Noxious Weed Monitoring Year 15 at the U.S. Air Force Academy

May 2020

COLORADO NATURAL HERITAGE PROGRAM

Noxious Weed Monitoring Year 15 at the U.S. Air Force Academy

Pam Smith and Amy Greenwell

Colorado Natural Heritage Program
Warner College of Natural Resources

Colorado State University
Fort Collins, Colorado 80523

May 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:
U.S. Air Force Academy Department of Natural Resources
8120 Edgerton Drive, Suite 40
USAF Academy, CO 80840-2400

Citation:
Smith, P. and A. Greenwell. 2020. Noxious Weed Monitoring Year 15 at the U.S. Air Force Academy. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Front Cover: Wayfaringtree (*Viburnum lantana*) garden escape, Jack's Valley view west; common St. Johnswort with biocontrol beetle; West Monument Creek view to the west.

EXECUTIVE SUMMARY

This report summarizes the results of the past fifteen years of population monitoring of noxious weeds at the U.S. Air Force Academy ("the Academy") and at Farish Recreation Area ("Farish"). Basewide monitoring has been conducted at the Academy at five year intervals: 2002, 2007, 2012 and 2018. (2002, 2007, 2012 and 2017 at Farish). In between years, areal mapping at known sites was conducted at the Academy for species with low cover and permanent plots were monitored for widespread species. In 2019, areal mapping was conducted and permanent plot monitoring was not conducted to begin a new monitoring and treatment focus. A new species of a List B noxious weed was observed at the Academy, oxeye daisy (*Leucanthemum vulgare*).

Fifteen noxious weeds species were prioritized for manual treatments by CNHP for 2019. This is the first year manual treatments have been part of the plan. The results of the basewide survey in 2018 showed increases in weeds despite treatments and a new strategy was developed to reduce 15 species that have a reasonable chance to be eradicated or reduced significantly in cover. One of the strategies to make treatments more successful was to conduct multiple visits to sites with extant occurrences throughout the same growing season. In 2019, it was found that a site visited in early spring often produced sprouts later in the season. The majority of treated sites (with herbicides or manual) had sprouting individuals later in the season. In past years, these sprouts would not have been treated and would have gone on to flower and produce seeds. Thus, removing the sprouts later in the season is expected to yield notable reductions for 2020.

Summary of Findings

As part of the manual treatments in 2019, there were a total of 621 site visits to manually treat plants including follow-up visits and a total of 17,356 shoots were removed in 2019. Species that were prevented from going to seed in 2019 included perennial pepperweed, Russian knapweed, myrtle spurge, orange hawkweed, oxeye daisy and bouncingbet.

In 2019, eight of the 15 targeted species are showing increasing trends. One site is located at Farish and seven at the Academy (orange and red arrows). Four species are showing decreasing trends (green arrows) and two are stable (yellow diamond) and one the status is not clear due to developments and construction activities (question mark) (Table 1).

Garlic mustard is increasing rapidly and is a priority for treatments and is problematic for control due to rapid reproduction and location in willow thickets. Orange hawkweed is currently very small and only located at one site but it has developed an extensive root system that may cause difficulties with control. Myrtle spurge. Russian knapweed and oxeye daisy have a high likelihood to be locally eradicated. Houndstongue, Scotch thistle and scentless chamomile are reaching numbers where eradication is unlikely across the Academy but local areas can be controlled. Tamarisk and perennial pepperweed are stable and have a high likelihood of being eradicated at the Academy. The four species that are decreasing in 2019 include Dalmatian toadflax, yellow spring bedstraw, bouncing bet and Common St. Johnswort. No plants were found for Dalmatian toadflax or yellow

spring bedstraw in 2019. However, these plants seem to reoccur at the same sites every few years. Both bouncingbet and common St. Johnswort are decreasing overall but have a low probability for eradication. Both species are being impacted by biocontrol agents (browsing and introduced agents) as well as removal by flooding.

Table 1. Summary of findings for noxious weed species monitored at the Air Force

Overall Trend	Scientific Name	Common Name	#CNHP Site Visits	# Shoots treated
	*Acroptilon repens*	Russian knapweed	14	116
	*Alliaria petiolata*	Garlic mustard	11	5,997
	*Cynoglossum officinale*	Houndstongue	107	1,566
	*Euphorbia myrsinites*	Myrtle spurge	93	432
	*Gallium verum*	Yellow spring bedstraw	1	0
?	*Hesperis matronalis*	Dame's rocket	2	0
	*Hieracium aurantiacum*	Orange hawkweed	2	1,257
	*Hypericum perforatum*	Common St. Johnswort	151	3,482
	*Lepidium latifolium*	Perennial pepperweed	8	6
	*Leucanthemum vulgare*	Oxeye daisy	5	52
	*Linaria dalmatica*	Dalmatian toadflax	8	0
	*Onopordum acanthium*	Scotch thistle	174	1,504
	*Saponaria officinalis*	Bouncingbet	33	3,133
	*Tamarix ramosissima*	Salt cedar	8	0
	*Tripleurospermum perforatum*	Scentless chamomile	4	23
	TOTALS		**621**	**17,356**

Summary of Recommendations

- Continue to focus on the 15 target species by conducting areal surveys and manual treatments where appropriate.
- Continue to coordinate treatment activities with resource management staff, herbicide contractor and CNHP to target areas of concern (rapid response). Provide the applicator with maps of rare species and wetland areas to help avoid impacts to rare plant and animal species during the 2020 season.
- Discontinue herbicide treatments on bouncingbet in 2020 at the Academy and monitor all populations to determine if natural declines are continuing to reduce populations.
- Continue to avoid weed treatments in monitoring plots at the Academy and Farish without consulting CNHP.
- List A, B or watch list or noxious weed species of management concern in need of rapid response actions include:
    - Bouncingbet (List B)
    - Common St. Johnswort (List C)
    - Dalmatian toadflax (List B)
    - Dame's rocket (List B)
    - Garlic mustard (State Watch List)
    - Houndstongue (List B)
    - Myrtle spurge (List A)
    - Orange hawkweed (List A)
    - Oxeye daisy (List B)
    - Perennial pepperweed (List B)
    - Russian knapweed (List B)
    - Salt cedar (List B)
    - Scentless chamomile (List B)
    - Scotch thistle (List B)
    - Yellow spring bedstraw (not listed, garden escape)

  Watch list for noxious weeds with potential to be found at the Academy and Farish include:

    - Purple loosestrife – potentially present at the Academy (List A)
    - Hairy willowherb – not found (List A - known from nearby county)
    - Mediterranean sage- not found (List A - known from nearby county)

Acknowledgements

The help and generosity of many experts is gratefully acknowledged. Brian Mihlbachler (USFWS), our primary contact at the Academy, played a critical role in this project. His assistance with project logistics and site conditions was extremely valuable, as was his time orienting CNHP personnel in 2019.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF MAPS

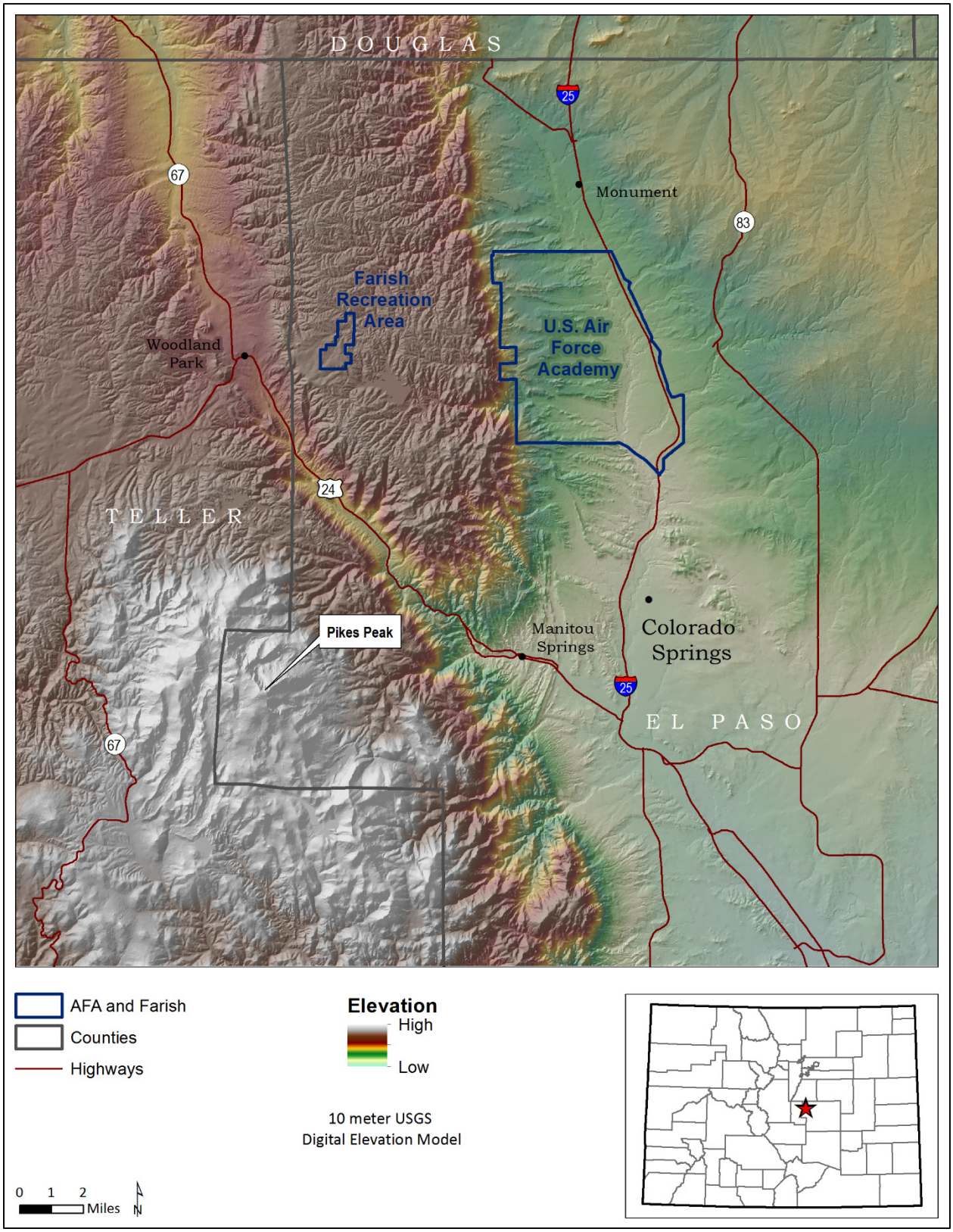
INTRODUCTION

Many local governments now require public and private landowners to manage noxious weeds. The U.S. Air Force Academy (referred to herein as "the Academy") follows state (Department of Agriculture) and County (El Paso County) weed control regulations for noxious weeds (Code of Colorado Regulations 2014). The Academy is located near Colorado Springs, Colorado (Map 1).

The Academy has also established management objectives for weed control in order to remain consistent with local weed regulations (Carpenter et. al 2004, Smith et al. 2015). The management objectives are defined as specific, desired results of integrated management efforts and include the following definitions:

- **Eradication**: Reducing the reproductive success of a noxious weed species in a largely uninfested region to zero and permanently eliminating the species or population within a specified period of time (until the existing seed bank is exhausted).
- **Containment:** Maintaining an intensively managed buffer zone that separates infested regions, where suppression activities prevail, from largely uninfested regions, where eradication activities prevail.
- **Suppression**: Reducing the vigor of noxious weed populations within an infested region, decreasing the propensity of noxious weed species to spread to surrounding lands, and mitigating the negative effects of noxious weed populations on infested lands.

Guidelines for controlling noxious weeds (including herbicide label instructions) are often based on agricultural landscapes instead of natural areas. There is a large distinction between these two land uses, especially for weed management, which was addressed in the 2015 update to the Noxious Weed Management Plan (Smith et al. 2015). Natural areas can be defined as non-crop areas that support native vegetation, and where management includes the protection of these areas as well as the generation of ecosystem services (Pearson & Ortega 2009). To successfully manage weeds in natural areas with high biodiversity is much more complex than in an agricultural area. Successful weed management in natural areas must also consider the management of the entire community and not just removal of individual weeds. A significant portion of the landscape at the Academy and Farish falls into the "natural areas" category and includes important wetland features. The Academy and Farish are important for local and global biodiversity conservation (Siemers et al. 2012). At least 31 plants, animals, and plant communities of conservation concern have been documented at the Academy. For example, Porter's feathergrass (*Ptilagrostis porteri*), a globally imperiled endemic of Colorado, and Southern Rocky Mountain cinquefoil (*Potentilla ambigens*), found only in Colorado and New Mexico (Siemers et al. 2012), have been documented on-site. In addition, the Academy is critically important for the conservation of the listed Threatened Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (Siemers et al. 2012, Schorr et al. 2019).



Map 1. Vicinity map for the U.S. Air Force Academy and Farish Recreation Area.

Timeline of Weed Mapping and Monitoring at the Academy

The Colorado Natural Heritage Program first mapped noxious weeds at the Academy and Farish in 2002 and has monitored noxious weeds at the Academy for the past 15 years. Below is a summary of weed mapping and monitoring by year since the surveys began in 2002. Refer to Appendix A for monitoring and mapping activities by species.

- **2002:** Approximately 3,900 weed locations were mapped at the Academy and Farish, with 14 species on the target list (Anderson et al. 2003).
- **2003:** Hoary cress (*Cardaria draba*) and Russian olive (*Elaeagnus angustifolia*) were remapped in 2003. In 2002, severe drought conditions suppressed the distribution of these two species. In 2003, populations increased due to ample spring moisture which necessitated a second year of mapping.
- **2004:** Based on data from the weed mapping conducted in 2002-2003, an integrated noxious weed management plan was developed (Carpenter et al. 2004) which supports the *Integrated Natural Resources Management Plan* for the Academy. The first report of Russian knapweed (*Acroptilon repens*) was submitted.
- **2005:** A monitoring program was established for 13 species of noxious weeds using a combination of permanent monitoring plots and areal mapping. Natural Resource staff at the Academy reported occurrences of myrtle spurge (*Euphorbia myrsinites*), a List A noxious weed. It was also noted that diffuse and spotted knapweeds were hybridizing at the Academy.
- **2006:** Permanent monitoring plots established in 2005 were re-sampled. All infestations of spotted knapweed and Russian knapweed were revisited and mapped. Myrtle spurge was added to the target weed list for mapping and assessment.
- **2007:** The second basewide noxious weed survey of the Academy and Farish was completed, with a total of 17 mapped species at approximately 5,500 locations (Anderson and Lavender 2008a).
- **2008:** Based on previous year's data, protocols were adjusted for the 2008 surveys. Tatarian honeysuckle (*Lonicera tatarica*) was discovered at the Academy.
- **2009:** A total of 14 species were targeted for monitoring. Two additional species were mapped: houndstongue (*Cynoglossum officinale*) and Dalmatian toadflax (*Linaria dalmatica*). Yellow toadflax was removed from monitoring due to its abundance. A habitat suitability model for spotted knapweed was produced.
- **2010:** Yellow spring bedstraw (*Gallium verum*) was discovered at the Academy and mapped. Diffuse knapweed (*Centaurea diffusa*) was not monitored.
- **2011:** Updated monitoring protocols were employed. The annual mapping of Tatarian honeysuckle began. Diffuse knapweed and hoary cress (*Cardaria draba*) were not monitored.
- **2012:** Collaboration with United States Fish & Wildlife Service (USFWS) and Texas A&M AgriLife Research Biocontrol Program resulted in the following modifications: 1) CNHP and Texas A&M began using the same monitoring program for the plot surveys; 2) CNHP took over the monitoring and management responsibilities for leafy spurge (*Euphorbia esula*)

and common St. Johnswort (*Hypericum perforatum*); 3) biocontrol plots (Texas A&M) for Canada thistle (*Cirsium arvense*) and diffuse knapweed (*Centaurea diffusa*) were compared to non-biocontrol plots (CNHP); 4) permanent plots were established for hoary cress (*Cardaria draba*) and leafy spurge (*Euphorbia esula*); and 5) the third basewide weed survey for the Academy and Farish was completed, mapping 22 weed species and an estimated 39% increase in area occupied (Lavender-Greenwell and Rondeau 2013).

- **2013:** Monitoring was the same as in 2012, except that Farish was not visited, and Canada thistle and Dame's rocket were not monitored. Diffuse knapweed and spotted knapweed hybridization was widespread. The two knapweed species (*Centaurea stoebe, C. diffusa*) and the hybrid knapweed were lumped together for plot results.
- **2014:** Monitoring was the same as in 2013, except that hoary cress (*Cardaria draba*) plots were not visited and Canada thistle plots were visited. Dame's rocket was mapped too late in the season to report trends. Hoary cress and Dame's rocket were prioritized for 2015.
- **2015:** Monitoring was the same as in 2014, except that hoary cress (*Cardaria draba*) plots were monitored and three new plots were established. In addition, five biocontrol plots were re-visited (and re-established) for knapweeds and a new Canada thistle plot was established. One Canada thistle monitoring plot was not visited because it was under water for most of the summer. One diffuse knapweed plot was removed from monitoring because it has been incorporated into a golf course. Five plots had rare plant or animal species located within them. A large population of a globally vulnerable, state imperiled species, the Rocky Mountain cinquefoil (*Potentilla ambigens*) was destroyed by recent flooding.
- **2016:** Monitoring at all permanent monitoring plots at the Academy (41) and Farish (30 plots) with a minimum of 10 plots for each species for 2016. Census monitoring was conducted at 412 out of 464 known sites. A List B noxious weed was collected in Kettle Creek (scentless chamomile – *Tripleurospermum perforatum*) that was new for the Academy and a new record for El Paso County. A specimen was deposited at the Colorado State University Herbarium (CSU).
- **2017:** Monitoring at 42 plots (all plots except hoary cress), all stable to decreasing trends; 236 out of a total of 468 areal weed sites visited (49%) had weeds present in 2017. Scentless chamomile was found in Kettle Creek for a second year. Fourth comprehensive weed map for Farish with a total of four mapped species at approximately 477 extant locations.
- **2018:** The fourth basewide noxious weed survey of the Academy was completed, with a total of 25 mapped species at over 9,300 extant locations at the Academy. Forty-five permanent plots were monitored for five species: Canada thistle (8 plots), hoary cress (10 plots), leafy spurge (10 plots), knapweeds (7 plots) and musk thistle (10 photo plots). Three detailed site plans were written for weed treatments in areas with plants and animals of conservation concern. A new List A noxious weed species, orange hawkweed (*Hieracium aurantiacum*), was discovered in 2018 at Farish.
- **2019:** Fifteen noxious weeds species were prioritized for manual treatments by CNHP for the first time. The strategy to include multiple visits within the same growing season to treat sprouts is expected to yield reductions for 2020. A new list B species, oxeye daisy (*Leucanthemum vulgare*), was added to the noxious weed list at the Academy.

METHODS

The objective of this project is to identify trends and evaluate the effectiveness of ongoing management of noxious weeds at the Academy. Since 2002, three types of monitoring have been utilized to measure the changes in noxious weed cover, density and distribution at the Academy and Farish.

- **Basewide weed mapping** includes visiting all known occurrences and surveying for new occurrences and new noxious weed species. This is the most intensive survey and it is conducted once every five years (a complete census of targeted species).
- **Annual mapping** occurs in between the basewide mapping years and is conducted by re-visiting the known occurrences of rapid response species or those with limited distributions.
- **Permanent plot monitoring** is used to determine trends for the most widespread species. At the Academy, five species have been targeted for permanent plots: Canada thistle, leafy spurge, hoary cress, knapweeds (spotted, diffuse and hybrids) and musk thistle. Photo plots are used to monitor musk thistle while a transect survey sampling method is used on the other four species.

The original recommendations for the design and deployment of monitoring plots offered by Carpenter et al. (2004) were used, and subsequently modified as new information was collected. Permanent plot sampling methods are described in Appendix B. The long-term monitoring plots were not surveyed in 2019 to allow time for more focus on the targeted monitoring and manual treatments that will be implemented.

Basewide weed mapping in 2018 was performed using a census survey method where weeds were documented by walking the property using GPS and GIS technology. Field technicians mapped noxious weed occurrences at the Academy from May through September in 2018 and in August of 2017 at Farish. Infestations were mapped as points, lines, or polygons, depending on the size and shape of each occurrence. Points and lines were buffered to estimate actual size. Irregularly shaped features greater than approximately 30 meters in any direction were mapped as polygons. Data were mapped using a Trimble Yuma rugged tablet with a built-in GPS receiver (accuracy between 2-5m) and ArcPad (ESRI 1995-2018), a portable version of Geographic Information Systems (GIS) software. Qualitative notes and actual counts and estimates for populations were made at each mapping site. When weeds were visible but exact locations were inaccessible, offsets were applied to the GPS or features were digitized heads-up using the 2015 NAIP aerial photo for reference. Notes were taken to document non-standard, “on the fly” mapping techniques. A more detailed description of the mapping protocol is provided in Appendix C. The next basewide weed mapping will be targeted for 2023.

Biocontrol introductions by Texas A&M AgriLife were discontinued in 2015 since most of the populations of weeds at the Academy were determined to be too small to support biocontrol agents. However, some of the noxious weed populations have the potential to grow to the point of being

able to support biocontrol agents, so monitoring for these agents should continue to be a part of the survey. Weed surveyors photographed and took notes on any biocontrol or potential biocontrol agents observed at survey sites. In addition, grazing by insects and animals was noted when observed. Common St. Johnswort, Canada thistle, musk thistle, bouncingbet, and leafy spurge are showing signs of significant impacts from biocontrol organisms and wildlife.

For 2019, some additional changes to the weed monitoring project were initiated to address the results from analyses of the first 15 years of monitoring data and the 2018 weed mapping survey (Smith and Greenwell 2019). The data are showing an increase in the coverage of weeds at the Academy. New locations as well as the re-occurrence of weeds in areas that have been previously treated were observed. In 2019, Colorado State University and CNHP included manual weed treatments in addition to the areal monitoring protocol as a means to address some of the increases. The focus was on rapid response weed species and those with more limited coverage where a manual treatment was feasible. Manual treatments by CNHP were based on species specific information for appropriate manual treatment methodologies. Each treatment was based on the species lifecycle to make sure appropriate timing and manual treatments would be most effective. Manual treatments were conducted on 15 species. The treatment methods for each species and detailed descriptions are provided in Tables 2 and 3. Perennial pepperweed was flagged by CNHP in the spring for initial herbicide treatments which were applied by the herbicide contractor, and CNHP conducted follow-up monitoring visits and manual treatments to remove sprouting plants not killed by herbicide.

The timing of weed treatments is one of the most critical factors in effective weed control. Many of the species sprout, bloom and go to seed at different times throughout the growing season. A treatment schedule was created to provide the timing as well as the types of treatments in 2019 for 15 noxious weeds. To be able to conduct the treatments and make multiple visits to sites, the long term monitoring plots were not monitored in 2019 and Tatarian honeysuckle was not monitored (Tables 2 & 3).

These changes for 2019 are part of an adaptive management action. These changes are to be made when it is clear current management strategies are not effective or new information on treatments have become available as specified in the Academy's Integrated Noxious Weed Management Plan (Carpenter and Perce 2004) as modified by Anderson and Lavender (2007), and Anderson and Lavender (2008b) and Smith et al. (2015).

A coordination meeting with the Academy Resource Manager and the herbicide applicator was held on May 9, 2019, to discuss timing and implementation of the new methods and how to better work together. Special maps were prepared for the contractor by CNHP to help focus efforts and to track where treatments are occurring or flagging is needed by contractor to help locate plants. It was our hope that both parties would communicate with one another for assistance on monitoring and treatment. Monitoring and manual treatments by CNHP began in April of 2019.

Table 2. Summary of weed treatment methods and actions for 2019.			
Latin Name	**Common Name**	**2019 Methods/Actions**	**2019 Action**
Acroptilon repens	Russian knapweed	Areal/Treat	Manual #1
Alliaria petiolata	Garlic mustard	Areal/Treat	Manual #2
Cynoglossum officinale	Houndstongue	Areal/Treat	Manual #1 (<100 plants)
Euphorbia myrsinites	Myrtle spurge	Areal/Treat	Manual #2
Gallium verum	Yellow spring bedstraw	Areal/Treat	Manual #2
Hesperis matronalis	Dames rocket	Areal/Treat	Manual #1
Hieracium aurantiacum	Orange hawkweed	Areal/ Treat	Manual #1&2
Hypericum perforatum	Common St. Johnswort	Areal/ Partial Treat	Manual #2 (< 100 plants)
Lepidium latifolium	Perennial pepperweed	Areal/Treat	Method #3
Leucanthemum vulgare	Oxeye daisy	Areal/Treat	Manual #2
Linaria dalmatica	Dalmatian toadflax	Areal/Treat	Manual #2
Onopordum acanthium	Scotch thistle	Areal/Partial Treat	Manual #1 (<100 plants)
Saponaria officinalis	Bouncingbet	Areal	Remove reproductive parts.
Tamarix ramosissima	Saltcedar	Areal/Treat	Method #3
Tripleurospermum perforatum	Scentless chamomile	Areal/Partial Treat	Manual #2
Long Term Monitoring Plot Species not Monitored in 2019 or 2020			
Cardaria draba	Hoary cress	Plot	---
Carduus nutans	Musk thistle	Photo Plot	---
Centaurea diffusa, C. maculosa and hybrid	Diffuse, spotted knapweeds	Plot	---
Cirsium arvense	Canada thistle	Plot	---
Euphorbia esula	Leafy spurge	Plot	---

Table 3. Description of weed treatment methods for 2019.	
Type	**Description of Actions**
Manual #1	**Sever below crown with knife pre-flower or rosette; revisit before fall all sites that had plants.**
Manual #2	**Pull entire root pre-flower; revisit all sites in fall that had plants; for hawkweed be very careful to remove ALL root fragments (as much as possible)**
Method #3 flagging	**Flag for herbicide application – spot treatment (dates and herbicide recommendations may be discussed with applicator in spring meeting)**

Precipitation

Annual precipitation can be a helpful indicator for interpreting weed monitoring data. Higher precipitation years often result in increased weed numbers for certain species for that year. The yearly total for 2019 at the Colorado Springs Municipal Airport (KWOS) was 11.70 inches which is very close to the average annual precipitation (1961-1990) of 12.33 inches (Figure 1).

These data may be helpful in future monitoring years to determine if there is any correlation with spring and summer precipitation. Musk thistle, Scotch thistle and houndstongue seem to have population increases that are strongly correlated with spring and summer precipitation patterns.

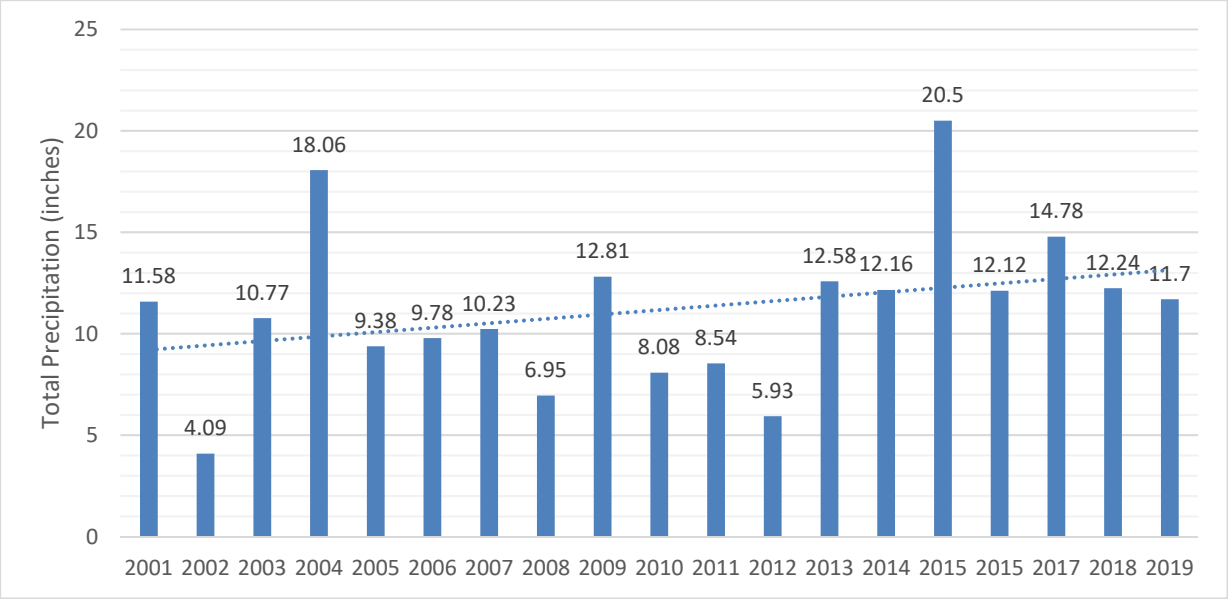


Figure 1. Average spring and summer precipitation. Spring = March-May, Summer = June-August. Blue dotted line is trend line (WU 2019).

RESULTS AND RECOMMENDATIONS

U.S. Air Force Academy

In 2018, 25 noxious weeds were mapped at the Academy. In all, over 9,300 extant occurrences covering approximately 424 acres were documented, with 18 species increasing in cover across the Academy. Noxious weeds have been increasing throughout the Academy since monitoring began in 2002 (Smith and Greenwell 2019, Figure 2).

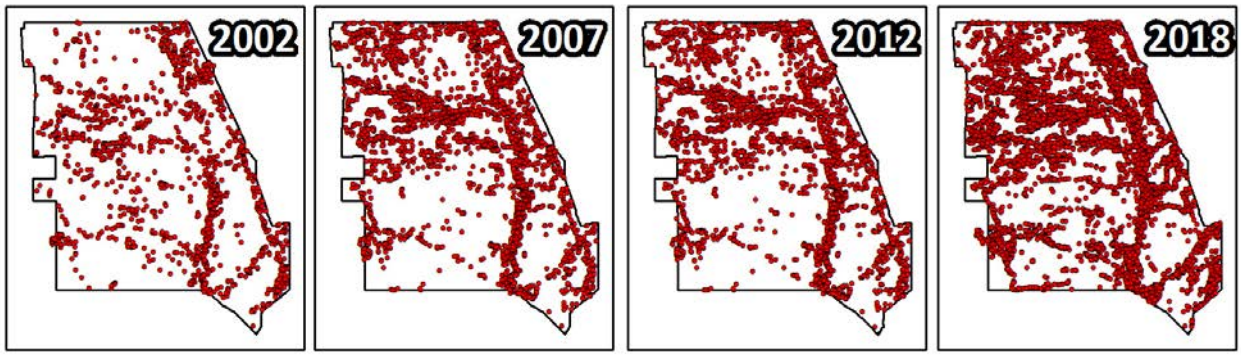


Figure 2. Distribution of known noxious weed occurrences at the U.S. Air Force Academy (excluding yellow toadflax).

A list of 17 species were originally proposed for monitoring and/or treatments for the 2019 season. Two of the 17 species were not treated or monitored and include purple loosestrife and Tatarian honeysuckle. A potential purple loosestrife observation was noted by the CNHP weed mapper in 2018 to be investigated. In 2019, the area was visited at an appropriate time for verification and no purple loosestrife plants were found. Tatarian honeysuckle was fully mapped in 2018 and as a woody perennial species, the distribution is not likely to change in one year. In addition, treatments that are necessary for these species are currently being carried out by the contractor and Academy staff. There were a couple of other changes with monitoring for 2019 that came about as the field season began. Dame's rocket sites east of I-25 and some large occurrences of Scotch thistle were not treated after discussions with the Academy as this area is currently being developed. Biological controls for one site at Jack's Valley were not introduced due to new information provided on availability and methodology for the Canada thistle rust biocontrol agent. A new List B noxious weed was observed, mapped and treated in 2019, oxeye daisy (*Leucanthemum vulgare*).

In 2019, CNHP conducted over 620 site visits including follow-up visits at the Academy and Farish to 15 rapid response species and removed 17,356 individuals. Of the 15 target species, Scotch thistle has the largest number of sites at the Academy followed by scentless chamomile, then common St. Johnswort, and houndstongue. A summary of results from 2019 in order of largest number of extant sites is provided in Table 4.

The decision to manually treat plants was made by the field team on a site by site basis, looking at the treatment necessary, number of individuals at the site, location, previous herbicide application

or the presence of biocontrol, and the biomass that needed to be removed. Perennial pepperweed, orange hawkweed, Russian knapweed and myrtle spurge were prevented from going to seed in 2019. Many of the remaining species were also largely prevented from going to seed and late season sprouts were treated. Five new photo monitoring plots were established in 2019. At the Academy photo plots were established for garlic mustard, Dalmatian toadflax, and perennial pepperweed to track treatment success. At Farish, a photoplot was established for orange hawkweed.

Table 4. Summary of site data for 15 targeted species in 2019.

Common Name	# Extant Sites	# Eradicated Sites	Estimated # Shoots (1st Pass)	# Shoots Removed in 2019
Scotch thistle	290	135	3,137	1,504
Scentless chamomile	116	3	2,525	23
Common St. Johnswort	74	28	11,543	3,482
Houndstongue	57	26	3,056	1,566
Myrtle spurge	34	29	375	432
Bouncingbet	29	9	4,063	3,133
Dame's Rocket	8	17	665	0
Garlic mustard	8	0	6,564	5,977
Oxeye daisy	5	0	52	52
Russian knapweed	3	11	94	116
Perennial pepperweed	2	0	212	6
Orange hawkweed	1	0	600	1,257
Saltcedar	1	9	1	0
Dalmatian toadflax	0	4	0	0
Yellow spring bedstraw	0	1	0	0
TOTALS	**629**	**272**	**32,887**	**17,356**

Russian Knapweed (*Acroptilon repens*)

Overall Trend: Moderate Increase

Management Goals: Suppression/Eradication

State List: B

- Perennial, spreading by lateral roots and from seeds
- Root buds active winter and spring
- Roots of newly established plants can expand rapidly and can be 8 ft. deep (Beck 2008)
- Emerges early spring, bolts May – June, flowers into fall (CWMA 2020a).
- Rapid Response is still a viable treatment at the AFA
- Seed longevity: 5 years (Code of Colorado Regulations 2014)

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

2019 Results

Russian knapweed was not observed at the Academy for five years in a row from 2013 to 2017 at 13 sites. It was found at three sites during the five-year base wide survey in 2018 (Greenwell and Smith 2019). One of the sites was new for 2018 bringing the total number of known sites to 14 (Section E7 Map 3). Past treatments have included digging and herbicide applications. The three extant sites in 2018 had a total of 44 individuals. In 2019, the management urgency was considered to be very high because the number of individuals increased from 44 in 2018 to 94 in 2019 (Table 5, Figure 3, Maps 2 & 3). Eleven of the 14 known Russian knapweed sites were visited in summer and three extant sites were visited again in the fall. The three sites that were not visited in 2019 were located on the east side of I-25 in an area that is being developed. The Russian knapweed population more than doubled between 2018 and 2019 at the new location while the other two populations remained stable (Table 5).

Table 5. All infestations of Russian knapweed at the Academy.					
	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---	---
2004	?	?	3	3	0
2005	< 0.01	54	3	2	1
2007	0.03	200	4	2	2
2008	0.025	157	4	2	2
2009	?	?	4	2	2
2010	0	0	4	0	4
2011	0	0	4	0	4
2012	0.05	543	12	10	2
2013	0	0	12	0	12
2014	0	0	12	0	12
2015	0	0	12	0	12
2016	0	0	12	0	12
2017	0	0	7	0	12
2018	0.02	44	14	3	11
2019	0.18	94	11	3	11

Basewide weed mapping performed during shaded years.

Figure 3. Number of Russian knapweed individuals and mapped features, 2005-2019.

Treatment 2019

There were a total of 94 individuals treated during the summer site visits at three extant sites. A second visit was conducted to these sites in late summer and another 22 individuals were removed for a total of 116 shoots (Table 6). All plants were treated by severing the root crowns 4-6 inches below the soil surface, bagging all cut plants and disposing of them in off-site dumpsters. The timing of the first visit in early July and the second visit in late August worked very well and no flowers or seeds were present at the time of the treatments. The 22 plants we treated during second visits would have been missed if we waited a year to monitor and these plants were prevented from going to seed. This demonstrates the importance of the follow-up visit which prevented plants from producing seeds at this site in fall of 2019. In addition, with perennial species like Russian knapweed that reproduce both by seed and vegetative shoots, not only is seed removal important but removing any photosynthetic parts. All sites visited in the fall were either not present (0 found) or reduced compared to the summer visit.

Table 6. Monitoring and treatment of Russian knapweed sites at the Academy in 2019.

2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	11	94	94	3/3	8
Pass 2	3	22	22	1/1	10
TOTALS	**11**	**116**	**116**	---	---

Recommendations

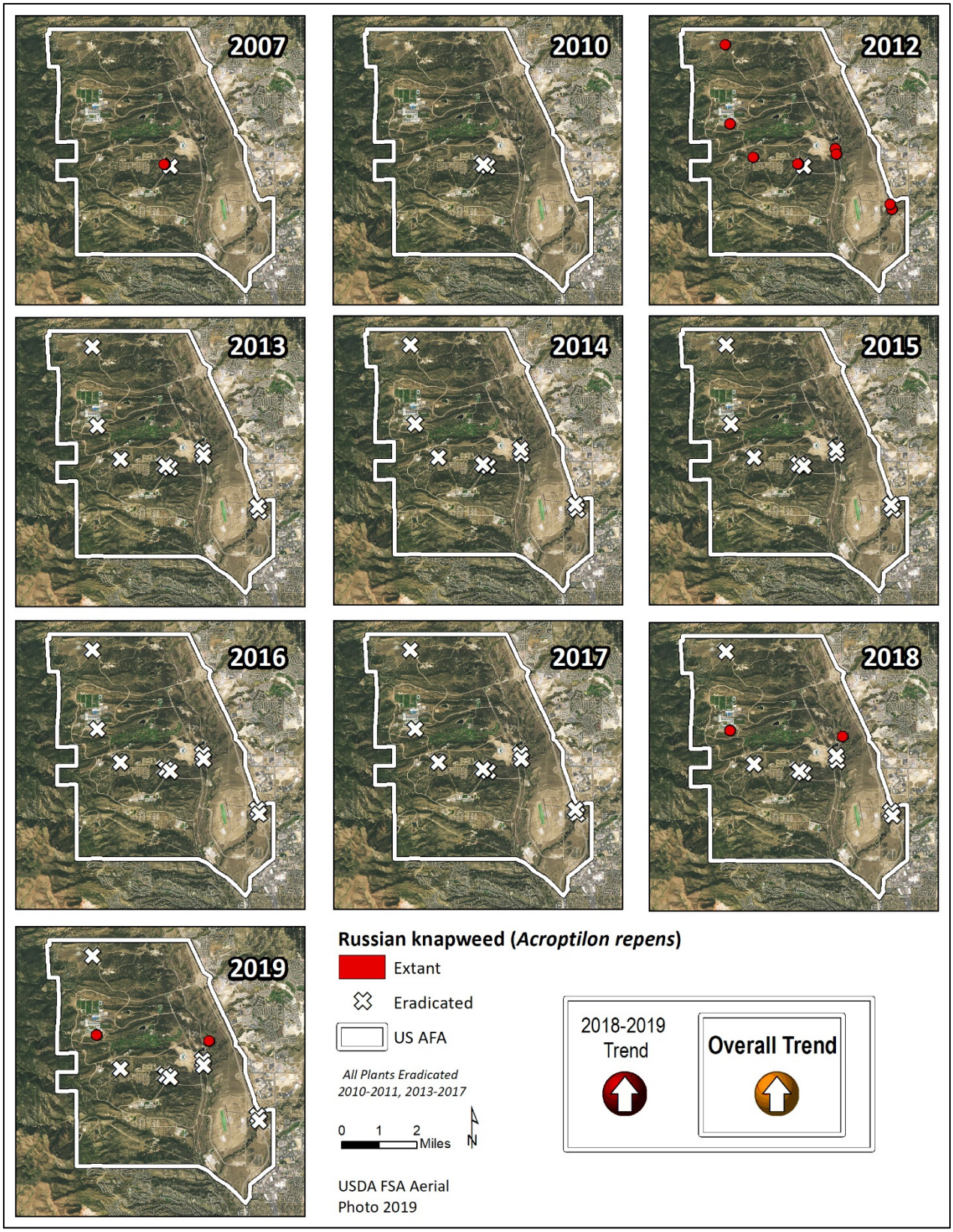
The management urgency continues to be very high for 2020. We will conduct a summer visit to all 11 sites before seed set and follow-up with a late summer/fall visit to sites that had Russian knapweed plants present at the first visit. Since seed longevity is estimated to be five years, follow-up visits should be maintained for at least five years. Encouraging native grasses to grow in areas where Russian knapweed has been treated is a recommended cultural control (Beck 2008, CDA-CSU 2020a). Newly established plants can be removed mechanically. This is recommended for the small areas at the Academy. Russian knapweed is found to be very susceptible to fall-applied herbicides (Beck 2008) which may be used on the largest population in the fall. Biological control is not yet available for Russian knapweed.

History of Sampling and Treatments:

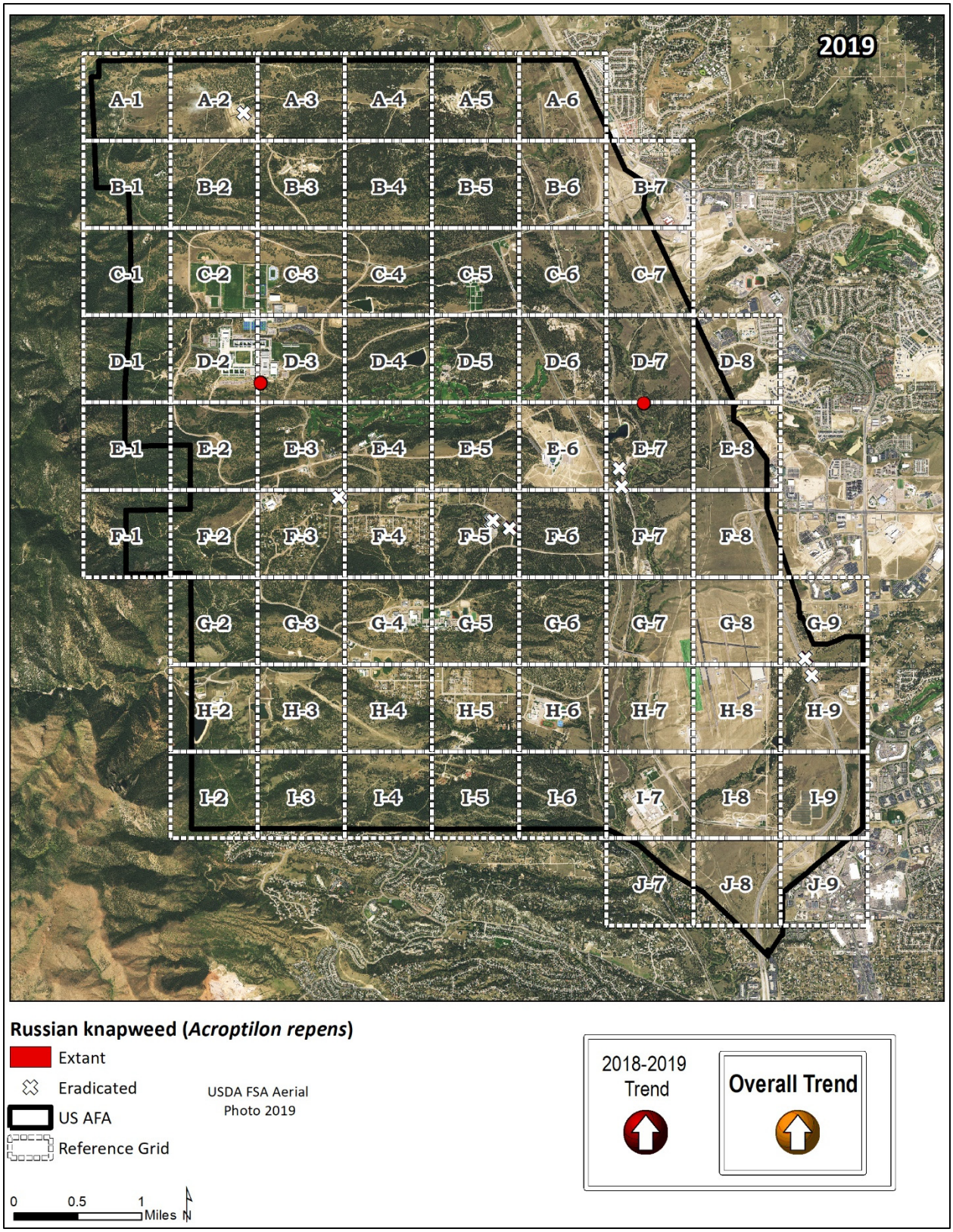
- The first appearance of Russian knapweed was in 2004 and by 2007 there were two extant occurrences and two eradicated occurrences, all near Douglass Way.
- By 2009, two occurrences were eradicated and two were sprayed that year (Rondeau and Lavender 2012). None of these infestations have re-established in subsequent years.
- In 2005, herbicide treatment was applied to part of the Skills Development Center and Douglass Way occurrences and the Skills Development Center was treated again in 2009.

Specific details about the first two locations can be found in Anderson and Lavender (2008b).

- In 2012, when 10 new locations were mapped, Russian knapweed occupied 0.05 acres with 543 shoots. This represented a 172% increase in number of shoots and a 400% increase in number of extant features since 2007.
- In 2013, all extant locations were treated (0.05 acres), and no live plants were observed in 2013 or in 2014. In 2014, a rosette was tentatively identified as Russian knapweed and was later identified as spotted knapweed.
- In 2015, no new populations were identified and no extant features were observed at eleven of the twelve known sites.
- In 2016, all twelve known sites were visited and no Russian knapweed plants were found.
- In 2017, seven of the twelve known sites were visited and no Russian knapweed plants were found.
- In 2018, fourteen sites were visited and three had Russian knapweed plants. One of the three sites represents a new location; it was found on the east side of the Academy with 35 individuals.
- In 2019, 11 out of 14 total sites were visited in the summer and three sites were extant. The three sites east of I-25 were not visited. In late summer the three extant sites were re-visited and two sites had sprouts that were removed. A total of 116 individuals were removed and no plants went to seed.



Map 2. Distribution of Russian knapweed at the Academy between 2007 and 2019.



Map 3. Distribution of Russian knapweed at the Academy in 2019 with the reference grid.

Garlic Mustard (*Alliaria petiolata*)

Overall Trend: Moderate Increase (New in 2018)

Management Goals: Eradication

State List: Watch List

- Annual/Biennial (winter annual)
- Self-fertile
- Germination early spring and fall
- Reproduction by seed
- Seeds viable for 7-10 years
- Allelopathic
- Crushed leaves smell like garlic (King County 2018)

Photos: Garlic mustard first year leaves (top) and second year plants (http://nyis.info/invasive_species/garlic-mustard/)

2019 Results

Garlic mustard was first mapped at the Academy in 2018 during the five-year base wide survey (Smith and Greenwell 2019). It was mapped at seven sites with 4,011 individuals along West Monument Creek and in 2019 increased to a total of eight sites with an estimated 6,564 individuals. The occupied acres almost doubled from 0.12 to 0.21 in 2019. (Table 7, Figure 4, Maps 4 & 5).

Table 7. All infestations of garlic mustard at the Academy.				
	Occupied Acres	**Estimated Number of Shoots**	**Number of Extant Features**	**Number of Eradicated Features**
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2018	0.12	4,011	7	0
2019	0.21	6,564	8	0

Basewide weed mapping performed during shaded years.

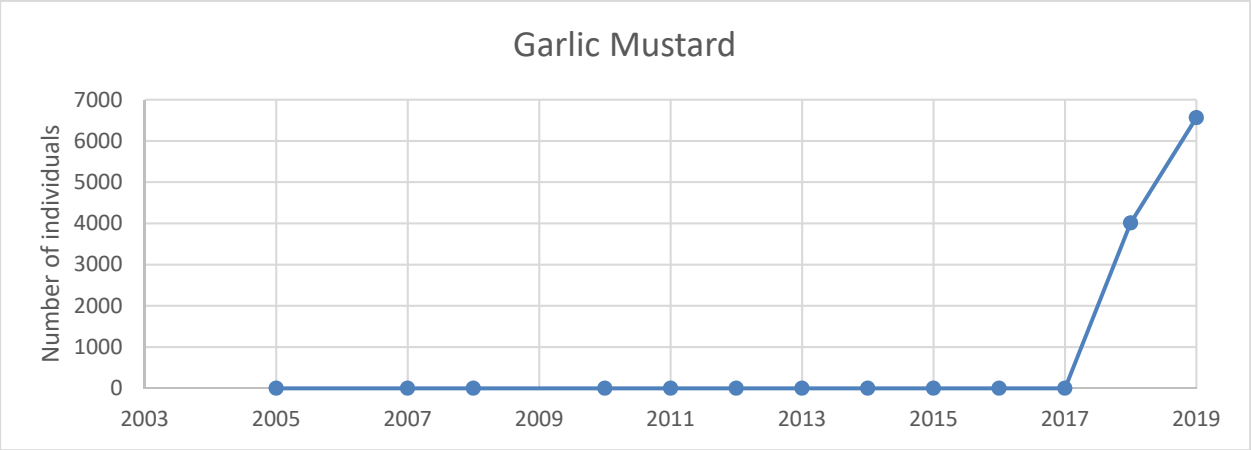


Figure 4. Number of garlic mustard individuals and mapped features, 2005-2019.

Treatment 2019

There were an estimated 6,564 shoots at eight sites with 2,291 removed in for the first pass visit in 2019, two sites were visited a second time (pass) and 2,186 individuals were counted (1,186 pulled) and one site (photo plot – easternmost occurrence) was visited a third time and all 2,500 sprouts were removed (Table 8.) Of those 11,250 individuals an estimated 4,276 were manually treated by pulling the entire plant including the roots at five sites. Two sites not treated include one with over 2,000 individuals in a dense willow thicket and one where poison ivy was dominating the site.

Table 8. Monitoring and treatment of garlic mustard sites at the Academy in 2019.					
2019	**# Features Visited**	**# Shoots Mapped**	**# Manually Treated Shoots**	**# Treated/Extant Features**	**# Eradicated Features**
Pass 1	8	6,564	2,291	8/8	0
Pass 2	2	2,186	1,186	2/8	0
Pass 3	1	2,500	2,500	1/8	0
TOTALS	---	**11,250**	**5,977**	---	---

In 2019, the original plan was to visit all sites at least two times and treat manually. Two sites had very dense vegetation cover (including poison ivy) and large numbers of garlic mustard plants (thousands) making it impractical to manually treat without a plan and different equipment. The potential to make the infestation worse is very high with garlic mustard.

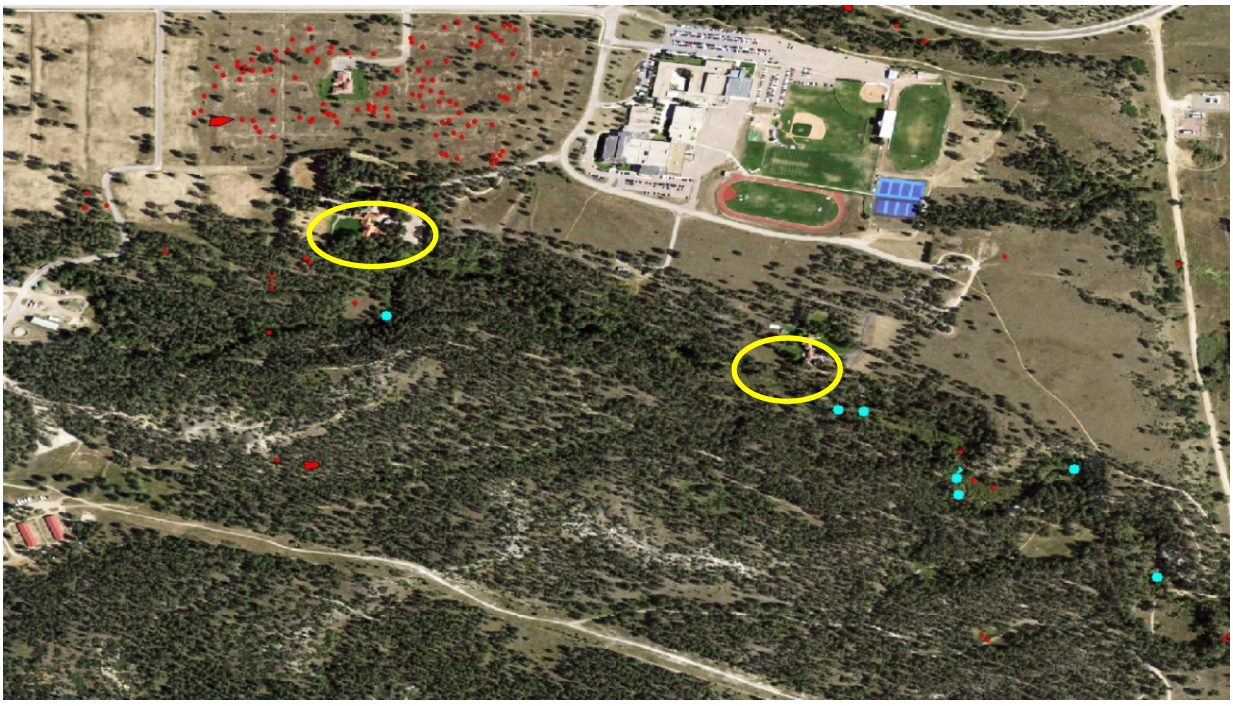
A photo plot was set up to determine the results of treating garlic mustard manually at the easternmost occurrence along W. Monument Creek.

Photo plot garlic mustard - before spring manual removal, May 2019, P. Smith.

Phot plot garlic mustard- after spring manual removal, May 2019, P. Smith.

During the first spring visit all 1,280 individuals largely vegetative or in flower were removed. Photos were taken before and after. The photo plot site was visited in the summer and all 1,186 plants were removed with a few that had gone to seed. The third visit showed the population was double what was pulled in the spring with 2,500 individuals which were also pulled.

The mapping data may indicate the source of the garlic mustard seeds are coming from residential sites upslope of the westernmost mapped occurrences of garlic mustard. Many garlic mustard infestations have been documented as being introduced from cultivated landscapes where yard waste is discarded into drainages (King county 2018). There are three factors that point to this: 1) no garlic mustard was mapped upstream of the two large manicured residences, 2) yard waste was being discarded into the W. Monument Creek drainage and 3) other common garden escapes were observed downslope of these residences including the wayfaring tree (*Viburnum lantana*), white campion (*Silene latifolia*) and a state watch listed noxious weed, hoary alyssum (*Berteroa incana*). If these residences are the source, it may worth additional effort to reduce or eradicate the garlic mustard from W. Monument Creek, including the three sites not treated in 2019.



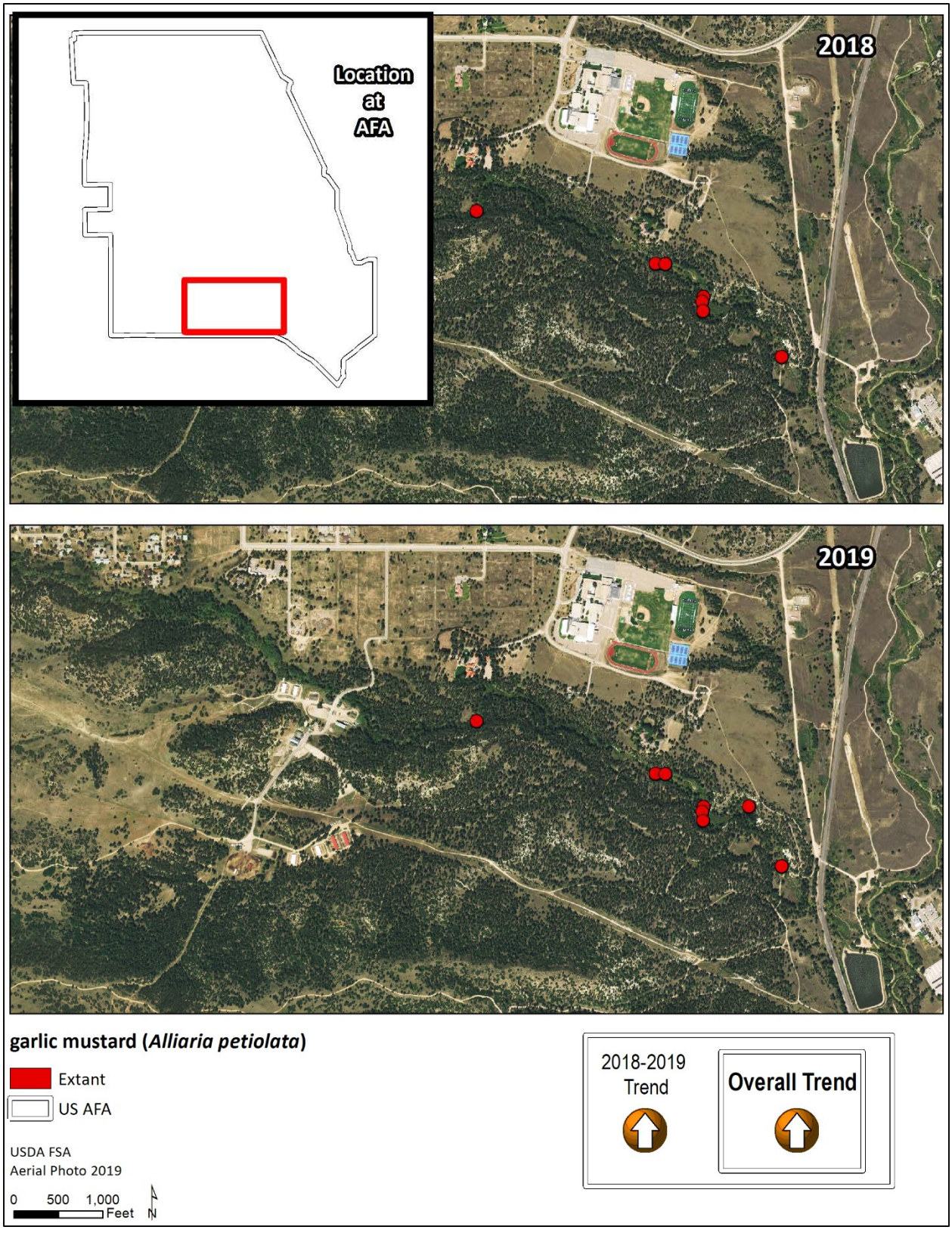
Recommendations

In 2020, we plan to continue to manually treat sites by removing all parts of the plant, especially the roots. We will continue to collect photo plot data as was done in 2019 to continue to gain information on manual treatments and seed bank. For the remaining sites it will be important to visit them as early in the spring as possible to make decisions about the practicality of treating these sites. Seed set usually occurs in June. The seedlings survive winter and stay green so they mature very early in the spring. Removing these seedlings all season is recommended. There are some native look-a-likes that grow with the garlic mustard and it is important not to remove these species. This plant prefers disturbances and invades these areas very quickly. Follow-up monitoring

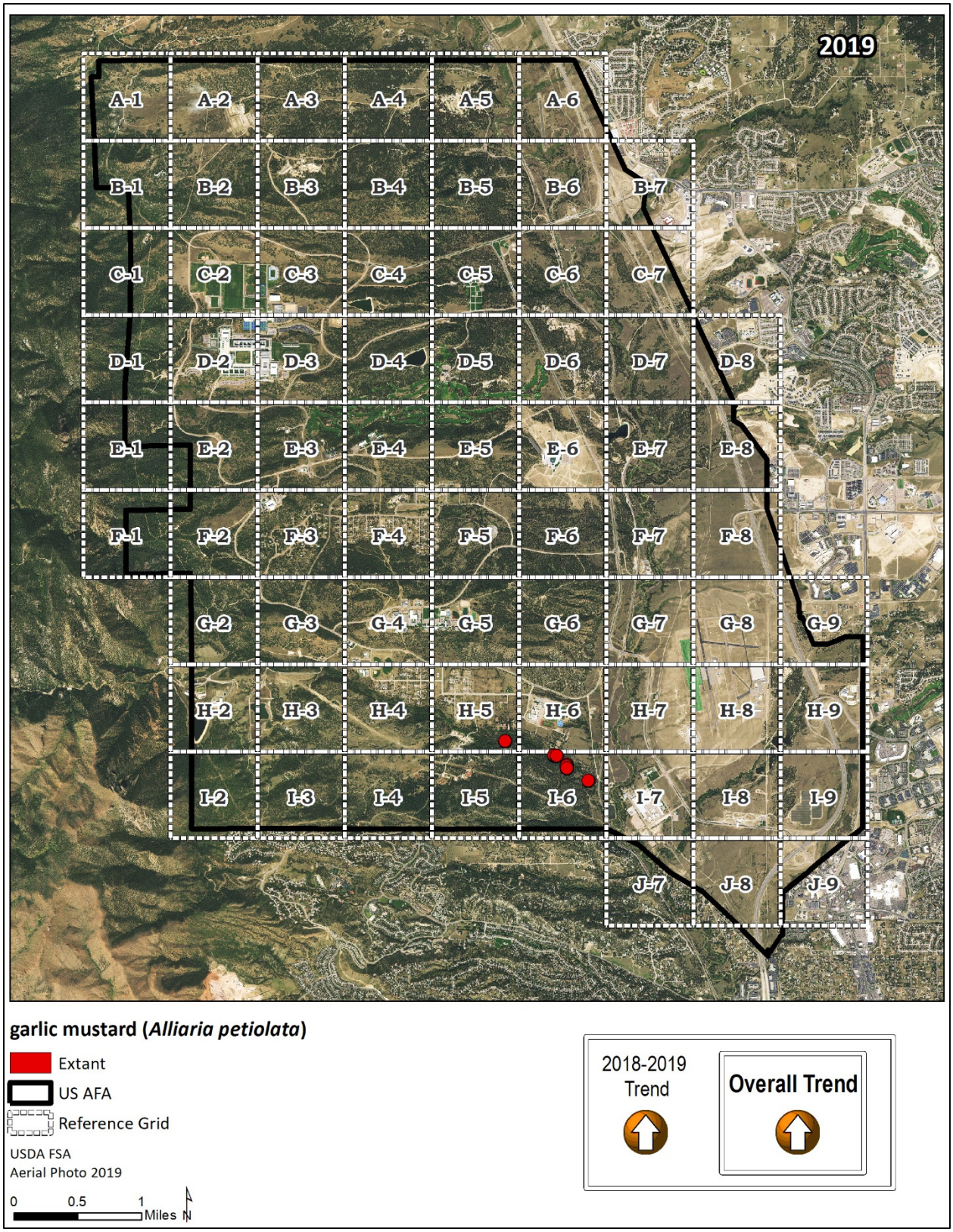
and planting of competitive species may be important for successful removal of garlic mustard. Monitoring at these sites should be conducted for at least seven years after treatments. Some sites have been treated with herbicide (pers. comm. Brian Mihlbachler 2019).

History of Sampling and Treatment:

- Garlic mustard was first discovered on the base during the 2018 basewide weed survey at seven mapped sites. Natural Resources Managers were notified immediately and herbicide applications were applied to at least two populations along West Monument Creek.
- In 2019, an eighth site was mapped and the populations have continued to expand. Hand-pulling was done at five sites with one site set up as a monitoring plot to track results. The monitoring plot showed there is likely an extensive seed bank as thousands of sprouts appeared after each manual treatment. The garlic mustard seeds may be coming from residential lawn clippings along W. Monument Creek.



Map 4. Close-up of garlic mustard at the Academy between 2018 and 2019.



Map 5. Distribution of garlic mustard at the Academy in 2019 with the reference grid.

Houndstongue (*Cynoglossum officinale*)

Overall Trend: Increasing (Decreasing 2018-2019)

Management Goals: Eradication/Suppression

State List: B

- 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 3 years (Colorado Code of Regulations 2014)

Houndstongue seeds, photo BLM

Photo by M. DiTomaso, University of California - Davis

2019 Results

In 2018, there were 4,514 individuals mapped at 50 extant sites and 22 eradicated sites.
In 2019, there were 3,056 individuals mapped at 57 extant sites and 26 eradicated features. Eleven new sites were mapped in 2019. There is a decrease in shoots from 2018 to 2019 and an increase in occupied acres and extant sites (Table 9, Figure 5, Maps 6 & 7).

Table 9. All infestations of houndstongue at the Academy.					
	Occupied Acres	**Estimated Number of Shoots**	**Total Number of Features Visited**	**Number of Extant Features**	**Number of Eradicated Features**
2002	---	---	---	---	---
2007	---	---	---	---	---
2009	0.09	95	8	8	0
2010	0.02	11	7	1	6
2011	<0.01 (10 m²)	21	8	2	6
2012	0.01	70	12	3	9
2013	0.05	48	15	7	8
2014	0.04	102	16	8	8
2015	0.20	534	31	22	11
2016	0.20	480	36	22	14
2017	0.41	787	37	26	13
2018	0.51	4,514	71	50	22
2019	0.62	3,056	67	57	26

Basewide weed mapping performed during shaded years.

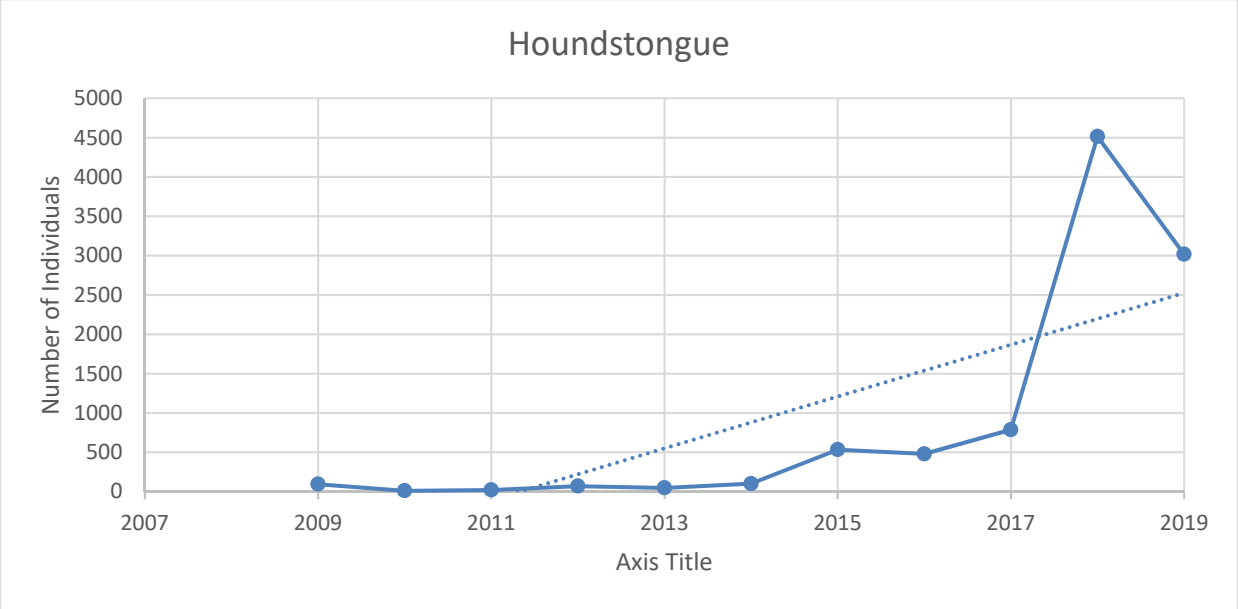


Figure 5. Number of houndstongue individuals, 2009-2019.

Treatment 2019

In 2019, 67 features were visited in early summer and 3,027 shoots were mapped at 47 extant features. There were 1,178 shoots manually removed at 40 of the sites and 20 sites were eradicated in early summer. In late summer, 40 features were re-visited and 3,758 shoots were mapped and 388 were treated manually at 16 of 23 extant sites. A total of 6,785 shoots were mapped at 47 extant feature with 1,566 treated in 2019 (Table 10).

Table 10. Monitoring and treatment of houndstongue sites at the Academy in 2019.

2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	67	3,027	1,178	40/47	20
Pass 2	40	3,758	388	16/23	17
TOTALS	---	**6,785**	**1,566**	---	---

In 2020, we propose to manually treat this site very early in the spring and include two follow-up visits in the summer and fall. The protection of intact vegetation is an important component of IPM at this site. We will continue to sever the plants four inches below the root crown to minimize soil damage and pull small sprouts. Cooperation with the weed spraying contractor is essential so that overlap does not occur.

Recommendations

Three sites at the Academy contain 70% (almost 3,600 individuals) of the total population of houndstongue: 1) west side of Ice Lake Road, 2) south and west of the Monument Creek waste water treatment plant (WWTP) and 3) a bluff area west of Monument Creek along the edges of a ponderosa pine forest in the east central area of the Academy. One single point on the south side of the WWTP contains 2,000 individuals. Targeting these localized major populations with a coordinated plan should lead to significant reductions in houndstongue. All of the other sites at the Academy have population counts that range from 0 to 200 individuals by the end of 2019 which should also be targeted for treatment.

Since all the known houndstongue sites are within the designated Special Weed Management Area (SWMA) delineated in the 2014 Weed Management Plan (Smith et al. 2015) site plans for known locations should be created before any more chemical or mechanical treatments occur to track what is occurring at these sites to more effectively control the weeds and prevent more weeds. Many features are located in wetland areas and some contain rare plant and animal species.

According to a number of studies (Nicholas et al. 2008, Norris 1999, Pritekel et al. 2006), if the focus is solely on the removal of a target weed species without consideration of impacts of the treatment on the surrounding vegetation, soils and fauna, the treatments will likely be unsuccessful and could create more problems. Herbicide treatments may also be contributing to the increases in numbers we are seeing. One of the problems previously identified at the Academy has been overkill

at treated sites, where adjacent plants are being injured and/or killed and surrounding soils are being left in a disturbed state post treatment. In addition, when bare soil is exposed in the treatment areas noxious weed species start to occupy the area. The soil damage and an increase in weeds, likely due to herbicide treatment in a wet meadow containing rare plants at the Academy, is shown in Photo 1. The disturbance of intact native species increases the likelihood of increasing the weed species footprint in this wetland. The first rule in weed treatment is to protect intact surrounding areas from disturbance.

Photo 1. Area treated in a wet meadow for houndstongue. Treated area left bare soils and has new sprouts of houndstongue and other non-native species and noxious weeds including Canada thistle and common mullein. P. Smith 2015.

Summary of Recommendations

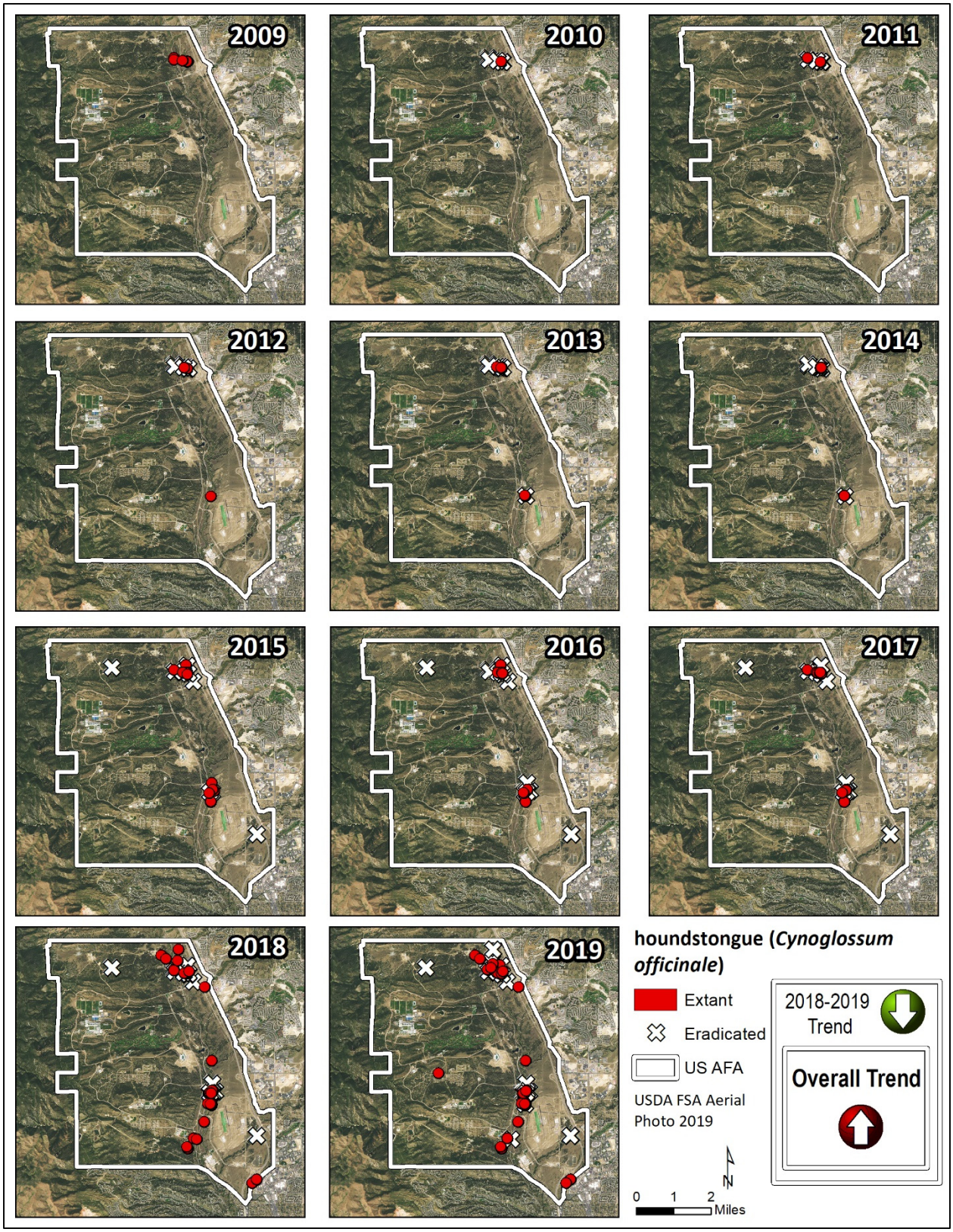
1. Protect intact habitats from disturbances (off road vehicles, unnecessary soil disturbances from chemical herbicide or manual treatments).
2. Treat in early spring and summer before flowers and seeds are produced.
3. Mechanical removal is recommended (CDA-CSU 2015a). The root can be severed about an inch below the soil surface at the rosette stage before the plant bolts and produces flowers and/or seeds. If flowers or seed heads are present, remove the top portion of the plant. These tops should be placed in a black plastic bag and removed from the site. The black

plastic bags should be left in the sun for a month to make sure the seeds are killed before discarding in the trash. Since this plant is a biennial, it dies after it produces flowers/fruits. Removal of the top portion causes less soil disturbance than digging the taproots.

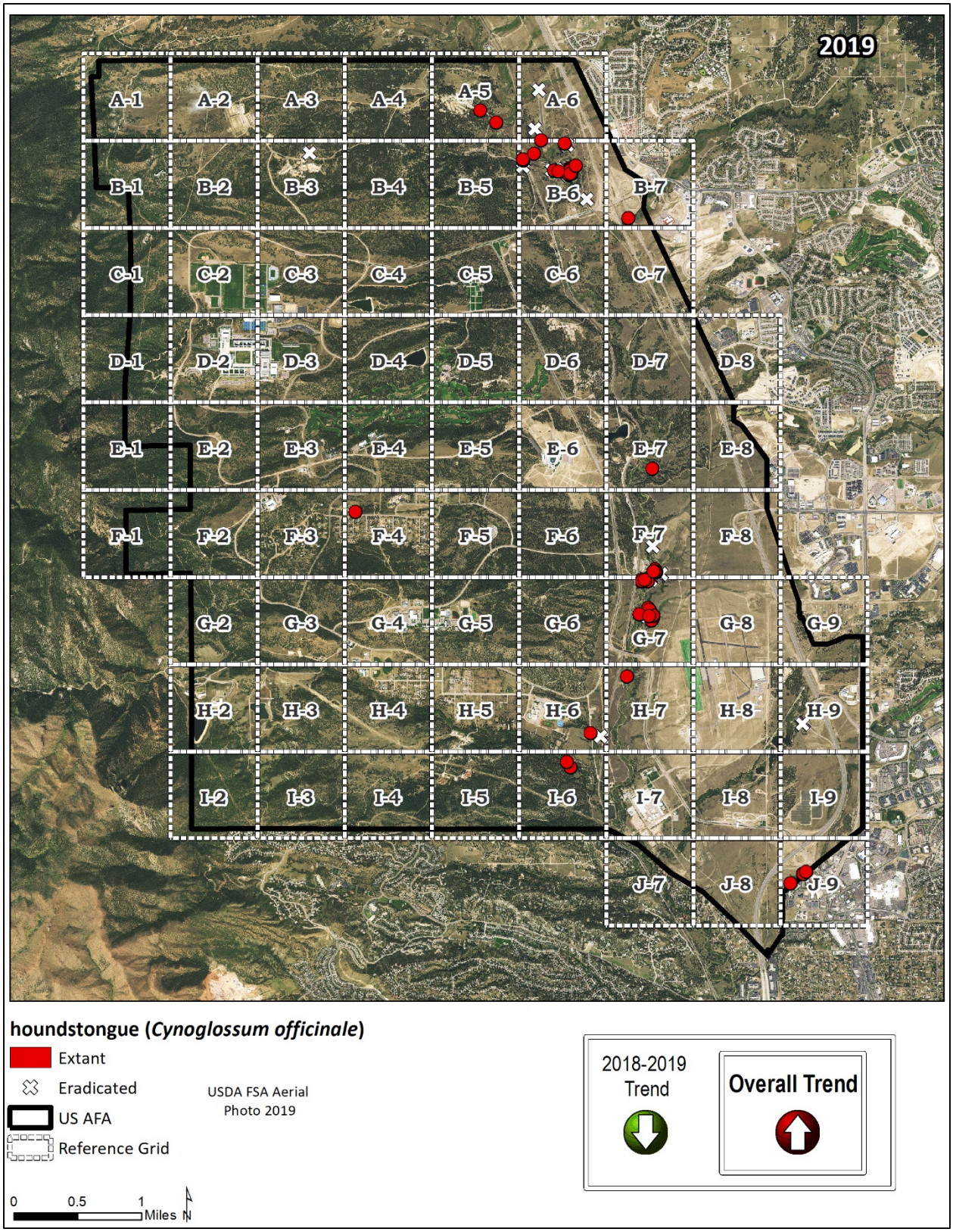
4. Areas where soil area greater than a square foot is left bare should be planted with a native seed mix at the appropriate time.
5. Sites should be carefully surveyed under dense vegetation at the known sites for rosettes.
6. Follow-up monitoring should be conducted multiple times during the growing season. Seed longevity is relatively short compared to other species (five years) and should continue for at least five years after no plants were found. Observations should be made on the condition of the treatment site: notes on whether noxious weeds moving into the site or smooth brome, is biodiversity increasing or decreasing, bare soil presence etc.
7. Herbicide use is not recommended. If it is the manager's choice, only utilize herbicides that are legal for wildlands and wetlands. A precise spot application to rosettes making sure that wetland applications are made with wetland appropriate herbicide and that floodplains and intermittently inundated areas are considered to be wetlands. Make sure all applicators can recognize rare plants and the rosette stage of houndstongue.
8. Create a site plan before an area is treated. Houndstongue is a biennial species that often will work itself out of a system if the disturbance pressures are released. Years that have wet spring and summer rains tend to show increases in populations.

History of Sampling and Treatment

- First populations discovered in 2009 at the Academy.
- Aggressively treated with herbicide in 2010. Populations declined but extant plants remained in 2010 and 2011.
- In 2012 a new site was located south of the existing known sites during the basewide weed survey.
- In 2013 no new sites were found and all known sites were treated.
- In 2014 two locations that had not been mapped as part of the weed monitoring project were sprayed for houndstongue by weed contractors.
- In 2015, there was an increase in the number of sites from 16 to 33 between 2014 and 2015 with a corresponding increase in the number of individuals observed (109 to 534 individuals, respectively). Many of the new plants were new rosettes and sprouts and some of them were in previously treated areas.
- In 2016, three new points were added. There was a slight decrease in the number of individuals between 2015 and 2016 from 585 to 480, respectively.
- In 2017, there was an increase from 480 to 787 plants at a total of 26 extant features.
- In 2018, basewide mapping showed 4,514 plants in 72 extant features. Much of the increased features were along Monument Creek.
- In 2019, there were 3,056 shoots mapped at 57 extant features. The majority of the plants are found at three sites: Ice Lake Road, the waste water treatment facility and a site along Monument Creek east side.



Map 6. Distribution of houndstongue at the Academy between 2009 and 2019.



Map 7. Distribution of houndstongue at the Academy in 2019 with the reference grid.

Myrtle Spurge (*Euphorbia myrsinites*)

Overall Trend: Increasing

Management Goals: Rapid Response

State List: A

- Evergreen perennial
- Reproduction by seeds which are projected 15 feet from plant by seed pods
- Plant is allelopathic
- Milky sap is an irritant
- Planted in gardens and readily escapes
- Possibly spread by birds at AFA due to random widely spread small occurrences
- Seed longevity 8 years
- Easily removed by hand (CWMA 2020b)

Photo: Dave Anderson

Photo: Wikimedia Commons

2019 Results

In 2019, the occupied acres almost doubled since 2018. Myrtle spurge is about to reach a point that is hard to manage as an eradication target at almost one acre of occupied habitat. In 2019, there were 375 shoots at 34 extant features. The number of individuals has fluctuated from 25 to 1,021 with the highest number reported in 2007 (Table 11). The overall trend has decreased since 2007 with fluctuations between 2016-2019 (Figure 6). Myrtle spurge is found throughout the Academy and new populations are regularly discovered (Maps 8 & 9).

Table 11. All infestations of myrtle spurge at the Academy.

	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---	---
2005	?	25	7	7	0
2006	?	243	10	10	0
2007	0.18	1,021	13	7	6
2008	0.66	419	18	13	5
2009	2.4	464	18	12	6
2010	0.5	56	22	10	12
2011	0.25	57	28	12	16
2012	0.23	113	35	10	25
2013	?	129	31	19	12
2014	0.7	179	34	7	27
2015	1.04	173	40	14	26
2016	0.70	185	42	17	26
2017	1.15	501	45	25	23
2018	0.51	222	61	26	35
2019	0.97	375	63	34	29

Basewide weed mapping performed during shaded years.

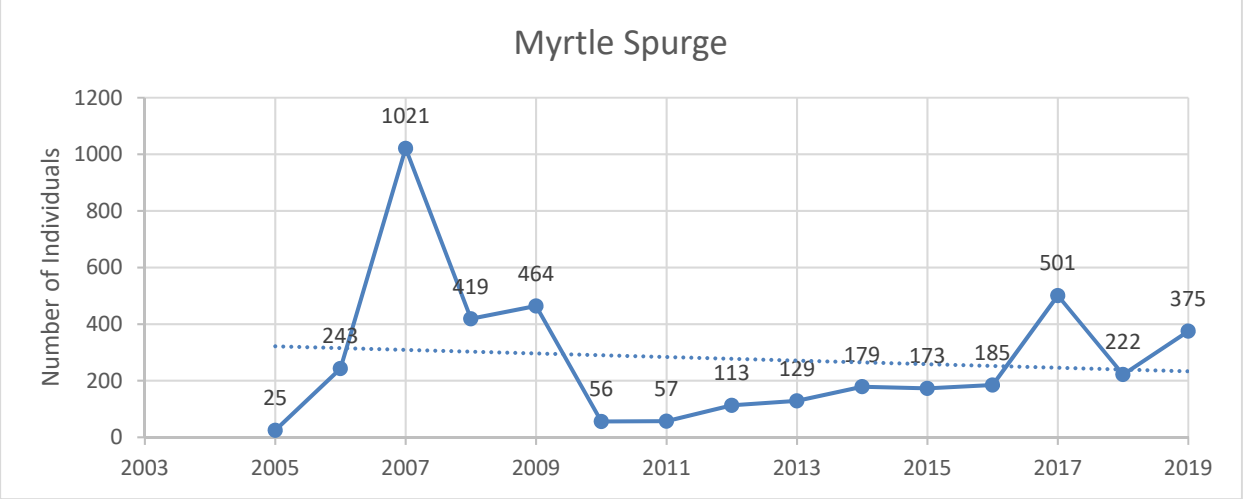


Figure 6. Myrtle spurge trend, 2005-2019.

Treatment 2019

In 2019, there were a total of 63 features with 34 extant and 29 eradicated sites. In early spring, 375 shoots were mapped and treated by Academy Staff. In early summer 29 features were re-visited with 56 shoots mapped and treated and a third site was visited twice with 1 sprout removed. Over the season there were 93 site visits with 432 mapped and treated shoots in 2019 (Table 12).

Table 12. Monitoring and treatment of myrtle spurge sites at the Academy in 2019.

2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	63	375	375	34/34	29
Pass 2	29	56	56	9/9	20
Pass 3	1	1	1	1/1	0
TOTALS	**93**	**432**	**432**	---	---

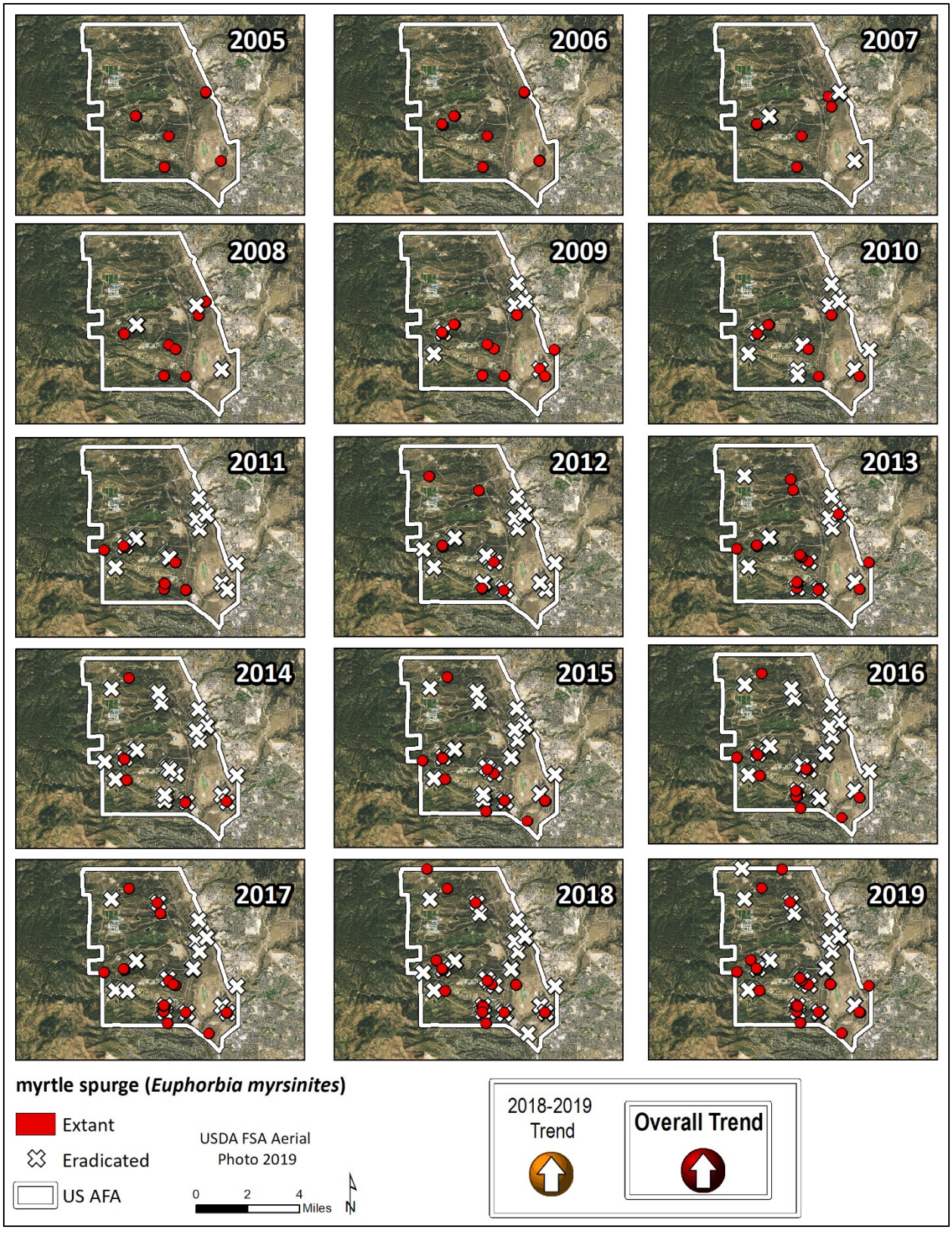
Recommendations

Visiting sites early in the season is recommended before the plants set seed. There are several reasons that myrtle spurge continues to be found at treated locations. The most likely reason is that the seed source is still present and too much soil disturbance is resulting from herbicides. Early removal before seed set will help to reduce the seed bank in the soil. More precise herbicide application needs to occur otherwise pulling is the best method. When the surrounding plants are inadvertently targeted cheat grass and other weeds are filling in the site (Photo 2). Myrtle spurge blooms as early as March in Colorado. Continue to monitor all known mapped or reported features for sprouts annually.

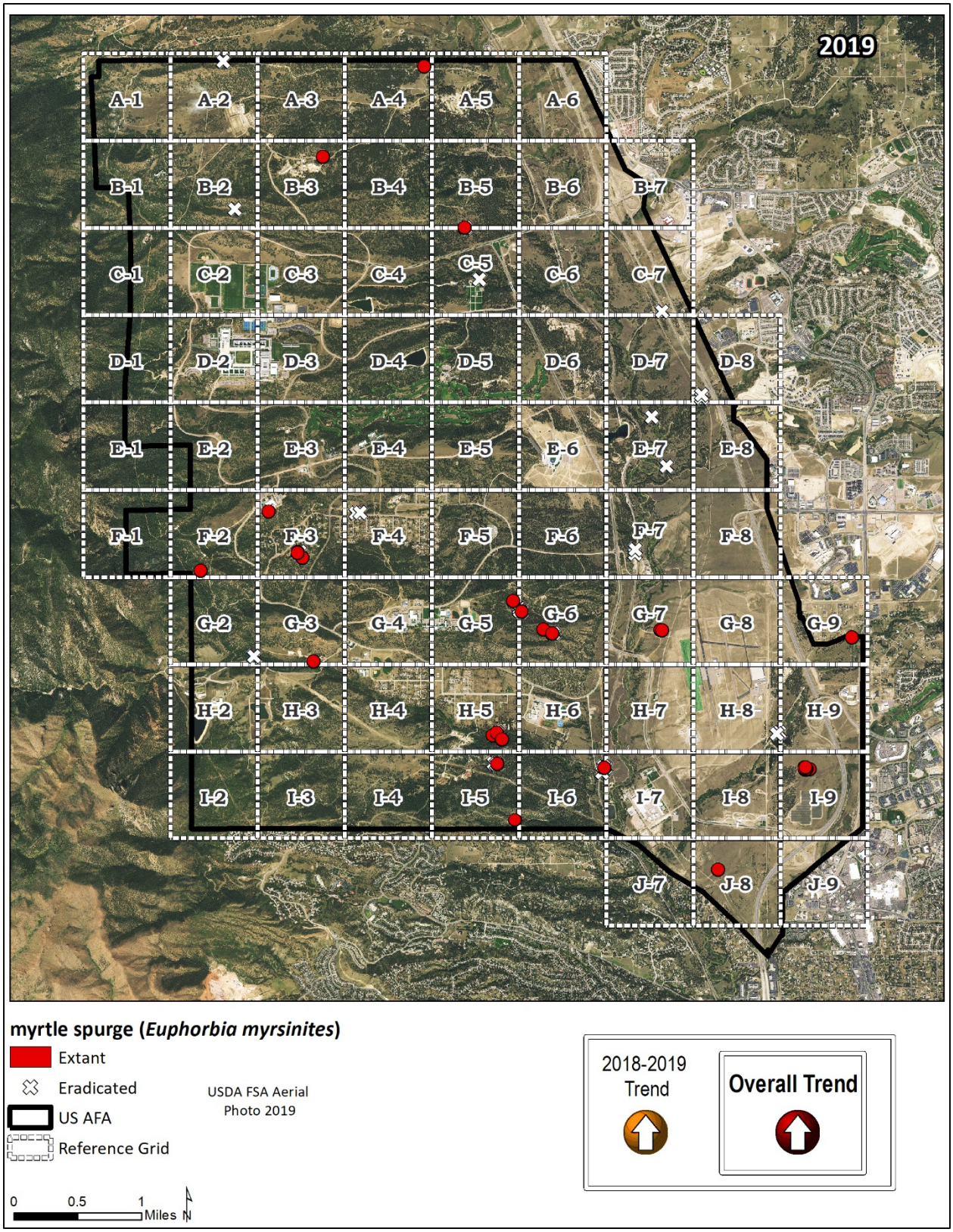
Photo 2. Treated myrtle spurge site with myrtle spurge returning; right side: smooth brome tillers moving into treated area (P. Smith 2016).

History of Sampling and Treatment:

- Natural Resources Staff at the Academy identified the presence of myrtle spurge in 2005 at an early stage of its invasion with seven sites and 25 individuals.
- In 2007, the highest number of plants (1,021) was documented for myrtle spurge.
- 2008-2016 yearly increases in the number of individuals.
- In 2016, 185 individuals were observed at 17 extant features.
- In 2017, we saw an increase in plants at or near known sites from 185 individuals in 2016 to 501 in 2017.
- In 2018, a basewide mapping effort showed myrtle spurge has spread across the entire property and continues to be found even in treated areas.
- In 2019, sprouts were pulled in the spring and throughout the summer. No seeds were produced at the known sites in 2019.



Map 8. Distribution of myrtle spurge at the Academy between 2005 and 2019.



Map 9. Distribution of myrtle spurge at the Academy in 2019 with the reference grid.

Yellow Spring Bedstraw (*Gallium verum*)

Overall Trend: Decreasing

Management Goals: Eradication – Rapid Response

State List: NA (Garden Escape)

- Perennial forb (can be vine-like)
- Has the potential to be invasive once it becomes established
- Blooms June-September
- Dry disturbed sites
- Escaped garden plant
- Seed longevity – no data found

Wikimedia photo

Yellow Spring Bedstraw at Air Force Academy 2015, Pam Smith, CNHP

2019 Results

No plants were found in 2019. Yellow spring bedstraw is a garden escape that was first documented in 2010, it was treated and then found again 2015 and 2018 at the single monitoring point (Table 13, Figure 7, Maps 10 & 11). All plants were removed in 2015 and no plants were found in 2016, 2017 and 2019. In 2018, 102 individuals were mapped and removed.

Table 13. All infestations of yellow spring bedstraw at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2010	<0.01 (28 m^2)	700	1	0
2011	<0.01 (3.1 m^2)	1	1	0
2012	0	0	0	1
2013	0	0	0	1
2014	0	0	0	1
2015	<0.01 (3.1 m^2)	10	1	0
2016	0	0	0	1
2017	0	0	0	1
2018	<0.01	102	1	0
2019	0	0	0	1

Basewide weed mapping performed during shaded years.

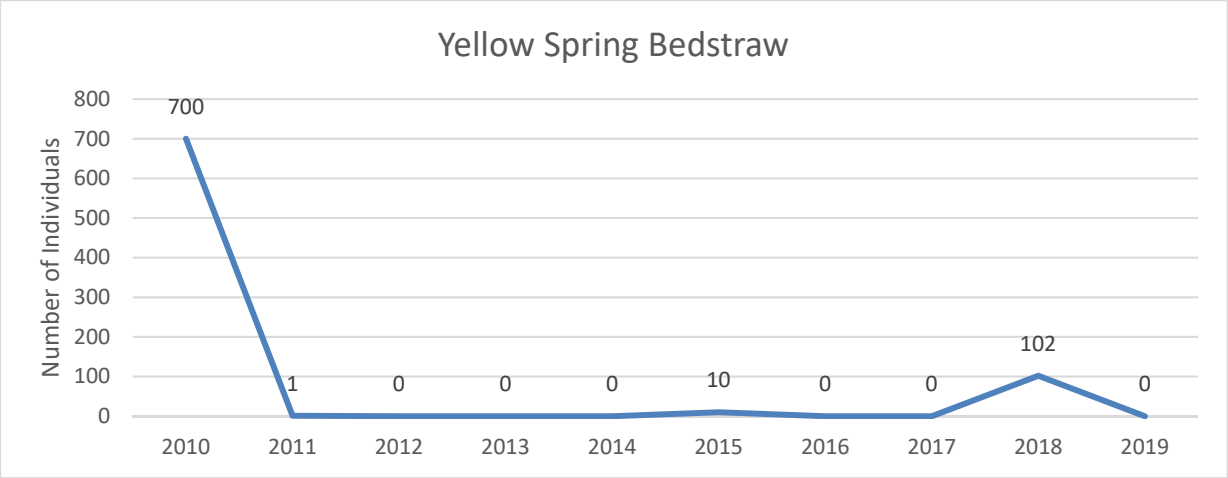


Figure 7. Yellow spring bedstraw trend, 2010-2019.

Treatment 2019

In 2019, there were no plants found in 2019 at the single occurrence of Yellow Spring Bedstraw (Table 14).

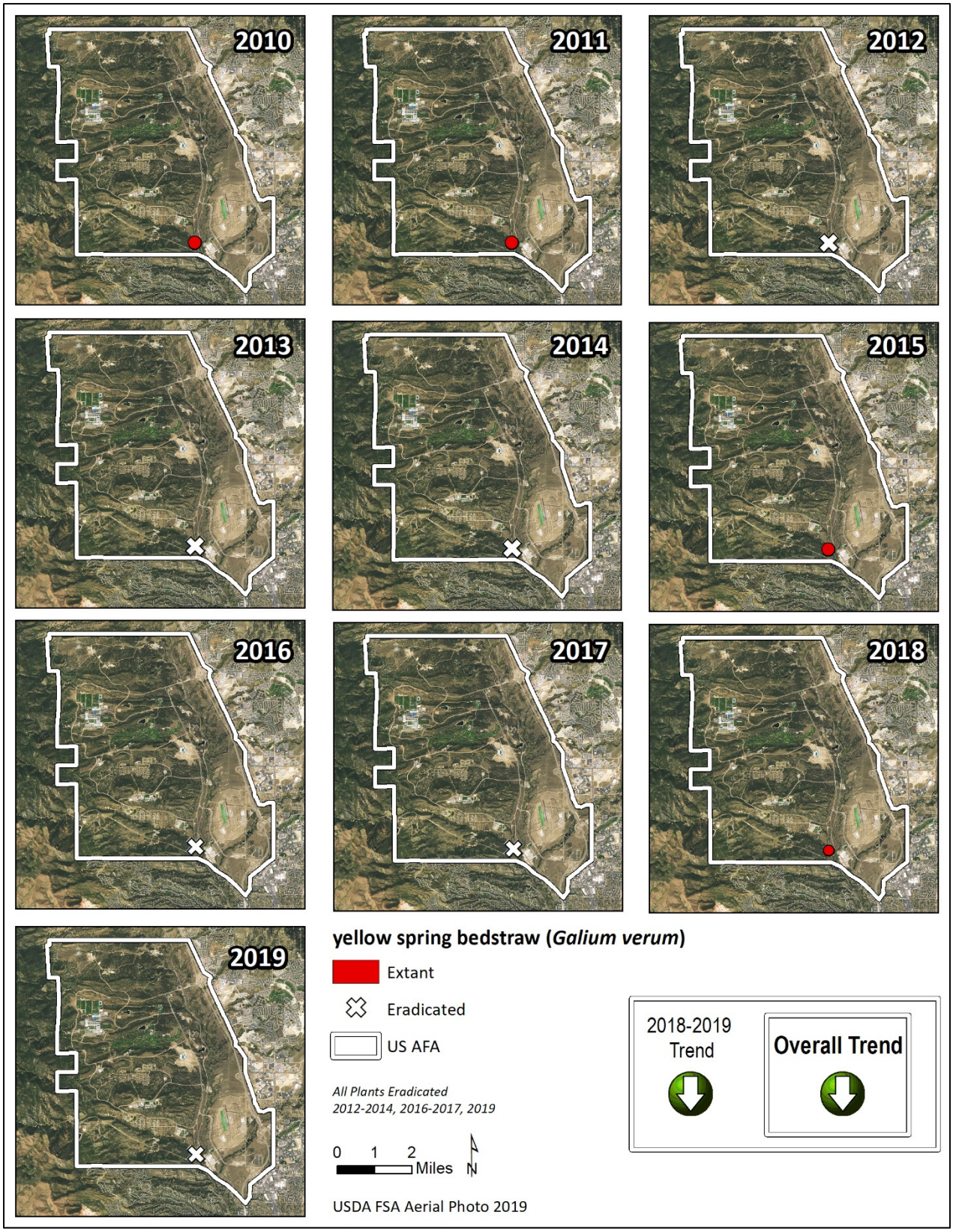
Table 14. Monitoring and treatment of yellow spring bedstraw sites at the Academy in 2019.					
2019	**# Features Visited**	**# Shoots Mapped**	**# Manually Treated Shoots**	**# Treated/Extant Features**	**# Eradicated Features**
Pass 1	1	0	0	0/0	1

Recommendations

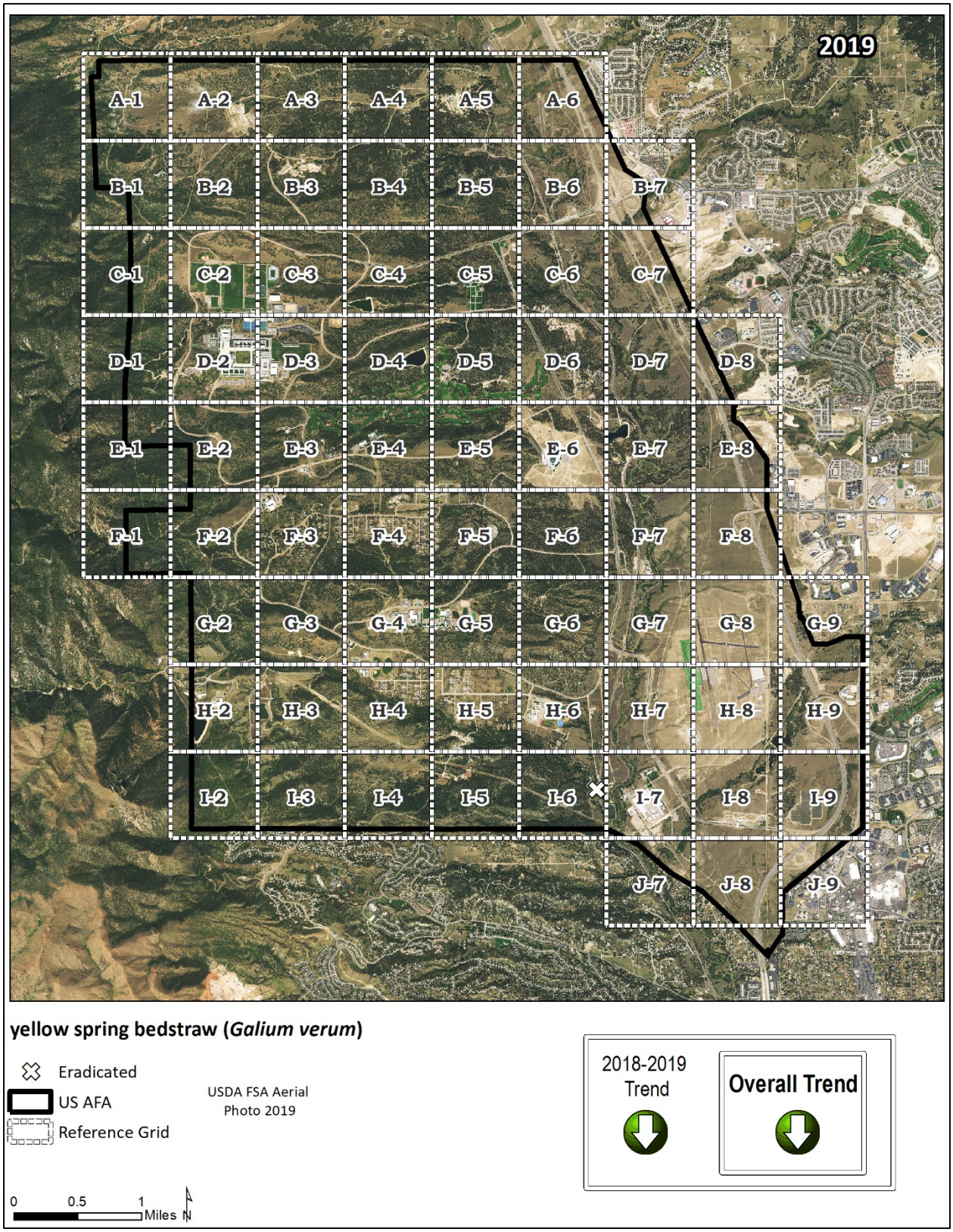
The seed longevity of this plant is not known. Although this plant is not on the State of Colorado noxious weed list, it is a garden escape that has been shown to be aggressive at the Air Force Academy and throughout southern Canada and the northern U.S. It is a rhizomatous perennial plant that does well in dry soils. It is found on the edge of a disturbed riparian area with many native shrubs and herbs at the Academy. Continue to monitor the area for yellow spring bedstraw and remove when detected. Put this species on a watch list for future weed mapping efforts. Keep records of treatments and photograph the site if possible.

History of Sampling and Treatment:

- This species was discovered at the Academy in 2010 with one occurrence found near Ice Lake. The occurrence consisted of 700 individuals in 28 m^2 (0.01 acres). All plants were treated by the Academy.
- CNHP visited this site in 2011 and located and pulled one individual.
- The 2012 mapping project misidentified two additional sites while the original site was still free of this weed.
- No plants were observed in 2012 - 2014.
- In 2015, 10 new plants were discovered at the known site and manually removed by CNHP.
- In 2016 and 2017, no plants were found. The area has been changed by flooding and landscape changes that included the addition of large boulders along the stream where the yellow spring bedstraw had been previously observed.
- In 2018, 102 shoots were found at the same location where it was originally discovered.
- In 2019, no shoots were found.



Map 10. Distribution of yellow spring bedstraw at the Academy between 2010 and 2019.



Map 11. Distribution of yellow spring bedstraw at the Academy in 2019 with the reference grid.

Dame's Rocket (*Hesperis matronalis*)

?

Overall Trend: Unknown

Management Goals: Eradication

State List: B

- Tall, showy short-lived perennial forb
- Garden escape
- Taproot and spreading secondary roots
- Reproduction only by seed
- Seeding late summer and fall with high number of seeds
- First year rosettes are green all winter and ready to grow early in the spring
- Seeds available to the public for horticulture
- Seed longevity is not known, can remain dormant for years (CWMA 2020c)

Top photo: Colostate.edu, Bottom photo rosette by Leslie J. Mehrhoft Univ. Connecticut Bugwood.org

2019 Results

Dames rocket is known from 24 occurrences on Academy property with a 25th monitored on an adjacent private property along the eastern boundary. The populations east of I-25 have had shoot numbers up to 16,871 that were reduced to less than 300 and then began to increase after 2016 (Table 15, Maps 12 & 13). For 2019, all of the points east of I-25 were not visited (21 points) after discussions with Academy staff. The results in Table 15 are assuming the sites are the same as in 2018. The I-25 corridor is under construction and many of the dames rocket plants will likely be impacted. The remaining four mapped points are located on the Academy west of I-25: two are along Kettle Creek south of South Gate Blvd. on the floodplain, and two are close to the southern boundary near the southwest corner. Only one of the four sites had plants present and they were treated by Academy staff in 2019.

Table 15. All infestations of dame's rocket at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	0.83	16,871	14	0
2013†	?	?	?	?
2014†	?	?	?	?
2015	0.08	280	2**	14
2016	0.08	294	3	14
2017	?	?	?	?
2018	0.04	665	8	17
2019	0.04	665	8	17

Basewide weed mapping performed during shaded years.

Treatment 2019

The two sites near Kettle Creek were visited in 2019 and one site was flooded due to beaver activity, and no plants were found at either site. One of the two sites near the southwest corner had 32 plants and the other had no plants. According to Academy staff the extant occurrence was sprayed by the herbicide contractor in June of 2019 (Table 16).

Table 16. Monitoring and treatment of dame's rocket sites at the Academy in 2019.

2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	2	32*	0*	0/1	3

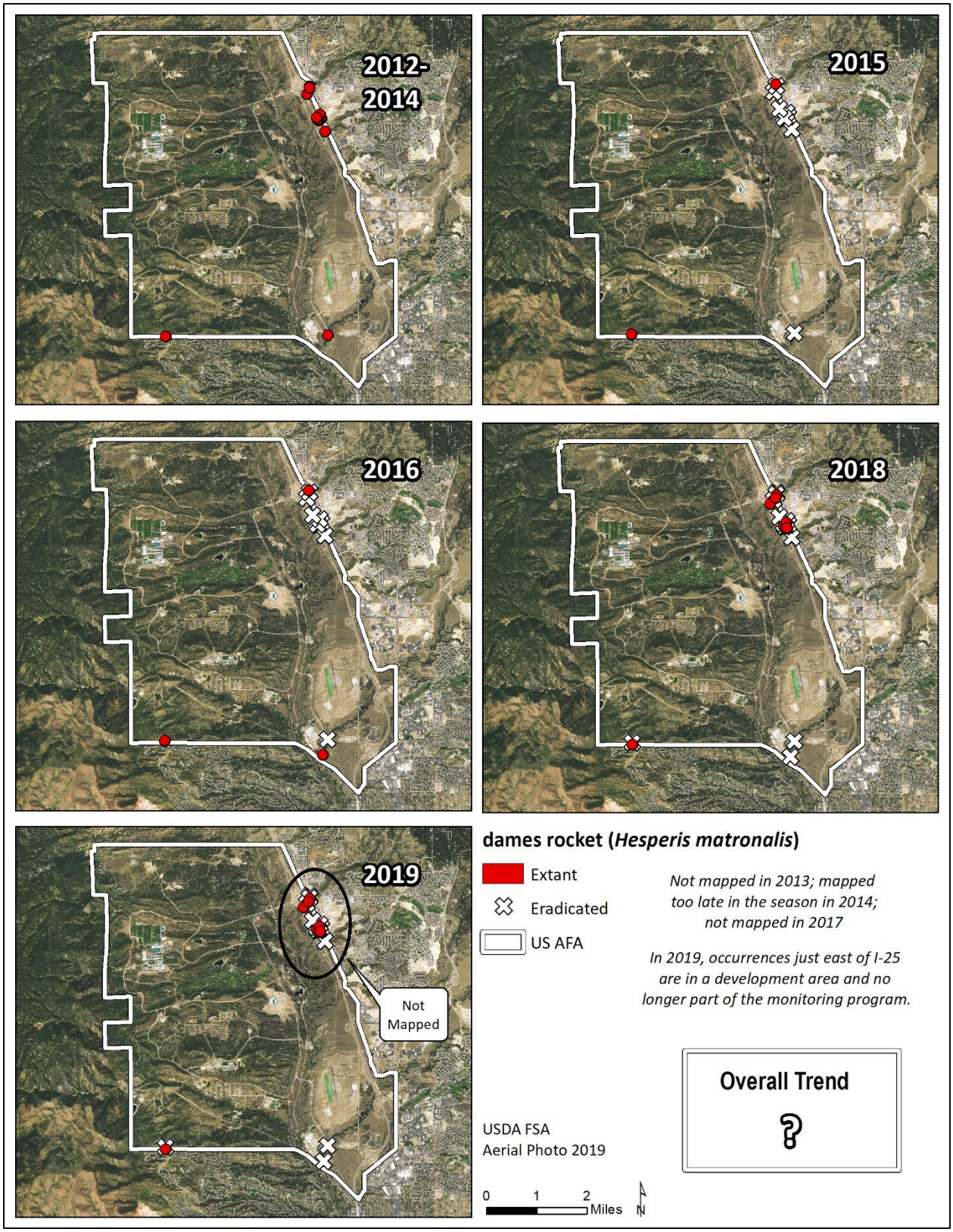
***Herbicide**

Recommendations

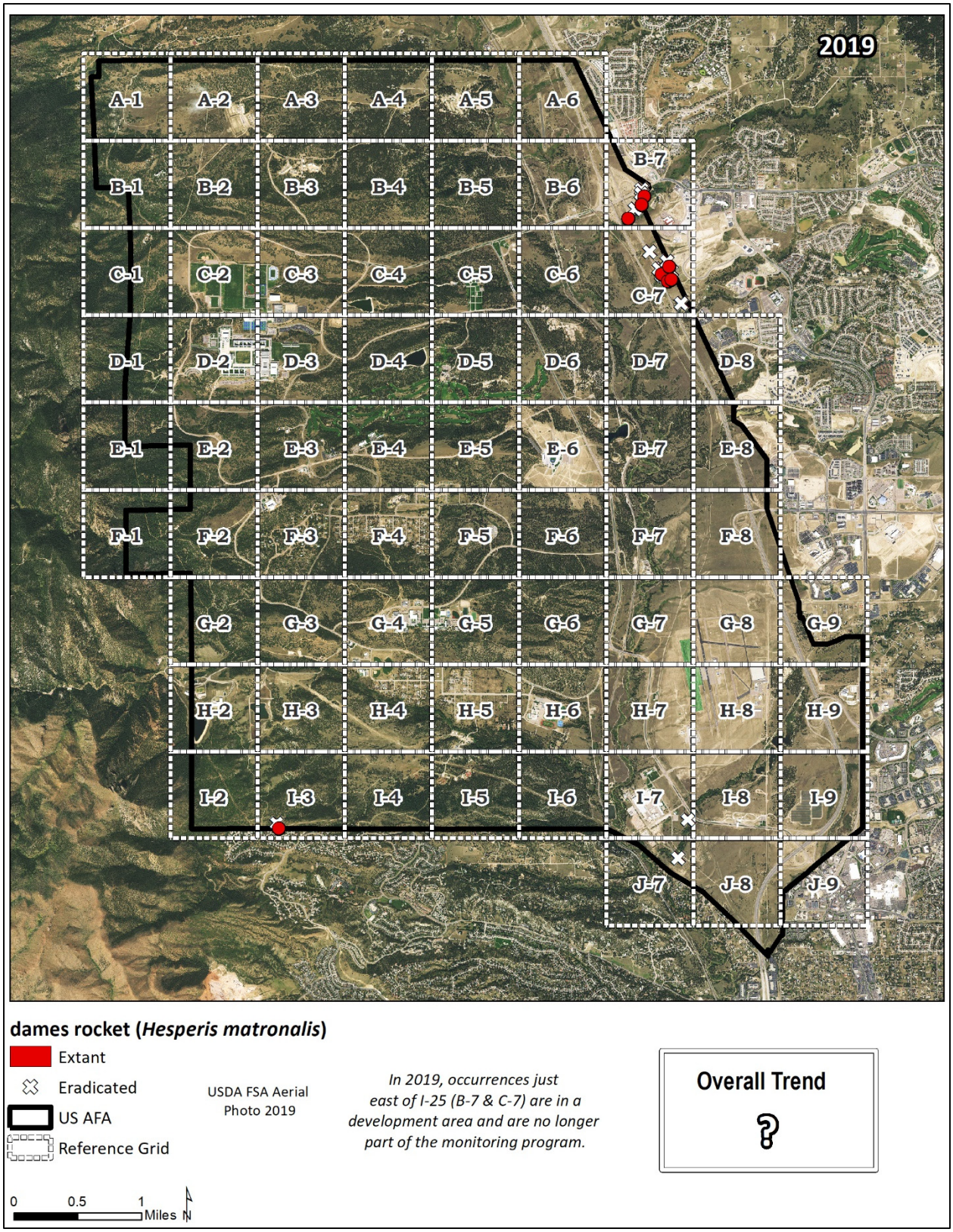
For 2020, all four sites west of I-25 will be visited and evaluated for treatments. Getting to plants before seed set is considered to be essential. Cutting flowering tops is recommended as well as manual removal. Herbicides are only recommended for late fall when native plants are dormant and the basal parts of the dame's rocket are susceptible to the chemical (glyphosate recommended). The number one priority is not to disturb nearby intact vegetation during any type of treatment. The applicator will need to recognize the rosettes (or have them flagged by CNHP). For small infestations, consider manual removal of plants with follow-up monitoring. Continuous herbicide treatments have the potential to exacerbate weed invasions and open up the area to more or different weed species. Rare plants, wetlands, and intact prairie uplands were located within the areas being treated. Because the seed longevity is quite long, all of the sites should be monitored for multiple years. Any future herbicide applications need to be done with a site plan that will require a more precise application method, herbicides that are acceptable at the proper stage (fall rosettes) and make sure chemicals are appropriate for wetlands and floodplains, and continued follow-up monitoring after any type of treatment.

History of Sampling and Treatment:

- Dame's rocket was first discovered in 2012, near I-25. The 2012 mapping project (Rondeau and Greenwell 2013) documented 0.18 occupied acres with 16,871 shoots in 14 locations.
- Dame's rocket was not monitored in 2013 and visited too late in the season in 2014.
- In 2015, there were two extant locations out of a total of 15 known locations. One of the locations was not visited in 2015 (south boundary location discovered in 2014 by base personnel) and presumed extant. Although plants have been impacted by herbicide application, excess overspray in the application of herbicides may be contributing to large areas of damage to adjacent native species in the natural areas.
- In 2016, two of the three known extant populations were visited by CNHP and one by Academy staff. One did not change and still contained 150 plants. The location in the south west part of the Academy was behind a locked gate and was not visited in 2016. A new location was documented in the south east part of the AFA in 2016 with 14 individuals.
- In 2017, no sites were visited due to a late field start date.
- In 2018, more than half of the known locations had dame's rocket plants. No new locations were mapped.
- In 2019, only plants west of the I-25 corridor were visited due to construction activities to the east. The only extant site was treated with herbicides in 2019 by the contractor.



Map 12. Distribution of dame's rocket at the Academy between 2012 and 2019.



Map 13. Distribution of dame's rocket at the Academy in 2019 with the reference grid.

Orange Hawkweed (*Hieracium aurantiacum*)

Overall Trend: Increasing (New in 2018 at Farish)

Management Goals: Eradication

State List: A

Photo: Pam Smith CNHP, Sept 2018 Farish

- Perennial
- Reproduction by seed, rhizomes and stolons
- Flowers June-August
- Native look-a-like is orange agoseris (*Agoseris aurantica*)
- Seeds are viable for seven years
- 100 to 1,000 seeds/plant (CWMA 2020d)

2019 Results

Orange hawkweed was first observed at Farish Recreation Area in 2018 when 200 plants were observed (Table 17). It was found in a shaded forest area near a campground access road. In June of 2019, a photo plot was established and 600 plants were removed manually. Only two plants were in flower with the rest vegetative. The root system is extensive and intertwined with the mosses and roots of native plants making it difficult to remove all the roots without a large soil disturbance. A fall visit was conducted in late August and another 656 individuals were removed at that time, without creating a big soil disturbance and keeping nearby vegetation intact (Table 18, Map 14). This is another site that demonstrates the importance of same season follow-up visits. We removed more plants in the fall than at the previous visit and no plants went to seed.

Table 17. All infestations of orange hawkweed at Farish.				
	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2017	---	---	---	---
2018	<0.01	200	1	0
2019	<0.01	600	1	0

Basewide weed mapping performed during shaded years.

Treatment 2019

In 2019, a total of 1,257 shoots removed at 1 extant site at two site visits, one in early summer and one in late summer. No plants went to seed in 2019 (Table 18).

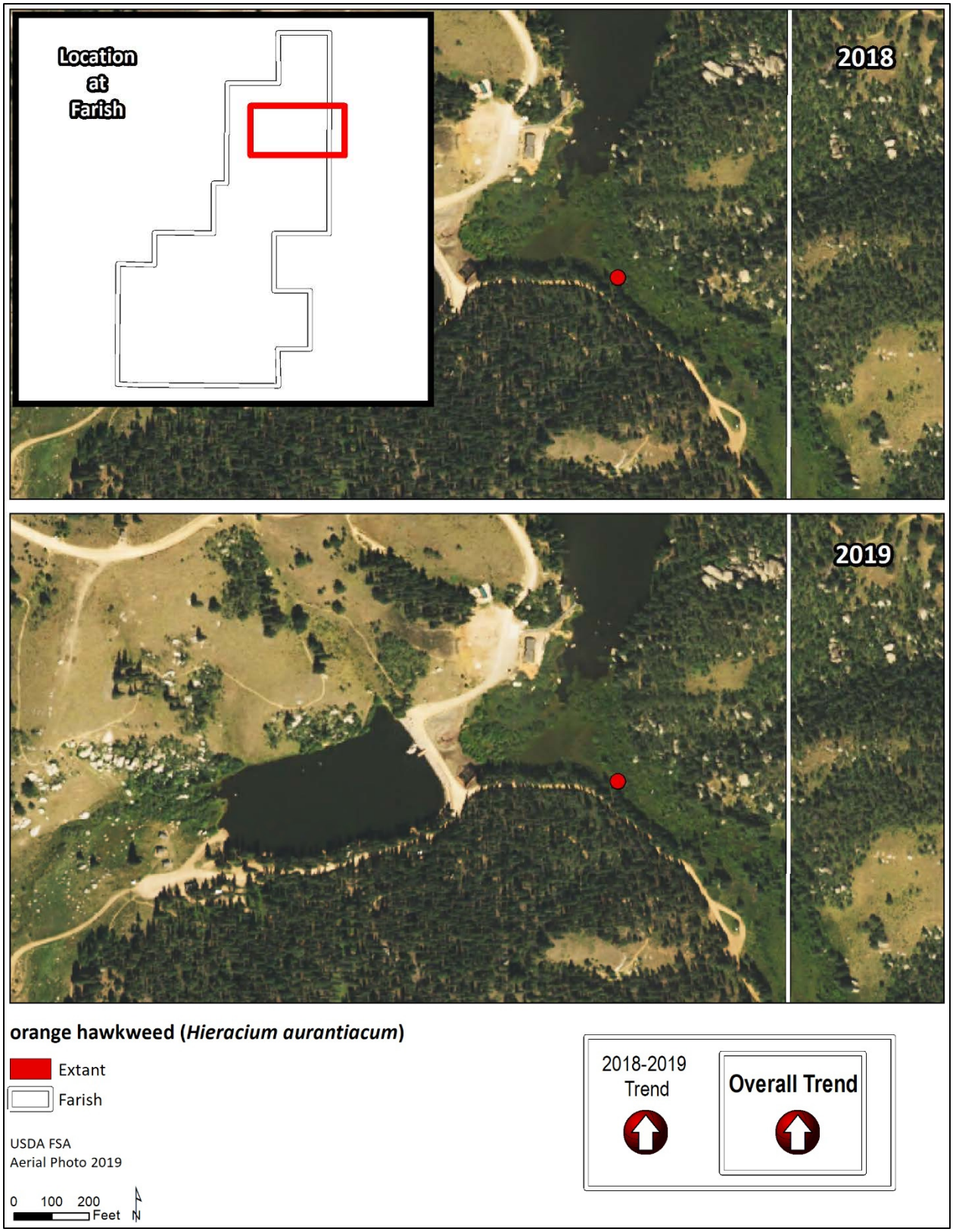
Table 18. Monitoring and treatment of orange hawkweed sites at Farish in 2019.					
2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	1	600	600	1/1	0
Pass 2	1	657	657	1/1	0
TOTALS	2	1,257	1,257	---	---

Recommendations

The plan for 2020 is to visit the site before flowers are produced in late May or early June. Counts and plot photos will be taken and all above ground parts and roots that can be removed without disturbing nearby native plants, will be bagged and transported off-site for disposal. A second and possible third visit will follow in late summer and/or fall to remove any plants found. Considerations may also include herbicide treatments and seeding based on the outcome of the early summer visit.

History of Sampling and Treatment:

- Orange hawkweed was first discovered at Farish on September 20, 2018, while conducting a survey of a nearby wetland in the campground area.
- In 2019, 600 plants were removed manually in the spring, followed by the removal of another 657 sprouts in late summer. No plants went to seed.



Map 14. Close-up of orange hawkweed at Farish between 2018 and 2019.

Common St. Johnswort (*Hypericum perforatum*)

Overall Trend: Decreasing

Management Goals: Containment

State List: C

- Perennial forb
- Early successional stage
- Invades disturbed areas
- Can produce fertile seeds without pollination
- Reproduction by seed and sprouts from lateral roots and crowns
- Grows in dry and wet areas in PMJM habitat
- Seeds viable in seed bank 20+ years

Photo by Renee Rondeau, CNHP

Photo by Michelle Washebek, CNHP

2019 Results

In 2019, there was a decrease in the estimated number of shoots and a slight increase in the occupied acres compared to 2018. Since 2012, there has been a large reduction in the number of plants, but the number of extant features is increasing from 47 in 2017 to 74 in 2019 and the occupied acres are rising (Table 19, Figure 8, Maps 15 & 16).

Table 19. All infestations of common St. Johnswort at the Academy.

	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002†	<0.10	363	5	5	---
2007	0.86	44,647	8	8	0
2008	1.07	130,371	13	13	0
2009	2.02	95,883	23	21	2
2010	1.47	82,733	26	20	6
2011	1.44	87,128	31	26	5
2012	1.16	83,115	39	29	10
2013	0.85	2,621	43	22	21
2014	1.12	3,604	52	33	19
2015	1.27	3,102	56	27	29
2016	1.02	6,717	60	32	27
2017	1.31	4,202	70	47	23
2018	1.26	16,416	83	57	27
2019	1.41	11,543	95	74	28

†2002 values from field notes, not adequately mapped in GIS. **Basewide weed mapping performed during shaded years.**

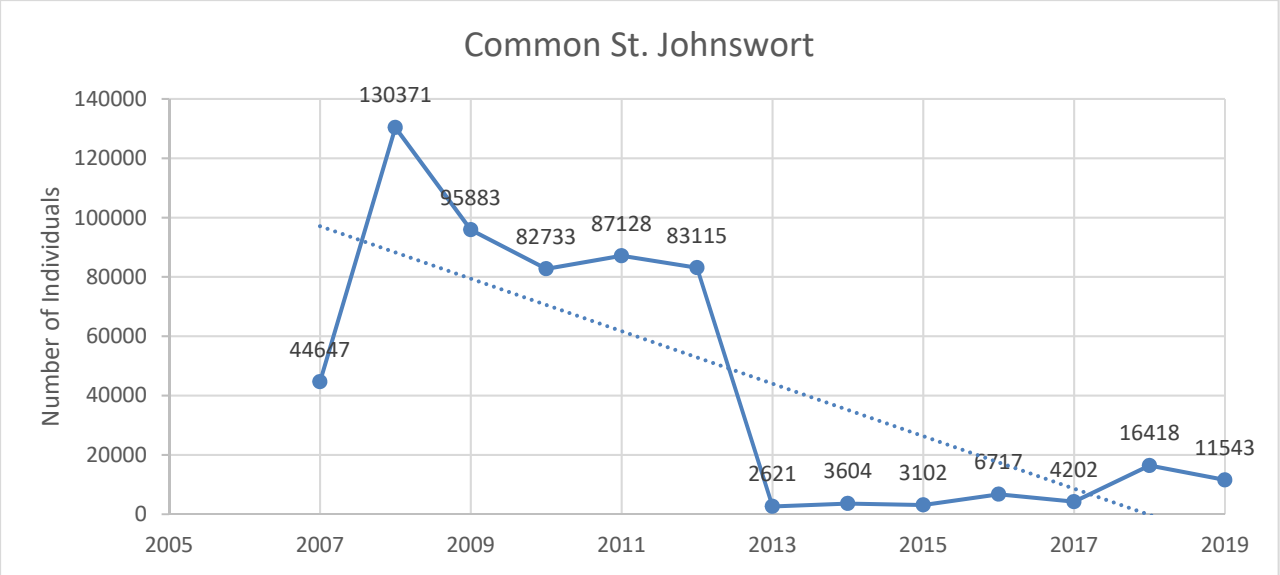


Figure 8. Number of individuals and extant features of common St. Johnswort, 2009-2019.

Treatment 2019

In 2019, a total of 95 common St. Johnswort features were visited for monitoring and treatment. Of those 95 sites, 71 were extant and contained 11,187 shoots. At a second visit later in the season to 56 sites had 27 extant with 6,717 shoots and 12 eradicated features. Therefore, a total of 3,482 shoots manually treated (Table 20). Sites not treated were either too large to treat manually, treated with herbicides or had active biocontrol agents observed in 2019.

Table 20. Monitoring and treatment of common St. Johnswort sites at the Academy in 2019.

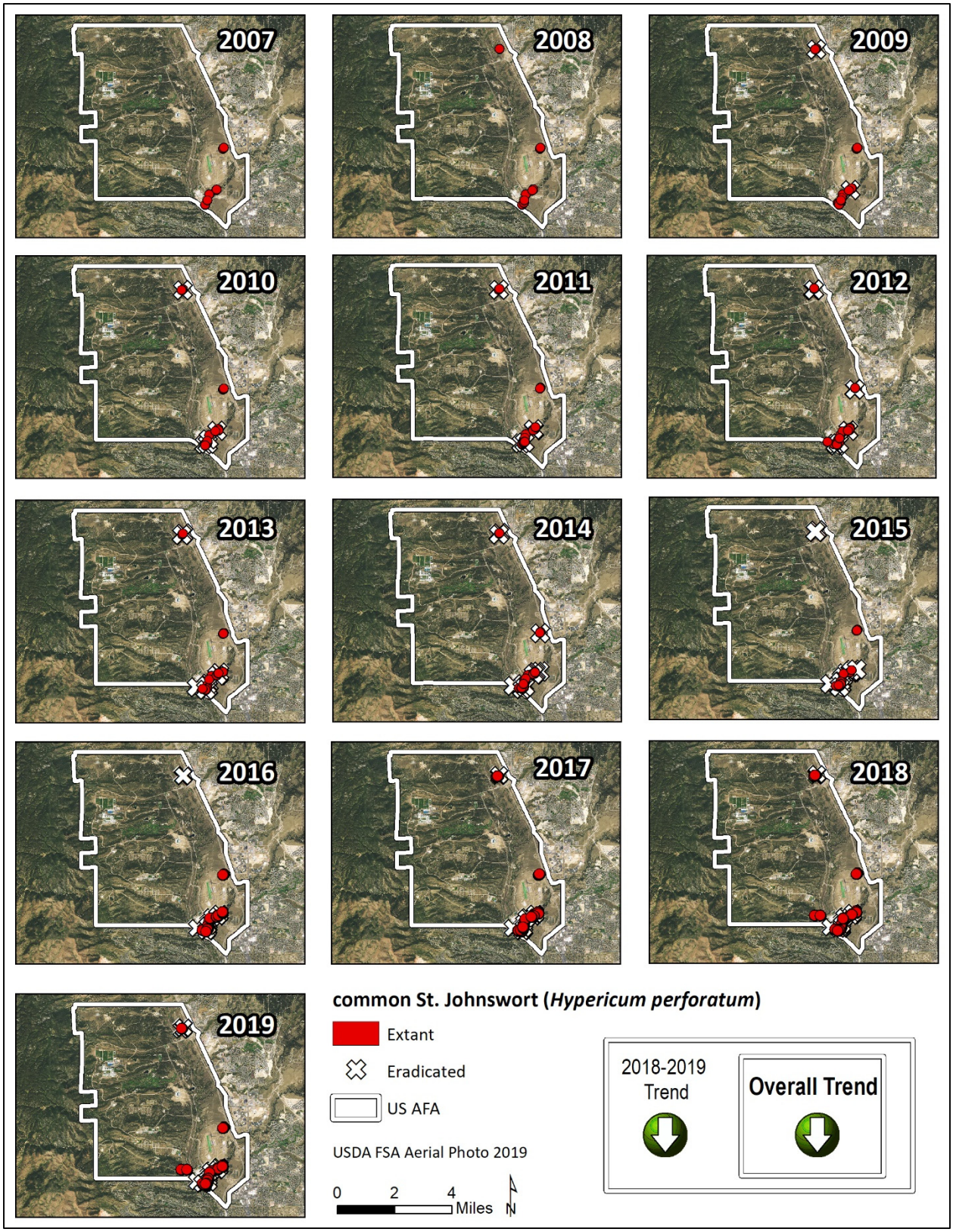
2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	95	11,187	2,315	40/71	24
Pass 2	56	6,717	1,167	27/44	12
TOTALS	**---**	**---**	**3,482**	---	---

Recommendations

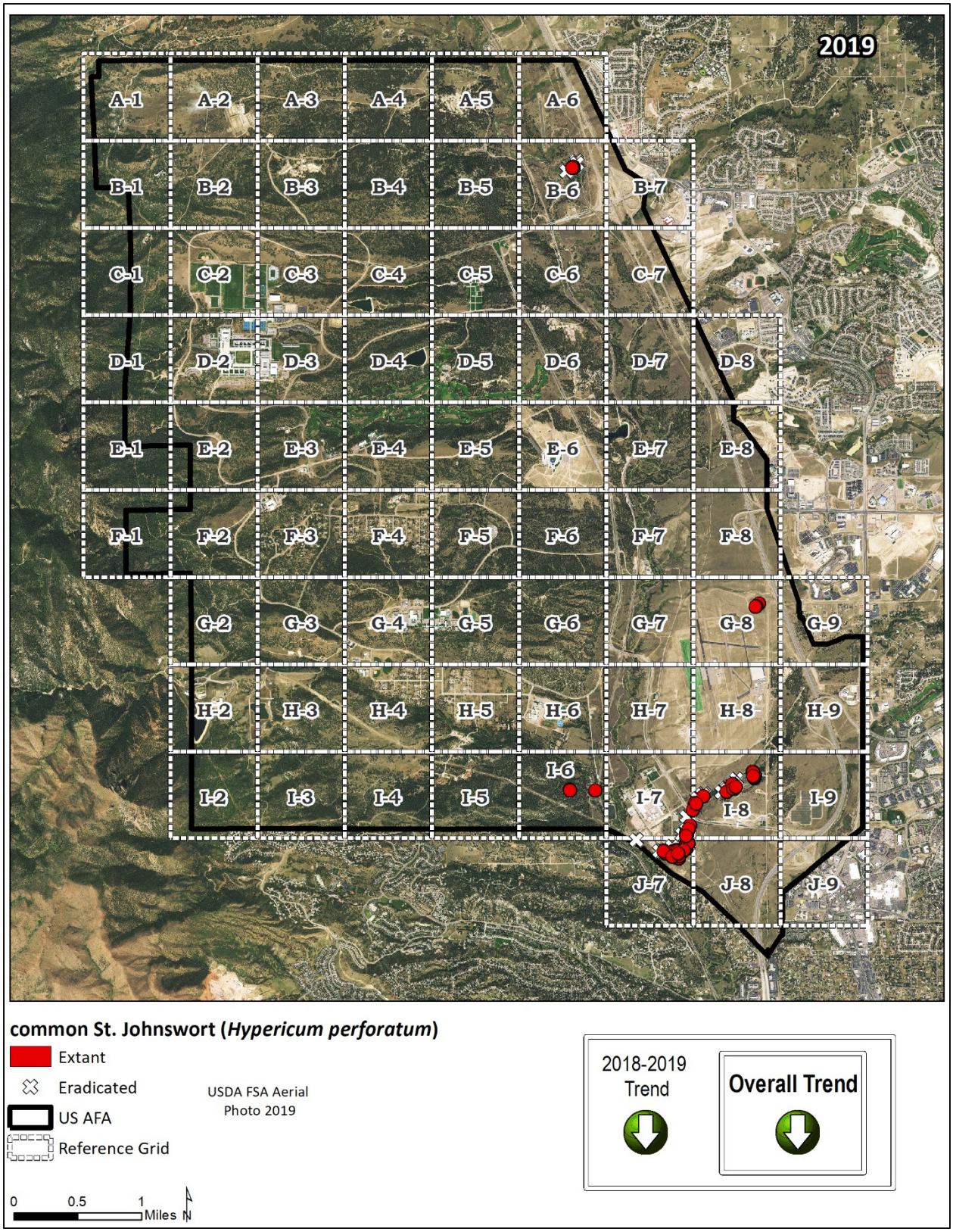
Large numbers of plants are removed during flooding events and washed downstream. In addition, biocontrol organisms are present and active at the Academy. However, the number of shoots has been increasing. Continued manual treatments are recommended for small sites. Discussions and coordination needs to me maintained with Academy staff, herbicide applicator and CNHP so that monitoring and treatments go smoothly in 2019. Some decreased in shoot numbers and occupied acres are due to flooding and some may be due to biocontrols which are commonly observed.

History of Sampling and Treatment:

- Common St. Johnswort was first seen at the Academy in 2002, but was described in field notes and not comprehensively mapped using the GPS.
- Common St. Johnswort was added to the monitoring list in 2007.
- The populations peaked in 2008-2009.
- Biocontrol efforts were discontinued in 2010.
- A significant decline occurred in 2012-2013, with a small spike in 2016.
- In 2017, the numbers of individuals declined while the number of extant sites increased.
- In 2018, basewide mapping showed an increase in the number of individuals and mapped features while the occupied acres remained relatively stable.
- In 2019, there was a decrease in the number of shoots compared to 2018 with a slight increase in occupied acres. Biocontrol organisms were observed at multiple sites.



Map 15. Distribution of common St. Johnswort at the Academy between 2007 and 2019.



Map 16. Distribution of common St. Johnswort at the Academy in 2019 with the reference grid.

Perennial Pepperweed (*Lepidium latifolium*)

Overall Trend: Stable (New in 2018)

Management Goals: Eradication, Rapid Response

State List: B

Photo: Kate Wright CNHP 2018 at the Academy

- Perennial
- Reproduction by seed and creeping roots
- Flowers May-July
- Roots to 9 feet deep and 10 feet lateral spread

2019 Results

Two locations of perennial pepperweed were mapped at the Academy in 2018, one is located in NE Jack's Valley and the other is near I-25 in the southeast part of the Academy. The number of plants and occupied acres has remained stable between 2018 and 2019 with just over 200 individuals (Table 21, Maps 17 & 18).

Table 21. All infestations of perennial pepperweed at the Academy.				
	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2018	0.02	213	2	0
2019	0.03	212	2	0

Basewide weed mapping performed during shaded years.

Treatment 2019

In 2019, CNHP flagged 12 plants at the northern occurrence and 200 at the southern occurrence in early summer for the herbicide contractor. All plants were then treated with herbicide and a second visit followed a few weeks later by CNHP where all the plants were found to be alive but were starting to be impacted by the treatment. The third visit in late summer showed there were three dead standing individuals at the northern site and six that were not yet killed at the southern site. The three dead standing individuals were again observed in late summer at the north site and with six extant individuals, three sprouting and three only partially killed were removed manually during the fourth visit in early fall. One of the sprouting individuals was flowering. In 2019, each site was visited four times for a total of eight site visits with 433 shoots mapped (Table 22). The herbicide treatment began to impact plants several weeks after application and six plants that sprouted were manually removed in late summer (Photo 3).

A photo plot was established to track the efficacy of treatments. The off-target damage was limited during the herbicide application, protecting native species in the vicinity of the pepperweed plants.

Table 22. Monitoring and treatment of perennial pepperweed sites at the Academy in 2019.					
2019	**# Features Visited**	**# Shoots Mapped**	**# Manually Treated Shoots**	**# Treated/Extant Features**	**# Eradicated Features**
Pass 1	2	212	0	0/2	0
Pass 2	2	**212***	0	**2***/2	0
Pass 3	2	9	0	2/2	0
Pass 4	2	9	6	2/2	0
TOTALS	**2**	**212**	**6**	**2/2**	**0**

***Herbicide application plants not dead.**

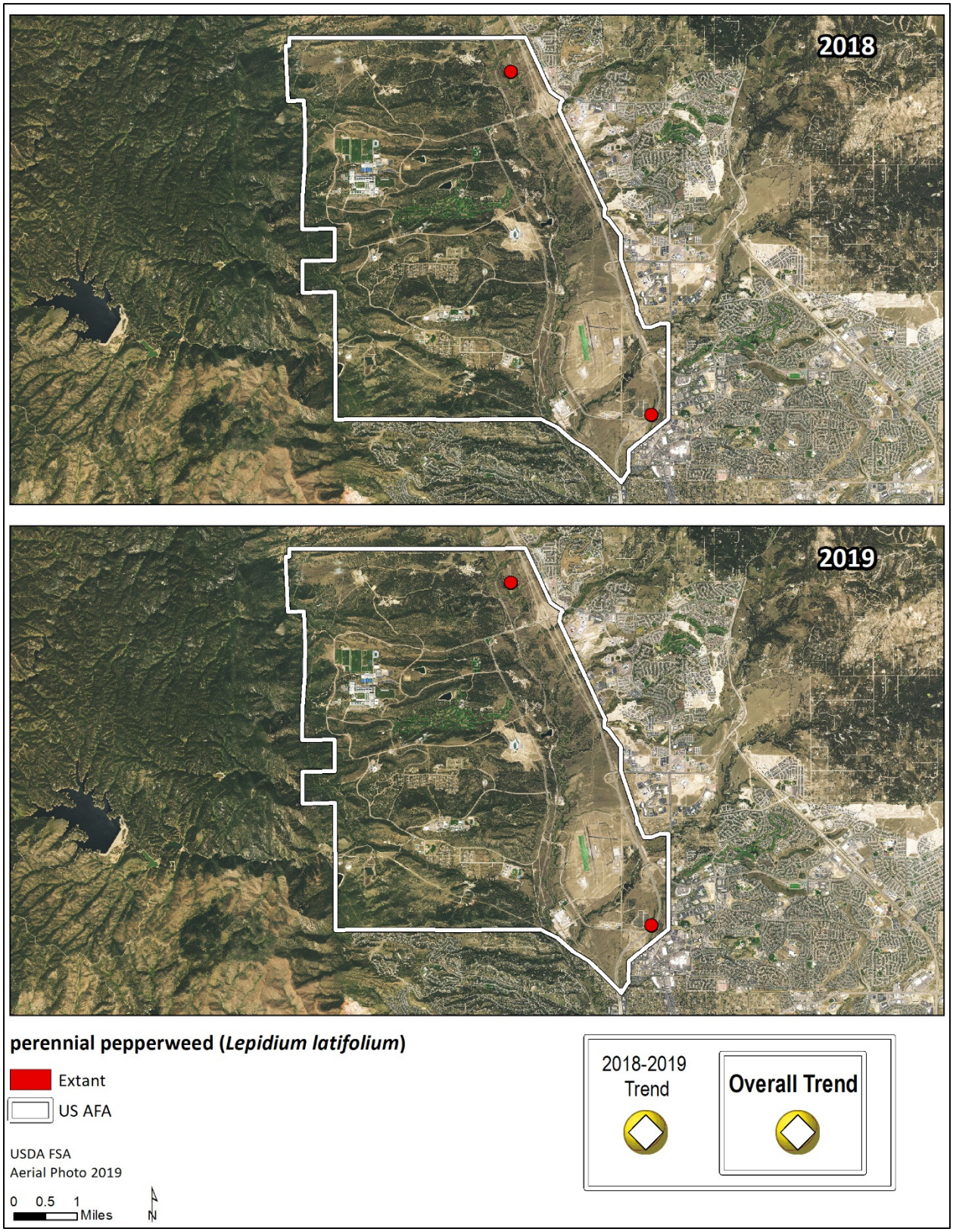
Photo 3. Two partially killed perennial pepperweed plants (left) that went on to sprout leaves and flowers in late summer.

Recommendations

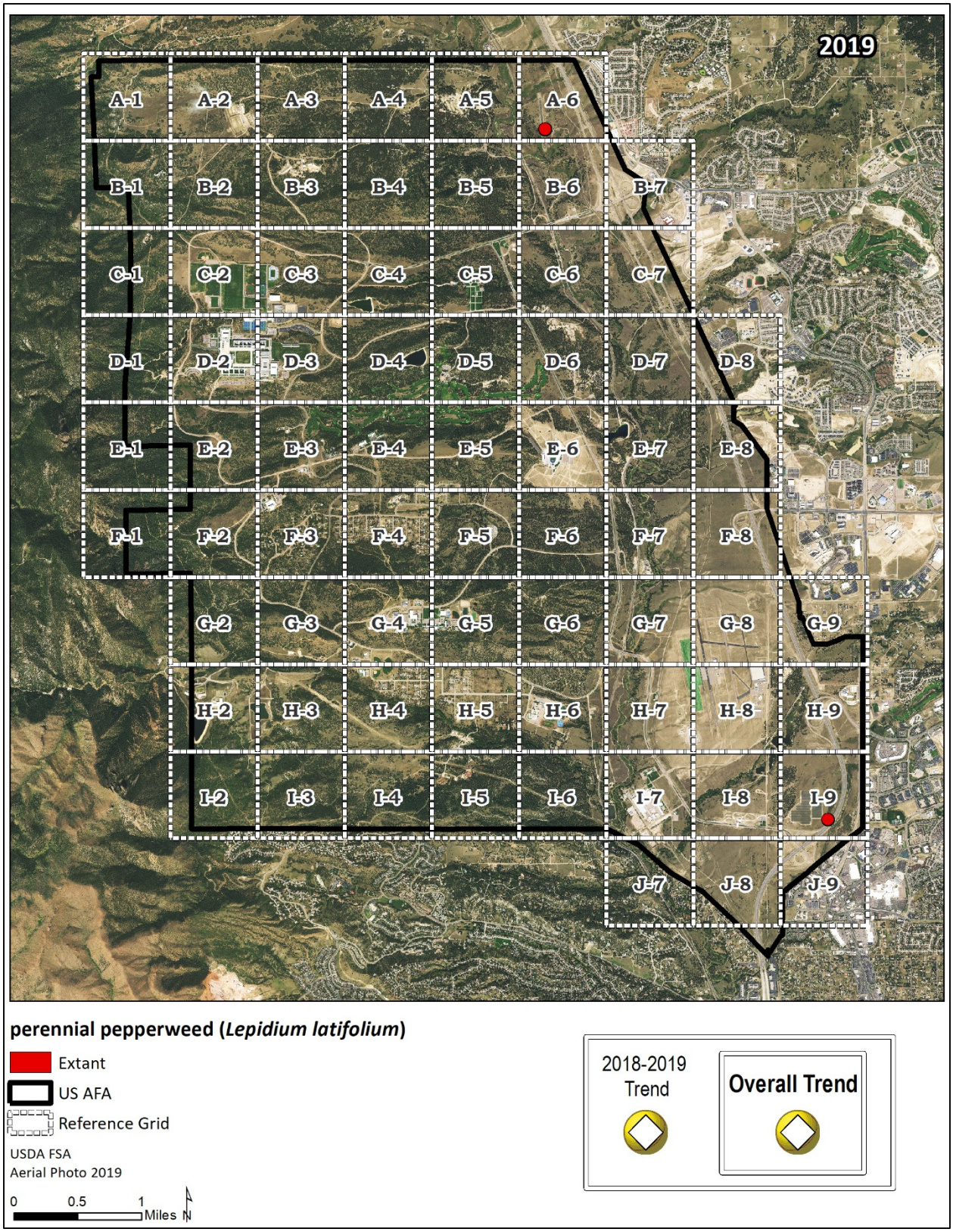
Rapid response treatments should continue for 2020. The most important aspect of treating this species is not to disturb the surrounding vegetation. Herbicide treatments alone do not work, a combination of mechanical, herbicide and plantings are necessary (Young et al 2002). A coordination of efforts will be determined after the early summer visit to see how last year's herbicide application is working.

History of Sampling and Treatment:

- Perennial pepperweed was first documented by CNHP during the 2018 basewide weed survey, although herbicide treatment data suggest it has been present since 2015.
- In 2019, the number of shoots were almost identical to 2018. All plants were treated with herbicide in early summer. Six plants re-sprouted and were removed manually in late summer. No plants went to seed at the known sites in 2019.



Map 17. Distribution of perennial pepperweed at the Academy between 2018 and 2019.



Map 18. Distribution of perennial pepperweed at the Academy in 2019 with the reference grid.

Oxeye Daisy (*Leucanthemum vulgare*)

Overall Trend: New in 2019

Management Goals: Eradication

State List: B

Left: Basal leaves of Oxeye Daisy, Joseph M. DiTomaso, Univ. California, Bugwood.org. Right: Mary Ellen Harte, Bugwood.org

- Garden Escape
- Short-lived perennial
- Reproduction by seeds, roots and root fragments
- Shallow root system
- Blooms June -August
- Resembles Shasta Daisy but much smaller (2 ft vs 4 ft tall, head less than 3' across vs up to 5")
- Upper leaves clasp the stem, lower leaves have petioles and are spoon shaped
- Seed longevity 38+ years (CDA-CSU 2015b)

Diagram by Mary Eaton/ Wikimedia Commons

2019 Results

The oxeye daisy is a new species of a List B Noxious Weed that was observed in Kettle Creek in 2019 (Maps 19 & 20). A total of 52 individuals at five locations were mapped and treated.

Treatment 2019

A total of 52 shoots of oxeye daisy were manually removed from five sites in 2019 (Table 23).

Table 23. Monitoring and treatment of oxeye daisy sites at the Academy in 2019.

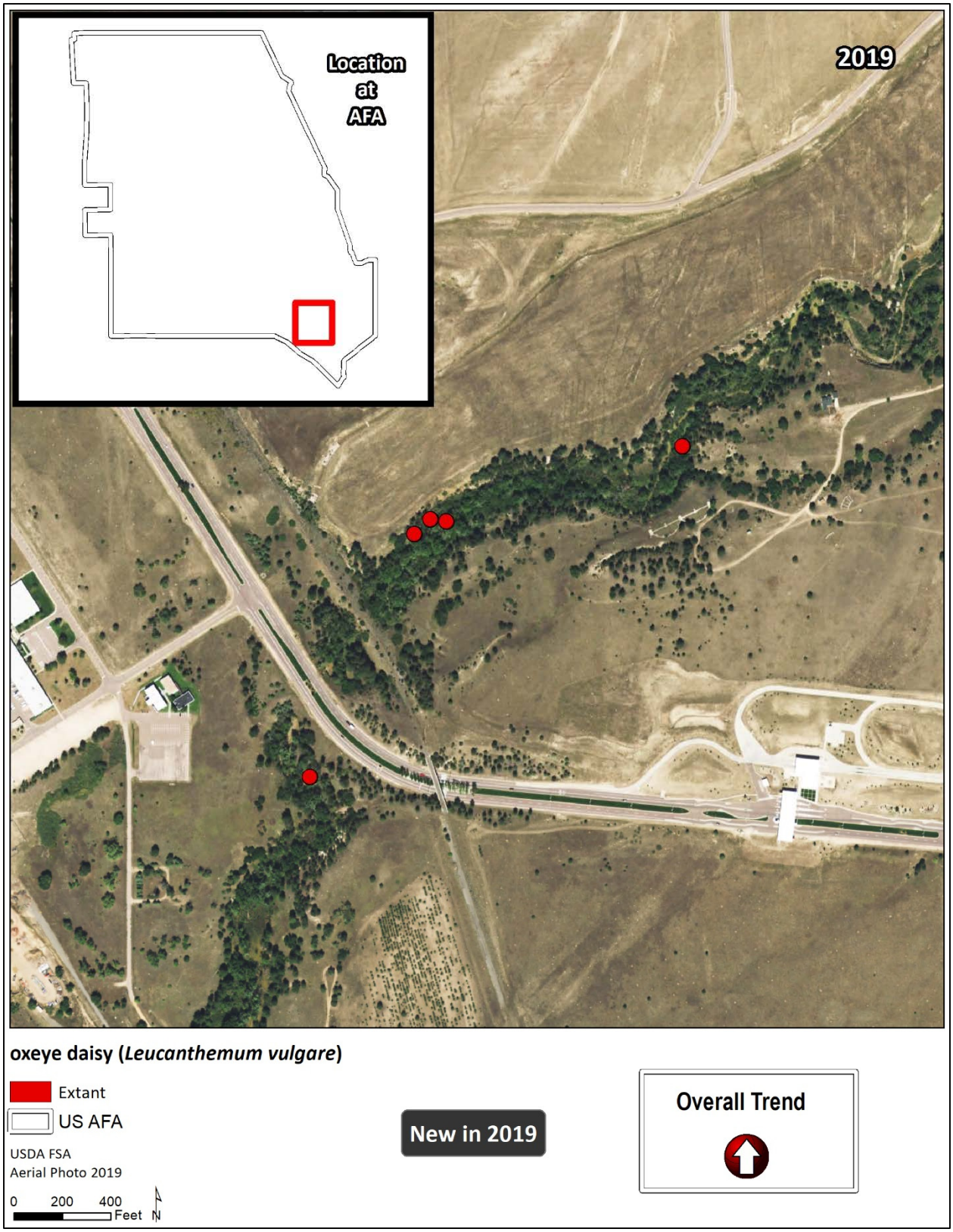
2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	5	52	52	5/5	0

Recommendations

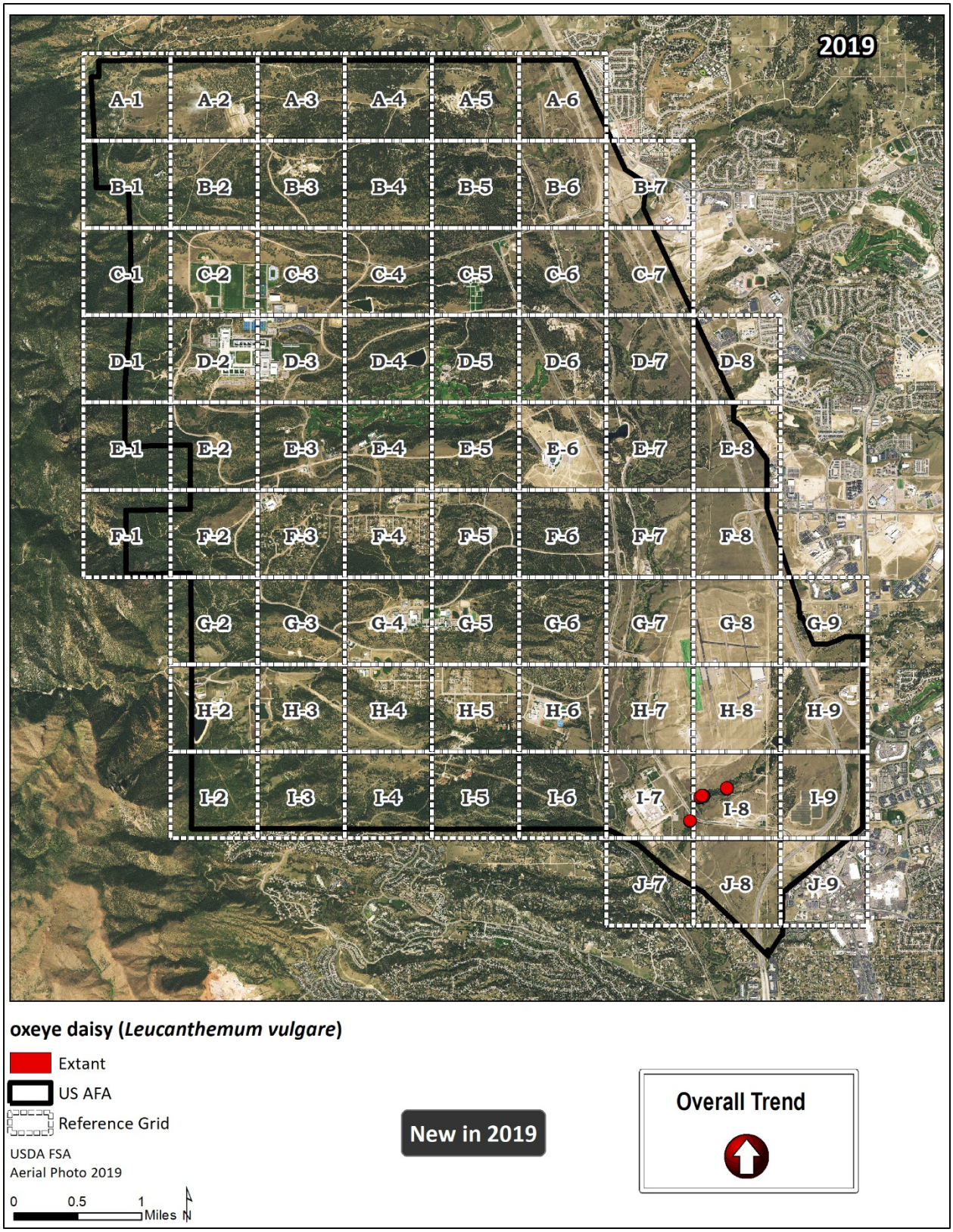
This is a high priority rapid response species. The source of seeds is most likely residential properties as oxeye daisy commonly escapes from gardens to wild lands. It is a short-lived perennial that can reproduce via both root fragments and seeds and can spread quickly. The seed longevity is extremely long. However, the shallow root system and low number of individuals observed makes manual removal a viable option (CDA-CSU 2015b) and continual monitoring is a necessary not only at Kettle Creek but across the base to look for new plants.

History of Sampling and Treatment

- 2019 is the first year oxeye daisy has been found at the Academy. All 52 individuals were removed at five features.



Map 19. Distribution of oxeye daisy at the Academy in 2019.



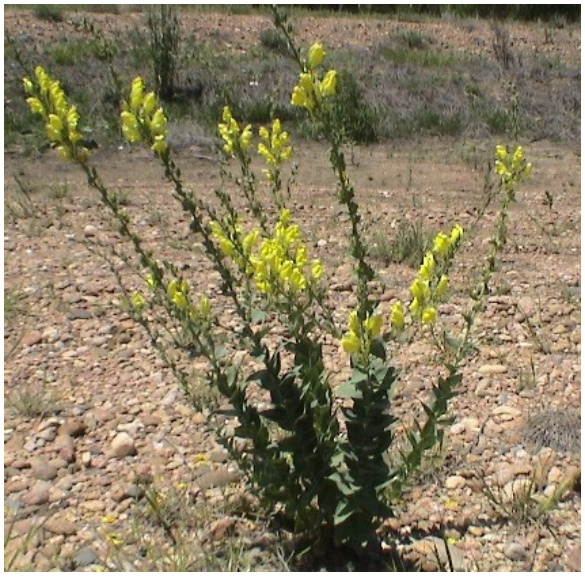
Map 20. Distribution of oxeye daisy at the Academy in 2019 with the reference grid.

Dalmatian Toadflax (*Linaria dalmatica*)

Overall Trend: Decreasing

Management Goals: Eradication, Rapid Response

State List: B



Photos: Colorado State University

- Perennial forb
- Prefers disturbed areas
- Escaped garden plant
- Emergence early spring, flowers May-June
- Reproduction by seeds and root buds
- Extensive root systems in established populations
- Difficult to control (USFS-USDA 2014b)

2019 Results

In 2019, no plants were observed in the spring or the fall at all four locations. However, these plants seem to reappear at treated sites after three to five years. In 2017, 480 plants were pulled near Kettle Pond at a site that had no plants in 2015, 1 plant in 2016 and 480 plants in 2017 which were pulled. There were 52 individuals mapped at the same location in 2018. This demonstrates the need for continuous yearly monitoring for the rapid response species at the Academy (Table 24, Figure 9, Maps 21 & 22).

Table 24. All infestations of Dalmatian toadflax at the Academy.

	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---	---
2007	---	---	---	---	---
2009	?	10	1	1	0
2010	0.50	107	3	2	1
2011	0	0	3	0	3
2012	0	0	3	0	3
2013	?	12	4	1	3
2014	<0.01 (12.5 m^2)	7	4	1	3
2015	0	0	4	0	4
2016	<0.01	1	4	1	3
2017	<0.01	480	4	1	3
2018	0.01	52	4	1	3
2019	0	0	4	0	4

Basewide weed mapping performed during shaded years.

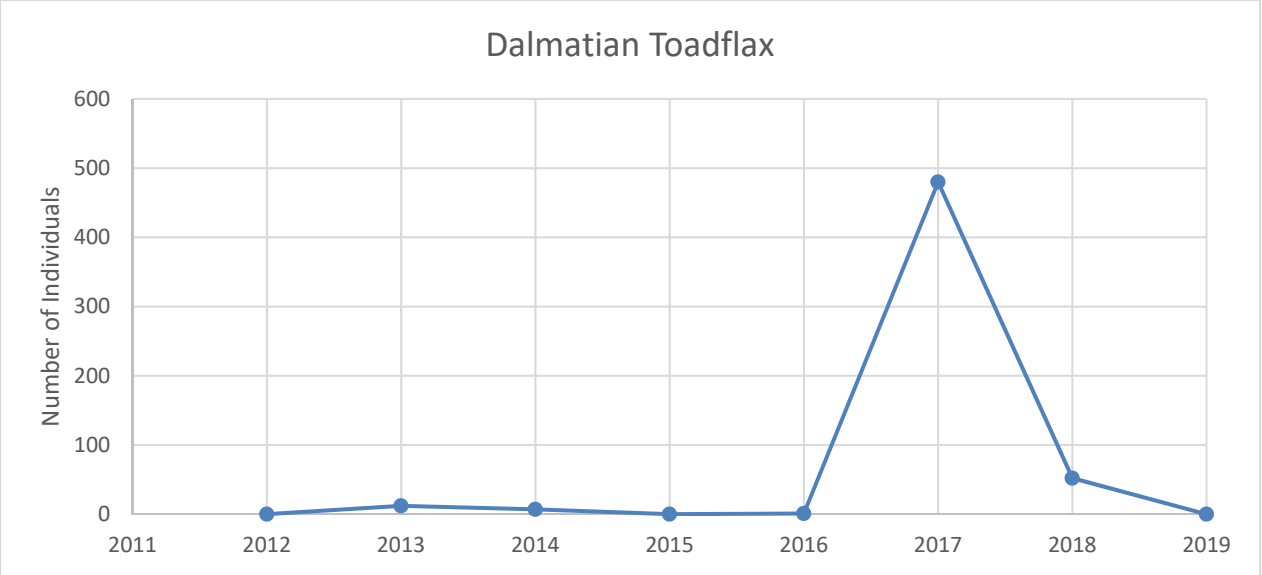


Figure 9. Number of individuals and extant features of Dalmatian toadflax, 2009-2019.

Treatment 2019

In 2019, there were no Dalmatian toadflax plants found at four known sites (Table 25).

Table 25. Monitoring and treatment of Dalmatian toadflax sites at the Academy in 2019.

2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	4	0	0	0/0	4
Pass 2	4	0	0	0/0	4

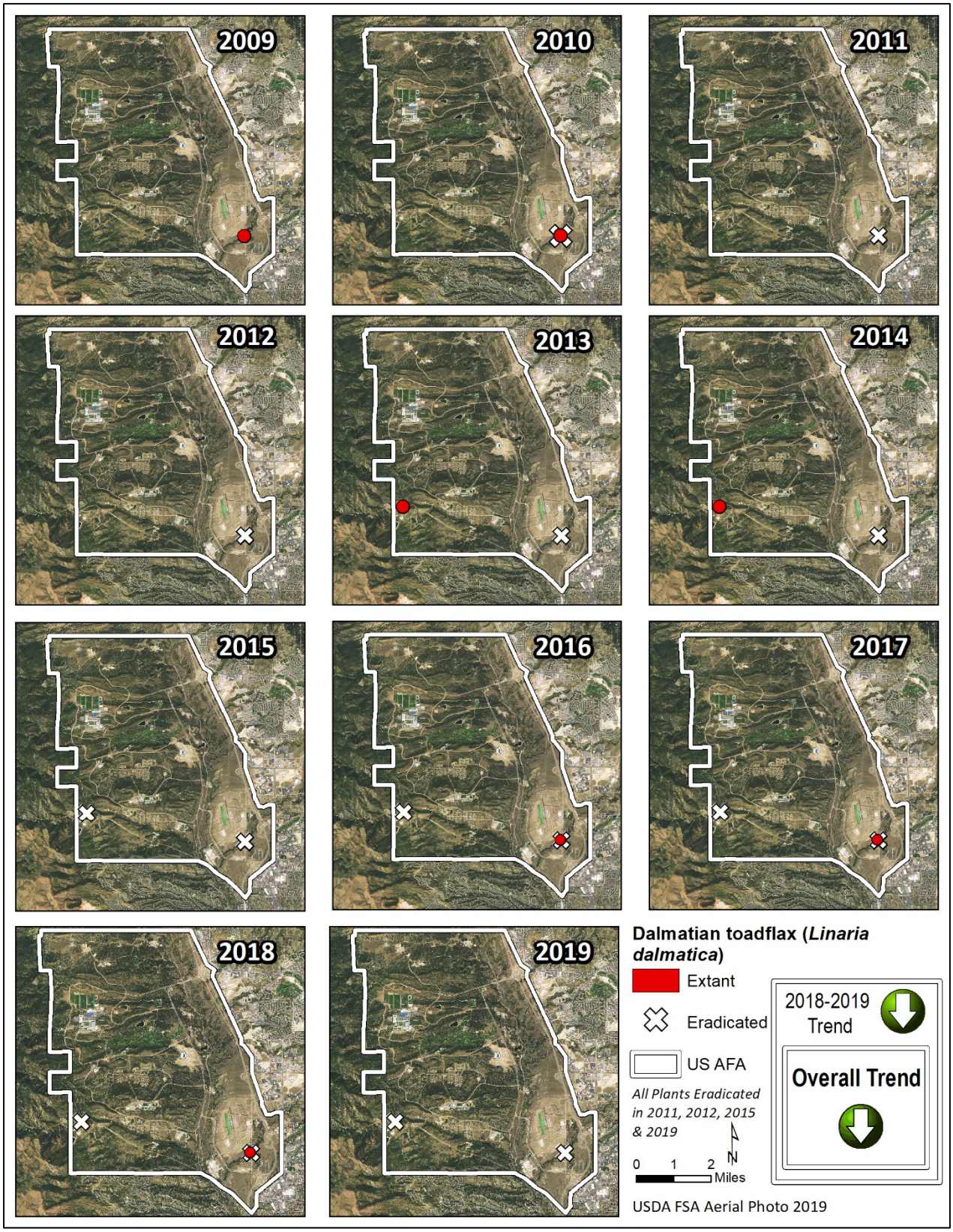
Recommendations

Continue to monitor known sites and remove new shoots as they are found, especially the site at Kettle Pond #1. A site plan should be in place to continue to document treatments and follow-up activities.

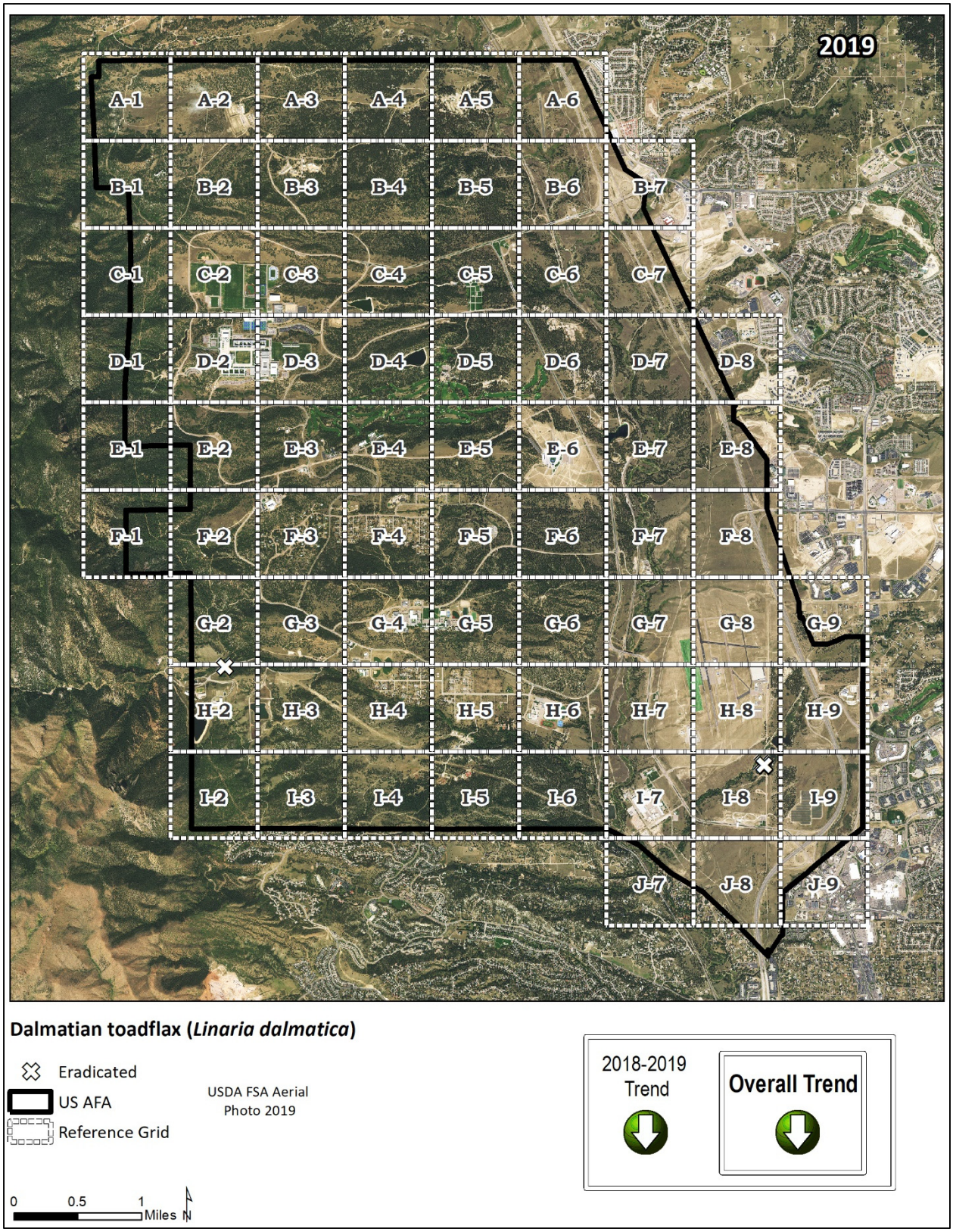
History of Sampling and Treatment:

- Dalmatian toadflax was discovered at the Academy in 2009 with one occurrence found near Kettle Lake #1 near the boat ramp. The occurrence consisted of a small number of plants.
- In 2010, two patches were mapped by CNHP with 107 shoots that covered approximately 203 m^2 (0.05 acres). The original infestation was eradicated, but two new infestations were found very close by, just north of the original occurrence.
- The Academy treated the 2010 sites and no plants were observed in 2011-2012.

- A new site on the western side of the Academy was discovered in 2013 which was treated immediately. This was far away from the previous infestations on the east side of the Academy near Kettle Lake #1.
- In 2014, seven plants were observed at the western known site, they were hand pulled and have not returned as of 2016 survey.
- In 2015, no plants were observed at the four known sites and no new infestations were found.
- In 2016, one individual was found (and pulled) at the original site at Kettle Lake #1 near the boat ramp.
- In 2017, there was a significant increase in a single year in the number of individuals the Kettle Lake #1 site where one plant was observed in 2016. All plants were removed by CNHP.
- In 2018, 52 plants were observed at the Kettle Lake #1 site and at no other locations.
- In 2019, no plants were observed at the four known sites.



Map 21. Distribution of Dalmatian toadflax at the Academy between 2009 and 2019.



Map 22. Distribution of Dalmatian toadflax at the Academy in 2019 with the reference grid.

Scotch Thistle (*Onopordum acanthium*)

Overall Trend: Increasing

Management Goals: Containment/Eradication

State List: B

- Biennial with a taproot that grows to 30 cm.
- Germination is in the fall
- Rosettes form first year
- Temperature and moisture content of soil are more important than nutrient content of soil for this species
- Reproduction is only by seed
- Drought resistant
- Seed longevity is 7-20 years (CDA 2016)

Photo: Scotch thistle rosettes, www.canadaplants.ca (left); www.readthis.tk (right).

2019 Results

Scotch thistle has been mapped at 425 sites since 2002 and currently occupies an estimated 2.35 acres at the Academy. Of those 425 sites, 290 are extant and 135 eradicated features (Table 26, Figure 10, Maps 23 & 24). CNHP visited 124 sites that included seven new locations A large number of sites were not visited in 2019 due to construction activities and some sites were not visited due to the large cover and impracticality of treating manually in 2019, the table data assumes sites not visited to be similar to counts in 2018.

Table 26. All infestations of Scotch thistle at the Academy.

	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002†	0.17	52	7	7	0
2005	0.42	137	12	12	0
2007	1.31	1,307	36	36	0
2008	1.14	144	44	27	17
2009	3.47	1,710	84	50	34
2010	0.66	669	91	61	30
2011	0.64	293	95	39	56
2012	0.30	889	139	66	73
2013	?	970	133	48	85
2014	0.84	1,224	155	74	81
2015	1.60	1,629	233	157	76
2016	1.13	1,331	255	128	127
2017	1.35	791	275	120	155
2018	2.04	1,914	417	275	143
2019	2.35	3,137	124	290	135

Basewide weed mapping performed during shaded years. †2002 values from field notes, not adequately mapped in GIS

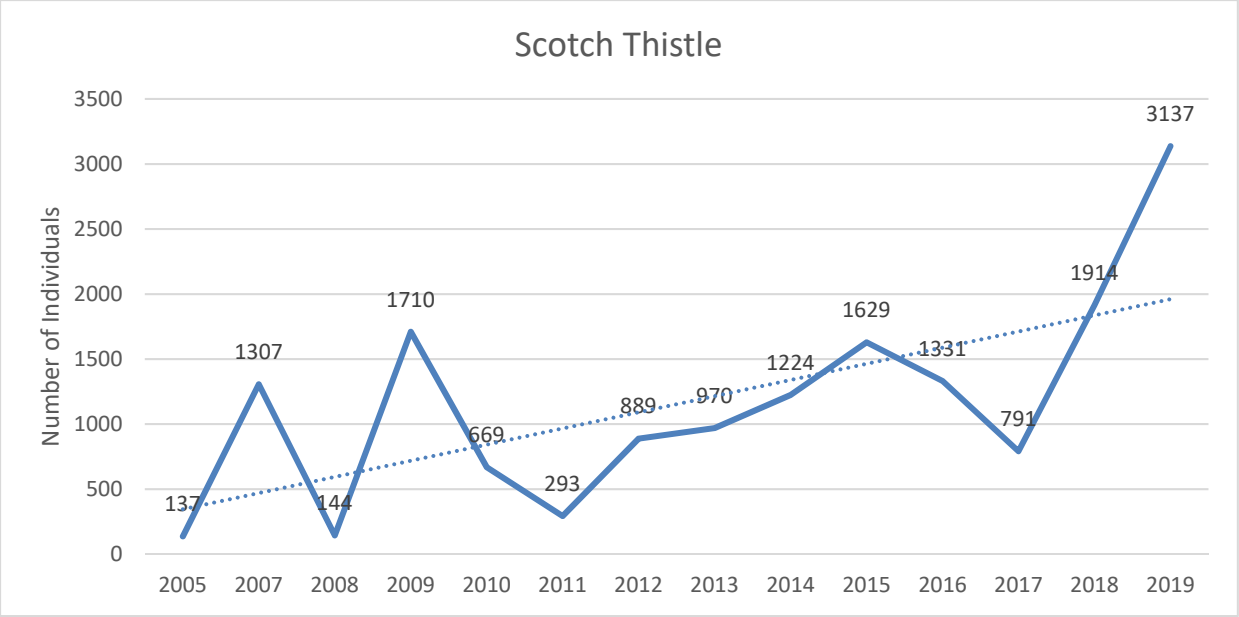


Figure 10. Number individuals and extant features of Scotch thistle, 2005-2019.

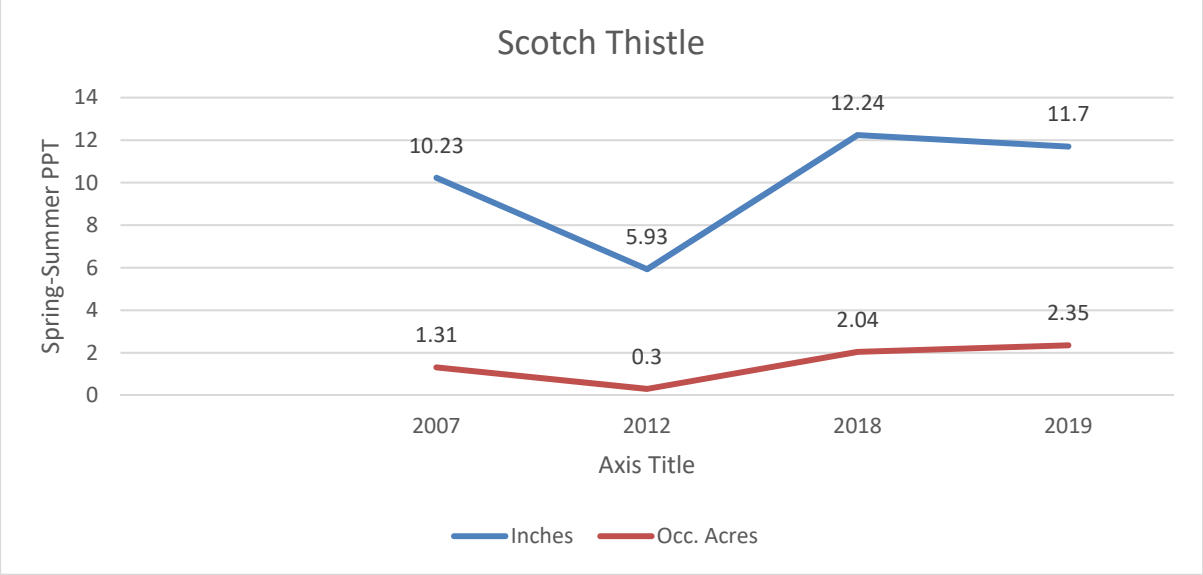


Figure 11. Comparison of spring-summer precipitation and occupied acres of Scotch thistle at the Academy 2007-2019.

Treatment 2019

In 2019, 124 mapped Scotch thistle features were visited for monitoring and treatment in early summer. Of those 124 sites, there were 1,933 shoots mapped and 1,158 shoots were manually at 71 out of a total of 78 extant features. Fifty sites were re-visited in late summer and 778 shoots were mapped with 346 treated manually at 23 of 28 extant features. A total of 1,504 shoots were

manually treated in 2019 (Table 27). Some sites were partially treated with herbicides and some were too large to treat manually.

Table 27. Monitoring and treatment of Scotch thistle sites at the Academy in 2019.

2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	124	1,933	1,158	71/78	46
Pass 2	50	778	346	23/28	22
TOTALS	**---**	**---**	**1,504**	---	---

For 2020, we will begin monitoring early in the spring to remove plants at the seedling stage and cut second year plants 4-6 inches below the root crown before they set seed. This will prevent off-target impacts to native species and prevent seed production at these sites. Summer and late summer or fall visits will be made to sites with plants present in the spring visit. Thirteen sites have not had any Scotch thistle present since 2010; these sites still need to be monitored as seed longevity has been estimated to be from seven to 20 years (CDA 2016) for Scotch thistle.

Recommendations

For 2020, the focus will be on removing new sprouts early in the spring which is far less damaging to soils than other treatments and to do follow-up treatments later in the season before missed plants or those that sprout later can bolt. Once plants have bolted they are much more difficult to treat without excessive soil disturbances. A coordinated effort with the herbicide applicator needs to be discussed for 2020 for the large populations of Scotch thistle at the Academy.

Several large dense patches of Scotch thistle were not visited in 2019. A large area east of USAF Academy Track and Field Facility (south of North Gate Blvd and north of the Parade Loop) in the northwest part of the Academy (Grid C-3, Map 24) was not monitored by CNHP due to construction activities (~150 features). In addition, an area west of the Air Academy High School near the intersection of Carlton Drive and E. Pine Loop was not surveyed (Grid H-5, Map 24) with 100+ features. Other mapped features not visited included areas previously reported as washed out, on the utilities gated property, active construction areas, developed areas and sites east of I-25. Features not visited in 2019 will be prioritized for visits early in 2020.

A site plan for each of the large treatment sites is recommended to help document what is occurring and what methods are helping or harming the removal of this species. Site assessments will take into consideration a variety of aspects of treatment that may be impairing success including: partial treatments, treating the proper growth stage and avoiding chemical overspray that leaves bare soil which impacts the native plants that could potentially help to provide competition. The ground disturbances associated with the chemical treatments as well as the inappropriate growth stage being treated are likely causing increases (Photo 4). The effects to local flora and fauna, water quality and soil microorganisms that result from excessive use of chemicals is also problematic. The site plan could include alternate options for treatments. Protecting existing vegetation in the grasslands is so important in keeping weeds from spreading. Removing the seed source is

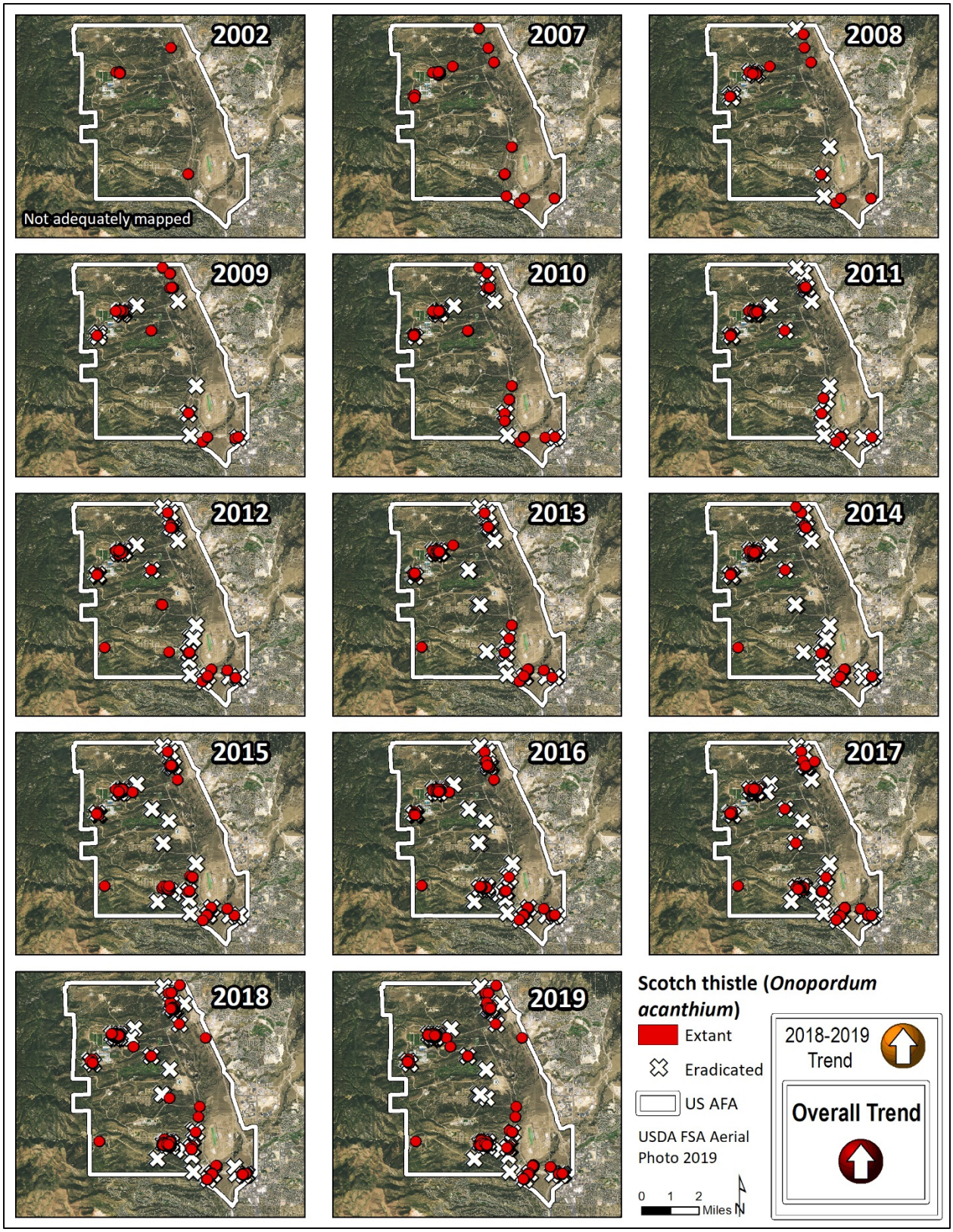
considered a key aspect of treating this species. Herbicides are only one tool and should not be used exclusively for control of this species.

Photo 4. Herbicide treated Scotch thistles showing overspray areas with bare soil and repopulation with other noxious weeds including houndstongue and cheatgrass. P. Smith 2015.

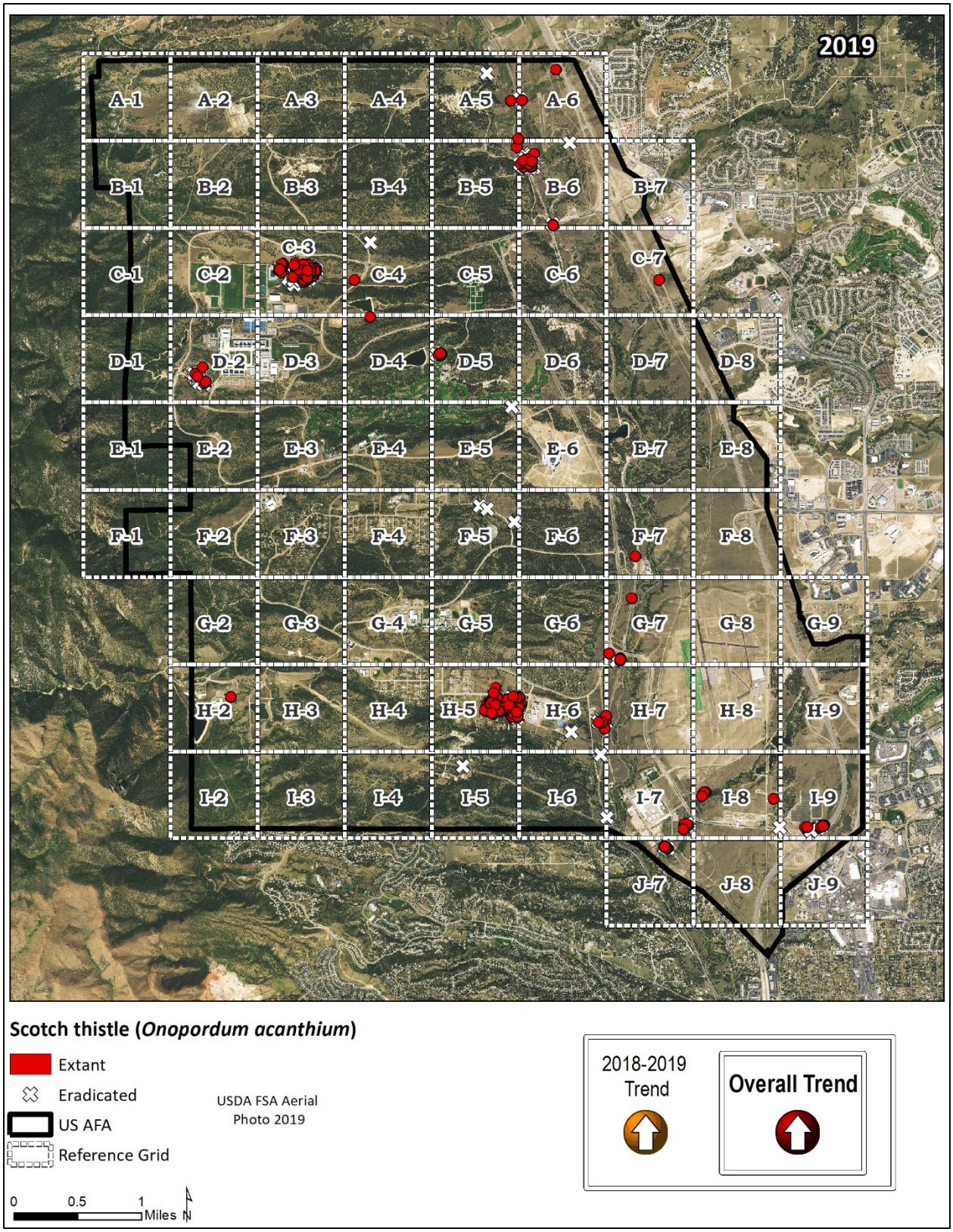
History of Sampling and Treatment:

- The occupied areas, number of individuals and the occupied acres at the Academy have fluctuated since Scotch thistle was first monitored in 2002.
- The population of Scotch thistle peaked in 2007 and 2009 with a decline in 2010.
- In 2014 and 2015 it was evident that many treated areas had sprouting individuals. Bare ground left behind in both successfully controlled and unsuccessfully controlled sites provided more habitat for noxious weeds.
- In 2015, the number of extant features was higher due to the addition of new survey areas that were not part of the previous year's survey. The overall trend since 2002 is increasing.
- In 2016, there were fewer extant sites compared to 2015 because the populations added in 2015 located west of Pine Valley High School were treated. However, the number of extant features are still the third highest recorded since monitoring began in 2002.
- In 2017, there were 120 extant sites (similar to the 128 in 2016) but fewer individuals were observed.

- In 2018, the basewide mapping showed 275 extant sites with almost 2,000 individuals observed.
- In 2019, Scotch thistle continues to increase with 290 extant features and 3,137 individuals mapped.



Map 23. Distribution of Scotch thistle at the Academy between 2002 and 2019.



Map 24. Distribution of Scotch thistle at the Academy in 2019 with the reference grid.

Bouncingbet (*Saponaria officinalis*)

Overall Trend: Decreasing

Management Goals: Eradication

State List: B

- Perennial
- Self-fertile
- Reproduction from seeds
- Colony former
- Blooms summer-fall
- Seed longevity is unknown (CDA-CSU 2019)

Photo: ct.botanicalsociety.org

Photo: Leaves of mature plant, missouristate.edu

2019 Results

In 2019, there were 38 known locations, 29 were extant and nine were eradicated sites with 4,063 shoots which is a decrease of about 500 plants from 2018. This species is considered to be decreasing overall since 2013, when 42,092 plants were observed at eight features, with a single location containing 37,699 individuals (estimate based on density). After treatments in 2013, there

were only 42 shoots in 2014. However, bouncingbet has been steadily increasing since 2014 (Table 28, Figure 12, Maps 25 & 26).

Table 28. All infestations of bouncingbet at the Academy.

	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002	?	?	1	1	0
2007					
2012					
2013	0.50	42,092	8	8	0
2014	0.14	42	8	2	6
2015	0.09	608	13	8	5
2016	0.05	535	13	8	6
2017	0.05	401	14	6	8
2018	0.17	4,585	34	26	8
2019	0.24	4,063	33	29	9

Basewide weed mapping performed during shaded years.

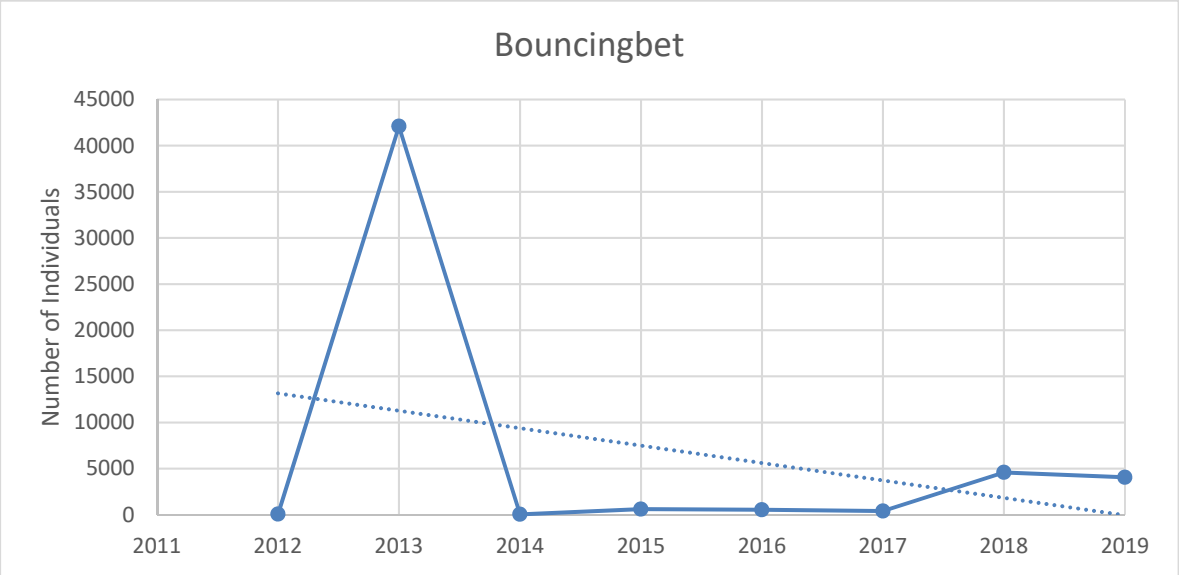


Figure 12. Number of individuals for bouncingbet, 2013-2019.

Treatment 2019

In 2019, 33 mapped bouncingbet features were visited for monitoring and treatment. Of those 33 sites, there were 3,133 shoots mapped at 25 extant features. The remaining eight features were eradicated in 2019 (Table 29). Four sites were new locations in 2019. CNHP did not visit three sites

along Pine Creek due to their location on very steep cliffs. All 25 extant sites visited were treated by removing all buds and flowers, bagging and disposing them off-site.

Table 29. Monitoring and treatment of bouncingbet sites at the Academy in 2019.					
2019	**# Features Visited**	**# Shoots Mapped**	**# Manually Treated Shoots**	**# Treated/Extant Features**	**# Eradicated Features**
Pass 1	33	3,133	3,133*	25/33	8

*3,133 plants counted and tops removed from plants with seeds and flowers present.

Recommendations

The most important aspect of keeping weeds contained is not to disturb the surrounding native plant species and leave behind bare soil post treatment. Flooding has removed at least 60 individuals in 2019 along Monument Creek from beaver activity and animals are grazing the bouncingbet in a significant way. For this reason and the fact, many herbicides have been causing excessive off-target damage and result in only temporary suppression, we recommend discontinuing herbicide treatments in the floodplain areas. Continue to monitor all known sites for the next few years to determine if a reduction in plant production is occurring naturally. Always be on the lookout for new populations. A site plan would help focus treatments and results for a more successful outcome by reducing non-target damage to native plants and soils. The site that contained thousands of individuals must be monitored yearly.

One of the most interesting observations for 2016 through 2018 is that nearly every single mature plant that was in the flower stage had the flowers or parts of the plants browsed by ungulates (Photo 5).

Photo 5. Browsed bouncingbet flower tops in 2016. Photo: P. Smith

Herbicides appear to be suppressing this species for a few years. However, most of the treated areas have re-sprouting bouncingbet, cheatgrass (List C), smooth brome (a rhizomatous non-native grass) or bare ground at herbicide treated sites (Photo 6). Smooth brome is difficult to control once it becomes established and is not a good cover for wildlands. Cheatgrass indicates recently

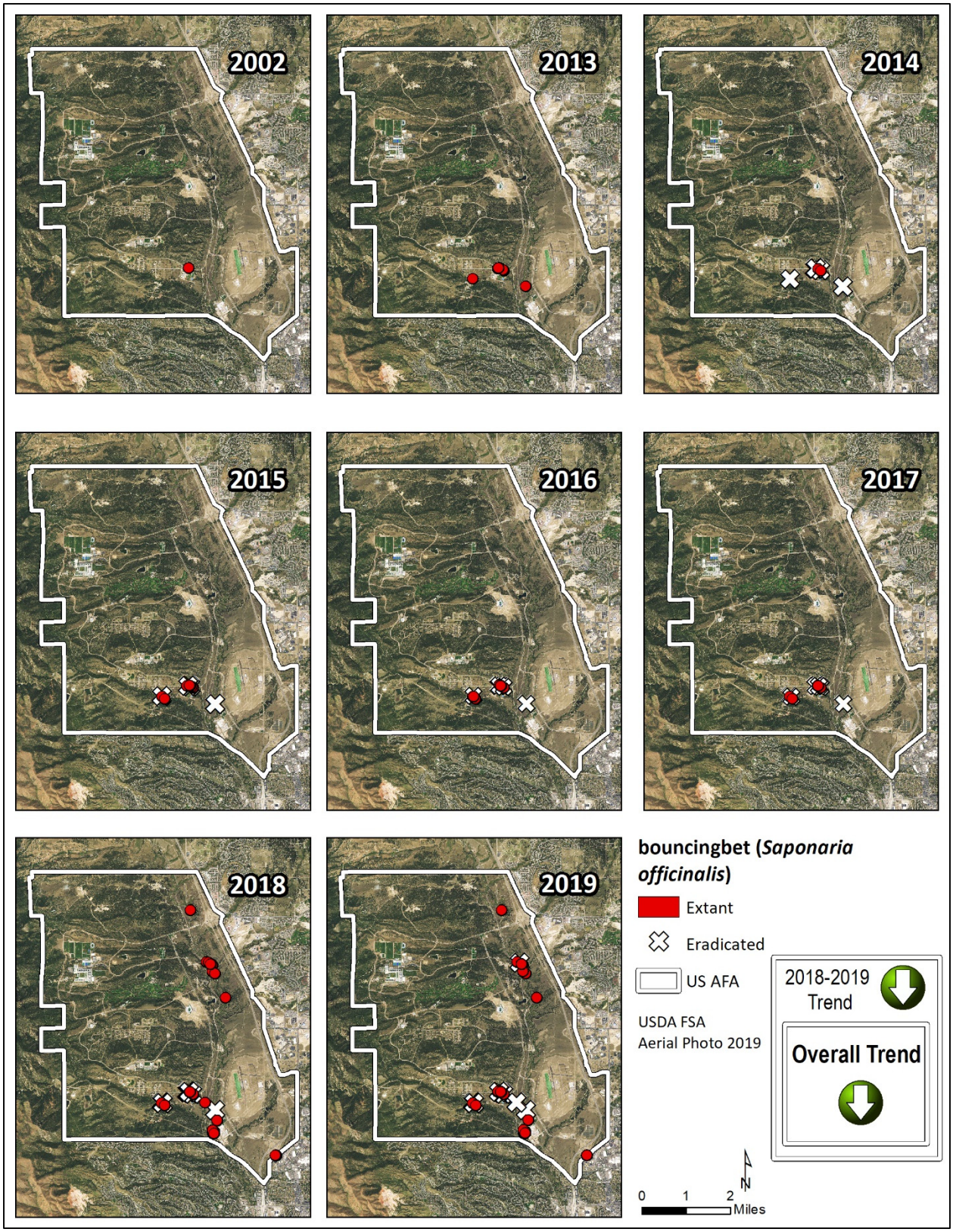
disturbed soils in treatment areas. Two sites were noted as being treated with herbicide in 2018 with yellow curling leaves observed. However, the counts were similar between 2018 and 2019 at these sites indicating the herbicide application was ineffective.

Photo 6. Bouncingbet herbicide treatment area with bouncingbet returning after a few years and cheatgrass filling in bare soils left by overspray in drainage area.

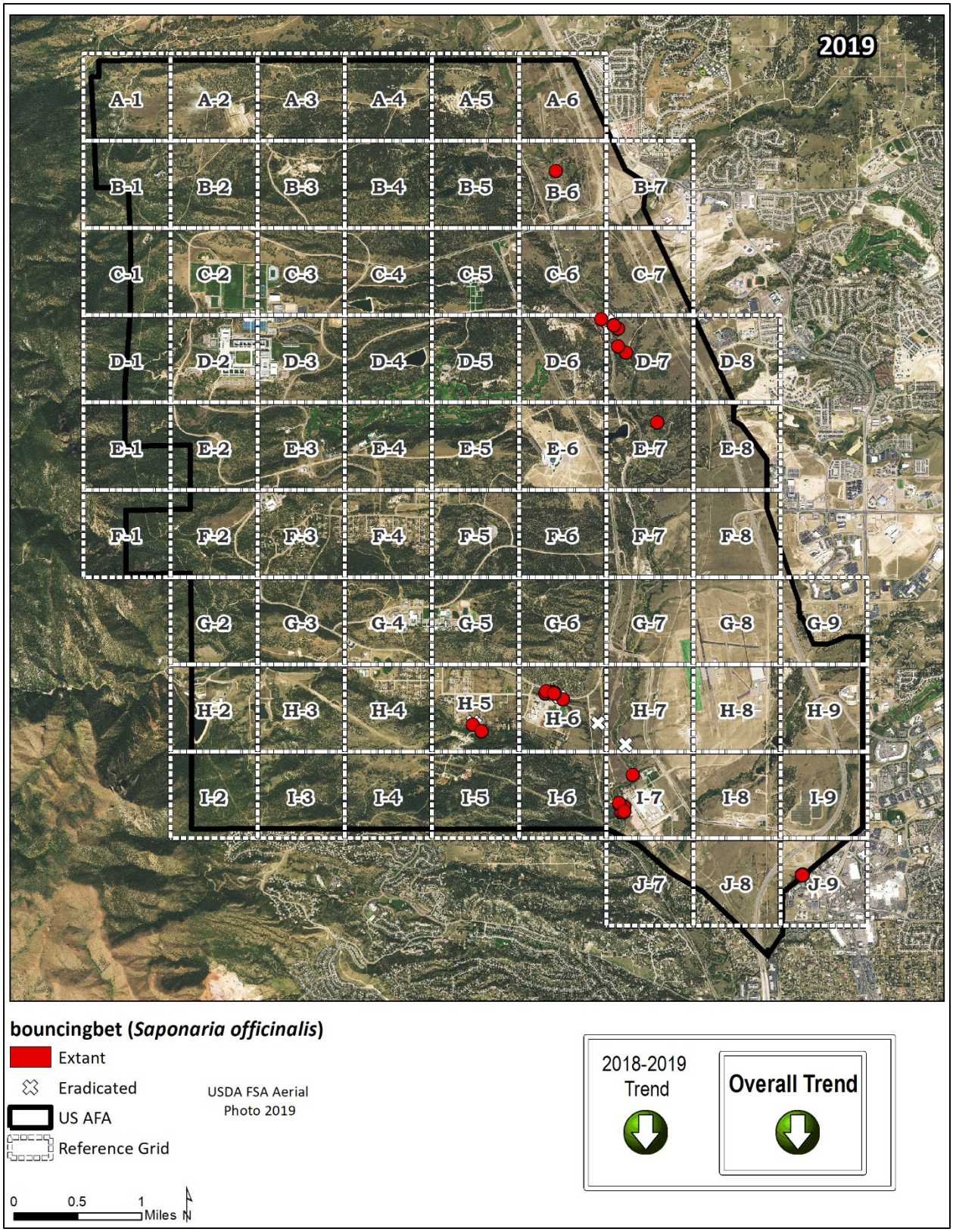
The plan for 2020 is for CNHP to visit all known bouncingbet sites again to see if topping the plants is reducing or increasing the plants. Decisions can be made as a result of this summer's monitoring to decide how to move forward. Bouncingbet is very complicated to treat. Sites range in counts from seven to 650 individuals and from less than one to several square meters in cover. Many of the plants are in dense vegetation in riparian areas making them very difficult to treat, especially those populations along the flood plains of Kettle and Monument Creeks. The dense growth and steep terrain are both obstacles. Recommendations for bouncingbet treatments include a combination of IPM with restoration. Most treatments can cause vegetative growth (CDA-CSU 2019). There are no recommendations for herbicide or mechanical treatments alone. In addition, there are no herbicides recommended for treating wildlands**,** only rangelands and pastures (CDA-CSU 2019).

History of Sampling and Treatment:

- Bouncingbet was mapped at one location in 2002 and not surveyed again until 2013.
- In 2013, three distinct areas were mapped, but distribution was still localized.
- The westernmost infestation was huge, representing almost 40,000 individuals.
- The 2013 locations were treated by the Academy.
- In 2014, there was a decrease in the number of extant features.
- In 2015, the number of extant features was identical to those in 2013. A small population has resurfaced near the huge infestation that was discovered and thought to be eradicated in 2013. Some new locations were mapped in 2015 but several previously treated sites are repopulating.
- In 2016-2017 all known bouncing bet sites with extant plants that had flower tops were grazed by wildlife. Previously treated sites showed damage from overspray and the return of bouncingbet to the chemically treated sites.
- The first year for basewide mapping for bouncingbet is 2018. The data show an overall decrease since it was first mapped in 2013, with an increase in mapped features.
- In 2019, there was an increase in mapped features and a decrease in number of individuals.



Map 25. Distribution of bouncingbet at the Academy between 2002 and 2019.



Map 26. Distribution of bouncingbet at the Academy in 2019 with the reference grid.

Salt Cedar (*Tamarix ramosissima*)

Overall Trend: Stable

Management Goals: Eradication, Rapid Response

State List: B

- 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 (CWMA 2020e)
- Provides habitat for nesting birds (USFS 2016)

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

2019 Results

In 2019, there was only one extant location of saltcedar and nine eradicated features at the Academy (Table 30, Maps 27 & 28). This species has a very high likelihood of being eradicated.

Table 30. All infestations of salt cedar at the Academy.

	Occupied Acres (m^2)	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	<0.01 (3.14 m^2)	1	1	0
2007	<0.01 (3.14 m^2)	1	1	1
2008	0	0	0	1
2009	<0.01 (6.28 m^2)	2	2	3
2010	0	0	0	5
2011	<0.01 (3.14 m^2)	1	1	4
2012	<0.01 (3.14 m^2)	1	1	4
2013	<0.01 (3.14 m^2)	1	1	5
2014	<0.01 (12.6 m^2)	1	1	6
2015	.03	6	4	5
2016	<0.01 (12.6 m^2)	1	1	8
2017	<0.01 (12.6 m^2)	1	1	8
2018	0.01	2	2	8
2019	<0.01 (12.6 m^2)	1	1	9

Basewide weed mapping performed during shaded years.

Treatment 2019

In 2019, eight sites were visited and only one extant occurrence was located. This species is treated with herbicide by Academy staff (Table 31).

Table 31. Monitoring and treatment of saltcedar sites at the Academy in 2019.

2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	8	1	0*	0/1	9

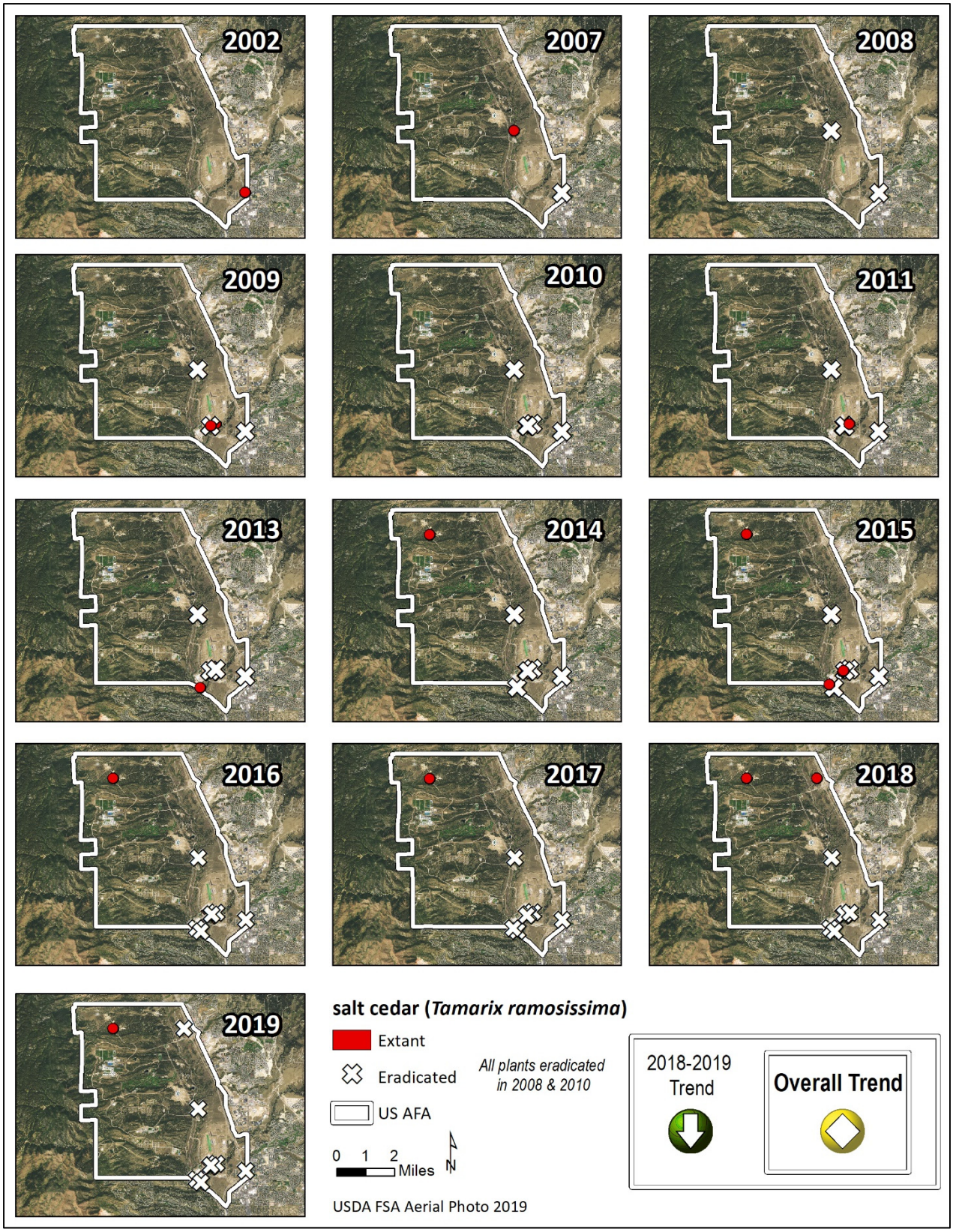
*Saltcedar is treated by the Academy Staff and Contractor.

Recommendations

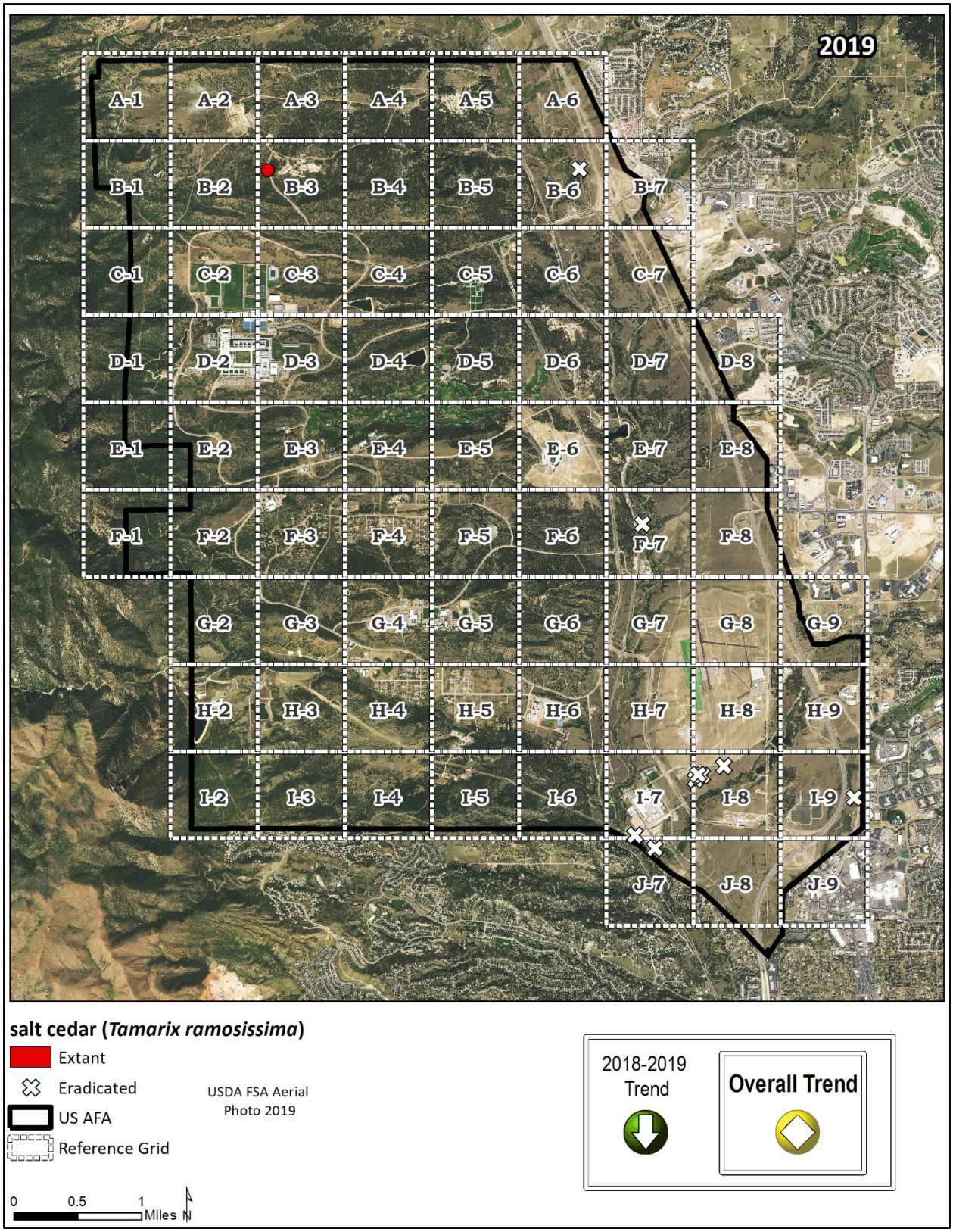
A cut stump with herbicide is recommend for saltcedar. For this method to be effective, plants are cut as close to the ground as possible (within 5 cm). According to Colorado Natural Areas BMPs for salt cedar, herbicide should be applied immediately (within seconds) to the cut since as the wound will 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. Follow-up monitoring is recommended. 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 (CPW 2013). Saltcedar can spread both by seed and vegetatively. Continued monitoring at the Academy is recommended at the known sites and to continue to look for it throughout the Academy, especially in ditches and riparian areas.

History of Sampling and Treatment:

- Salt cedar was known from five separate sites between 2002 and 2013.
- In 2008 and 2010, no plants were observed at the Academy.
- Between 2011 and 2014, the number of individuals remained stable with one plant documented each year.
- In 2015, two new sites included four individuals; one previously known extant site had been manually cut and was re-sprouting. This year's survey represented an increase in the number of extant features monitored from one to four. Five monitoring sites were found to have no living salt cedar plants in 2015.
- In 2016, six out of nine sites visited had no salt cedar present, two sites were not visited in 2016 (one near the airport and one across I-25, both of which were not found in 2015). One site had seven sprouts at Jacks Valley in 2016.
- In 2017, eight of nine sites with salt cedar were visited; the only site with salt cedar present was in Jacks Valley. The sprouts appear to have been browsed by wildlife.
- In 2018, two extant locations of salt cedar were mapped, each with a single individual. Natural Resource Managers pulled them in 2018.
- In 2019, there was only one extant location of saltcedar.



Map 27. Distribution of salt cedar at the Academy between 2002 and 2019.



Map 28. Distribution of salt cedar at the Academy in 2019 with the reference grid.

Scentless Chamomile (*Tripleurospermum (inodorum) perforatum*)

Overall Trend: Increasing

Management Goals: Rapid Response – Kettle Creek, Restoration – Monument Creek

State List: B

Photo: Pam Smith, Kettle Creek, July 2016

- Annual, biennial to short-lived perennial
- Seedlings emerge in the spring, flowers June-October
- Seedlings can produce a dense mat, out competing other species
- Seeds and flowers are continually formed
- Each flower head can produce 300,000 seeds
- Habitats roadsides, streambanks and drainages (CWMA 2020f)

2019 Results

Scentless chamomile was not found in Kettle Creek in 2019. It became apparent that rapid response actions to remove plants along Monument Creek due to the degree of infestation would not be practical and may not even be beneficial. Scentless chamomile was first observed in 2016 at a couple of sites along Kettle Creek. After the basewide mapping in 2018, over 2,500 individuals at 117 features, consisting of 2,530 individuals occupying 0.42 acres were mapped largely along Monument Creek (Table 32, Maps 29 & 30).

Table 32. All infestations of scentless chamomile at the Academy.

	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---	---
2007	---	---	---	---	---
2012	---	---	---	---	---
2016	<0.01 acres (3.14 m^2)	2	1	1	0
2017	<0.01 acres (3.14 m^2)	1	2	1	1
2018	0.41	2,530	119	117	2
2019	0.42	2,525	4	116	3

Basewide weed mapping performed during shaded years.

Treatment 2019

In 2019, four features were visited and 23 individuals were removed (Table 33). No plants were found in the Kettle Creek drainage.

Table 33. Monitoring and treatment of scentless chamomile sites at the Academy in 2019.

2019	# Features Visited	# Shoots Mapped	# Manually Treated Shoots	# Treated/Extant Features	# Eradicated Features
Pass 1	4	23	23	3/3	1

Recommendations

The number of plants along Monument Creek (>2,500) is large enough that rapid response actions are not practical. The original plan for 2019 was to focus on Kettle Creek for rapid response actions and to incidentally treat scentless chamomile as we come across it on our way to monitor and treat other species along Monument Creek. We visited the first four sites and realized that removal of wild chamomile is not difficult, but removal of the plant biomass was an issue. Due to the profuse

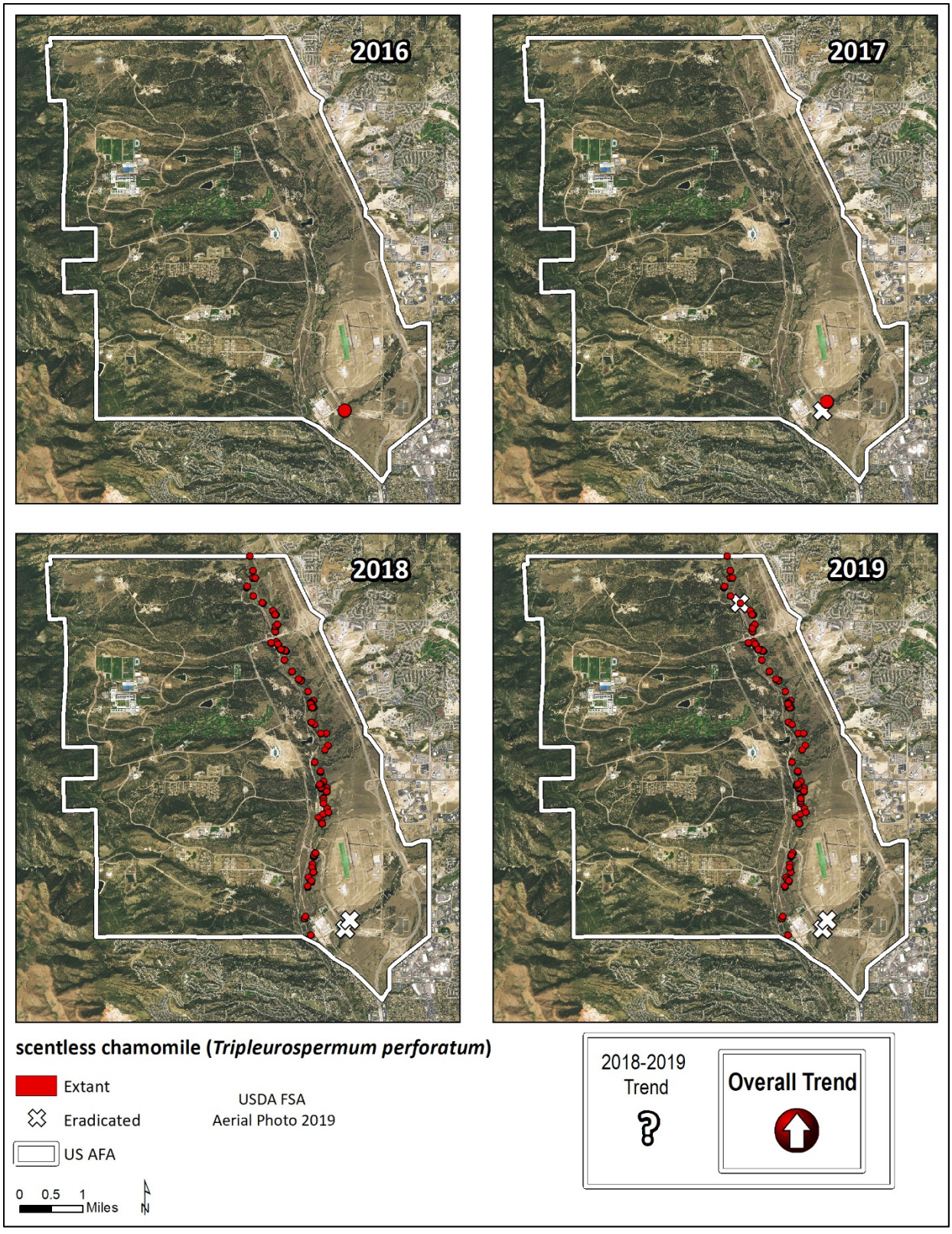
flowering and seed production, the entire plant needs to be removed and the plants get quite large so that even a few can take up an entire garbage bag. We realized we did not have the man-power and infrastructure to remove very many plants much less hundreds of plants. In addition, after further consideration it was apparent that pulling plants along the floodplain created a significant soil disturbance that would likely invite other weeds or scentless chamomile into the new disturbance, thus negating our efforts. Since this drainage is highly disturbed due to its location near a large metropolitan area, the water is polluted and the flows are unnatural, it tends to be weedy. The wild chamomile seed source (and other weed seed and propagules) is likely coming from outside the property boundaries. Whether chemical or mechanical, the effort would likely result in a larger noxious weed footprint in the Monument Creek drainage. Outside of a restoration effort, success in controlling wild chamomile is highly unlikely. However, this is not the case for smaller drainages at the Academy including Kettle Creek. The smaller shady drainages have an advantage with dense vegetation and inputs from the highly developed eastern boundary.

For 2020, monitoring all small drainages, including Kettle Creek, for new occurrences of scentless chamomile is a priority. For local rapid response actions mechanical removal works well in sandy sediment which allows for easy removal with the roots intact. All plants will need to be carried out and discarded as they flower and fruit continuously.

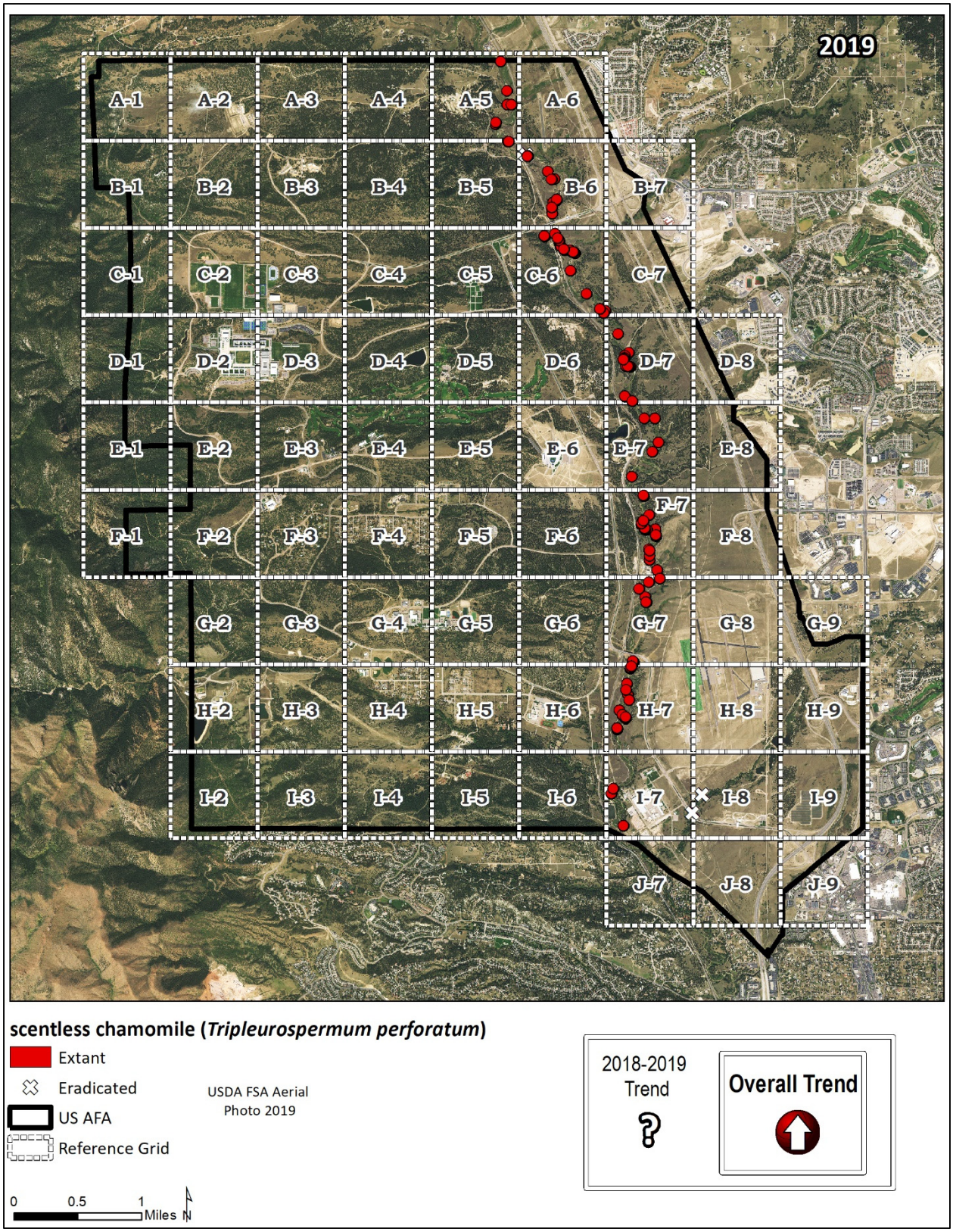
Due to the disturbance regime, influx of excess nutrients, pollution and unnatural flow cycles and constant seed source likely coming from outside the Academy efforts to eradicate or control scentless chamomile would probably not be successful along Monument Creek. Replanting bare areas with appropriate seed mixes and restoration activities are likely the only way to combat the constant influx of noxious weeds. Protecting intact shoreline vegetation is critical for preventing the increase in the weed footprint. The removal of plants without combining it with a restoration or planting activity is not recommended for Monument Creek.

History of Sampling and Treatment:

- The first observation of scentless chamomile was in 2016 at the Academy. It was also a county record for El Paso County. Two individuals were found along the Kettle Creek drainage. An herbarium specimen was deposited at Colorado State University to document the county record.
- In 2017, a new location with a single individual was observed (and pulled) about 250 meters from the original site. The original site was also visited and no plants were found.
- In 2018, the first basewide mapping for noxious weeds was conducted since scentless chamomile had been discovered in 2016. Over 2,500 plants were mapped along Monument Creek and none were mapped on Kettle Creek where it was originally found.
- In 2019, it was apparent there were too many plants along Monument Creek to consider eradication as a goal. Kettle Creek and all other small drainages should still be targeted for rapid response activities. For Monument Creek, restoration and planting of native species may be the only way to control on wild chamomile.



Map 29. Distribution of scentless chamomile at the Academy between 2016 and 2019.



Map 30. Distribution of scentless chamomile at the Academy in 2019 with the reference grid.

REFERENCES

Anderson, D.G., A. Lavender, and R. Abbott. 2003. Noxious Weed Survey of the U.S. Air Force Academy and Farish Outdoor Recreation Area. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program.

Anderson, D.G. and A. Lavender. 2007. Noxious Weed Monitoring at the U.S. Air Force Academy – Year 2 Results. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program.

Anderson, D.G. and A. Lavender. 2008a. Noxious Weed Survey of the U.S. Air Force Academy and Farish Outdoor Recreation Area. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program.

Anderson, D.G. and A. Lavender. 2008b. Noxious Weed Monitoring at the U.S. Air Force Academy-Year 3 Results Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program.

Beck, K.G. 2008. Russian knapweed fact sheet no. 3.111. Colorado State University Extension, Fort Collins, CO.

Bugwood.org website. https://wiki.bugwood.org/Alliaria_petiolata. Accessed April 2020.

Carpenter, A.T., S.G. Perce, M. Schmidt, and N. Lovell. 2004. Integrated Noxious Weed Management Plan- U.S. Air Force Academy and Farish Outdoor Recreation Area. El Paso County, Colorado. Produced for the U.S. Air Force Academy by Land Stewardship Consulting Company in collaboration with URS, Inc.

CDA-CSU 2015a. Colorado Department of Agriculture, Colorado State University Houndstongue Fact Sheet Rev 7/15. https://drive.google.com/file/d/1z6ZJBmGlTO0tkeGGp4Tk1x3U6pV64OQ3/view. Accessed 6/3/2019.

CDA-CSU 2015b. Colorado Department of Agriculture – Colorado State University. Identification and Management Oxeye Daisy (*Leucanthemum vulgare*) Rev 7/15. https://drive.google.com/file/d/1XJqjgXg6tloPZshrH45ZZ50Gh16HKDXS/view. Accessed April 2020.

CDA-CSU 2016. Colorado Department of Agriculture-Colorado State University Scotch Thistle Fact Sheet Rev 11/16 https://drive.google.com/file/d/1WmVjBrUvXVbPQARemLNAR5iSbeN_vnAu/view. Accessed April 2020.

CDA-CSU 2019. Colorado Department of Agriculture – Colorado State University. Identification and Management of Bouncingbet (*Saponaria officinalis* L.) Rev 2/19. https://drive.google.com/file/d/1H2PwtB90SpFz2Drre6eCJdyVSb4xdl-z/view. Accessed April 2020.

Code of Colorado Regulations. 2014. Secretary of State, State of Colorado, Department of Agriculture, Conservation Services Division. 8 CCR 1206-2 Rules Pertaining to the Administration and Enforcement of the Colorado Noxious Weed Act: http://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=6027&fileName=8%20CCR%201206-2

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

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

CWMA 2020b. Colorado Weed Management Association. Myrtle Spurge, Euphorbia myrsinites. https://cwma.org/weed-information/weed-list/myrtle-spurge/ Accessed April 2020

CWMA 2020c. Colorado Weed Management Association. Dame's rocket, Hesperus matronalis. https://cwma.org/weed-information/weed-list/dames-rocket/ Accessed April 2020. www.cwma.org/DamesRocket.html

CWMA 2020d. Colorado Weed Management Association. Orange Hawkweed (Hieracium aurantiacum). https://cwma.org/weed-information/weed-list/orange-hawkweed/ Accessed April 2020.

CWMA 2020e. Colorado Weed Management Association. Salt Cedar (Tamarix spp). https://cwma.org/weed-information/weed-list/salt-cedar/Accessed April 2020

CWMA 2020f. Colorado Weed Management Association. Scentless chamomile, Tripleurospermum perforatum) https://cwma.org/weed-information/weed-list/scentless-chamomile/Accessed April 2020.

King County 2018. Garlic Mustard Identification and Control. Alliaria petiolata. https://www.kingcounty.gov/services/environment/animals-and-plants/noxious-weeds/weed-identification/garlic-mustard.aspx. Accessed April 2020.

Lavender-Greenwell, A. and R. Rondeau. 2013. Noxious Weed Survey of the U.S. Air Force Academy and Farish Outdoor Recreation Area – 2012. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program.

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.

Norris, R.F. 1999. Ecological Implications of Using Thresholds for Weed Management. University of California, Davis, CA 95616.

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.

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.

Rondeau, R. and A. Lavender. 2012. Noxious Weed Monitoring at the U.S. Air Force Academy- Year 7 Results. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program.

Rondeau, R. and A. Lavender. 2013. Noxious Weed Monitoring at the U.S. Air Force Academy- Year 8 Results. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program.

Schorr, R., P. Smith, and J. Siemers. 2019. United States Air Gorce Academy Targeted Biological Inventory Update. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program. Colorado State University.

Siemers, J., D.G. Anderson, R. Schorr, and R. Rondeau. 2012. United States Air Force Academy Biological Inventory. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Smith, P. and A. Greenwell. 2019. Noxious Weed Monitoring (Year 14) & Mapping at the U.S. Air Force Academy and Farish. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Smith, P., S. Panjabi and J. Handwerk. 2015. Integrated Noxious Weed Management Plan- U.S. Air Force Academy and Farish Outdoor Recreation Area. El Paso County, Colorado. Produced for the U.S. Air Force Academy by the Colorado Natural Heritage Program.

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

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

WU 2019. Weather Underground Colorado Springs Weather History for KCOS https://www.wunderground.com/history/airport/KCOS/. Accessed March 2020.

Young, J. A., C. D. Clements and R.R. Blank. 2002. Herbicide residues and perennial grass establishment on perennial pepperweed sites. Journal of Range Management. 55(2): 194-196. [45253]

APPENDIX A. SUMMARY OF MONITORING ACTIVITIES BY SPECIES AT THE ACADEMY SINCE 2002

Monitoring activities (not necessarily mapping) are indicated by brown shading. M = mapped, PM = partially mapped, * indicates year discovered.

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Russian knapweed (*Acroptilon repens)*			M*	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Garlic mustard (*Alliaria petiolata*)																	M*	M
Siberian peashrub (*Caragana arborescens)*											M						M	
Hoary cress (*Cardaria draba)*	M	M				M					M						M	
Musk thistle (*Carduus nutans)*	M					M					M						M	
Diffuse knapweed (*Centaurea diffusa)*	M					M					M						M	
Diffuse / spotted knapweed hybrid (*C.* x *psammogena*)				M*		M					M						M	

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Spotted knapweed (*Centaurea stoebe)*	M			M	M	M					M						M	
Canada thistle (*Cirsium arvense*)	M					PM					M						M	
Bull thistle (*Cirsium vulgare*)	M					M					M						M	
Field bindweed (*Convolvulus arvensis*)	M					M												
Houndstongue (*Cynoglossum officinale*)								M*	M	M	M	M	M	M	M	M	M	M
Common teasel (*Dipsacus fullonum*)	M					M					M						M	
Russian olive (*Elaeagnus angustifolia*)	M	PM		PM		M					M						M	
Leafy spurge (*Euphorbia esula*)	M					M					M						M	
Myrtle spurge (*Euphorbia myrsinites*)				M*	M	M		M	M	M	M	M	M	M	M	M	M	M
Yellow spring bedstraw (*Gallium verum*)									M*	M	M	M	M	M	M	M	M	M

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Dame's rocket (*Hesperis matronalis*)											M*		PM	M	PM		M	PM
Orange hawkweed (*Hieracium aurantiacum*)																	M*	M
Common St. Johnswort (*Hypericum perforatum*)	M			M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Perennial pepperweed *(Lepidium latifolium)*																	M*	M
Oxeye daisy (*Leucanthemum vulgare*)																		M*
Dalmatian toadflax (*Linaria dalmatica*)								M*	M	M	M	M	M	M	M	M	M	M
Yellow toadflax (*Linaria vulgaris*)	M					PM					PM						PM	
Tatarian honeysuckle (*Lonicera tatarica*)							M*			M	M	M	M	M	M	M	M	
Scotch thistle (*Onopordum acanthium*)	M			M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Bouncingbet (*Saponaria officinalis*)	M*											M	M	M	M	M	M	M

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Salt cedar (*Tamarix ramosissima*)	M					M	M	M	M	M	M	M	M	M	M	M	M	M
scentless chamomile (*Tripleurospermum perforatum*)															M*	M	M	PM

APPENDIX B. TRANSECT SURVEY PROTOCOLS FOR THE ACADEMY UTILIZED FOR BIOCONTROL AND NON-BIOCONTROL PLOTS FOR HOARY CRESS, CANADA THISTLE, KNAPWEEDS, AND LEAFY SPURGE

The following methods were implemented in 2011 by TAMU and in 2012 by CNHP.

Materials needed for transect establishment:

Compass
50 m survey tape (2 or 3)
GPS unit, with the needed background file(s) for site(s) being surveyed
Wooden stakes
Orange marking paint
Dead blow hammer (2)

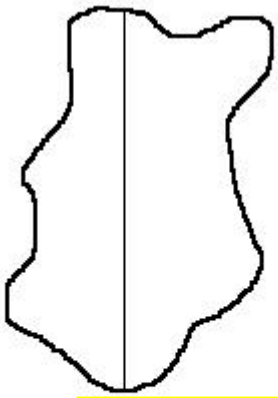
Materials for SURVEY ONLY:
Quadrat 50 x 50 cm (2)
50 m survey tape (minimum of 2, however 3 can also work well.
GPS unit, with the current year's shapefile for data entry

Standard survey procedure:

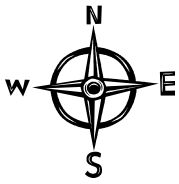
- The technique outlined here will apply to the majority of sites
- The general concept is to aim for a 50 m transect through the center of weed infestation. Sometimes it may be necessary to do a shorter transect in order to stay within the habitat. Ideally, the 25 m long bisecting transects have the 12.5 m mark crossing the main 50 m long transect. These secondary transects can be shortened if habitat does not extend the entire 25 m length.
- Identify a line which bisects the weed infestation along the longest axis, for a maximum of 50m. (Fig. 1)
- Five transects will be created, intersecting the bisecting line (Fig. 1) at points that are 5%, 25%, 50%, 75% and 95% of the line's length. These will span the width of the infestation, or a maximum of 25m. (Fig. 2)
    - If this is the first establishment of transects, mark beginning and end points with survey stakes and orange marking paint.
- Conduct weed and agent surveys at 3 m intervals, starting at the 0 m mark along each 50m and 25 m transect, recording survey data using ArcPad
    - In general, the 0 m mark for primary and lateral transects are either South or West.

- Vegetation surveys will be conducted along these transects, following the appropriate methods outlined for the weed at the site.
- Quadrats will be placed with the lower left corner of the quadrat placed at the 3 m interval point along the transect, always on the right side as looking from up the transect from the 0 m mark.

Fig. 1



0 m mark is south or west



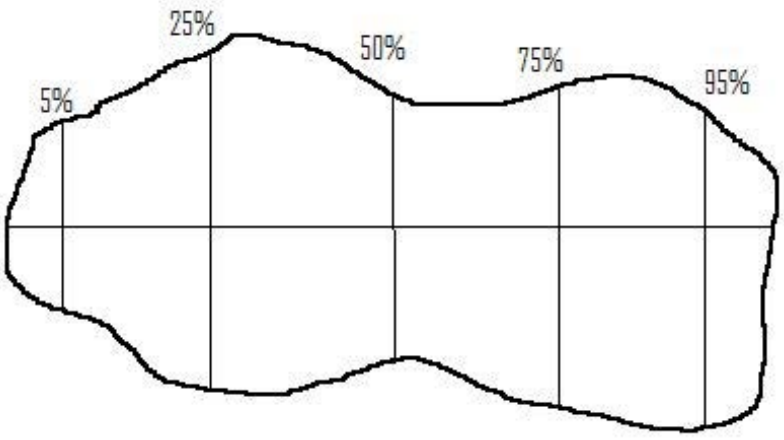


Fig. 2

0 m mark is south or west

Survey strategy for "unmappable" sites (never used in 2012)

- For sites deemed unmappable because of size and/or excessively rough topography.
- Should comprise a minimal proportion of total sites
- Two variations
    - Variation 1: An unmappable site having a linear pattern of weed infestation
        - Identify the largest reach of the site that is accessible; perhaps defined by access points from roads.
        - Consider the first accessible point along the infestation the "beginning" of the area and the last accessible point the "end" of the area. (Fig. 3)
        - Use the 5%-25%-50%-75%-95% method outlined above (in standard methods) to partition the infestation into roughly equal sections (the division of the infestation into these sections may be approximate). (Fig. 4)
        - At the midpoint of each of these dividing lines, create a 25 m long transect, that will lie along the longest axis of the infestation. (Fig. 5)
            - If this is the first establishment of transects, mark beginning and end points with survey stakes and orange marking paint.
        - Conduct weed and agent surveys at 3 m intervals along each 50 m and 25 m transect, recording survey data using ArcPad
            - Vegetation and agent surveys will be conducted along these transects, following the appropriate methods outlined for the weed and agent(s) at the site.
            - Quadrats will be placed with the lower left corner of the quadrat placed at the 3 m interval point along the transect.

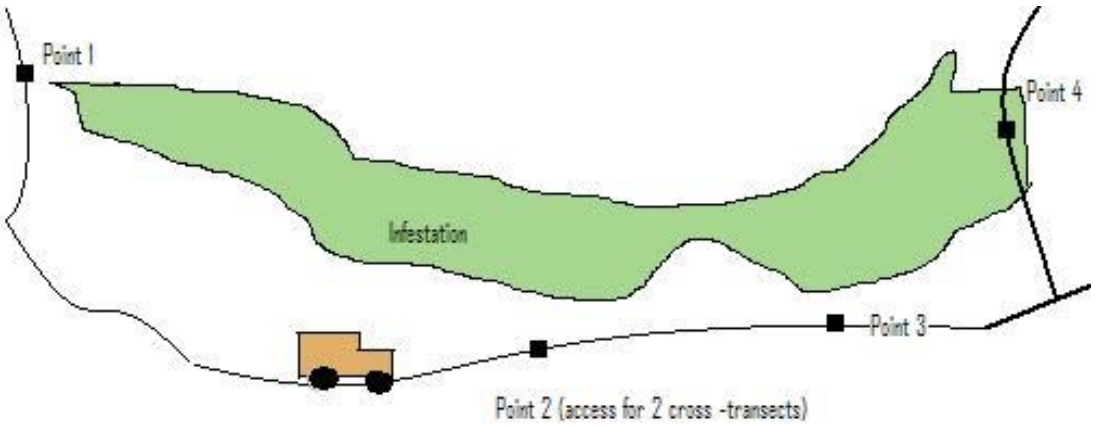

Point 1
Point 4
Infestation
Point 3
Point 2 (access for 2 cross -transects)

Fig. 3

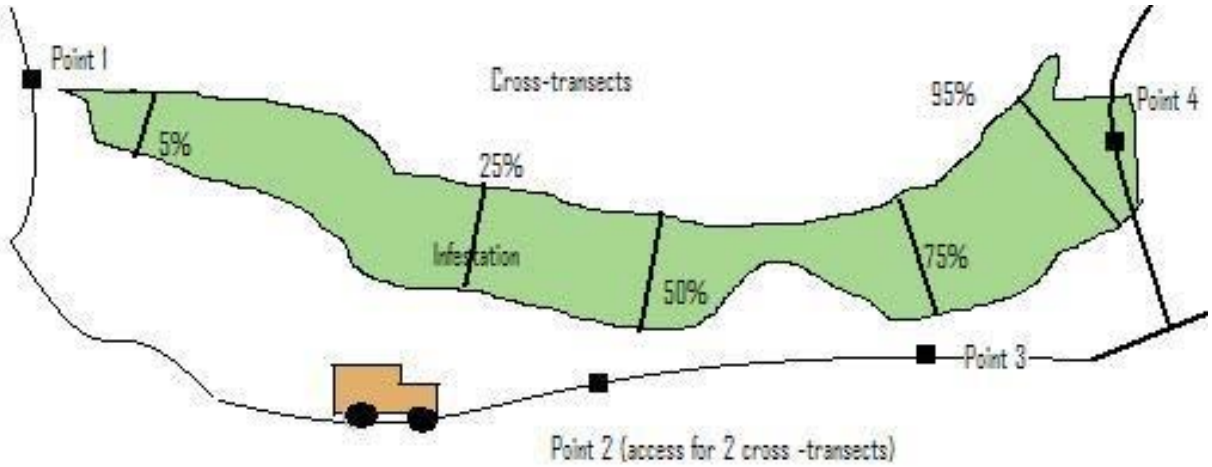

Point 1
Cross-transects
95%
Point 4
5%
25%
Infestation
50%
75%
Point 3
Point 2 (access for 2 cross -transects)

Fig. 4

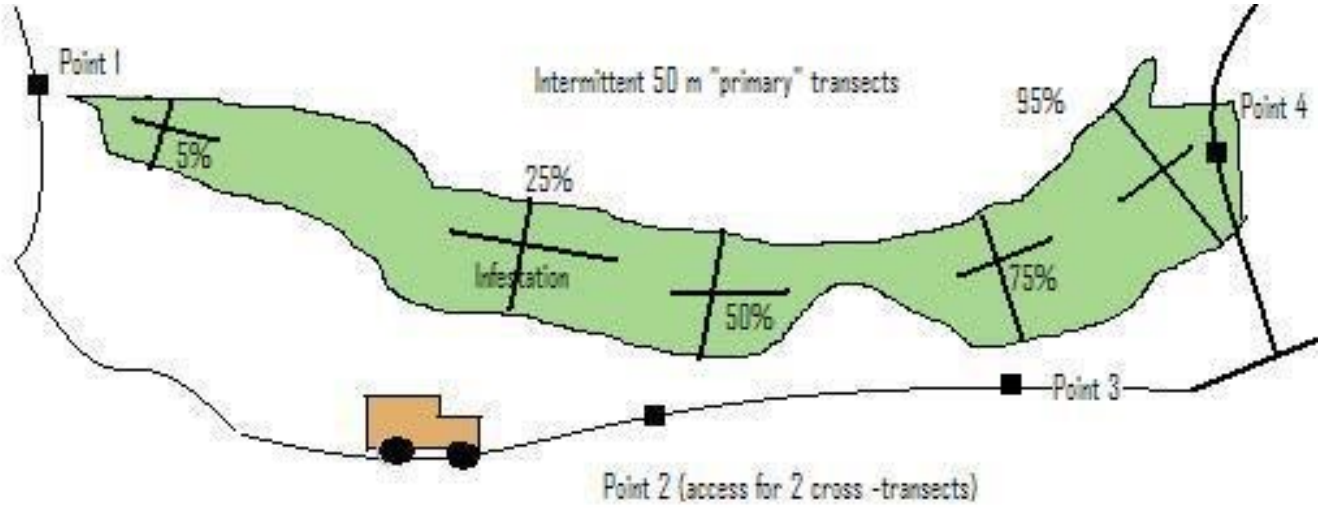


Fig. 5

Collecting data at each50 x 50 cm quadrat, (every 3 m, starting at 0 m mark):

- **Reproductive stage**: chosen for the most mature stage in the quadrat.
  - Seedling, bud, flowering, seed, post seed
- **Density**
  - Number of shoots/stems arising from ground within the quadrat
- **Cover, use the following categories:**
  - 0, 1, 3, 5, 7, 10, 15, 20, 25, 30, 35, etc.
- **Height (cm)**
  - Measure tallest stem in quadrat
- For knapweeds and Canada thistle only:
  - Count the number of **flower heads** on the tallest stem
  - **Measure flower diameter, including phyllaries, (mm)**
- **Comments: general comments about the transect should be placed in the first quadrat at the 0 m mark.**

Photos: Take a photo from the 0 m and 50 m mark of the primary transect, looking down the transect.

APPENDIX C. MAPPING PROTOCOL

Noxious weed occurrences were mapped in the field using ArcPad version 10.2 R5 (ESRI 1995-2018), a portable version of GIS software that allows users to efficiently create and attribute spatial data remotely using a tablet computer. ArcPad was installed on a Trimble Yuma rugged tablet with a Windows 7 operating system and a built-in GPS receiver module. The Yuma tablet has improved display capabilities for outdoor use, a rugged exterior to withstand adverse weather conditions, a stable operating system and hard drive, and a large screen to help with navigation and data collection. According to Trimble specifications, the GPS is accurate to within 2-5m using SBAS (Satellite-Based Augmentation System). To ensure data accuracy during the collection process, SBAS was activated and warning systems were enabled in ArcPad to notify the user when the PDOP (Position Dilution of Precision) exceeded 6 and the EPE (Estimated Position Error) exceeded 8. Twenty points were averaged at each location, and 10 vertices were averaged for lines and polygons.

Weeds were mapped as points, lines or polygons, depending on the size and configuration of the occurrence. Linear features were mapped as lines and assigned a buffer width to estimate area. Irregularly shaped features greater than approximately 30 meters in any direction were mapped as polygons. All other features were mapped as points and assigned a radius. Since weeds are mobile from year to year, and the GPS has inherent inaccuracies, weeds of the same species within 5 meters of each other were mapped as one feature. If previously mapped infestations were not located, they were marked as eradicated, as opposed to deleted, in order to track the soil seed bank and ensure future visits to historically infested areas.

All features were collected using the GPS unless otherwise noted in the attribute table. Features that were inaccessible due to natural barriers or exclosures were digitized “heads-up” using the 2015 NAIP digital orthophoto 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 in a specific area (e.g., dense oak thickets affecting the ability to map location or estimate individuals). The botany technician had the option to document number of individuals or density as number of individuals per square meter. If density was noted, the number of individuals was calculated in the office by multiplying density by the size of the infestation in square meters.

In 2019, monitoring protocols were adjusted for rapid response species. Occurrences were mapped and attributed and then plants were mechanically removed from most sites. Occurrences with plants were revisited multiple times during the growing system for most species. Subsequent visits documented the visit date and the number of remaining plants.

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%, Moderate; 25-75%, High; 75-100%, Very High

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

COMMENT – Free text field

DATUM – Datum

FEATTYPE – Point, line or polygon

USOWNER – Federal land ownership

LOCALOWNER – Local land ownership

US_STATE – U.S. state

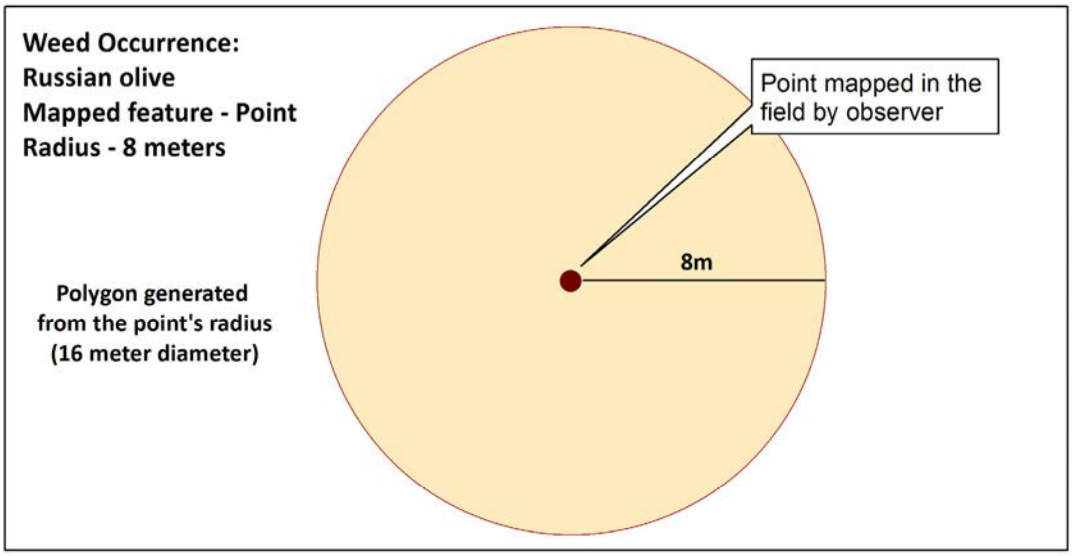
COUNTRY - Country

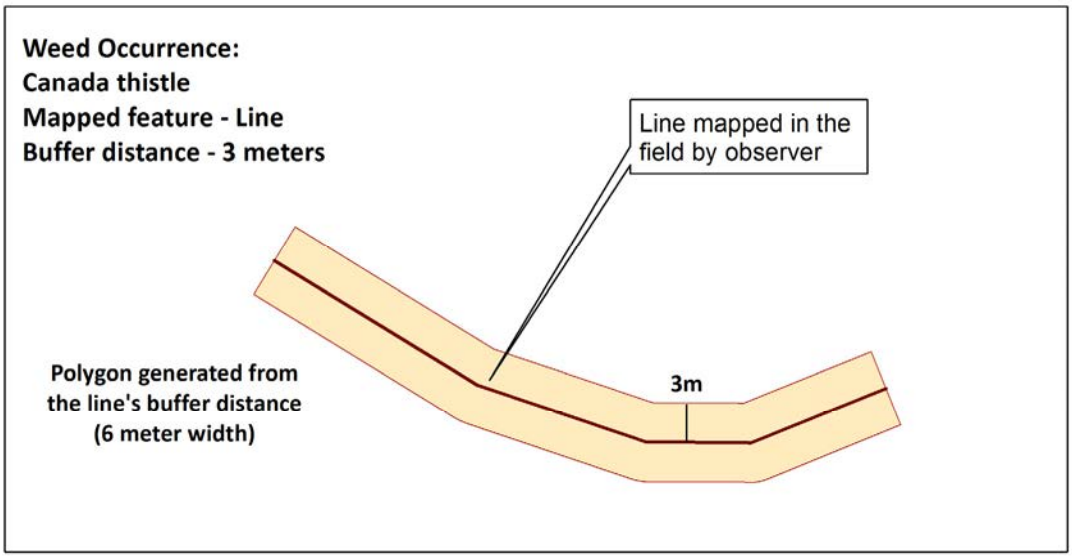
EXAMINER –Field observer

MAPAGENCY – Mapping agency

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

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





APPENDIX D. 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, Siberian peashrub)
   □ 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://www.colorado.gov/)
   Is the site located near (<10 m) of a rare plant or within a rare plant community? YES/NO

7. Describe actions that are being considered for this site*:_____

_____

_____

8. What are the expected results of proposed action(s)? _____

_____

_____

9. What are the potential negative impacts of proposed actions? _____

_____

_____

10. Describe the goal for the proposed action(s):
    □ **Eradication** (only for small populations; puncturevine, bull thistle, 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:_____

DATE OF PHOTO: _____TIME_____

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

ASPECT/COMPASS HEADING FOR PHOTO: _____

***HERBICIDE**:

If herbicides are planned for SWMAs, 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:_____

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: