman 1998). Therefore, significant seed reduction is possible with correctly timed stem cutting.

There are riparian and wetland appropriate herbicides available for the treatment of common teasel, but if success can be achieved with mechanical treatments, 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 complex. 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 2011).

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.

History of Sampling and Treatments:

- Common teasel was discovered and pulled by Natural Resources staff prior to 2018.
- Common teasel was first mapped by CNHP in 2018.
- In 2020, CNHP mapped 1.4 acres of common teasel with three extant and one eradicated site. Twenty-nine site visits were made to three extant sites and 1,662 shoots were manually removed over the season by FEWAFB and CNHP.

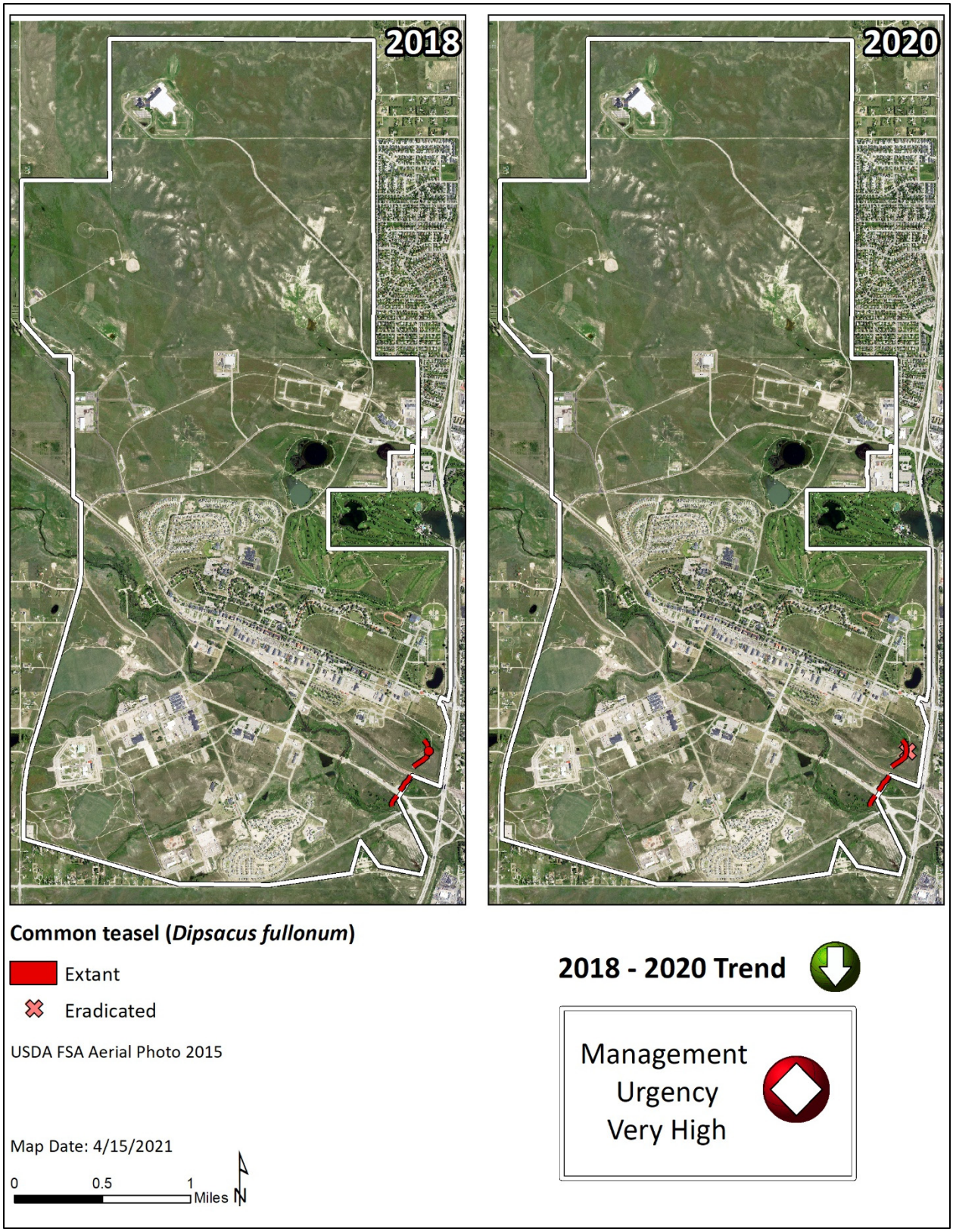


Figure 13. Distribution of common teasel at FEWAFB in 2018 and 2020.

Russian Olive (*Elaeagnus angustifolia*) 2020 Update

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

2020 Results

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. The management urgency is ranked as high because there is a high probability for eradication at FEWAFB. The 2020 results indicate there was an increase in the number of shoots from 87 in 2018 to 102 in 2020. However, the number of extant features decreased from 42 in 2018 to 34 in 2020 (Table 19 and Figure 14).

Table 19. Mapping of Russian olive at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	---	---	---	---
2014	4.2	?	?	?
2018	1.5	87	42	0
2020	1.4	102	34	8

Mapping by NW (2004), SWCA (2014), and CNHP (2018 & 2020)

2020 Treatment

The resource management staff conduct all treatments for Russian olive at the FEWAFB. In 2020, 42 mapped features were visited with 102 individuals at 34 extant sites, and eight sites with plants in 2018 were eradicated (Table 20).

Table 20. Monitoring and treatment of Russian olive sites at the FEWAFB in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	42	102	0	34	8
TOTALS	**42**	**102**	**0**	---	---

Recommendations

The first priority for Russian olive is 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.

History of Sampling and Treatments:

- SWCA mapped 4.2 acres of Russian olive in 2014. This was the highest amount of Russian olive at FEWAFB since monitoring.
- In 2018, CNHP mapped 1.5 acres. Much of the area has been reduced since 2014. Many of the remaining trees are large mature individuals.
- In 2020, CNHP mapped 1.4 acres with 102 individuals at 34 sites, eight features were eradicated.

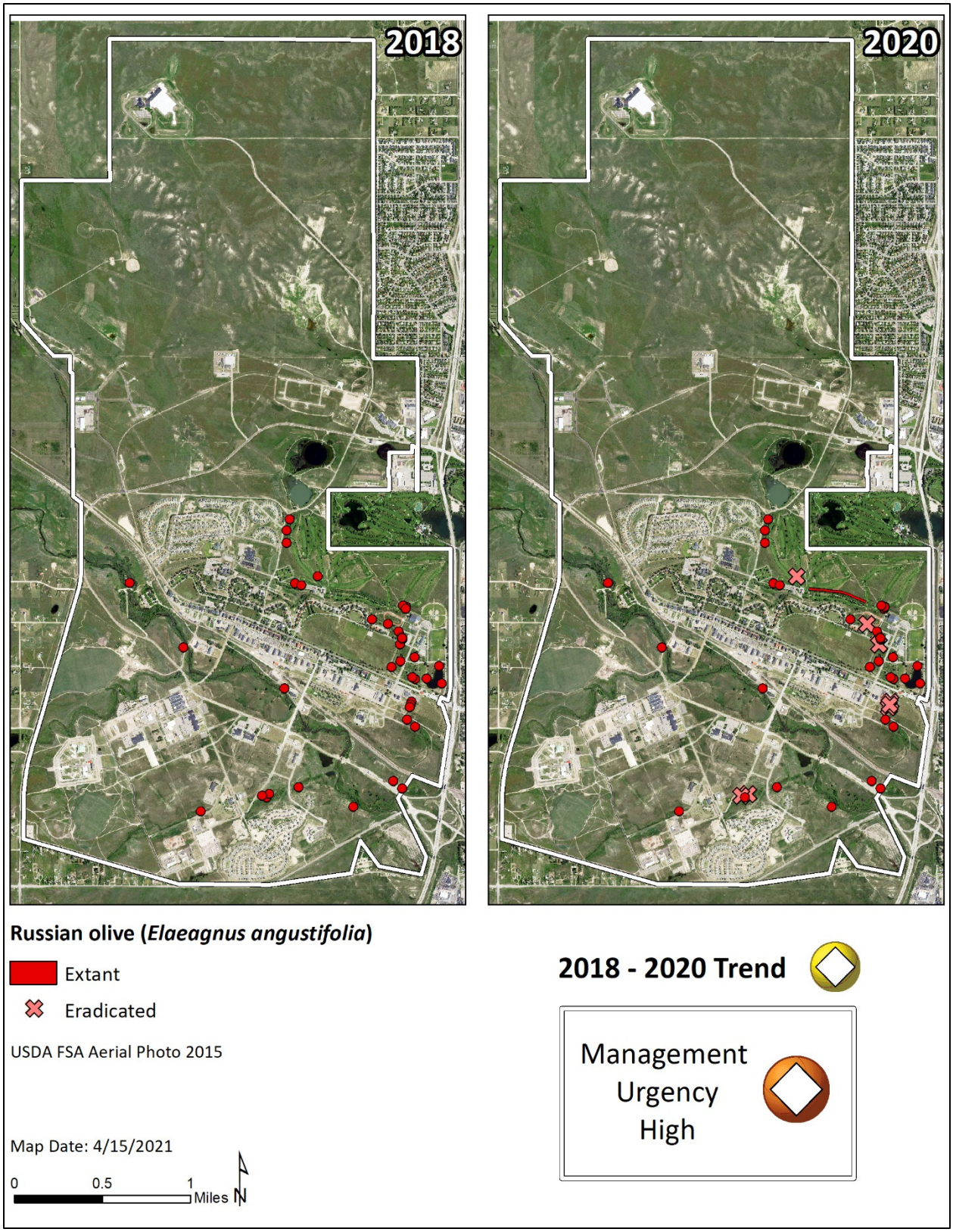


Figure 14. Distribution of Russian olive at FEWAFB in 2018 and 2020.

Leafy Spurge (*Euphorbia esula*) 2018

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 Results

Leafy spurge was mapped across 143.4 acres primarily in the creek and drainage areas on FEWAFB (Table 21 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 21. Mapping of leafy spurge at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	28.4	?	?	?
2014	134.0	?	?	?
2018	143.4	5,621,166	101	0

Mapping by NW (2004), SWCA (2014), and CNHP (2018)

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 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 2014b).

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.

History of Sampling and Treatments:

- Leafy spurge was first mapped in 2004 with 24.8 occupied acres.
- In 2014, 134 acres of leafy spurge were mapped.
- In 2018, 143.4 acres of leafy spurge were mapped, with an estimated 5,621,166 individuals at 101 extant sites.
- In 2020, leafy spurge was not mapped.

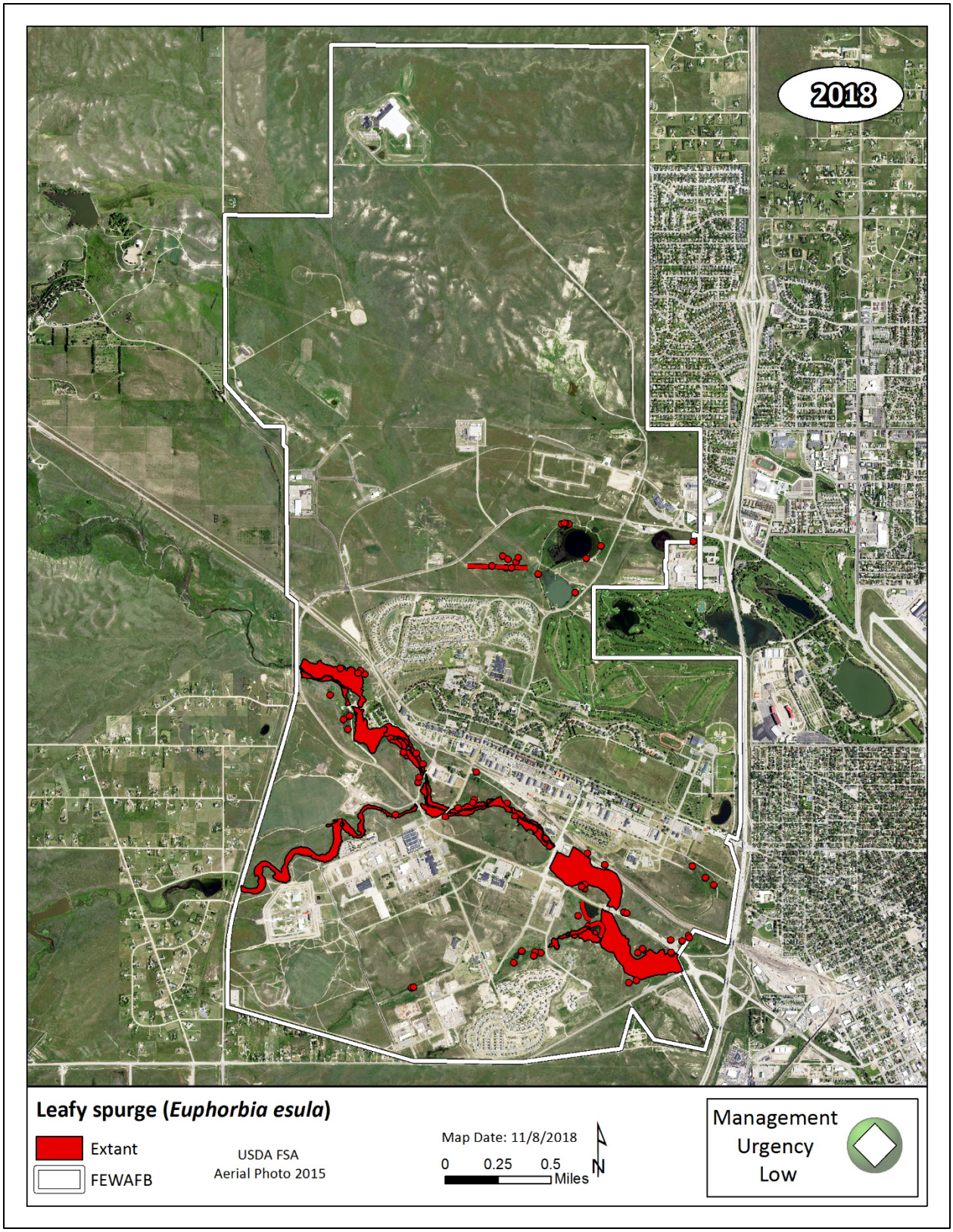


Figure 15. Distribution of leafy spurge at FEWAFB in 2018.

Baby's Breath (*Gypsophila paniculata*) 2020 Update

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

- Perennial, escaped ornamental with large taproot to 13 feet
- Flowers June – September
- 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
- Drought tolerant
- Difficult to remove once established

2020 Results

The management urgency is considered very high for Baby's breath. In 2020, it increased in cover from <0.1 acre to 0.2 acres; the number of extant features went from nine in 2018 to 28 in 2020 and the number of shoots increased by 151 individuals since 2018 (Table 22). The majority of individuals were found along cut roadsides along CATM road (Figure 16). The potential for eradication is high due to the low coverage and number of individuals.

Table 22. Mapping of baby's breath at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	---	---	---	---
2014	---	---	---	---
2018	<0.1	76	9	0
2020	0.2	217	28	4

Mapping by NW (2004), SWCA (2014), and CNHP (2018 & 2020)

2020 Treatment

During the first pass, 217 individuals were treated by removing sprouts and/or cutting the plant below the root crown, 213 individuals were removed during the second pass and another 86 for the third pass in 2020. A total of 516 individuals were removed in 80 site visits over the summer (Table 23). No inflorescences were found during this summer indicating no seeds were produced this season.

Table 23. Monitoring and treatment of baby's breath at FEWAFB in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	32	217	217	28	4
Pass 2	32	213	213	17	15
Pass 3	16	86	86	8	8
TOTALS	**80**	**516**	**516**	---	---

Recommendations

Preventing seed production and suppressing the root system is the primary 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 sprout; if severed above the caudex, the plant has the chance to sprout (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.

History of Sampling and Treatments:

- Baby's breath was first identified by CNHP in 2018. CNHP mapped <0.1 acres.
- In 2020, the population of baby's breath increased in cover, number of features as well as number of individuals. The sites were treated multiple times during the growing season and no seeds were produced this year.

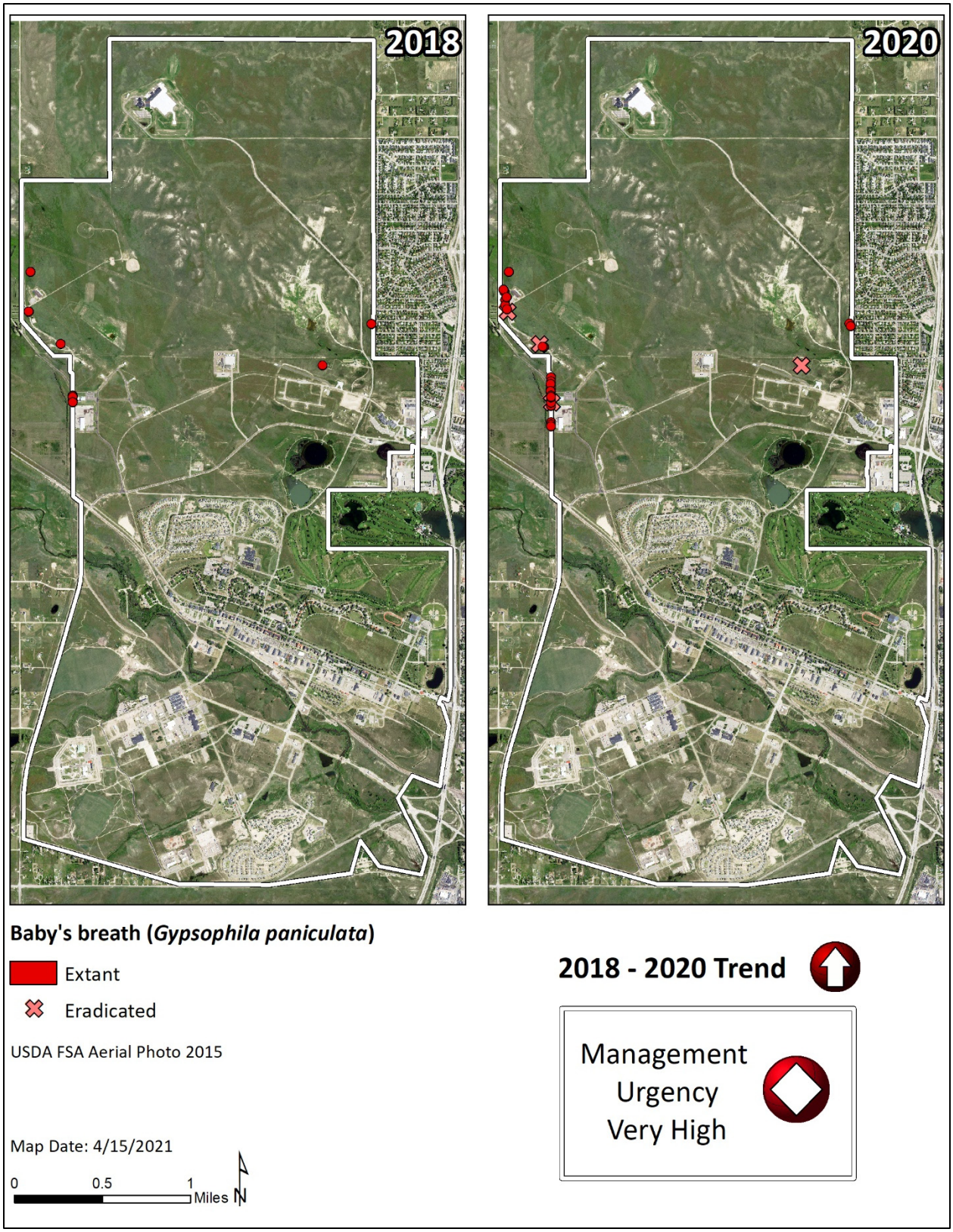


Figure 16. Distribution of baby's breath at FEWAFB in 2018 and 2020.

Dalmatian Toadflax (*Linaria dalmatica*) 2018

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 garden escape
- 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 2014c)
- Plants commonly only live up to 3 years (Weed and Schwarzlander 2014)

2018 Results

Dalmatian toadflax was not mapped in 2018 due to the wide distribution across FEWAFB. It is, especially common in the northern part of the base, with 3,913 acres mapped in 2014 (Table 24). Attempting to map Dalmatian toadflax is cost prohibitive 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 24. Mapping of Dalmatian toadflax at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	50.2	?	?	?
2014	3,913	?	?	?
2018	---	---	---	---

Mapping by NW (2004), SWCA (2014), and CNHP (2018)

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.*

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 (see discussion on biocontrol in Appendix D).

Cultural

Combining grazing and biocontrol could 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 and timing would be important.

History of Sampling and Treatments:

- Dalmatian toadflax was first mapped in 2004 with 50.2 occupied acres.
- In 2014, 3,913 acres of Dalmatian toadflax were mapped.
- In 2018, Dalmatian toadflax was not mapped.
- In 2020, Dalmatian toadflax was not mapped.

Purple Loosestrife (*Lythrum salicaria*) 2020 Update

Management Urgency: Very High

Management Goals: Rapid Response Eradication

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

- Long-lived (>20 years), rhizomatous wetland perennial that escapes from residential plantings
- Seeds can build up and dominate large areas quickly
- 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 roots, seeds and broken stems
- Simple smooth-edged leaves grow opposite or whorled from stiff, 4-6 sided stems
- Purple flowers in spikes at the top of 6-10 feet stems from July to September

2020 Results

In 2020, purple loosestrife was found at nine sites on FEWAFB (Figure 17). The number of extant features and shoots has increased since 2018. The nine extant features had 179 individuals (Table 25). Because of the low cover of 0.02 acres (~66 square meters), rapid response actions have the potential to result in eradication of purple loosestrife. The high likelihood for purple loosestrife to spread to other disturbed wetlands at FEWAFB along with the fairly small size of the occurrence warrants a very high management urgency.

Table 25. Mapping of purple loosestrife at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	---	---	---	---
2014	0.1	?	?	?
2018	<0.1	62	4	0
2020	0.02	179	9	1

Mapping by NW (2004), SWCA (2014), and CNHP (2018 & 2020)

2020 Treatment

In 2020, at 10 mapped features there were 26 site visits and a total of 270 plants removed. The entire plant was removed, bagged and disposed of in dumpsters. During the summer visits there were fewer sprouts removed at subsequent visits (Table 26).

Table 26. Monitoring and treatment of purple loosestrife at the FEWAFB in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	10	179	179	9	1
Pass 2	10	57	57	5	5
Pass 3	6	34	34	2	4
TOTALS	**26**	**270**	**270**	---	---

Recommendations

Purple loosestrife occurrences are relatively small but they are increasing. Rapid response is very important at this stage and it is easy to lose control with this species as the seed bank can produce large blooms in a single season in areas that had just a few plants the year before. Currently, eradication is possible with immediate rapid response actions that include repeated removal of all plant parts multiple times during the same growing season.

Preventing the plants from going to seed is extremely important during the growing season so seeds do not build up in the seed bank. When treating manually, it is important that all plant parts are bagged and disposed of as trash. Plants can re-establish from fragments of roots and stems. 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 for Wyoming. 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.

History of Sampling and Treatments:

- Purple loosestrife was first documented in 1998.
- SWCA mapped purple loosestrife at FEWAFB in 2014 with only a few occurrences. 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.
- In 2018, CNHP mapped <0.1 acres of purple loosestrife across 4 features.
- In 2020, purple loosestrife increased the number of extant features and number of individuals.

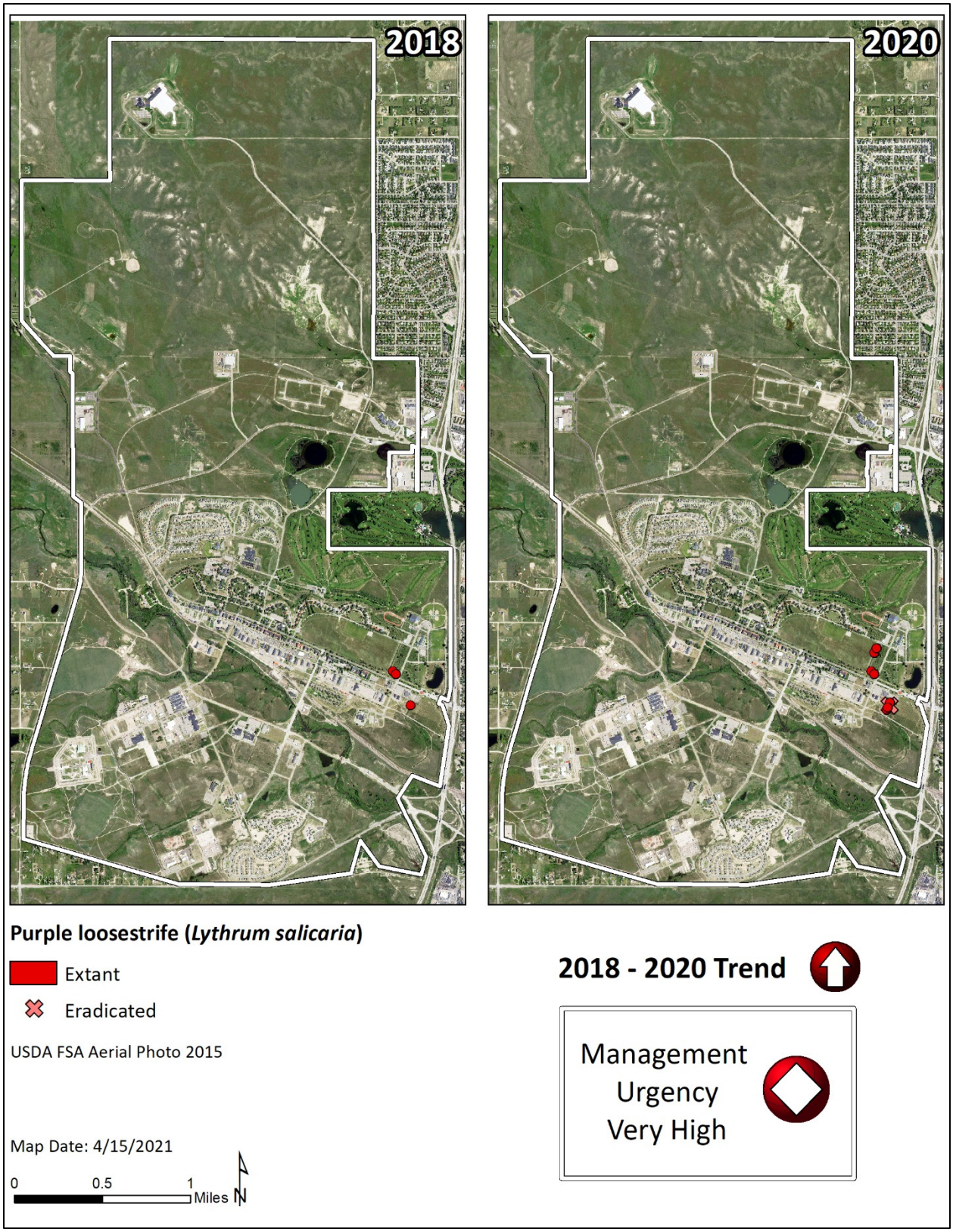


Figure 17. Distribution of purple loosestrife at FEWAFB in 2018 and 2020.

Scotch Thistle (*Onopordum acanthium*) 2020 Update

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 stout taproot that grows to 12 inches, stem to 10 feet
- Reproduction is only by seed
- Seed longevity is 7-20 years. (CDA 2016)
- Seed production 8,000-40,000 seeds per plant (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

2020 Results

In 2020, just under 42 square meters (0.01 acres) of Scotch thistle were mapped compared to over five acres in 2014. Ongoing treatments by FEWAFB staff have resulted in a dramatic decline since Scotch thistle was mapped in 2014; it was not found in the 2004 survey. There are seven known locations on the base and in 2020 four features were eradicated and three were extant containing 35 shoots (Table 27, Figure 18). Management urgency is considered very high because continued rapid response actions are likely to eradicate this species at FEWAFB.

Table 27. Mapping of Scotch thistle at FEWAFB.

	Occupied Acres	Estimated # of Shoots (Pass 1)	# of Extant Features	# of Eradicated Features
2004	---	---	---	---
2014	5.1	?	?	?
2018	<0.1	78	7	0
2020	0.01	35	3	4

Mapping by NW (2004), SWCA (2014), and CNHP (2018 & 2020)

2020 Treatment

A total of 244 individuals were treated during 21 site visits to seven known sites throughout the growing season in 2020. The first visit (pass) in 2020 resulted in the removal of 35 shoots. However, at the two subsequent visits in mid and late summer the numbers of sprouts found increased with 73 removed in mid-summer and 136 sprouts removed in late summer (Table 28). This demonstrates the extremely high importance for the same-season follow-up visits. Scotch thistle sprouts all summer long and without follow-up visits, it is likely plants would have bolted and gone to seed. Each bolted plant is estimated to contain from 8,000 to 40,000 seeds per plant (CDA 2016). Each plant that is prevented from going to seed is significant in reducing the seed bank. In addition, the sprouts are much easier to remove than mature bolted plants or very large rosettes and with far less soil disturbance. The majority of the Scotch thistle is found in two features near the race track.

Removal of the rosettes should result in reduced seed production and lower numbers of plants that need to be treated for 2021. Large rosettes and bolted plants were treated by severing the plant at least four inches below the root crown, which kills the plant. All the flowers and seed heads found were bagged and disposed of in a dumpster to reduce the seed bank.

Table 28. Monitoring and treatment of Scotch thistle at FEWAFB in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	7	35	35	3	4
Pass 2	7	73	73	1	6
Pass 3	7	136	136	1	6
TOTALS	**21**	**244**	**244**	---	---

Recommendations

Scotch thistle is a biennial which reproduces only from seeds. Therefore, preventing seed production is the primary goal. For 2021, visit all seven Scotch thistle sites as early as possible to begin to remove any sprouts. This should continue at least two more times in the mid and late summer season to prevent seed production. Continued monitoring at these sites will become much less labor intensive if the sprouts are removed especially over the next few years.

Severing the bolted plants and large rosettes at least four inches below the root crown is recommended if mature plants are found. Mature Scotch thistle plants get very large, up to 10 feet tall with a large thick root, even though this is a short-lived biennial species. The large mature plants are extremely difficult to remove because of the large biomass and extensive spines. So preventing the plants from maturing is very beneficial and makes treatment much more efficient. Targeted manual digging when the plants are still in the rosette stage is ideal because no seeds are available to spread during removal efforts and the plants are much smaller and easier to remove. Extreme care should be taken not to disturb surrounding soils when removing plants, as this makes new habitat for weeds. Monitoring for new plants should occur for many years as the seeds are estimated to remain viable from seven to 20 years (CDA 2016).

Herbicides are not recommended at this time due to the low cover and necessity for multiple treatments throughout the growing season at the same site. Any treatments that leave behind bare soils should be avoided. Follow-up after treatments for new sprouts multiple times during the same growing season is by far the most important action for successful results. Herbicides typically can't be applied in the same area multiple times in the same growing season. Spot application with a backpack sprayer would be recommended but only works well for rosettes. Since the plants are so easy to treat manually, it is most cost-effective and likely more successful to manually treat the plants.

History of Sampling and Treatments:

- Scotch thistle was first identified and mapped in 2014 by SWCA. 2014 contained the most acreage of scotch thistle at 5.1 acres.
- Acreage drastically decreased in 2018 when CNHP mapped this species. CNHP mapped <0.1 acres of scotch thistle.
- In 2020, the number of extant features and number of Scotch thistle individuals decreased since 2018. The extant Scotch thistle features had new sprouts at all follow-up site visits.

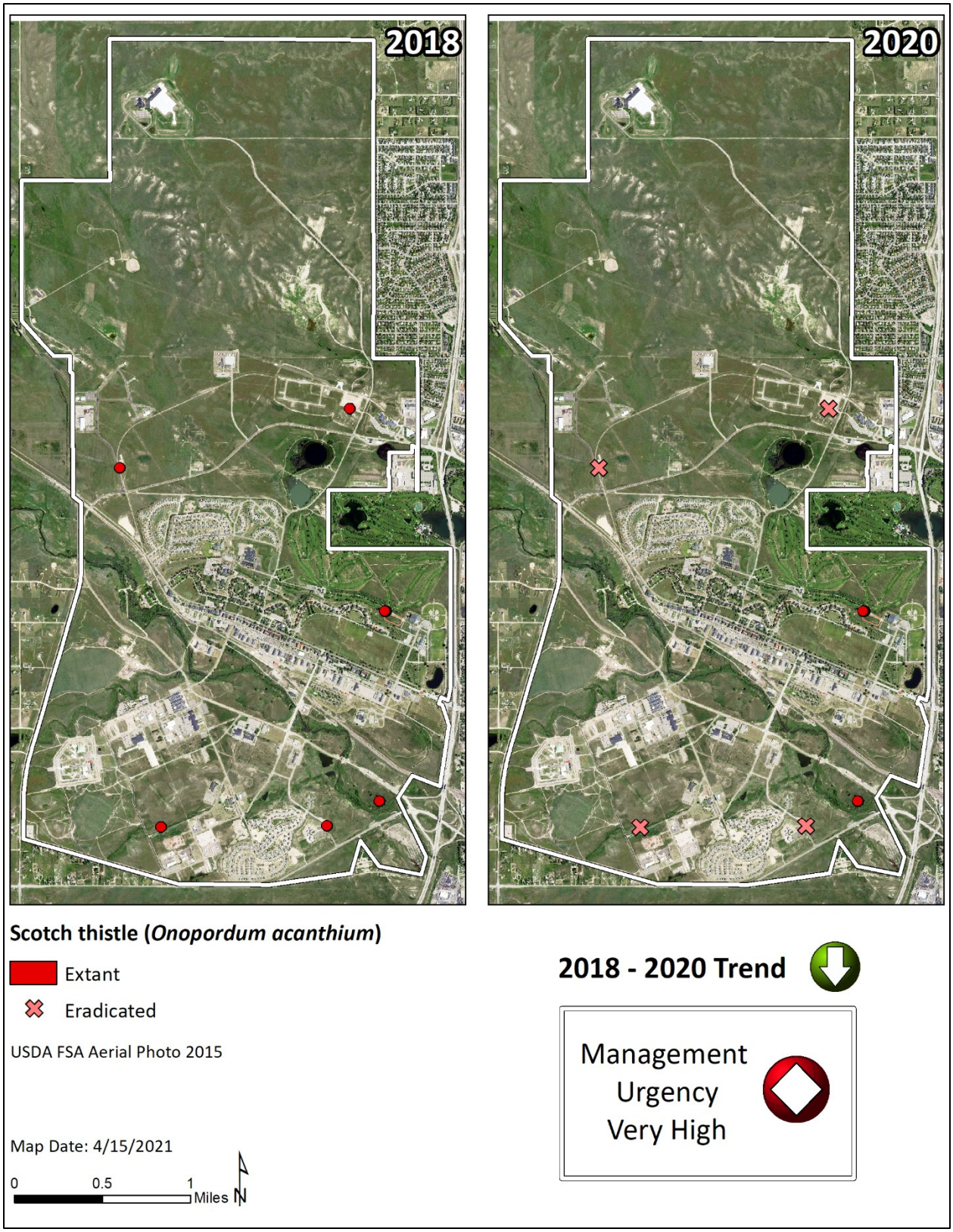


Figure 18. Distribution of Scotch thistle at FEWAFB in 2018 and 2020.

RECOMMENDATIONS

Protect Natural Areas

The protection of undisturbed sites is the best measure to prevent the spread of noxious weeds and is the first rule of successful weed management in natural areas. We recommend that the natural areas of FEWAFB continue to be monitored for rapid response species of weeds. Natural areas should be protected from unnecessary disturbances. Native species provide weed competition in addition to ecosystem services like pollinator habitat, soil stability, habitat structure, diversity, wetland protection and pollution abatement.

Monitoring

Monitoring the cover of weeds as well as monitoring after weed treatments provides data that can result in successful weed management. Many weed species experience natural declines, while newly introduced species can rapidly expand. In addition, management activities may cause weed footprints to expand or decline. Perennial species with underground root buds that are stimulated by above ground treatment activities (e.g. Canada thistle and hoary cress) can increase with inappropriate treatments. 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. These can result from natural controls already present in the system being given time to work. 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. These changes in weed populations can only be discovered by having a monitoring program.

Site Plans

Sites where weeds have been mapped have different characteristics. They may be in a field with other noxious weeds, or with native plants, or rare plants and animals. They will vary in terms of wetness from being a wetland to an upland and in between. Some areas have higher degrees of disturbance and different types of disturbances which can range from the influx of polluted water to vehicles or construction activities, etc. The cover of native and non-native species and where they are located can all impact treatments. The biology of the target species and the level of infestation at a site also vary and will change the type of treatment. Site plans are short reports that are written before a treatment is undertaken. A site plan must include a goal (or goals) to be achieved for that particular site. Removing or killing plants for one season is not considered a goal, it is an action. What is the anticipated role of the actions that are undertaken and will they accomplish the goal for the target area? An example of a goal is preventing all seed production, or containment by targeting satellite populations for control or introducing biocontrol. 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.

One of the most important activities involved with weed management is to record treatments and monitor post treatment for success. The Site Assessment Worksheet helps immensely with this exercise and informs time-saving, cost-saving, and course corrections. Use the plan to design the size of the treatment which needs to be manageable, 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 which are essential for successful treatments should also be included in the plan. This helps to determine if treatments are working or not. Site plans for natural areas being experimentally grazed for weed control or with biocontrol introductions are also appropriate (Appendix A).

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. A site plan which has been implemented is instrumental in recognizing when a change in management is necessary.

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.

Noxious weeds with widespread cover and no available biocontrols include houndstongue and hoary cress at FEWAFB. These species can be treated on a small, localized scale based on priorities and goals for individual sites. Houndstongue and hoary cress populations are especially challenging due to their prevalence in riparian areas and within TES habitat for the Prebles Meadow Jumping Mouse and the rare Colorado butterfly plant. Monitoring for newly infested satellite populations that can be successfully treated is a means to contain the spread of hoary cress. Small populations of houndstongue can be treated to reduce the overall cover and number of extant sites following the protocols used for the treatments as described below with multiple site visits (at least three) within the growing season to remove plants and prevent seed production.

Early Detection Rapid Response (EDRR)

Continue rapid response activities starting early in the growing season, using mechanical treatments multiple times during the same season every year for the high management urgency species (common burdock (*Arctium minus*), musk thistle (*Carduus nutans*), baby's breath

(*Gypsophila paniculata*), purple loosestrife (*Lythrum salicaria*), Scotch thistle (*Onopordum acanthium*), common teasel (*Dipsacus fullonum*), and bull thistle (*Cirsium vulgare*)). Baby's breath, common teasel and purple loosestrife, have the highest potential to expand rapidly even in a single year, and should be prioritized for treatment over other species if resources are limited.

Table 29. Summary of suggested weed treatment methods and actions for 2021.

Latin Name	Common Name	Site Visits Per Season	2021 Action
Arctium minus	Common burdock	3 spring/summer/fall	Manual #1
Centaurea diffusa	Diffuse knapweed	*	Biocontrol
Cardaria draba	Whitetop	As found	Treat satellite populations
Carduus nutans	Musk thistle	3 spring/summer/fall	Manual #1
Cirsium arvense	Canada thistle	*	Future biocontrol
Cirsium vulgare	Bull thistle	3 spring/summer/fall	Manual #1
Convolvulus arvensis	Field bindweed	*	Biocontrol
Cynoglossum officinale	Houndstongue	3/ localized targets	Manual #1
Dipsacus fullonum	Common teasel	Visit bi-weekly	Manual #1
Elaeagnus angustifolia	Russian olive	Monitor	Method #3
Euphorbia esula	Leafy spurge	*	Biocontrol
Gypsophila paniculata	Baby's breath	3 spring/summer/fall	Manual #1
Linaria dalmatica	Dalmatian toadflax	*	Biocontrol
Lythrum salicaria	Purple loosestrife	3 spring/summer/fall	Manual #2
Onopordum acanthium	Scotch thistle	3 spring/summer/fall	Manual #1

***Mapping and monitoring as needed for introduction of biocontrol organisms.**

Table 30. Description of weed treatment methods for 2021.

Type	Description of Actions
Manual #1	**Sever below crown with knife pre-flower or rosette; revisit before fall all sites that had plants.**
Manual #2	**Pull entire root pre-flower; revisit all sites in fall that had plants; for hawkweed be very careful to remove ALL root fragments (as much as possible)**
Method #3	**Herbicide application/manual removal by FEWAFB staff or – spot treatment (dates and herbicide recommendations may be discussed with applicator in spring meeting)**

Training and Education

Educate FEWAFB staff to be on the lookout for new occurrences of noxious weeds and learn to recognize native plants that resemble noxious weeds. Educate staff about unnecessary disturbances and how weeds seeds or plants can be transported on equipment and clothing.

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. The impacts of any proposed treatment should always be considered. All treatments have the potential to cause harm to soils, wildlife and native plant species.

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. Some common native thistles known from the FEWAFB or the vicinity that resemble non-native thistles include: Flodman's thistle (*Cirsium flodmanii* –right photo), Wyoming thistle (*Cirsium pulcherrimum* – left photo), wavyleaf thistle (*Cirsium undulatum*), prairie thistle (*Cirsium canescens*), and yellowspine thistle (*Cirsium ochrocentrum*).

Photo: Cirsium pulcherimmum (Wyoming thistle) Wildflower Search Website: https://wildflowersearch.org/search?&PlantName=Cirsium+pulcherrimum

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

Biocontrol

Investigate the use of biocontrols for diffuse knapweed, Dalmatian toadflax, leafy spurge, field bindweed and Canada thistle as discussed in individual species sections above. These organisms are available at the Palisades Insectary in Colorado. The organism for Canada thistle is not ready for widespread application because the methods are still being refined. However, the organism is native to the area, it is a rust which is a type of fungus that could potentially be naturally present. Biocontrol organisms have been used in the past at FEWAFB. More information is available at: https://ag.colorado.gov/conservation/biocontrol on the different organisms and how to obtain them from the USDA Palisade Insectary in Colorado (https://visitpalisade.com/portfolio-item/palisade-insectary/). 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.

Herbicides

Herbicides should be used as a last resort in natural areas due to potential impacts to soil, surface and ground water quality, and non-target impacts. Many of the treatments are designed for agricultural lands and are not the best choice for wild lands and wetlands. Herbicides should be used with a site plan and an integrated pest management approach. Follow-up monitoring post herbicide application is just as important as it is with mechanical treatments. Herbicides should not be used multiple times within the same growing season or for very large infestations without a restoration plan. Herbicide use combined with the use of biocontrol organisms can be complicated and must be done with attention to timing and life cycles of both the biocontrol organisms and the life cycle of the noxious weed.

REFERENCES

Bean, D. 2012. Palisade Colorado Insectary. Biocontrol, the Insectary, Spring 2012. https://colorado.gov/pacific/sites/default/files/2012SpringBioControlNewsletter.pdf. Accessed December 2018.

Beck, K. G. 2013. Fact Sheet 3.110. Colorado State University Extension. www.ext.colostate.edu.

CDA 2009. Colorado Department of Agriculture, Colorado State University, Common Burdock Fact Sheet https://www.colorado.gov/pacific/sites/default/files/Common%20burdock%20Factsheet.pdf

CDA 2015. Colorado Department of Agriculture, Colorado State University Purple Loosestrife fact Sheet Rev 7/15. https://drive.google.com/file/d/1vEKQgTMD9XBX6ihJPiCuw5uM2qriuZW5/view Accessed December 2018.

CDA 2016. Colorado Department of Agriculture, Colorado State University Scotch thistle fact Sheet Rev 11/16. https://drive.google.com/file/d/1WmVjBrUvXVbPQARemLNAR5iSbeN_vnAu/view Accessed December 2018.

CDA 2018. Colorado Department of Agriculture- Conservation Services. Canada thistle biocontrol. https://www.colorado.gov/pacific/agconservation/canada-thistle-biocontrol Accessed December 2018.

CDA 2020. Colorado Department of Agriculture Noxious Weed List, updated Jun 2020. https://drive.google.com/file/d/0Bxn6NtpJWc9JRFE3LW1RWFVXY1E/view Website accessed March 2021

CPW 2013. Weed Management Techniques and Prevention BMPs. Colorado Natural Areas Program. http://cpw.state.co.us/aboutus/Pages/RS-NoxiousWeedsSpeciesProfiles.aspx

Cheesman, D. 1998. The impact of some field boundary management practice on the development of *Dipsacus fullonum* L. flowering stems, and implications for conservation. Agriculture, Ecosystems & Environment Vol. 68, Issues 1-2. Mar 1998, pp. 41-49.

CSU 2011. Colorado State University Extension: Colorado Livestock Series Fact Sheets Nitrate Poisoning. http://extension.colostate.edu/docs/pubs/livestk/01610.pdf Accessed December 2018.

CSU 2013a. Colorado State University Extension: Colorado Noxious Weed Fact Sheets Musk thistle. http://extension.colostate.edu/topic-areas/natural-resources/musk-thistle-3-102/ Accessed January 2019.

CSU 2013b. Colorado State University Extension: Colorado Noxious Weed Fact Sheets: Canada thistle. http://extension.colostate.edu/topic-areas/natural-resources/canada-thistle-3-108/ Accessed January 2019.

Code of Colorado Regulations (CCR). 2014. Secretary of State, State of Colorado, Department of Agriculture, Conservation Services Division. 8 CCR 1206-2 Rules Pertaining to the

Administration and Enforcement of the Colorado Noxious Weed Act: http://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=6027&fileName=8%20CCR%201206-2

Cranshaw, W. 2009. Status of Biological Control Agents Used for Managing Invasive Plants in Colorado. CSU Extension, Fort Collins, CO.

CWMA. 2017. Colorado Weed Management Association. Leafy Spurge, Euphorbia esula. https://cwma.org/weed-information/weed-list/leafy-spurge/ Accessed January 2019.

DiTomaso, J.M., G.B. Kyser et al. 2013. Weed Control in Natural Areas in the Western United States. Weed Research and Information Center, University of California. 544 pp. Gypsophila paniculata, baby's breath. Also https://wric.ucdavis.edu/information/natural%20areas/wr_G/Gypsophila.pdf

Duncan, C. 2018. Biology and Management of Common Teasel. Techline Invasive Plant News. https://www.techlinenews.com/articles/2013/1/25/biology-and-management-of-common-teasel

El Paso County. 2014. Noxious Weeds and Control Methods. Community Services Department Environmental Division: http://adm.elpasoco.com/Environmental%20Division/Forestry%20and%20Noxious%Weeds/Pages/default.aspx

Environmental Systems Research Institute, Inc. (ESRI). 1995-2018. ArcPad 10.2 R5. GIS Software Program.

Heidel, B., J. Handley and D. Tuthill. 2018. 30-year population trends of Colorado butterfly plant (*Oenothera coloradensis*; Onagraceae), a short-lived riparian species on F. E. Warren Air Force Base, Laramie County, Wyoming. Prepared for U.S. Fish and Wildlife Service and F. E. Warren Air Force Base by the Wyoming Natural Diversity Database (University of Wyoming), Laramie, WY.

Heidel, B. and S. Laursen. 2002. Distribution of Noxious Weeds In Riparian Corridor Habitat of Threatened Plant and Animal Species on F. E. Warren Air Force Base. Wyoming Natural Diversity Database (University of Wyoming), Laramie, WY.

ISCB. 2018. The Invasive Species Council of British Columbia. Noxious Weeds, Common Burdock. https://bcinvasives.ca/invasive-species/identify/invasive-plants/burdock. Accessed November 2018.

INRMP. 2018. U. S. Air Force Integrated Natural Resources Management Plan, F. E. Warren Air Force Base.

King County Government, Washington. 2018. Common teasel, Dipsacus fullonum. https://www.kingcounty.gov/services/environment/animals-and-plants/noxious-weeds/weed-identification/common-teasel.aspx Accessed December 2018.

Montana Audubon 2010. Russian Olive Policy Guidance Document. Montana Audubon, Helena, MT

MSU Extension 2017. Montana State University Extension Weed Post Common Burdock 7/2017 accessed March 2020. http://msuinvasiveplants.org/documents/extension/weed_posts/2017/June%202017%20Weed%20Post_common%20burdock.pdf

Mui, C.H.Y. and S. Spackman Panjabi. 2016. Recommended Best Management Practices for Managing Noxious Weeds on Sites with Rare Plants. Colorado Department of Agriculture-Noxious Weed Program and Colorado State University Colorado Natural Heritage Program. http://www.cnhp.colostate.edu/download/documents/2016/BMP_Noxious_Weeds_on_Sites_with_Rare_Plants_CMui_SPanjabi_May_2016.pdf

NatureServe 2021. NatureServe Explorer Website : *Gaura neomexicana* ssp. *coloradensis*. Site updated 03/05/2021. Website accessed March 18, 2020 https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.149254/Gaura_neomexicana_ssp_coloradensis

Nicholas, R., D.L. Larson, and S.C. Huerd. 2008. Soil modification by invasive plants; effects on native and invasive species of mixed-grass prairies. Biological Invasions. 10:177-190.

North Dakota State University (NDSU). 2018. Website photos. https://www.ag.ndsu.edu/publications/crops/identification-and-control-of-invasive-and-troublesome-weeds-in-north-dakota and https://www.ag.ndsu.edu/agcomm/photos-illustrations Accessed December 2018.

North Wind. 2005. Invasive Plant Species Control Plan F. E. Warren Air Force Base, Wyoming. North Wind, Inc., Idaho Falls, ID.

NV 2002. University of Nevada Cooperative Extension: Fact Sheet 02-57, Managing Scotch Thistle. https://www.unce.unr.edu/publications/files/nr/2002/FS0257.pdf. Accessed December 2018.

Oregon State University. 2018. College of Agricultural Sciences. Canada thistle, Cirsium arvense. https://horticulture.oregonstate.edu/weed/canada-thistle Accessed December 2018.

Parker, C. and A. Gassman. 2016. Datasheet report for Linaria dalmatica (Dalmatian toadflax), Invasive Species Compendium Datasheet Report, updated November 2018. CABI-CH; Switzerland. https://www.cabi.org/ISC/datasheetreport/30827#tonaturalEnemies

Pearson, D. and Y. Ortega. 2009. Managing Invasive Plants in Natural Areas: Moving Beyond Weed Control - In: Weeds: Management, Economic Impacts and Biology. Editor: Rudolph V. Kingerly. Nova Science Publishers, Inc. pp. 1-22.

Pearson, D.E., Ortega, Y.K., Runyon, J, and L. Buttler. 2016. Secondary invasion: The bane of weed management. Elsevier, Biological Conservation. Volume 197, May 2016, pp. 8-1. https://www.sciencedirect.com/science/article/abs/pii/S0006320716300726

Price, J. 2018. Filamentous friends and mycological messiahs: Canada thistle fungus show promise in Colorado. Fungi 10(4):50-54.

Pritekel, C., A. Whittemore-Olson, N. Snow, J. C. Moore. 2006. Impacts from invasive plant species and their control on the plant community and belowground ecosystem at Rocky Mountain National Park, USA. Applied Soil Ecology. 32(1):132-141.

Rawinski, T. 1982. The ecology and management of purple loosestrife (*Lythrum salicaria* L.) in central New York. Ithaca, NY: Cornell University. 88 p. Thesis.

Schubert, Alex. 2018. Personal communication regarding treatment activities at F. E. Warren Air Force Base.

Sher, A. and K. Lair, M. DePrenger-Levin, and K. Dohrenwend. 2010. Best Management Practices for Revegetation after Tamarisk Removal in the Upper Colorado River Basin. Denver Botanic Gardens, University of Denver. 56 pp.

Sing, S.E., R. De Clerck-Floate, R.W. Hansen, H. Pearce, C.B. Randall, I. Toševski, and S.M. Ward. 2015. Biology and Biological Control of Dalmatian and Yellow Toadflax. USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, West Virginia. FHTET-2015-03.

Smith, P., A. Greenwell, and A. Meier. 2018. Noxious Weed Monitoring at the U.S. Air Force Academy: Year 13. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

SWCA. 2014. Invasive Plant Species Control Plan F. E. Warren Air Force Base Cheyenne, Wyoming. Report prepared for the U.S. Fish and Wildlife Service, Mountain Prairie Region, Lakewood, CO. 97p. SWCA Environmental Consultants. Broomfield, CO.

Tasker, L., A. Greenwell, G. Doyle, P. Smith. 2019. Noxious Weed Survey of Francis E. Warren Air Force Base. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

The Nature Conservancy. 2011. Herbicide Use in Natural Areas A Guide for Volunteer Land Stewards. Copyright 2010, The Nature Conservancy Updated October 2011. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5386111.pdf

Thompson, Daniel Q.; Stuckey, Ronald L.; Thompson, Edith B. 1987. Spread, impact, and control of purple loosestrife (*Lythrum salicaria*) in North American wetlands. Fish and Wildlife Research 2. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 55 p.

Tosevski, Ivo & Caldara, Roberto & Jovic, Jelena & Hernández-Vera, Gerardo & Baviera, Cosimo & Gassmann, Andre & Emerson, Brent. (2015). Host-associated genetic divergence and taxonomy in the Rhinusa pilosa Gyllenhal species complex: An integrative approach. Systematic Entomology. 40. 268–287.

Tu, M., C. Hurd, J.M. Randall and The Nature Conservancy. 2001. Weed Control Methods Handbook: Tools & Techniques for Use in Natural Areas. 533pp. http://digitalcommons.usu.edu/govdocs/533

UC Davis Weed Research and Information Center. 2013. Weed Control in Natural Areas in the Western United States.

U.S. Department of Agriculture (USDA). 1999. Executive Order 13112 – Invasive Species. Available online at https://www.invasivespeciesinfo.gov/executive-orders-invasive-species Accessed November 2018.

U.S. Department of Agriculture (USDA). 2017a. Field Guide for Managing Russian Olive in the Southwest TP-R3-16-24 Revised June 2017 https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd563043.pdf

U.S. Department of Agriculture (USDA). 2017b. Field release of the stem gall weevil *Rhinus pilosa* (Coleoptera: Curculionidae) for classical biological control of yellow toadflax (Linaria vulgaris) (Plantaginaceae) in the contiguous United states. Environmental Assessment, December 2017.

USFS Fire Effects Information System (FEIS) 2016. Tamarisk. http://www.fs.fed.us/database/feis/plants/tree/tamspp/all.html

USFS-USDA 2005. Department of Agriculture Forest Service. Weed of the Week: Common Burdock. Forest Health Staff, Newtown Square, PA. https://www.invasive.org/weedcd/pdfs/wow/common-burdock.pdf. Accessed October 2018.

USFS-USDA 2014a. Department of Agriculture Forest Service. Field guide for Managing Whitetop in the Southwest. Southwest Region. September 2014.

USFS-USDA 2014b. Department of Agriculture Forest Service. Field Guide for Managing Leafy Spurge in the Southwest. Southwestern Region. September 2014.

USFS-USDA 2014c. Department of Agriculture Forest Service. Field Guide for Managing Dalmatian and Yellow Toadflaxes in the Southwest. Southwest Region TP-R3-16-06. September 2014. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410111.pdf

Weed A.S. and M. Schwarzländer, 2014. Density dependence, precipitation and biological control agent herbivory influence landscape-scale dynamics of the invasive Eurasian plant Linaria dalmatica. Journal of Applied Ecology, 51(3):825-834. http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1365-2664

Western Regional Climate Center (WRCC). 2018. Cheyenne WSFO AP, Wyoming (481675). Available online at http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wy1675. Accessed November 2018.

Wikimedia Commons. 2018. https://commons.wikimedia.org/ Photos accessed November 2018.

Wyoming Weed and Pest Council (WWPC). 2018. Wyoming Weed and Pest Control Act Designated Weed List. https://wyoweed.org///wp-content/uploads/2018/07/StateDesignatedList_2018.pdf. Accessed November 2018.

Zouhar, K. 2001. Centaurea diffusa. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/plants/forb/cendif/all.html Accessed April 2017.

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.

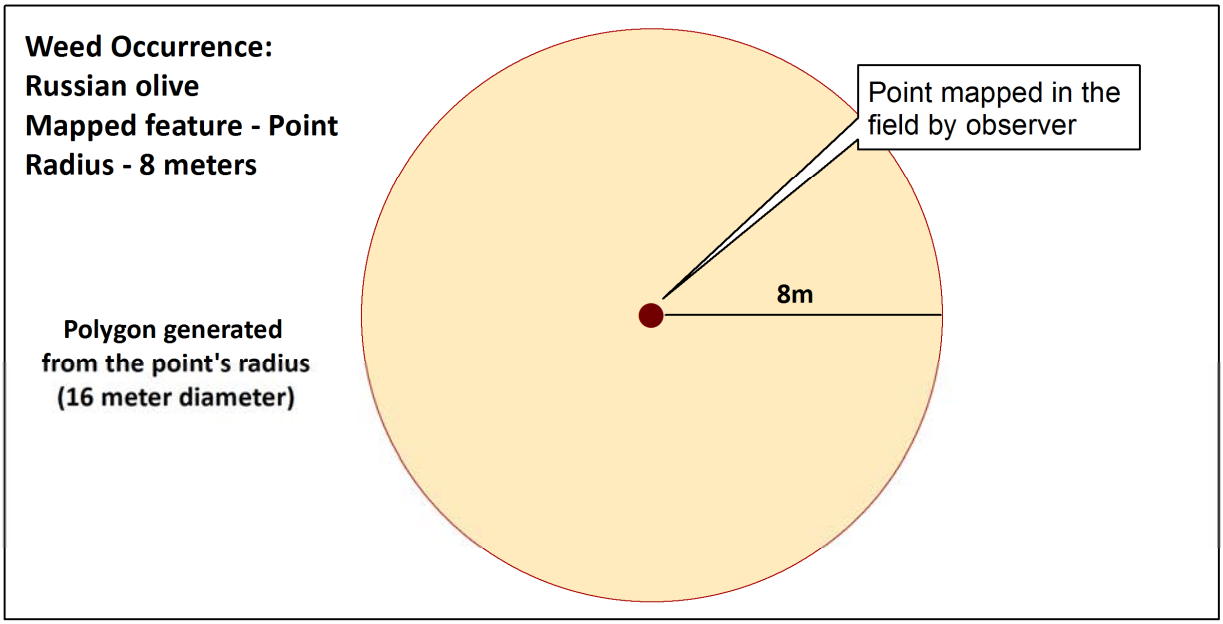
In 2018, riparian areas along Crow Creek and Diamond Creek proved difficult to map. Vegetation was dense, with weed species frequently co-occurring. It was often impossible to penetrate thick stands of weeds and willows to search the interior of the riparian areas. In these dense areas, co-occurring weeds were mapped together and split into separate features as density changed. In cases where one polygon mapped in the field represented many species, species and densities were describe in notes and polygons for each species were generated in the office. This scenario occurred most frequently with Canada thistle, leafy spurge, and houndstongue. Density and size were then used to estimate number of individuals.

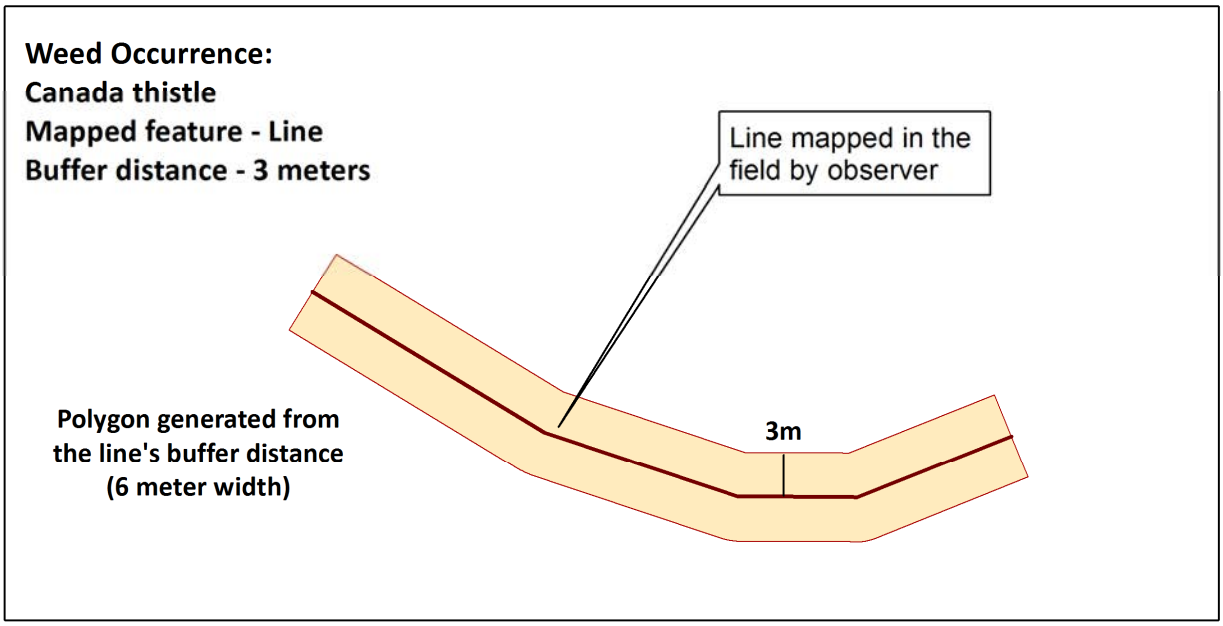
All features were collected using the GPS unless otherwise noted in the attribute table. Features that were inaccessible due to natural barriers or exclosures were digitized “heads-up” using the 2015 NAIP digital orthophoto quad for reference. Attributes were collected using customized field forms designed 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.





APPENDIX D. BIOCONTROL

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 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).