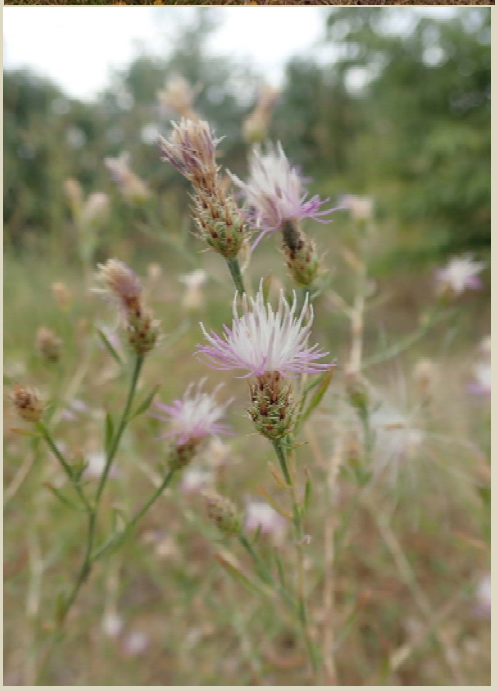
Noxious Weed Survey of Buckley Air Force Base 2019

April 2020



Noxious Weed Survey of Buckley Air Force Base

2019

Pam Smith, Amy Greenwell, and Lisa Tasker

Colorado Natural Heritage Program
Warner College of Natural Resources

Colorado State University
Fort Collins, Colorado 80523

WARNER COLLEGE
OF NATURAL RESOURCES
COLORADO STATE UNIVERSITY

COLORADO NATURAL HERITAGE PROGRAM

April 2020

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.

Colorado Natural Heritage Program
Warner College of Natural Resources
Colorado State University
1475 Campus Delivery
Fort Collins, CO 80523
(970) 491-7331

Report Prepared for:
Buckley Air Force Base
U.S. Fish and Wildlife Service
660 South Aspen Street MS 86
Buckley AFB, CO 80011

Recommended Citation:
Smith, P., A. Greenwell, and L. Tasker. 2020. Noxious Weed Survey of Buckley Air Force Base 2019. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Front Cover: Top: Musk thistle with pollinator: Middle: Prairie landscape, Bottom: Pink flowered form of diffuse knapweed, Buckley Air Force Base 2019. Photos by Lisa Tasker (CNHP).

EXECUTIVE SUMMARY

In the summer of 2019, the Colorado Natural Heritage Program (CNHP) mapped noxious weeds at Buckley Air Force Base (BAFB) located in Aurora, Colorado. The mapping was undertaken to provide another year of data on noxious weeds at the base for comparison to prior years of weed mapping data (North Wind, Inc. 2005, GMI 2008, Amec Foster Wheeler 2015).

Summary of Findings

Twelve noxious weeds were targeted for basewide weed mapping in 2019. Two of the target species were not found (puncturevine and yellow toadflax). However, two List B noxious weeds not previously known from the base were found with relatively low cover (hoary cress and Russian knapweed). Three mapped species have potential for eradication, four species have potential for control or containment, and five species are so widespread that containment is likely no longer possible and Integrated Pest Management (IPM) is recommended (Table 1).

Table 1. Summary of findings for noxious weed species at BAFB in 2019 in order of highest to lowest management urgency. As ranks shift from low to very high, the likelihood of eradication increases.

Management Urgency Ranks: low, medium, high, very high (eradication possible)			
Urgency	Scientific Name	Common Name	Comment
	Acroptilon repens	Russian knapweed	**Very high possibility for eradication:** 5 features, 4 small and treatable, 5th large area biocontrol might be appropriate. All occurrences in the same vicinity.
	Tamarix spp.	Salt cedar	**Very high possibility for eradication:** 11 mapped features with a total of 71 individuals.
	Elaeagnus angustifolia	Russian olive	**High possibility for eradication/control:** 21 mapped features. Treatable with cut stump/herbicide with monitoring for sprouts and suckering. Some sites may not need treatment based on proximity to natural areas.
	Lepidium draba	Hoary cress (whitetop)	**High possibility for control:** New in 2019. Eradication unlikely for 6 of 9 mapped features, 3 with <300 individuals, remaining 6 sites with hundreds to thousands of individuals and will require restoration and native plantings.
	Centaurea diffusa	Diffuse knapweed	**Medium possibility for control:** Widespread with a cover **>** 2.5 acres, a point where eradication is considered unlikely. Biocontrol is available and a low maintenance option for control. Herbicides not sustainable for natural areas and not for effective long-term control without IPM.

Management Urgency Ranks: low, medium, high, very high (eradication possible)			
Urgency	Scientific Name	Common Name	Comment
	Dipsacus fullonum	Common teasel	**Medium possibility for control/containment:** Widespread – with 29 mapped features; about half are small patches.
	Euphorbia esula	Leafy spurge	**Medium possibility for control/containment:** Widespread - 142 mapped features. Biocontrol agents present and also readily available from CO Dept. of Agriculture.
	Carduus nutans	Musk thistle	**Low possibility for control/containment:** Widespread - partially mapped in 2019, over 1,000 mapped features. Small isolated patches can be treated mechanically to reduce cover, seed production and spread.
	Cirsium arvense	Canada thistle	**Low possibility for control/containment:** Widespread – 616 mapped features. Any actions must include IPM and a plan with restoration/replanting and years of follow-up treatments. New biocontrol fungal agent being developed.
	Cynoglossum officinale	Houndstongue	**Low possibility for control/containment:** Widespread – 109 mapped features. Target small areas for eradication with site plans to reduce cover and seed production.
	Linaria dalmatica	Dalmatian toadflax	**Low possibility for control/containment:** Widespread – >500 mapped features. Any actions must include IPM and a plan with restoration and years of follow-up treatments. Biocontrol agents are available.
	Onopordum acanthium	Scotch thistle	**Low possibility for control/containment:** Widespread – 459 mapped features. Target small areas for eradication with a site plan to reduce cover and seed production.
Not Found	*Linaria vulgaris*	Yellow toadflax	**Not Found** in 2019; reported in 2014 survey. Monitor reported sites along E. Toll Gate Creek and **watch for new occurrences at BAFB**. A small hybrid population was documented in 2019 and mapped with Dalmatian toadflax.
Not Found	*Tribulus terrestris*	Puncturevine	**Not Found** in 2019; reported 26 acres in 2014. Monitor reported sites in northeast and west central BAFB and **watch for new occurrences at BAFB**.

Summary of Recommendations

The extensive weed cover at BAFB and overlap of numerous noxious weed species in a matrix of native and non-native species makes precise delineation difficult. This will also hamper weed treatments that need to be based on specific species growth characteristics and phenological characteristics for each species being treated. Healthy native vegetation needs to be identified and protected or the weed footprint has a high probability for increasing. Areas that contain native species are thought to offer the best protection against the invasion of more weeds. To treat noxious weeds at BAFB, we recommend the following:

- Discontinue mapping of the most widespread species at BAFB (musk thistle, Scotch thistle, Dalmatian toadflax, Canada thistle, and houndstongue). These species have reached such extensive cover that weed mapping is not effective and resources would be better targeted elsewhere.
- Focus on Rapid Response species that include Russian knapweed, Russian olive, salt cedar, and hoary cress that have low enough cover that eradication is a possibility at BAFB.
- Use biological control agents for Dalmatian toadflax, hybrid toadflax, leafy spurge, Russian knapweed and diffuse knapweed. A new fungal agent is being tested for Canada thistle. Check the most up to date information on the Colorado Department of Agriculture noxious weed website.
- Create site plans for weed treatments. A Site Assessment Worksheet is provided in Appendix A. Initiating a treatment with no goal other than to kill weeds has a very high likelihood of failing and increasing weed cover. 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.
- Conduct follow-up monitoring post treatments for successful weed management. This is the most often overlooked part of integrated pest management.
- Natural lands at BAFB should be treated differently than agricultural/developed lands or roadsides. Different strategies are needed in these areas where the surrounding plants and animals must be protected.
- Treating areas that are under constant disturbance (i.e. continuous flooding, soil disturbances from maneuvers, vehicles, soil clearing herbicides) is likely a waste of resources and is not recommended.
- Colorado State Threatened, Species of Special Concern, Priority Wetland Species and Habitats at BAFB should be considered when treating landscapes for weeds at BAFB.
- Recommendations for each mapped noxious weed species are included in the individual noxious weed species sections.
- Follow Best Management Practices (BMPs) for noxious weed invasion prevention.

Acknowledgements

The help and generosity of many experts is gratefully acknowledged. Dustin Casady (USFWS) was our primary contact at BAFB and his assistance with project logistics was extremely valuable as was his time orienting CNHP personnel in 2019. Dustin was also very helpful in providing pertinent BAFB natural resource documents which greatly expanded the background information necessary to complete this report.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

INTRODUCTION

Buckley Air Force Base (BAFB) is located in Aurora, Colorado (Figure 1). The base includes approximately 3,300 acres with 1,100 acres considered natural areas (Pers. Comm. Dustin Casady, USFWS).

In the summer of 2019, the Colorado Natural Heritage Program (CNHP) targeted 12 state-listed noxious weeds known to occur on the base for mapping within 1,100 acres of natural areas. The target list included 11 List B and 1 List C designated noxious weeds by the Colorado Department of Agriculture (CDA 2019) known to occur at BAFB from previous weed mapping and monitoring projects. No List A noxious weeds have been reported for BAFB (Table 2). Approximately 65 of the 1,100 acres of natural areas targeted for surveys were mowed and thus not surveyed leaving 1,035 total acres to be surveyed for noxious weeds in 2019.

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 Colorado Department of Agriculture (CDA 2019) stresses the importance of a program of Early Detection and Rapid Response as key to mitigating new infestations of invasive weeds, as do most reputable state weed programs.

In general, noxious weeds are increasing despite efforts undertaken to control and eradicate them. Research has shown that successful weed treatment is not always possible depending on the degree of infestation, the site characteristics, plant life history, available resources to conduct treatments, and the disturbance regime. Many treatments that were thought to be effective have proven to be not only ineffective but could contribute to the increases in weeds. To address this, a number of organizations that manage natural areas recommend the preparation of a site plan before noxious weed treatments are undertaken (Pearson et al. 2016, Mui and Spackman Panjabi 2016, CPW 2013, UC Davis Weed Research and Information Center 2013, Sher et al. 2010, TNC 2011, and Tu et al. 2001). Site plans are especially helpful where other natural resources need protection (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. Follow-up monitoring post treatment is an integral part of success. 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 (TNC 2011). A site plan template is included in Appendix A. The ongoing disturbances to the natural systems at BAFB which include the removal of native plants and animals are likely a large contributor to the expansion of noxious weed species.

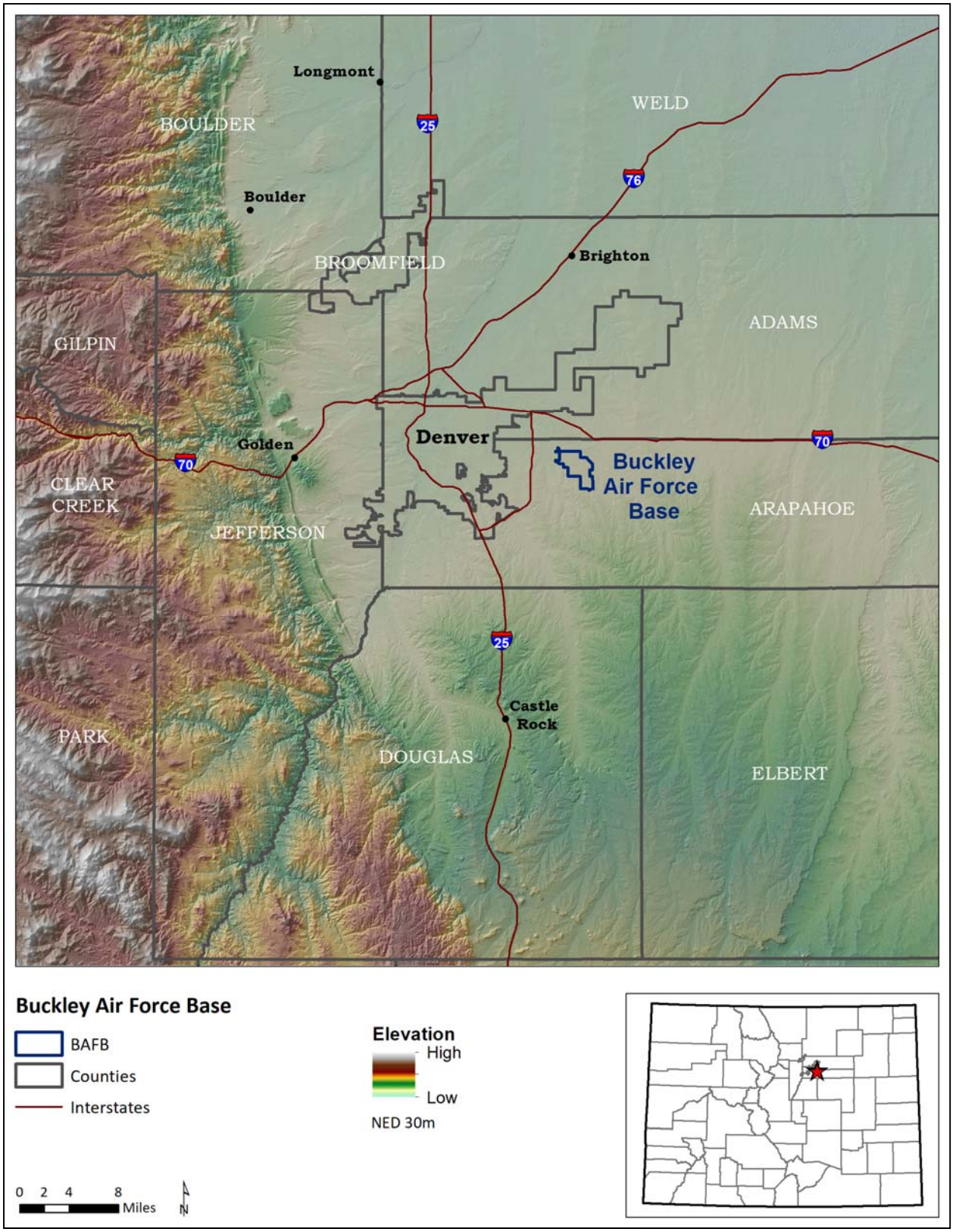


Figure 1. Location of Buckley Air Force Base in Colorado.

Site Description

Historically, much of BAFB consisted of native shortgrass prairies dominated by buffalo and grama grasses (*Bouteloua* spp. and *Buchloe dactyloides*), cacti (*Opuntia* spp.) and woody shrubs. Riparian and wetland vegetation is found near intermittent streams, such as East Toll Gate Creek and its un-named tributary as well as un-named drainage flowing from Williams Lake (a man-made water feature) to Sand Creek in the northeast (Figure 2). The riparian area along Toll Gate Creek, an intermittent stream, was dominated by the plains cottonwood (*Populus deltoides* ssp. *monilifera*) and willows (*Salix exigua, S. amygdaloides*), and used to be similar to riparian areas found throughout the eastern plains of Colorado. Dominant species in and adjacent to Toll Gate Creek also included golden currant (*Ribes aureum*), American licorice (*Glycyrrhiza lepidota*), prairie rose (*Rosa arkansana*), Indianhemp (*Apocynum cannabinum*) and western wheatgrass (*Pascopyrum smithii*) as understory species. Common non-native taxa included leafy spurge (*Euphorbia esula* var. *uralensis*), Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), common mullein (*Verbascum thapsus*) and field bindweed (*Convolvulus arvensis*), as common non-native taxa (CEMML 2006).

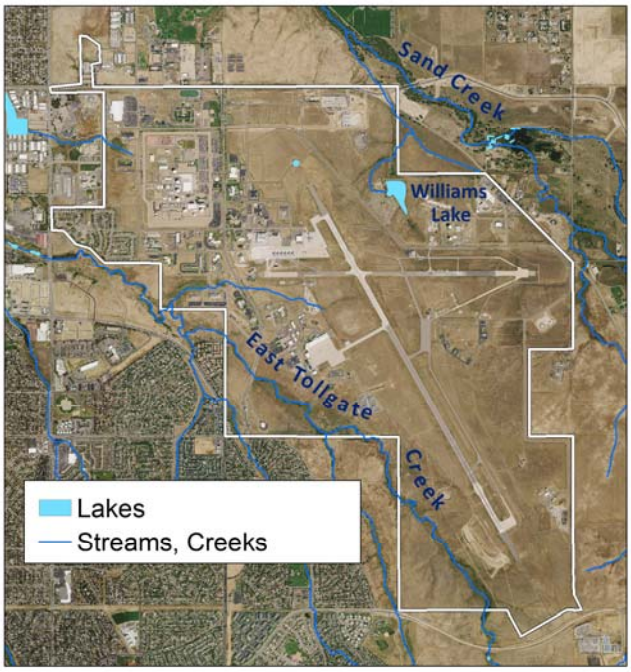


Figure 2. Hydrology at Buckley AFB.

The plant communities at Buckley AFB have changed significantly from pre-settlement conditions. The natural areas used to have a much higher biological diversity. In 2005, the plant list included 78% of the known species in Arapahoe County (CEMML 2006). The removal of trees and shrubs below Williams Lake and along Toll Gate Creek and at other locations, in addition to the removal of animals including raptors, other birds and prairie dogs, thought to impact aircraft under the Bird/Wildlife Aircraft Strike Hazard (BASH) program, have likely resulted in a landscape that no longer supports a high degree of biological diversity. The wetlands and meadows that are an important part of the Central Flyway bird migratory route and supported the burrowing owl, bald eagles, other raptors and a variety of song birds (Schorr 2013) have likely been impacted. These manipulations for management have contributed to increases in weed cover. Noxious weeds have been spreading since they were first mapped in 2004. Reports from studies conducted in 2007 and 2014 (GMI 2008, Amec Foster Wheeler 2015) indicate rapid spread across the property of both new and previously existing weeds. Currently, the BAFB includes 3,300 acres with 1,100 acres considered to be natural areas at BAFB in 2019 (Figure 3).

METHODS

Noxious weed species mapped during previous weed surveys (Amec Foster Wheeler 2015, GMI 2008 and North Wind, Inc. 2005) and a floristic survey from 2005 (CEMML 2006) conducted at Buckley AFB were used to create a list of target weed species for this survey (Table 2). Approximately six weeks of field work was completed during the summer of 2019. Natural areas at the base (Figure 3) were visited in July, August, and September. Weeds were surveyed using a census survey method where weeds were documented by walking the property using GPS and GIS technology. Infestations were mapped as points, lines, or polygons, depending on the size and shape of each occurrence. Points and lines were buffered to estimate actual or minimum size. Irregularly shaped features greater than approximately 30 meters in any direction were mapped as polygons. Data were mapped using a Mesa 2 rugged tablet with a built-in GPS receiver (accuracy between 2-5m) and ArcPad (ESRI 1995-2018), a portable version of GIS software.

Qualitative notes and actual counts and estimates for populations were made at each mapping site. A total number of individuals or density as number of individuals per square meter was estimated. When weeds were visible but exact locations were inaccessible, offsets were applied to the GPS or features were digitized heads-up using the 2017 NAIP aerial photo for reference. Notes were taken to document non-standard, "on the fly" mapping techniques. Standing dead weeds were mapped as extant since they were alive during a recent growing season and likely produced seeds or could sprout in the next growing season.

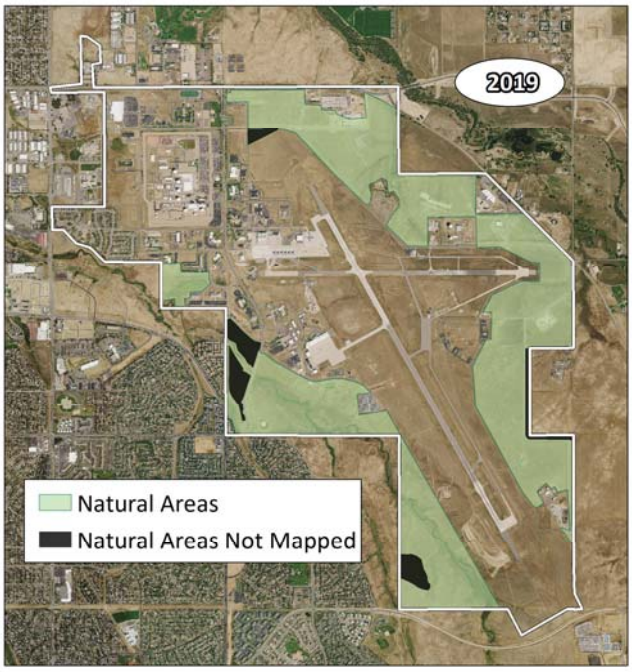


Figure 3. Noxious weed survey areas at Buckley AFB in 2019.

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

Table 2. Original target list for noxious weed mapping at Buckley AFB in 2019.

Scientific Name	Common Name	Colorado Noxious Weed List	Mapped in 2014 (Amec Foster Wheeler)	Mapped in 2019 (CNHP)
Carduus nutans	Musk thistle	B	X	X (Partial)
Centaurea diffusa	Diffuse knapweed	B	X	X
Cirsium arvense	Canada thistle	B	X	X
Cynoglossum officinale	Houndstongue	B	X	X
Dipsacus fullonum	Common teasel	B	X	X
Elaeagnus angustifolia	Russian olive	B	X	X
Euphorbia esula	Leafy spurge	B	X	X
Linaria dalmatica	Dalmatian toadflax	B	X	X
Linaria vulgaris	Yellow toadflax	B	X	Not Found
Onopordum acanthium	Scotch thistle	B	X	X
Tamarix spp.	Salt cedar	B	X	X
Tribulus terrestris	Puncturevine	C	X	Not Found

Collection of weed data was subject to limitations imposed by human resources, time, and safety. Seasonal precipitation and weather patterns can influence results. Most of the base was surveyed by foot or vehicle. Discrepancies in mapping methods and survey efforts from previous years exist.

RESULTS AND RECOMMENDATIONS

In 2019, 12 priority species were targeted for mapping at BAFB (Table 2). Two of the targeted species, puncturevine and yellow toadflax, were not found in 2019. However, two species which have not been mapped previously, Russian knapweed and hoary cress, were mapped in 2019 for a total of 12 mapped weed species (Table 3). Overall, more than 3,100 weed occurrences covering more than 280 acres were mapped at BAFB in 2019 (Figure 4). Musk thistle was only partially mapped due to the widespread cover across BAFB.

Of the 12 species mapped in 2019, eradication is possible for three species which were mapped with less than an acre in cover: Russian olive, salt cedar (tamarisk), and Russian knapweed. In addition, hoary cress is still at a level that control is highly possible. Once a weed has reached a cover of about an acre spread across a natural landscape, eradication becomes much less likely. Based on our experience, many species can be difficult to remove permanently from a natural system once established over a few years, especially perennial species with vegetative reproduction.

The remaining eight noxious weed species (Canada thistle, Dalmatian toadflax, houndstongue, diffuse knapweed, leafy spurge, common teasel, musk thistle, and Scotch thistle) have reached coverages where eradication is unlikely and control may only be practical in small areas at BAFB. In addition, the majority of these species occur in a matrix of other noxious weeds, as well as native and non-native plants, adding to the difficulty of successful treatments. Some sites may be amenable to restoration efforts. Most of the weed species were already widespread in 2004 when the first weeds were mapped (North Wind, Inc. 2005, CEMML 2006). Increases are probably due to several factors: 1) ongoing and historical disturbances to soils within or adjacent to natural areas, 2) ineffective treatments, and 3) treatments not occurring.

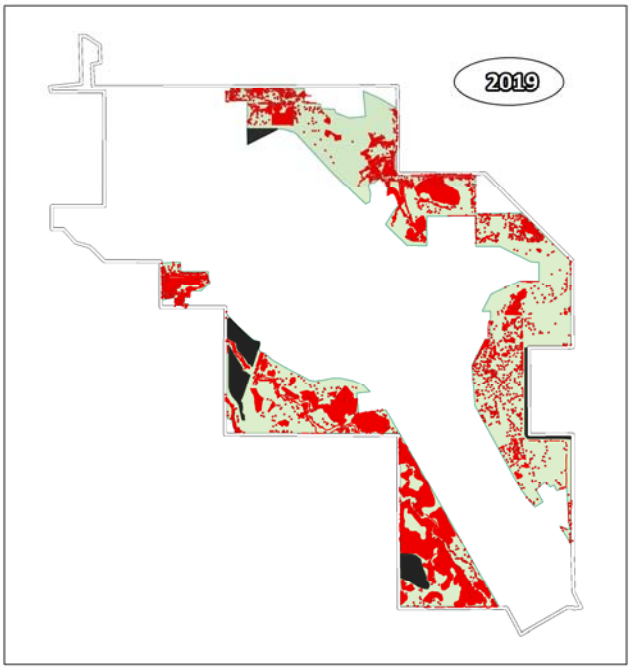


Figure 4. Distribution of noxious weeds mapped at Buckley AFB in 2019.

The reported weed cover for 2019 targets compared to previous BAFB weed surveys in 2004 (North Wind, Inc. 2005), 2007 (GMI 2008) and 2014 (Amec Foster Wheeler 2015) are included in Table 3. However, comparisons for increases and decreases between years are not directly related due to differences in mapping methodologies and the number of mapped acres across BAFB.

A total of 20 Colorado state-listed noxious weeds have been known from BAFB and include 14 List B and six List C noxious weeds. Weeds previously recorded at BAFB that were not part of the 2019 survey are listed in Table 4. In the past, BAFB weed surveys have included other additional List C noxious weeds and unlisted weeds, most with extensive covers. Mapping widespread species takes a large amount of effort often resulting in a map that is not useful. In addition, annual species like Russian thistle have been found to be an excellent soil stabilizer that does not persist and has actually been found to be helpful in prairie restorations by CNHP. Understanding the lifecycle of plants and which are likely to inhabit disturbed areas or treated areas must be part of weed management strategies along with the elimination of the weed as habitat for more weeds may be created by treatments and other local disturbances.

Table 3. Noxious weed acreages at BAFB reported from surveys in 2004, 2007, 2014, and 2019 in order by Scientific Name, List B, C with eradication potential.

(NR=not reported, W=widespread)

Scientific Name	Common Name	2004	2007	2014	2019	Eradication
LIST B						
Acroptilon repens	Russian knapweed	NR	NR	NR	0.39 acres	Possible
Carduus nutans	Musk thistle	W	18.5 acres	534 acres	>80 acres*	Not likely
Centaurea diffusa	Diffuse knapweed	2 locations	0.7 acres	2.54 acres	>6 acres	Not likely
Cirsium arvense	Canada thistle	>20 locations	29 acres	309 acres	>48 acres	Not likely
Cynoglossum officinale	Houndstongue	NR	.001 acres	7.62 acres	>3.35 acres	Not likely
Dipsacus fullonum	Common teasel	NR	.004 acres	24 acres	>3 acres	Not likely
Elaeagnus angustifolia	Russian olive	3 locations	97 stems	15.6 acres	0.28 acres	Possible
Euphorbia esula	Leafy spurge	30+ locations	5.2 acres	173 acres	>8 acres	Not likely
Lepidium draba	Hoary cress	NR	NR	NR	0.41 acres	Possible (with restoration)
Linaria dalmatica	Dalmatian toadflax	West side	29 acres	396 acres	>159 acres	Not likely
Linaria vulgaris	Yellow toadflax	NR	NR	.01 acres	NF	Not Found
Onopordum acanthium	Scotch thistle	NR	NR	284 acres	>19 acres	Not likely
Tamarix spp.	Salt Cedar	NR	3 stems	.01 acres	0.12 acres	Possible
LIST C						
Tribulus terrestris	Puncturevine	NR	NR	26.3 acres	NF	Not Found

* Comprehensive mapping not completed in 2019 for musk thistle due to widespread cover.

Table 4. Noxious weed acreages at Buckley AFB reported from 2004, 2007 & 2014 for species not mapped in 2019. (NR=not reported, R=reported, W=widespread)

Scientific Name	Common Name	2004	2007	2014	Eradication
STATE WATCH LIST					
Iris pseudacorus	Yellow flag iris	NR	NR	1 site	Not Found in 2019
LIST B					
Centaurea maculosa	Spotted knapweed	1 location	NR	NR	Not Found in 2019
LIST C SPECIES – PREVIOUSLY MAPPED BUT NOT MAPPED IN 2019					
Bromus tectorum	Downy brome	W	892.3 acres	410.2 acres	Not likely
Convolvulus arvensis	Field bindweed	W	2,612 acres	528 acres	Not likely
Elymus repens	Quackgrass	NR	1.17 acres	NR	Potentially eradicated
Erodium cicutarium	Redstem fillary	NR	---	---	Low priority
Verbascum thapsus	Common mullein	NR	32 acres	515 acres	Low priority
UNLISTED SPECIES – NOT MAPPED IN 2019					
Kochia scoparia	Kochia	W roads	19 acres	323 acres	Low priority
Melilotus officinalis	Yellow sweet clover	R	---	---	Low priority
Rumex crispus	Curly dock	NR	NR	389 acres	Low priority
Salsola tragus	Russian thistle	W roads drainages	8 acres	501 acres	Low priority

Summary of Recommendations:

The extensive weed cover at BAFB and overlap of numerous noxious weed species in a matrix of native and non-native species makes precise delineation difficult. This will also hamper weed treatments which need to be based on specific species growth characteristics and phenological characteristics for each species being treated. Healthy native vegetation needs to be identified and protected or the weed footprint has a high probability for increasing. Areas that contain native species are thought to offer the best protection against the invasion of more weeds. To manage noxious weeds at BAFB, we recommend the following:

- **Discontinue Mapping Widespread Species.** Five species (musk thistle, Scotch thistle, Dalmatian toadflax, Canada thistle, and houndstongue) have reached such extensive cover that basewide weed mapping is cost prohibitive and no longer effective.

- **Focus on Rapid Response Species.** Four species (Russian knapweed, Russian olive, salt cedar, and hoary cress) have low enough cover that eradication is a possibility at BAFB.

- **Biocontrol.** Once species reach a certain level where eradication is not likely and control measures may not contain species due to high cover and large seed sources in the vicinity, biocontrol is the best alternative. Biological controls are currently available for Dalmatian toadflax, hybrid toadflax, leafy spurge, Russian knapweed and diffuse knapweed. A new fungal agent is being tested for Canada thistle. Check the most up to date information on the Colorado Department of Agriculture noxious weed website.

- **Site Planning Before Treatments.** Recommendations for weed treatment must include a plan for what the site will look like once a treatment occurs. Initiating a treatment with a single goal to kill weeds has a very high likelihood of failing and can even result in increased weed cover. One of the most important activities involved with weed management is to record treatments and monitor post treatment activities within the same growing season. The same season follow-up allows for the capture of sprouts or plants that were missed and to assess whether the treatment is working. If a single plant is missed and goes to seed a whole new set of plants will have a jump start for the next season. The Site Assessment Worksheet helps immensely with this exercise and informs time-saving, cost-saving, and course corrections (Appendix A). 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.

- **Follow-up Monitoring.** Follow-up monitoring post treatments is essential for successful weed management and it is the most often overlooked part of integrated pest management. If resources for site plans and follow-up monitoring are not available, treatments should be carefully considered, especially in the sensitive areas at BAFB where an increase in weeds could result.

- **Natural Landscapes Should not be Treated the same as Agricultural/Developed Lands or Roadsides.** A significant portion of the landscapes impacted by noxious weeds at BAFB fall into the "natural areas" category and include important riparian and wetland features that harbor species that should be protected. 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. Many weed species may experience natural declines and some management activities could actually cause weed footprints to expand, especially perennial species that have underground root buds that are stimulated by above ground treatment activities (e.g. Canada thistle, Russian thistle, and hoary cress). These natural declines can be picked up by monitoring and these are far more effective than many treatments that harm or impact soils and water quality. Many weedy species reduce in number naturally given enough time as part of the successional pattern in areas where the

disturbance regime is reduced or removed. Landscapes follow a successional pattern that often replaces annual and biennial species with perennial forbs, grasses and eventually woody species over time.

- **Treating Noxious Weeds in Continuously Disturbed Settings.** Treating areas that are under constant disturbance (i.e. continuous flooding, soil disturbances from maneuvers, vehicles, soil clearing herbicides) is a waste of resources and is not recommended.

- **Colorado State Threatened, Species of Special Concern, Priority Wetland Species and Habitats at BAFB.** There are 11 elements of conservation concern for animals, plants and plant communities that have been identified at BAFB (Fayette et al. 2000, CEMML 2006, Sovell 2011, Schorr 2013. CEMML 2006). In addition, there are 10 Priority Wetland Species that have been identified in the recent Colorado Parks & Wildlife State Wildlife Action Plan (SWAP) update that are found in Arapahoe County and have the potential to be found at BAFB (CPW 2015b). A table that includes all of these elements of conservation concern with the updated Colorado Parks & Wildlife Priority Wetland Species for BAFB is provided in Appendix C. These species and their habitats should be included in site plans when planning weed treatments or other development activities at BAFB.

- **See Individual Noxious Weed Species Sections below for Detailed Treatment Recommendations.** Individual species sections are listed in alphabetical order by scientific name. They provide detailed information on plant biology and treatments.

- **Follow General BMPs for Noxious Weed Invasion Prevention:**
  - ❖ Prevent the spread of noxious weeds to new areas by development activities by monitoring after soil disturbances for weeds.
  - ❖ Clean all equipment, vehicles, and machinery used in weed infested sites before moving to new areas.
  - ❖ Monitor imported garden plants for residences and businesses, residential lawn clipping dumping and only use weed-free hay to prevent introduction of noxious weeds.
  - ❖ Prevent unnecessary soil disturbances and protect intact native vegetation.
  - ❖ Reseed disturbed soils with desirable, competitive native species after construction projects or infrastructure related activities to discourage the influx of noxious weeds.
  - ❖ Plant competitive native species in and around weedy areas to prevent spread to new areas.

Russian Knapweed (*Acroptilon repens*)

Management Urgency: Very High - few occurrences, some densely infested. New in 2019.

Management Goals: Rapid Response/Prevention/ Biocontrol

Photo: Russian knapweed flower, note papery non-spiny phyllaries (left Lisa Tasker CNHP) and lobed leaves with hairy stems (Photo CSU Extension JK Web).

- Perennial, spreading by lateral roots and from seeds – forming dense colonies.
- Root buds active winter and spring.
- Emerges early spring, bolts late May – June, flowers into fall.
- Seed longevity is 2-8 years.
- Allelopathic – plants produce chemicals that inhibit other plants.
- Seeds are a contaminant in hay; also introduced by vehicles (CWMA 2020).

2019 Mapping

Russian knapweed (*Acroptilon repens*) has not previously been mapped at BAFB (Table 5, Figure 5). A high management urgency rank is assigned as rapid response actions have the potential to result in eradication at four of the five mapped sites. The four small occurrences were mapped with only 5-22 individuals. These sites require quick response as this species can expand very quickly within a single year. The largest site covers 0.22 acres with > 6,300 individuals (Photo below) and may be extremely difficult to eradicate at this level of infestation.

Dense Russian knapweed occurrence at BAFB 2019. Photo: Lisa Tasker, CNHP.

Table 5. Russian knapweed noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	*Not Found*	*Not Found*	*Not Found*	0.39
Estimated Number of Shoots	---	---	---	6,385
Number of Mapped Features	---	---	---	5

Recommendations

Russian knapweed has likely been at BAFB for a number of years and has likely built up an extensive root biomass and seed bank at the largest mapped site. The other four sites could be satellite populations of the large infestation that are expanding (Figure 5). The largest site may be too heavily infested to eradicate without restoration activities. Prevention and biocontrol introduction are likely the most effective methods to provide control with the least amount of effort for the large site. Restoration activities may provide control if resources are available.

Prevention

The first recommendation is prevention. Stop the spread of the seeds by not driving vehicles and other machinery through infested sites. Protect intact vegetation in the area from disturbances that leave open soil for the Russian knapweed seeds to spread. Once Russian knapweed is established it is very difficult to control due to the extensive root system and the production of chemicals that inhibit growth of other plants (allelopathy). It is very easy to stimulate the plant to spread by manipulating the stems with mowing or chemicals if not done without a site plan.

Biocontrol

Areas with a cover greater than 1/8th of an acre are large enough to support biocontrol organisms that are currently available from the CDA Insectary (CDA-CSU 2015a). The Insectary recommends releases between April and June. The gall midge (*Jaapiella ivannikovi*) is available now and low maintenance. It is appropriate for areas that will not be disturbed by chemicals, heavy grazing or mowing. Other biocontrol agents for Russian knapweed are being investigated at this time (CDA-CSU 2015a).

Mechanical

Mowing is not recommended for this species (unless it is a field that can be mowed multiple times throughout the growing season for multiple years to exhaust the roots). Pulling is recommended for the four sites that have less than 25 individuals. However, if this is going to be successful multiple treatments *within the same growing season* that remove all vegetative portions and as much of the root as possible needs to take place for multiple years and multiple times during the growing season in June and September. If there can be no follow-up actions then no treatment is recommended as these activities stimulate the underground root system to send up more shoots the following year. Russian knapweed also produces chemicals that make it difficult for other species to grow near them (allelopathy) adding another layer of difficulty to treat.

Chemicals

Chemicals only work in the short-term and are for agricultural settings. They can't be used with biocontrol for this species. Even in agricultural systems, herbicides must be used in conjunction with mowing and properly timed herbicide applications. In natural areas, a restoration planting of competitive plants needs to occur after treatments as bare ground will allow the plants to reinvade (CDA-CSU 2015a).

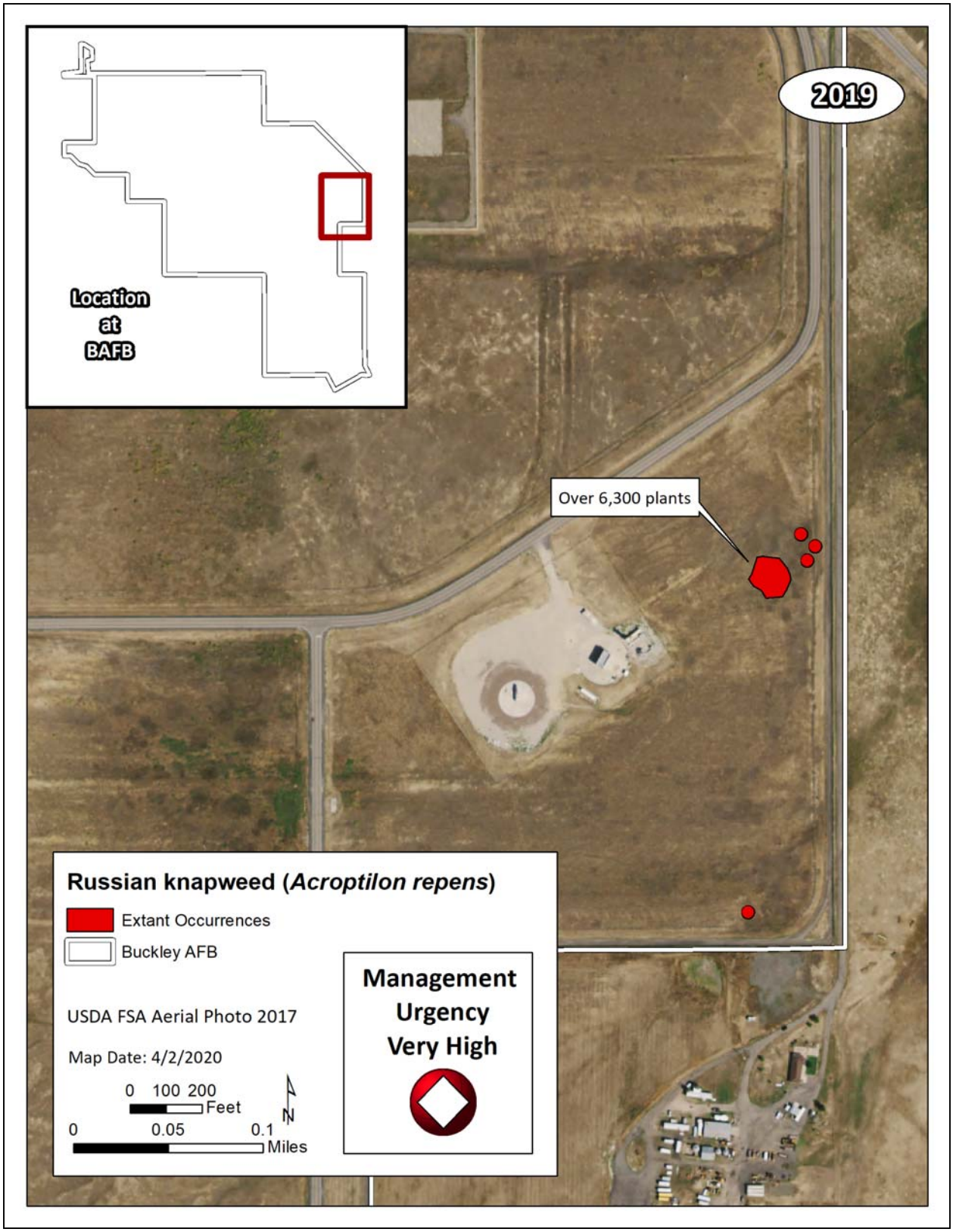


Figure 5. Distribution of Russian knapweed at Buckley Air Force Base in 2019.

Musk Thistle (*Carduus nutans*)

Management Urgency: Low – widespread species

Management Goals: Manage small populations where they can be monitored pre-post treatments.

Photo: Left: Musk thistle flowers, Michelle Washebek (CNHP) Right: Musk thistle plant, Wikimedia Commons 2018.

- 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).

2019 Mapping

Musk thistle has been widespread on BAFB property for more than 16 years and was considered to be in numbers too high to eradicate as early as 2004 (North Wind Inc. 2005, CEMML 2006). The coverage of this species in 2019 was so extensive that after 1,000+ features were mapped we discontinued that effort (Table 6, Figure 6). Basewide weed mapping is no longer cost effective or useful for this species. A low management urgency rank is assigned because eradication and control is unlikely at this level of infestation (Photo below).

Tree row planting area in 2019 with dense infestation of musk thistle at BAFB. Photo: Lisa Tasker, CNHP.

Table 6. Musk thistle noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019*
Occupied Acres	Widespread	19	534	>80
Estimated Number of Shoots	---	---	---	>940,000
Number of Mapped Features	---	---	---	>1,074

*Partially mapped in 2019 due to widespread distribution.

Recommendations

Due to the high cover of musk thistle, eradication is not a realistic goal. The best strategy for tackling musk thistle is through proactive actions which include preventing spread to new areas, monitoring for new occurrences and preventing unnecessary soil disturbances. Musk thistle is a biennial species and reproduces solely by seed production. It is more easily controlled than deep-rooted perennial species with vegetative reproduction. Remove the seed source and you can reduce musk thistle. Small areas can be locally eradicated at BAFB with appropriate techniques and follow-up monitoring to attempt to reduce cover. A site plan is essential to determine potential outside sources of seed, and to document pre- post conditions and the results of management actions.

Mechanical

For small areas (<0.5 acres), mechanical methods are recommended (CDA-CSU 2016a). The best time to treat musk thistle, no matter what the treatment is in the rosette stage (1st year and 2nd year rosettes). Bolted stages when treated can actually stimulate the plants, or leave behind seeds. To prevent excess soil disturbance a large sharp knife can be used to sever the plant about 4-6 inches below the soil surface. Follow-up monitoring must occur throughout the growing season as the rosettes continue to show up and expand over the summer (CDA-CSU 2016a).

It is important that flowers and seeds be removed if present and follow-up monitoring must be conducted to look for rosettes and sprouts throughout the same growing season. 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. When treating small areas herbicides are not recommended. However, if an herbicide is used, only targeted spot spraying of plants in the rosette stage is recommended with continued monitoring within the same growing season to remove late emerging sprouts and missed plants. Do not treat bolted budding, flowering or seeding plants. Timing of herbicide applications, limiting overspray and same-season follow-up monitoring is key to a successful result. If sufficient resources are not available to conduct follow-up monitoring and treatments as described above, resources would be better used in other ways. Annual monitoring multiple times during the growing season would need to continue for a minimum of 10 years from the last observed musk thistle plant at the site based on the seed longevity of 10 years (CCR 2014).

Mowing, chopping, and dead heading are not recommended as these actions stimulate growth (CDA-CSU 2016a).

Cultural

Cultural methods that have been shown to be effective include plantings with native competing forbs and grasses (CDA-CSU 2016a).

Biocontrol

Biocontrol is not recommended at this time as some of the organisms released have been found on other non-target plants (CDA-CSU 2016a).

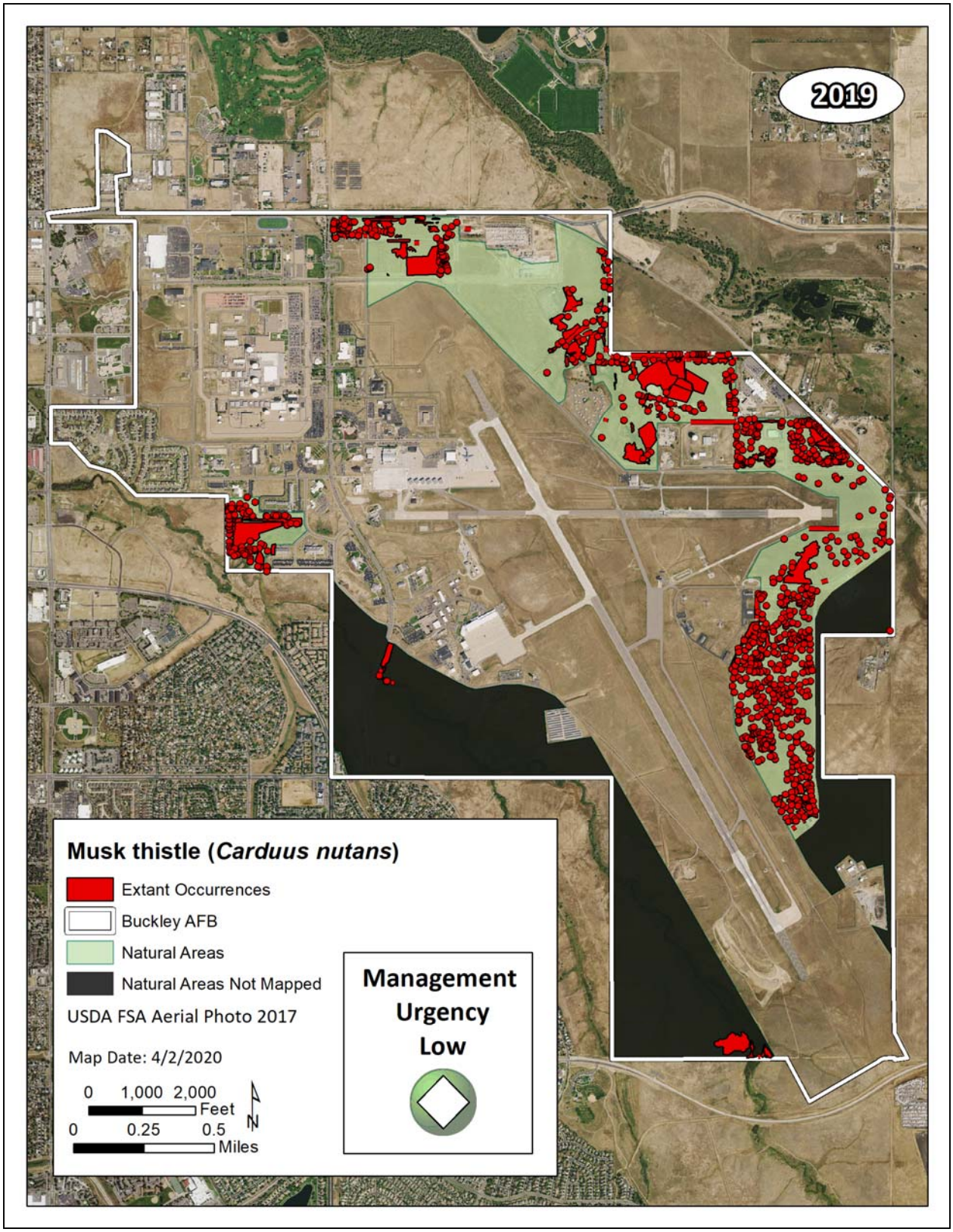


Figure 6. Distribution of musk thistle at Buckley Air Force Base in 2019.

Diffuse Knapweed (*Centaurea diffusa*)

Management Urgency: Medium

Management Goals: Localized treatments to reduce available seeds and biocontrol.

Photos: Top left: diffuse knapweed plant. Top right: diffuse knapweed mature flower. Flowers can be white or pink. Photos Wikimedia Commons 2018.

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

- Short-lived non-creeping perennial, biennial, or annual.
- Spreads by seeds, germination throughout growing season.
- Seed longevity of 8-10 years (CCR 2014) – wind dispersed.
- Provides nectar and pollen for honeybees.
- Plant has tumbleweed mobility.
- It forms rosettes in its early growth stage (1-2 years).
- Can sprout from the root crown after top-kill (Zouhar 2001).

2019 Mapping

Diffuse knapweed was controllable when it was first mapped in 2004 with only two mapped features (North Wind, Inc. 2005). The diffuse knapweed population was mapped at 0.7 acres in 2007 (GMI 2008) with a very large increase in 2014 to more than two and half acres (Amec Foster Wheeler 2015). In 2019, there were greater than 6 occupied acres and 33,000 shoots at 116 mapped features (Table 7, Figure 7).

In 2004, there was one site mapped with spotted knapweed (*Centaurea maculosa*), a close relative of diffuse knapweed, near a roadside that appears to have been eradicated due to rapid response activities. It has not been mapped since 2004 and was not on the floristic survey in 2005 (CEMML 2006) or subsequent surveys (Amec Foster Wheeler 2015).

Table 7. Diffuse knapweed noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	---	0.7	2.54	>6.0
Estimated Number of Shoots	---	---	---	>33,000
Number of Mapped Features	2	---	---	116

Recommendations

Knapweeds become very difficult to control once they become established and when their total cover exceeds 2.5 acres (Zimmerman et al. 2011) which was exceeded in 2014 at BAFB (Amec Foster Wheeler 2015). The key to effectively controlling knapweed is by preventing plants from flowering and going to seed during the growing season and by preventing ground disturbance from overspray or manual removal.

Prevention is the first priority to stop the spread of knapweed seeds to new sites. Infested areas visited by mowers, vehicles and other equipment spread seeds. Since this species is fairly widespread, biocontrol is likely the best choice. No matter which set of treatments is selected, a site plan is important so that consideration of surrounding environmental conditions, proximity of other noxious weeds and native species, and site specifics can be part of the strategy. Treating a roadside is different than prairie grasslands, for example. Follow-up monitoring, timelines for activities, records of treatments, locations, photo plots for monitoring and adaptive management strategies are needed as knapweeds can increase if treatments are not carried out with a strategy (Pearson et al. 2016, Pearson and Ortega 2009).

Biocontrol

Large populations can be treated with biocontrol and this is likely the best choice for many areas at BAFB. The seedhead weevil (*Larinus minutus*) and the root weevil fly (*Cyphocleonus achates*) have been used together showing fair to good results in three to five years. These insects are available in Colorado (CDA-CSU 2015b). The knapweed seedhead fly (*Urophora quadrifasciata*) was documented in 2015 at BAFB by Sovell et al. 2016. This species along with other seed head agents

and root borers will help get knapweed under control. Ideal sites will not be disturbed for 10 years by development or pesticide use (Shelton 2020).

Mechanical

Mechanical methods can be effective for small populations (Jefferson County 2019). Cutting plants below the soil surface works well especially before the plants set seed. Treating at the rosette stage is the most effective for all knapweed treatments. The key is not to allow more seeds to be set. Small roadside treatments or in areas that need rapid response actions would likely benefit most from mechanical treatments.

Cultural

Do not use treatments that leave behind bare ground. These areas need to be replanted or diffuse knapweed will return (CDA-CSU 2015b).

Chemical

Herbicides are not the first choice for knapweeds at BAFB. Recommended herbicides need to be applied before the mature plants set seed but some need them to be in flower which is very difficult to achieve in a mixed population. Rosettes in the spring or fall are better targets. Most populations are in different growth stages even within the same populations throughout the growing season. The herbicides recommended to treat diffuse knapweed are not appropriate for wildlands. Herbicides can be applied using a backpack sprayer or a wick application for small areas to minimize damage to non-target plants providing competition to knapweed. One of the reasons there has been such a low success with herbicides results from unintended soil disturbances by increasing bare ground, changing soil pH and the balance of soil organisms, and negatively impacting surrounding native plants (Pearson et al. 2016, Pearson and Ortega 2009). Diffuse knapweed plants are hard to spray without impacting the ground due to the growth form with small leaves and bushy habit.

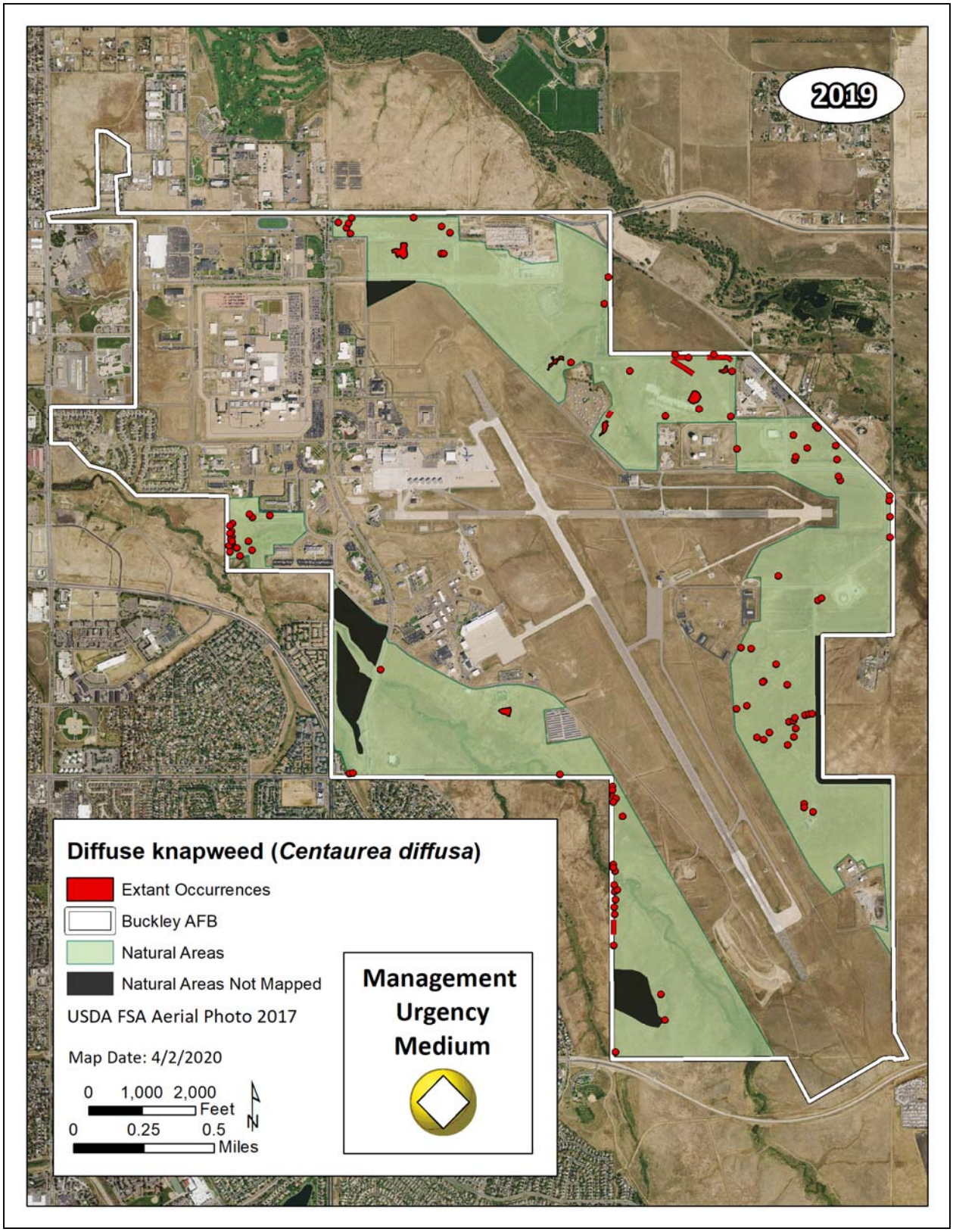


Figure 7. Distribution of diffuse knapweed at Buckley Air Force Base in 2019.

Canada Thistle (*Cirsium arvense*)

Management Urgency: Low – widespread.

Management Goals: Monitor for spread, treat new satellite populations or new infestations.

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

Canada thistle near E. Tollgate Road in 2019. Photo: Lisa Tasker, CNHP.

2019 Mapping

In 2019, more than 48 acres of Canada thistle were mapped with more than an estimated 5,850,000 shoots at 616 mapped features at BAFB (Table 8, Figure 8). Basewide weed mapping is no longer cost effective for this species. Due to the large cover and difficulty in successfully treating large infestations this species was given a low urgency ranking.

Table 8. Canada thistle noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	Widespread	29	309	>48
Estimated Number of Shoots	---	---	---	>5,850,000
Number of Mapped Features	---	---	---	616

Recommendations

Coverage of Canada thistle is so extensive at BAFB that it is considered a low priority for eradication. This species is extremely difficult to control and can increase its footprint when the top growth is removed by mechanical or chemical methods. Within the larger discussion for Canada thistle, there is no single treatment that will remove it from an infested site (CDA-CSU 2015c). 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 action is likely the best course of action.

1) 1st priority is rapid response on newly established populations (USFS-USDA 2014a).
2) Strategy to contain or reduce Canada thistle that includes long-term planning and Integrated Pest Management (IPM) (USFS-USDA 2014b).
3) Need to plan on a minimum of 5 up to 10 years of active IPM and must have follow-up monitoring and reseeding or restoration activities as part of the plan (USFS-USDA 2014a).

Cultural

Canada thistle does not do well in heavily shaded areas. In some areas, planting shrubs and trees may be appropriate.

Mechanical

Mechanical removal including mowing and hand pulling are not recommended if you can't completely deplete the underground root system which is extremely difficult to do, especially in areas with extensive cover (CDA-CSU 2015c). Small areas are easier to attempt control. The treatments would have to occur many times over the course of one season and for multiple years to prevent sprouts from underground roots from producing leaves to feed the underground system. This has taken as many as 10 treatments in one season in our experience.

Biocontrol

There are no known effective biocontrols at this time. A Gall Fly (*Urophora cardui*), and *Hadroplontus litura*, a stem-mining weevil, have been around for over 40 years and are thought to be ineffective on a population level. The Canada thistle rust fungus (*Puccinia punctiformis*) is being investigated as a potential biocontrol agent to be distributed. It is an option for managers to explore in the near future and is in the investigative stage (CDA-CSU 2015c).

Native ungulates have been observed eating Canada thistle and removing roots during browsing activities. Wildlife and pollinator safety is another reason why chemical control should be carefully considered before use.

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 (see Appendix A). The most immediate recommended course of action is monitoring which can confirm whether the population is stable, decreasing or increasing in cover.

Chemical

Herbicide applications are not recommended without a site plan and a strategy for use as part of other IPM protocols. 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 and many cause damage to other broad-leaved species.

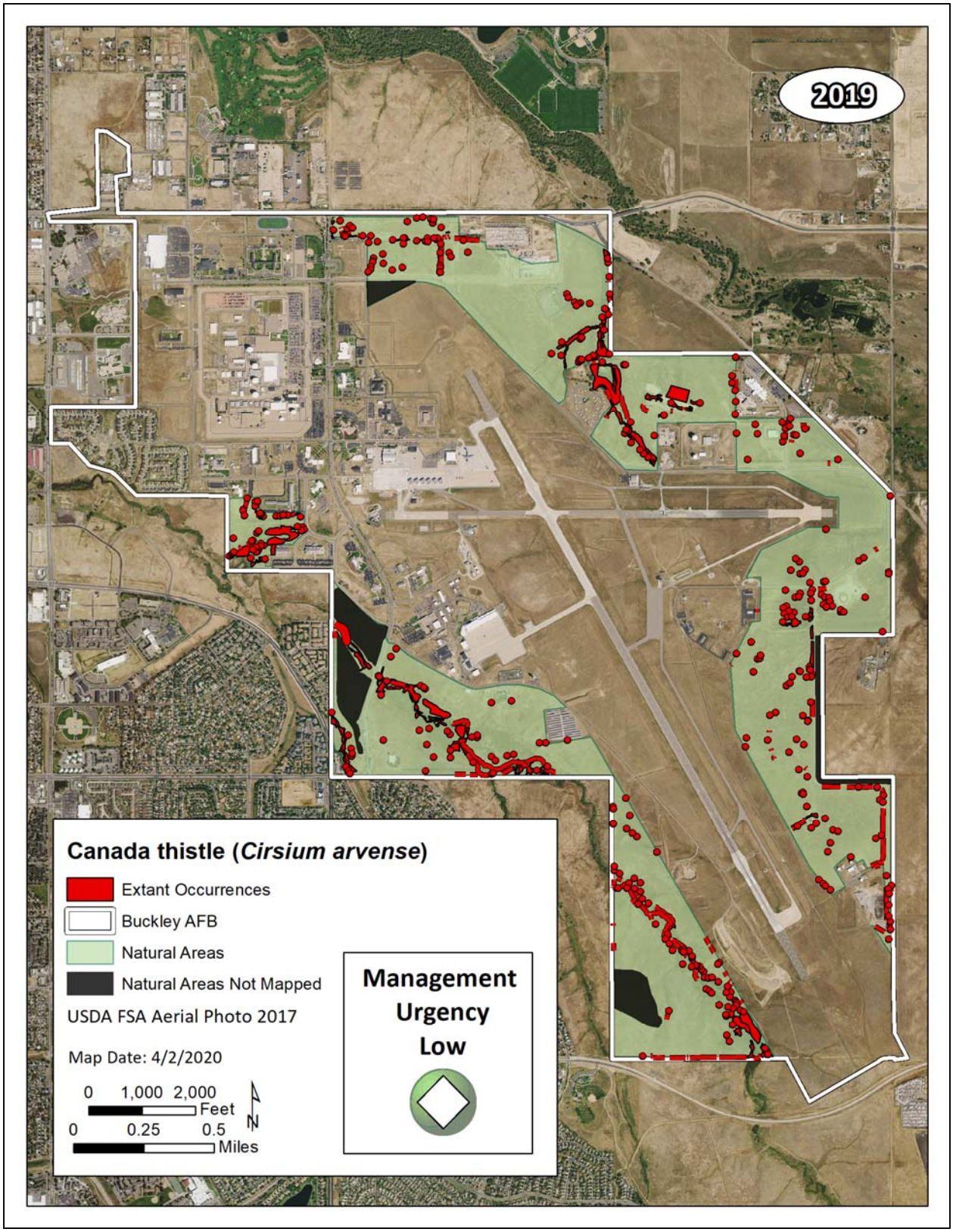


Figure 8. Distribution of Canada thistle at Buckley Air Force Base in 2019.

Houndstongue (*Cynoglossum officinale*)

Management Urgency: Low - widespread

Management Goals: Reduce cover and seed production

Photos: Left: Houndstongue in fruit and flower, Georgia Doyle (CNHP) Top right: Houndstongue rosette, Wikimedia Commons 2018.

- 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).

Houndstongue was first mapped with very low cover (less than 1/10th of an acre) in 2007 at BAFB (GMI 2008). In 2014, eight acres of houndstongue were mapped at BAFB, and was considered to be of moderate management urgency due to the fairly widespread cover.

2019 Mapping

Houndstongue is currently widely distributed across BAFB and 109 features were mapped in 2019 covering over three acres with more than 142,000 shoots (Table 9 and Figure 9). Basewide weed mapping is no longer cost effective for this species. The level of coverage is large enough that the management urgency has been ranked as low due to the difficulty to eradicate at this stage. Local control of small populations could reduce seeds and cover.

Table 9. Houndstongue noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	*Not Found*	0.001	7.62	>3.35
Estimated Number of Shoots	---	---	---	>142,600
Number of Mapped Features	---	---	---	109

Recommendations

Site plans are recommended to identify populations to treat, to track results and to establish goals (see Appendix A). A successful treatment calls for minimal soil disturbance, flower and seed removal from the site and plans for follow-up monitoring within the same growing season. Roughly half of the mapped features could be treated manually with less than 150 plants. Mechanical removal at small sites can locally reduce the seeds and cover of houndstongue. The unnatural levels of disturbance within and surrounding the sites may be supporting weed expansions and invasions.

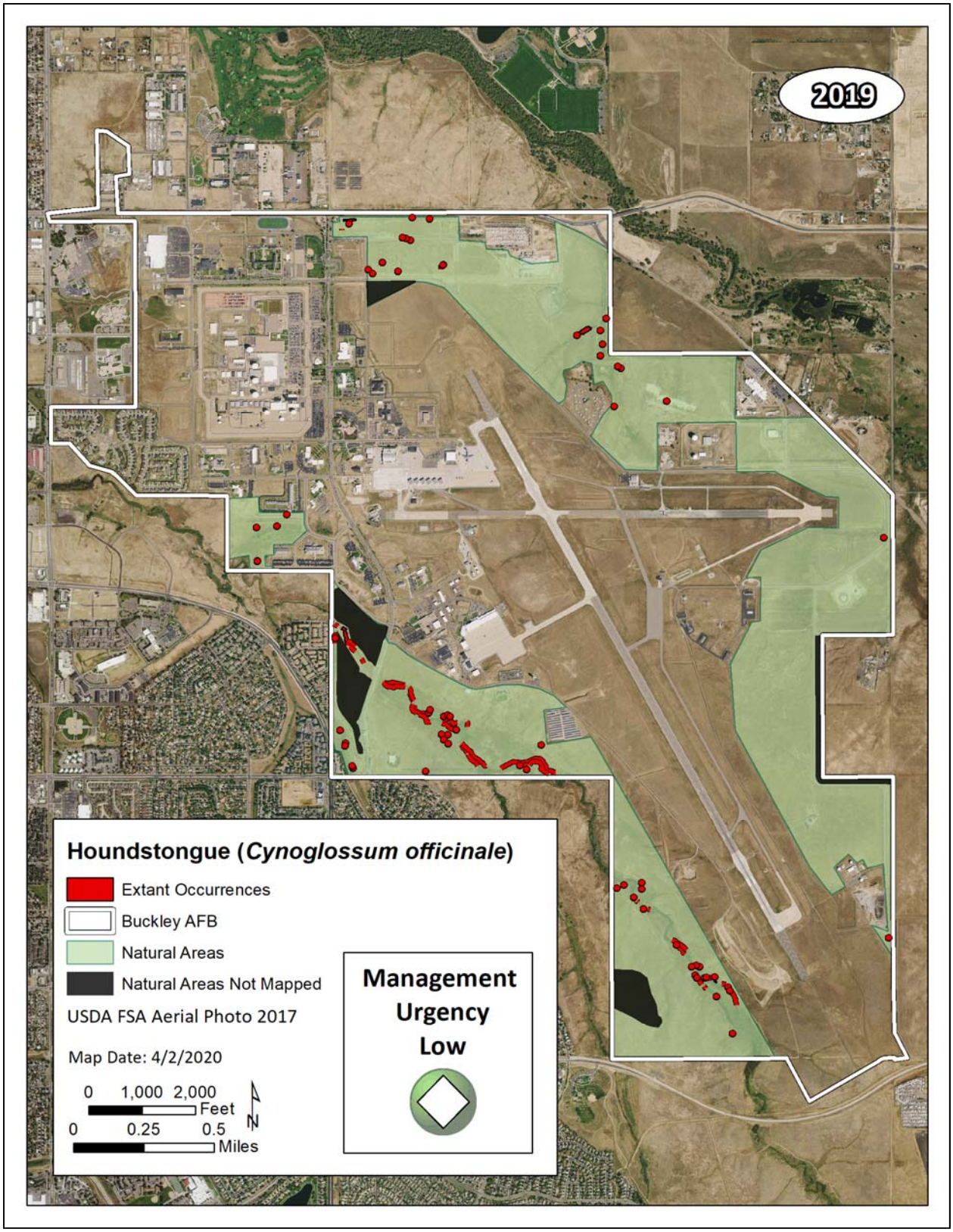


Figure 9. Distribution of houndstongue at Buckley Air Force Base in 2019.

Common Teasel (*Dipsacus fullonum*)

Management Urgency: Medium

Management Goals: Containment / Eradicate small populations (<100 individuals)

Left photo: Common teasel at Buckley AFB with native perennial grass and other List B noxious weeds, top right: flowering head, wikimedia.org, bottom right: first year rosette: King County 2018.

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

Common teasel is found largely in the western natural areas at BAFB. About half of the mapped areas contain less than 100 individuals and are good candidates for eradication. Some sites have thousands of individuals. Therefore, the overall management urgency is ranked as medium. The smaller more isolated populations should be prioritized for control and containment or eradication depending on the cover and site characteristics and resources at BAFB. Many noxious weed occurrences at BAFB are mixed with native species and other weeds making treatments more

difficult. The photo above shows common teasel, leafy spurge, Canada thistle with native sunflowers and a native perennial grass foxtail barley (*Hordeum jubatum*).

2019 Mapping

Common teasel was mapped at 29 sites on greater than three acres on the BAFB (Table 10 and Figure 10). It has spread since it was first discovered in 2007.

Table 10. Common teasel noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	*Not Found*	0.004	24	>3
Estimated Number of Shoots	---	---	---	>105,000
Number of Mapped Features	----	---	---	29

Recommendations

The coverage of teasel is significant at BAFB and approaching a level where eradication is unlikely in some of the denser infestations, roughly half of the mapped occurrences. Creating a clear plan for treatments and follow-up monitoring strategies are essential to gain control of teasel populations. Sizing up the entire infestation, visualizing the desired result, timelines for follow-up monitoring from actions and knowing what species are likely to replace the invader as well as estimating the resources needed to be successful is extremely important at this stage. Integrated Pest Management that includes multiple techniques, a clear goal for each site, and restoration activities are recommended for treating teasel.

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

The Colorado Department of Agriculture and Colorado State University (CDA-CSU 2016b) recommend the following for common teasel:

1) Effective integrated management means using a variety of eradication methods along with restoration, prevention of seed production and dispersal, and monitoring.
2) Maintain robust healthy native landscapes.
3) Restore degraded sites.
4) Avoid soil disturbance.
5) Prevent seed production in the first and second year.
6) Prevent seed from dispersing, e.g. contaminated equipment. Rest sites until restored. Change land use practices. Use methods appropriate for the site.

Mechanical

The protection of any intact vegetation in and around infestations is the first goal and best protection against increasing this or other weeds. Pulling the entire plant in sprouting stage is acceptable. Severing the root crown of the plant (section below the soil surface) with a sharp knife or digging tool at various stages of growth will kill plants (Duncan 2018). For follow-up monitoring after treatments when small sprouts are present, the entire plant can be pulled. For dense infestations where removal would cause a large area of open soil, cutting bolting or flowering stems has been shown to significantly reduce seed viability and production. In experiments it was found that teasel stems cut before flowering would regrow but with significantly fewer flower heads than uncut plants and stems cut during or after flowering produced no new flower heads. 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.

Chemical

Herbicides used for teasel are only recommended for rangelands and pastures and not natural areas (CDA-USDA 2016b). Herbicides can create a new set of problems, such as destroying soil microbes, prohibiting germination of other desirable plants, and increasing the mortality of surrounding desirable vegetation. Using herbicides in wetlands is even more problematic. The location of surface water, depth to groundwater and sensitivity of the site to trampling when applications occur as well as timing can determine outcomes. Impacts to water quality and local fauna are also important to consider as is off target damage to other plant species (TNC 2011). Monitoring of treatment sites may need to occur for up to 14 years after successfully controlling infestations.

Biocontrol

There are currently no biological controls available for common teasel.

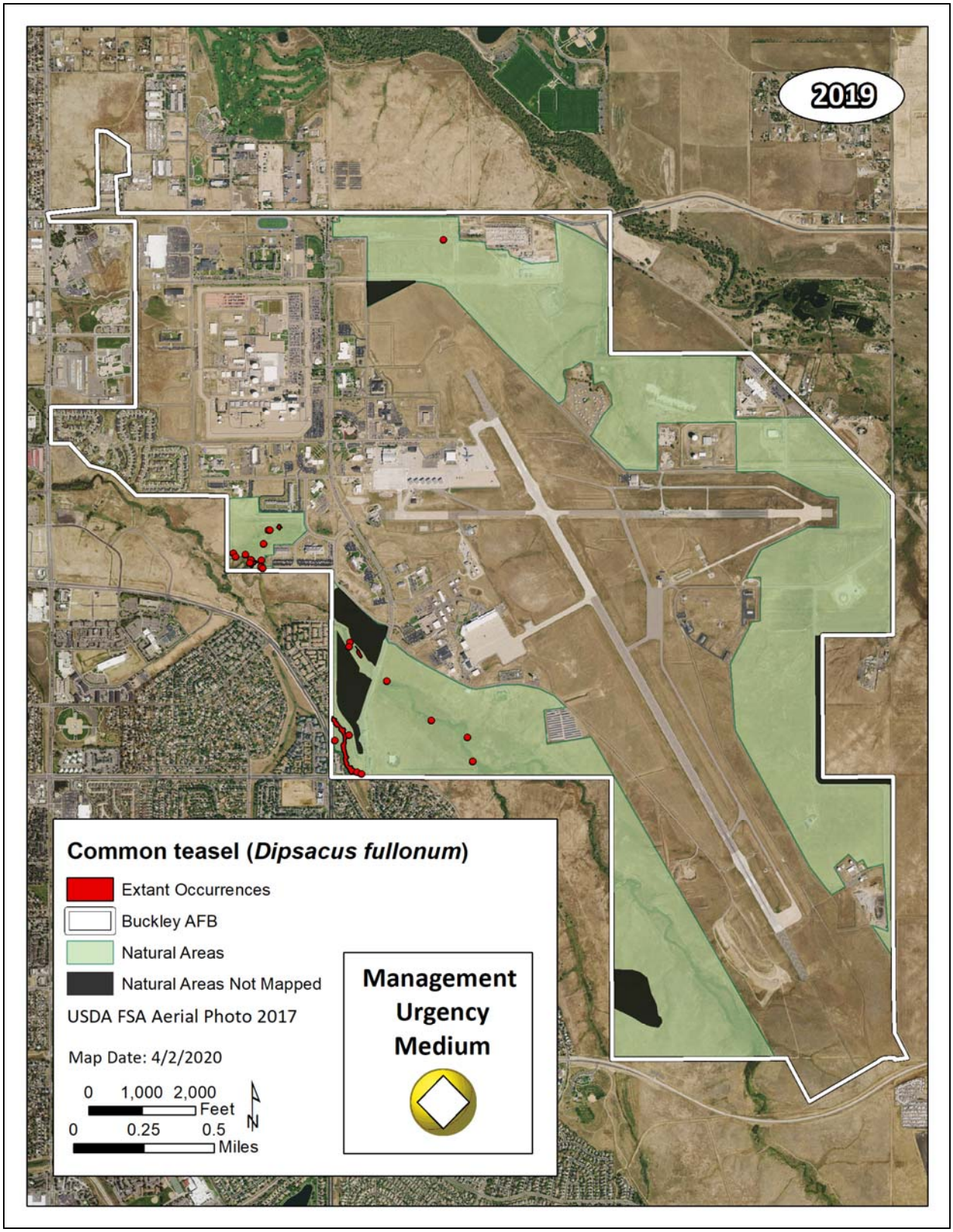


Figure 10. Distribution of common teasel at Buckley Air Force Base in 2019.

Russian Olive (*Elaeagnus angustifolia*)

Management Urgency: High

Management Goals: Eradication / Containment

Photo: mature Russian olive, Wikimedia Commons 2018.

Photo: fruits of Russian olive, Wikimedia Commons 2018.

- Ability to establish in the absence of disturbance (Montana Audubon 2010).
- Reproduction by seeds and suckers.
- Seeds are largely dispersed by birds and mammals and are viable for 3 years (CDA-CSU 2015d).
- Can enhance wildlife in disturbed environments where native species have been removed (CDA-CSU 2015d).
- May or may not rapidly spread depending on site characteristics.
- Injured trees sprout, cutting down trees or girdling can cause them to sucker.
- Difficult to control once established.
- Nitrogen-fixing capabilities.

2019 Mapping

Russian olives at BAFB include both mature and smaller trees, shrubs and sprouts. The numbers of trees are at a level where elimination is possible. The management urgency is site-specific and should be based on the size, location and proximity to a natural area. The management rank was assigned as a high urgency due to the current low coverage of Russian olive at BAFB. There were 21 mapped features with an estimated 70 shoots occupying 0.28 acres which represents a significant decrease since 2014 (Table 11 and Figure 11).

Table 11. Russian olive noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	3 locations	97 stems	15.6	0.28
Estimated Number of Shoots	---	---	---	70
Number of Mapped Features	---	---	---	21

Recommendations

The first priority for Russian olive should be rapid response removal of small sprouts and shrubs and containment may be satisfactory where large individuals are surrounded by developments. 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, managers 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. Trees must be treated individually with the appropriate herbicide, at the appropriate time of year and with a method where the herbicide is applied within minutes of application to a cut stump or the plant will produce suckers (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. Large 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 (CDA-CSU 2015d).

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. This canker is not approved or provided by the Colorado Department of Agriculture (CDA-CSU 2015d).

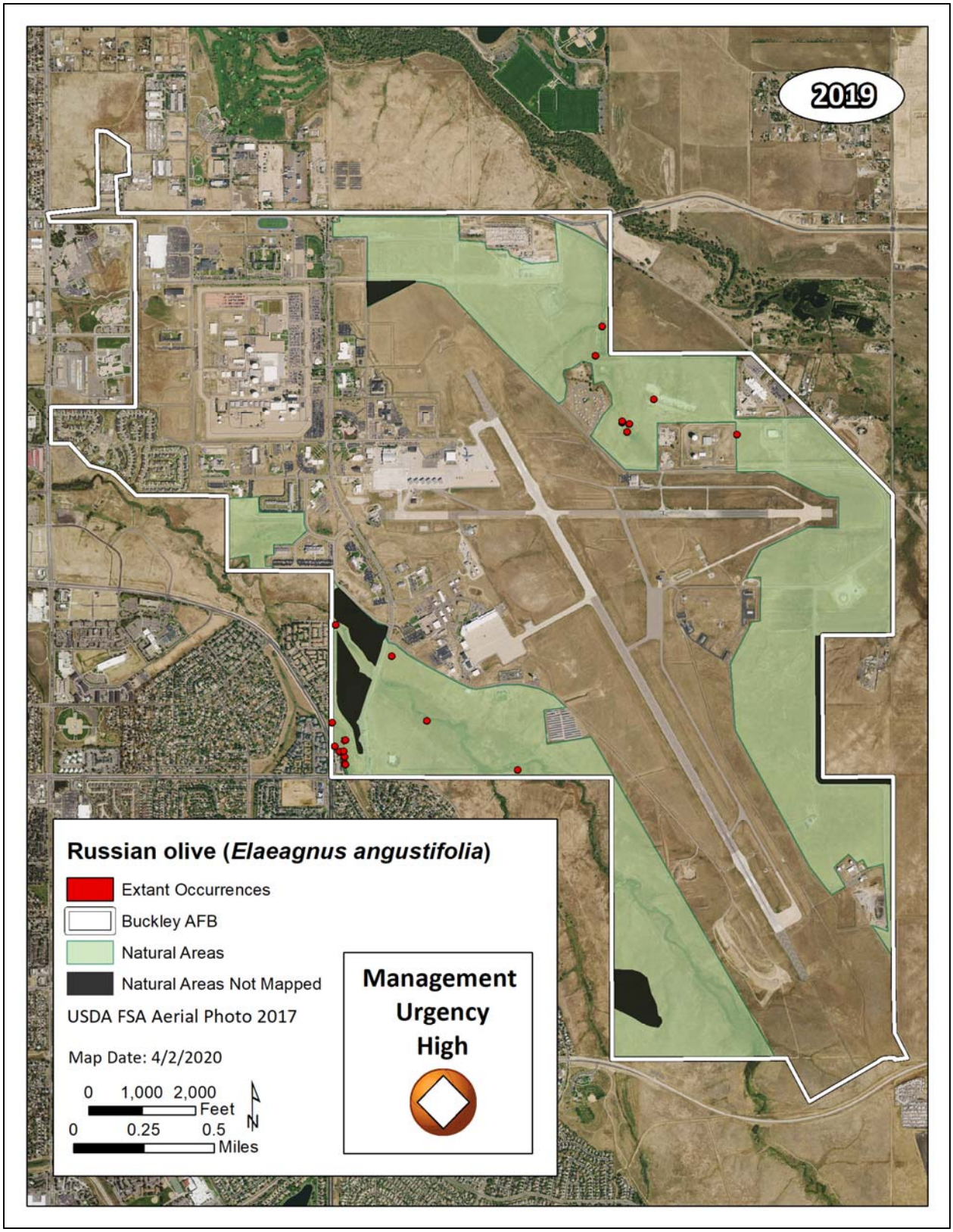


Figure 11. Distribution of Russian olive at Buckley Air Force Base in 2019.

Leafy Spurge (*Euphorbia esula*)

Management Urgency: Medium

Management Goals: Biocontrol/ Prevention/Containment

Photo: leafy spurge with Canada thistle and smooth brome at BAFB 2019 (left); flowers top right and milky sap bottom right, Lisa Tasker (CNHP)

- Perennial with extensive, deep root system, allelopathic.
- Reproduction from seeds and vegetatively from root buds.
- Seeds ejected up to 15 feet from plant (CDA-CSUe).
- Plant has white milky sap, caustic to skin.
- Seed longevity 5-8 years, mostly germinate in first two years (CWMA 2017).
- Young plants easily mistaken for yellow toadflax.
- Flowers early, mid-April- May (Ackerfield 2018).
- Extremely difficult to control (CWMA 2017).

Leafy spurge was well-established at BAFB in 2004 at over 30 locations (North Wind, Inc. 2005). Between 2007 and 2014 the occupied acres increased dramatically from 5.2 to 173 acres (GMI 2008, Amec Foster Wheeler 2015). Despite the widespread nature and the difficulty of treating leafy spurge, this species is assigned a moderate urgency rank since there are biocontrol agents readily available and some are currently present on the base (Sovell et al. 2016).

2019 Mapping

Leafy spurge was mapped at 142 sites across BAFB covering more than eight acres in various habitats including moist riparian and upland sites (Table 12 and Figure 12). It was commonly found co-occurring with other noxious weeds at BAFB including Canada thistle.

Table 12. Leafy spurge noxious weed survey results at BAFB 2004 - 2019.

	2004	2007	2014	2019
Occupied Acres	30+ locations	5.2	173	>8
Estimated Number of Shoots	---	---	---	>555,200
Number of Mapped Features	---	---	---	142

Recommendations

The leafy spurge populations are well-established and cover large areas of BAFB. Due to copious seed production and extensive root systems, large occurrences of leafy spurge are extremely difficult to successfully manage. Eradication is not likely. Rapid re-establishment of leafy spurge occurs commonly after what appears to be a successful management effort because of the large nutrient reserve stored in the roots. Further, leafy spurge produces an allelopathic compound that inhibits the growth of other plants (CWMA 2017). However, biocontrol agents have come a long way since they were first introduced and likely offer the best solution along with containment and prevention protocols.

Biocontrol

Biocontrol organisms are available through the Colorado Department of Agriculture. Biocontrol is an option for impacting large and dense infestations. An arthropod survey conducted in 2015 (Sovell et al. 2016) documented two leafy spurge biocontrol organisms: the red-headed leafy spurge stem borer (*Oberea erythrocephala*) and the black dot leafy spurge flea beetle (*Aphthonia nigriscutus*). The red-headed leafy spurge stem borer adults feed on above ground parts and the larvae bore into the stem and root crown (CDA-CSU 2015e). Monitoring for the presence of organisms could be helpful to see if purchasing additional agents would be beneficial. A number of different biocontrol organisms are available for Colorado and can be introduced to enhance results as needed. Monitoring before and after introductions is essential to understand if and what areas the biocontrols are working.

Cultural

Planting competitive native species can help control leafy spurge by containing populations and preventing the spread leafy spurge to other sites (CDA-CSU 2015e).

Grazing

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

Herbicides and Mechanical Treatments

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 (see Appendix A) prior to any treatment decisions is critical to being successful and understanding management impacts of this difficult to manage species.

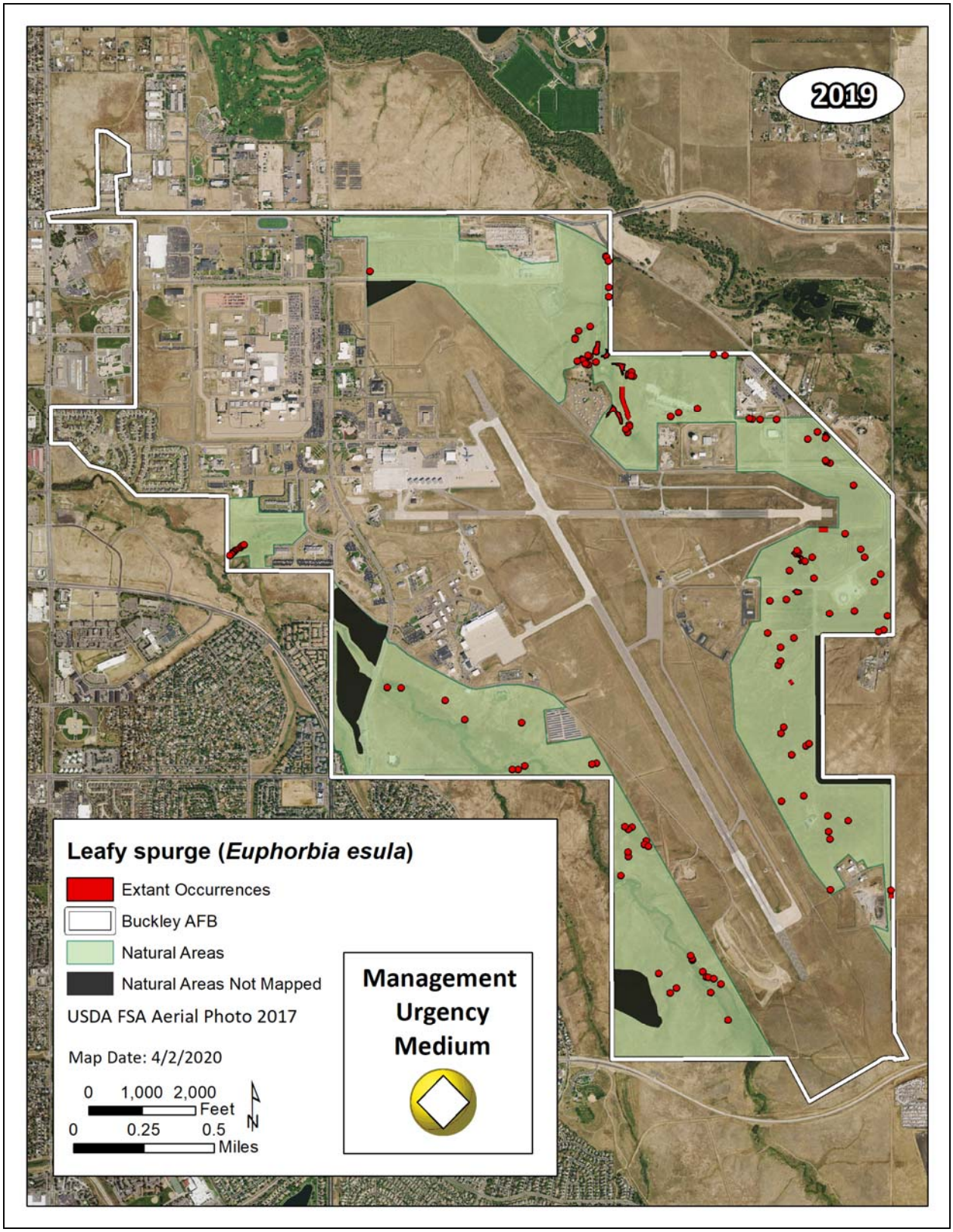


Figure 12. Distribution of leafy spurge at Buckley Air Force Base in 2019.

Hoary Cress (*Lepidium draba*)

Management Urgency: High – new in 2019

Management Goals: Rapid Response/ Containment

Upper left: rosette; bottom left seed heads for hoary cress, BAFB 2109. Lisa Tasker (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 3 years. (CCR 2014)

Hoary cress, also known as whitetop (*Lepidium draba*), was mapped for the first time in 2019 at BAFB. It was not noted in the previous weed mapping efforts in 2004, 2007, 2014 or the floristic survey in 2005 (North Wind, Inc. 2005, GMI 2008, Amec Wheeler Foster 2015 and CEMML 2006). It is assigned a high (not very high) management urgency rank because only a few of the populations mapped are likely to be eradicated. More than half of the nine sites contain hundreds to thousands of plants and are too big to treat without a major restoration.

2019 Mapping

There are nine mapped features that contain 36 to 7,500 individuals occupying 0.41 acres with an estimated 37,488 shoots. One feature contains an estimated 23,000 shoots (Table 13, Figure 13). There are three sites with 300 or less individuals and these sites have the potential to be locally eradicated. The remaining sites containing hundreds or thousands of individuals are likely too big to eradicate without restoration.

Table 13. Hoary cress noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	*Not Found*	*Not Found*	*Not Found*	0.41
Estimated Number of Shoots	---	---	---	37,488
Number of Mapped Features	---	---	---	9

Recommendations

Rapid response efforts are warranted for three of the sites which contain fewer than 300 individuals. The other sites contain too many to eradicate and containment is recommended. Deep-rooted perennial species like hoary cress are difficult if not impossible to control once established and containment becomes the management strategy. Potential treatments need to be considered very carefully and resources must be available to prepare a monitoring and treatment plan with pre- and post- monitoring as part of any actions (see Appendix A). Herbicides are not recommended at this time as the approved herbicides to treat hoary cress are only for rangelands and pasturelands and not riparian or natural areas (CDA 2015). 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 treatments is inappropriate, it can increase densities via spreading seeds and stimulating new shoots from underground root buds (USFS-USDA 2014c).

1) Create a site plan that includes manual rapid response techniques with same season pre-post – monitoring for the three small sites (<300 individuals).
2) Preventing seeds from spreading to other areas should be a major consideration for all nine sites. Any activities that could spread seeds to new areas need to be recognized and cleaning of equipment and vehicles that pass through or will be doing development activities.
3) Seed longevity is three years, plans to monitor several times during a single growing season should be in place for at least three consecutive years at treatment sites.

4) Consideration should be given to the current state of the vegetation at the site, is it currently within a weed infested area? Is it treatable or will the removal of plants release more weeds? Are there upstream seed sources?
5) Containment can be accomplished by monitoring the existing large populations and treating from the outside any new sprouts or satellite populations. Planting vegetation that can out-compete hoary cress can help contain the spread.

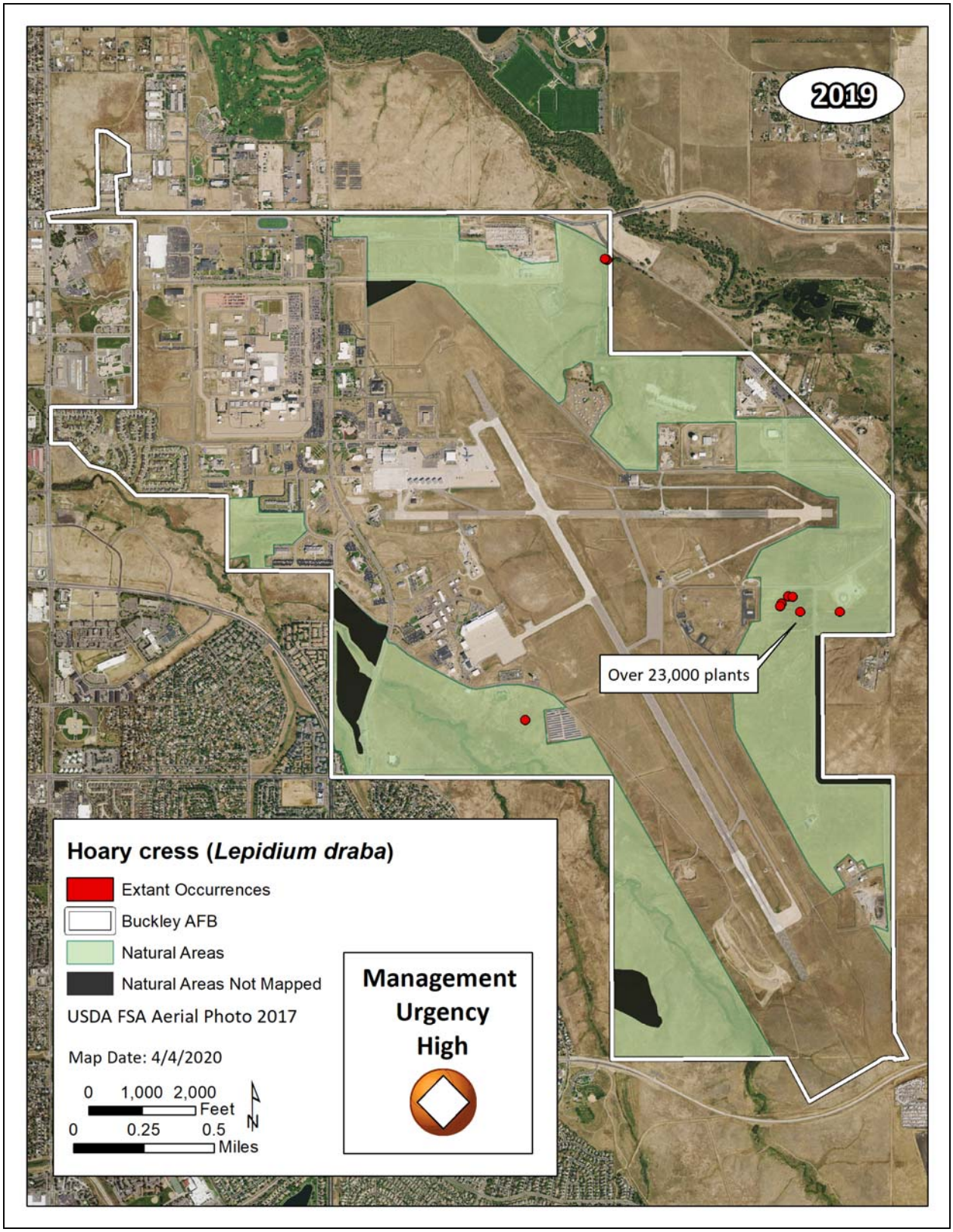


Figure 13. Distribution of hoary cress at Buckley Air Force Base in 2019.

Dalmatian Toadflax (*Linaria dalmatica*)

Management Urgency: Low - widespread

Management Goals: Prevention, Containment

Dalmatian toadflax flowers (left) and in field south of Chapel at BAFB 2019. Lisa Tasker (CNHP)

- Perennial.
- Reproduction from seed and extensive creeping rhizomes.
- Seed longevity at least 10 years (CDA-CSU 2015f).
- Hybridizes with yellow toadflax.
- Flowers May-October (Ackerfield 2018).
- Extremely difficult to control (CWMA 2017, CDA-CSU 2015f).

Dalmatian toadflax has a widespread distribution at BAFB that has been present for well over a decade at high levels (Table 14). Eradication is not likely at this stage of infestation and therefore, this species is assigned a low management urgency rank.

2019 Mapping

At BAFB, there are 516 mapped features with over 159 occupied acres and an estimated 5,000,000 shoots across the natural areas (Table 14, Figure 14). Basewide weed mapping is no longer cost effective for this species. This species is very difficult to control once it becomes established. In addition, Dalmatian toadflax and yellow toadflax hybridize and produce offspring that are more aggressive than either parental species (Turner 2012). The Dalmatian toadflax and yellow toadflax hybrid shown in the photo to the right was mapped in 2019 with Dalmatian toadflax at BAFB. The hybrid is identified by leaf shape which is intermediate between the very narrow leaves of yellow toadflax and the wider leaves of Dalmatian toadflax (CDA-CSU 2015f).

Hybrid Dalmatian toadflax.
Photo by Lisa Tasker (CNHP).

Table 14. Dalmatian toadflax noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	Widespread west side	29	396	>159
Estimated Number of Shoots	---	---	---	> 5,000,000
Number of Mapped Features	---	---	---	516

Recommendations

At this stage of infestation and the degree of disturbance and development at the base, biocontrol is the best option. Biocontrol organisms are available in Colorado through the Colorado Department of Agriculture Insectary. The toadflax flower-eating beetle (*Brachypterolus pulicarius*) was documented in 2015 at BAFB (Sovell et al. 2016).

Biocontrol

Sampling should be done to determine if other biocontrol organisms are present and at what densities, especially the stem boring weevil (*M. janthiniformis*). This particular biocontrol agent has been found to control Dalmatian toadflax. If these weevils are absent or in low numbers, then BAFB should consider pursuing new releases with a careful monitoring program that includes a site assessment and monitoring plan (see Appendix A). The stem boring weevil is readily available through the Colorado Department of Agriculture's insectary (CDA-CSU 2015f). 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.

Grazing

Grazing could be considered along with other IPM techniques for restoration efforts based on site characteristics and policies at the BAFB.

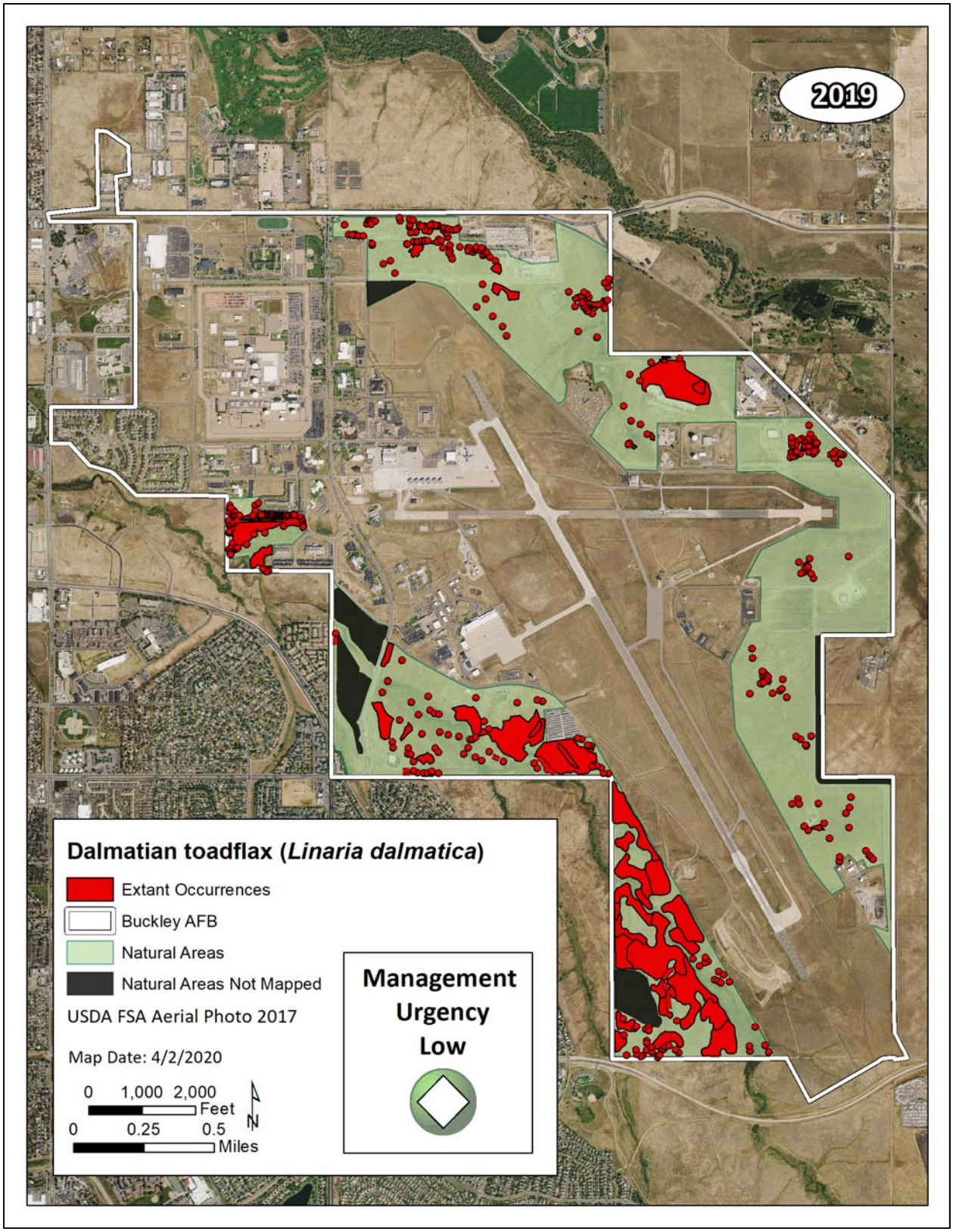


Figure 14. Distribution of Dalmatian toadflax at Buckley Air Force Base in 2019.

Yellow Toadflax (*Linaria vulgaris*)

Management Urgency: *Not Found* - 2019

Management Goals: Monitor/ Rapid Response

Photos: Yellow toadflax at the Air Force Academy, Colorado Springs. Michelle Washebek 2007 (CNHP).

- Perennial
- Reproduction by seed and creeping roots
- Flowers June – September
- Hybridizes with Dalmatian toadflax
- Biological controls are available for yellow toadflax (CDA-CSU 2015g).

Mapping 2019

Yellow toadflax was mapped in 2014 with 0.01 acres (Amec Foster Wheeler 2015) and was not found in the 2019 survey (Table 15). Therefore, this species is considered a *Watch List* species for BAFB which would shift to a Rapid Response species if found. It is possible that mowing interfered with the mapping of yellow toadflax in 2019 because Natural Resource Managers have reported seeing it west of East Tollgate Creek (personal communication Dustin Casady, USFWS) and some of these areas were mowed in 2019; however, field botanists checked the 2014 mapped areas very carefully and could only find what appeared to be a hybrid between yellow toadflax and Dalmatian toadflax. There is potential that the hybrid may have been mapped as yellow toadflax in 2014, as the identity was recently recognized in the literature and presented in the state noxious weed list.

Table 15. Yellow toadflax noxious weed survey results at BAFB 2004-2019.

	2004	2007	2014	2019
Occupied Acres	*Not Found*	*Not Found*	0.01	*Not Found*
Estimated Number of Shoots	---	---	---	---
Number of Mapped Features	---	---	---	---

Recommendations

Yellow toadflax was not found in the 2019 survey but has been noted in a small area in 2014. Therefore, management recommendations are to survey the previously mapped site for at least another four years for yellow toadflax and be prepared to take rapid response actions. For infestations less than one acre, hand pulling can be used for control. It is most effective on young plants in moist, sandy or loose soils. For older plants and those growing in compacted soils, the yellow toadflax can sprout in newly disturbed soil where the roots were not entirely removed. Multiple visits in the same growing season over many years may be necessary to remove and/or control yellow toadflax. Large open areas and disturbances nearby will offer new places for toadflax to grow. Limiting disturbances and planting native species in these areas helps to limit the spread of yellow toadflax (Sing et al. 2016).

Biocontrol

Biocontrol is an option for large infestations and has been documented at BAFB. The yellow toadflax stem mining weevil (*Mecinus janthinus*) has been documented at BAFB (Sovell 2011). Biocontrol organisms are available for use in Colorado through the Department of Agriculture's insectary (CDA-CSU 2015g). However, the cover may not be large enough to support them as a viable control method.

Scotch Thistle (*Onopordum acanthium*)

Management Urgency: Low - widespread

Management Goals: Manage small populations in areas with low disturbance

Photo: Mature Scotch thistle, Lisa Tasker (CNHP)

Top: Scotch thistle flower, wikimedia.org
Bottom: rosette beginning to bolt, Wikimedia Commons 2018

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

2019 Mapping

Scotch thistle was not noted in the vegetation survey of 2005 (CEMML 2006) or the weed survey of 2007 (GMI 2008). However, it was widespread throughout the BAFB by 2014 occupying 284 acres. In 2019, there were 459 mapped features in over 19 occupied acres and more than 97,000 shoots (Table 16 and Figure 15). Basewide weed mapping is no longer cost effective for this species. Management urgency is low since eradication and possibly control is unlikely due to the widespread nature and current level of infestation at BAFB.

Table 16. Scotch thistle noxious weed survey results at BAFB 2004 -2019.

	2004	2007	2014	2019
Occupied Acres	*Not Found*	?	284	>19
Estimated Number of Shoots	---	---	---	>97,200
Number of Mapped Features	---	---	---	459

Recommendations

Treatments should be localized with a plan in mind for what success will look like. Scotch thistle is a biennial which reproduces from seeds. Therefore, preventing seed production is an important goal. Treating small areas where there are no current soil disturbances that lead to bare soils could reduce seeds and cover.

Manual

Manual methods work for infestations <0.5 acres. Early spring removal of first year sprouts and cutting root stocks of older rosettes is most effective way to control seed production without causing soil and non-target native species disturbance. For bolted plants, severing the tap root below the root crown (4-6 inches below the soil surface) will effectively kill them. However, you must bag and remove from the site all flower and seed heads. In addition, chopping, mowing and deadheading will stimulate growth (CDA-CSU 2016c). Therefore, it is important to make sure the root is severed below the soil surface. Targeted manual digging when the plants are still in the rosette stage is ideal because no seeds are available to accidentally spread during removal efforts. Extreme care should be taken not to disturb surrounding soils as much as possible. Monitoring for new plants within the same growing season needs to occur for many years as the seeds remain viable for over 20 years. Same season follow-up is necessary because the seeds can sprout at different times in the growing season.

Chemical with IPM

Targeted spot spraying of plants in the rosette stage with a backpack sprayer in natural areas is recommended if herbicides are used with continued annual monitoring within the same season and for multiple years. Herbicides recommended for this species do not include natural areas (CDA-CSU 2016c). However, it takes about the same amount of effort to cut the plant below the root crown as it does to visit with a backpack sprayer. Follow-up monitoring needs to occur within the same season as sprouts can show up throughout the summer and missed rosettes can bolt and produce seeds. Timing of herbicide applications (not on bolted seed heads) and limiting overspray are also

key to a successful program. Overspray should always be avoided so as to limit impacts to desirable nearby plants that provide important competition. Any treatments that leave behind bare soils should be avoided or Scotch thistle and other weeds such as downy brome (cheatgrass) will move in. Planting native species in disturbed areas and protecting intact native vegetation can help contain and prevent the spread.

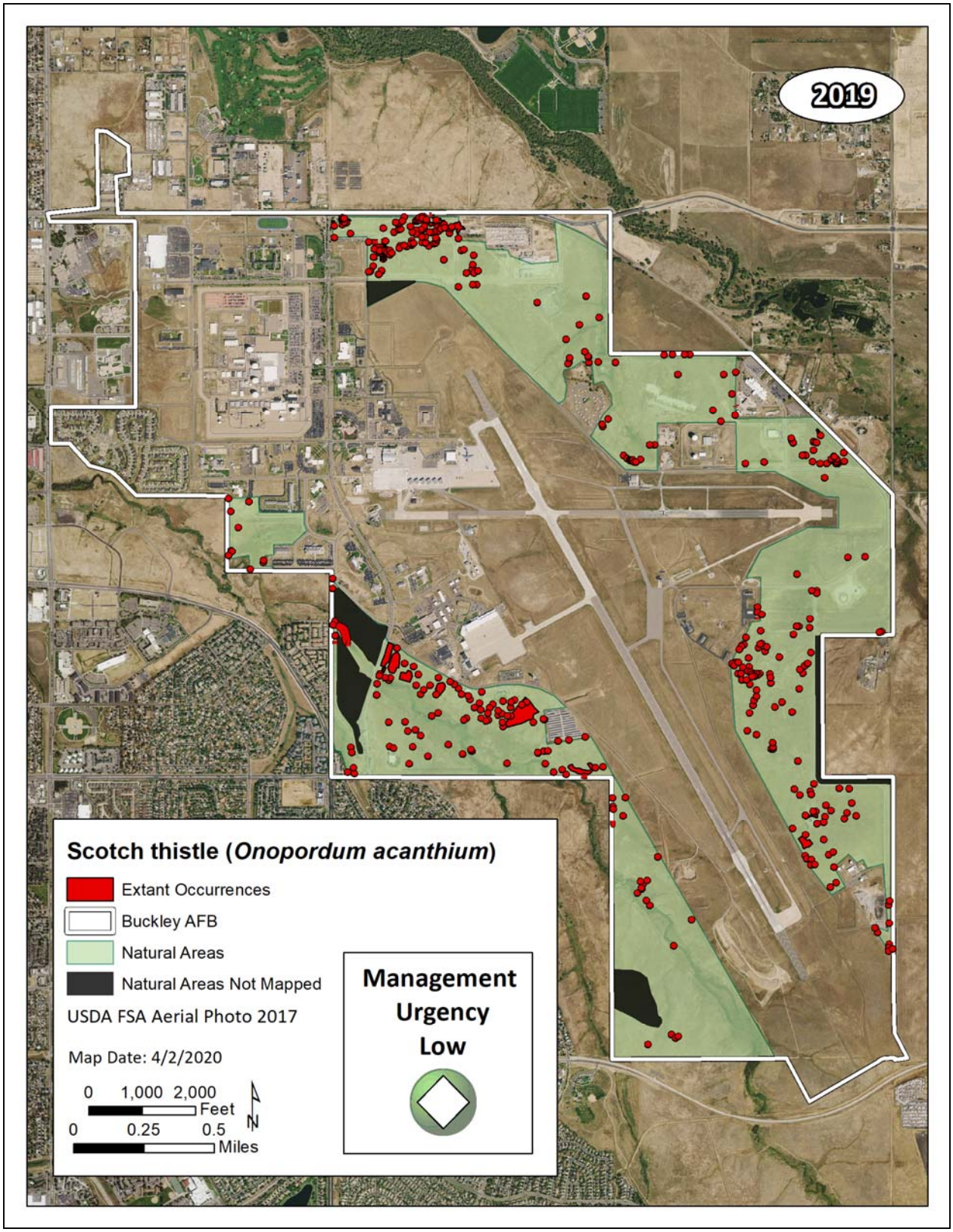


Figure 15. Distribution of Scotch thistle at Buckley Air Force Base in 2019.

Salt Cedar (*Tamarix ramosissima*)

Management Urgency: Very High – low cover

Management Goals: Rapid Response / Cut stump-herbicide / Revegetation

- Tall shrub or small tree
- Reproduction by roots, submerged stems and seeds
- Flowers April-September
- Sprouts if stumps are cut
- Seed longevity is short <1 year, ~45 days (CWMA 2018)
- Provides habitat for nesting birds (USDOI-USGS 2009)

Photos: Renee Rondeau (left), Calphotos.berkely.edu (right).

Salt cedar (tamarisk) appears to be increasing at BAFB. Due to the low cover and increase in the number of sites from three to 11 between 2007 and 2019, this species is assigned a very high management urgency rank because eradication is possible.

Salt cedar was first mapped in 2007 at BAFB with only three stems (GMI 2008) and in 2014 with a cover of 0.1 acres (Amec Foster Wheeler 2015). Salt cedar was not found in the 2004 survey (North Wind, Inc. 2005) or in the floristic survey conducted in 2005 (CEMML 2006).

2019 Mapping

In 2019, salt cedar was mapped at 11 locations at BAFB with 0.12 occupied acres and with an estimated 71 shoots (Table 17, Figure 16). The urgency rank is very high because salt cedar is increasing and still within a range that can potentially be eradicated with rapid response efforts.

Table 17. Salt cedar noxious weed survey results at BAFB 2004 -2019.

	2004	2007	2014	2019
Occupied Acres	*Not Found*	3 stems	0.1	0.12
Estimated Number of Shoots	---	---	---	71
Number of Mapped Features	---	---	---	11

Recommendations

Since the known population includes 11 sites, eradication is possible. A cut-stump method for treatment has been found to be effective in small occurrences. For this method to be effective, plants are cut as close to the ground as possible (within 5 cm). According to Colorado Natural Areas Best Management Practices (BMPs) for salt cedar, herbicide should be applied immediately (within seconds) to the cut since as the wound will heal quickly and decrease the amount of herbicide that will be translocated into the stump (CPW 2013). Herbicide should be applied around the perimeter of the cut stump or stems. The two herbicides recommended by Colorado State Parks for this method are Triclopyr and Imazapyr. The timing for these treatments will determine success. The plants need to be at the stage where they are translocating vascular fluids.

If bare soil or soil disturbance occurs, new plantings of native shrubs and forbs are recommended. Follow-up monitoring for sprouts within a year is recommended (CDA-CSU 2015g, CPW 2013). Salt cedar can spread both by seed and vegetatively. Therefore, continued monitoring at all known sites is recommended at least once a year and twice if plants are treated. The seed longevity is very short (< 1 year).

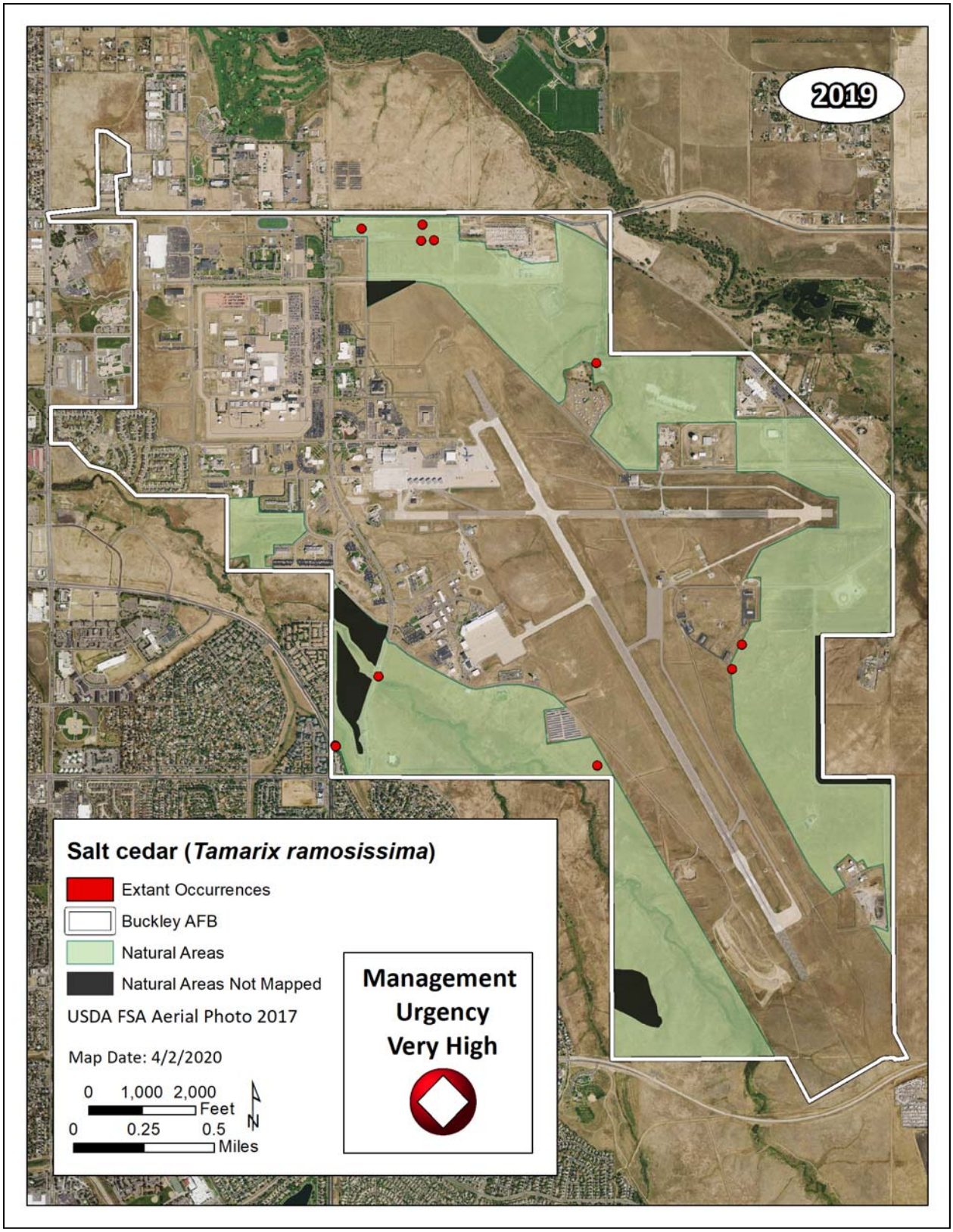


Figure 16. Distribution of salt cedar at Buckley Air Force Base in 2019.

Puncturevine (*Tribulus terrestris*)

Management Urgency: *Watch List* - not found in 2019

Management Goals: Monitor / Rapid Response

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

- Annual, prostrate herbaceous plant.
- Reproduction by seeds.
- Flowers June-September (Ackerfield 2018).
- Seed longevity is 4-5 years (CDA-CSU 2009)
- Found roadsides, waste places, old fields.

In 2014, over 26 occupied acres were mapped near Williams Lake in the northeast and in the central area west of E. Sunlight Way south of the solar arrays (Amec Foster Wheeler 2015). It was not found in the 2019 survey. Therefore, this species will be considered a Rapid Response species if it is found at BAFB.

2019 Mapping

Puncturevine is the only List C species that was monitored. Most List C species are considered too widespread to treat effectively and eradication is usually not possible or they are annuals or short-lived successional stage species that do not tend to persist in most instances. Puncturevine is an annual that reproduces solely by seeds with have a relatively short seed longevity of four to five years in the soil. This species was not detected in the 2019 survey (Table 18).

Table 18. Puncturevine noxious weed survey results at BAFB 2004 -2019.

	2004	2007	2014	2019
Occupied Acres	*Not Found*	*Not Found*	26.3	*Not Found*
Estimated Number of Shoots	---	---	---	---
Number of Mapped Features	---	---	---	---

Recommendations

Due to the previously mapped cover of 26.3 occupied acres (Amec Foster Wheeler 2015), monitoring these previously occupied areas should be done yearly for at least four more years. Since puncturevine reproduces only by seed, preventing seed production is the key to successful control. Rapid response actions should be taken immediately if puncturevine is found. Record the site location, date, number of plants and action(s) taken. Also, keep a look out for new occurrences near the previously mapped locations.

Mechanical

These plants are easily removed by hand-pulling. Removing all of the roots and bagging any flower parts and seeds is important (CDA-CSU 2009). Using a piece of carpet has been found to be useful to remove the very prickly seed heads. Follow-up treatments within the same season and for at least five years after no plants are found is required to deplete the seed bank. Replanting is recommended to keep puncturevine from returning.

Depending on the size of the infestations and where they are located both chemical and biological options are available (CDA-CSU 2009). A couple of biocontrol agents are available for use in Colorado from the CDA Insectary. This may be an option based on the specific site characteristics and the size of the infestation. Monitoring annually for at least five years will be important to determine success and if the organisms are remaining after they are introduced to the sites.

REFERENCES

Ackerfield. 2018. Flora of Colorado. Colorado State University Herbarium. BRIT Press. 2015 updated 2018. Fort Worth, Texas. 820 pp.

Amec Foster Wheeler. 2015. Invasive Plant Species Control Plan for Buckley Air Force Base. Amec Foster Wheeler Environment & Infrastructure, Inc., CO.

CCR. 2014. Code of Colorado Regulations. 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

CDA 2019. Colorado Department of Agriculture Noxious Weeds. Accessed via the internet at https://www.colorado.gov/pacific/agconservation/noxious-weed-species .

CDA 2015. Colorado Department of Agriculture. Hoary cress (*Lepidium draba*) Identification and Management, Updated July 2015. https://drive.google.com/file/d/17D0sBsNu22QVA1W4zkqPIhEd868DfEkA/view Accessed March 2020.

CDA-CSU 2016a. Colorado Department of Agriculture, Colorado State University, Musk thistle (*Carduus nutans* L.) Identification and Management Rev 11/16. https://drive.google.com/file/d/1BxKYg66YNE3mfhGla0uB2k4ugVtH0ePd/view Accessed March 2020.

CDA-CSU 2016b. Colorado Department of Agriculture – Colorado State University. Common Teasel (*Dipsacus fullonum* L.) Identification and Management. https://drive.google.com/file/d/1z6ZJBmGlTO0tkeGGp4Tk1x3U6pV64OQ3/view . Rev. 11/16. Accessed March 2020.

CDA-CSU 2016c. Colorado Department of Agriculture, Colorado State University Scotch thistle (*Onopordum acanthium, O. tauricum*) Identification and Management. Rev 11/16. https://drive.google.com/file/d/1WmVjBrUvXVbPQARemLNAR5iSbeN_vnAu/view Accessed March 2020.

CDA-CSU 2015a. Colorado Department of Agriculture – Colorado State University, Russian Knapweed (*Acroptilon repens*) Identification and Management, https://www.colorado.gov/pacific/agconservation/russian-knapweed . Updated July 2015. Accessed March 2020.

CDA-CSU 2015b. Colorado Department of Agriculture – Colorado State University, Diffuse Knapweed (*Centaurea diffusa*) Identification and Management, https://drive.google.com/file/d/1ryGRysI-vtgWGLVaX5Nx58-qao7FJ8QT/view . Updated July 2015. Accessed March 2020.

CDA-CSU 2015c. Colorado Department of Agriculture – Colorado State University, Canada Thistle (*Cirsium arvense*) Identification and Management. https://drive.google.com/file/d/1VD0akK6512uYeraw77xI7XVKujmUh81u/view. Updated July 2015. Accessed March 2020.

CDA-CSU 2015d. Colorado Department of Agriculture – Colorado State University Russian Olive (*Elaeagnus angustifolia*) Identification and Management. https://drive.google.com/file/d/18pDzVp6Gwl42CQmQZdyQh4PvMqkatahk/view Accessed April 2020.

CDA-CSU 2015e. Colorado Department of Agriculture – Colorado State University Leafy spurge (*Euphorbia esula*) Identification and Management. https://drive.google.com/file/d/1Jf7qjicuILhElTIYCHgXLTrCRQY4fWiS/view. Accessed March 2020.

CDA-CSU 2015f. Colorado Department of Agriculture – Colorado State University. Dalmatian toadflax (*Linaria dalmatica*) Identification and Management. https://drive.google.com/file/d/1UixrD402kCTgmZq5TmHGQ_5oJd8-fgTR/view Updated July 2015. Accessed March 2020.

CDA-CSU 2015g. Colorado Department of Agriculture – Colorado State University. Yellow toadflax (*Linaria vularis*) Identification and Management. https://drive.google.com/file/d/1jG5JhpaA_Xxlqdmx_Jz8zE8tWFzHE6Yk/view Updated July 2015. Accessed March 2020.

CDA-CSU 2015h. Colorado Department of Agriculture – Colorado State University. Salt cedar (*Tamarix* spp.) Identification and Management. https://drive.google.com/file/d/1qMxP9ogp7Z_Q_bnCSlF6wyKdkIELKOCO/view Updated July 2015. Accessed March 2020.

CDA-CSU 2009. Colorado Department of Agriculture – Colorado State University. Puncturevine (*Tribulus terrestris*) Identification and Management Updated August 2009. https://drive.google.com/file/d/1ueJT_KBYuqTQ2wrC6I77QEhbDU2CQpJW/view

CEMML 2006. Floristic Survey of Buckley Air Force Base Conservation Area B and Toll Gate Creek, Arapahoe County, CO. The Center for Environmental Management of Military Lands. Colorado State University, Fort Collins, CO March 2006.

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.

Colorado Parks and Wildlife (CPW). 2015. Colorado's 2015 State Wildlife Action Plan. http://cpw.state.co.us/aboutus/Pages/StateWildlifeActionPlan.aspx Accessed March 2020.

CPW 2015a. Species Profiles State Endangered, Threatened and Special Concern. cpw.state.co.us/learn/Pages/SpeciesProfiles.aspx. Accessed March 26, 2020.

CPW 2015b. Colorado Parks and Wildlife (CPW). State Wildlife Action Plan: A Strategy for Conserving Wildlife in Colorado. Denver, Colorado. https://cpw.state.co.us/Documents/LandWater/WetlandsProgram/PrioritySpecies/County-Occurrences-Table.pdf https://cpw.state.co.us/aboutus/Pages/StateWildlifeActionPlan.aspx

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

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.

CWMA 2020. Colorado Weed Management Association Website: Russian knapweed (*Acroptilon repens*) https://cwma.org/weed-information/weed-list/russian-knapweed/ Accessed March 2020.

CWMA. 2018. Colorado Weed Management Association. Salt Cedar https://cwma.org/weed-information/weed-list/salt-cedar/ Accessed March 2020.

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

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

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

Fayette, K., R. Schorr, D. Anderson and E. Mohr. 2000. Natural Heritage Inventory at Buckley Air National Guard Base, Arapahoe County, Colorado. Colorado Natural Heritage Program, Colorado State University.

GMI 2008. Final Invasive Species Control Plan Buckley Air Force Base, CO. Prepared for: Department of the Air Force Headquarters Air Force Center for Engineering and the Environment, 3300 Sidney Brooks, Brooks City-Base, Colorado 78235. For contract: FA8903-08-D-8792 Task order: 0005. Prepared by: Geo-Marine, Inc. 2201 Ave K, Suite A2, Plano, Texas 75074. May 2009.

Jefferson County. 2019 Diffuse Knapweed Fact Sheet. Jefferson County, CO. https://www.jeffco.us/2466/Diffuse-Knapweed

King County. 2018. King County Government, Washington 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

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

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, Inc. 2005. Invasive Species Control Plan Buckley Air Force Base, Colorado. Prepared for: Air Force Space Command (HQ AFSPC/CEVP) 150 Vandenberg Street, Peterson Air Force Base, Colorado 80914. Prepared under contract: FA8903-04-D-8695 by: North Wind, Inc. P.O. Box 51174, Idaho Falls, Idaho 83405. NWI-ID-2005-030, May 2005.

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.

Pearson, D.E., Y.K. Ortega, J.B. Runyon and J.L. Butler. 2016. Secondary Invasion: The bane of weed management. Biological Conservation 197 (2016) 88-17.

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.

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.

Schorr. 2013. Raptor and Songbird Surveys at Buckley Air Force Base Aurora, Colorado Distribution of Winter Raptors and Abundance of Songbirds. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Shelton, A. A Guide to Natural Enemies in North America. Cornell University Website: https://biocontrol.entomology.cornell.edu/weedfeed/UrophoraQuadrifasciata.php. Accessed March 2020.

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. 2016.

Biology and Biological Control of Dalmatian and Yellow Toadflax. USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, West Virginia. FHTET-2016-01.

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.

Sovell, J., B. Kondratieff and B. Kuhn. 2016. Baseline Arthropods (Hexapoda) Survey on Buckley Air Force Base, Colorado. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Sovell, J. 2011. Amphibian and Reptile Survey Report and Management Plan for Buckley Air Force Base, Colorado. Prepared for U. S. Department of Defense, Buckley Air Force Base, CO 80011-9564.

TNC (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

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

Turner, M.F.S. 2012. Viability and Invasive Potential of Hybrids between Yellow Toadflax (*Linaria vulgaris*) and Dalmatian Toadflax (*Linaria dalmatica*). Doctoral Thesis Colorado State University, Fort Collins, CO 80523.

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

USDOI–USGS 2009. Saltcedar and Russian Olive Interactions with Wildlife by Heather L. Bateman and Eben H. Paxton Chapter 4 of Saltcedar and Russian Olive Control and Demonstration Act Science Assessment Edited by Patrick B. Shafroth, Curtis A. Brown, and David M. Merritt Scientific Investigations Report 2009–5247 U.S. Department of the Interior U.S. Geological Survey https://mtaudubon.org/wp-content/uploads/2017/09/BatemanandPaxton2010chapterSaltCedarROlive-Interactions-with-Wildlife.pdf Accessed March 2020.

USFS-USDA 2014a. Department of Agriculture Forest Service. Field Guide for Managing Canada Thistle in the Southwest. September 2014. TP-R3-16-14.

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 Whitetop in the Southwest. Southwest Region. September 2014.

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

Zimmerman, C., M. Jordan, G. Sargis, H. Smith, and K. Schwager. 2011. An Invasive Plant Management Decision Analysis Tool. Verison1.1. The Nature Conservancy. Arlington, VA.

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. 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 Mesa 2 rugged tablet with a Windows 10 operating system and a built-in GPS receiver module. The Mesa 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. 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. 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. When buffer distances were not collected, a minimum buffer of 1 meter was applied. Since weeds are mobile from year to year, and the GPS has inherent inaccuracies, in general weeds of the same species within 5 meters of each other were mapped as one feature.

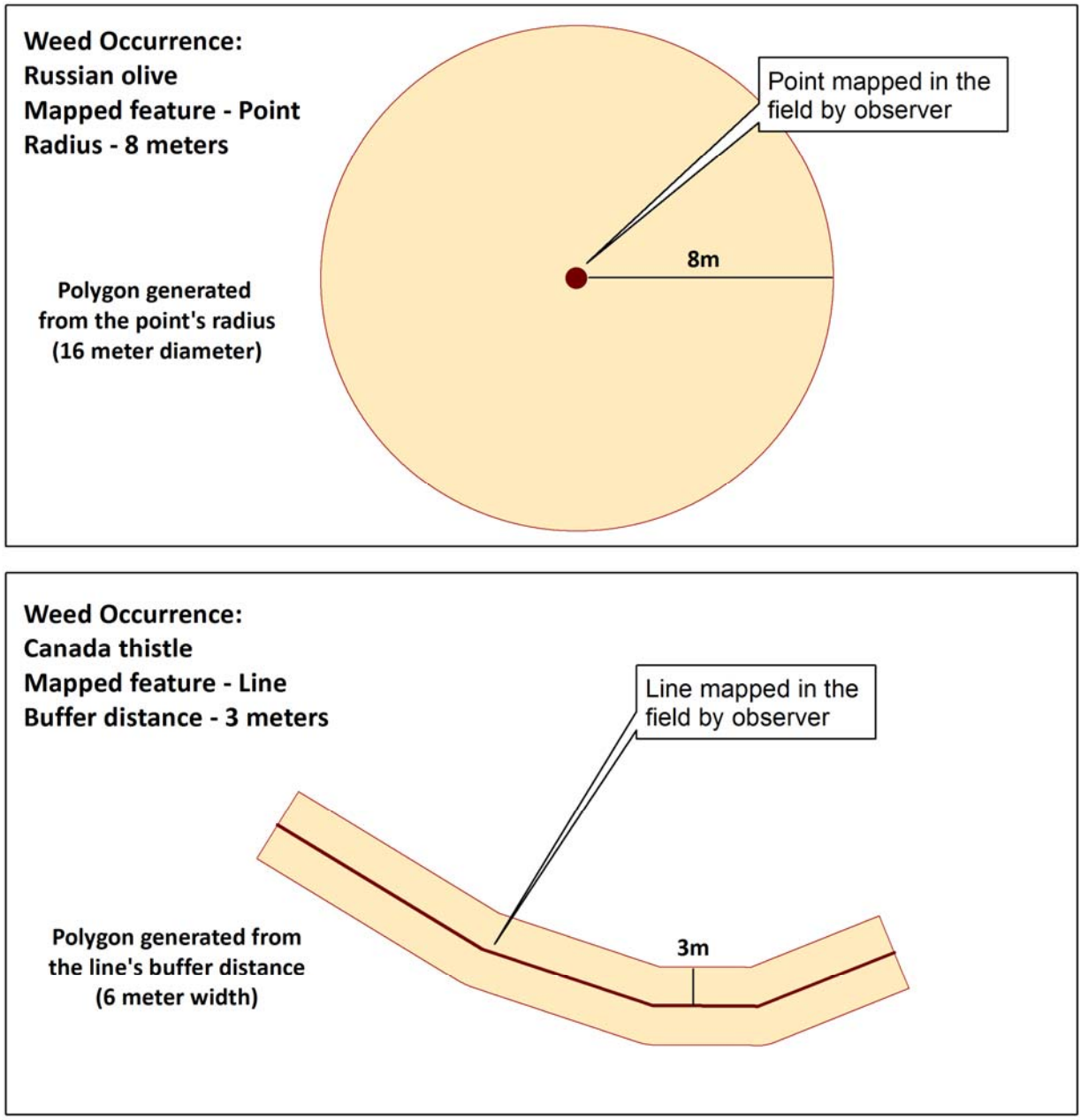
Mapping widespread noxious weeds at Buckley AFB was very difficult due to the large cover and number of noxious weed species. BAFB has such high weed cover that not only is treating them all an unlikely task, but creating a meaningful map for resource managers was also a challenge. Musk thistle is an example of a noxious weed species that is almost ubiquitous at BAFB and it was dropped from the target list after partial mapping revealed the densities were too great to yield a helpful map. In the southwest section, densities for Dalmatian toadflax were captured in points and polygons and were extrapolated in the office. In dense riparian areas where weed species co-occurred, some occurrences were drawn onto hard copy maps with aerial imagery and digitized in the office. Several areas were not mapped due to recent mowing that prohibited proper species identification. These mowed areas are shown on the species distribution maps along with one section in the south that was not mapped due to time constraints.

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 2017 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.

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 C. ELEMENTS OF CONSERVATION CONCERN

Elements of conservation concern include plants, plant communities and animals that have been recognized by the state and/or the federal government that need to be protected due to their significant contribution to our country or state's natural resources. The documentation of these species or the potential for them to inhabit BAFB is an important aspect to understand before weed treatments are undertaken as many treatments, especially in wetlands or those that remove vegetation cover, can negatively impact these elements. These species and communities (Table 19) must be considered when preparing site plans and conducting weed management activities at the base.

There are no known federally listed or threatened species known to occur at Buckley AFB. However, there are four animal elements of conservation concern for the State of Colorado documented at BAFB, and one of them is considered State Threatened, the Burrowing Owl (*Athene cunicularia*). The Bald Eagle (*Haliaeetus leucocephalus*), Ferruginous Hawk (*Buteo regalis*) and the Black-tailed Prairie Dog (*Cynomys ludovicianus*) are also considered to be Colorado Species of Conservation Concern found at BAFB (Schorr 2013).

Since the last survey was conducted for birds and mammals, the Colorado State Wildlife Action Plan (SWAP) was updated (CPW 2015b). Based on the information for Arapahoe County there are a number of species that are now recognized as Species of Greatest Conservation Need, Tier 1 and Tier 2. Tier 1 species are considered to have the highest priority and these are also included in Table 19 with their likelihood of being found at BAFB.

The Burrowing Owl is the only state threatened species known from BAFB and is documented from the southwestern section of BAFB (Schorr 2013). Nesting Burrowing Owls have been documented on Buckley AFB (Schorr 2013).

The Bald Eagle and Ferruginous Hawk are both Colorado State Species of Concern (Table 19) that have been documented at BAFB (Schorr 2013). In 2007, the Bald Eagle was removed from the list of federally threatened species. The Bald Eagle is considered uncommon or locally-common winter resident in Colorado's western valleys, mountain parks, and eastern plains. Habitat for the Bald Eagle is usually near reservoirs and rivers, and in the winter it may be found hunting over prairie dog towns. Bald Eagles have been documented on Buckley AFB, but do not breed here (Schorr 2013). The black-tailed Prairie Dog is also a Colorado State Species of Concern as well as SWAP Tier 2, USFS and BLM Sensitive and CNHP G4S3 fully tracked species that has been documented at BAFB (Table 19).

Since Buckley AFB is within the Central Flyway migratory path for many birds, there is the potential to have up to 300 species that visit the base throughout the year. Many of these species have regulatory protection because of conservation concern, while others are significant management issues because of their potential for Bird Aircraft Strike Hazard (BASH) risk (Schorr 2013).

The undeveloped grasslands present at BAFB still perform critical functions such as offering habitat for wildlife. Past assessments of the critical biological resources have identified animal species of concern at BAFB (Schorr 2013, Sovell 2011). Habitats or plant communities at BAFB of conservation concern include Shortgrass Prairie and Eastern Plains Streams (CPW 2015b).

Table 19. List of Colorado Threatened, Species of Concern/Priority Wetland Species, USFS Sensitive, BLM Sensitive species that exist or could potentially be found at BAFB in 2019.

Common Name	Scientific Name	Status	Documented at BAFB	Documented in Arapahoe County
BIRDS				
Bald Eagle	*Haliaeetus leucocephalus*	**State Special Concern** Priority Species CO Wetlands	Schorr 2013	CPW 2015a
Burrowing Owl	*Athene cunicularia*	**State Threatened**	Schorr 2013	CPW 2015a
American bittern	*Botaurus lentiginosus*	Priority Species CO Wetlands, **SWAP Tier 2**	Possible	CPW 2015b
Dabbling Ducks		Priority Species CO Wetlands	Possible	CPW 2015b
Ferruginous Hawk	*Buteo regalis*	**State Special Concern, BLM, USFS**	Schorr 2013	CPW 2015a
Least Tern	*Sternula albifrons*	**State Endangered**, Priority Species CO Wetlands, **SWAP Tier 2**	Unlikely	CPW 2015a
Lewis's Woodpecker	*Melanerpes lewis*	Priority Species CO Wetlands, **SWAP Tier 2**	Possible	CPW 2015b
Long-billed Curlew	*Numenius americanus*	Priority Species CO Wetlands, **SWAP Tier 2**	Possible	CPW 2015b

Common Name	Scientific Name	Status	Documented at BAFB	Documented in Arapahoe County
Sandhill Crane	*Grus americana*	Priority Species CO Wetlands	Possible	CPW 2015b
Short-eared Owl	*Asio flammeus*	Priority Species CO Wetlands, **SWAP Tier 2**	Possible	CPW 2015b
MAMMALS				
Black-tailed Prairie Dog	*Cynomys ludovicianus*	**State Special Concern, BLM, SWAP Tier 2, USFS, CNHP G4S3**	CEMML 2006, Fayette et al. 2000	CPW 2015a
Preble's Meadow Jumping Mouse	*Zapus hudsonius preblei*	**Federally Threatened, State Special Concern, SWAP Tier 1,** Priority Species CO Wetlands, **CNHP G5T2/S1**	Not Found (Schorr 2013)	CPW 2015a
AMPHIBIANS				
Northern Leopard Frog	*Rana pipiens*	**State Special Concern,** Priority Species CO Wetlands **BLM, SWAP Tier 1, USFS, CNHP G5S3**	Possible	CPW 2015a
REPTILES				
Common Garter Snake	*Thamnophis sirtalis*	**State Special Concern, SWAP Tier 2, CNHP G5/S3 WL**	Possible	CPW 2015a
Lined Snake	*Tropidoclonion lineatum*	**CNHP G5/S3 WL**	Sovell 2011	

Common Name	Scientific Name	Status	Documented at BAFB	Documented in Arapahoe County
Northern Manylined Skink	*Plestiodon multivirgatus multivergatus*	**CNHP G5T5/S4 full**	Sovell 2011	
Red-sided Garter Snake	*Thamnophis sertalis parietalis*	Priority Species CO Wetlands, **SWAP Tier 2**	Possible - Unlikely	CPW 2015b
Western Painted Turtle	*Chrysemys picta bellii*	**CNHP G5\S5 Partial Track**	Sovell 2011	
FISH				
Orange Spotted Sunfish	*Lepomis humilus*	Priority Species CO Wetlands, **SWAP Tier 1**	Possible	CPW 2015b
Plains Topminnow	*Fundulus sciadicus*	Priority Species CO Wetlands, **SWAP Tier 1**	Possible	CPW 2015b
INVERTEBRATES				
Monarch Butterfly	*Danaus plexippus*	USFS Sensitive G4/G5	Sovell et al. 2016	
Paiute Dancer Damselfly	*Argia alberta*	G4/S1S2	Sovell et al. 2016	
HABITATS (Plant Communities)				
Shortgrass Prairie		Colorado Habitat of Concern	CEMML 2006, Schorr 2013	CPW 2015b
Eastern Plains Streams		Colorado Habitat of Concern	CEMML 2006, Schorr 2013	CPW 2015b