Noxious Weed Monitoring Year 16 at the U.S. Air Force Academy

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COLORADO NATURAL HERITAGE PROGRAM

Noxious Weed Monitoring Year 16 at the U.S. Air Force Academy

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

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Front Cover: Garlic mustard (*Alliaria petiolata*) along West Monument Creek, yellow spring bedstraw (*Galium verum*) along West Monument Creek, myrtle spurge (*Euphorbia myrsinites*) in September snow; Monument Creek floodplain.

EXECUTIVE SUMMARY

This report summarizes the results of the past sixteen 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 2020, areal mapping was conducted for 17 species. Many sites were treated manually to remove plants following specific manual weed treatment protocols. These treated sites received follow-up visits for monitoring and additional treatments as necessary. Sites were visited from 1-3 times depending on the species and monitoring results.

Sixteen noxious weeds species were prioritized for manual treatments by CNHP for 2020. A new List B species, common tansy (*Tanacetum vulgare*) was mapped in 2020 bringing the total to 17 species. The results of the basewide survey in 2018 showed increases in weeds despite treatments and a new strategy was developed to reduce 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 for species considered to have low cover across the Academy. 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. Removing the sprouts later in the season has yielded notable reductions for myrtle spurge, perennial pepperweed and orange hawkweed in 2020.

Summary of Findings

As part of the manual treatments in 2020, there were a total of 749 site visits to manually treat plants including follow-up visits. A total of 8,998 shoots were removed in 2020 by CNHP (Table 1). Species that were prevented from going to seed in 2020 included perennial pepperweed, Russian knapweed, myrtle spurge, orange hawkweed, oxeye daisy, bouncingbet, and some Scotch thistle.

In 2020, three species are showing increasing trends at the Academy compared to 2019: garlic mustard, oxeye daisy and yellow spring bedstraw, with >100% change (red arrows), and two species, Russian knapweed and houndstongue are showing moderate increases of less than 100% change (orange arrows). Two species, Scotch thistle and salt cedar are stable with less than a 10% change (yellow diamonds) and Dalmatian toadflax continues to be eradicated as it was in 2019 (yellow diamond). Six species are showing decreasing trends (green arrows): myrtle spurge, dames rocket, orange hawkweed, perennial pepperweed, Common St. Johnswort, and bouncingbet. Two species have trends that are not clear due to lack of data, Tatarian honeysuckle and scentless chamomile (question marks) (Table 1). A new species was mapped, common tansy, at one location along West Monument Creek.

See individual species sections for more detailed information.

Table 1. Summary of treatments for noxious weeds monitored at the Academy in 2020.					
Trend 2019-2020	Scientific Name	Common Name	#CNHP Site Visits	Total # Shoots	# Shoots Treated
	*Acroptilon repens*	Russian knapweed	15	293	293
	*Alliaria petiolata*	Garlic mustard	22	24,791	2,422
	*Cynoglossum officinale*	Houndstongue	77	3,665	465
	*Euphorbia myrsinites*	Myrtle spurge	78	132	132
	*Galium verum*	Yellow spring bedstraw	4	1,049	749
	*Hesperis matronalis*	Dame's rocket	2	0	0
	*Hieracium aurantiacum*	Orange hawkweed	2	245	245
	*Hypericum perforatum*	Common St. Johnswort	102	9,658	1,858
	*Lepidium latifolium*	Perennial pepperweed	6	114	114
	*Leucanthemum vulgare*	Oxeye daisy	15	706	706
	*Linaria dalmatica*	Dalmatian toadflax	8	0	0
?	*Lonicera tatarica*	Tatarian honeysuckle	29	85	0
	*Onopordum acanthium*	Scotch thistle	328	2,353	397
	*Saponaria officinalis*	Bouncingbet	32	1,339	1,339
	*Tamarix ramosissima*	Salt cedar	5	1	0
NEW	*Tanacetum vulgare*	Common tansy	1	15	0
?	*Tripleurospermum perforatum*	Scentless chamomile	23	278	278
TOTALS			**749**	**44,724**	**8,998**

Summary of Recommendations

- Continue to focus on rapid response target species by conducting areal surveys and manual treatments multiple times in the same growing season for: myrtle spurge, orange hawkweed, Russian knapweed, perennial pepperweed, oxeye daisy, Scotch thistle, Dame's rocket, Dalmatian toadflax, common tansy, scentless chamomile, bouncingbet and houndstongue.
- 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 2021 season.

- Conduct a survey of Monument Creek to map garlic mustard along West Monument Creek.
- Begin Scotch thistle and houndstongue mapping and manual treatments much earlier in the spring at as many populations as possible. Treating sprouts is the easiest and most effective way to control these species and to prevent seed production.
- Dalmatian toadflax, and dame's rocket sites should be monitored at least once and twice if plants are found on the first pass.
- Continue to monitor all populations of bouncingbet and remove flowering stems in 2021.
- The use of monitoring plots at the Academy and Farish is under discussion for future monitoring efforts.
- List A, B or watch list or noxious weed species of management concern in need of rapid response actions include:
    - Myrtle spurge (List A)
    - Orange hawkweed (List A)
    - Perennial pepperweed (List B)
    - Russian knapweed (List B)
    - Oxeye daisy (List B)
    - Scotch thistle (List B)
    - Houndstongue (List B)
    - Salt cedar (List B)
    - Dalmatian toadflax (List B)
    - Dame's rocket (List B)
    - Common tansy (List B)
    - Scentless chamomile (List B)
    - Bouncingbet (List B)
    - Common St. Johnswort (List C)
    - Garlic mustard (State Watch List)
    - Yellow spring bedstraw (not listed, garden escape)
    - Tatarian honeysuckle (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)
    - Dyers woad – not found (List A – documented in the vicinity)

Acknowledgements

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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.

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).

Herbicide Use in Natural Communities

Guidelines for controlling noxious weeds (including herbicide label instructions) are often based on agricultural landscapes instead of natural plant communities or wildlands. 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). These areas were delineated at the Academy as Special Weed Management Areas (Smith et al. 2015, Figure 1). 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. The presence of rare plants, pollinators, and wildlife, including a threatened mammal species (Preble's Meadow Jumping Mouse) that lives in riparian areas at the Academy, needs consideration. Although many herbicides are tested for toxicity to animals to some degree, the adjuvants often added to herbicides and the mixtures of herbicides used by contractors are not (Wagner et al. 2017).

Weed infestations are most often the result of previous land disturbances, therefore, the primary goal in weed management in natural communities is to prevent or minimize disturbances to soil and native plants. Herbicides can cause soil disturbances by harming soil organisms, changing soil chemistry and killing surrounding plant species and are considered a last resort by numerous wildland managers (Sources A-D, Appendix E).

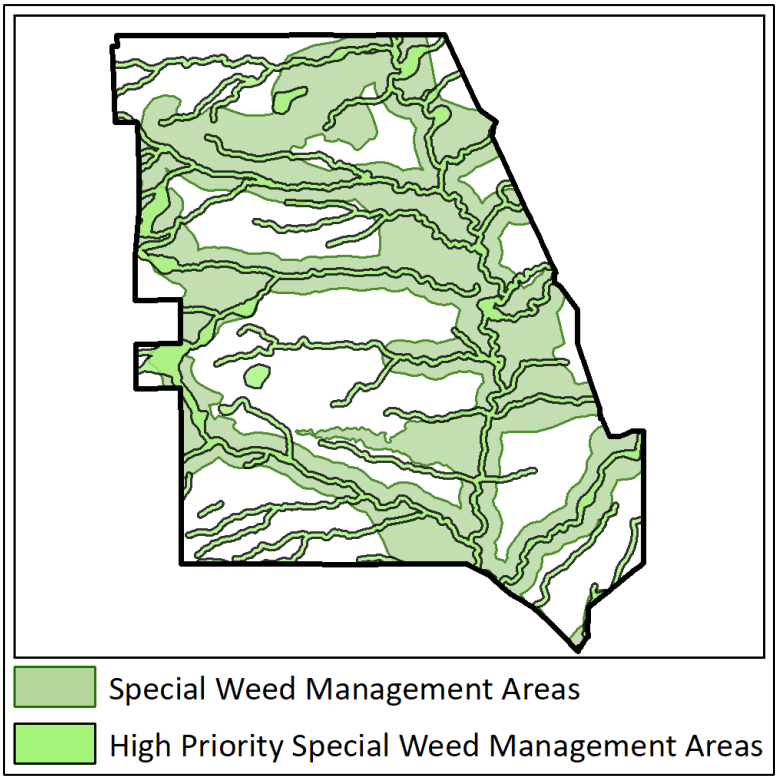


Figure 1. Special Weed Management Areas at the Academy.

The efficacy of herbicide treatments has not been well-documented in North America. There is scientific literature on the efficacy of herbicides for controlling target weeds but most of this research focuses exclusively on the target plant with no information on the desirable natives and the outcomes are only monitored over a short period of time neglecting the economic impacts of management actions (Wagner et al. 2017). The research suggests herbicides alone are not effective in the long-term and typically result in re-infestations of the same or different noxious weeds species (Pearson et al. 2016). Careful consideration needs to be made by land managers to consider if an herbicide will do more conservation good than harm in each situation (Source A in Appendix E). This is the basis for the following herbicide application guidelines in natural communities at the Academy.

Guidelines for Herbicide Use in Natural Areas

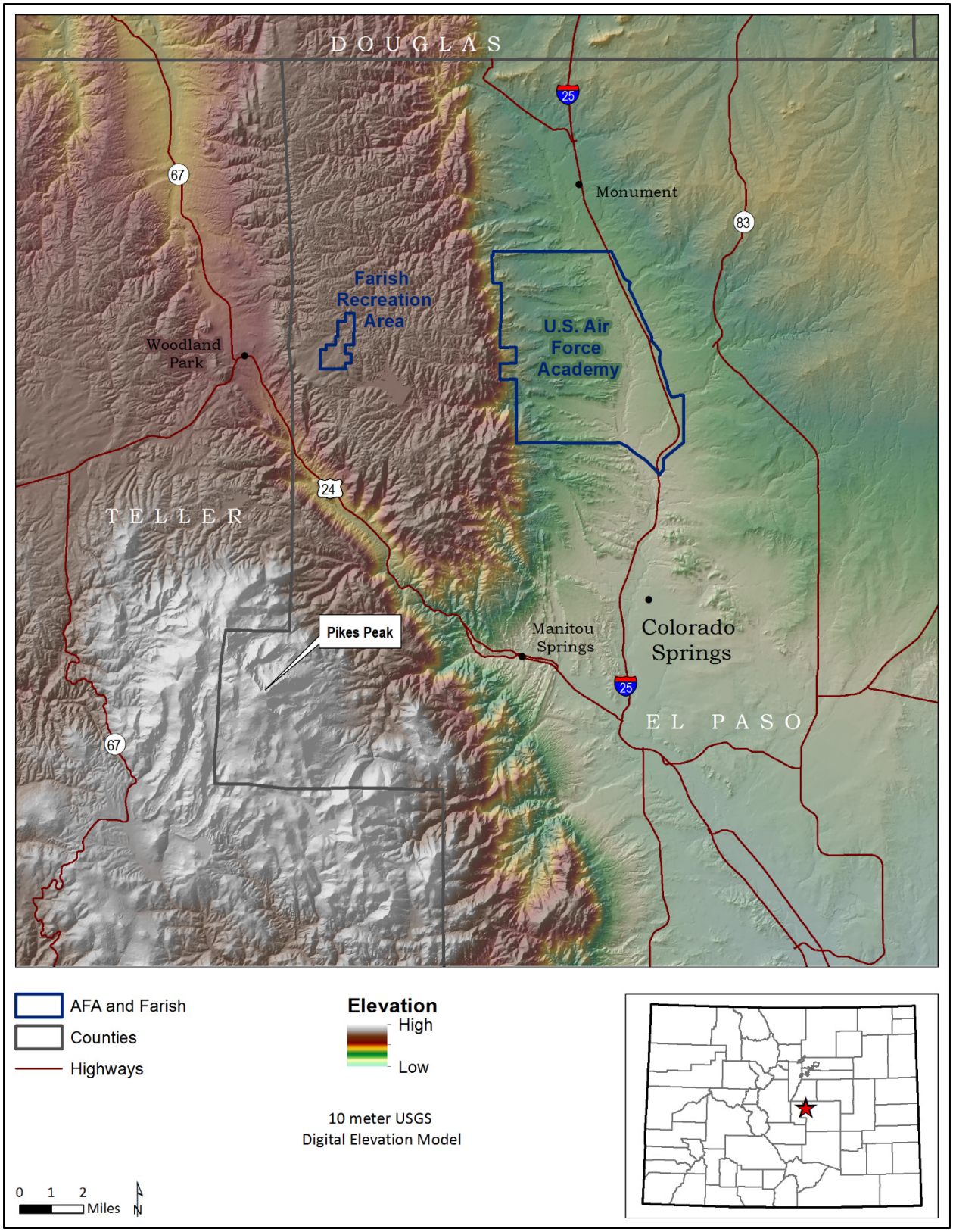
1) If other methods (manual removal, biocontrol) are available, those should be used first. Herbicides should be used as a last resort and when all other reasonable alternatives have been ruled out in natural plant communities (Sources A-D in Appendix E).
2) Consider potential impacts of treatment to determine if there will be more impacts from treating than not treating (Sources A-D in Appendix E).
3) Spot applications of herbicide that target individual plants by either wiping herbicide with a wicking cloth or a precise spray that is aimed at the target plant minimizing harm to

adjacent plants and soils is highly recommended by numerous land conservation agencies (GPMCT 2019, Sources A-D in Appendix E).

4) Consider herbicides that are selective for broadleaf weed species to protect native grasses, that are effective against the target species (Source B). The Special Management Areas are not rangelands. Recommended dosing and application methods for rangelands can damage natural resources and harm wildlife. Follow label instructions for wildlands and wetlands. Using herbicides in areas with Preble's Meadow Jumping Mice and rare plant species is not recommended.
5) Time herbicide application to the susceptible life stage and to minimize seed production. Avoid spraying bolted thistles in late stages and mid-summer application of herbicides which are less effective, require larger amounts of herbicide and result in greater off-target damage.
6) Consider not treating species with active biocontrol.
7) Document all herbicide applications.
8) Follow-up monitoring of treated sites to measure effectiveness and to catch late season sprouts.
9) Adaptive management flexibility to change a course of action if a certain method is unsuccessful or needs adjustment.
10) Use an integrated approach to treatments. Chemical treatments alone are almost never successful and are used as a part of an integrated control program when necessary in wildlands.

Reasonable Goals to Reduce Weed Cover at the Academy

1) All activities that prevent the spread of noxious weeds across the Academy, including avoiding disturbance of natural lands, cleaning equipment is the most effective. (Wagner et al. 2017)
2) Focus on mapping, monitoring and treatments for rapid response species that have less widespread cover (Wagner et al. 2017).
3) Utilize biocontrol for species that have widespread cover.
4) Staff and contractors can be on the lookout for new infestations as weed monitoring and management activities occur in between five-year basewide monitoring efforts.
5) Avoid treating large areas with dense infestations of widespread weed species without a restoration plan. Treating satellite populations or edges may help contain some noxious weeds.
6) See individual species recommendations for specific details.



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 (*Galium 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 weed 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. Surveying West Monument Creek for

garlic mustard was added to the tasks. A new list B species, oxeye daisy (*Leucanthemum vulgare*), was added to the noxious weed list at the Academy.

- **2020:** 17 species were monitored and 16 noxious weed species were prioritized for manual treatments by CNHP for the second year. A new list B species, common tansy (*Tanacetum vulgare*), was mapped in 2020.

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, four 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. Plot monitoring was suspended since 2019.
- **Monitoring with treatments** was added in 2019 as a method to address weed increases by rapid response species. This new method combines areal mapping with treatments and includes multiple visits to sites that had plants at the initial monitoring visit to look for sprouts.

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 and 2020 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.

In 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.

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 2020 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 2020 (Tables 2 & 3). 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.

The changes and modification that began in 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).

Table 2. Summary of weed treatment methods and actions for 2020.			
Latin Name	**Common Name**	**2020 Methods/Actions**	**2020 Action**
Acroptilon repens	Russian knapweed	Areal/Treat	Manual #1
Alliaria petiolata	Garlic mustard	Areal/Treat	Manual #1 & Method 3
Cynoglossum officinale	Houndstongue	Areal/Treat	Manual #1
Euphorbia myrsinites	Myrtle spurge	Areal/Treat	Manual #2
Galium 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
Saponaria officinalis	Bouncingbet	Areal	Remove reproductive parts.
Tamarix ramosissima	Salt cedar	Areal/Treat	Method #3
Tanacetum vulgare	Common tansy	Areal/Treat	Manual #1&2
Tripleurospermum perforatum	Scentless chamomile	Areal/Partial Treat	Manual #2
Long Term Monitoring Plot Species not Monitored in 2019 - 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 2020.	
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)**

A coordination meeting with the Academy Resource Manager and the herbicide applicator was held on May 13, 2020, to discuss timing and implementation of the new methods and coordination. 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 is our hope that

both parties communicate with one another for assistance on monitoring and treatment. Monitoring and manual treatments by CNHP began in May of 2020.

Noxious weed sites east of I-25 were not monitored after discussions with the Academy. I-25 east is being developed and Pine Creek is a highly disturbed system where treating weeds is futile without a restoration plan. The large population of Scotch thistle near Pine Loop and west of the High School that is located in a residential area cleared for development, was also not visited in 2020.

For 2021, early spring surveys will target mapping garlic mustard. This species has been an aggressive invader at the Academy since it was discovered in 2018. It has reached a cover that is already difficult to eradicate. A full survey upstream of the known populations along West Monument Creek will be conducted to look for new infestations. Garlic mustard is a state watch list species on the Colorado Noxious Weed List (CDA 2021). This plant has been shown to be highly problematic in wildlands, especially in riparian areas.

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 2020 yearly total at the Colorado Springs Municipal Airport (KWOS) was 7.85 inches, about 4.5 inches below the average annual precipitation (1961-1990) of 12.33 inches (Figure 2). 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, bouncingbet and houndstongue seem to have population increases that are strongly correlated with spring and summer precipitation patterns.

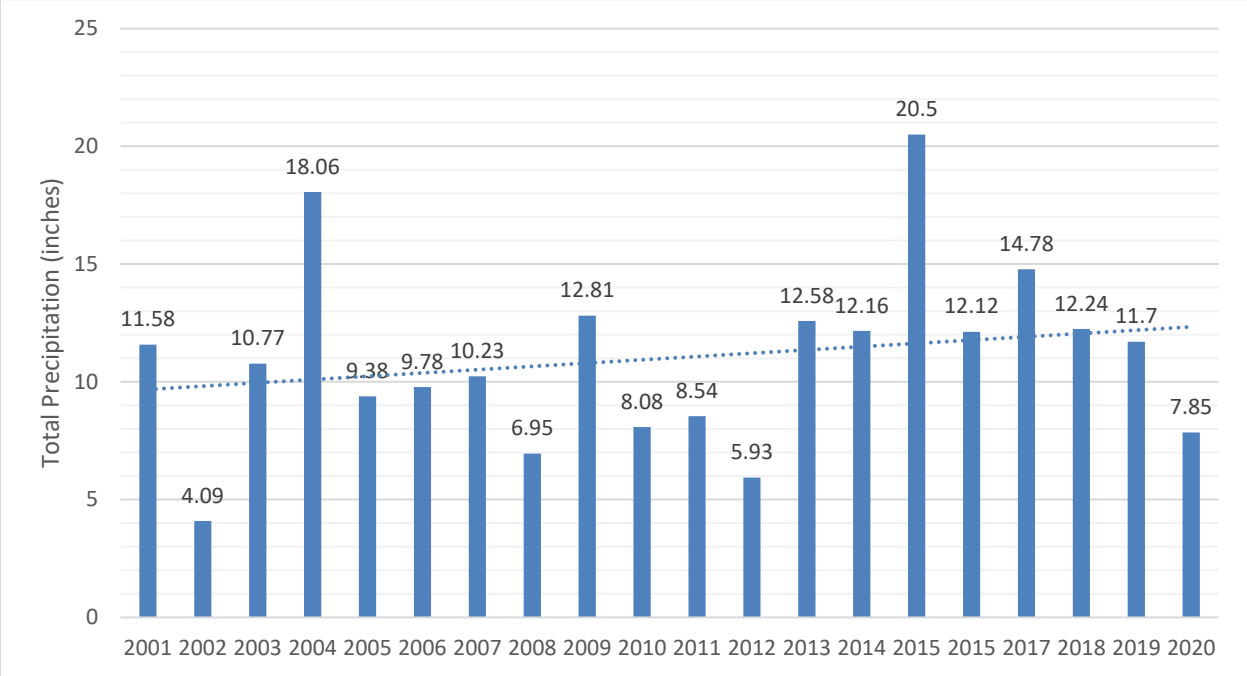


Figure 2. Average spring and summer precipitation. Spring = March-May, Summer = June-August. Blue dotted line is trend line (WU 2020).

RESULTS AND RECOMMENDATIONS

U.S. Air Force Academy

Noxious weeds have been increasing throughout the Academy since monitoring began in 2002 (Smith and Greenwell 2019, Figure 3).

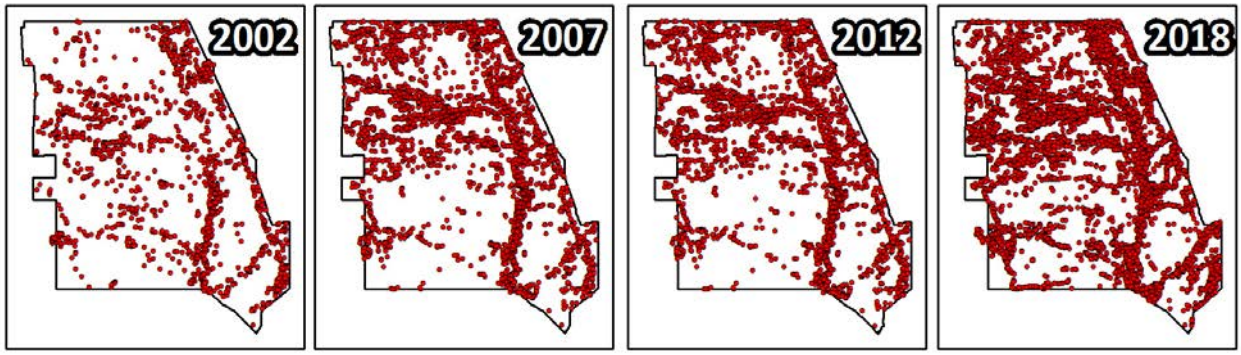


Figure 3. Distribution of known noxious weed occurrences at the U.S. Air Force Academy (excluding yellow toadflax).

A list of 16 species were proposed for monitoring and/or treatments for the 2020 season. A new List B Noxious weed, common tansy (*Tanecetum vulgare*), a garden escape, was mapped along the West Monument Creek drainage in 2020. This brings the list of noxious weed species monitored to 17.

In 2020, three species, garlic mustard, oxeye daisy, and yellow spring bedstraw are showing increases in 2019-2020 trends and two species, houndstongue and Russian knapweed are showing moderate increases. Three species, Scotch thistle, Dalmatian toadflax, and salt cedar are stable. Seven species are showing decreasing trends including: myrtle spurge, perennial pepperweed, bouncingbet, Common St. Johnswort, dame's rocket and orange hawkweed (at Farish). Two species, Tatarian honeysuckle and scentless chamomile, have trends are that are not clear because all sites were not sampled. Common tansy was mapped for the first time.

As part of the manual treatments in 2020, there were a total of 749 site visits to manually treat plants including follow-up visits. A total of 8,998 shoots were removed in 2020 by CNHP (Table 1 above). Species that were prevented from going to seed in 2020 included perennial pepperweed, Russian knapweed, myrtle spurge, orange hawkweed, oxeye daisy, bouncingbet, and some Scotch thistle.

Garlic mustard is increasing rapidly in West Monument Creek and is problematic for control due to rapid reproduction and location in dense native vegetation such as willow thickets. Both mechanical and chemical treatments are being undertaken along with follow-up monitoring. This species is currently watch listed by the State of Colorado. Other species that have the potential to get out of control include Russian knapweed, orange hawkweed, and oxeye daisy. One population of

Russian knapweed northeast of the Natural Resource Office is a high priority site. Kettle Creek is the area where oxeye daisy could quickly expand and is also a high priority for treatment and monitoring. At Farish, orange hawkweed is a high priority even though there is only a single extant population. It appears to be declining after two years of mechanical removal but it is a high priority because of its ability to increase rapidly and reach levels that are almost impossible to control. The new populations of yellow spring bedstraw along Monument Creek indicates this species is spreading.

Medium priority species include Common St. Johnswort, Dame's rocket, bouncingbet and scentless chamomile. Local control and suppression are attainable. Biocontrols are commonly found on Common St. Johnswort.

Species that are decreasing but are considered a high priority for monitoring and treatment are myrtle spurge, bouncingbet, perennial pepperweed, and orange hawkweed. Dalmatian toadflax is a high priority for monitoring despite having been absent at all known locations due to its history of reoccurring suddenly and in large numbers. All of these species have a high likelihood of being eradicated. Salt cedar has only one extant occurrence and will likely be eradicated.

Flooding, precipitation patterns, biocontrol agents as well as the multiple treatments to remove sprouts within the same season are all contributing to reducing the rapid response species at the Academy.

Russian Knapweed (*Acroptilon repens*)

Trend 2019-2020: Moderately Increasing

Management Goals: 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).

2020 Results

Russian knapweed has shown a moderate increase from 2019 to 2020. For a period of five years from 2013 to 2017, all known sites were eradicated (Table 4). However, Russian knapweed has been steadily increasing since 2017 (Maps 2 & 3). In addition, the basewide mapping survey in 2018 yielded three extant locations including two new features (Table 4, Grid # D-7/E-7 Map 3). In 2019, the three extant sites were treated manually multiple times throughout the growing season as part of the new change in methods for 2019. In 2020, two sites had plants for the first visit of the 2020 season (1st pass). Table 4 and Figure 4 below provide a summary of the data and include the first pass data for the 2019 and 2020 seasons. Table 5 in the treatment section details the treatments and follow-up treatments (2nd and 3rd passes) in the same growing season. Russian knapweed sites located east side of I-25 were not monitored in 2019 and 2020.

Table 4. Mapping of Russian knapweed at the Academy.				
	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2004	?	?	3	0
2005	< 0.01	54	2	1
2007	0.03	200	2	2
2008	0.025	157	2	2
2009	?	?	2	2
2010	0	0	0	4
2011	0	0	0	4
2012	0.05	543	10	2
2013	0	0	0	12
2014	0	0	0	12
2015	0	0	0	12
2016	0	0	0	12
2017	0	0	0	12
2018	0.02	44	3	11
2019	0.18	94	3	11
2020	0.18	183	2	12

Basewide weed mapping performed during shaded years.

Figure 4. Number of Russian knapweed individuals, 2005-2020.

2020 Treatment

All sites except those east of I-25 were visited in 2020. There were a total of 183 individuals treated during the first site visit (Pass 1) at two extant sites. A second pass was conducted in late summer and another 75 individuals were removed from two extant sites. Because this species is known to sprout throughout the growing season, a third pass was conducted and 35 shoots were found at one location (northeast of the Natural Resources building) for a total of 293 shoots removed visiting 11 known sites in 15 site visits (Table 5).

All plants were treated by severing the root crowns 4-6 inches below the soil surface or removing entire plants, bagging all cut plants and disposing of them in off-site dumpsters. Although the numbers of sprouts have increased the footprint of the site has stayed the same.

The 75 plants treated during second site visit (pass), and 35 plants removed during the third pass, 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 visits which prevented plants from producing seeds at this site and removing sprouts that show up later in the season. With perennial species like Russian knapweed that reproduce by seed and vegetative shoots, both seed removal and removing any photosynthetic parts multiple times during the season to weaken the root system are important.

Table 5. Monitoring and treatment of Russian knapweed sites at the Academy in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	11	183	183	2	9
Pass 2	3	75	75	1	2
Pass 3	1	35	35	1	0
TOTALS	**15**	**293**	**293**	---	---

Recommendations

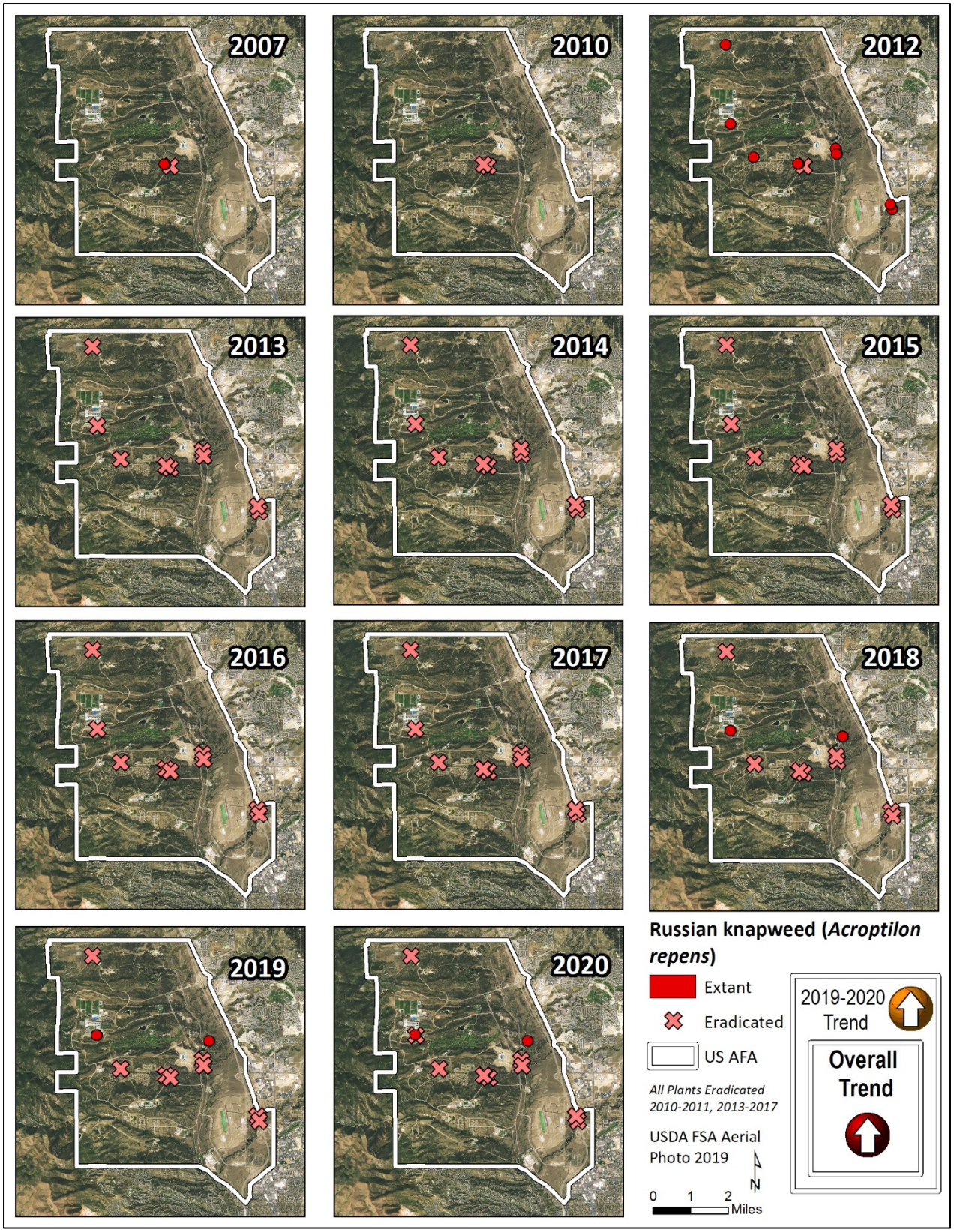
The management urgency continues to be very high for 2021 Early summer visits to all 11 sites before seed set will be conducted and follow-up with a late summer/fall visits to sites that had Russian knapweed plants present at the first visit. Continuing to remove above-ground parts to prevent seed production is a high priority.

Seed longevity is estimated to be five years; follow-up visits should be maintained for at least five years from the last extant occurrence. 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. This should be re-assessed in 2021 with Natural Resources personnel after the 2021 summer surveys. Biological control is not yet available

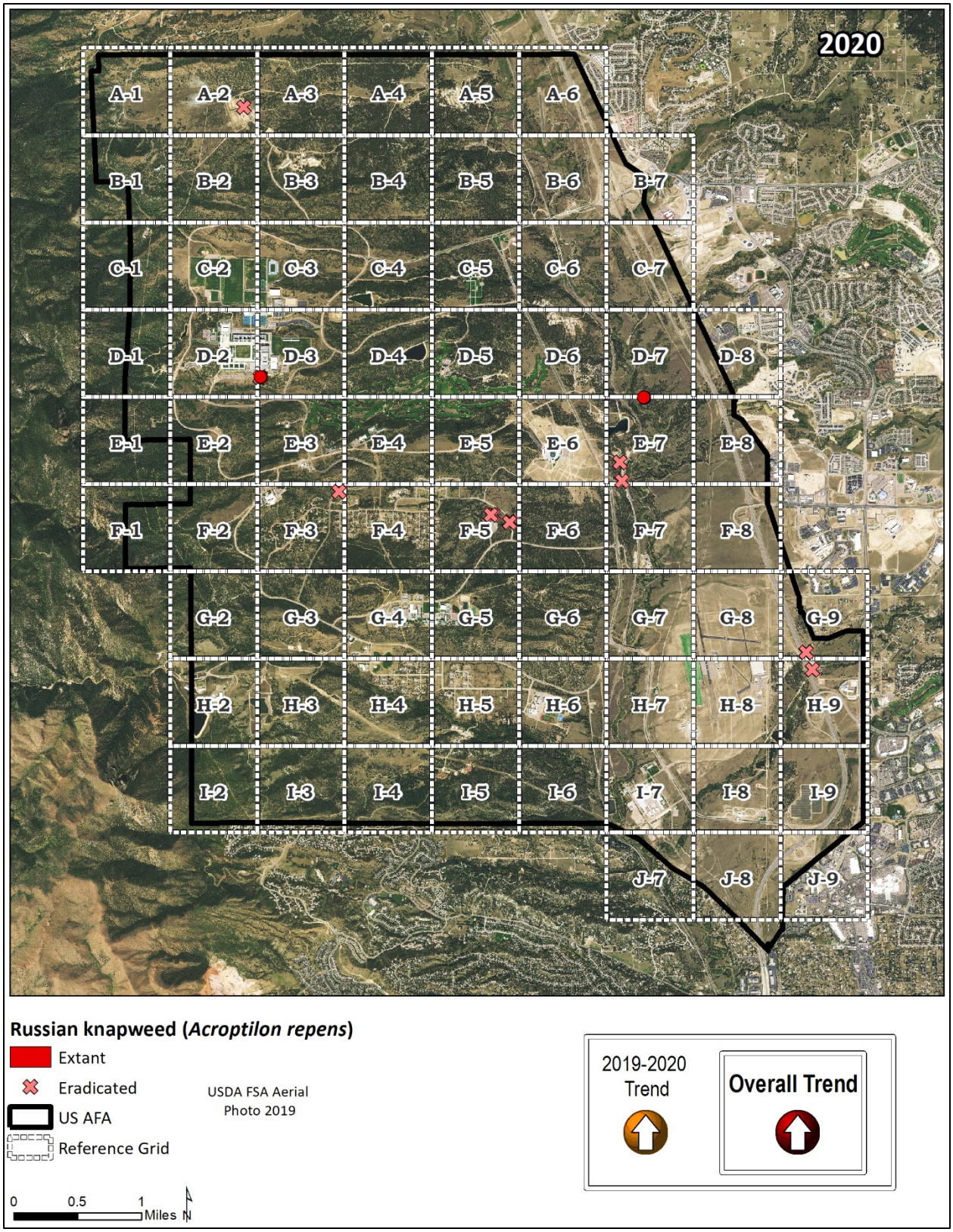
for Russian knapweed and currently the populations are not large enough to consider an application.

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.
- In 2020, 11 sites were visited and two sites contained Russian knapweed plants. Three sites east of I-25 were not visited. A total of 293 individuals were removed during the summer. No plants went to seed in 2020.



Map 2. Distribution of Russian knapweed at the Academy between 2007 and 2020.



Map 3. Distribution of Russian knapweed at the Academy in 2020 with the reference grid.

Garlic Mustard (*Alliaria petiolata*)

Trend 2019-2020: Increasing

Management Goals: Eradication /Containment

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/)

2020 Results

Garlic mustard has increased at an alarming rate since it was first mapped at the Academy in 2018 during the basewide survey (Smith and Greenwell 2019). It was originally 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. Despite manual and herbicide treatments in 2019, there was a big increase to more than 24,660 individuals which is four times the numbers compared to 2019. Many of these were very small sprouts. The number of sites increased from eight in 2019 to 14 in 2020 (Table 6, Figure 5, Maps 4 & 5). At three sites, herbicide treatments occurred before counts

could be conducted so thousands more plants are likely present than are reported in the table. Two sites had no plants found at the first pass (extirpated). West Monument Creek was surveyed early in the season to look for populations upstream of the known occurrences and only one sprouting individual was found about 460 meters upstream from the westernmost known occurrence. Roughly 1,800 meters of West Monument Creek has known populations of garlic mustard.

Table 6. Mapping of garlic mustard at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2018	0.12	4,011	7	0
2019	0.21	6,564	8	0
2020	1.03	24,660+	12	2

Basewide weed mapping performed during shaded years.

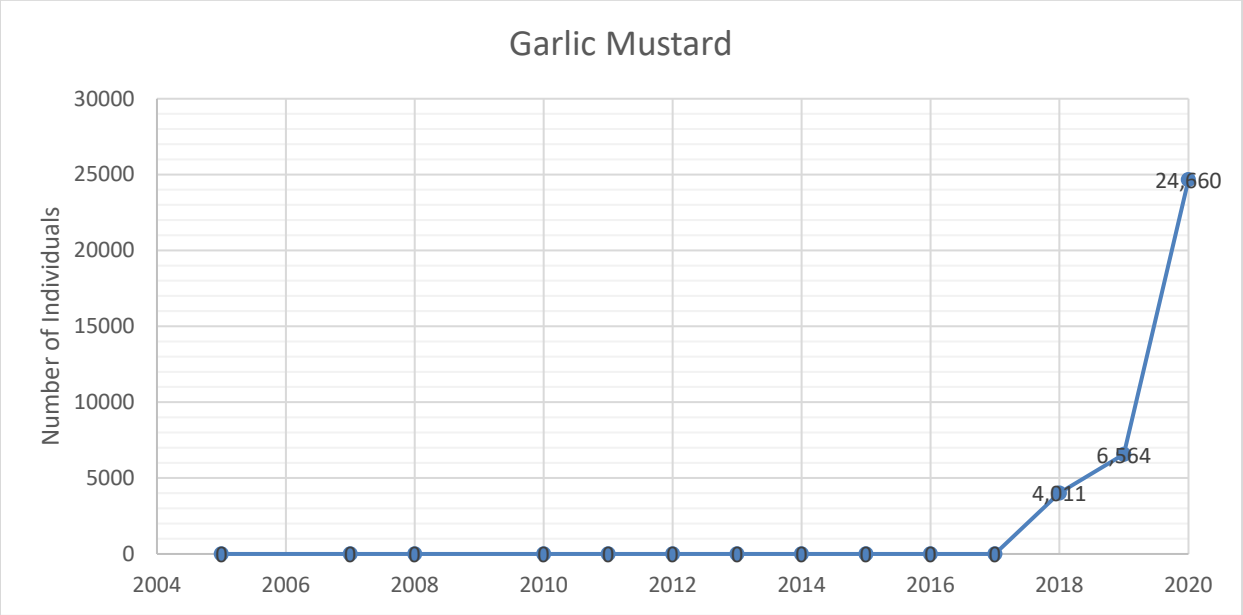


Figure 5. Number of garlic mustard individuals, 2018-2020.

2020 Treatment

In 2020, a combination of pulling and aggressive herbicide applications were used to control the garlic mustard. This species is a watch list noxious weed but has a very high potential to be invasive and is a high priority for monitoring and containment. Three sites had been sprayed before CNHP visited and there was no way to estimate the number of shoots treated at those locations. Those sites were counted as extant but no shoots were counted. The first visit by CNHP to all 14 sites yielded over 24,660 estimated shoots and the number is likely much larger if there had been counts

before herbicide was applied. It is clear that the seed bank along West Monument Creek has a significant amount of garlic mustard seeds. At the second pass later in the summer 131 individuals were mapped at four sites (Table 7). The easternmost site, where only manual treatments have occurred, had only 11 plants. This site has very little soil disturbance compared to some of the herbicide treated sites in 2019-2020 (Photos 1-4).

Table 7. Monitoring and treatment of garlic mustard sites at the Academy in 2020.

	# Sites Visited	Estimated # Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	14	24,660+	2,291	12	2
Pass 2	8	131	131	4	4
TOTALS	**22**	**24,791**	**2,422**	---	---

Photo 1. Easternmost garlic mustard site prior to spring manual removal in May 2019. P. Smith

Photo 2. Easternmost garlic mustard site post spring manual removal in May 2019. P. Smith

Photo 3. Easternmost garlic mustard site post summer manual removal in June 2020. Note very small amount of off-target damage to nearby vegetation and soil. P. Smith

Photo 4. Herbicide treatment area for garlic mustard with off-target impacts to native vegetation including woody plants. Note new sprout of garlic mustard in the treatment area (insert on right). Photo P. Smith 2020.

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 (Photo 5). 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 at the Academy: 1) no garlic mustard was mapped upstream of the two large manicured residences, 2) yard waste was being discarded into the West 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*), a new List B noxious weed found in 2020 common tansy, as well as a state watch listed noxious weed, hoary alyssum (*Berteroa incana*). If these residences are the source, it may worth an effort to contact the residents to reduce or eradicate the garlic mustard and other potentially invasive species from entering West Monument Creek. Watch list is defined by the Colorado Department of Agriculture as "intended to serve advisory and educational purposes only. Its purpose is to encourage the identification and reporting of these species to the Commissioner in order to facilitate the collection of information to assist the Commissioner in determining which species should be designated as noxious weeds." (https://ag.colorado.gov/conservation/noxious-weeds/species-id). Garlic mustard is also a watch list species but it has shown itself to be highly invasive at the Air Force Academy while hoary

alyssum has not. The Resource Managers can decide if hoary alyssum is worth monitoring to document spread. So far, from our experience it has been noted in this area for a couple of years but does not appear to be highly invasive and has stayed in the immediate disturbed area but it has not been mapped to document this.

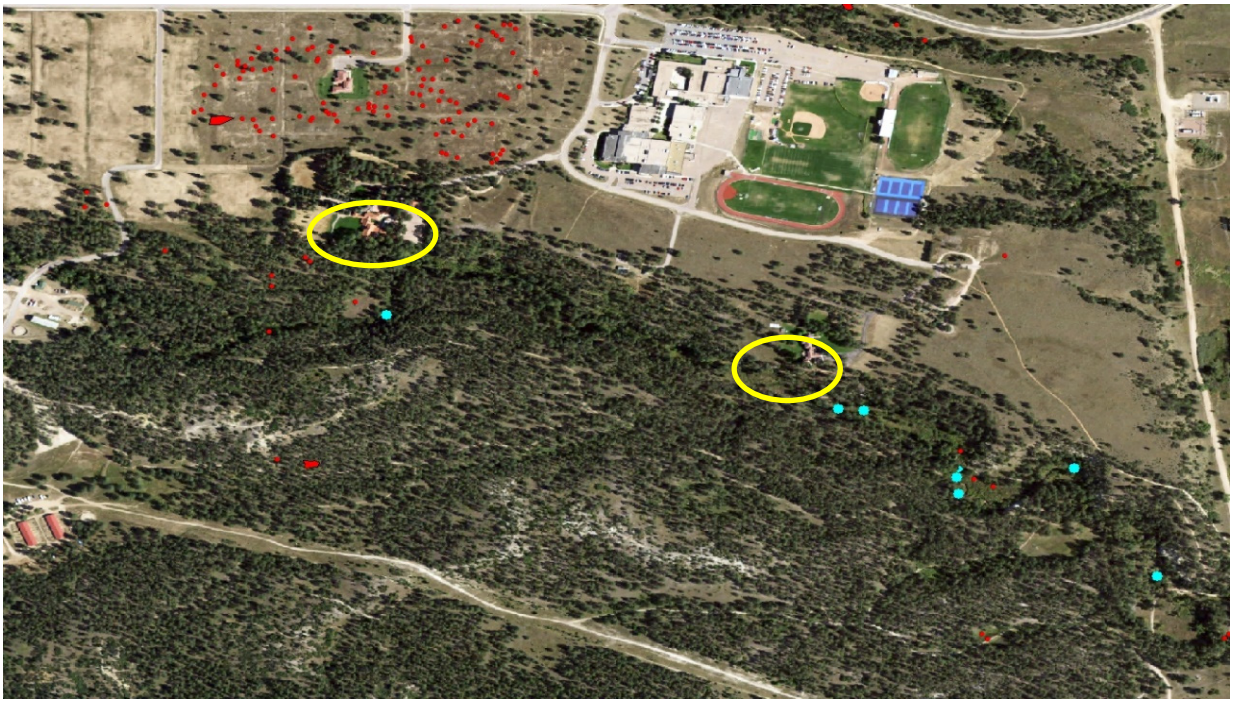


Photo 5. Air photo: yellow circles show locations where yard waste was observed on the slopes behind large residences at the Academy that are upslope and upstream from mapped garlic mustard locations along West Monument Creek (blue dots).

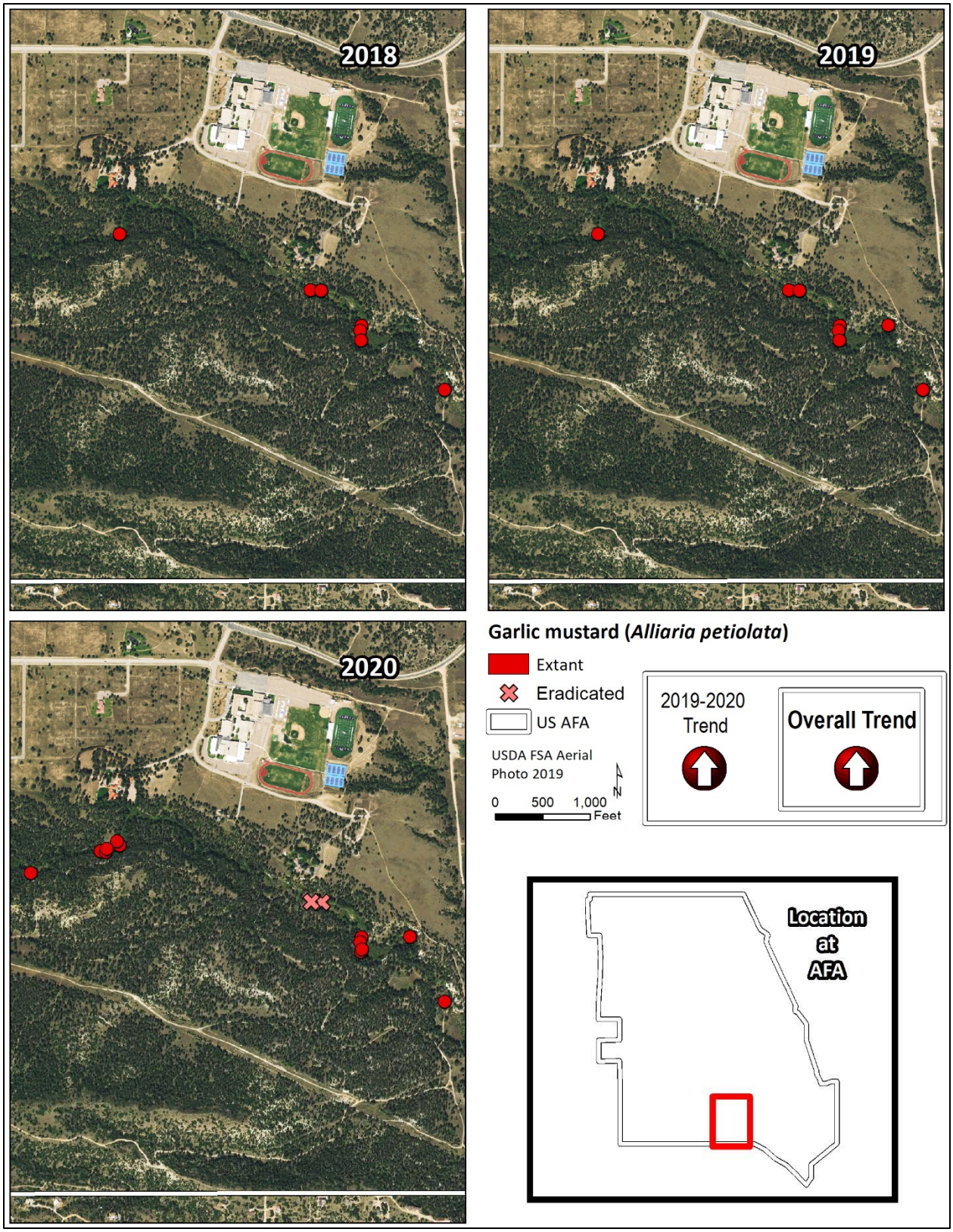
Recommendations

1) Survey West Monument Creek: In 2021, we will focus on surveying West Monument Creek very early in the spring to look for sprouts and to monitor all 14 known sites. The vegetation is less dense and the sprouts should be easier to see. In addition, the entire stretch of the creek will be surveyed to see if there are any plants occurring upstream as was done in 2020. The most important focus will be on the results of the early spring monitoring to look at the results of the 2020 treatments. This will determine what the next treatment steps will be.
2) Talk to upslope landowners or residents and survey the property if possible for potential noxious weeds. Many of the species sold on the internet and through garden stores are invasive, especially in riparian areas.

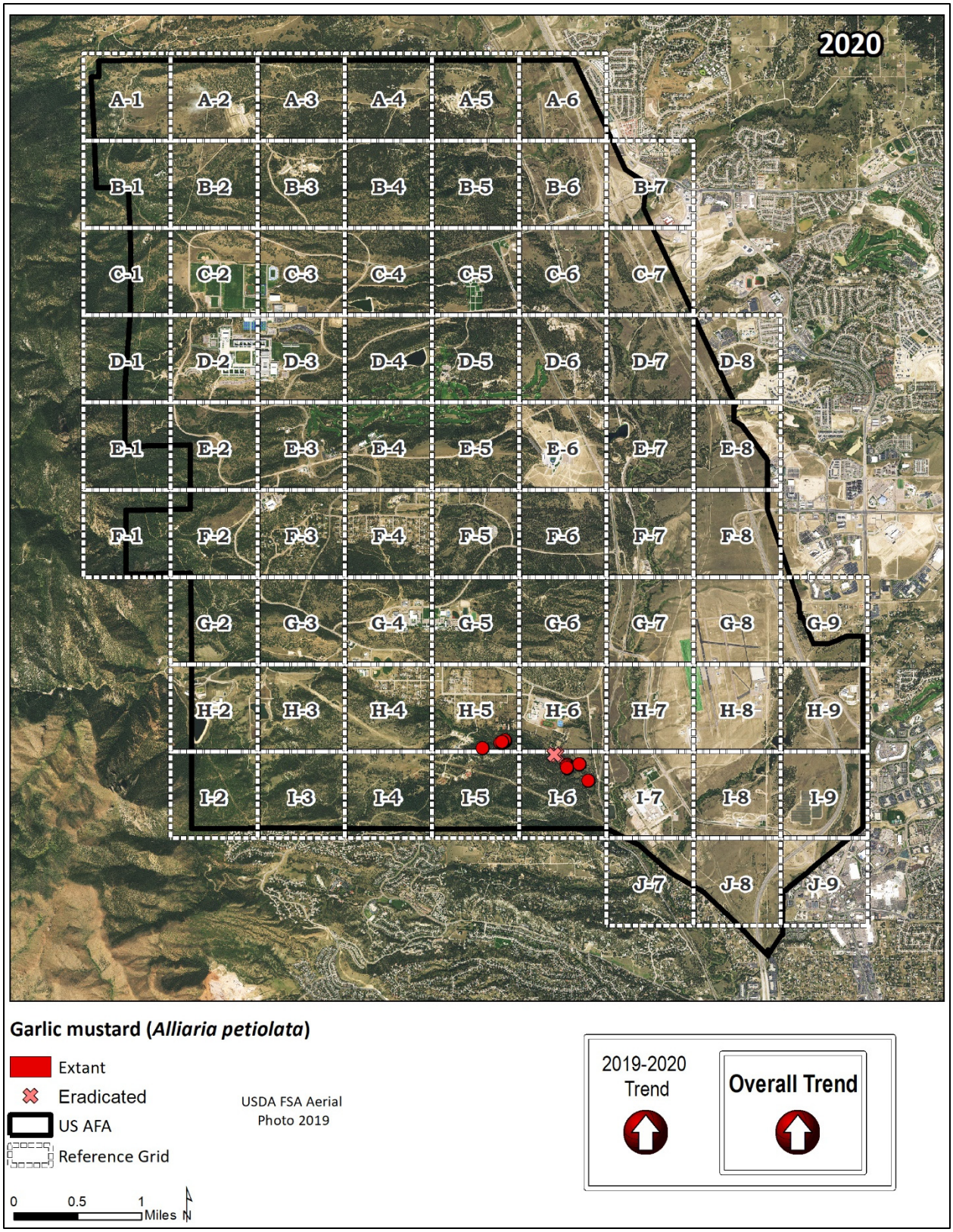
History of Sampling and Treatment:

- Garlic mustard was first discovered during the 2018 basewide survey at seven mapped sites. 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 West Monument Creek.
- In 2020, a very large increase in the number of sprouts was observed along with an increase in the number of mapped sites. A plan to survey earlier and include the entire western part of West Monument Creek, and monitor and treat more frequently is planned for 2021.



Map 4. Close-up of garlic mustard at the Academy between 2018 and 2020.



Map 5. Distribution of garlic mustard at the Academy in 2020 with the reference grid.

Houndstongue (*Cynoglossum officinale*)

Trend 2019-2020: Moderately Increasing

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, top photo BLM

Photo by M. DiTomaso, University of California - Davis

Houndstongue rosette, Kingcounty.gov

2020 Results

Houndstongue has increased moderately from 2019 to 2020. In 2020, the estimated total number of houndstongue individuals is 3,961 at 49 extant sites compared to 3,056 at 57 sites in 2019. Overall houndstongue is increasing across the Academy (Table 8, Figure 6, Maps 6 & 7). The largest populations are near the WWTP area that contained 2,660 individuals in 2020 (Grids F-7, G-7 on Map 7).

Table 8. Mapping of houndstongue at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2009	0.09	95	8	0
2010	0.02	11	1	6
2011	<0.01 (10 m^2)	21	2	6
2012	0.01	70	3	9
2013	0.05	48	7	8
2014	0.04	102	8	8
2015	0.20	534	22	11
2016	0.20	480	22	14
2017	0.41	787	26	13
2018	0.51	4,514	50	22
2019	0.62	3,056	57	26
2020	0.65	3,691	49	35

Basewide weed mapping performed during shaded years.

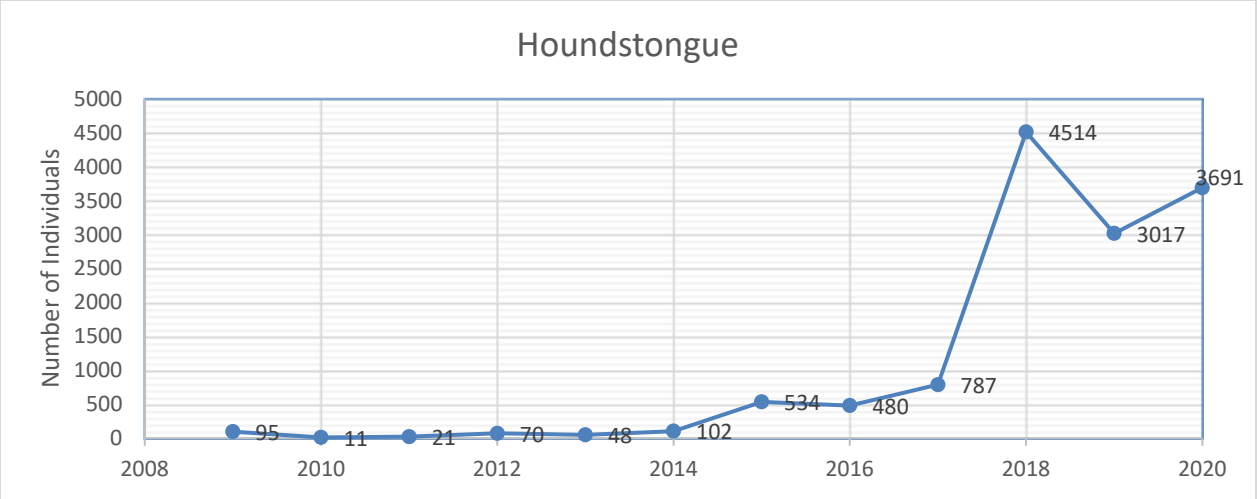


Figure 6. Number of houndstongue individuals, 2009-2020.

2020 Treatment

In 2020, there were 84 known locations for houndstongue. There were 3,665 individuals mapped at 43 extant sites, 465 individuals were manually removed. Populations with less than 50 to 100 individuals were treated manually (Table 9). Five sites located along Pine Creek drainage and two in the I-25 median were not visited in 2020 due to their locations in highly disturbed systems.

Table 9. Monitoring and treatment of houndstongue sites at the Academy in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	76	3,665	465	43	33
Pass 2	1	0	0	0	1
TOTALS	**77**	**3,665**	**465**	---	---

In 2021, we propose to manually treat sites very early in the spring and include follow-up visits for extant sites in the summer or fall. Targeting the young plants is most effective. Removing bolted stems results in more soil disturbance and more biomass needs to be removed. The plants often go to seed. We will continue to sever the plants four inches below the root crown to minimize soil damage and pull small sprouts.

Recommendations

The management priority for houndstongue is high. Treatments should begin much earlier in the season. Three sites at the Academy contain most 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. Targeting localized major populations with a coordinated plan should lead to significant reductions in houndstongue. Multiple monitoring and treatment visits must occur within the same season for multiple years to reduce the seed bank (Photo 6).

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). If herbicides are utilized follow the Guidelines for Herbicide Use in Natural Areas section of the report. Site plans for known locations are advised so that the contractor and CNHP coordinate their efforts. Many features are located in moist areas near wetlands and drainages, and some contain rare plant and animal species.

Photo 6. Herbicide treated area left bare soils in a wet meadow that now supports the target weed, houndstongue as well as Canada thistle and common mullein. P. Smith 2015

Summary of Recommendations

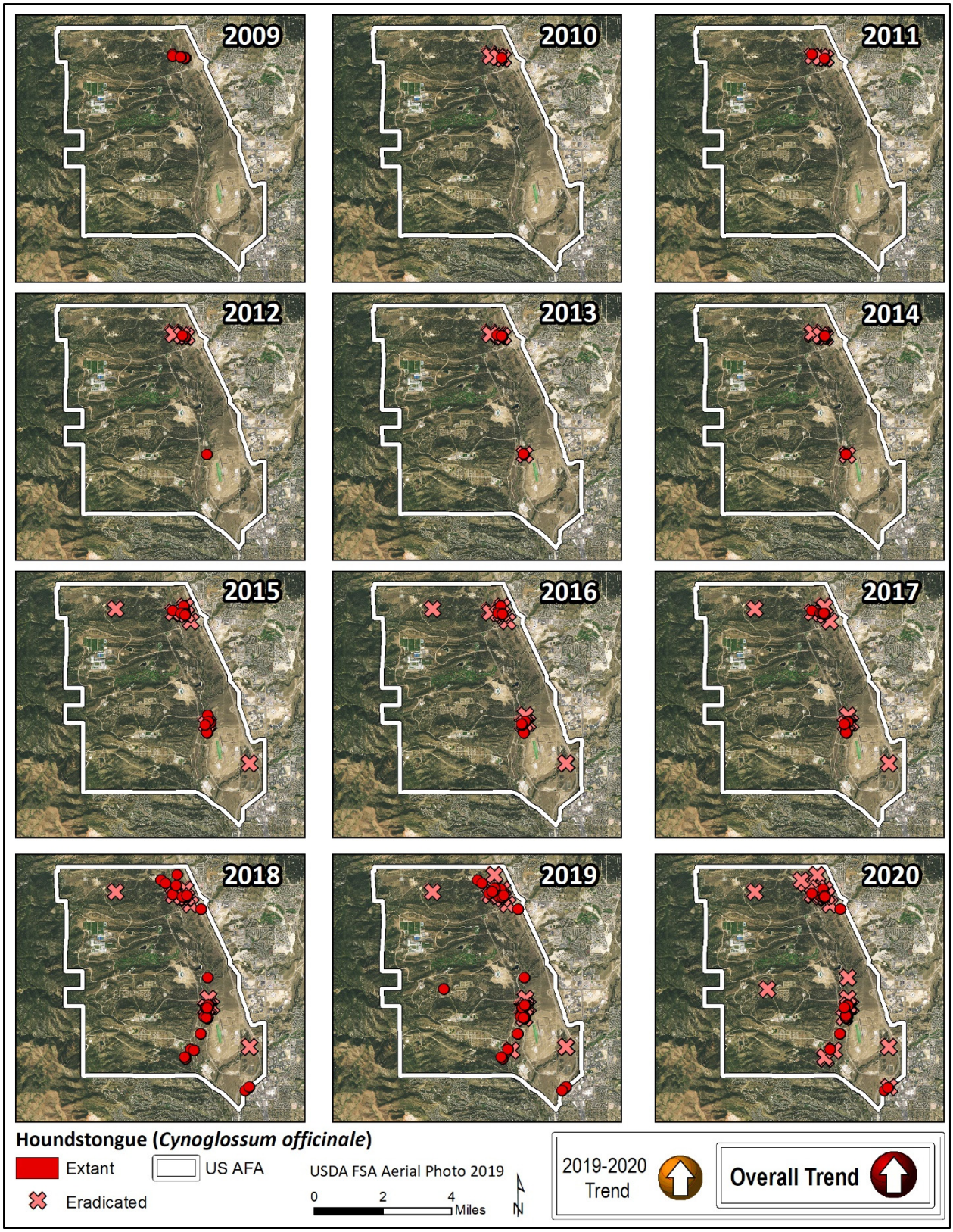
The management of houndstongue is a high priority. The focus will be on early spring and summer and fall manual treatments of rosettes before flowers and seeds are produced (CDA-CSU 2015a). Sites should be carefully surveyed under dense vegetation at the known sites for rosettes. Follow-up monitoring will be conducted multiple times during the growing season. Seed longevity is relatively short compared to other species (five years) and there is a good possibility for reduction or eradication at the Academy.

Herbicide use is not recommended at this time in natural plant communities. Follow herbicide use recommendations in the introduction section of this report. Make sure all applicators can recognize rare plants and the rosette stage of houndstongue.

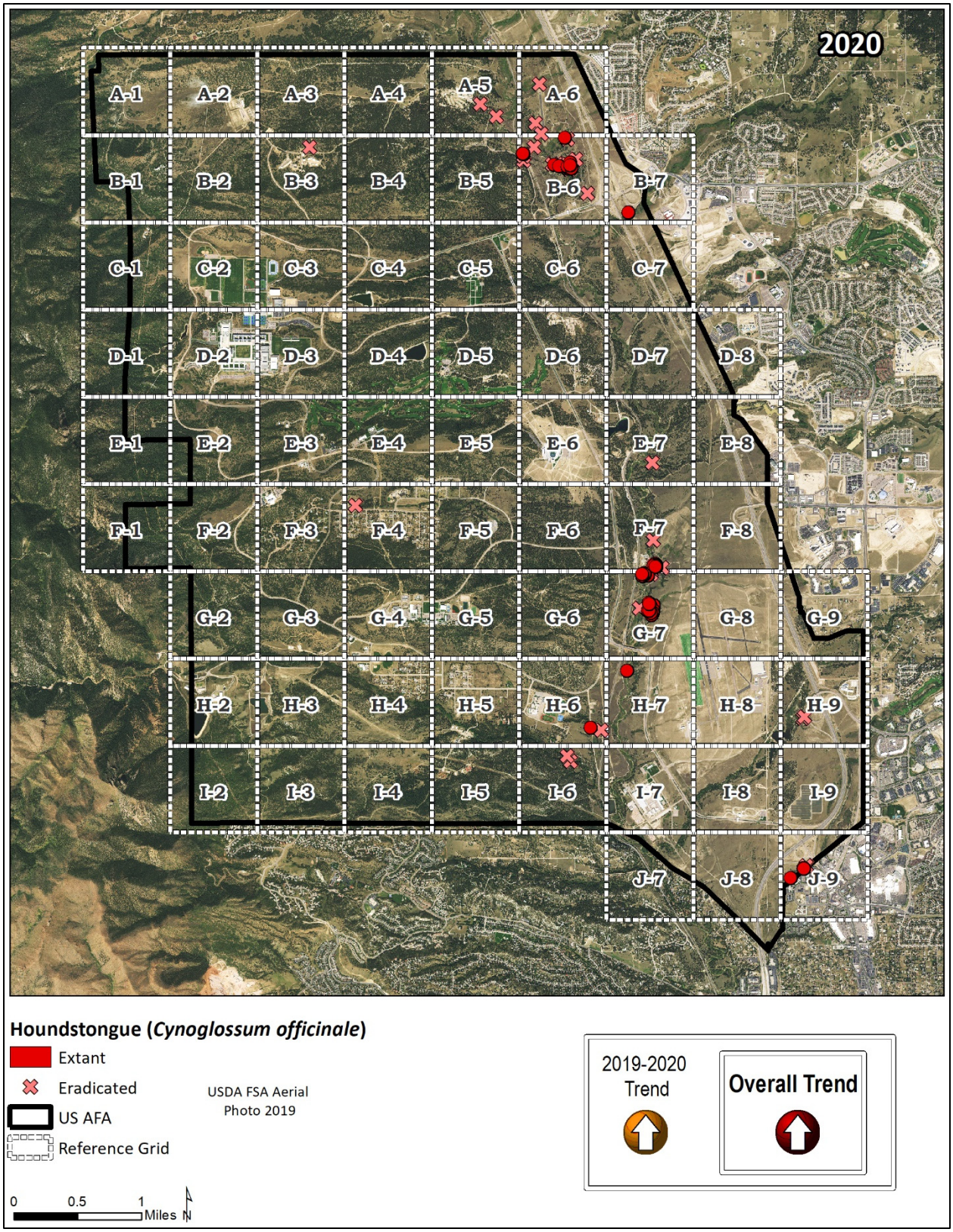
History of Sampling and Treatment

- 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 3,573 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.
- In 2020, houndstongue is increasing in numbers of shoots but decreasing in the number of extant sites. Nine sites contain the majority of the plants.



Map 6. Distribution of houndstongue at the Academy between 2009 and 2020.



Map 7. Distribution of houndstongue at the Academy in 2020 with the reference grid.

Myrtle Spurge (*Euphorbia myrsinites*)

Trend 2019-2020: Decreasing (Overall 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

2020 Results

Myrtle spurge has decreased significantly from 2019 to 2020, with 375 shoots in the spring of 2019 to 63 in 2020 (Table 10, Figure 7). In 2019, a new focus to manually treat myrtle spurge early in the spring and at multiple times through the growing season has resulted in a significant decline in the number of individuals and extant sites at the Academy. Myrtle spurge is found throughout the Academy and new populations are regularly discovered (Maps 8 & 9).

Table 10. Mapping of myrtle spurge at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2005	?	25	7	0
2006	?	243	10	0
2007	0.18	1,021	7	6
2008	0.66	419	13	5
2009	2.4	464	12	6
2010	0.5	56	10	12
2011	0.25	57	12	16
2012	0.23	113	10	25
2013	?	129	19	12
2014	0.7	179	7	27
2015	1.04	173	14	26
2016	0.70	185	17	26
2017	1.15	501	25	23
2018	0.51	222	26	35
2019	0.97	375	34	29
2020	0.41	63	16	47

Basewide weed mapping performed during shaded years.

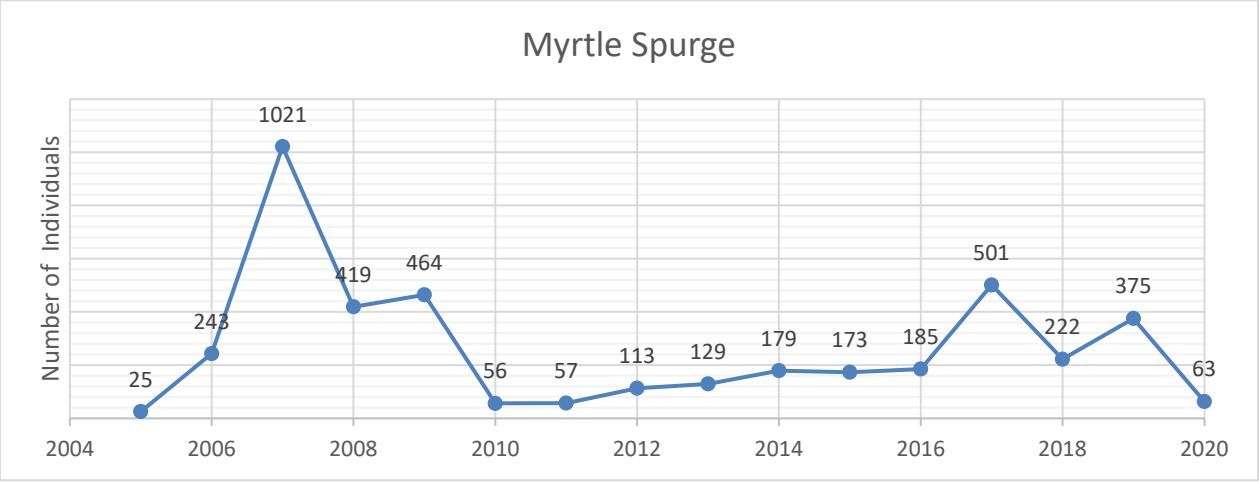


Figure 7. Number of Myrtle spurge individuals, 2005-2020.

2020 Treatment

In 2020, 132 shoots were manually treated by CNHP during 78 site visits. During the first pass, 13 extant features visited had 42 shoots that were treated, compared to 375 removed at 34 extant sites in 2019 (Table 11). The myrtle spurge sites not visited in 2020 include those located east of I-25 and three features west of I-25 that will be a priority for visiting in spring of 2021.

Table 11. Monitoring and treatment of myrtle spurge sites at the Academy in 2020.

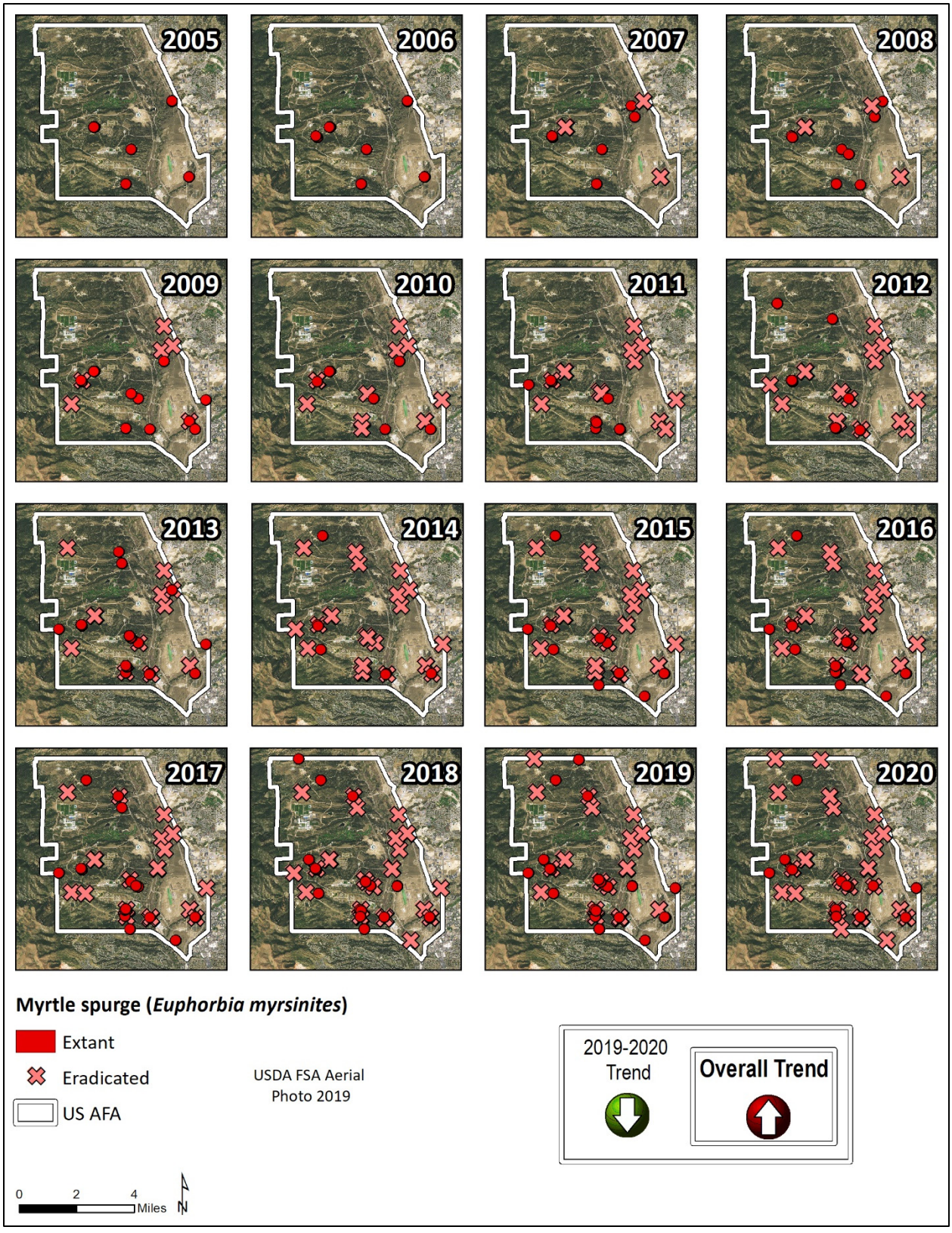
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	57	42	42	13	44
Pass 2	18	64	64	6	12
Pass 3	3	26	26	1	2
TOTALS	**78**	**132**	**132**	---	---

Recommendations

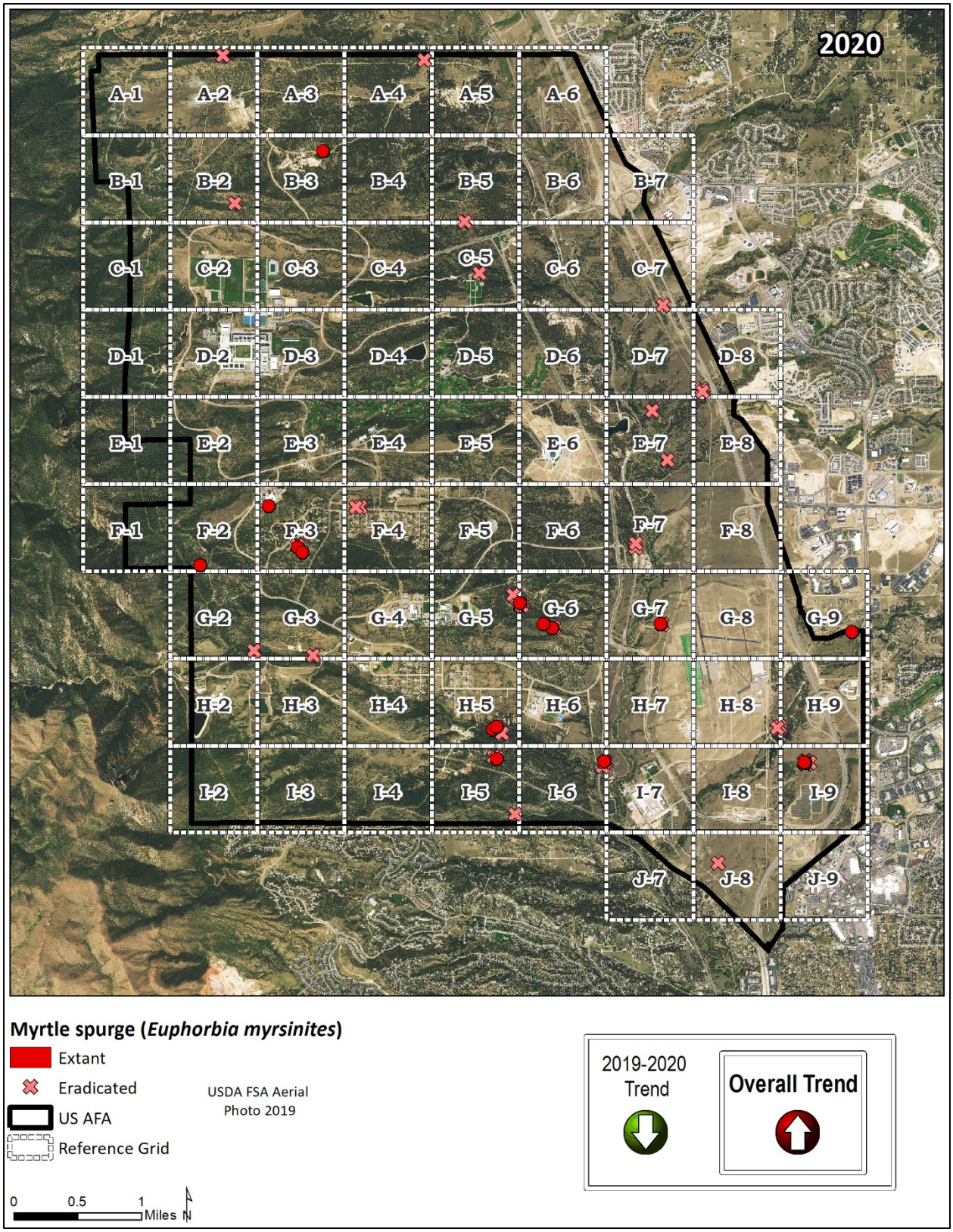
Myrtle spurge removal is a very high management priority. Visiting known myrtle spurge sites early in the season (myrtle spurge blooms as early as March) should continue as in 2019 and 2020. Follow-up monitoring at all extant sites two to three times during the growing season appears to be reducing the population at the Air Force Academy. This should continue for all extant sites for at least eight more years as myrtle spurge seeds are thought to stay viable eight years in the soil. All staff and weed monitoring personnel should be on the lookout for new populations. Myrtle spurge plants tend to be found throughout the base at new locations as a result of seed dispersal from on and off the Academy and seem to return after a few years of being absent.

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.
- In 2020, there was a reduction in the number of sites and number of individuals compared to 2019. Sprouts were pulled early in the spring and throughout the summer which resulted in no seed production at the sites.



Map 8. Distribution of myrtle spurge at the Academy between 2005 and 2020.



Map 9. Distribution of myrtle spurge at the Academy in 2020 with the reference grid.

Yellow Spring Bedstraw (*Galium verum*)

Trend 2019-2020: Increasing

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

2020 Results

There was a large increase in 2020 for yellow spring bedstraw including a new mapped feature. The existing site had 640 sprouts in 2020. This site seems to re-sprout every couple of years. In addition, a new site was found 650 meters upstream of the known site along West Monument Creek with at least 300 individuals in several patches (Grid I-6, Map 11). Yellow spring bedstraw is a garden escape that was first documented in 2010. It was treated and then found again in 2015, 2018 and 2020 (Table 12, Figure 8, Maps 10 & 11).

Table 12. Mapping of yellow spring bedstraw at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2010	<0.01	700	1	0
2011	<0.01	1	1	0
2012	0	0	0	1
2013	0	0	0	1
2014	0	0	0	1
2015	<0.01	10	1	0
2016	0	0	0	1
2017	0	0	0	1
2018	<0.01	102	1	0
2019	0	0	0	1
2020	0.08	940	2	0

Basewide weed mapping performed during shaded years.

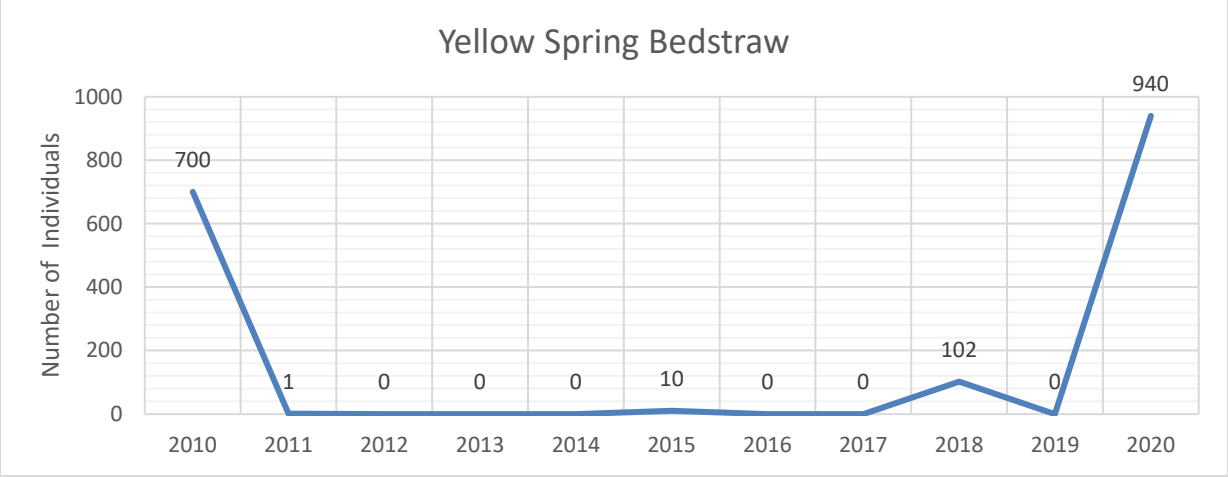


Figure 8. Number of yellow spring bedstraw individuals, 2010-2020.

2020 Treatment

The original site was manually treated and all stems and roots were removed at three different passes throughout the growing season. The number of sprouts were reduced over the course of the growing season from 640 to 9 by the third pass in late summer. The new site was discovered in the middle of the summer and was flagged for the herbicide applicator (Table 13).

Table 13. Monitoring and treatment of yellow spring bedstraw sites at the Academy in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	2	940	640	2	0
Pass 2	1	100	100	1	0
Pass 3	1	9	9	1	0
TOTAL	**4**	**1,049**	**749**	---	---

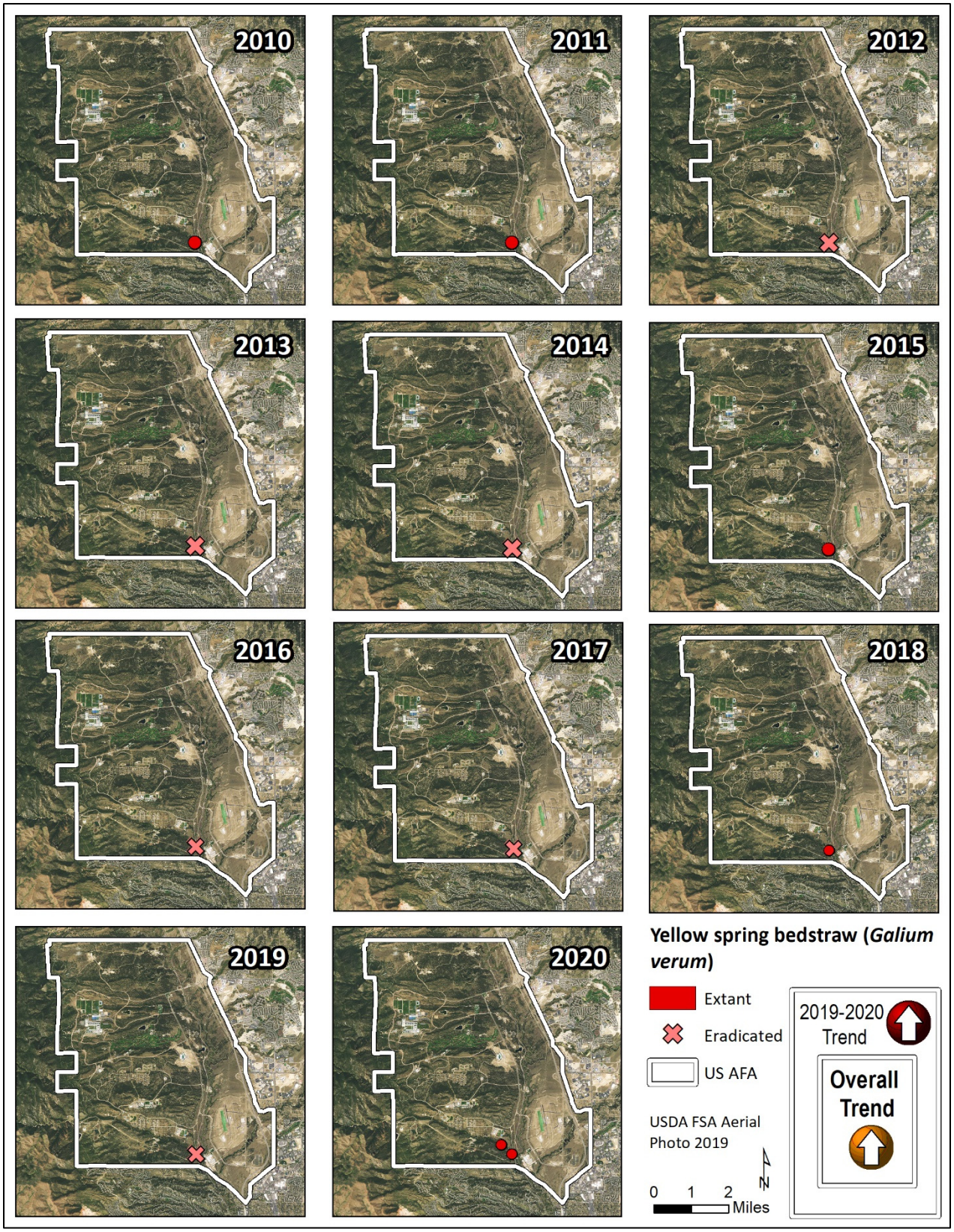
Recommendations

Yellow spring bedstraw is a high management priority due to the relative low cover at this time and the potential to increase quickly. 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 disturbed riparian areas with many native shrubs and herbs at the Academy. Continue to monitor 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. This species may be entering from garden waste upslope of West Monument Creek.

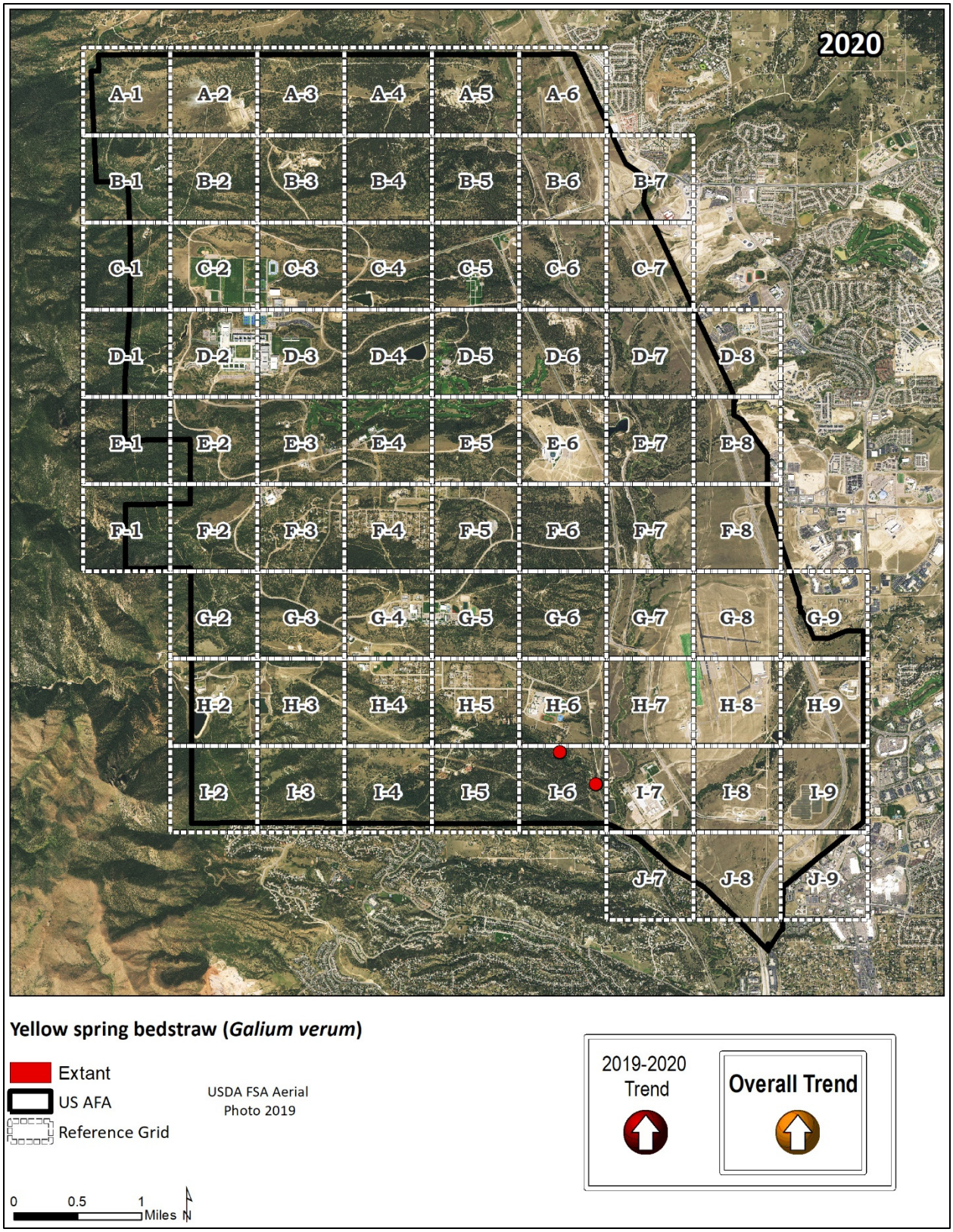
History of Sampling and Treatment:

- 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.

- In 2020, the known site had 640 new sprouts which were pulled. Two more follow-up visits were conducted removing 100 and 9 plants respectively. A new site with at least 300 individuals was located along West Monument Creek and flagged for herbicide application.



Map 10. Distribution of yellow spring bedstraw at the Academy between 2010 and 2020.



Map 11. Distribution of yellow spring bedstraw at the Academy in 2020 with the reference grid.

Dame's Rocket (*Hesperis matronalis*)

Trend 2019-2020: Decreasing (Overall 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

2020 Results

The 2020 survey was identical to 2019 with only two sites visited by CNHP along Kettle Creek (Grids I-7& J-7, Map 13). Two sites near the southwest corner of the southern boundary were treated by Academy staff in 2019 with herbicide. The four sites located west of I-25 are likely decreasing.

East of I-25

Dames rocket is known from 21 occurrences on Academy property east of I-25 and another on adjacent private property along the eastern boundary. Occurrences east of I-25 were not monitored in 2019 or 2020. 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 14, Maps 12 & 13). The I-25 corridor is under construction and many of the dames rocket plants will likely be impacted.

Table 14. Mapping of dame's rocket at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
East and West of I-25				
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	633	7	14
West of I-25				
2019	<0.01	32	1	3
2020	<0.01	32	1	3

Basewide weed mapping performed during shaded years.

2020 Treatment

The two sites near Kettle Creek were visited in 2019 and 2020. 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 in 2019. According to Academy staff, the extant occurrence was sprayed by the herbicide contractor in June of 2019. These two sites near the south boundary were not visited by CNHP in 2020 (Table 15).

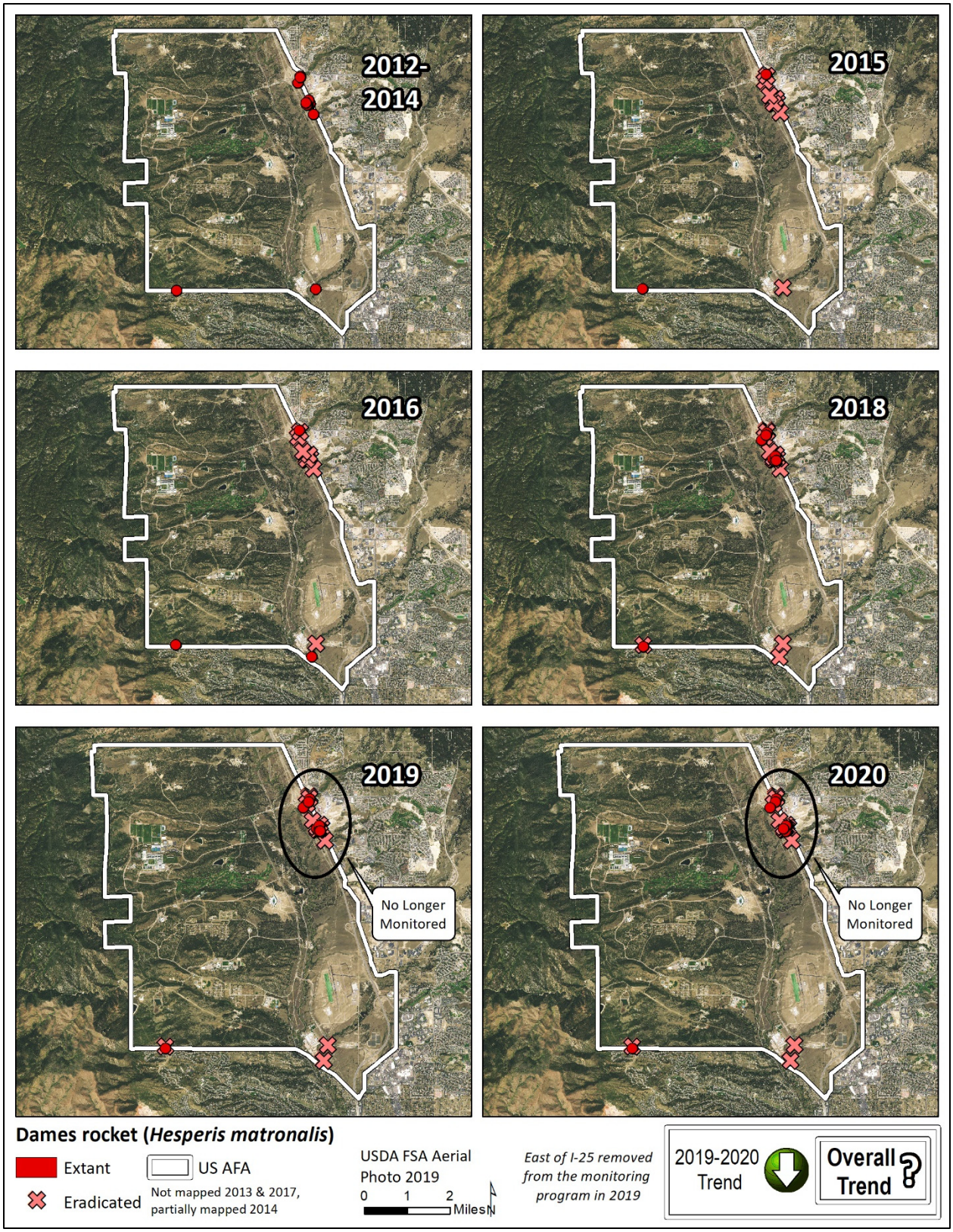
Table 15. Monitoring and treatment of dame's rocket sites at the Academy in 2020.					
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	2	0	0	0	2

Recommendations

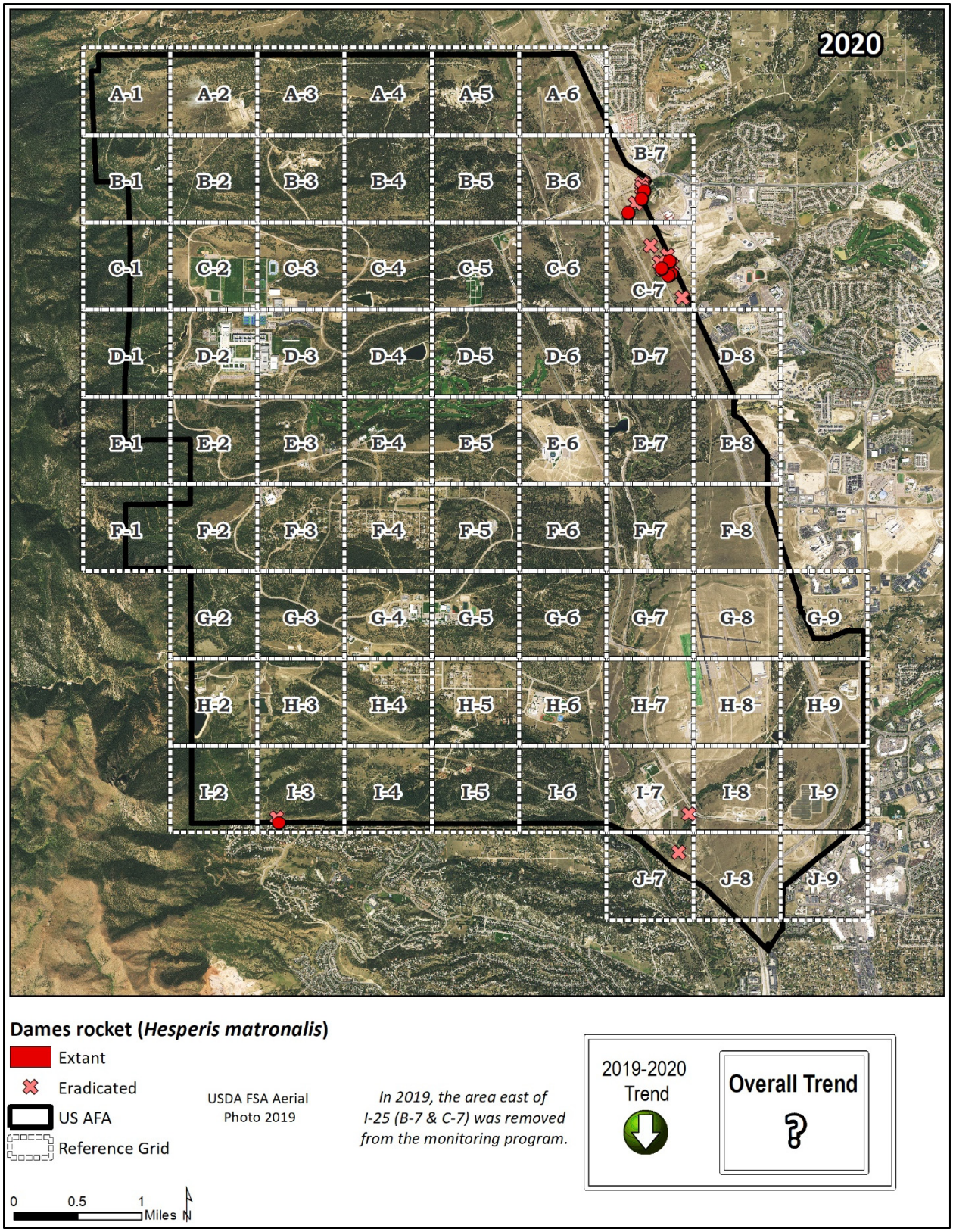
The management urgency for Dame's Rocket is medium. This species is being well-controlled west of I-25 (and under construction east of I-25). For 2020, all four sites west of I-25 will be visited and evaluated for treatments. Getting to plants before seed set is considered to be essential. Cutting flowering 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). 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. Because the seed longevity is quite long, all of the sites should be monitored for multiple years.

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 two sites west of I-25 along Kettle Creek were visited and no plants were found. The contractor sprayed 32 individuals at one of the two westernmost sites, and the second site was eradicated. No sites east of I-25 were visited due to construction and development activities.
- In 2020, only two sites east of I-25 along Kettle Creek were visited, one site was flooded by beaver activity and the other was eradicated. No sites east of I-25 were visited.



Map 12. Distribution of dame's rocket at the Academy between 2012 and 2020.



Map 13. Distribution of dame's rocket at the Academy in 2020 with the reference grid.

Orange Hawkweed (*Hieracium aurantiacum*)

Trend 2019-2020: Decreasing (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)

2020 Results

In 2020, orange hawkweed declined at Farish Recreation Area (Tables 16 & 17, Map 14). Orange hawkweed was first observed at Farish Recreation Area in 2018 when 200 plants were observed. No treatment took place in 2018. In June of 2019, 600 sprouts were found at the site and removed manually. A fall visit was conducted in late August and another 656 sprouts were removed at that time bringing the total number of plants to 1,256 in 2019. The large reduction observed in 2020 demonstrates the importance of same season follow-up visits. This represents a very large decrease since manual treatments began in 2019.

Table 16. Mapping of orange hawkweed at Farish.				
	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2017	---	---	---	---
2018	<0.01	200	1	0
2019	<0.01	600	1	0
2020	<0.01	145	1	0

Basewide weed mapping performed during shaded years.

2020 Treatment

In 2020, 145 sprouts were removed during the spring visit and 100 in the late summer visit, bringing the total number of sprouts to 245. This is a significantly smaller number of individuals compared to 2019, and with a much smaller biomass. Most of the individuals were sprouts an inch or less tall. Therefore, we will continue to manually treat the population in the spring and follow-up with a mid to late summer visit to remove sprouts as we did in 2019 (Table 17). No plants went to seed in 2019 or 2020.

Table 17. Monitoring and treatment of orange hawkweed sites at Farish in 2020.					
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	1	145	145	1	0
Pass 2	1	100	100	1	0
TOTALS	2	**245**	**245**	---	---

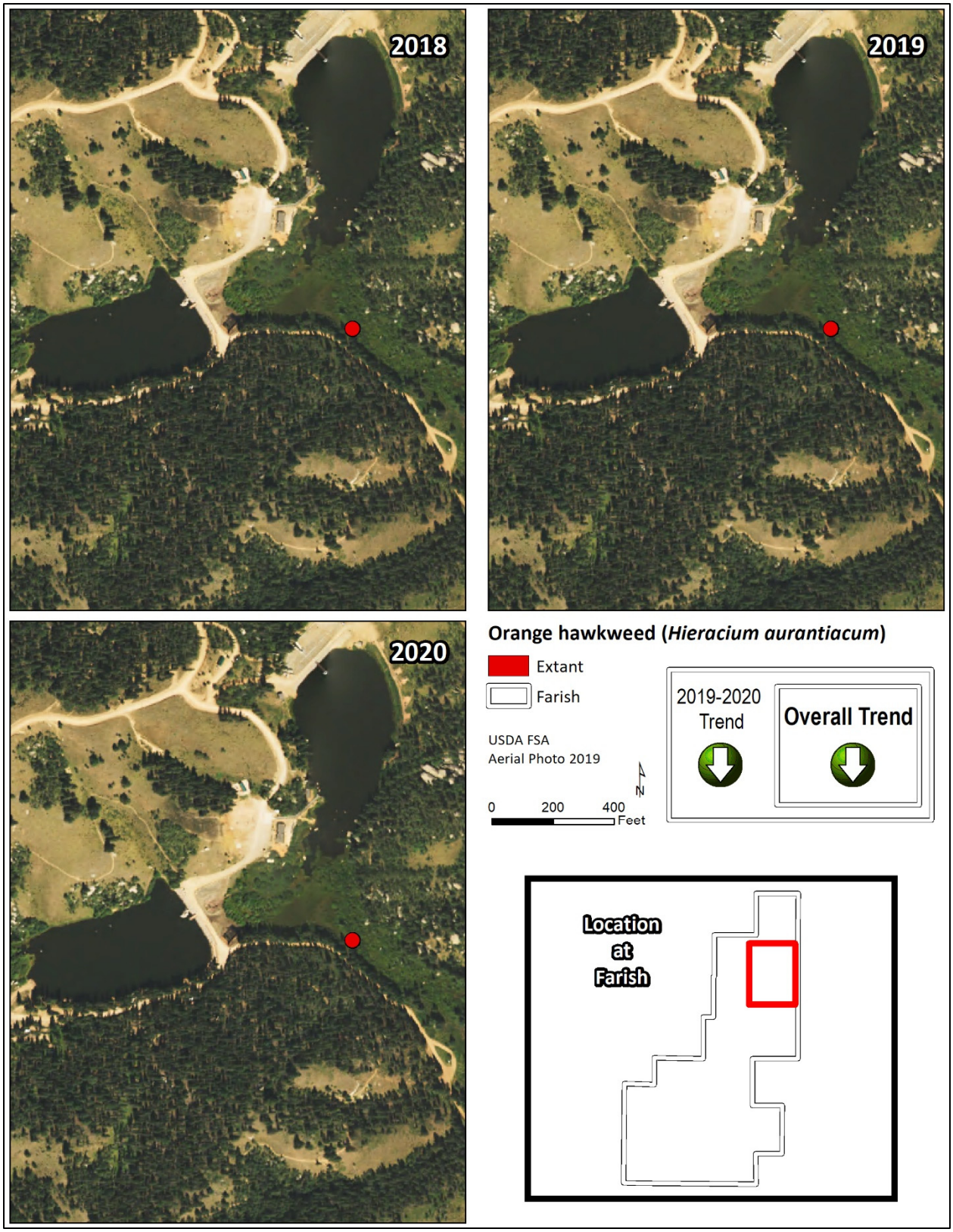
Recommendations

The management urgency for this species is very high. This species has the potential to spread quickly without immediate suppression or eradication. The plan for 2021 is to visit the site before flowers are produced in late May or early June as was done in 2020. Counts and photographs 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. We will revisit two sites reported by the weed contractor that were not located in 2020.

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.
- In 2020, 145 plants were removed manually in the spring, followed by the removal of another 100 in the late summer. No plants went to seed. Only very small sprouts less than one inch tall were observed (and removed). Two additional sites were reported by the weed contractor which were not found.



Map 14. Close-up of orange hawkweed at Farish between 2018 and 2020.

Common St. Johnswort (*Hypericum perforatum*)

Trend 2019-2020: 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

2020 Results

In 2020, common St. Johnswort was decreasing in cover and number of shoots compared to 2019. The estimated number of shoots went from 11,543 in 2019 to 8,987 in 2020, and a decrease in the occupied acres of 1.41 in 2019 to 1.29 in 2020. In 2018, there were a total of 84 mapped sites which increased to 102 in 2019 and to 104 in 2020. Since 2012, there has been a large reduction in the number of plants, while the number of extant features increased from 47 in 2017 to 74 in 2019 and decreased to 65 in 2020. (Table 18, Figure 9, Maps 15 & 16).

Table 18. Mapping of common St. Johnswort at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002†	<0.10	363	5	---
2007	0.86	44,647	8	0
2008	1.07	130,371	13	0
2009	2.02	95,883	21	2
2010	1.47	82,733	20	6
2011	1.44	87,128	26	5
2012	1.16	83,115	29	10
2013	0.85	2,621	22	21
2014	1.12	3,604	33	19
2015	1.27	3,102	27	29
2016	1.02	6,717	32	27
2017	1.31	4,202	47	23
2018	1.26	16,416	57	27
2019	1.41	11,543	74	28
2020	1.29	8,987	65	39

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

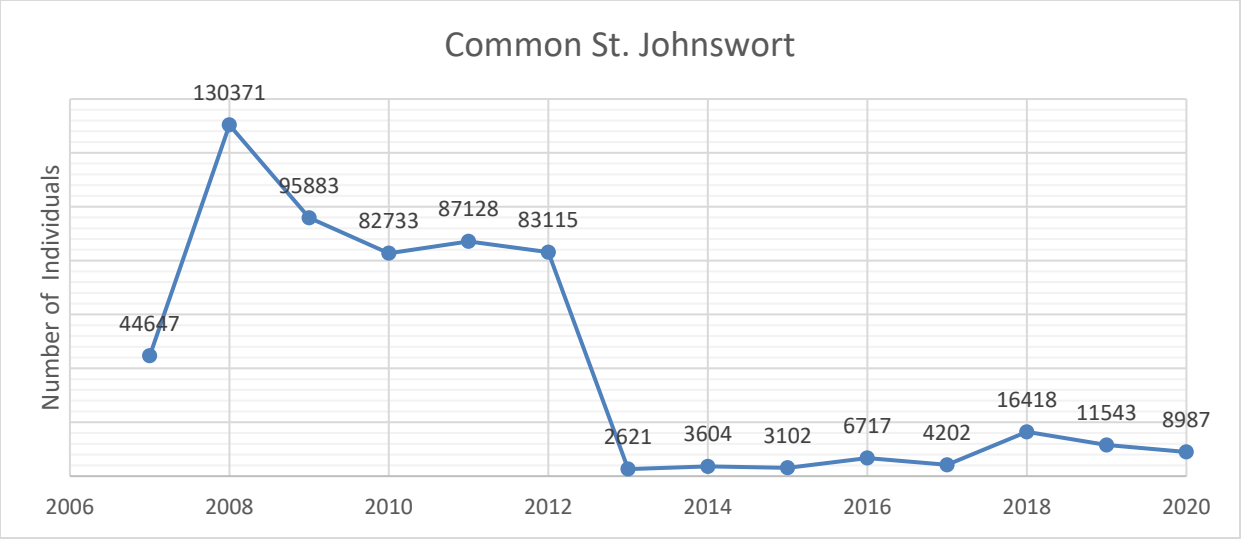


Figure 9. Number of common St. Johnswort individuals, 2007-2020.

2020 Treatment

In 2020, a total of 93 common St. Johnswort features were visited for monitoring and treatment out of 104 known sites. Of those 93 sites, 55 were extant and contained 8,307shoots. At a second visit later in the season to nine sites, 1,351 individuals were found as well as four eradicated features. A total of 1,858 shoots were manually treated (Table 19). Sites not treated were either too large to treat manually, treated with herbicides, were flooded or had active biocontrol agents observed in 2020. The sites at the airport were also not treated.

Table 19. Monitoring and treatment of common St. Johnswort sites at the Academy in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Site with Plants	# Sites without Plants
Pass 1	93	8,307	1,657	55	38
Pass 2	9	1,351	201	5	4
TOTALS	**102**	**9,658**	**1,858**	---	---

Recommendations

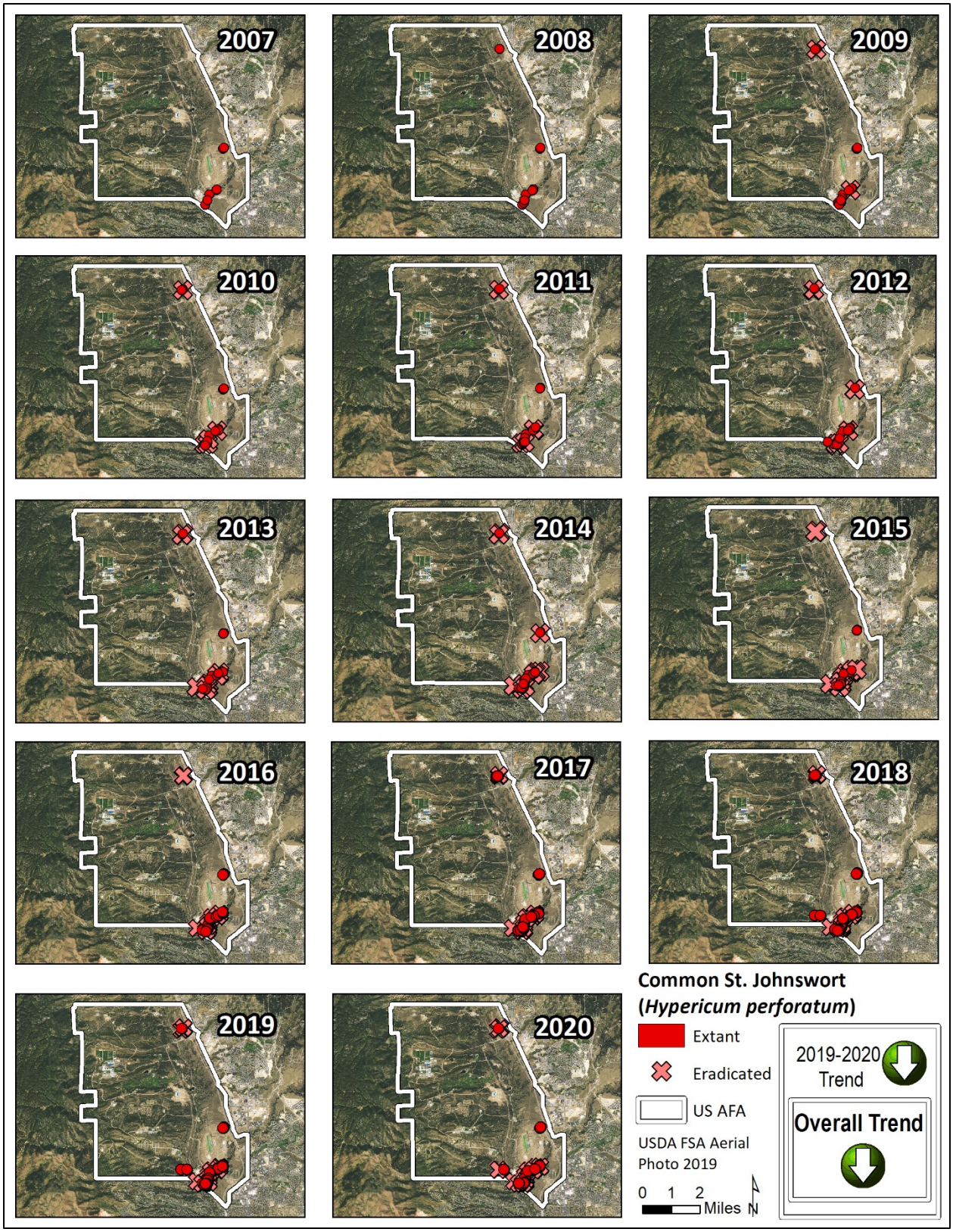
The management urgency for common St. Johnswort is medium. The active floodplain of Kettle Creek as well as some of the upper benches, are prone to infestations of common St. Johnswort. These areas are easily invaded if the soils are disturbed (Photo 7). Large numbers of plants are removed during flooding 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. Communication needs to be maintained with

Academy staff, the herbicide applicator and CNHP so that monitoring and treatment efforts are coordinated in 2021.

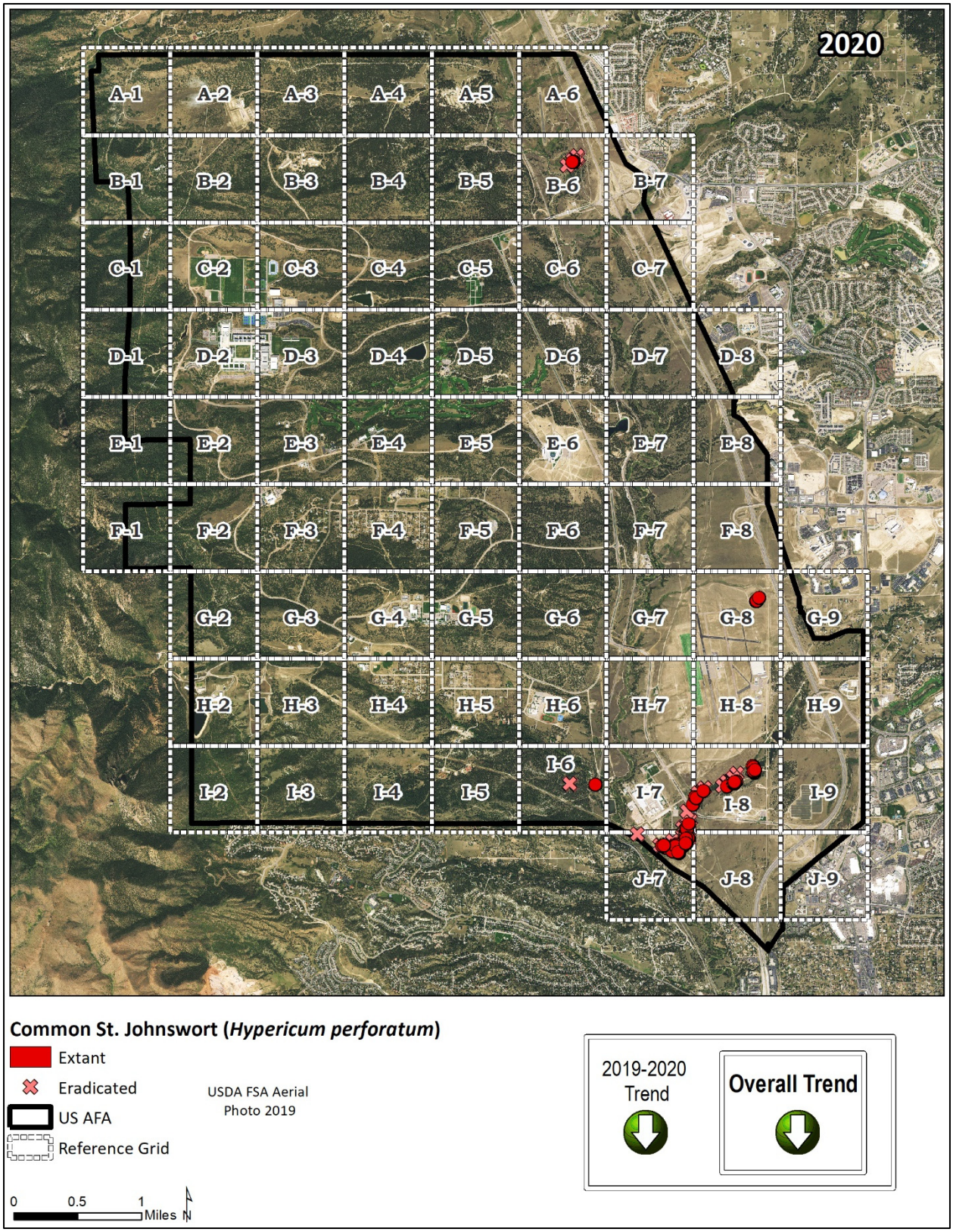
Photo 7. Native grasslands like this one along the Kettle Creek floodplain are thought to prevent the spread of noxious weeds like common St. Johnswort. September 2019 P. Smith

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.
- In 2020, there was a slight increase in the number of shoots compared to 2019. Biocontrol was observed at many sites and herbicide treatments were being applied.



Map 15. Distribution of common St. Johnswort at the Academy between 2007 and 2020.



Map 16. Distribution of common St. Johnswort at the Academy in 2020 with the reference grid.

Perennial Pepperweed (*Lepidium latifolium*)

Trend 2019-2020: Decreasing

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

2020 Results

The two known perennial pepperweed locations at the Academy (Grids A-6 & I-9, Map 18) decreased in the number of shoots in 2020 by 89% compared to 2019 for the first monitoring pass of the season (Table 20, Figure 10, Maps 17 & 18). Some of the sprouts removed in 2020 appear to be seeds sprouting and some are sprouts coming from existing plants.

Table 20. Mapping of perennial pepperweed at the Academy.				
	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2018	0.02	213	2	0
2019	0.03	212	2	0
2020	0.03	23	2	0

Basewide weed mapping performed during shaded years.

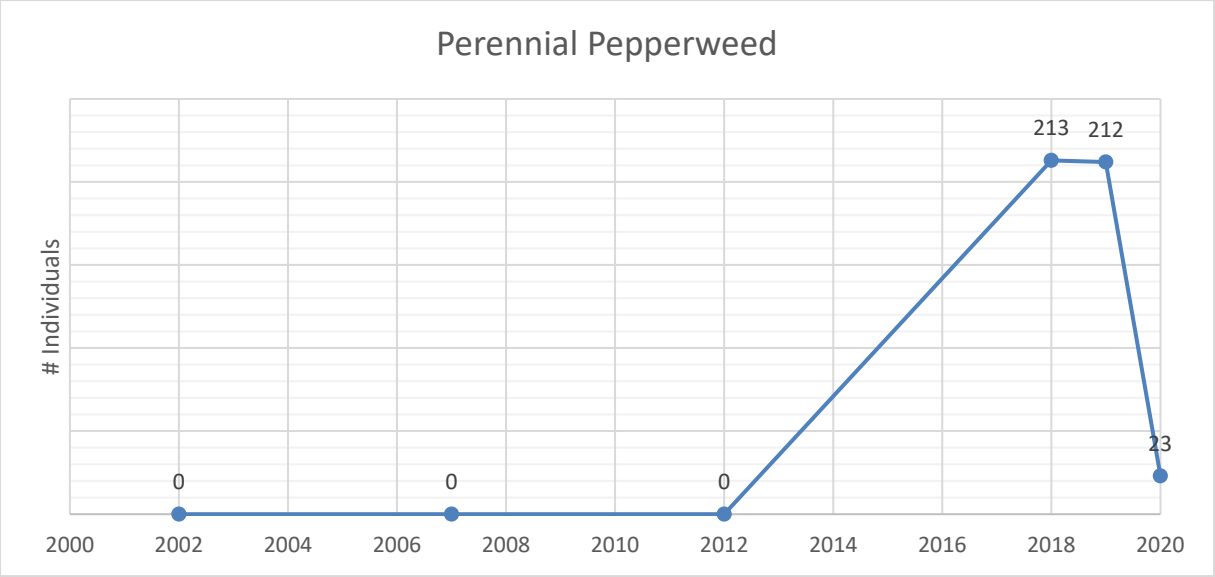


Figure 10. Number of perennial pepperweed individuals, 2002-2020.

2020 Treatment

There were 23 individuals counted and treated for the first pass in 2020. Manual treatments were conducted during three visits to each of the two known sites throughout the growing season for six visits (Table 21). Sprouts were removed at all three visits at the I-25 site (Grid I-9, Map 18) and at the first two visits (0 found at late summer visit) for the Aardvark site (Grid A-6, Map 18). A total of 114 shoots were removed in 2020 which is a significant decrease compared to 2019.

In 2019, CNHP flagged plants for herbicide treatment. Plants re-sprouted later in the season and again in 2020 post herbicide treatment (Photo 8). The sites have been treated manually multiple times a season to remove sprouts and vegetative sprouts of plants that come up throughout the growing season since the herbicide was applied (Table 21).

Table 21. Monitoring and treatment of perennial pepperweed sites at the Academy in 2020.					
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	2	23	23	2	0
Pass 2	2	65	65	2	0
Pass 3	2	26	26	1	1
TOTALS	**6**	**114**	**114**	---	---

Photo 8. Two top-killed perennial pepperweed plants (left) that sprouted leaves and flowers later in summer of 2019. P. Smith

The off-target damage was limited during the herbicide application for some spots, protecting native grasses in the vicinity of the pepperweed plants (Photo 8 above). However, at some spots there are patches of dead native grasses and forbs in the overspray zone with Canada thistle moving into the overspray zone (Photo 9).

Photo 9. Perennial Pepperweed herbicide treatment one-year post application shows the importance of protecting native species. The dead plants include native fescue grasses and forbs in the large overspray area. Canada thistle is growing in the treated area (bottom center). Aardvark site 2020, P. Smith.

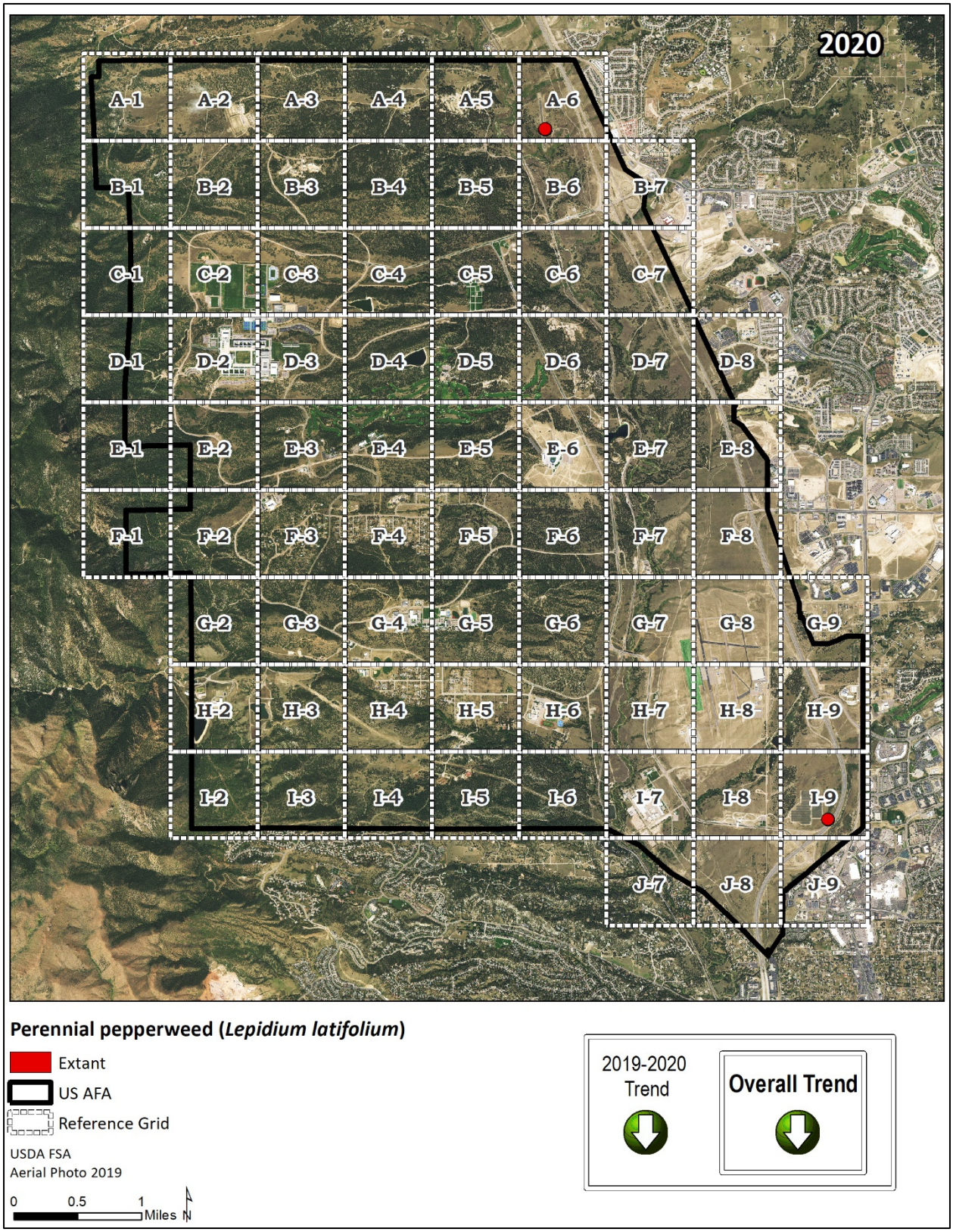
Recommendations

The management urgency for perennial pepperweed is very high. This species has the potential to get out of control quickly and the root reserves need to be depleted and seed production stopped. Rapid response treatments should continue for 2021. Mechanical methods are being used although and herbicide was applied initially. This integrated approach should eliminate the small populations at the Academy (Young et al 2002).

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.
- In 2020, there was a significant decrease in plants at both known locations, and plants were prevented from going to seed.

Map 17. Distribution of perennial pepperweed at the Academy between 2018 and 2020.



Map 18. Distribution of perennial pepperweed at the Academy in 2020 with the reference grid.

Oxeye Daisy (*Leucanthemum vulgare*)

Trend 2019-2020: Increasing

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

2020 Results

In 2020, there was an increase in the number of sites and numbers of individuals since the species was first observed in Kettle Creek in 2019. In 2019, there were five known sites with 40 individuals. In 2020, there was a significant increase to nine sites with 455 individuals mapped and treated (Table 22). Of the nine known sites, three are eradicated and had between 6-10 individuals in 2019 that had been manually treated. The four new sites and one of the extant sites account for the sharp increase. Many of the plants removed were very small sprouts in 2020. This species appears only to occur at Kettle Creek (Map 19 & 20, Grids I-7, I-8).

Table 22. Mapping of oxeye daisy at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2018	---	---	---	---
2019	<0.01	40	5	---
2020	0.02	455	6	3

2020 Treatment

The first pass to nine sites (4 new in 2020) resulted in 455 individuals mapped and pulled (Maps 19 & 20). An additional 251 plants were pulled during the second pass for a total of 706 individuals. (Table 23). It is important to follow-up and pull late season sprouts. This species can gain control very quickly and is difficult to remove manually once it reaches over 100 individuals at a site.

Table 23. Monitoring and treatment of oxeye daisy sites at the Academy in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	9	455	455	6	3
Pass 2	6	251	251	4	2
Total	**15**	**706**	**706**	---	---

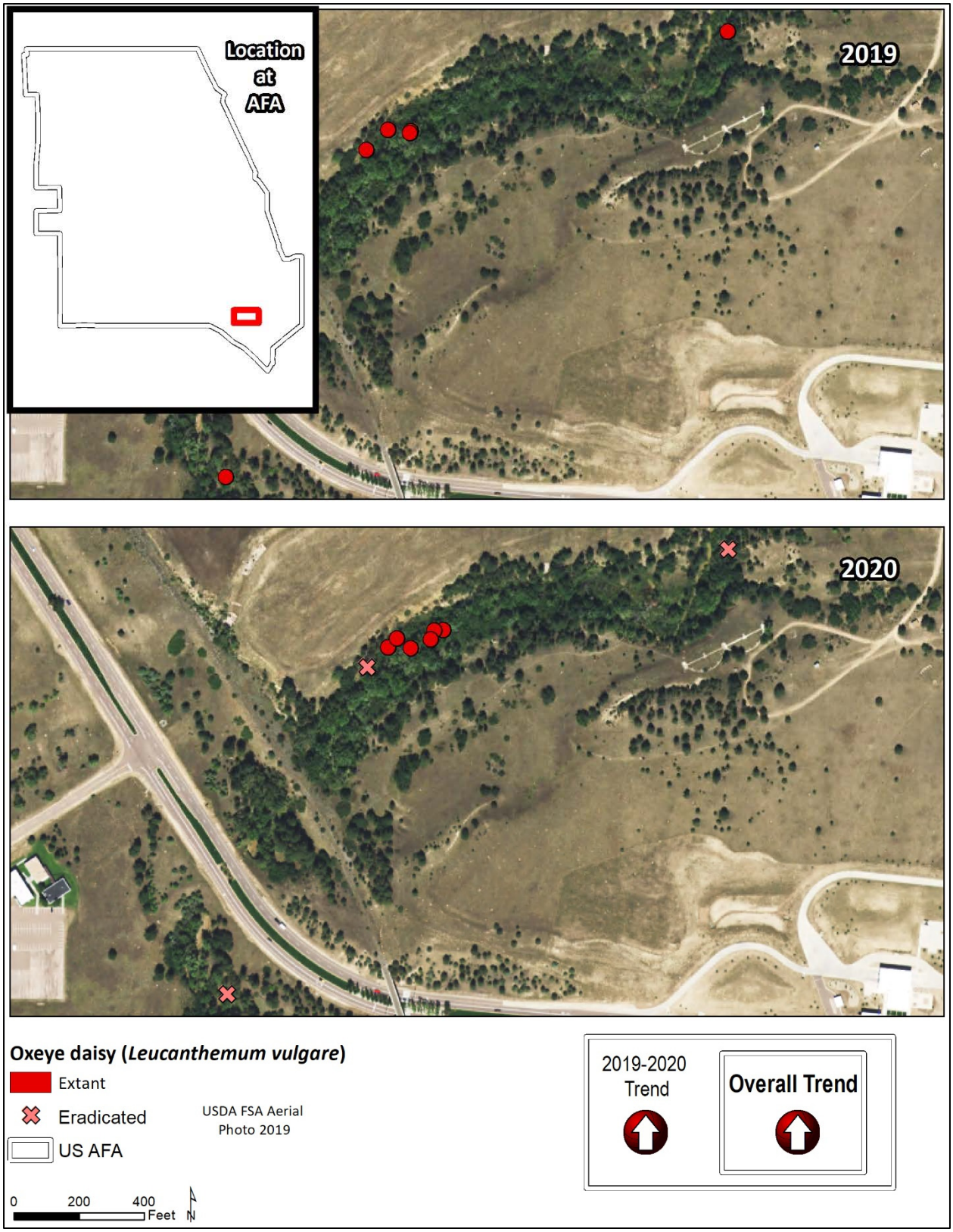
Recommendations

The management urgency for oxeye daisy is very high. These plants are difficult to remove and rapid response is extremely important to get control at this stage in the infestation. At this point eradication seems possible but could get out of hand quickly without yearly multi-season surveys and treatment. In 2020, it became apparent that pulling plants is an effective way to control plants at most of the manually treated sites. Same season follow-up will be essential to keep this species from increasing. The source of seeds is most likely residential properties as oxeye daisy commonly

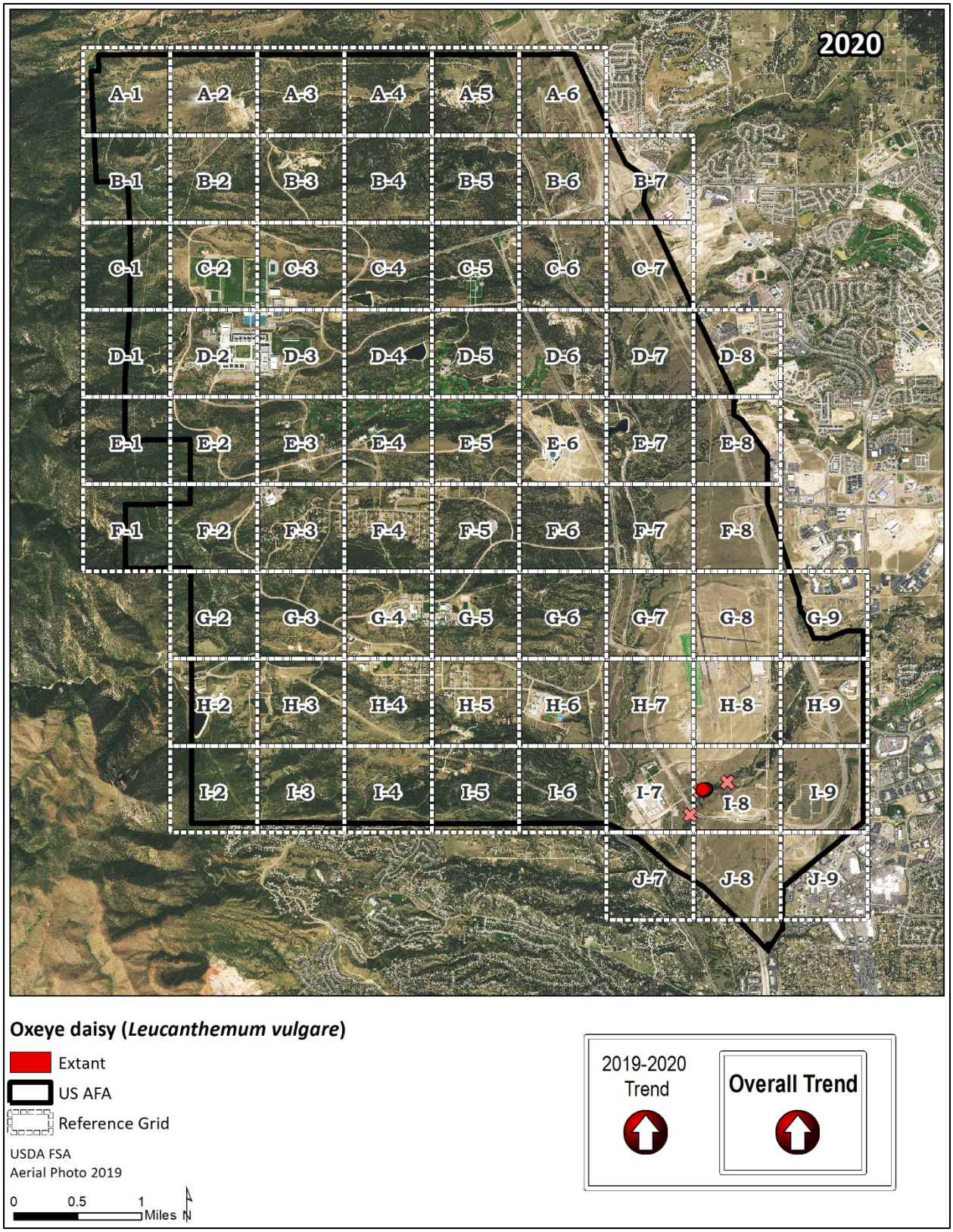
escapes from gardens to wild lands. It is a short-lived perennial that can reproduce via both root fragments and seeds and can spread quickly. The seed longevity is extremely long. However, the shallow root system and low number of individuals observed makes manual removal a viable option (CDA-CSU 2015b) 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 40 individuals were removed at five features.
- In 2020, there was an increase in the number of sites from five in 2019 to nine in 2020, and an increase from 40 in 2019 to 455 shoots in 2020.



Map 19. Distribution of oxeye daisy at the Academy between 2019 and 2020.



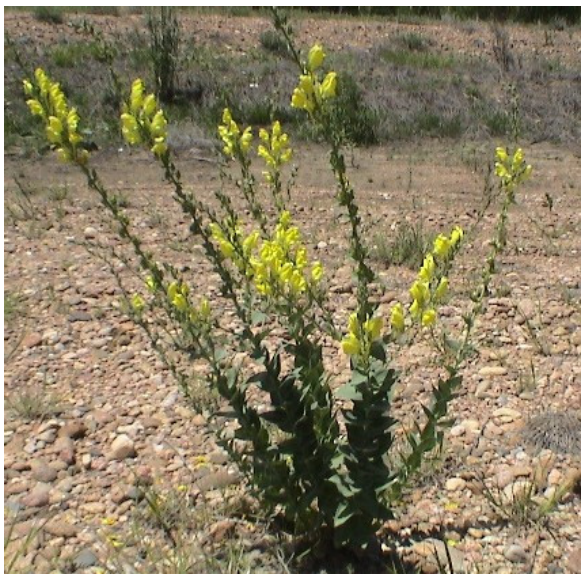
Map 20. Distribution of oxeye daisy at the Academy in 2020 with the reference grid.

Dalmatian Toadflax (*Linaria dalmatica*)

Trend 2019-2020: Stable (Overall 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)

2020 Results

In 2020, no plants were observed in the spring or the fall at all four locations (Grids H-2 & I-8, Map 22). 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 11, Maps 21 & 22).

Table 24. Mapping of Dalmatian toadflax at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2009	?	10	1	0
2010	0.50	107	2	1
2011	0	0	0	3
2012	0	0	0	3
2013	?	12	1	3
2014	<0.01	7	1	3
2015	0	0	0	4
2016	<0.01	1	1	3
2017	<0.01	480	1	3
2018	0.01	52	1	3
2019	0	0	0	4
2020	0	0	0	4

Basewide weed mapping performed during shaded years.

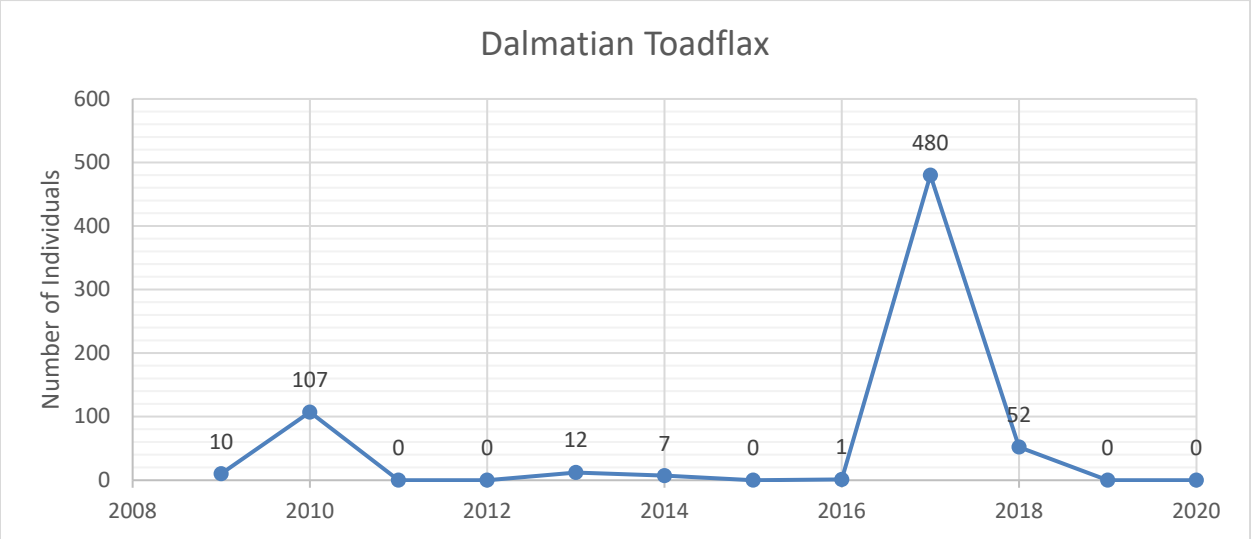


Figure 11. Number of Dalmatian toadflax individuals, 2009-2020.

2020 Treatment

In 2020, 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 2020.

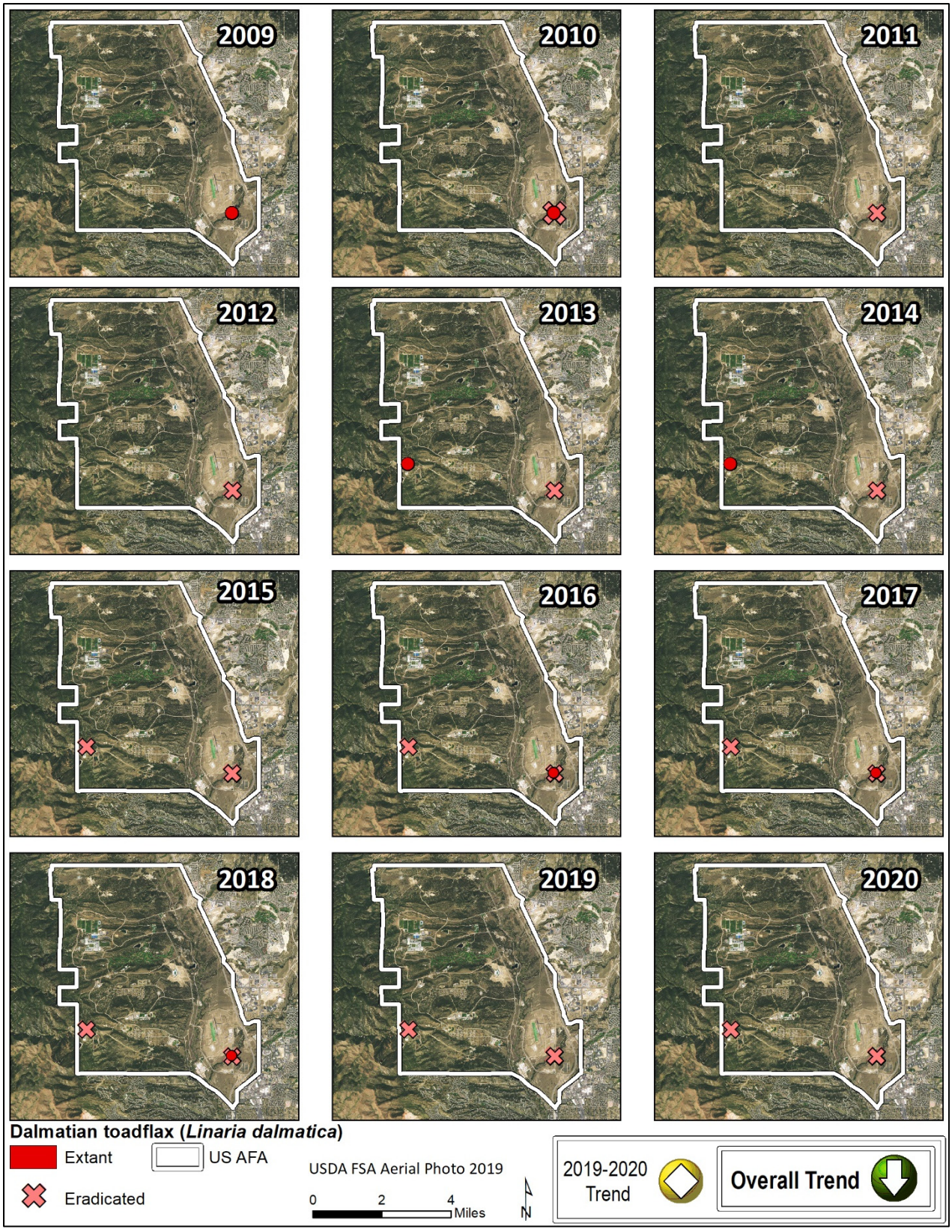
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	4	0	0	0	4
Pass 2	4	0	0	0	4
TOTAL	**8**	**0**	**0**	---	---

Recommendations

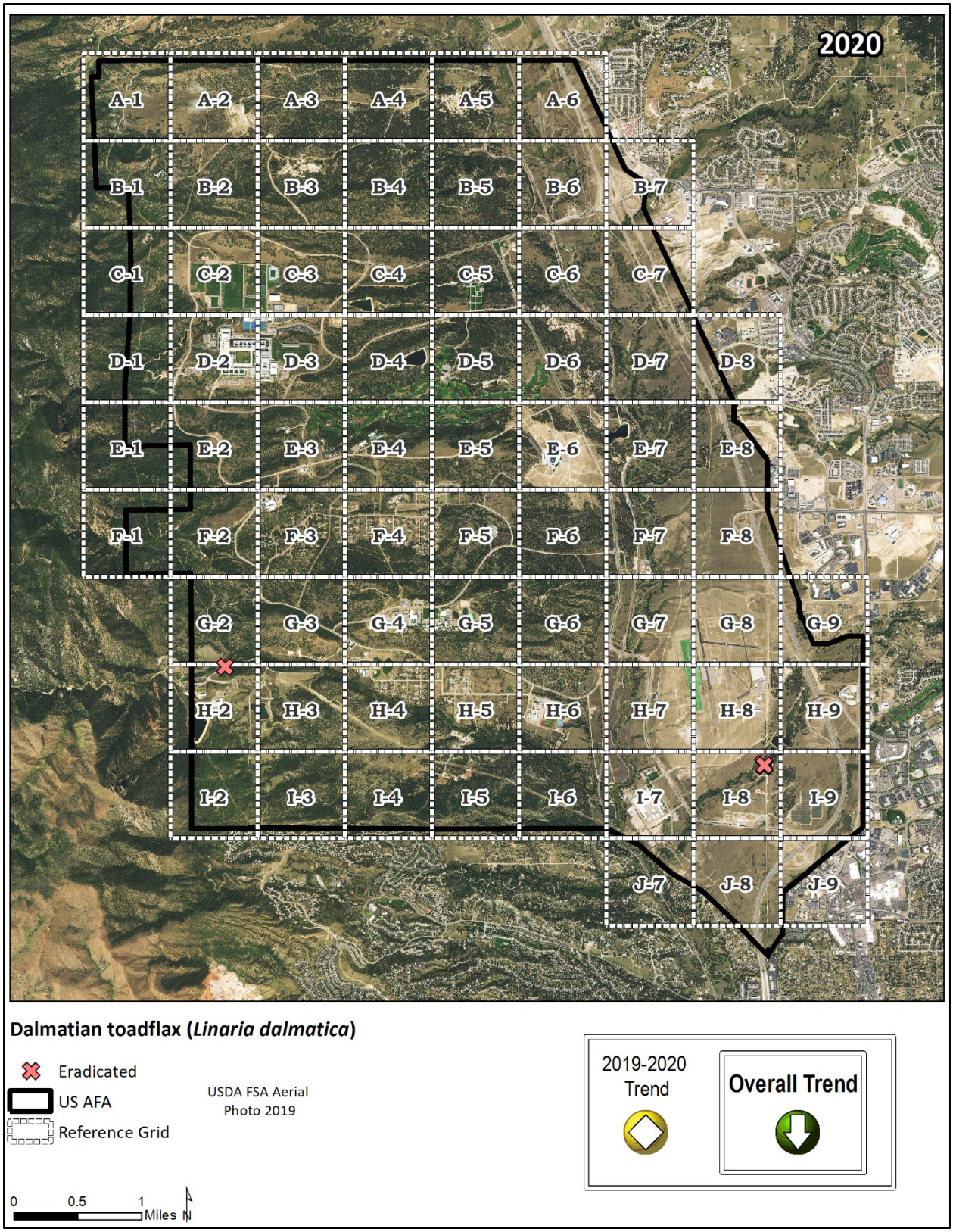
The management urgency for Dalmatian toadflax is considered high even though no plants were found. This species has years where no plants are found, followed by sudden and substantial increases. Continuing to monitor known sites and removing new shoots as they are found, is important.

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.
- In 2020, no plants were observed at the four known sites.



Map 21. Distribution of Dalmatian toadflax at the Academy between 2009 and 2020.



Map 22. Distribution of Dalmatian toadflax at the Academy in 2020 with the reference grid.

Tatarian Honeysuckle (*Lonicera tatarica*)

?

Trend 2019-2020: Unknown (Overall Increasing)

Management Goals: Containment

State List: NA (Garden Escape)

- Tall shrub
- Commonly planted and escaping to disturbed sites
- Seeds are spread widely by animals
- At the AFA one population is growing with a rare plant species, American currant
- Plants can sprout after treatments

Photos: Wikimedia Commons

2020 Results

In 2020, there was a decline in the number of individuals from 132 in 2018 to 113 in 2020. Since Tatarian honeysuckle was not monitored in 2019, the 2019-2020 trend is unknown. There were 35 extant features with nine eradicated features in 2020. Four of the features mapped in 2020 were new and account for the increase in acres from 0.60 to 0.81 in 2020 (Table 26). Eight features mapped east of I-25 along Pine Creek drainage that contained 31 individuals in 2018 were not mapped as well as seven features on the Academy in 2020 (which contained one individual each in 2018) with one eradicated site. Note that Table 26 includes the numbers of individuals and sites recorded at the last survey for points not visited in 2020 (Table 26, Map 23 & 24).

Table 26. Mapping of Tatarian honeysuckle at the Academy.				
	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2008†	0.15	20	1	0
2012†	0.15	20	1	0
2013	0.18	28	5	0
2014	0.21	31	5	2
2015	0.40	48	9	1
2016	0.24	22	8	4
2017	0.24	8	6	3
2018	0.60	132	35	5
2019	?	?	?	?
2020	0.81	113	35	9

Basewide weed mapping performed during shaded years. † Number of shoots at the original site documented in 2008 was previously reported to be 30 individuals, an estimate from a distance. This site was visited in 2014 for an actual count of 20.

2020 Treatment

The resource management staff conduct all treatments for Tatarian honeysuckle at the AFA. In 2020, we conducted 29 site visits at 27 sites (2 were revisits to known sites) and found 85 individuals (Table 27).

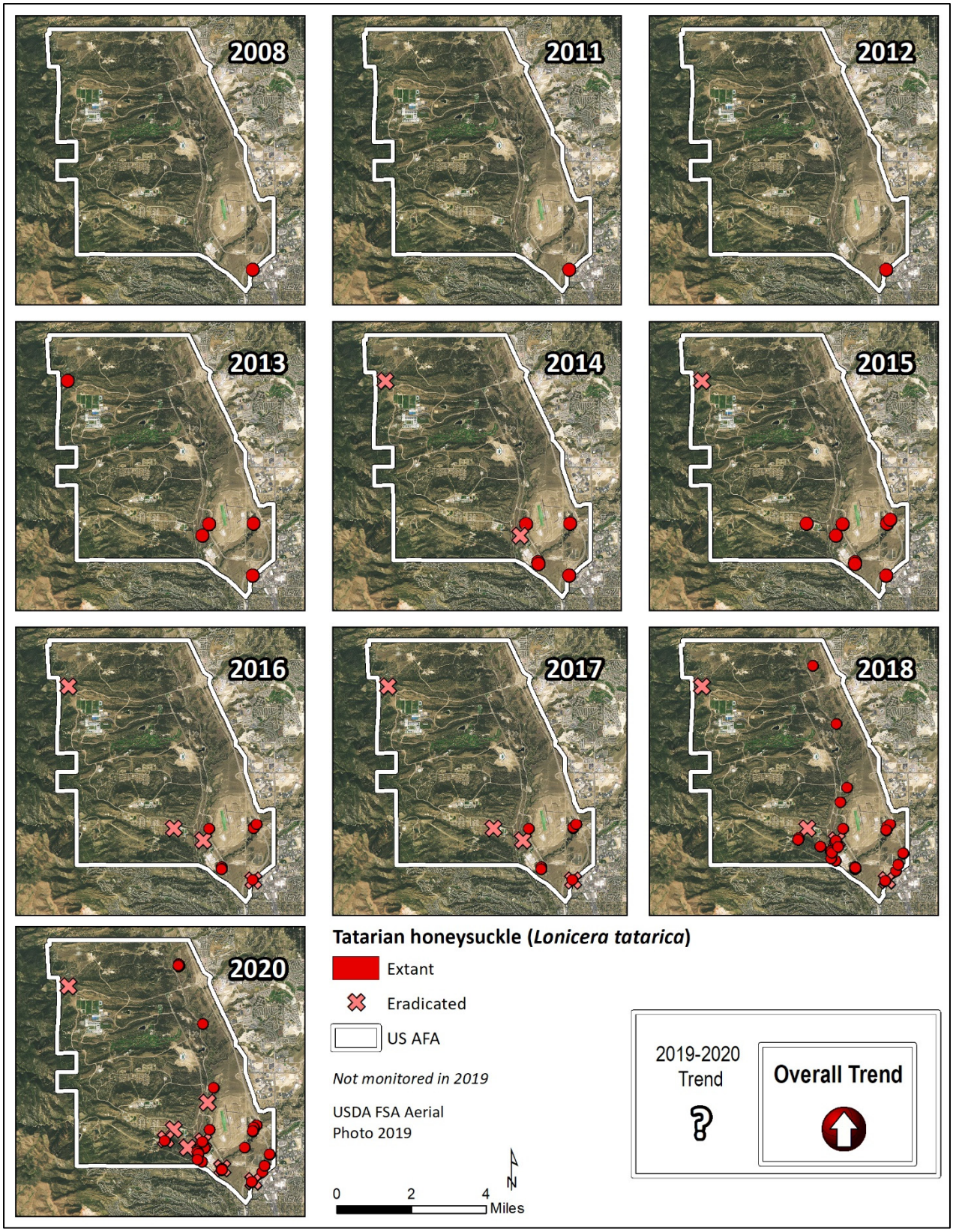
Table 27. Monitoring and treatment of Tatarian honeysuckle sites at the Academy in 2020.					
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	27	83	0	23	4
Pass 2	2	2	0	1	1
TOTAL	**29**	**85**	**0**	---	---

Recommendations

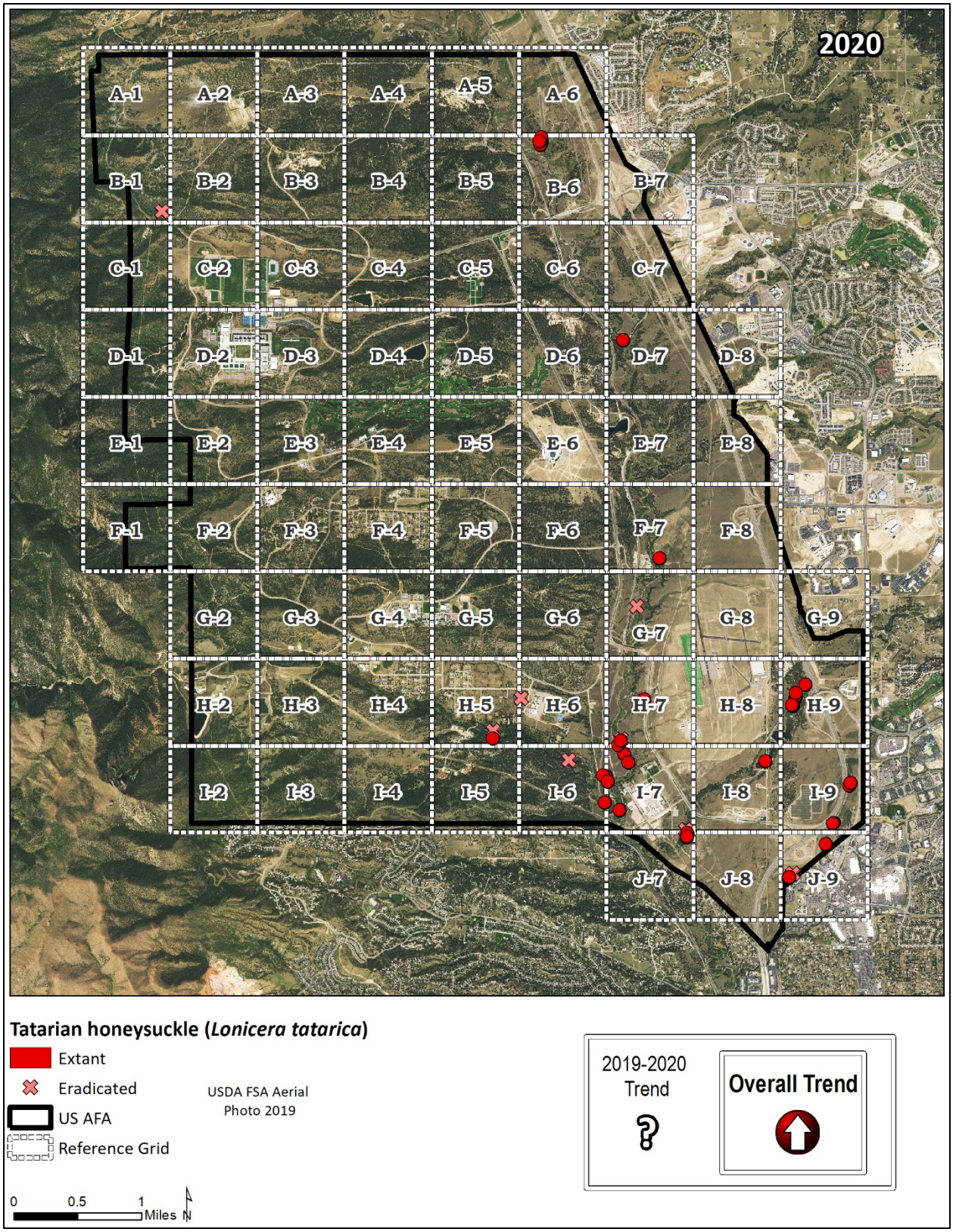
The management urgency for Tatarian honeysuckle is medium. For 2020, we will continue to monitor known sites as sprouting is common after treatment and it is the main way the trees spread. Tatarian honeysuckle is a prolific seed producer but most of the plants found at the Academy are small trees or large shrubs and have been present for a number of years. Some of the increases are due to finding new occurrences of mature plants. When Tatarian honeysuckle is not flowering it is very easy to miss in surveys of dense vegetation. The Academy personnel have been conducting removal of Tatarian honeysuckle.

History of Sampling and Treatment:

- Tatarian honeysuckle was first discovered at the Academy in 2008 with American currant (*Ribes americanum*), a State rare plant species tracked by CNHP.
- Tatarian honeysuckle occupied 0.15 acres with approximately 30 individuals at one site in 2012.
- In 2013, four new locations were documented with eight individuals. The original site was not revisited, but was assumed extant.
- In 2014, the original site documented in 2008 was visited for an actual count and found to have 20 individuals. The original number of 30 individuals was an estimate. This site is difficult to access due to dense growth and steep terrain.
- In 2015, there was an increase from 31 to 48 individuals and from 5 to 9 extant mapped features. Sprouting trees at treatment contributed to this increase.
- In 2016, all known sites were visited and 2 new sites were added. At the site on the SE side of the AFA there were 20 individuals in 2014. There was a substantial decline at this site in 2016, with only one living individual and 19 standing dead trees, apparently of natural or man-made hydrological influences.
- In 2017, one site which had 13 individuals last year appears to be defoliated and accounts for a drop from 2016. If these trees don't re-sprout, it will represent a true decline.
- In 2018, the basewide mapping shows an increase from one individual in 2012 to 35 in 2018. Some of the trees are mature and those don't reflect an increase. Some increases are sprouts that occur as a result of treatments.
- In 2019, Tatarian honeysuckle was not monitored.
- In 2020, 27 sites were visited with 85 individuals at 80 extant sites. No sites were visited East of I-25 along Pine Creek which included eight features with 31 individuals mapped in 2018.



Map 23. Distribution of Tatarian honeysuckle at the Academy between 2008 and 2020.



Map 24. Distribution of Tatarian honeysuckle at the Academy in 2020 with the reference grid.

Scotch Thistle (*Onopordum acanthium*)

Trend 2019-2020: Stable (Overall 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-CSU 2016)

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

2020 Results

In 2020, Scotch thistle populations are considered stable between 2019 and 2020 but increasing overall. There was an increase in the occupied acres and in the number of individuals but a decrease in the number of extant features at the Academy compared to 2019. Scotch thistle has been mapped at over 400 sites since 2002 and currently occupies an estimated 3.59 acres at the Academy (Table 28, Figures 12 & 13, Maps 25 & 26). In 2020, 296 sites were visited. A very large population of Scotch thistle in an area west of the Air Force Academy High School near the intersection of Carlton Drive and E. Pine Loop was not surveyed (Grid H-5, Map 26) that was mapped with 100+ features in 2018. Other points not visited include sites east of I-25 and eight points scattered around the base at Grids A-5, B-6, C-4, E-5, G-7 and H-6.

Table 28. Mapping of Scotch thistle at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002†	0.17	52	7	0
2005	0.42	137	12	0
2007	1.31	1,307	36	0
2008	1.14	144	27	17
2009	3.47	1,710	50	34
2010	0.66	669	61	30
2011	0.64	293	39	56
2012	0.30	889	66	73
2013	?	970	48	85
2014	0.84	1,224	74	81
2015	1.60	1,629	157	76
2016	1.13	1,331	128	127
2017	1.35	791	120	155
2018	2.04	1,914	275	143
2019	2.35	3,137	290	135
2020	3.59	3,364	268	163

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

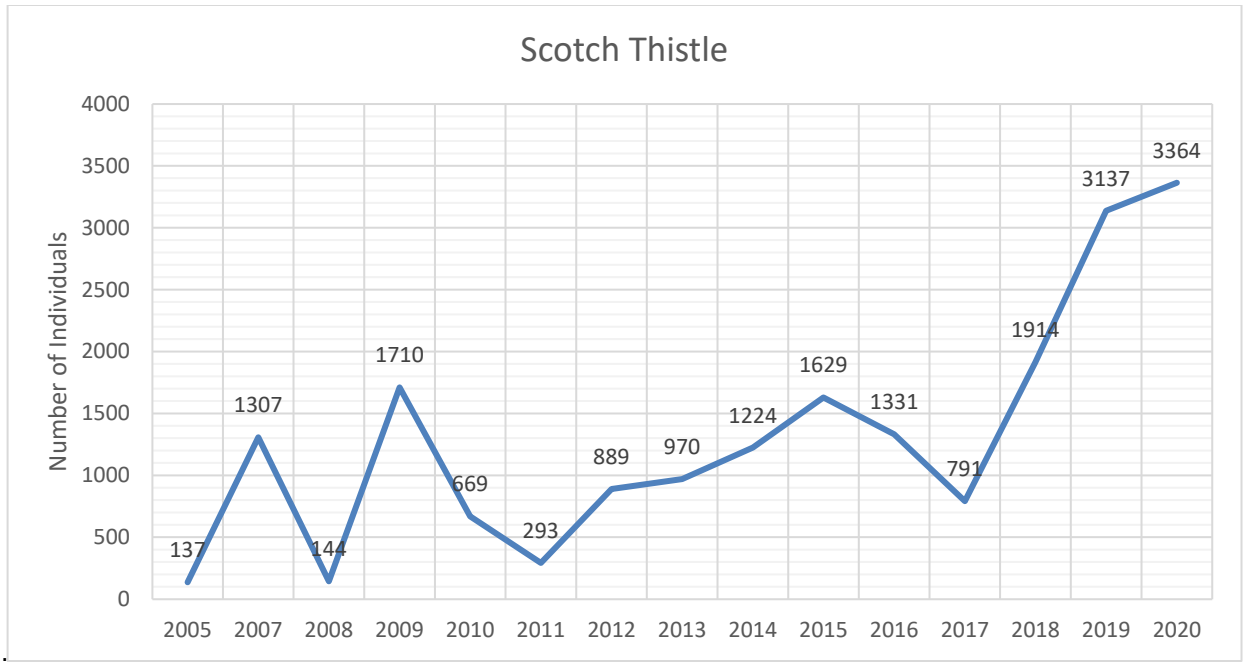


Figure 12. Number of Scotch thistle individuals, 2005-2020.

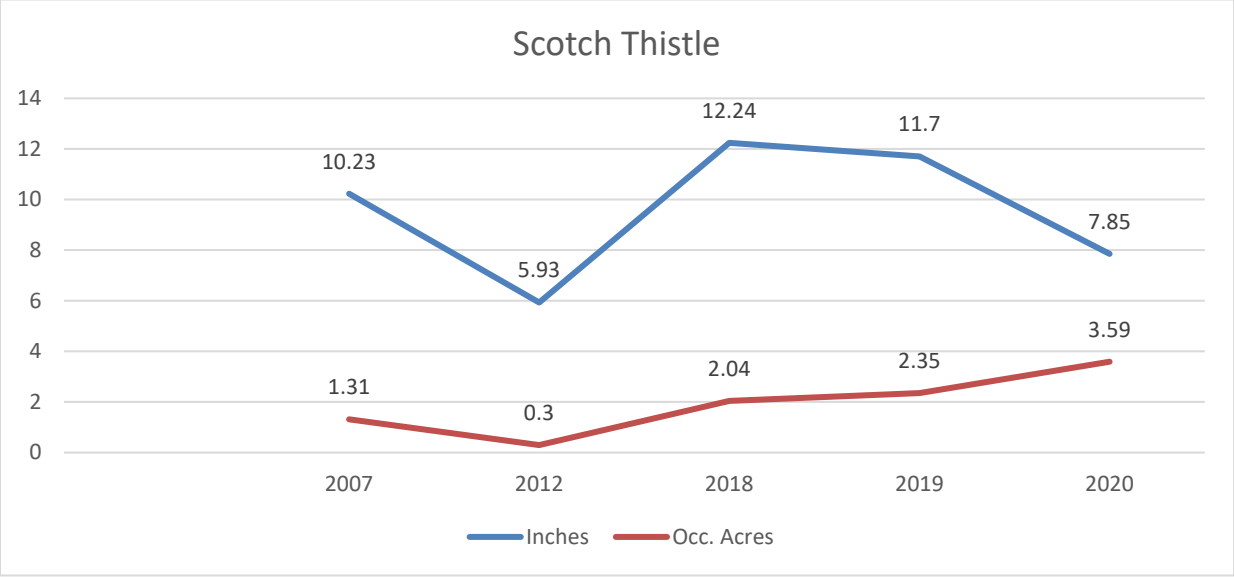


Figure 13. Comparison of spring-summer precipitation and occupied acres of Scotch thistle at the Academy, 2007-2020.

2020 Treatment

In 2020, a total of 296 sites were visited with 146 extant sites containing 2,333 individuals for the first pass of the season (Table 29). Some sites contained just a few individuals while others contained up to several hundred. All rosettes that were encountered were pulled. Large plants post flower that had dropped their seeds (dead standing) were not removed. Sites with 50 or more were

not manually treated in the middle of the summer. Over the summer we removed 397 plants (Table 29), some rosettes and some bolted individuals.

Table 29. Monitoring and treatment of Scotch thistle sites at the Academy in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	296	2,333	386	146	150
Pass 2	20	6	4	6	14
Pass 3	12	14	7	6	6
TOTALS	**328**	**2,353**	**397**	--	---

Recommendations

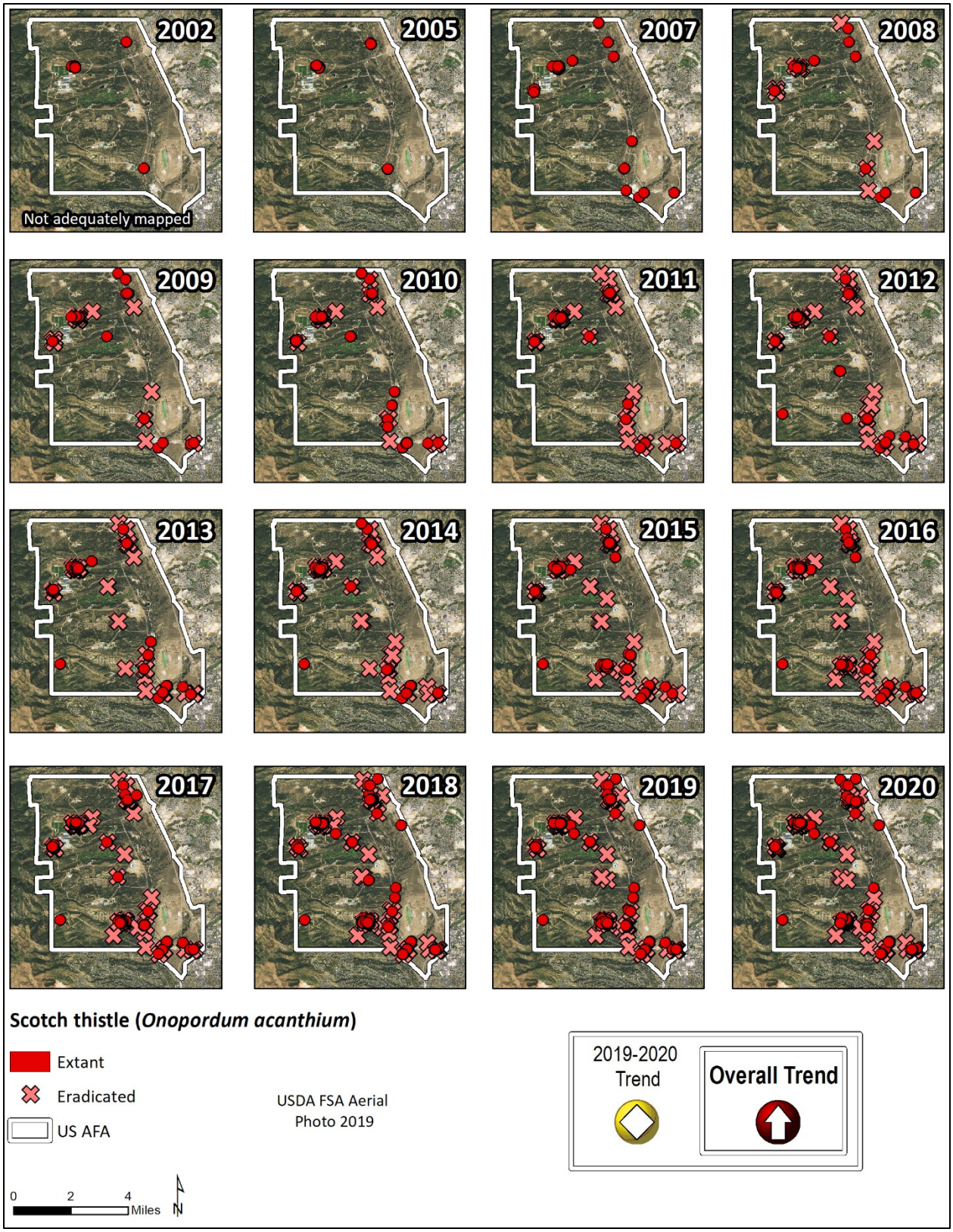
The management urgency for Scotch thistle is high. The focus for 2021 will include spring surveys to remove as many rosettes as possible and to revisit as many sites as possible throughout the growing season. It is most important to focus on removing plants before seeds set and before the plants get to a large size. Seeds are the only way this species reproduces, so preventing plants from going to seed and removing sprouts throughout the growing season should yield decreases. Even one plant left behind in a cleared area can result in hundreds of new plants the following season. For example, in 2018 the weed mapper documented seven weed points with a total of 51 individuals. These individuals were not treated. When the site was surveyed in 2020, there were 300 plants at the site. The key is removal of rosettes throughout the growing season as they sprout with the goal of having no seed production. Bolted individuals are the most difficult to treat effectively and viable seeds can still be produced (Photo 10).

Photo 10. Bolted heads of treated Scotch thistle with houndstongue and cheatgrass. P. Smith 2015

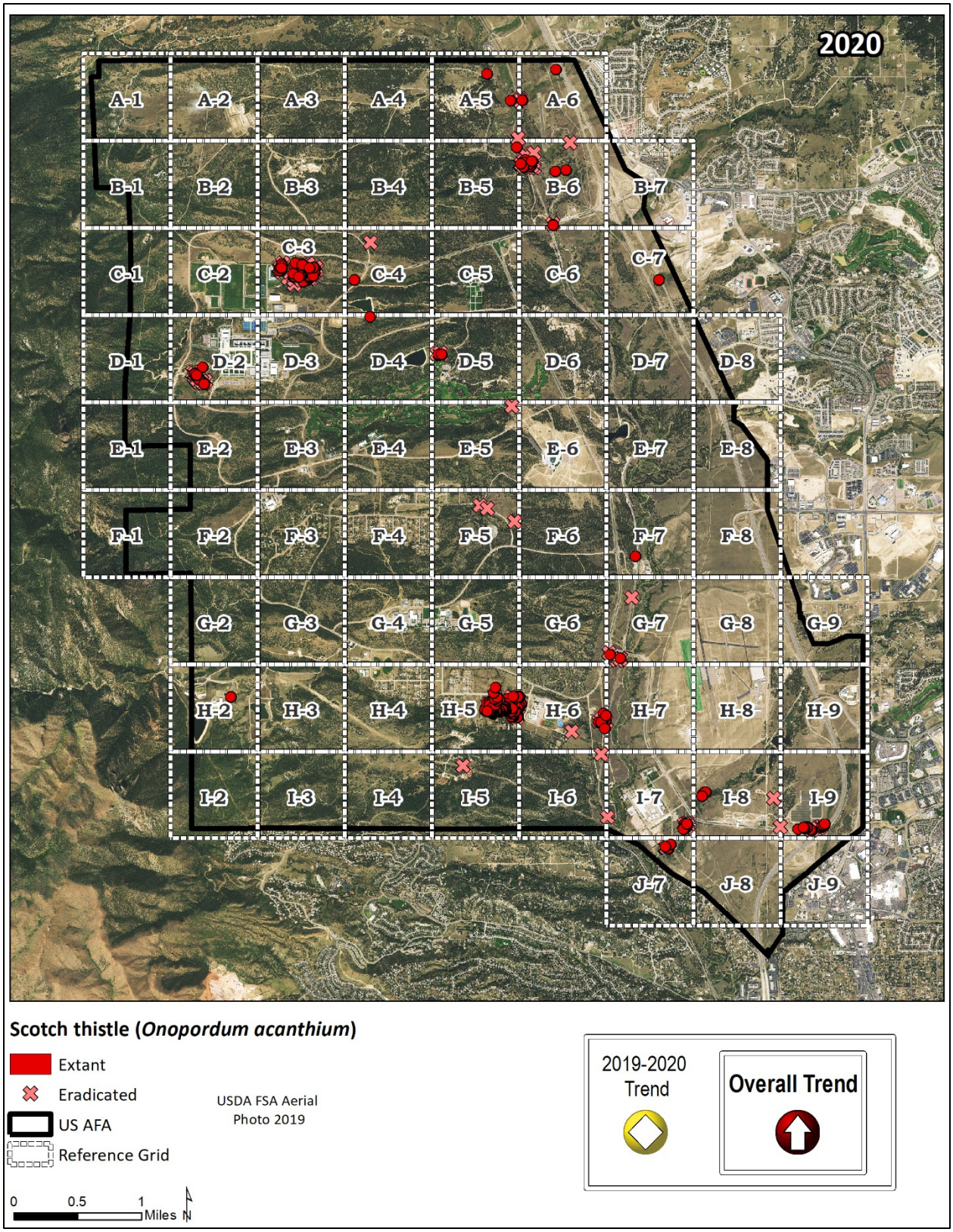
History of Sampling and Treatment:

- 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.
- In 2020, there were 296 sites visited with half of the sites eradicated. Scotch thistle continues to increase across the base with new locations in newly disturbed areas.



Map 25. Distribution of Scotch thistle at the Academy between 2002 and 2020.



Map 26. Distribution of Scotch thistle at the Academy in 2020 with the reference grid.

Bouncingbet (*Saponaria officinalis*)

Trend 2019-2020: Decreasing

Management Goals: Eradication

State List: B

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

Photo: ct.botanicalsociety.org

Photo: Leaves of mature plant, missouristate.edu

2020 Results

Bouncingbet is considered to be decreasing at the Academy in 2019-2020 as well as overall. There are a total of 38 known sites for bouncingbet and four were not visited in 2020. We estimate there are 2,337 individuals with a total of 24 extant and 14 eradicated sites across the Academy (Table 30). One site not visited was located along Monument Creek (80 plants in 2019) and three sites not

visited were located in Pine Creek (911 individuals in 2018). Pine Creek was not visited as it is a highly disturbed system. There has been a decline in the numbers of shoots since 2018 and 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 (Table 30, Figure 14, Maps 27 & 28).

Table 30. Mapping of bouncingbet at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	?	?	1	0
2007	---	---	---	---
2012	---	---	---	---
2013	0.50	42,092	8	0
2014	0.14	42	2	6
2015	0.09	608	8	5
2016	0.05	535	8	6
2017	0.05	401	6	8
2018	0.17	4,585	26	8
2019	0.24	4,063	29	8
2020	0.20	2,337	24	14

Basewide weed mapping performed during shaded years.

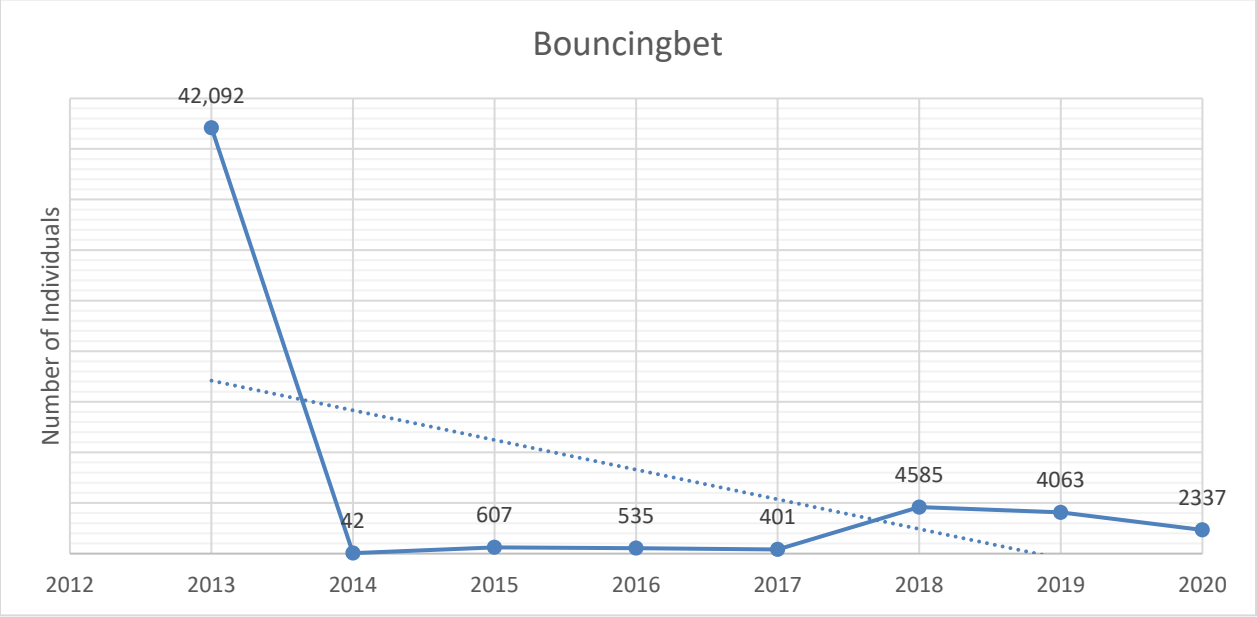


Figure 14. Number of bouncingbet individuals, 2013-2020.

2020 Treatment

In 2020, 32 mapped bouncingbet features were visited for monitoring and treatment. Of those 32 sites, there were 1,339 individuals mapped at 19 extant features (Table 31). Two sites were new locations in 2020. CNHP did not visit three sites along Pine Creek due to their location on very steep cliffs. All extant sites visited were treated by removing all buds and flowers, bagging and disposing them off-site.

Table 31. Monitoring and treatment of bouncingbet sites at the Academy in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	32	1,339	1,339	19	13

Recommendations

Management urgency for bouncingbet is considered to be medium. Spring and summer precipitation appear to be predictive of population changes with more individuals in wet years. Flooding has removed at least 60 individuals in 2019 along Monument Creek from beaver activity. Wildlife continue to graze the flower tops. Continue to monitor all known sites for the next few years to determine if a reduction in plant production is occurring. CNHP will continue to remove reproductive parts to prevent seed production.

One of the most interesting observations for 2016 through 2020 is that flower tops and buds are browsed by ungulates (Photo 11).

Photo 11. 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 (Photo 12). 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.

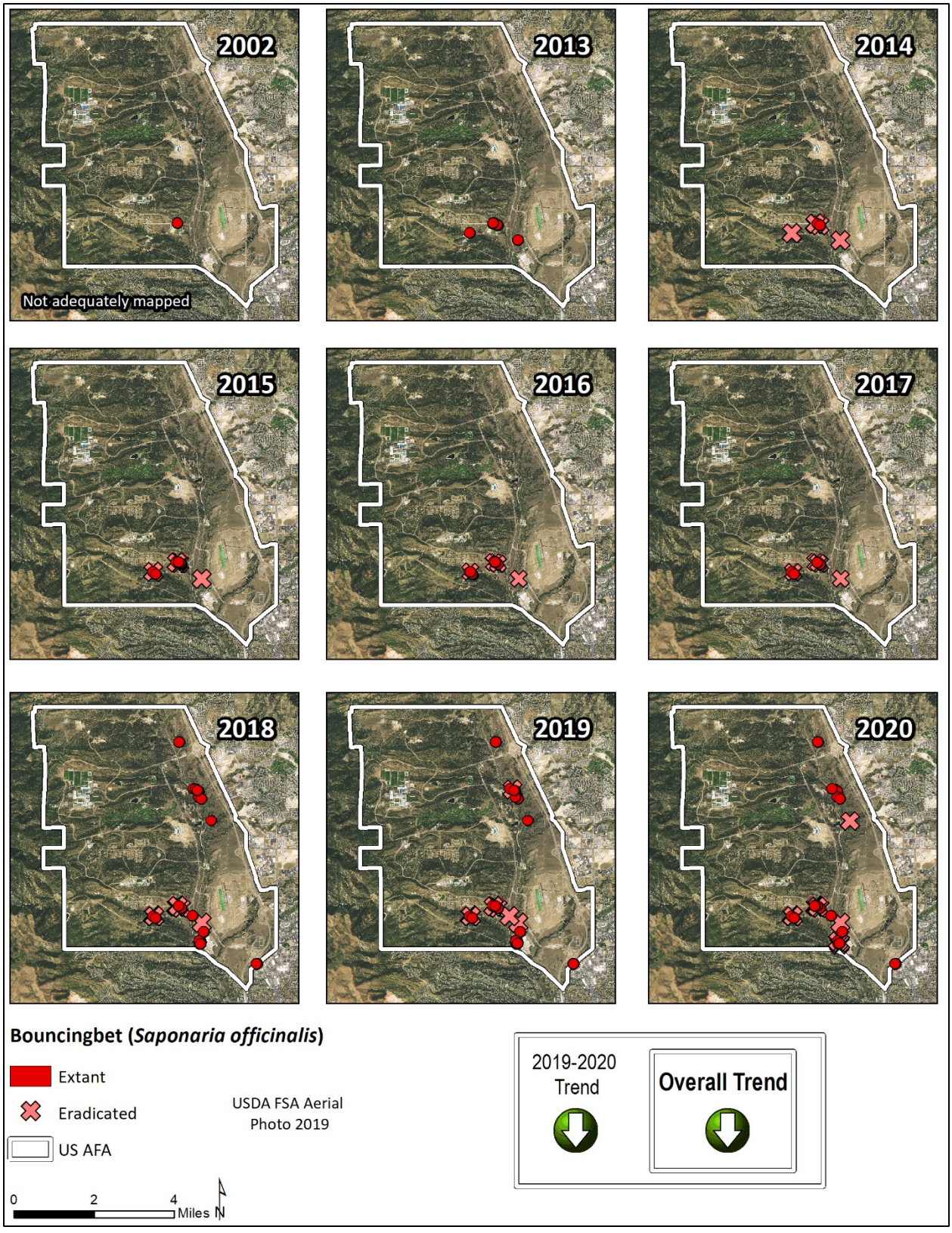
Photo 12. Bouncingbet herbicide treatment area with bouncingbet returning after a few years and cheatgrass filling in bare soils left by overspray in drainage area. Photo P. Smith 2016

Many of the plants are in dense vegetation in riparian areas making them very difficult to treat, especially those populations along the floodplains of Kettle and Monument Creeks. The dense growth and steep terrain are both obstacles. Most treatments can cause vegetative growth (CDA-CSU 2019a). There are no recommendations for herbicide or mechanical treatments alone. In addition, there are no herbicides recommended for treating wildlands**,** only rangelands and pastures for bouncingbet (CDA-CSU 2019a).

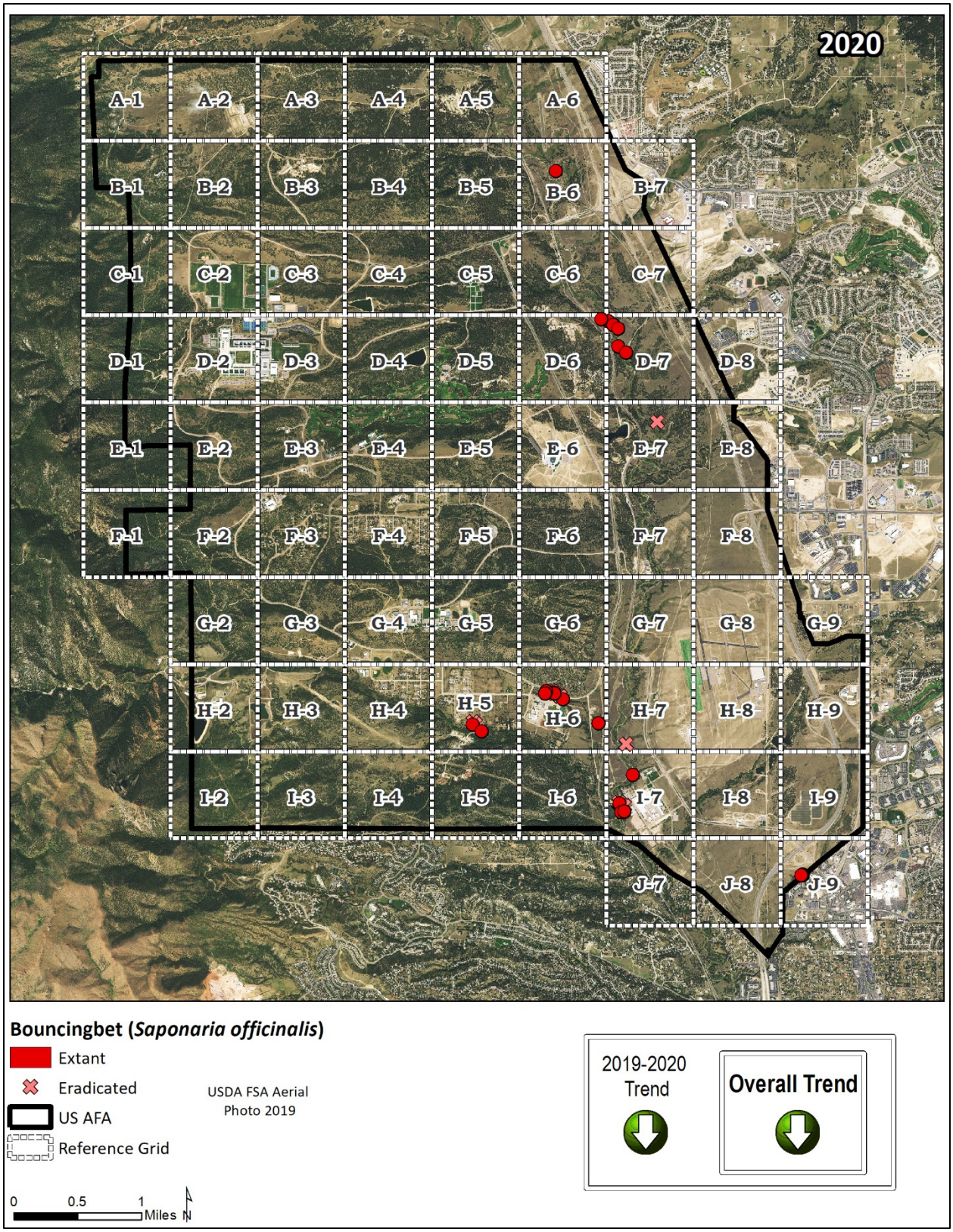
History of Sampling and Treatment:

- 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.
- In 2020, there was a decrease from 2019 in numbers of individuals, occupied acres and an increase in eradicated sites. The very dry conditions of 2020, shoreline flooding and perhaps continuous removal of reproductive parts have contributed to the decrease.



Map 27. Distribution of bouncingbet at the Academy between 2002 and 2020.



Map 28. Distribution of bouncingbet at the Academy in 2020 with the reference grid.

Salt Cedar (*Tamarix ramosissima*)

Trend 2019-2020: 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 FEIS 2016)

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

2020 Results

In 2020, only one extant location of salt cedar was mapped. There are a total of 10 known occurrences at the Academy: five were not visited in 2020, four on the south side of the airport which were extirpated in 2019 and one on the east of I-25 which is thought to be extirpated (Table 32, Maps 29 & 30). The only extant feature is located along a roadside in Jack's Valley West and has been there for many years. It has been manually treated by Academy staff but continues to re-sprout. This species has a very high likelihood of being eradicated.

Table 32. Mapping of salt cedar at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	<0.01	1	1	0
2007	<0.01	1	1	1
2008	0	0	0	1
2009	<0.01	2	2	3
2010	0	0	0	5
2011	<0.01	1	1	4
2012	<0.01	1	1	4
2013	<0.01	1	1	5
2014	<0.01	1	1	6
2015	.03	6	4	5
2016	<0.01	1	1	8
2017	<0.01	1	1	8
2018	0.01	2	2	8
2019	<0.01	1	1	9
2020	<0.01	1	1	9

Basewide weed mapping performed during shaded years.

2020 Treatment

In 2020, five sites were visited and only one extant occurrence was located. This species is treated by Academy staff (Table 33).

Table 33. Monitoring and treatment of salt cedar sites at the Academy in 2020.

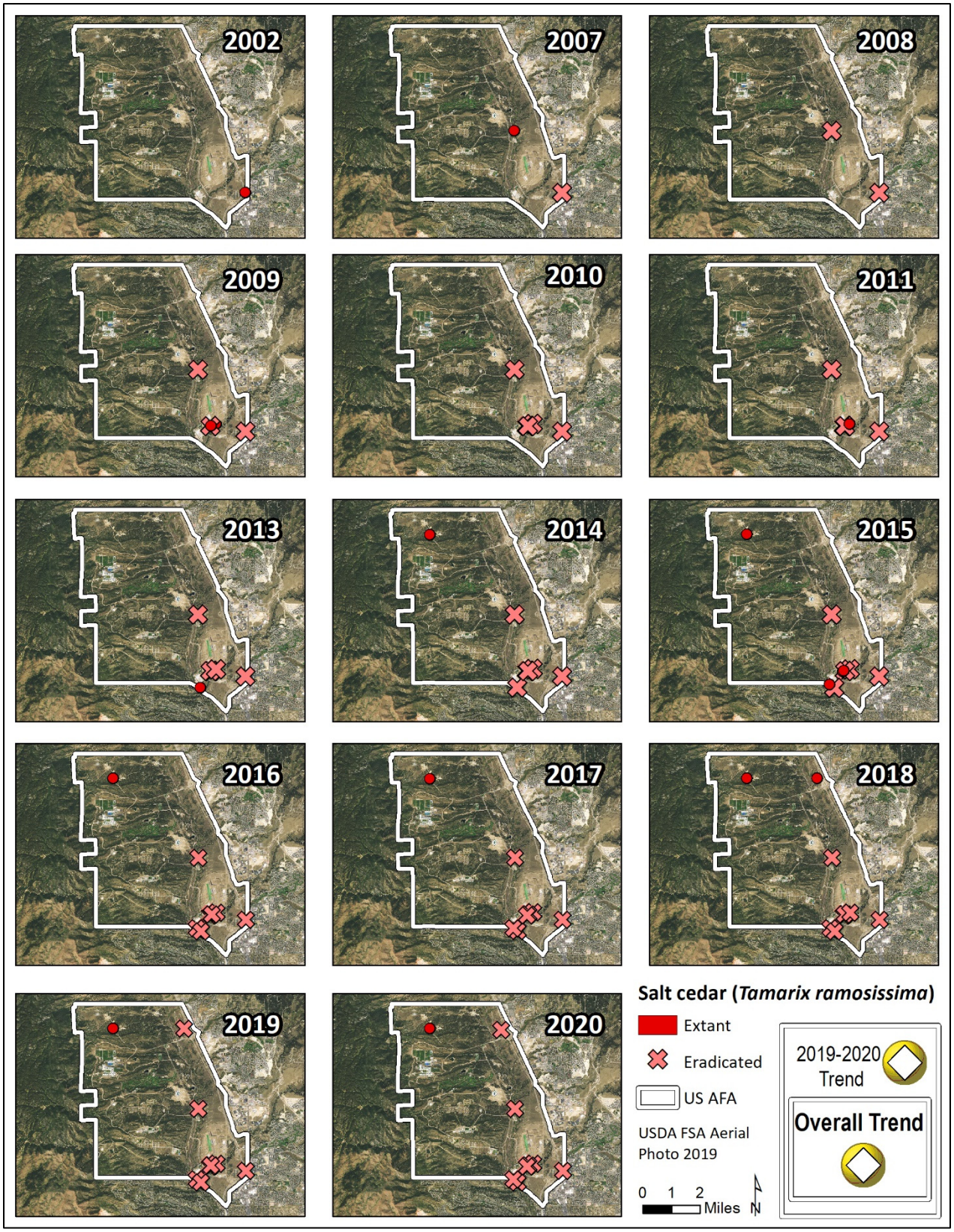
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	5	1	0	1	4

Recommendations

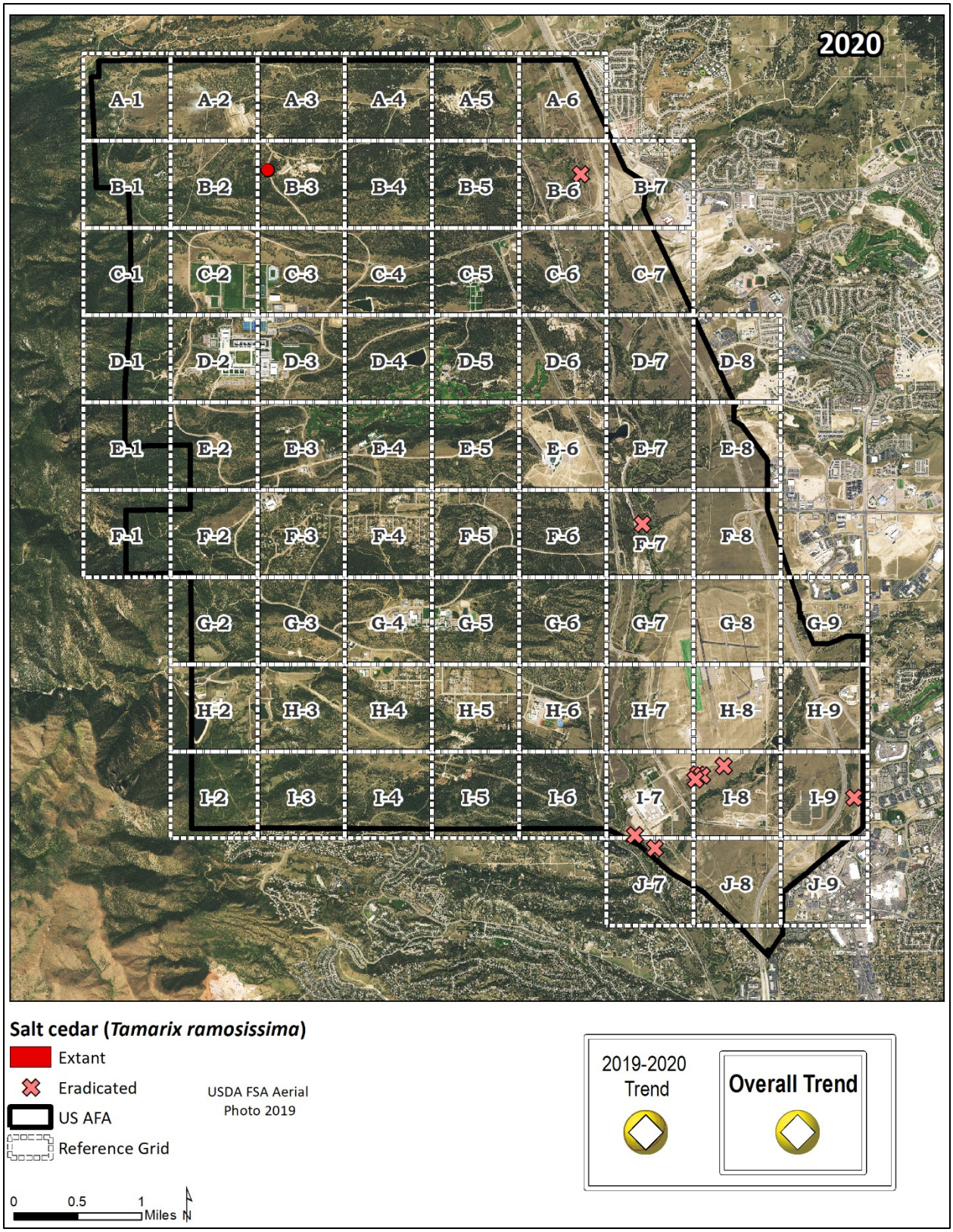
The management urgency is high due to the potential for invasion and since it spreads by seed and vegetatively. The Academy is treating the only known extant sites using a cut stump with herbicide method recommend for salt cedar. For this method to be effective, plants are cut as close to the ground 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 (CPW 2013). Staff and contractors are monitoring eradicated sites, the known site as well as ditches, drainages and riparian areas for new occurrences at the Academy.

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 salt cedar.
- In 2020, only one extant location was observed out of five sites visited. The five sites not visited were located along the south side of the airfield and one east of I-25, all did not have plants present in 2019.



Map 29. Distribution of salt cedar at the Academy between 2002 and 2020.



Map 30. Distribution of salt cedar at the Academy in 2020 with the reference grid.

Common Tansy (*Tanacetum vulgare*)

New 2020

Management Goals: Eradication, Rapid Response

State List: B

- Perennial, woody forb
- Reproduction by seed, some vegetative
- Flowers June-September
- Escaped ornamental
- No long distance wind dispersal appendages, plants stay close to parents
- Seed longevity in soil is thought to be short 2 years (CDA 2019b)
- Seeds viable on dried heads to three years (White 1997)

Common tansy at the Academy in 2020. P. Smith

Photo (left) Common tansy with close-up of flowers and leaves. Minnesota Department of Agriculture

2020 Results

This is the first year common tansy has been mapped as a List B noxious weed at the Academy. Although it is mapped at a single site, it likely occurs elsewhere and was not part of the 2018 basewide monitoring. There were 15 individuals mapped at one location in the area where a number of garden escapes have been observed along West Monument Creek (Maps 31 & 32).

2020 Treatment

In 2020, one site was documented with 15 plants although others are likely at the Academy (Table 34). Treatment was not undertaken at that time as a treatment plan needed to be discussed with Academy staff.

Table 34. Monitoring and treatment of common tansy sites at the Academy in 2020.

	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	1	15	0	1	0

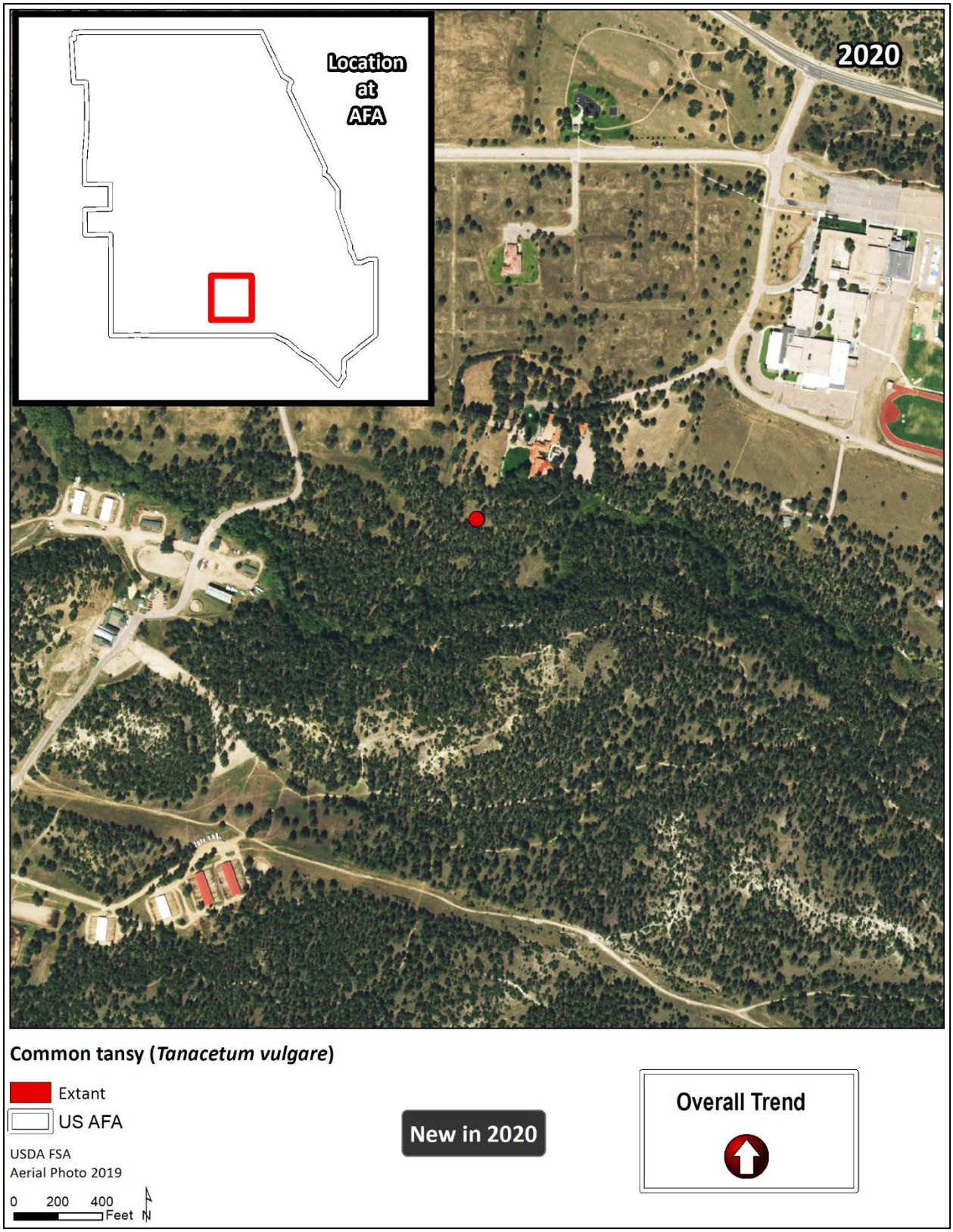
Recommendations

The site where common tansy was located is also where a number of garden escape species have been observed. The area is downslope of residences with manicured lawns/gardens that have been discarding yard waste into the drainage and where seeds and plant fragments have likely been transported off these properties during rain or snow melt into the West Monument Creek drainage. Contacting the residents is recommended as some of the species have been quite invasive at the Academy and include garlic mustard and yellow spring bedstraw. Hoary alyssum (CDA Watch List Noxious Weed) has also been observed there along with non-native shrubs and grasses found on manicured properties.

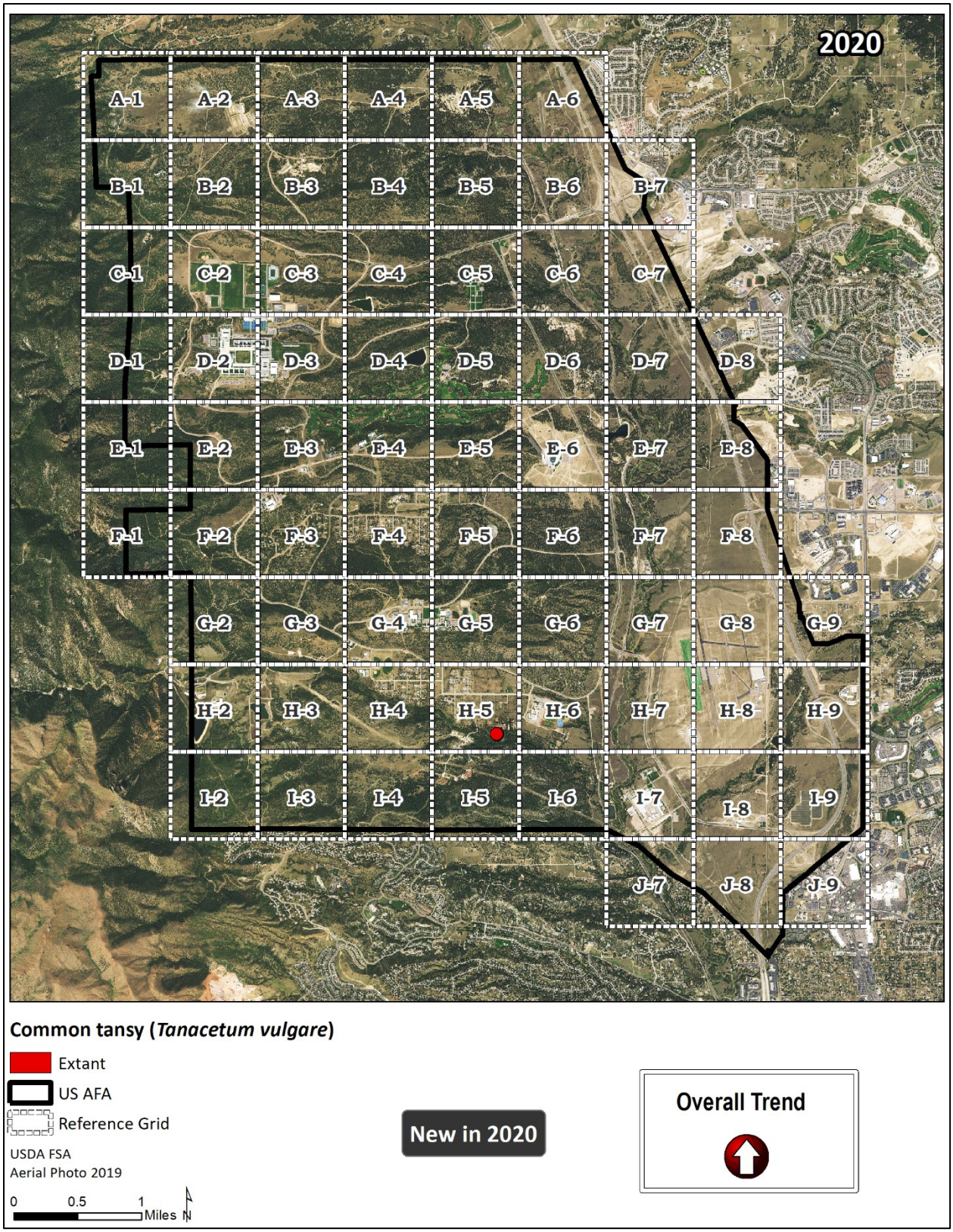
For 2021, we recommend treating the small population by digging up plants, followed by multiple monitoring and treatment visits (CDA-CSU 2019b). Although common tansy can spread both by seed and by roots (rhizomes), spread is mainly by seeds which can remain viable for three years on dried heads (CDA-CSU 1019b). Therefore, removal of dried vegetation as well as fresh flowers and sprouts is recommended not only to deplete resources to the roots but to reduce the seed bank. The roots can be thick and woody. Continued monitoring at the Academy is recommended at the known site and to continue to look for it throughout the Academy, especially in disturbed areas and near residential areas. The current management urgency is high as this species has a low cover and a high potential for eradication.

History of Sampling and Treatment:

- In 2020, common tansy was added to the monitoring list for the Academy.



Map 31. Distribution of common tansy at the Academy in 2020.



Map 32. Distribution of common tansy at the Academy in 2020 with the reference grid.

Scentless Chamomile (*Tripleurospermum (inodorum) perforatum*)

?

Trend 2019-2020: Unknown (Overall Increasing)

Management Goals: Rapid Response – Kettle Creek, Containment - 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)

2020 Results

This species is widespread in Monument Creek and the 2019-2020 trend is unclear because only a portion of the total population was visited in both years. There are a total of 120 known sites with 112 extant with an estimated 2,462 shoots that occupy an estimated 0.4 acres based on 2020 data and basewide mapping in 2018 (Table 35, Maps 33 & 34). Scentless chamomile was first observed in 2016 at a couple of sites along Kettle Creek. These plants were manually treated and scentless chamomile was not found in Kettle Creek in 2019 or in 2020. Results for a number sites visited in 2018 and 2019 where the plants were removed demonstrated that plants did not return after a year or two. All eight eradicated sites visited in 2020 have remained free of scentless chamomile, and the majority have remained that way for more than one growing season. It seems unlikely that such a large infestation (over 6 miles) can be eradicated but control and containment may be achieved and reduce the seeds being transported upstream or downstream.

Table 35. Mapping of scentless chamomile at the Academy.

	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2016	<0.01	2	1	0
2017	<0.01	1	1	1
2018	0.41	2,530	117	2
2019	0.42	2,525	116	3
2020	0.40	2,462	112	8

Basewide weed mapping performed during shaded years.

2020 Treatment

In 2020, 23 features were visited and 278 individuals were removed (Table 36). No plants were found in the Kettle Creek drainage. For the sites visited in 2020 that were treated in previous years, eight had no plants present in 2020. This is a small sample but it appears the manual treatments are effective at Kettle Creek. Putting time and effort into pulling these plants should yield results in reducing the volume of scentless chamomile in the Monument Creek drainage. It appears to be eradicated from Kettle Creek for now. The management urgency is medium due to the large area and numbers of plants.

Table 36. Monitoring and treatment of scentless chamomile sites at the Academy in 2020.					
	# Site Visits	# Shoots Mapped	# Manually Treated Shoots	# Sites with Plants	# Sites without Plants
Pass 1	23	278	278	15	8

Recommendations

In 2020, after revisiting some of the treated scentless chamomile sites, it became apparent that pulling the plants had resulted in removal for a number of sites for multiple seasons. So for 2021, we have already begun working with Academy staff to get resources to make manual removal more practical. We should be able to treat many more plants in 2021 and hopefully begin to reduce the population along Monument Creek. After the first season of pulling scentless chamomile, we found it easy to remove and that removal of the biomass was limiting treatment. 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 will also continue to focus on Kettle Creek for rapid response actions since no plants have been seen since 2018 after manual treatments.

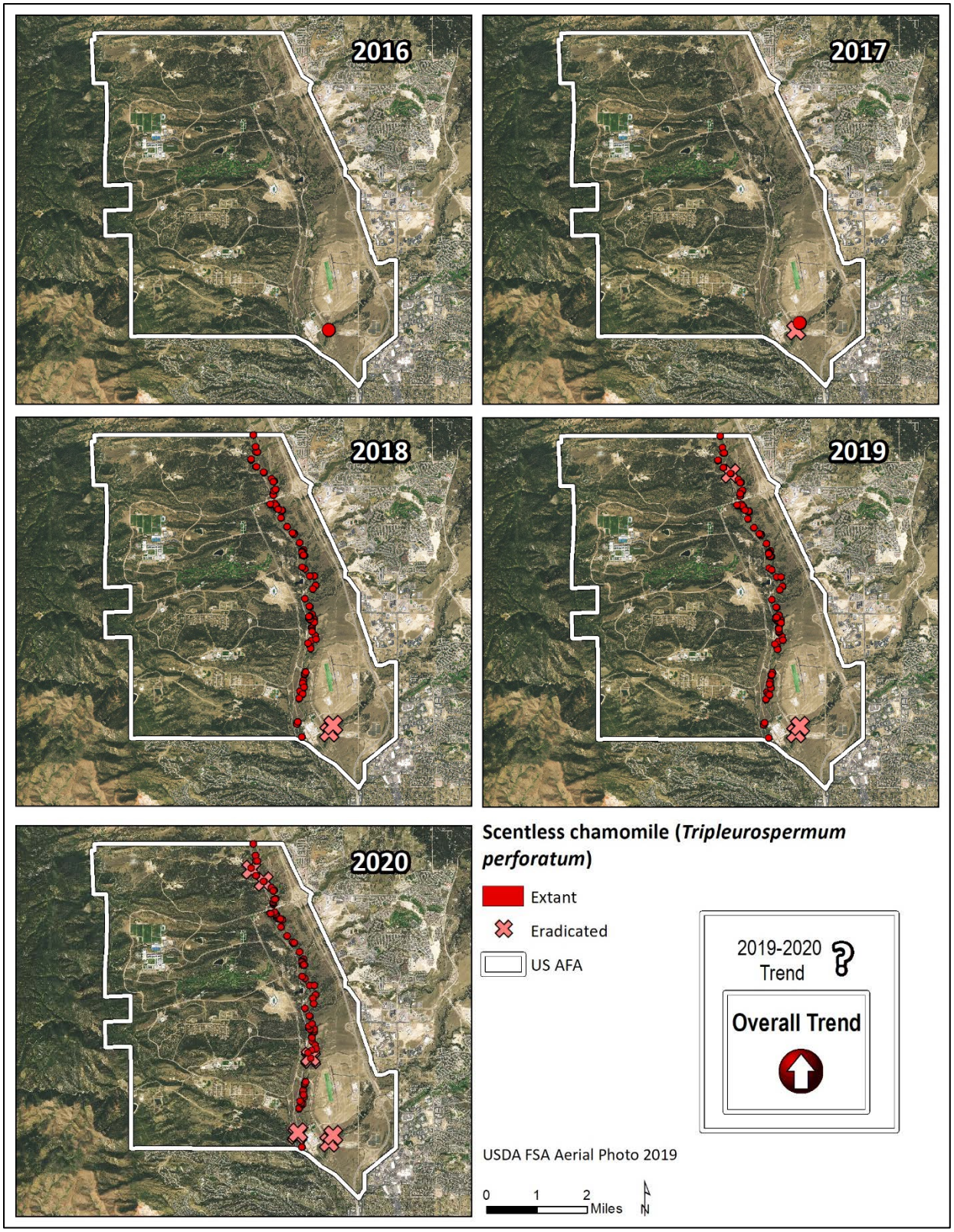
Since Monument Creek is highly disturbed due to its location near a large metropolitan area, the water is polluted and the flows are unnatural, it tends to be weedy. The scentless chamomile seed source (and other weed seed and propagules) is likely coming from outside the property boundaries.

For 2021, monitoring all small drainages, including Kettle Creek, for new occurrences of scentless chamomile is a top 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.

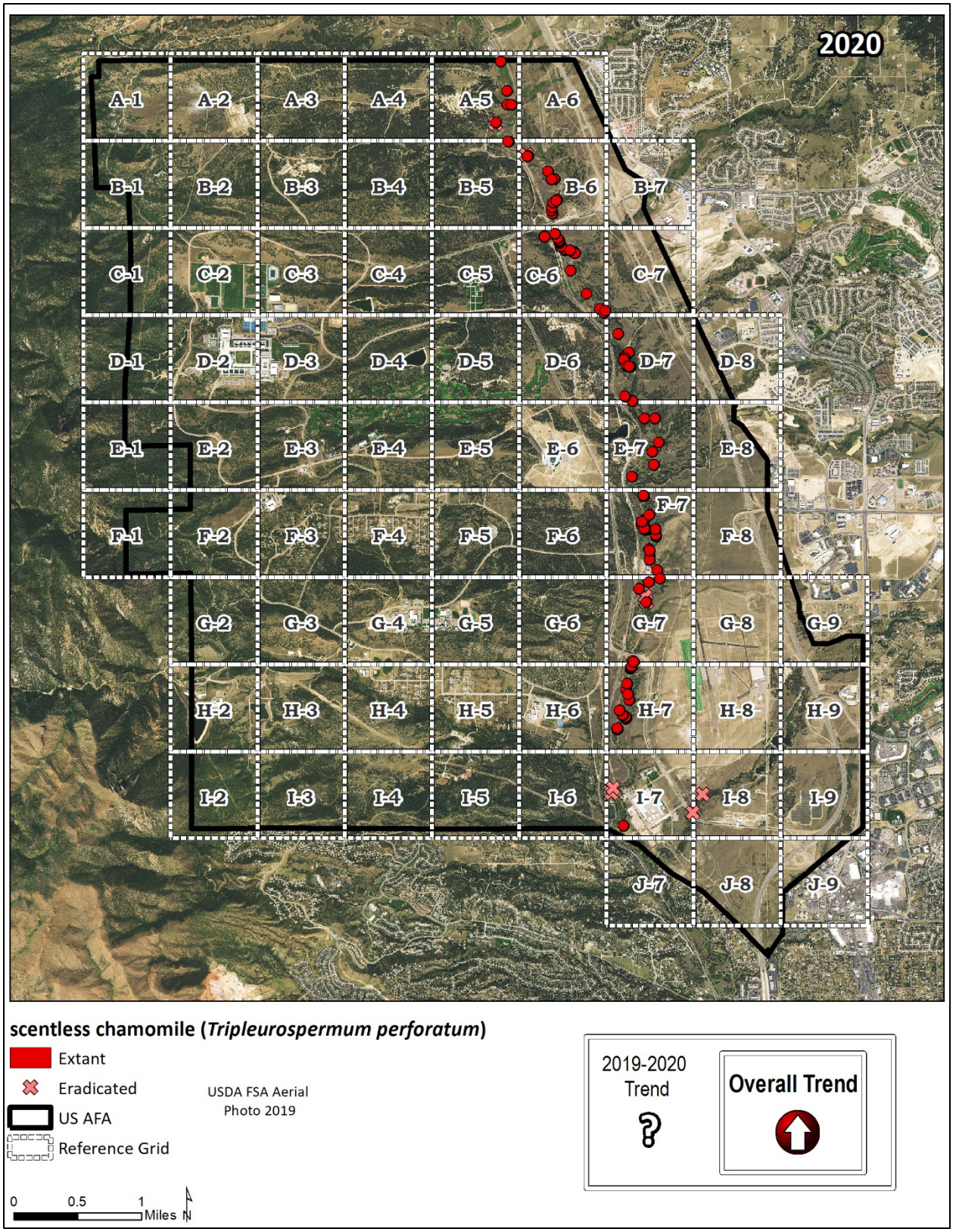
History of Sampling and Treatment:

- 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 scentless chamomile.

- In 2020, we visited only a portion of the known sites (23 sites) to monitor previously treated areas to see if the plants were returning. We found that eight of the sites had remained free of plants for one or more growing seasons. A plan to coordinate efforts with the Academy staff will be implemented to remove more scentless chamomile plants along Monument Creek in 2021 and to carefully monitor other drainages at the Academy.



Map 33. Distribution of scentless chamomile at the Academy between 2016 and 2020.



Map 34. Distribution of scentless chamomile at the Academy in 2020 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 2021. Colorado Department of Agriculture Noxious Weed List. https://ag.colorado.gov/conservation/noxious-weeds/species-id Accessed March 2021.

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.

CDA-CSU 2019b. Colorado Department of Agriculture-Colorado State University, Identification and Management of Common Tansy (*Tanacetum vulgare* L). Rev 2/19

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.

GPMCT 2019. Pesticide Use in Wildlands. Great Pond Mountain Conservation Trust. September 2019. https://www.greatpondtrust.org/pesticide-use-in-the-wildlands/

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.E., Ortega, Y.K., Runyon, J, and L. Buttler. 2016. Secondary invasion: The bane of weed

management. Elsevier, Biological Conservation. Volume 197, May 2016, pp. 8-1. https://www.sciencedirect.com/science/article/abs/pii/S0006320716300726

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 Force 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

Wagner, V., Antunes, P.M., Irvine, M. and C.R. Nelson. 2017. Herbicide usage for invasive non-native plant management in wildland areas of North America. Journal of Applied Ecology, Vol. 54, Issue 1 pp. 198-204 https://doi.org/10.1111/1365-2664.12711

White, D.J. 1997. *Tanacetum vulgare* L. Weed Potential Biology, response to herbivory, and prospects for classical biological control in Alberta, Edmonton AB: University of Alberta, Canada. 163 pp. Thesis

WU 2020. 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	2020
Russian knapweed (*Acroptilon repens)*			M*	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Garlic mustard (*Alliaria petiolata*)																	M*	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	2020
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	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	M
Yellow spring bedstraw (*Galium verum*)									M*	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	2020
Dame's rocket (*Hesperis matronalis*)											M*		PM	M	PM		M	PM	PM
Orange hawkweed (*Hieracium aurantiacum*)																	M*	M	M
Common St. Johnswort (*Hypericum perforatum*)	M			M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Perennial pepperweed *(Lepidium latifolium)*																	M*	M	M
Oxeye daisy (*Leucanthemum vulgare*)																		M*	M
Dalmatian toadflax (*Linaria dalmatica*)								M*	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		M
Scotch thistle (*Onopordum acanthium*)	M			M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	PM
Bouncingbet (*Saponaria officinalis*)	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	2020
Salt cedar (*Tamarix ramosissima*)	M					M	M	M	M	M	M	M	M	M	M	M	M	M	PM
common tansy (*Tanacetum vulgare*)																			M*
scentless chamomile (*Tripleurospermum perforatum*)															M*	M	M	PM	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)

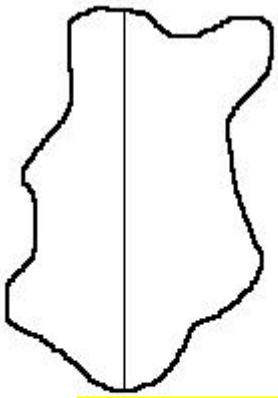
Materials for SURVEY ONLY:
Quadrat 50 x 50 cm (2)
50 m survey tape (minimum of 2, however 3 can also work well.
GPS unit, with the current year's shapefile for data entry

Standard survey procedure:

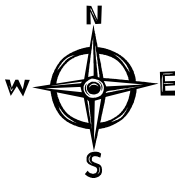
- The technique outlined here will apply to the majority of sites
- The general concept is to aim for a 50 m transect through the center of weed infestation. Sometimes it may be necessary to do a shorter transect in order to stay within the habitat. Ideally, the 25 m long bisecting transects have the 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



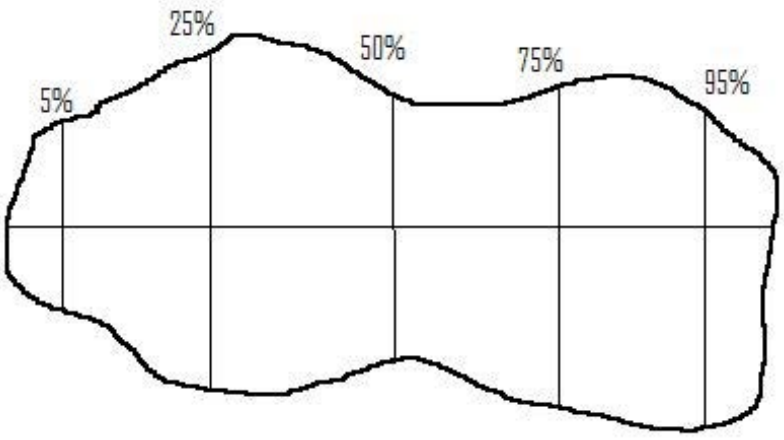


Fig. 2

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.

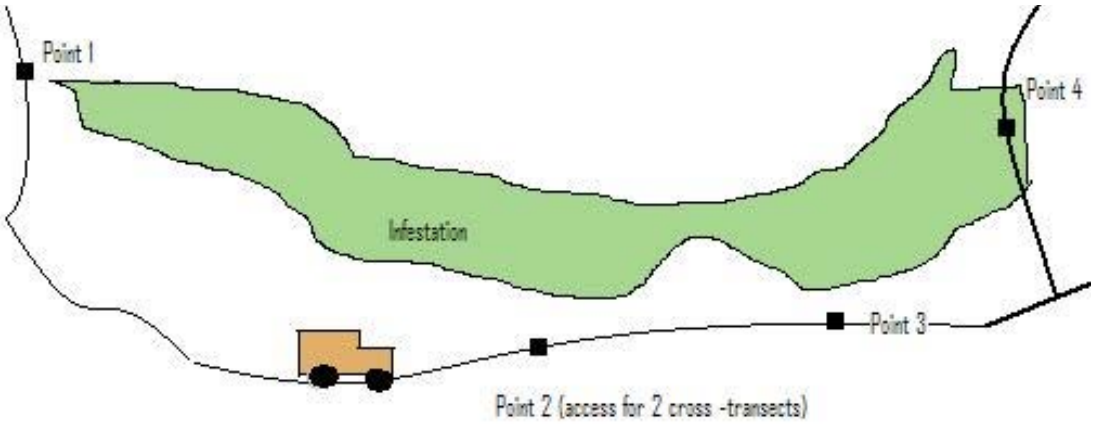

Point 1
Point 4
Infestation
Point 3
Point 2 (access for 2 cross -transects)

Fig. 3

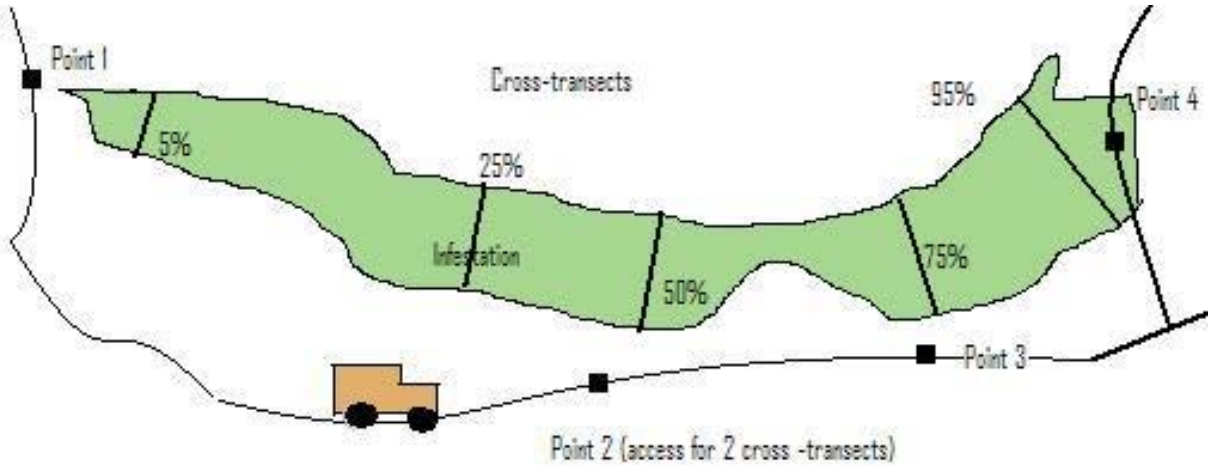

Point 1
Cross-transects
95%
Point 4
5%
25%
Infestation
50%
75%
Point 3
Point 2 (access for 2 cross -transects)

Fig. 4

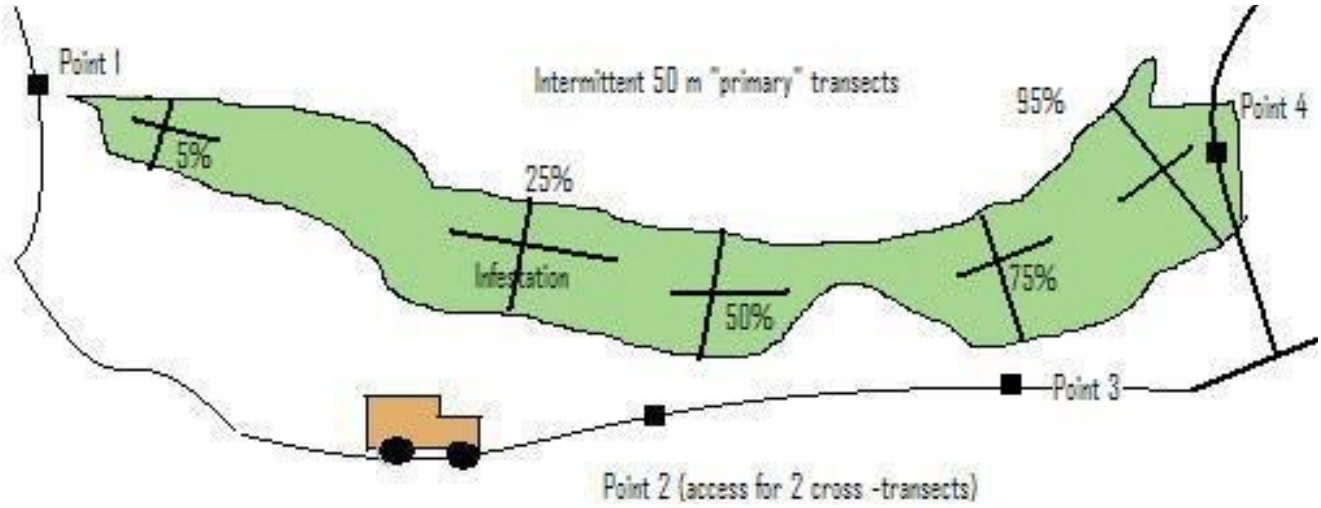


Fig. 5

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

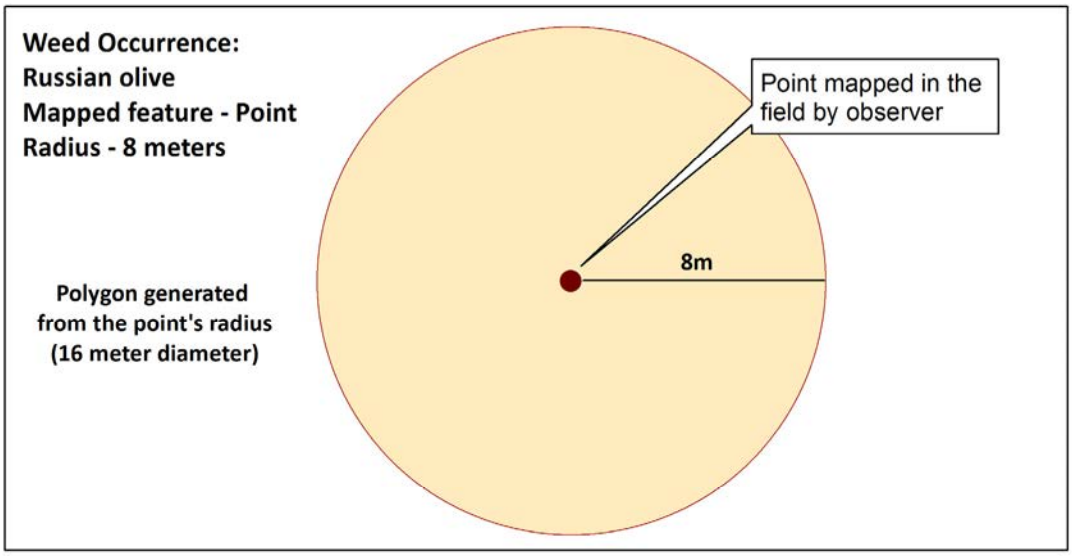
COUNTRY - Country

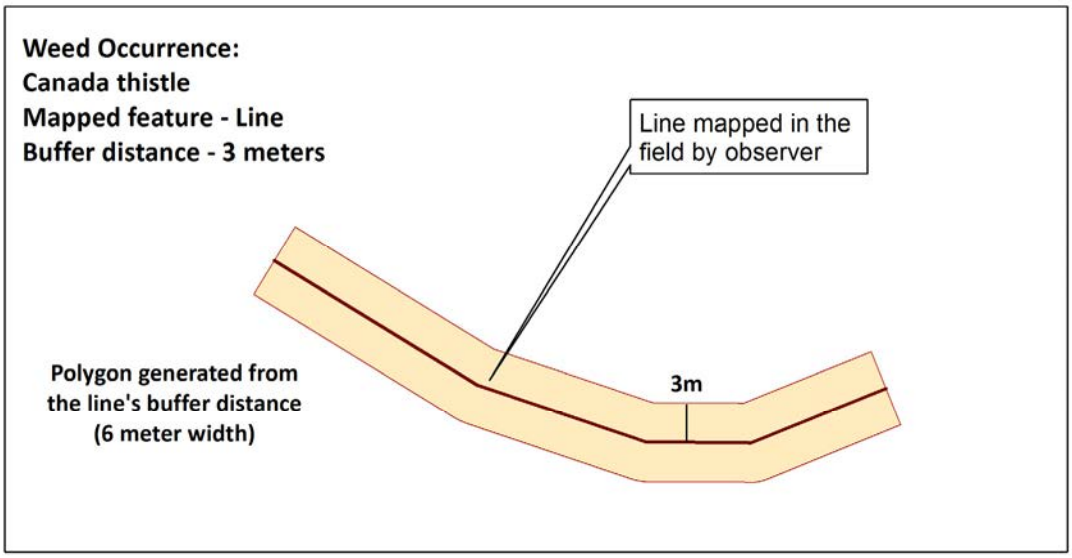
EXAMINER –Field observer

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:

APPENDIX E. SOURCES FOR HERBICIDE USE RECOMMENDATIONS:

A. **The Nature Conservancy** https://www.invasive.org/gist/products/handbook/methods-handbook.pdf Weed Control Methods Handbook, The Nature Conservancy, Tu et al.

"PURPOSE These Guidelines are designed to ensure that you carefully consider the overall impacts of herbicide use on your conservation targets, other native species, and the ecological system. Base all decisions whether to control weeds, and whether to use herbicides instead of other methods, on the conservation targets and management goals for the site. In addition, the health and safety of applicators and others in the vicinity must be considered BEFORE pesticides are applied. Simply put, one should be confident that the proposed herbicide will do more conservation good than harm and not endanger the health of the applicators or others in the area.

TO SPRAY OR NOT TO SPRAY? Determining the right course of action in weed management can be difficult. For many land managers, whether to apply herbicides is an ethical decision that is not taken lightly. Herbicides are often used as a last resort, when other attempts have failed, and action is imperative. The following checklist summarizes the steps that need to be taken to ensure that proper consideration has been given to current weed problems, and that the use of herbicides is warranted for each individual case.

1. Determine whether invasive plants threaten conservation targets or management goals on the site. Use herbicides (versus other control methods) only if confidant they can be used safely and will do more conservation good than harm.
2. If you decide to use herbicides, record your reasons for doing so. TNC's Site Conservation Program (http://www.consci.org/scp) can help you identify targets and threats, and make a Site Conservation Plan. TNC's Site Weed Management Plan Template (http://tncweeds.ucdavis.edu/products.html) can help you set control priorities and develop a plan to implement them.

B. **Boulder County** https://assets.bouldercounty.org/wp-content/uploads/2017/03/weed-policy.pdf

The County uses herbicides with the lowest rates recommended for effective weed control, that have the lowest toxicity and volatility, and are spot sprayed whenever possible, instead of broadcast on weed infestations. Almost all herbicides used are selective for control of broadleaf weed species. Grasses are unaffected. Notification of herbicide applications in areas with public access are posted daily at 303-441-3940.

Boulder County Open Space and Parks

https://www.bouldercounty.org/open-space/management/weeds/

"Staff utilizes an integrated pest management approach to controlling weeds that include mowing, hand pulling, insect bio-control, cultural control (tilling weeds and planting desirable vegetation), and herbicide application. Herbicides are only used in targeted areas.

When controlling noxious weeds on open space properties, staff are careful to use the least damaging and most effective weed control strategies available. Staff always consider the local ecology to maintain and support the rich ecosystems of open space lands."

C. **El Paso County**:
El Paso County Community Services Department Environmental Division: Noxious Weeds and Control Methods Updated 2018
https://assets-communityservices.elpasoco.com/wp-content/uploads/Environmental-Division-Picture/Noxious-Weeds/Noxious-Weed-Control-Book.pdf

"Herbicides are used when there is no better alternative. You must decide if the treatment will result in less weeds over time."

D. **TNC** Illinois Nature Preserves
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5386111.pdf

Herbicide Use in Natural Areas: A Guide for Volunteer Land Stewards TNC Illinois Nature Preserves 2011

"Philosophy of Herbicide Use in Nature Preserves: Use of herbicides on Illinois nature preserves should be limited to situations in which managers or decision makers determine that no other reasonable means of control area available. Herbicides are potential damaging to the environment, and these hazards dictate that herbicides should be used only when less potentially damaging methods are available, effective, or feasible. Natural or mechanical methods of controlling invasive plant species (i.e. introduction of fire, mowing, cutting, or hand removal) are preferable to chemical control."

E. **Wagner**, V., Antunes, P.M., Irvine, M. and C.R. Nelson. 2017. Herbicide usage for invasive non-native plant management in wildland areas of North America. Journal of Applied Ecology, Vol. 54, Issue 1 pp. 198-204 https://doi.org/10.1111/1365-2664.12711

Although controlling established non-native invasive species should be a last resort in the chain of management actions, as prevention and detection are generally more effective (Leung *et al*. 2002; Olson & Roy 2005), management programmes tend to invest in controlling established populations rather than in prevention strategies (Finnoff *et al*. 2007; Radosevich, Holt & Ghersa 2007).

Choosing an appropriate control method is challenging because managers need to consider key biological and ecological aspects of the target species, predict the efficacy of treatment, anticipate potential adverse effects on non-target organisms and take into account technical and economic feasibility (e.g. Derickx & Antunes 2013). In addition, a manager's choice for a control method will be constrained by external factors, such as policy regulations and public opinion (Veitch & Clout 2001; Radosevich, Holt & Ghersa 2007).

Herbicides were initially developed to control unwanted weeds in crop systems but now are widely used in invasive non-native plant management (hereafter invasive plant management) in more natural ecosystems (Radosevich, Holt & Ghersa 2007, Clout & Williams 2009 Fig. 1). Herbicides offer several advantages relative to other management methods: they can control invasive non-native plants quickly, require little human labour, can be relatively inexpensive and do not directly physically disturb soil structure (Clout & Williams 2009. However, there is evidence that at least some herbicides pose risks to non-target organisms (Freemark & Boutin 1995; Wagner & Nelson 2014) and to human health (Alavanja, Hoppin & Kamel 2004).

Unfortunately, the use of herbicides as a management tool for wildlands has not been adequately assessed for North American agencies or countries. Additionally, although there is a large body of scientific literature on the efficacy of herbicides for controlling target weeds (e.g. Kettenring & Reinhardt Adams 2011), most of this research focuses exclusively on the target plant rather than on the desirable natives, monitors outcomes only over a short period of time (but see Crone, Marler & Pearson 2009) and does not consider economic aspects of management actions.