Noxious Weed Monitoring (Year 14) & Mapping at the U.S. Air Force Academy and Farish

May 2019

COLORADO NATURAL HERITAGE PROGRAM

Noxious Weed Monitoring (Year 14) & Mapping at the U.S. Air Force Academy and Farish

Pam Smith and Amy Greenwell

Colorado Natural Heritage Program
Warner College of Natural Resources

Colorado State University
Fort Collins, Colorado 80523

May 2019

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

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

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

Citation:
Smith, P. and A. Greenwell. 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.

Front Cover: Yellow toadflax with biocontrol beetle 2018; orange hawkweed at Farish 2018; biocontrol beetle on leafy spurge2018; chemically treated site 2018, northeast Jack's Valley.

EXECUTIVE SUMMARY

This report summarizes the results of the past fourteen years of population monitoring of noxious weeds at the U.S. Air Force Academy ("the Academy") and 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 used to monitor widespread noxious weed species at the Academy (2018) and Farish (2016). These data are used to determine population trends. The 2018 basewide survey included 26 species that were mapped across the Academy and Farish. Four new species of noxious weeds were included in the 2018 survey, three new noxious weeds at the Academy and one at Farish. Site plans are provided as separate attachments to assist with weed management activities in 2019 for three areas: Northeast Jack's Valley Seep, Farish Fen with a globally imperiled (G2) grass species Porter's feathergrass (*Ptilogrostis porteri*) and the Farish site with the newly discovered (2018) orange hawkweed.

Summary of Findings

In 2018, the Colorado Natural Heritage Program (CNHP) mapped 25 noxious weeds across the Academy. In all, over 9,300 extant occurrences covering approximately 424 acres were documented at the Academy. The 2018 basewide survey showed that 18 weed species (78%) are increasing across the base (Table 1). Three of these species are new since the last basewide survey in 2012 and include scentless chamomile, garlic mustard and perennial pepperweed. A new location for salt cedar was discovered in northeast Jack's Valley and was subsequently treated by Academy staff. Three of the mapped species include escaped ornamental species that are not included on the state noxious weed list but are of management concern to Academy Resource Management (Siberian peashrub (*Caragana arborescens*), Tatarian honeysuckle (*Lonicera tartarica*) and yellow spring bedstraw (*Galium verum*)). Of these, Siberian peashrub has shown the most significant increase since it was first mapped in 2012, while Tatarian honeysuckle increases are largely due to new discoveries of mature trees. The yellow spring bedstraw is thought to be decreasing but seems to return every three to five years at the same location. Four state-listed noxious weed species are declining and include Russian knapweed (*Acroptilon repens*), Russian olive (*Elaeagnus angustifolia*), Dame's rocket (*Hesperus matronalis*) and bouncingbet (*Saponaria officinale*). Hoary cress (*Cardaria draba*) was found to be stable, and one noxious weed species, yellow toadflax (*Linaria vulgaris*), was not monitored due to the widespread nature of the plant at the Academy.

In addition to basewide mapping, permanent plots were monitored for several widespread species at the Academy: Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), hoary cress, knapweeds (*Centaurea diffusa, C. stoebe*, and a hybrid known as *Centaurea* x *psammogena*), and leafy spurge (*Euphorbia esula*). A total of 45 plots (100x50m) were monitored in 2018: 10 plots for hoary cress, leafy spurge, musk thistle; eight plots for Canada thistle, and seven plots for knapweeds. All monitoring plots showed stable or stable to decreasing populations.

Table 1. Summary of findings for noxious weed species monitored at the Air Force Academy in 2018.			
Overall Trend	Scientific Name	Common Name	Comment
	*Acroptilon repens*	Russian knapweed	Present in 2018 after 5 year absence.
	*Alliaria petiolata*	Garlic mustard	New in 2018, 7 sites, needs careful attention.
	*Caragana arborescens*	Siberian peashrub	Significant increase since 2012.
	*Cardaria draba*	Hoary cress	Site # increase/plots stable.
	*Carduus nutans*	Musk thistle	Site # increase/plots decrease.
	*Centaurea diffusa, C. stoebe* & x *psammogena*	Diffuse, spotted and hybrid knapweeds	Diffuse most common, increasing/plots stable.
	*Cirsium arvense*	Canada thistle	Increase/plots stable to slight decrease.
	*Cirsium vulgare*	Bull thistle	Increase # and sites, occ. acres stable.
	*Cynoglossum officinale*	Houndstongue	Increase #, sites, and occ. acres.
	*Dipsacus fullonum*	Common teasel	Increase # and sites, occ. acres stable.
	*Elaeagnus angustifolia*	Russian olive	Overall decrease, # shoots stable.
	*Euphorbia esula*	Leafy spurge	Stable 2012-2018, plots decrease.
	*Euphorbia myrsinites*	Myrtle spurge	Populations' w/large fluctuations, new sites 2018.
	*Gallium verum*	Yellow spring bedstraw	Present in 2018 after 2 year absence.
	*Hesperis matronalis*	Dame's rocket	Returning to previously treated areas.
	*Hypericum perforatum*	Common St. Johnswort	Floods and biocontrol reduce cover.
	*Lepidium latifolium*	Perennial pepperweed	New in 2018. Careful treatments to prevent spread.
	*Linaria dalmatica*	Dalmatian toadflax	One site clear for 5 years before reappearing in large numbers, this site decreasing 2017-2018.
?	*Linaria vulgaris*	Yellow toadflax	Too widespread to map at the Academy.
	*Lonicera tatarica*	Tatarian honeysuckle	Increases include mature plants and a few new sprouts.
	*Onopordum acanthium*	Scotch thistle	Most increases in previously treated areas.
	*Saponaria officinalis*	Bouncingbet	Browse on flower tops significant.
	*Tamarix ramosissima*	Salt cedar	New location found in 2018, removed.
	*Tripleurospermum perforatum*	Scentless chamomile	New in 2016. Eradication unlikely.

Shaded rows indicate monitoring plots

Many Canada thistle and leafy spurge plots had active biocontrol organisms present. In northeast Jack's Valley, musk thistles were heavily utilized by insects (potential biocontrol organisms) that appeared to prevent flowering. Rare plants and animals have been observed at a number of monitoring plots.

In 2017 and 2018, five noxious weed species were mapped at Farish (musk thistle, Canada thistle, leafy spurge, orange hawkweed (*Hieracium aurantiacum*) and large infestations of yellow toadflax). In all, 477 extant occurrences covering approximately 16.5 acres were documented during the 2017 survey. Two noxious weed species are increasing, one is moderately increasing but stable at Farish, and the fourth is a new species, orange hawkweed that was first observed in 2018. Orange hawkweed covers a small area and is a good candidate for eradication. The fifth species, yellow toadflax, was partially mapped so an overall trend is unknown (Table 2).

Table 2. Summary of findings for noxious weed species monitored at Farish Recreation Area in 2017.

Overall Trend	Scientific Name	Common Name	Comment
↑	*Carduus nutans*	Musk thistle	Large increase since 2002, largest cover of any mapped noxious weed at Farish.
↑	*Cirsium arvense*	Canada thistle	Large increase since 2002.
↑	*Euphorbia esula*	Leafy spurge	One site is known to occur near the border of Farish and private land for over a decade. The occurrence has grown in size but has not crossed the fence line.
↑	*Hieracium aurantiacum*	orange hawkweed	A small occurrence was discovered during a 2018 field workshop with CNHP and resource management staff.
?	*Linaria vulgaris*	Yellow toadflax	Too widespread to comprehensively map. CNHP mapped infestations > ¼ acre only.

Summary of Recommendations

- Continue to improve on weed treatment documentation at the Academy and Farish.
- Utilize more integrated management techniques.
- Weed treatments in sensitive areas and areas with native vegetation and active biocontrols should include minimal disturbances and limited herbicide applications.
- Precise methods of herbicide application (individual plants) with herbicides approved for natural areas should be used within the designated Special Weed Treatment Areas (Smith et al. 2015).
- 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 2019 season.
- Discontinue herbicide treatments on bouncingbet in 2019 at the Academy and monitor all populations to determine if natural declines are continuing to reduce populations.
- Continue to avoid weed treatments in monitoring plots at the Academy and Farish.

- List A, B or watch list or noxious weed species of management concern in need of rapid response actions include:
    - Bouncingbet (List B)
    - Common St. Johnswort (List C)
    - Dalmatian toadflax (List B)
    - Dame's rocket (List B)
    - Garlic mustard (State Watch List)
    - Houndstongue (List B)
    - Myrtle spurge (List A)
    - Orange hawkweed (List A)
    - Perennial pepperweed – (List B)
    - Russian knapweed (List B)
    - Salt cedar (List B)
    - Scentless chamomile (List B)
    - Scotch thistle (List B)
    - Tatarian honeysuckle (not listed, garden escape)
    - Yellow spring bedstraw(not listed, garden escape)

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

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

Site plans have been created for weed management activities at the Academy and Farish that will be implemented in 2019. Two weed treatment site plans are part of a management plan written for a fen wetland that includes a rare plant that occurs at Farish, Porter's feathergrass (*Ptilagrostis porteri*). Within this management plan a site plan is also included for orange hawkweed (List A noxious weed), that was discovered in 2018 during a rare plant survey. A third site plan has been included for a small 12 acre wetland seep in northeast Jack's Valley that contains four Colorado Natural Heritage Program (CNHP) tracked rare plants, two tracked rare animals and eight species of listed noxious weeds. (These are included as separate attachments).

Acknowledgements

The help and generosity of many experts is gratefully acknowledged. Brian Mihlbachler (USFWS), our primary contact at the Academy, played a critical role in this project. His assistance with project logistics and with identifying study sites was extremely valuable, as was his time orienting CNHP personnel in 2018. Kate Wright and Maddy Pfaff completed the weed survey field work at the Air Force Academy in 2018 and Alyssa Meier completed the weed survey at Farish Recreation Area in 2017.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF MAPS

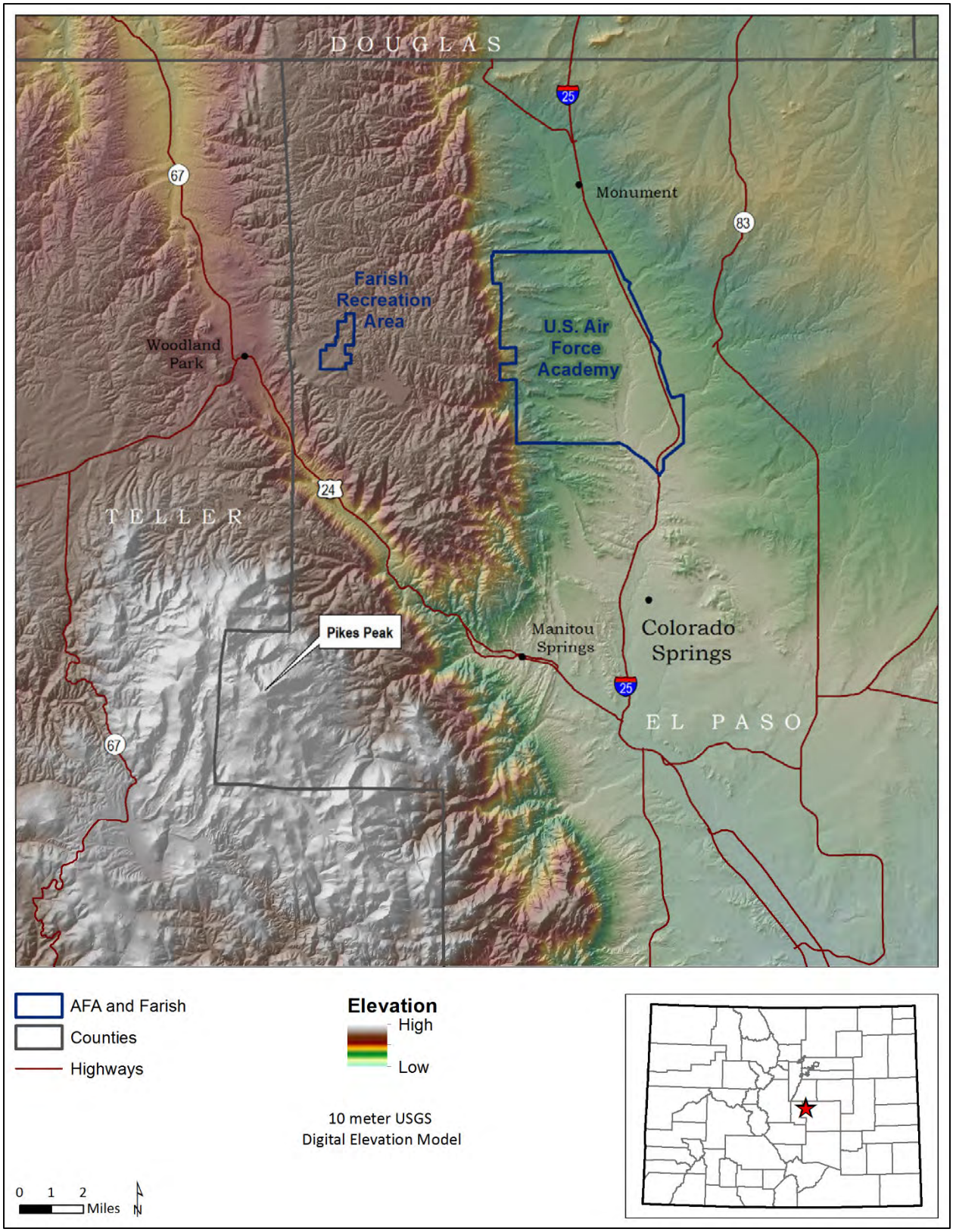
INTRODUCTION

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

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

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

Guidelines for controlling noxious weeds (including herbicide label instructions) are often based on agricultural landscapes instead of natural areas. There is a large distinction between these two land uses, especially for weed management, which was addressed in the 2015 update to the Noxious Weed Management Plan (Smith et al. 2015). Natural areas can be defined as non-crop areas that support native vegetation, and where management includes the protection of these areas as well as the generation of ecosystem services (Pearson & Ortega 2009). To successfully manage weeds in natural areas with high biodiversity is much more complex than in an agricultural area. Successful weed management in natural areas must also consider the management of the entire community and not just removal of individual weeds. A significant portion of the landscape at the Academy and Farish falls into the "natural areas" category and includes important wetland features. The Academy and Farish are important for local and global biodiversity conservation (Siemers et al. 2012). At least 31 plants, animals, and plant communities of conservation concern have been documented at the Academy. For example, Porter's feathergrass (*Ptilagrostis porteri*), a globally imperiled endemic of Colorado, and Southern Rocky Mountain cinquefoil (*Potentilla ambigens*), found only in Colorado and New Mexico (Siemers et al. 2012), have been documented on-site. In addition, the Academy is critically important for the conservation of the listed Threatened Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (Siemers et al. 2012, Schorr et al. 2018).



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 14 years. Below is a summary of weed mapping and monitoring by year since the surveys began in 2002. Refer to Appendix A for monitoring and mapping activities by species.

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

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

METHODS

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

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

The original recommendations for the design and deployment of monitoring plots offered by Carpenter et al. (2004) were used, and subsequently modified as new information was collected. Permanent plot locations are shown in Map 2 and plot sampling methods are described in Appendix B.

Weed mapping 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.

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. A potential new biocontrol, a native rust, is being considered for Canada thistle. It will be investigated for introduction in 2019 at the Academy.

Precipitation

Annual precipitation can be a helpful indicator for interpreting weed monitoring data. Higher precipitation years often result in increased weed numbers for certain species for that year. The yearly total for 2018 was 12.24 inches which is very close to the average annual precipitation (1961-1990) of 12.33 inches (red line on Figure 1). The highest spring and summer precipitation was recorded in 2015 of 25.25 inches which is over 60% above average. The 2015 annual precipitation was the second highest recorded since record-keeping began in 1948; the high of 27.58 inches was recorded in 1999 (Western Regional Climate Center 2015). A summary of the average spring and summer precipitation (March – August) shows that 2004, 2015 and 2017 were above average for spring and summer precipitation, while 2002, 2008 and 2012 were very dry years (Figure 1). During basewide noxious weed survey years, 2007 and 2018 were the closest to average, while 2002 and 2012 were well below average.

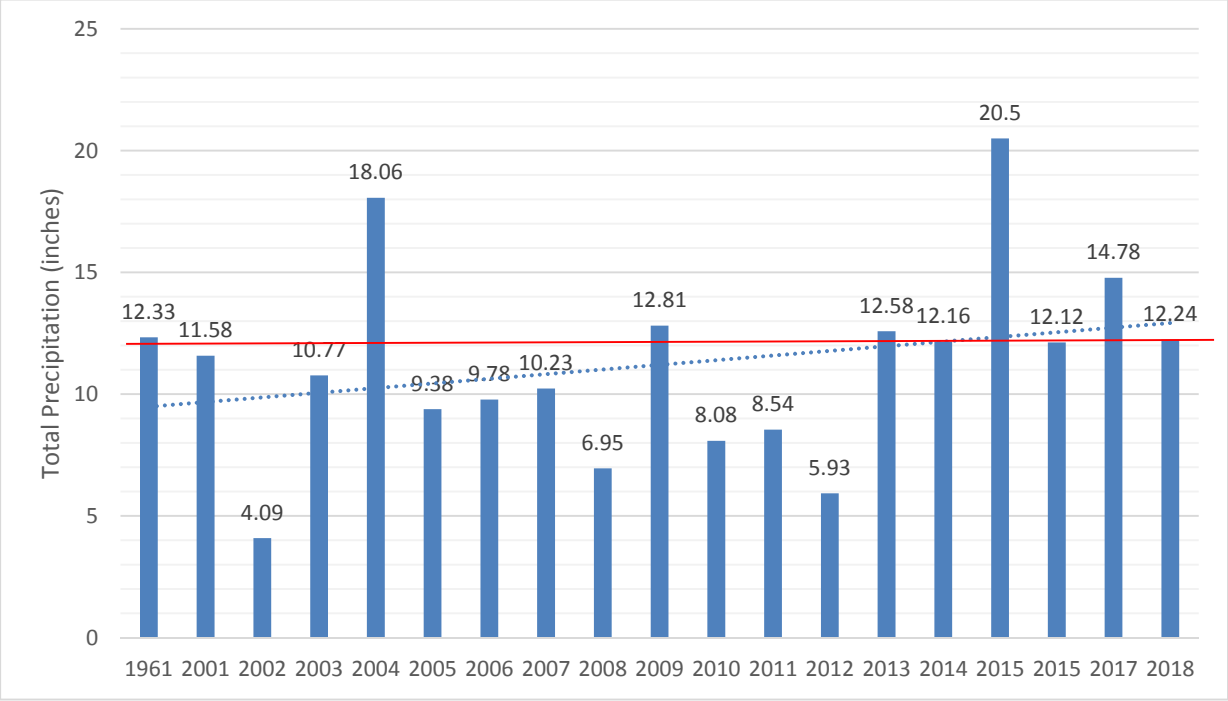
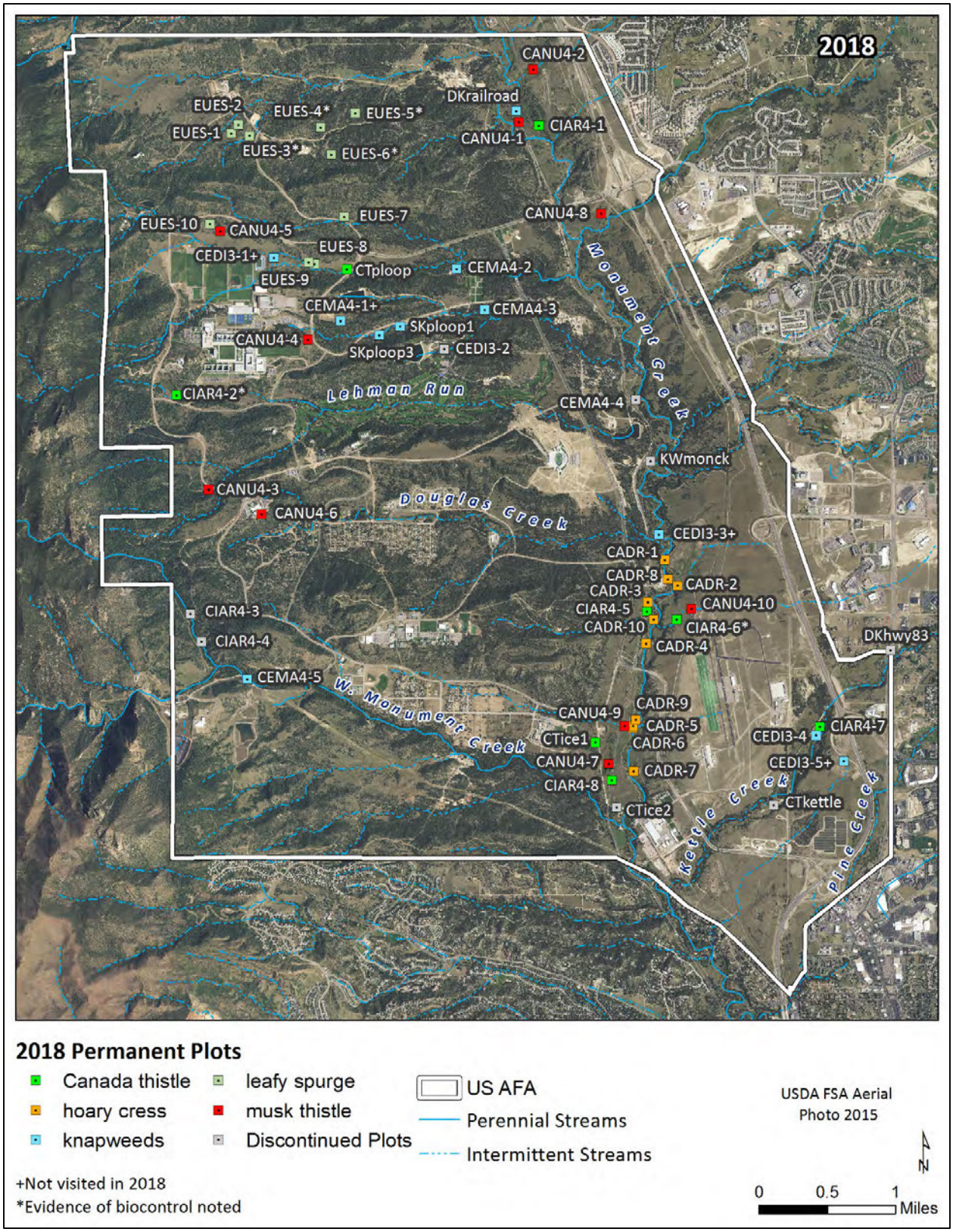


Figure 1. Average spring and summer precipitation. Spring = March-May, Summer = June-August. Blue dotted line is trend line, red line is 1961-1990 average (WU 2019).

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



Map 2. Locations of noxious weed permanent monitoring plots at the Academy.

RESULTS AND RECOMMENDATIONS

Weeds at the Academy have been spreading in numbers and scope since the first weed survey in 2002. In order make efficient use of resources, CNHP developed designated mapping areas for Canada thistle at the Academy in 2007 and for all widespread species at the Academy and Farish in 2012 (Figures 2 & 3), meaning only locations within designated mappings areas were surveyed for widespread species in 2012. Designated mapping areas were intended to capture biologically important areas (based on CNHP Potential Conservation Areas) and areas likely to contain weeds. Over time, this concept proved to be problematic for several reasons. Noxious weeds with limited distributions still required comprehensive mapping in exclusion areas and new noxious weed species were discovered in exclusion areas. The result was significant mapping in exclusion areas, defeating the original purpose. Additionally, CNHP continually discovers new locations of rare and imperiled species at the Academy and every year more information about the biology and needs of species of concern is known. Potential Conservation Area boundaries are adjusted based on new information and the designated mapping areas were tied to a specific point in time (2012). For these reasons, CNHP abandoned the idea of designated mapping areas and surveyed the entire base in 2018 and all of Farish in 2017. In this report, all mapping trends and summary data tables are derived from the number of individuals, occupied acres, and number of extant features within designated mapping areas; however, for widespread species, all known infestations are reported in the individual species sections.

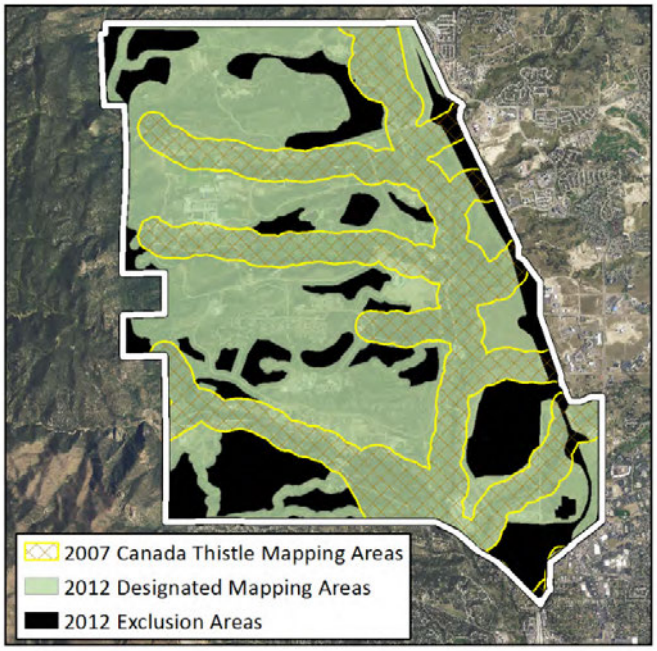


Figure 2. Designated Mapping Areas at the Academy.

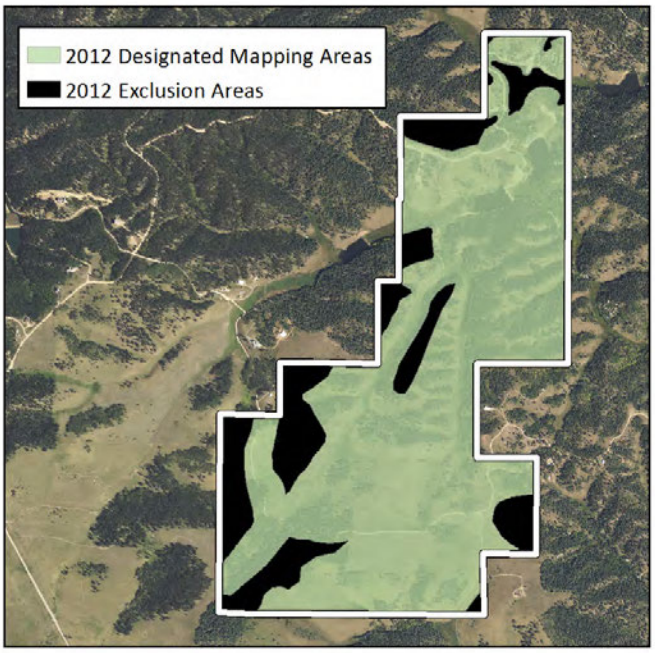


Figure 3. Designated Mapping Areas at Farish.

U.S. Air Force Academy

In 2018, 25 noxious weeds were mapped at the Academy. In all, over 9,300 extant occurrences covering approximately 424 acres were documented. Noxious weeds have been increasing throughout the Academy since monitoring began in 2002 (Figure 4).

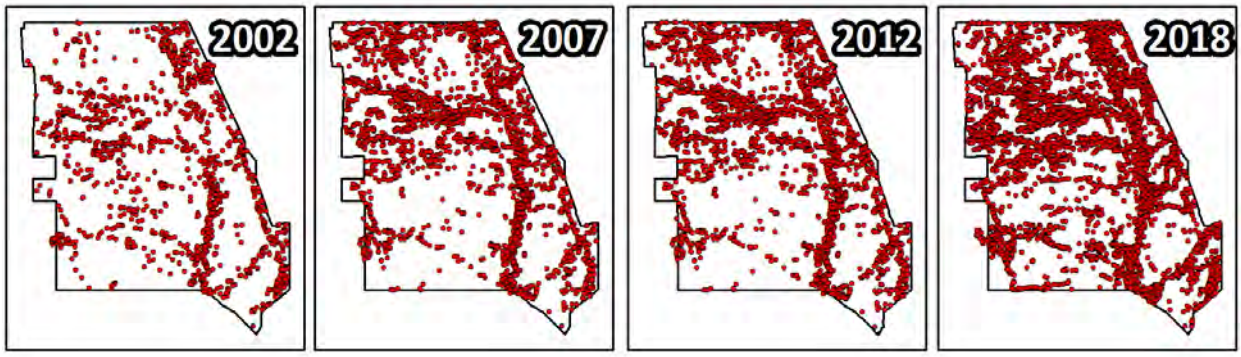


Figure 2. Distribution of known noxious weed occurrences at the U.S. Air Force Academy (excluding yellow toadflax).

Species were mapped as points, lines or polygons depending on the shape and size of the populations. Areal mapping species included:

- Russian knapweed (*Acroptilon repens*)
- garlic mustard (*Alliaria petiolata*)
- Siberian peashrub (*Caragana arborescens*)
- hoary cress (*Cardaria draba*)
- musk thistle (*Carduus nutans*)
- diffuse knapweed (*Centaurea diffusa*)
- spotted knapweed (*Centaurea stoebe*)
- hybrid knapweed (*Centaurea* x *psammogena*)
- Canada thistle (*Cirsium arvense*)
- bull thistle (*Cirsium vulgare*)
- houndstongue (*Cynoglossum officinale*)
- common teasel (*Dipsacus fullonum*)
- Russian olive (*Elaeagnus angustifolia*)
- leafy spurge (*Euphorbia esula*)
- myrtle spurge (*Euphorbia myrsinites*)
- yellow spring bedstraw (*Galium verum*)
- dame's rocket (*Hesperis matronalis*)
- common St. Johnswort (*Hypericum perforatum*)
- perennial pepperweed (Lepidium latifolium)
- Dalmatian toadflax (*Linaria dalmatica*)
- Tatarian honeysuckle (*Lonicera tatarica*)

- Scotch thistle (*Onopordum acanthium*)
- bouncingbet (*Saponaria officinalis*)
- salt cedar (*Tamarix ramosissima*)
- scentless chamomile (*Tripleurospermum* (*Matricaria) perforatum*)

Of the 25 species mapped, 18 (72%) are considered to be increasing across the Academy with three of these weed species mapped for the first time in 2018 (garlic mustard, perennial pepperweed, and scentless chamomile). Three species include escaped ornamental species (Siberian peashrub, Tatarian honeysuckle and yellow spring bedstraw) that are not included on the state noxious weed list but are of management concern to Academy Resource Management. Of these, Siberian peashrub has shown the most significant increase since it was first mapped in 2012, while Tatarian honeysuckle increases are largely due to new discoveries of mature trees. The yellow spring bedstraw is thought to be decreasing but seems to return every three to five years at the same location. A new location for salt cedar was discovered in northeast Jack's Valley and was subsequently treated by Academy staff. Salt cedar and common St. Johnswort are considered to be slightly increasing. Hoary cress is considered to be stable and has not increased or decreased significantly since 2002. The remaining four species are declining and include Russian knapweed, Russian olive, Dame's rocket, and bouncingbet. Russian knapweed, which had not been observed in five years, was found at two previously known locations and one new location in 2018. Dalmatian toadflax had not been seen in 5 years until it was found at one site in 2017. The 2017 site had extant plants in 2018. One noxious weed species (yellow toadflax) was not monitored due to the widespread nature of the plant at the Academy. Details for individual weed species are provided in the species sections below.

In 2018, 45 permanent monitoring plots were surveyed at the Academy including: 10 plots each for leafy spurge, musk thistle and hoary cress, 8 plots for Canada thistle; and 7 plots for the knapweeds. None of these plots were treated by the herbicide applicator since 2015. Leafy spurge, Canada thistle, musk thistle and knapweed plots all show stable to decreasing trends. Biocontrol organisms may be contributing to these results as evidenced by direct observations of biocontrol organisms or the resulting impacts to plants in the form of galls and flower damage. Details are provided in the sections below on individual species.

A summary of the 2018 findings, observations, and recommendations at the Academy is provided in Table 3, summary data from the four noxious weed surveys at the Academy are provided in Table 4, and changes in weed distribution and abundance at the Academy from the four noxious weed surveys are provided in Table 5.

Table 3. Summary of findings and observations at the Academy with recommendations.	
Basewide Areal Monitoring Sites 2018	**Recommendations**
Over 9,300 extant features covering ~424 acres in 2018	Continue to monitor extant and eradicated sites. Prioritize species with a high chance for suppression or eradication.
Rapid response species for 2019: purple loosestrife, garlic mustard, myrtle spurge, Russian knapweed, Dalmatian toadflax, salt cedar, yellow spring bedstraw	These species have potential to be eradicated from the Academy. Treatment methods are extremely important, especially for garlic mustard which is difficult to control once it becomes established. If treatments are not carried out at the appropriate time of year and without follow-up planting and monitoring it could easily become established.
Houndstongue, Scotch thistle, are showing increases in cover and/or the number of extant sites.	Improve real-time communications with AFA staff and weed contractor. These species continue to increase despite aggressive treatment efforts. A review of treatment methods is underway.
Biennial species are being treated with herbicides while in flower: 1) musk thistle, 2) Scotch thistle, 3) teasel, 4) houndstongue, and 5) some knapweeds	Make sure weed contractor understands proper use of herbicides for biennial species – herbicides are for rosette stage or pre-flower. Spot applications are important to avoid collateral soil damage and an increase in weeds and soil disturbances that have been previously observed at treatment sites, especially in natural areas where herbicides should be used sparingly.
Bouncingbet is being actively controlled by browsing animals. All flower tops were grazed at all areal sites in 2016, 2017 and a majority in 2018.	Do not treat bouncingbet for the 2019 season. Monitor all known sites for browse in 2019. The natural browsers are more efficient and less stressful on the natural systems.
Myrtle spurge is increasing despite aggressive treatments.	CNHP will provide locational data to the Academy on a regular basis. Use mechanical or precise herbicide application methods. Where soils are disturbed, plantings of native species could prevent more weed cover.
Some wetlands and moist areas are being treated with herbicides.	Protect wetlands and intermittently flooded areas from herbicides and soil disturbance. Wetlands are not easy to detect in the summer months. Certain herbicides can contaminate groundwater in these areas. CNHP will provide a polygon of areas to be considered as wetlands for the staff and contractor to protect groundwater contamination.
Scentless chamomile, first documented in 2016, was found to be significantly established along Monument Creek in 2018.	This species is a low priority treatments. The large number of plants, the annual nature of the species and the location in an active floodplain with a constant source of weed seeds from the urban developments to the east, make successful treatments unlikely.
Russian knapweed, Dalmatian toadflax and yellow spring bedstraw were thought to be eradicated but have returned mostly to previously treated sites.	These species seem to be suppressed for three to five years and then return. Continue to monitor areal sites for at least five years after the last extant observation and be on the lookout for new locations.

Table 4. Summary data for mapped weed occurrences at the Academy from 2002 to 2018 during basewide survey years. Values for species in bold are from comparable designated mapping areas only.

Species		2002				2007				2012				2018			
Scientific Name	Common Name	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
Acroptilon repens	Russian knapweed	---	---	---	---	0.03	200	2	2	0.05	543	10	4	0	44	3	11
Alliaria petiolata	garlic mustard	---	---	---	---	---	---	---	---	---	---	---	---	0.12	4,011	7	0
Caragana arborescens	Siberian peashrub	---	---	---	---	0	0	0	0	9.71	89,270	43	0	24.97	106,348	183	3
Cardaria draba†	hoary cress	20.47	1,671,728	164	---	12.76	1,035,489	241	0	13.08	828,036	203	77	19.52	1,707,408	300	58
Carduus nutans	**musk thistle**	15.91	2,207	272	---	27.03	49,588	1,020	4	15.20	125,297	1,082	639	21.75	77,442	1,909	1,118
Centaurea diffusa	**diffuse knapweed**	45.42	130,589	251	---	119.86	394,197	913	0	100.58	1,334,253	1,255	406	158.41	1,423,367	2,407	630
Centaurea stoebe	**spotted knapweed**	4.67	3,485	54	---	57.52	127,627	319	16	53.02	543,144	565	156	48.92	479,304	846	276
Centaurea x psammogena	**hybrid knapweed**	---	---	---	---	1.75	2,810	118	0	5.93	42,991	240	54	2.42	22,110	279	155
Cirsium arvense	**Canada thistle**	79.27	408,121	358	---	90.68	379,992	543	0	90.17	1,079,070	776	221	92.35	1,718,919	1,126	401
Cirsium vulgare	**bull thistle**	**5.54	**596	**73	---	6.42	4,347	128	0	1.19	4,089	207	79	3.96	14,982	407	170
Cynoglossum officinale	houndstongue	---	---	---	---	---	---	---	---	0.01	70	3	9	0.51	4,514	50	22
Dipsacus fullonum	common teasel	18.33	1,693	35	---	10.51	53,454	181	0	9.26	116,595	319	65	11.27	123,921	364	185

Species		2002				2007				2012				2018			
Scientific Name	Common Name	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
Elaeagnus angustifolia†	**Russian olive**	38.70	1,079	216	---	13.30	531	89	129	10.80	557	154	173	6.78	632	95	262
Euphorbia esula	**leafy spurge**	0.91	28,338	32	---	7.58	336,337	152	2	10.64	275,713	204	30	11.16	227,961	214	78
Euphorbia myrsinites	myrtle spurge	---	---	---	---	0.18	1,021	7	0	0.23	113	10	25	0.51	222	26	35
Galium verum	yellow spring bedstraw	---	---	---	---	---	---	---	---	0.00	0	0	1	0.00	102	1	0
Hesperis matronalis	dames rocket	---	---	---	---	---	---	---	---	0.83	16,871	14	0	0.04	665	8	17
Hypericum perforatum	common St. Johnswort	**<0.10	**363	5	---	0.86	44,745	10	0	1.16	83,115	29	10	1.26	16,416	57	27
Lepidium latifolium	perennial pepperweed	---	---	---	---	---	---	---	---	---	---	---	---	0.02	213	2	0
Linaria dalmatica	Dalmatian toadflax	---	---	---	---	---	---	---	---	0.00	0	0	3	0.01	52	1	3
Lonicera tatarica	Tatarian honeysuckle	---	---	---	---	---	---	---	---	0.15	30	1	0	0.60	132	35	5
Onopordum acanthium	Scotch thistle	**0.17	**52	7	---	1.31	1,307	36	0	0.30	889	66	73	2.04	1,914	275	143
Saponaria officinalis	bouncing-bet	0.19	Unknown	1	---	---	---	---	---	---	---	---	---	0.17	4,585	26	8
Tamarix ramosissima	salt cedar	<0.01	1	1	---	0.00	1	1	1	0.00	1	1	4	0.01	2	2	8
Tripleurospermum perforatum	scentless chamomile	---	---	---	---	---	---	---	---	---	---	---	---	0.41	2,530	117	2
		226.48	**2,248,252**	**1,396**		**331.57**	**2,431,646**	**3,760**	**154**	**309.53**	**4,540,647**	**5,182**	**2,029**	**407.25**	**5,937,796**	**8,740**	**3,617**

Table 5. Changes in weed distribution and abundance at the Academy from 2002 to 2018 during basewide survey years. Change calculated in between basewide survey years is noted in parentheses.

Scientific Name	Common Name	2018 Occupied Acres	2002 - 2007 % Change	2007 - 2012 % Change	2012 - 2018 % Change		Overall % Change Occupied Acres	2018 Estimated # of Shoots	2002 - 2007 % Change	2007 - 2012 % Change	2012 - 2018 % Change		Overall % change Estimated # of Shoots	2018 # of Extant Features	2002 - 2007 % Change	2007 - 2012 % Change	2012 - 2018 % Change		Overall % change # of Extant Features		Overall Trend
Acroptilon repens (2007)	Russian knapweed	0.02	---	69%	-61%		**-34%**	44	---	172%	-92%		**-78%**	3	---	400%	-70%		**50%**		**Decrease**
Alliaria petiolata (2018)	garlic mustard	0.12	---	---	---		---	4,011	---	---	---		---	7	---	---	---		---		**New 2018**
Caragana arborescens (2012)	Siberian peashrub	24.97	---	---	157%		**157%**	106,348	---	---	19%		**19%**	183	---	---	326%		**326%**		**Increase**
Cardaria draba	hoary cress	19.52	-38%	3%	49%		**-5%**	1,707,408	-38%	-20%	106%		**2%**	300	47%	-16%	48%		**83%**		**Stable**
Carduus nutans	musk thistle	21.75	70%	-44%	43%		**37%**	77,442	2147%	153%	-38%		**3409%**	1,909	275%	6%	76%		**602%**		**Increase**
Centaurea diffusa	diffuse knapweed	158.41	164%	-16%	57%		**249%**	1,423,367	202%	238%	7%		**990%**	2,407	264%	37%	92%		**859%**		**Increase**
Centaurea stoebe	spotted knapweed	48.92	1131%	-8%	-8%		**947%**	479,304	3562%	326%	-12%		**13653%**	846	491%	77%	50%		**1467%**		**Increase**
Centaurea x psammogena (2007)	hybrid knapweed	2.42	---	239%	-59%		**38%**	22,110	---	1430%	-49%		**687%**	279	---	103%	16%		**136%**		**Increase**
Cirsium arvense	Canada thistle	92.35	14%	-1%	2%		**17%**	1,718,919	-7%	184%	59%		**321%**	1,126	52%	43%	45%		**215%**		**Increase**
Cirsium vulgare (2007)	bull thistle	3.96	?	-82%	234%		**-38%**	14,982	?	-6%	266%		**245%**	407	?	62%	97%		**218%**		**Increase**
Cynoglossum officinale (2009)	Hounds-tongue	0.51	---	-1000%	5949%		**450%**	4,514	---	-26%	6349%		**56325%**	50	---	-63%	1567%		**525%**		**Increase**
Dipsacus fullonum	common teasel	11.27	-43%	-12%	22%		**-38%**	123,921	3057%	118%	6%		**7220%**	364	417%	76%	14%		**940%**		**Increase**
Elaeagnus angustifolia	Russian olive	6.78	-66%	-19%	-37%		**-82%**	632	-51%	5%	13%		**-41%**	95	0%	75%	-38%		**-56%**		**Decrease**

Scientific Name	Common Name	2018 Occupied Acres	2002 - 2007 % Change	2007 - 2012 % Change	2012 - 2018 % Change		Overall % Change Occupied Acres	2018 Estimated # of Shoots	2002 - 2007 % Change	2007 - 2012 % Change	2012 - 2018 % Change		Overall % change Estimated # of Shoots	2018 # of Extant Features	2002 - 2007 % Change	2007 - 2012 % Change	2012 - 2018 % Change		Overall % change # of Extant Features		Overall Trend
Euphorbia esula	leafy spurge	11.16	737%	40%	5%		**1132%**	227,961	1087%	-18%	-17%		**704%**	214	375%	34%	5%		**569%**		**Increase**
Euphorbia myrsinites (2005)	myrtle spurge	0.51	?	30%	123%		**? % increase**	222	3984%	-89%	96%		**788%**	26	0%	43%	160%		**271%**		**Increase**
Galium verum (2010)	yellow spring bedstraw	0.00	---	-100%	? %		**-89%**	102	---	-100%	? %		**-85%**	1	---	-100%	? %		**0%**		**Decrease**
Hesperis matronalis	dames rocket	0.04	---	---	-96%		**-96%**	665	---	---	-96%		**-96%**	8	---	---	-43%		**-43%**		**Decrease**
Hypericum perforatum (2007)	common St. Johnswort	1.26	?	34%	9%		**46%**	16,416	?	86%	-80%		**-63%**	57	?	190%	97%		**470%**		**Moderate Increase**
Lepidium latifolium (2018)	perennial pepperweed	0.02	---	---	---		---	213	---	---	---		---	2	---	---	---		---		**New 2018**
Linaria dalmatica (2009)	Dalmatian toadflax	0.01	---	?	? %		**? % increase**	52	---	-100%	? %		**420%**	1	---	-100	? %		**0%**		**Moderate Increase**
Lonicera tatarica (2008)	Tatarian honeysuckle	0.60	---	0%	298%		**298%**	132	---	0%	560%		**560%**	35	---	0%	3400%		**3400%**		**Increase**
Onopordum acanthium (2005)	Scotch thistle	2.04	212%	-77%	578%		**385%**	1,914	854%	-32%	115%		**1297%**	275	200%	83%	317%		**2192%**		**Increase**
Saponaria officinalis (2013)	Bouncing-bet	0.17	?	?	-67%		**-67%**	4,585	?	?	-89%		**-89%**	26	?	?	225%		**225%**		**Decrease**
Tamarix ramosissima	salt cedar	0.01	0%	0%	704%		**704%**	2	0%	0%	100%		**100%**	2	0%	0%	100%		**100%**		**Moderate Increase**
Tripleurospermum perforatum (2016)	scentless chamomile	0.41	---	---	52741%		**52741%**	2,530	---	---	126400%		**126400%**	117	---	---	11600%		**11600%**		**Increase**

Farish Recreation Area

In 2017 and 2018, five noxious weed species were mapped at Farish Recreation Area. In all, 477 extant occurrences covering approximately 16.5 acres were documented. Noxious weeds have been increasing throughout Farish since monitoring began in 2002 (Figure 5).

Areal mapping species included:

- musk thistle (*Carduus nutans)*
- Canada thistle (*Cirsium arvense*)
- leafy spurge (*Euphorbia esula*)
- orange hawkweed (*Hieracium aurantiacum*)
- yellow toadflax (*Linaria vulgaris*)

Canada thistle and musk thistle were comprehensively mapped and both are increasing. Aside from yellow toadflax, musk thistle is the most widespread noxious weed at Farish. Large (> approximated ¼ acre) occurrences of yellow toadflax were mapped, but smaller infestations were not due to its widespread distribution. Therefore, trends were not evaluated for yellow toadflax. Leafy spurge is contained to one location just outside the border and was not located within Farish. One small occurrence of orange hawkweed was discovered during a 2018 rare plant field trip and was not located during the 2017 field survey. Summary data for mapped weed infestations at Farish 2002-2018 are included in Table 6 and changes in weed distribution and abundance are provided in Table 7.

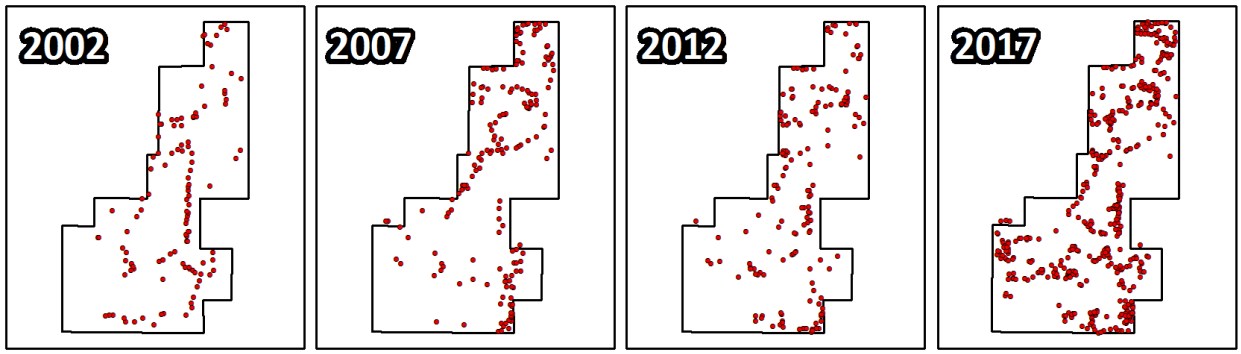


Figure 3. Distribution of known noxious weed occurrences at Farish.

Table 6. Summary data for mapped weed occurrences at Farish from 2002 to 2017/2018 during survey years. Values for species in bold are from comparable designated mapping areas only.

Species		2002				2007				2012				2018			
Scientific Name	Common Name	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features	Occupied Acres	Estimated # of Shoots	# of Extant Features	# of Eradicated Features
Carduus nutans	**musk thistle**	0.82	56	13	---	2.46	643	42	0	1.12	2,829	84	20	12.48	568,697	357	21
Cirsium arvense	**Canada thistle**	0.23	3,488	8	---	1.55	14,734	23	1	1.27	24,082	35	8	3.96	169,599	74	10
Euphorbia esula	leafy spurge	---	---	---	---	0.03	113	1	0	0.03	113	1	0	0.31	94,248	1	0
Hieracium aurantiacum	orange hawkweed	---	---	---	---	---	---	---	---	---	---	---	---	0.01	200	1	0
		1.05	**3,544**	**21**		**4.03**	**15,490**	**66**	**1**	**2.42**	**27,024**	**120**	**28**	**16.76**	**832,744**	**433**	**31**

Table 7. Changes in weed distribution and abundance at Farish from 2002 to 2017/2018 during survey years.

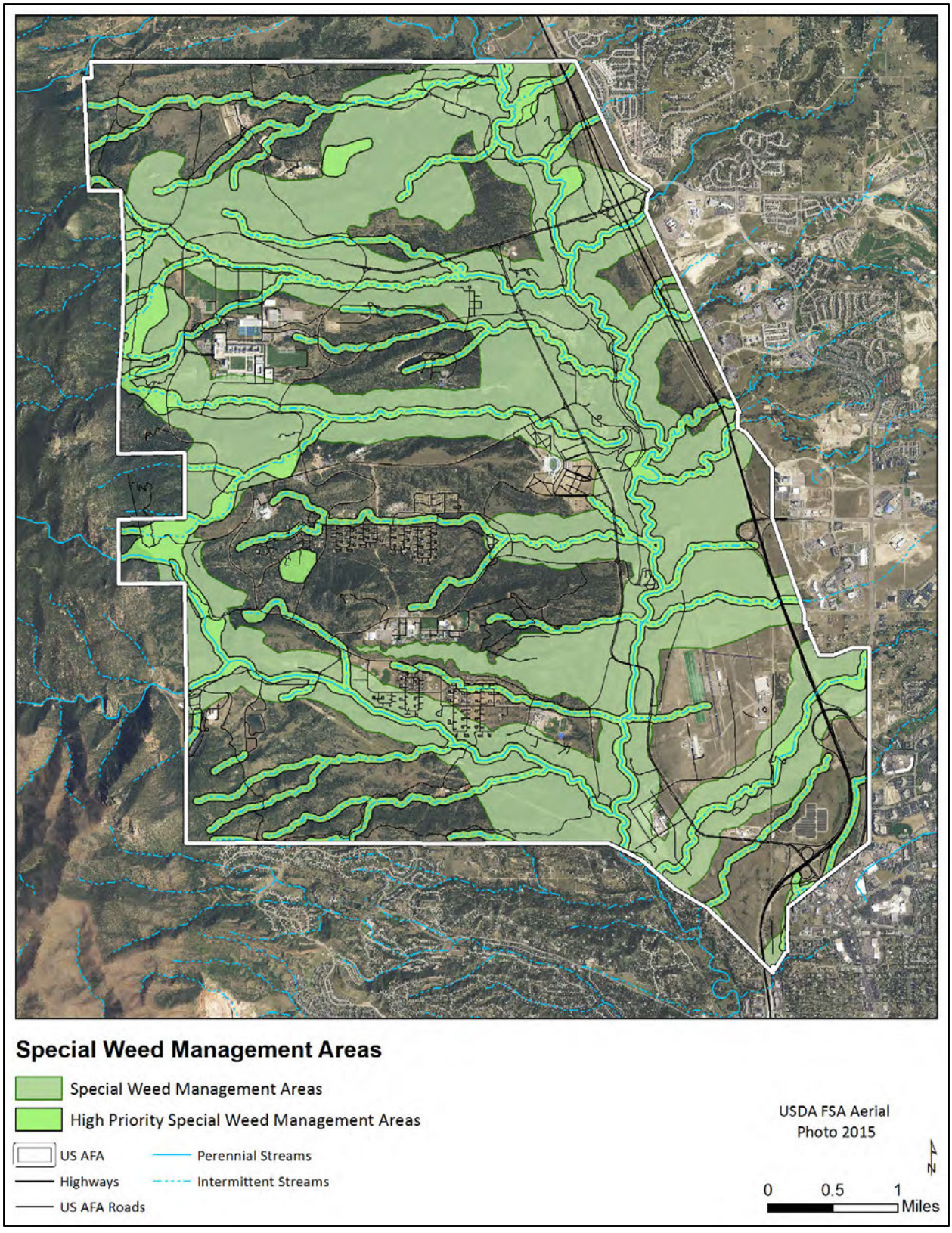
Scientific Name	Common Name	2017 Occupied Acres	2002 - 2007 % change	2007 - 2012 % change	2012-2017 % change		Overall % Change Occupied Acres	2018 Estimated # of Shoots	2002 - 2007 % change	2007 - 2012 % change	2012-2017 % change		Overall % change Estimated # of Shoots	2018 # of Extant Features	2002 - 2007 % change	2007 - 2012 % change	2012-2017 % change		Overall % change # of Extant Features		Overall Trend
Carduus nutans	musk thistle	12.48	199%	-54%	887%		**1245%**	568,697	1048%	340%	19655%		**997877%**	357	223%	100%	299%		**2477%**		Increase
Cirsium arvense	Canada thistle	3.96	577%	-18%	211%		**1630%**	169,599	322%	63%	604%		**4762%**	74	188%	52%	106%		**800%**		Increase
Euphorbia esula	leafy spurge	0.31	---	0%	1017%		**1017%**	94,248	---	0%	83305%		**83305%**	1	---	0%	0%		**0%**		**Moderate Increase**
Hieracium aurantiacum	orange hawkweed	0.01	---	---	---		---	200	---	---	---		---	1	---	---	---		---		Increase

CNHP Elements of Conservation Concern and Treatments

The Academy is home to a number of noxious weed species as well as elements of conservation concern including rare plants, animals and plant communities. Protecting these resources while controlling noxious weeds is complex.

Protocols for treating weeds in the vicinity of rare plants have been developed by the State of Colorado and CNHP (Mui and Panjabi 2016). It is important to note that weed management is a science still considered to be in its infancy. Newly published research should be considered in future weed management and this information is best shared in a yearly workshop with resource management personnel and on-the-ground applicators. This year we have provided a site assessment worksheet to help create site plans for treatment (Appendix D). Site plans are recommended by multiple agencies and weed treatment guides (USFS Fire Effects Information System (FEIS) 2016, Interagency Workgroup 2016, Pearson et al. 2016, Mui and Panjabi 2016, CPW 2013, UC Davis Weed Research and Information Center 2013, CSU 2010, Sher et al. 2010, and Tu et al. 2001). Site plans document treatments, assess success, and help develop adaptive management strategies to reduce the use of herbicides, ineffective or harmful treatments and increase the success of weed management at the Academy. CNHP developed three site plans for the Academy and Farish to treat weeds in areas with sensitive biological resources. These are provided as two separate attachments: *Site Plan for the Seep in Northeast Jack's Valley* and *Management Plan for Porter's feathergrass (Ptilagrostis porteri) at Farish Recreation Area.*

Areas with elements of conservation concern are included within the Special Weed Management Areas delineated in 2015 and the High Priority Special Weed Management Areas delineated in 2018 (Map 3). Special Weed Management Areas contain sensitive natural resources and a "natural areas" approach is recommended. The high priority special weed management areas are part of the wetland system and have a high likelihood of containing wetlands and areas that have special requirements for herbicides. Many of these areas are subjected to frequent and/or high velocity flooding events which can impact treatments. These are also the areas where the Preble's meadow jumping mice and other rare species are found. It is important to note that many herbicides are only approved for agriculture or rangelands, and not for wildlands.



Map 3. Special Weed Management Areas at the Academy.

Russian Knapweed (*Acroptilon repens*)

Overall Trend: Decreasing (Increasing 2017-2018)

Management Goals: Suppression

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 (CSU 2013).
- 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).

2018 Mapping Results

Russian knapweed had not been observed at the Academy for at least five years (2013-2017). In 2018, 44 individuals were found at three locations (Table 8, Figure 6, Maps 4 & 5). One of the locations was in a new area where Russian knapweed had not been previously mapped and included 35 individuals.

Table 8. All infestations of Russian knapweed at the Academy.					
	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---	---
2004	?	?	3	3	0
2005	< 0.01	54	3	2	1
2007	0.03	200	4	2	2
2008	0.025	157	4	2	2
2009	?	?	4	2	2
2010	0	0	4	0	4
2011	0	0	4	0	4
2012	0.05	543	12	10	2
2013	0	0	12	0	12
2014	0	0	12	0	12
2015	0	0	12	0	12
2016	0	0	12	0	12
2017	0	0	7	0	12
2018	0.02	44	14	3	11

Basewide weed mapping performed during shaded years.

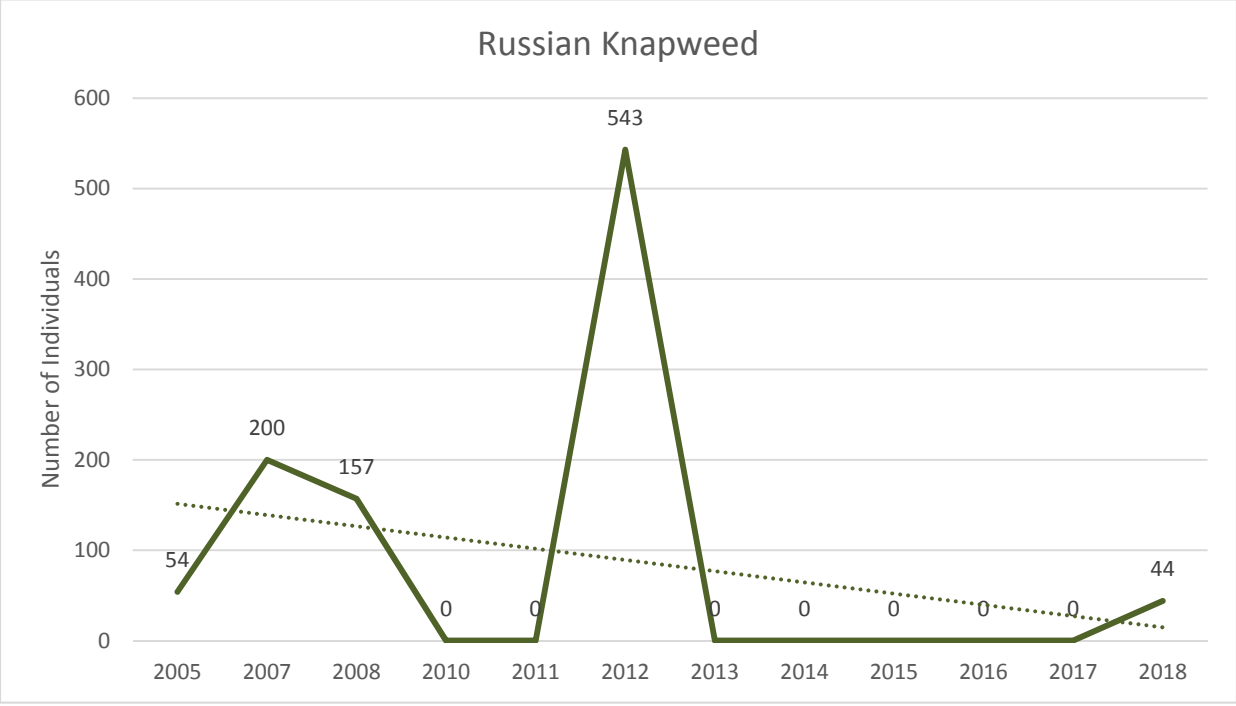


Figure 4. Number of Russian knapweed individuals and mapped features, 2005-2018.

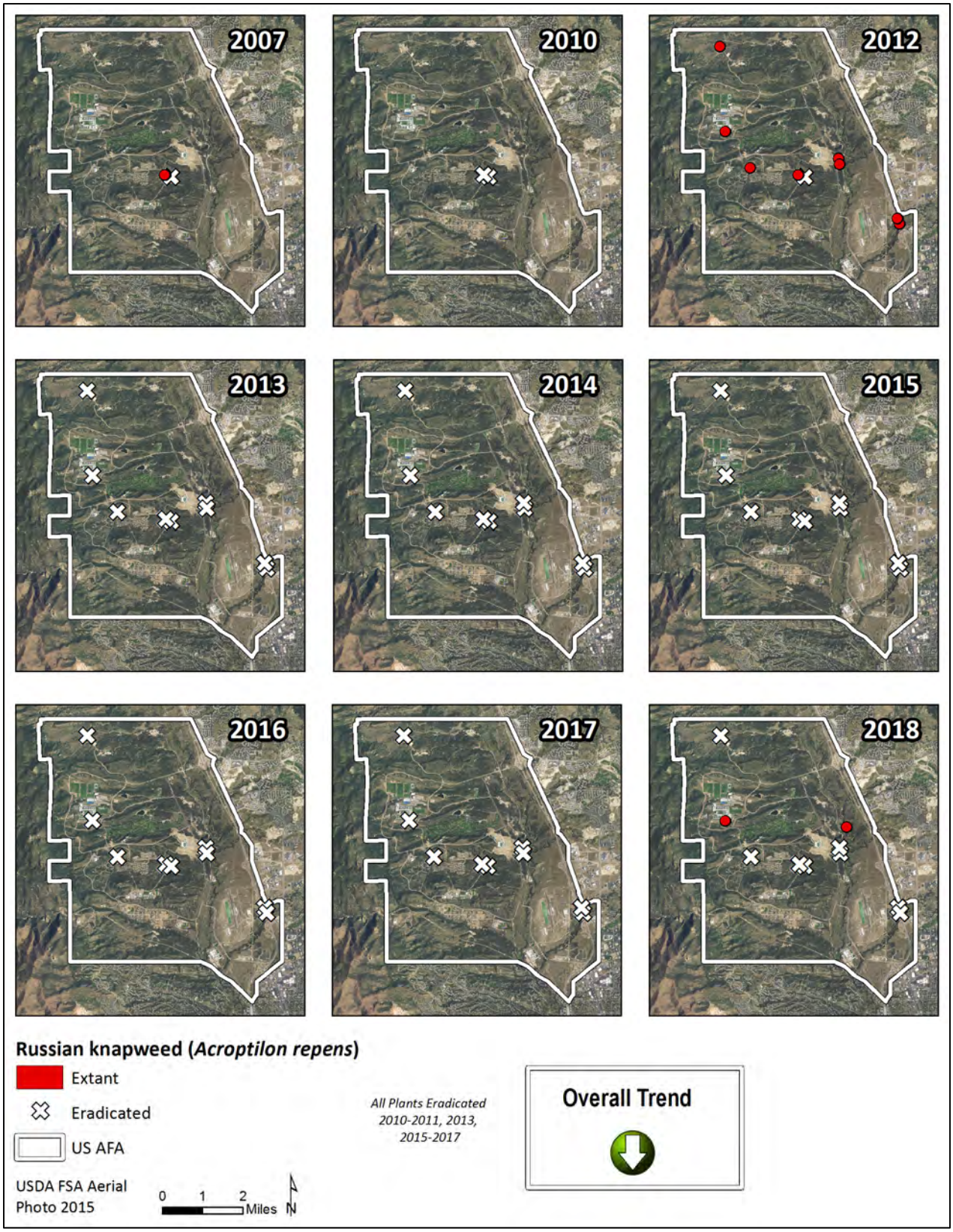
Recommendations

Visit all 14 known sites for at least one to two more years for the census surveys and the three sites with plants found in 2018 should be surveyed for at least five more years based seed longevity for Russian knapweed which is thought to be around five years. Weed technicians may need training to identify Russian knapweed in pre-flowering stages that are preferred for treatments. It should remain on the rapid response search list for the Academy.

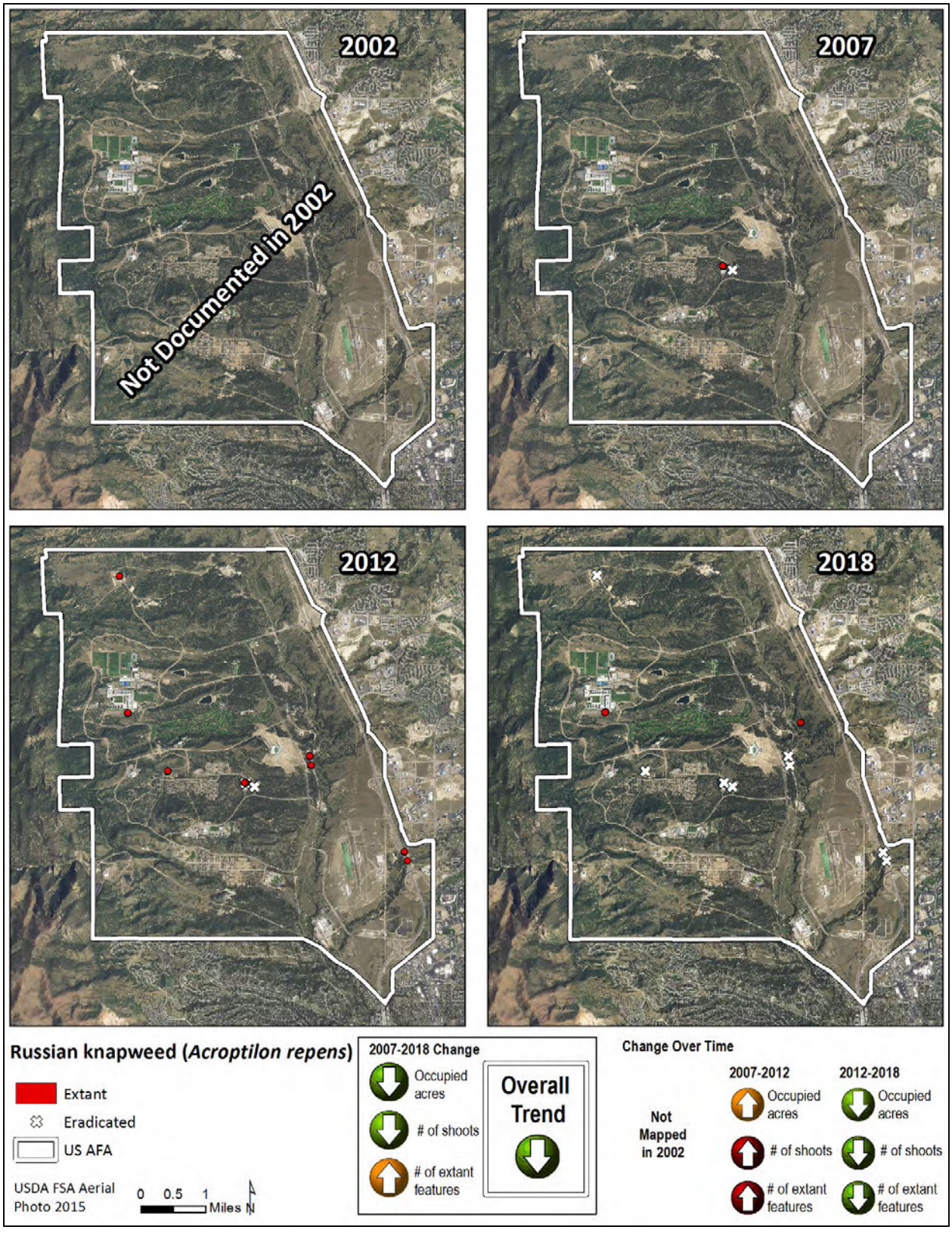
Russian knapweed is extremely difficult to control once it becomes established. Re-visiting sites where the plants have been treated either mechanically and or chemically should be a high priority to prevent re-establishment. Encouraging native grasses to grow in areas where Russian knapweed has been treated is a recommended cultural control (Beck 2008). 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 site with 35 plants, if they appear to have been present for more than a year with a well-established root system. Biological control is not yet available for Russian knapweed.

History of Sampling and Treatments:

- The first appearance of Russian knapweed was in 2004 and by 2007 there were two extant occurrences and two eradicated occurrences, all near Douglass Way.
- By 2009, two occurrences were eradicated and two were sprayed that year (Rondeau and Lavender 2012). None of these infestations have re-established in subsequent years.
- In 2005, herbicide treatment was applied to part of the Skills Development Center and Douglass Way occurrences and the Skills Development Center was treated again in 2009. Specific details about the first two locations can be found in Anderson and Lavender (2008b).
- In 2012, when 10 new locations were mapped, Russian knapweed occupied 0.05 acres with 543 shoots. This represented a 172% increase in number of shoots and a 400% increase in number of extant features since 2007.
- In 2013, all extant locations were treated (0.05 acres), and no live plants were observed in 2013 or in 2014. In 2014, a rosette was tentatively identified as Russian knapweed and was later identified as spotted knapweed.
- In 2015, no new populations were identified and no extant features were observed at eleven of the twelve known sites.
- In 2016, all twelve known sites were visited and no Russian knapweed plants were found.
- In 2017, seven of the twelve known sites were visited and no Russian knapweed plants were found.
- In 2018, fourteen sites were visited and three had Russian knapweed plants. One of the three sites represents a new location; it was found on the east side of the Academy with 35 individuals.



Map 4. Distribution of Russian knapweed at the Academy between 2007 and 2018.



Map 5. Distribution of Russian knapweed at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Garlic Mustard (*Alliaria petiolata*)

Overall Trend: Increasing (New in 2018)

Management Goals: Eradication

State List: Watch List

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

- 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 (CWMA 2018)

2018 Mapping Results

Garlic mustard has not been previously mapped at the Academy. In 2018, seven features were mapped including 4,011 individuals along West Monument Creek (Table 9, Maps 6 & 7). Over 2,000 individuals were documented from one site. Some sites have been treated in with herbicide (pers. comm. Brian Mihlbachler 2018).

Table 9. All infestations of garlic mustard at the Academy.				
	Occupied Acres	**Estimated Number of Shoots**	**Number of Extant Features**	**Number of Eradicated Features**
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2018	0.12	4,011	7	0

Recommendations

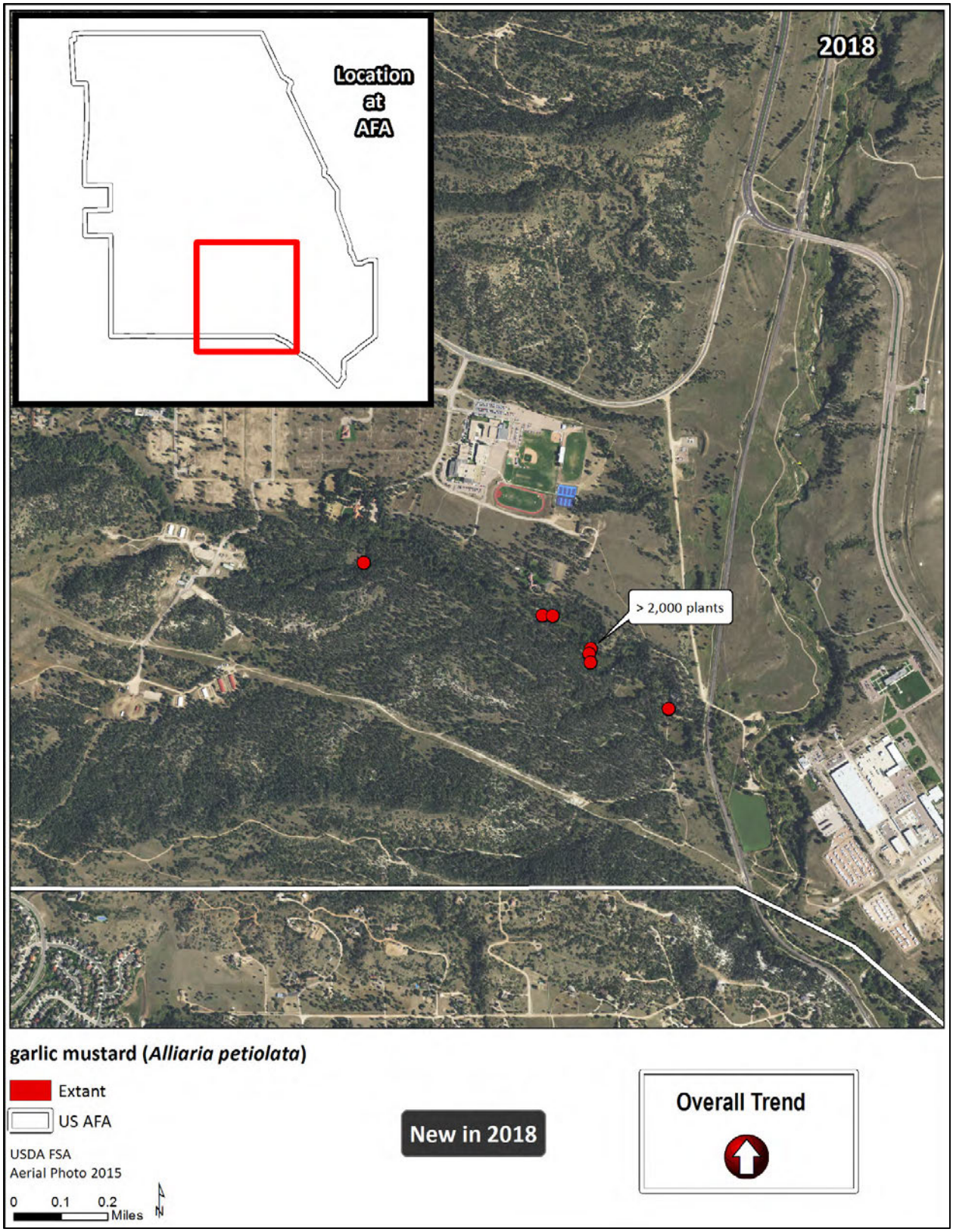
Treatments should start as soon as possible. Hand pulling is effective if you can remove at least half of the root for small populations. Herbicides can be used in the spring (most effective) for large populations. Any treatments should be done before seed set (http://nyis.info/invasive_species/garlic-mustard/). Follow-up monitoring and planting of competitive species may be important for successful removal of garlic mustard. Monitoring at these sites should be conducted for at least seven years after treatments.

Photo: garlic mustard at the Academy, Kate Wright, CNHP.

History of Sampling and Treatment:

- Garlic mustard was first discovered on the base during the 2018 basewide weed survey. Natural Resources Managers were notified immediately and herbicide applications were applied to at least two populations along West Monument Creek.

Map 6. Distribution of garlic mustard at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).



Map 7. Close-up of garlic mustard at the Academy in 2018.

Siberian Peashrub (*Caragana arborescens*)

Overall Trend: Increasing

Management Goals: Considering Management

State List: NA (Escaped Ornamental)

- Small tree
- Ornamental escaping to disturbed wildlands
- Nitrogen-fixer
- Pods form in early June – July
- Prefers full sun, sandy open sites
- Reproduction by seed and vegetative
- Seed longevity at least 5 years in a laboratory https://www.fs.fed.us/rm/pubs_series/wo/wo_ah727/wo_ah727_321_323.pdf

Photo by Richard A. Howard, hosted by the USDA-NRCS PLANTS Database

2018 Mapping Results

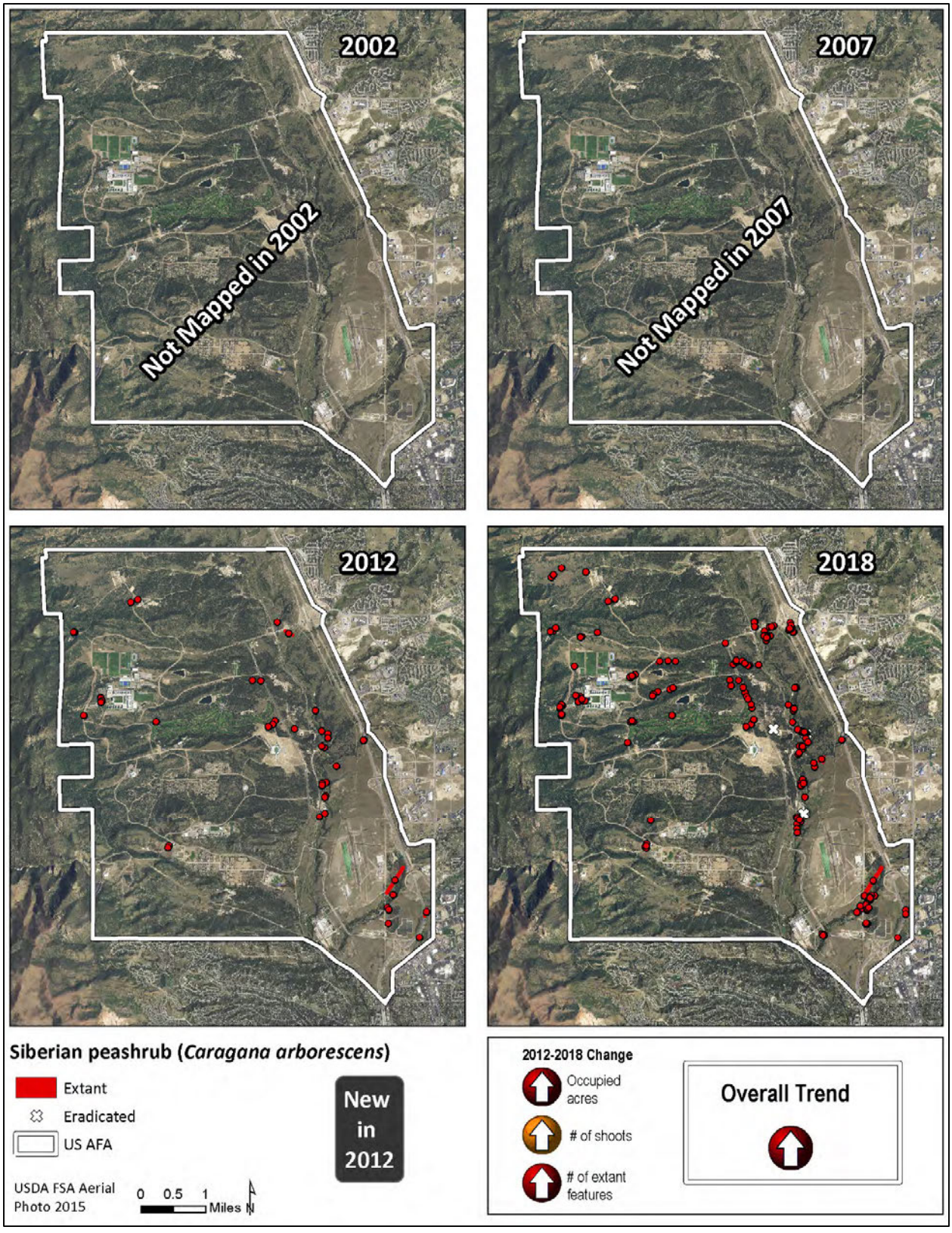
Siberian peashrub was present on the base in 2002 and 2007; however, Natural Resource Managers noticed it was spreading and it was mapped in 2012 during the basewide weed survey. In 2018, 183 features were mapped and the known acreage more than doubled (Table 10, Map 8).

Table 10. All infestations of Siberian peashrub at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	9.71	89,270	43	---
2018	24.97	106,348	183	3

History of Sampling and Treatment:

- First mapped in 2012 during the basewide weed survey.
- Results of the 2018 basewide weed survey show the number of mapped features more than tripled and acreage more than doubled between 2012 and 2018.



Map 8. Distribution of Siberian peashrub at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Hoary Cress (*Cardaria draba*)

Overall Trend: Stable (Increasing 2012-2018)

Management Goals: Containment

State List: B

- Perennial that reproduces by seeds and lateral roots
- Flowers May-June
- Grows to 2 feet tall with root depths to 32 inches
- Prefers disturbed alkaline soils
- Seed longevity is 3 years (Code of Colorado Regulations 2014)

Photo by Michelle Washebek, CNHP

2018 Mapping and Monitoring Overview

Overall, both the mapping and monitoring data indicate stable trends for hoary cress. Both the mapping data and monitoring plot data show decreases in cover and density, while the mapping data show an 82% increase in the number of sites with hoary cress across the Academy. Details for the monitoring and mapping data are included below.

2018 Mapping Results

The 2018 mapping data show an increase of 82% in the number of extant features compared to 2002 (Table 11, Map 9). The increase in estimated shoot numbers was 2% and the number of occupied acres decreased by 5% (Table 11). Although there were significantly more features

mapped in 2018 compared to 2002, the numbers of shoots increased only slightly and occupied acres decreased.

Table 11. All infestations of hoary cress at the Academy.				
	Occupied Acres	**Estimated Number of Shoots**	**Number of Extant Features**	**Number of Eradicated Features**
2002†	20.47	1,671,728	164	0
2007	12.76	1,035,489	241	0
2012	13.08	828,036	203	77
2018	19.52	1,707,408	300	58

†2002 values are sums of 2002 and 2003 mapping

2018 Monitoring Results

A total of 10 permanent plots were surveyed in 2018; they show slightly decreasing frequencies from 2013–2018 (Map 10). This is also the reflected by the number of shoots counted which has decreased from 6,446 in 2013 to 3,474 in 2018 (46%). The number of shoots in each plot have decreased yearly since 2013 (Table 12).

Table 12. Summary of hoary cress permanent plot data, 2012-2018.

Permanent Plot Sampling Method							
Year	*# Plots Sampled*	*# Quads Sampled*	*# Quads with Plants*	*Frequency (%)*	*Total # Shoots*	*AVG Height (cm)*	*AVG# shoots/plot*
2012	7	434	212	49	5,350	25	764
2013	7	428	213	50	6,446*	22	920*
2014	Not Sampled						
2015	10	618	273	44	5,615	37	562
2016	10	617	278	45	3,649	46	365
2017	Not Sampled						
2018	10	602	247	40	3,474*	16	347

*Herbicide was applied to parts of CADR-2 and CADR-3 after 2013 sampling and in 2018 in CADR 9 prior to sampling.

Hoary cress frequency (% of quadrats within a plot containing hoary cress) has been decreasing since 2012/2013 from 49/50% to 46% in 2018 (Table 13). Standard deviation (SD) is a measure of variance from the mean. The Average Standard Deviations (ASDs) from 2012-2018 are similar, ranging from 18-22%. A change greater than the average SD for all four years within the same plot (e.g. plus or minus 20) was considered to be an overall increase or a decrease. CADR-2 showed a

decrease from 2013 to 2015 (*) as well as an overall decrease from 2012-2018, while all other hoary cress plots have remained stable (Table 13, Figure 7).

Table 13. Frequency of hoary cress in permanent plots, 2012-2018. Frequency = % of quadrats with hoary cress. Colors indicate overall trend: yellow is stable or <1 average standard deviation ASD (20%), and green represents a decrease of >1 ASD. * indicates a change of >1 ASD for that year. Bolded and shaded numbers indicate plot partially sprayed with herbicide.

Plot Name	FREQ 2012 (%)	FREQ 2013 (%)	FREQ 2015 (%)	FREQ 2016 (%)	FREQ 2018 (%)	AVG FREQ 2012-2018
CADR-1	81	82	82	77	65	77 (57-97)
CADR-2	65*	**67***	16*	26	18	38 (18-58)
CADR-3	21	**26**	24	16	21	22 (2-42)
CADR-4	52	50	40	50	60	50 (30-70)
CADR-5	37	39	41	40	41	40 (20-60)
CADR-6	26	26	29	39	27	29 (9-49)
CADR-7	65	61	68	70	53	63 (43-83)
CADR-8	---	---	43	46	18	36 (16-56)
CADR-9	---	---	45	52	**56**	51 (31-71)
CADR-10	---	---	**53**	50	45	49 (29-69)
AVG	**49**	**50**	**44**	**45**	**40**	**46**
ASD	**22**	**21**	**19**	**18**	**18**	**20**

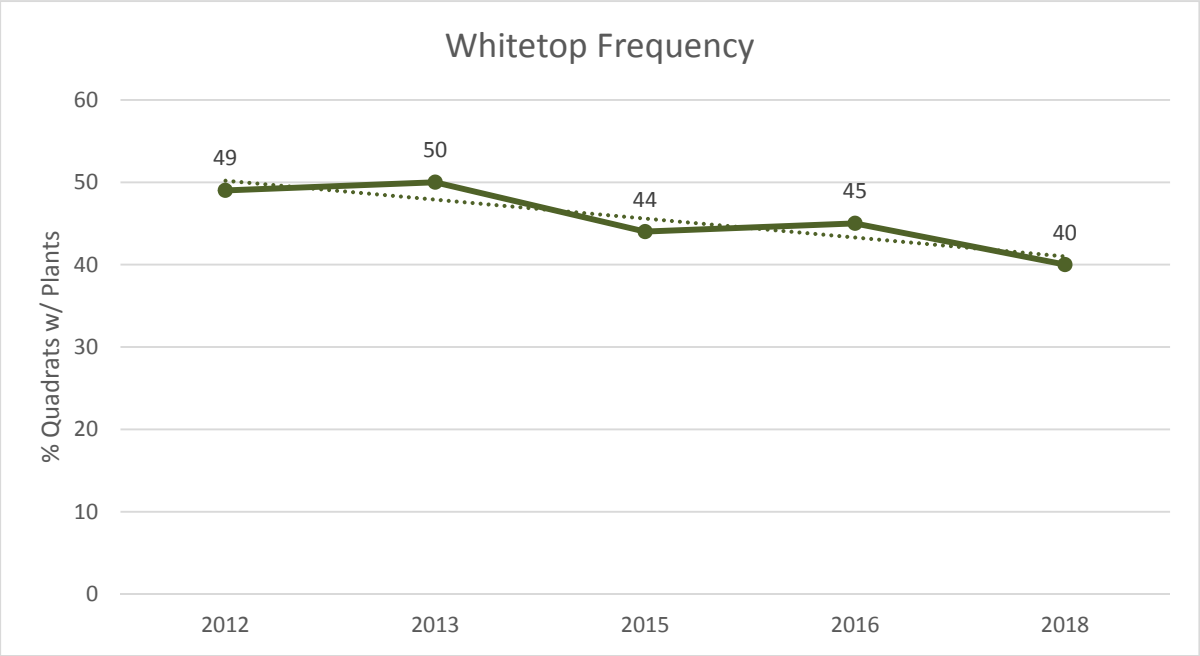


Figure 5. Hoary cress frequency at 10 permanent plots, 2012-2018.

Density is calculated from the average number of stems arising from the ground in half meter quadrats and averaged for each plot; percent cover is an estimate of how much area is occupied within the half meter quadrats and averaged for the plot. In 2018, all of the monitoring plots showed no increases and two plots showed decreases greater than the ASD (plus or minus 8); overall the density is relatively stable from 2012-2018 (Table 14).

Table 14. Average density of hoary cress in permanent plots, 2012-2018. Color indicates overall trend: yellow is stable with less than one standard deviation. * indicates a change of >1 ASD for that year. Bolded and shaded numbers indicate plot partially sprayed with herbicide.

Plot Name	*AVG Density 2012*	*AVG Density 2013*	*AVG Density 2015*	*AVG Density 2016*	*AVG Density 2018*	*AVE Density 2012-2018*
CADR-1	27	30*	12	10*	11	18
CADR-2	7	**11**	1	1	3	5
CADR-3	1	**3**	1	1	1	1
CADR-4	7	8	24*	6	8	11
CADR-5	9	12	8	8	6	9
CADR-6	5	4	3	2	3	3
CADR-7	31	37*	20	15	11*	23
CADR-8	---	---	10	6	2	6
CADR-9	---	---	5	6	**6**	6
CADR-10	---	---	**7**	5	6	6
AVG	**12**	**15**	**9**	**6**	**6**	**9**
SD	**12**	**13**	**8**	**4**	**4**	**8**

The average percent cover of hoary cress in the plots showed a decrease in three plots since 2012-2015 (CADR 1, 7 & 8), while the remaining plots were stable (Table 15). The cover can be influenced by weather and time of sampling.

Table 15. Average % cover of hoary cress in permanent plots, 2012-2018. Colors indicate overall trend: yellow is stable with less one average standard deviation (ASD); green indicates a decrease of at least one ASD. * indicates a change of >1 ASD for that year. Bolded and shaded numbers indicate plot partially sprayed with herbicide.

Plot Name	*AVG Cover (%) 2012*	*AVG Cover (%) 2013*	*AVG Cover (%) 2015*	*AVG Cover (%) 2016*	*AVG Cover (%) 2018*	*AVG Cover 2012-2018*
CADR-1	12	13*	11	5	1*	8
CADR-2	6	**9***	1	1	1	4
CADR-3	0	**1**	1	<1	0.5	1
CADR-4	2	5	3	2	1	3
CADR-5	2	3	6	3	0.5	3
CADR-6	1	1	3	1	0.3	1
CADR-7	11	20*	18*	8	2*	12
CADR-8	---	---	11*	3	0.3*	5
CADR-9	---	---	5	2	**1**	3
CADR-10	---	---	**6**	2	1	3
AVG	**5**	**7**	**7**	**3**	**1**	**5**
SD	**5**	**7**	**5**	**2**	**0.5**	**4**

Recommendations

Continue to monitor 10 permanent plots at least every three years. Trends from that data will confirm if a natural decrease is occurring which currently appears to be the case. Herbicide should not be applied to permanent plots (unless it is added to the study design) to determine if the trend continues to be stable to decreasing naturally.

Target newly established satellite populations for control efforts. Hoary cress, like many deep-rooted perennial species, is difficult if not impossible to control once it has become established. It is thought that targeting newly established satellite populations is more effective for control, while the established populations should be monitored for expansion (USFS-USDA 2014a).

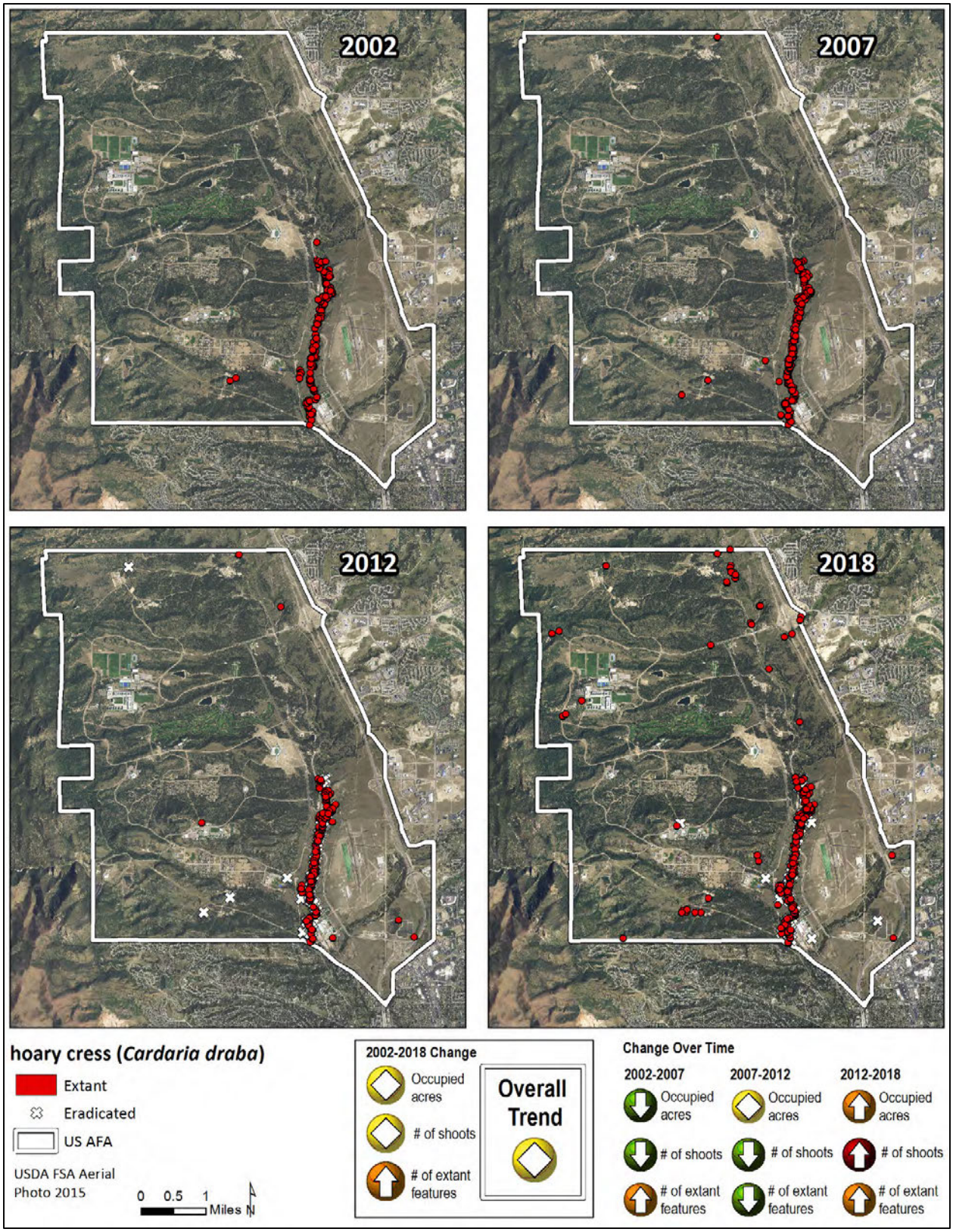
There are no state-approved biocontrol organisms currently available for hoary cress. It is important to consider that difficult to control species can naturally decline over time (Norris 1999) and hoary cress may have saturated the habitat where it can be found at the Academy. Continued monitoring without herbicide applications to plots can help determine if this is occurring at the Academy.

A backpack hand-held sprayer or wick method are recommended for natural areas if chemical treatments are used (only recommended for satellite populations), especially in areas known to contain resources of conservation concern and where the native vegetation needs to be protected

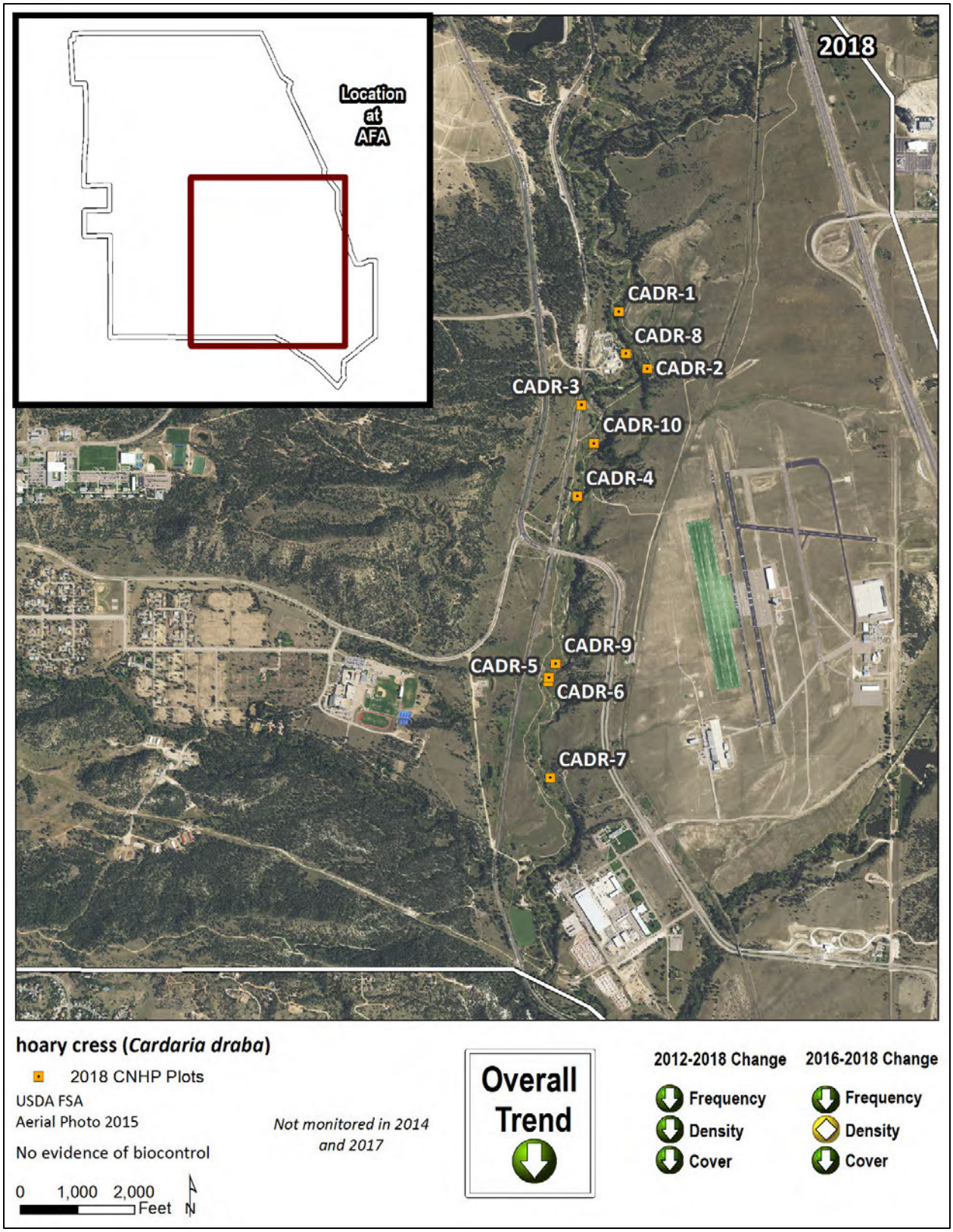
or where smooth brome is in the vicinity (Smith et al. 2015). The most important consideration for this species at the Academy is to determine if populations are expanding, stable or naturally decreasing. Treatments have the potential to increase smooth brome coverage or that of other invasive species, if they are not carried out with care to protect surrounding native vegetation, wetlands, and intact soils. Another consideration is that the seed sources are constantly entering Monument Creek from the developed areas to the east and the scouring from frequent flooding is causing a disturbance zone that allows for increases in weeds.

History of Sampling and Treatment:

- In 2002, hoary cress was mostly concentrated along Monument Creek in the south half of the Academy (Anderson et. al. 2003).
- Extreme drought in 2002 followed by relatively average precipitation in 2003 necessitated a second year of mapping in 2003.
- In 2007, a lone occurrence was identified along Monument Creek on the north end of the Academy (Anderson and Lavender 2008b).
- In 2012, eight random sites known to have hoary cress in 2007 were used to establish eight permanent plots.
- Census mapping for hoary cress distribution across the Academy property was conducted in 2002, 2007, and 2012.
- In 2013, seven of the eight plots were monitored. Frequency was stable between 2012 and 2013, density increased from 2012 to 2013. The average cover of hoary cress increased from 2012 to 2013. Herbicide was partially applied to CADR-2 and CADR-3 after 2013 field site visit.
- No plots were monitored in 2014.
- Seven of the plots sampled in 2013 were resampled in 2015. Three new additional plots were established to bring the total number of plots to 10. The average frequency and average density were both lower than 2012-2013; the percent average cover was the same as 2013.
- 10 plots were sampled in 2015. The frequency decreased in CADR-2, average density decreased in CADR-1 and CADR-7 and the percent cover decreased in CADR-1, CADR-2, CADR-7 and CADR-8. Everything else remained stable with no increases detected.
- 10 plots were sampled in 2016. The overall trend was stable for nearly all plots for frequency, average density and percent cover. There was an overall decrease in frequency in CADR-2 and a decrease in percent cover for CADR-7.
- No plots were monitored in 2017 due to late start date for field work.
- In 2018, basewide weed mapping was conducted across the Academy that included the census species from 2013. Ten permanent plots were monitored. Herbicides were applied in many areas with partial treatments due to thick plant growth. Some areas were chemically treated to bare soil.



Map 9. Distribution of hoary cress at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).



Map 10. 2018 hoary cress plots at the Academy.

Musk Thistle (*Carduus nutans*)

Overall Trend: Increasing (plots decreasing)

Management Goals: Suppression

State List: B

Photo by Michelle Washebek

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

2018 Overall Results

Overall the weed mapping data shows musk thistle at the Academy is increasing while the monitoring data show a decline with nine out of 10 musk thistle plots showing a significant reduction in plants. An area in east Jack's Valley has a large number of plants being impacted by an insect which appears to prevent flowers from forming. Musk thistle cover seems to be strongly related with spring and summer precipitation values. The occupied acres at the Academy show a strong correlation with fluctuations in spring-summer precipitation; occupied acres are lower for 2002 and 2013 (low precipitation years) and higher in 2007 and 2018 (high precipitation years - Figure 8). The reductions observed in the monitoring plots appear largely to be due to invasions by smooth brome, a likely result of overly aggressive herbicide applications to wild grasslands.

2018 Mapping Results at the Academy

The estimated number of shoots have increased from 2002 to 2012 with a decrease from 2012 to 2018 while the number of extant features has been rising from 2002-2018 (Tables 16 & 17, Map 11). The number of occupied acres has been fluctuating with 2002 and 2012 with the lowest occupied acres and 2007 and 2018 with the highest occupied acres. These years correlate with the spring and summer precipitation with years with less rainfall have lower occupied acres and vice versa (Figure 8).

Table 16. Infestations of musk thistle within comparable designated mapping areas at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	15.91	2,207	272	---
2007	27.03	49,588	1,020	4
2012	15.20	125,297	1,082	639
2018	21.75	77,442	1,909	1,118

In 2012, musk thistle was mapped in designated mapping areas only. The full scope of known infestations is detailed below.

Table 17. All infestations of musk thistle at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	16.15	2,244	280	---
2007	28.95	76,213	1,072	4
2012	17.43	166,992	1,136	639
2018	23.04	105,218	1,977	1,152

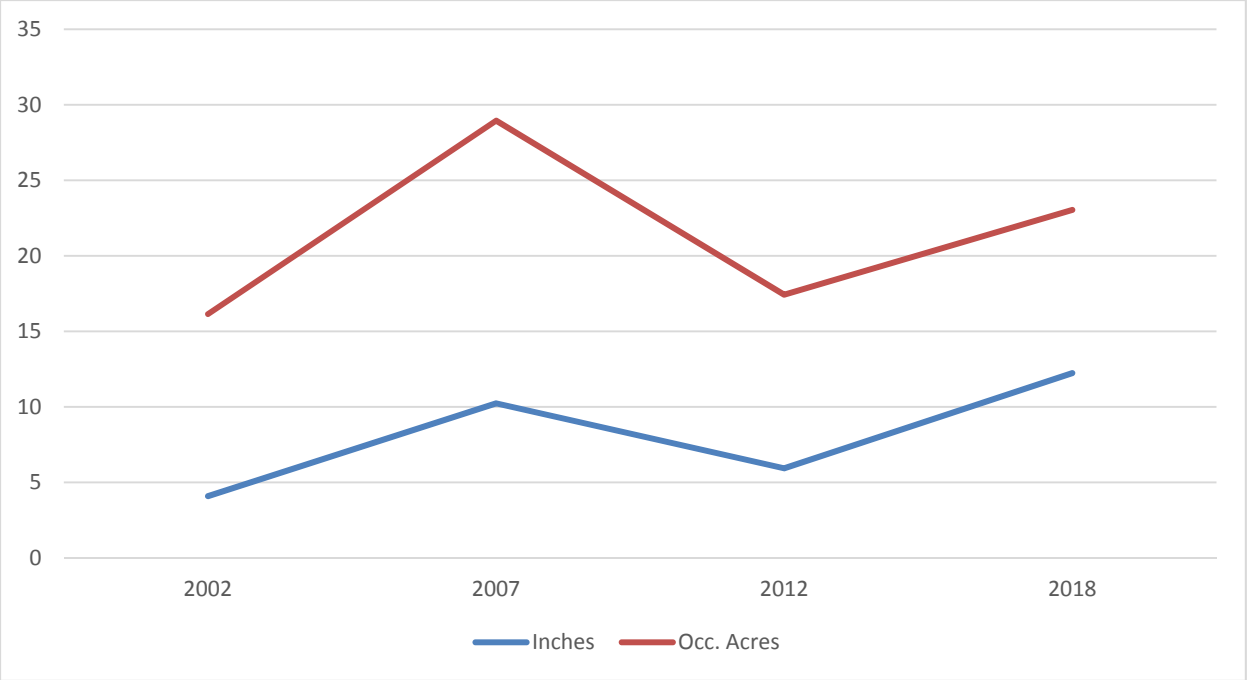


Figure 6. Comparison of spring-summer precipitation and occupied acres of musk thistle at the Academy.

2018 Monitoring Results

The overall trend since 2008 is decreasing at nine out of 10 photo monitoring plots at the Academy (Map 12). The average number of plants per plot has ranged from 6 to 100 individuals with an average of 25 per plot in 2018 (Table 18, Figure 9).

Table 18. Musk thistle photo plot counts 2008-2018.

	CANU 1	CANU 2	CANU 3	CANU 4	CANU 5	CANU 6	CANU 7	CANU 8	CANU 9	CANU 10	AVG/ Plot
2008	11	6*	1*	1	1	10*	102*	212	160	500	100
2009	134	80	2*	63	27	45	90*	31*	1*	--	53
2010	9*	5*	1*	0*	10*	33*	25*	10*	1*	40*	13
2011	7*	160*	8*	0*	0	3	0*	7*	0*	400	59
2013	7*	0	1	0	6	2	5*	7	0	28*	6
2014	40*	0*	0	0	17*	4	0	0	0	0	6
2015	34	10*	2	3	7*	0	6	0	4	32	10
2016	52	5	0	23	5	12	17	6	0	130	25
2017	58	17	0	9	0	50	0	0	0	224	36
2018	12	38	0	3	0	6	10	0	0	180	25
SUM	364	321	15	102	73	165	255	273	166	1534	
AVG	36.4	32.1	1.5	10.2	7.3	16.5	25.5	27.3	16.6	170.4	
ASD	37.4	48.6	2.3	18.9	8.3	17.9	36.1	62.2	47.8	167.1	**45**
	-	-	-	-	-	-	-	-	-	+	

*Herbicide, > 1ASD, <1ASD

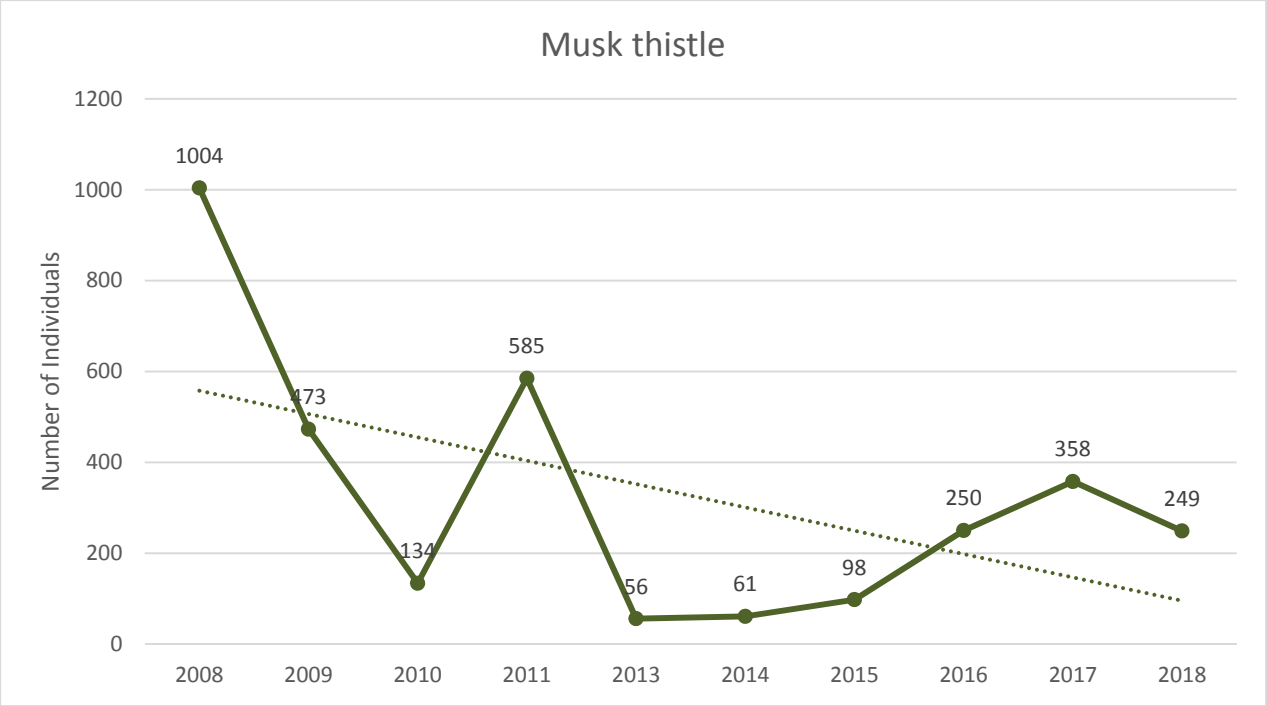


Figure 7. Musk thistle counts at 10 photo plots, 2008-2018.

Recommendations

Field observations show weed treatments may be contributing to increases in musk thistle as well as the spread of smooth brome into grasslands. Herbicides are being applied in a broadcast fashion in wildland areas and to bolted plants with flowering/seed heads. Since this plant is a biennial, it dies after it flowers. The seed heads and/or flowers are still viable on the treated plants and the soil disturbances from the overspray are generating more musk thistle and other weeds such as cheatgrass and smooth brome (Photo 1). In addition, the first year rosettes which should be the targets for herbicide application or mechanical treatments are missed. The time of year the plants are sprayed, the growth stage of the plants (bolted), the amount of herbicide and overspray, as well as the incomplete treatments need to be addressed to improve treatment success.

Future treatments should not include broadcast herbicide applications in areas with native vegetation. Spot treatments at the rosette stage or severing the rosettes below the root crown while leaving the root in the ground is recommended to protect the soil from excess disturbance. In Jack's Valley on the east side the musk thistle is being impacted by insects. They appear to inhibit flower development.

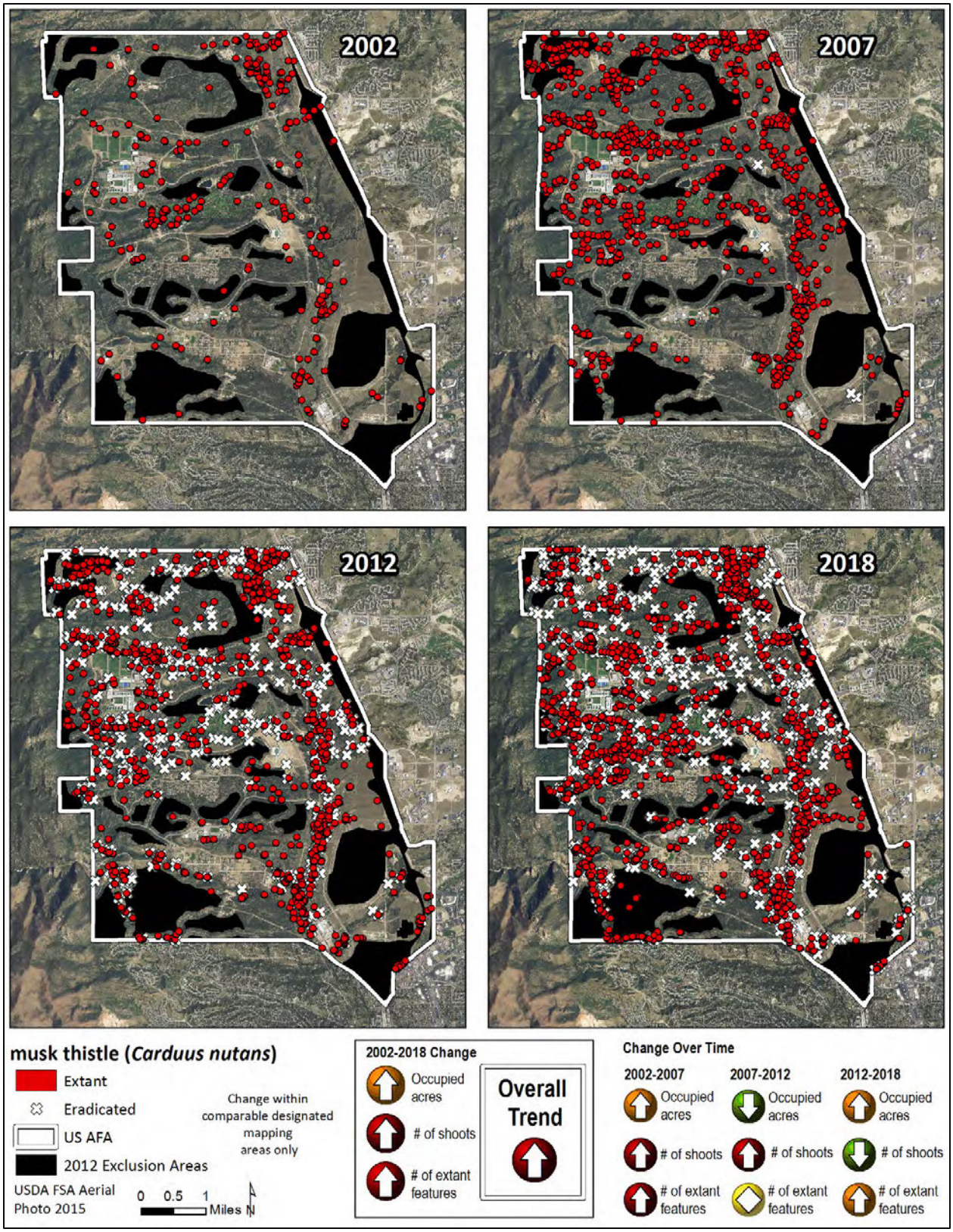
Photo 1. The black spots on the leaves are insects which appear to make leaves wrap around and prevent or reduce flower production. Inset shows impacted flower head.

Before herbicides are used, a site plan should be prepared because many areas where the plots have been treated are seeing a reduction in the biodiversity of plants and increasing weeds. A non-native and very aggressive perennial grass, *Bromus inermis* (smooth brome), which is harder to treat (although it is not on the State Noxious Weed List in Colorado) is becoming dominant. This grass is less beneficial to wildlife and is no longer recommended for use in restorations and plantings because of its aggressive nature (USDA-NRCS 2002). Plot CANU-7 has been treated several consecutive years with herbicides. While there has been a reduction in musk thistle plants, smooth brome is now dominant (Photo 2). The result of the herbicide treatment is a decrease in biodiversity at this site even though the weed goals are being met. Once smooth brome dominates it remains in this condition for many years. Repeated herbicide applications over multiple consecutive years are not recommended for this reason.

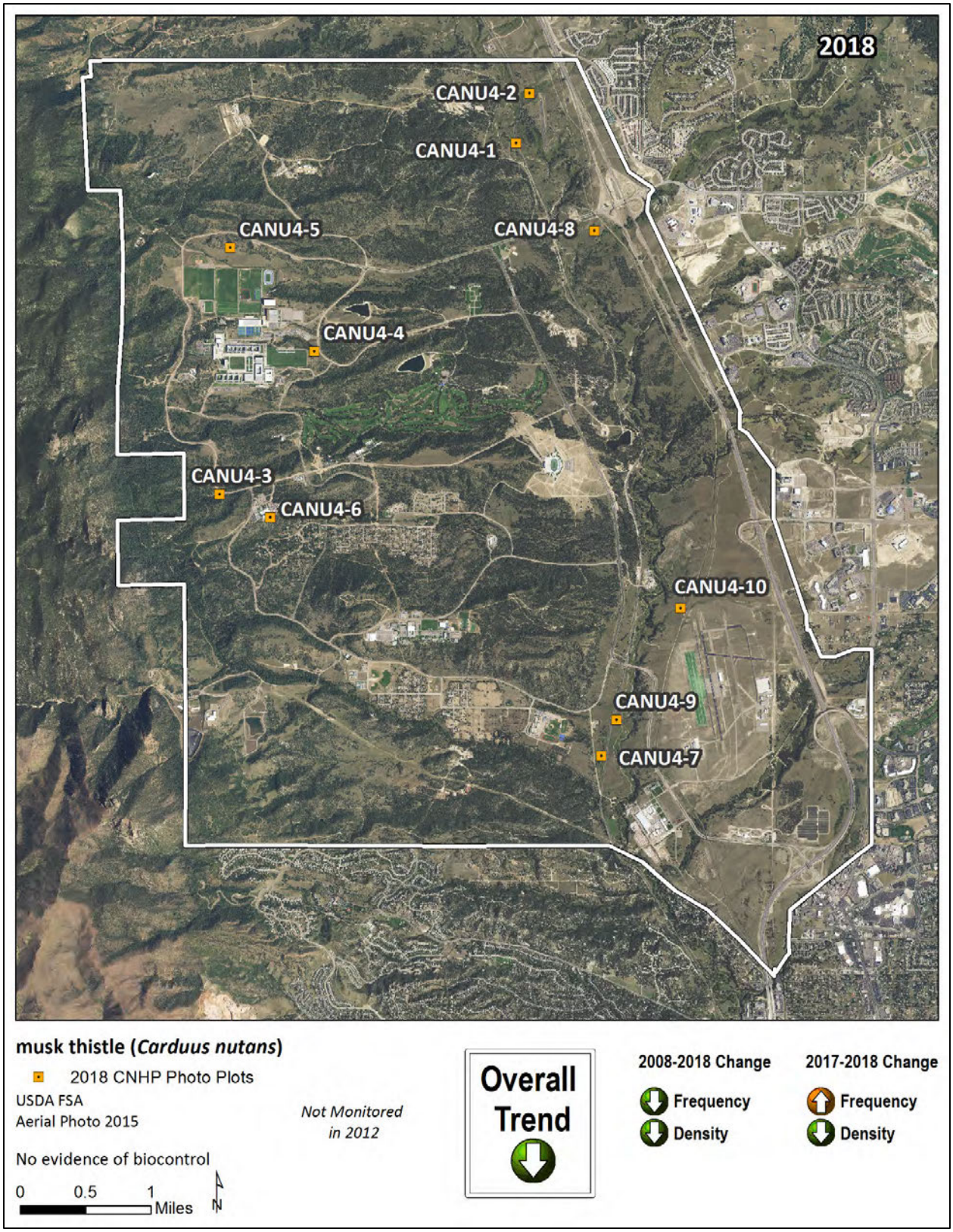
Photo 2. CANU-7 plot was treated with herbicide five years in a row. There was a reduction from 120 musk thistle to 6 plants in 2015 (17 in 2016). However, the native grasses and forbs present in 2008 have been replaced with a non-native aggressive grass – smooth brome (CNHP 2008, 2015).

History of Sampling and Treatment:

- All ten plots were visited in 2008-2015 with the exception of 2012.
- All plots have been treated at least once if not multiple times with herbicides based on our field observations.
- Census mapping for musk thistle distribution across the Academy property was conducted in 2002, 2007, and 2012.
- The numbers of individuals recorded in the plots in 2015 were significantly lower than when the plots were initiated in 2008. Precipitation patterns may explain the increase in plants noted in 2015. Two years in a row at CANU 2 a native plant (*Scrophularia lanceolata*) appeared to be treated with herbicides.
- In 2016-2017, there was an increase in the number of plants. The overall trend is decreasing but musk thistle has been increasing since 2013 and could be related to precipitation and inappropriate herbicide applications.
- Basewide mapping in 2018 with 10 photo monitoring plots updated. Weed survey shows an increase in musk thistle, while photo plots show a decrease.



Map 11. Distribution of musk thistle at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).



Map 12. 2018 musk thistle plots at the Academy.

2017 Musk Thistle Mapping Results at Farish

The basewide mapping data show an increase in occupied acres, number of extant features and numbers of shoots at Farish Recreation Area (Tables 19 & 20, Map 13).

Table 19. Infestations of musk thistle within comparable designated mapping areas at Farish.

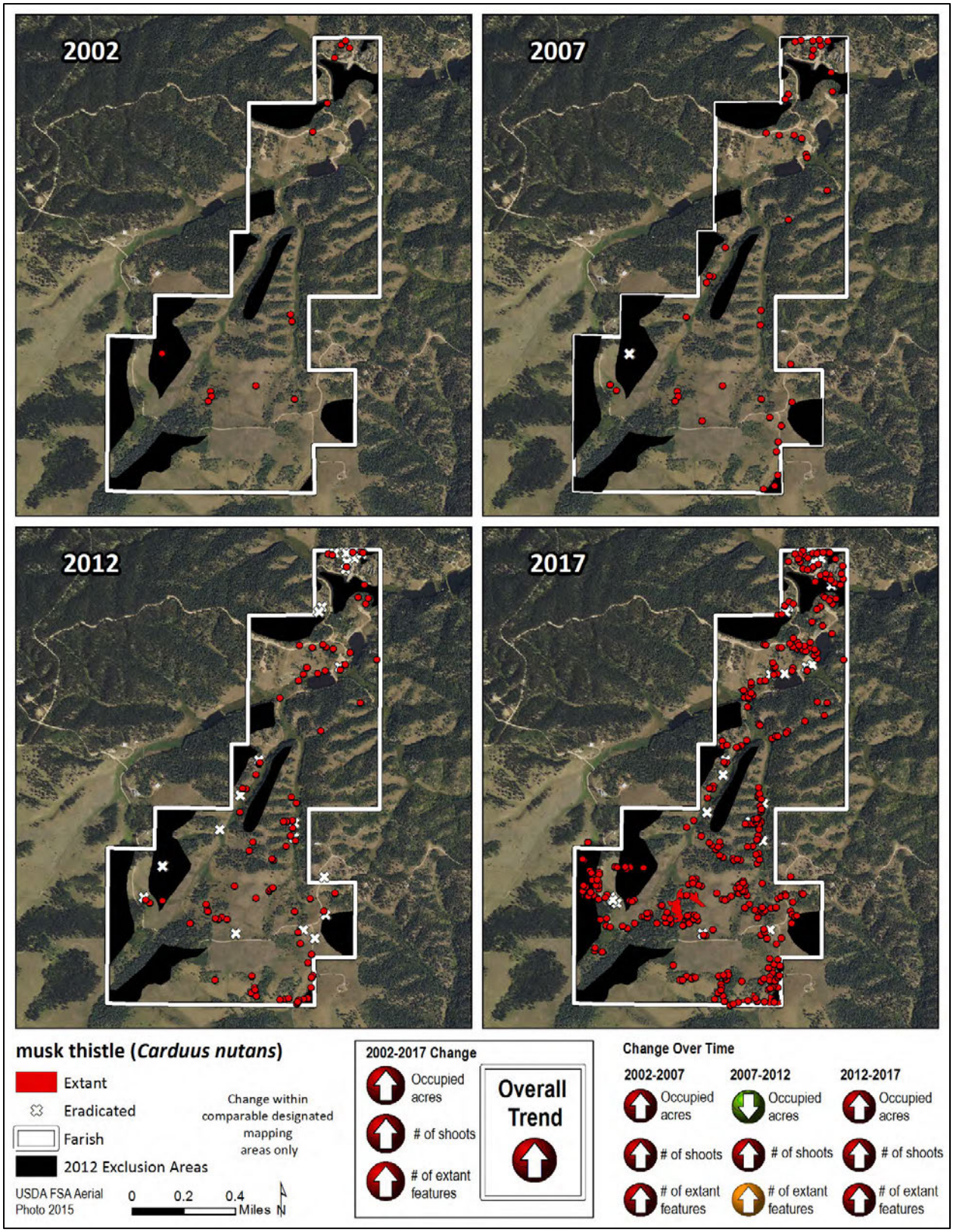
	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	0.82	56	13	---
2007	2.46	643	42	0
2012	1.12	2,829	84	20
2017	11.06	558,867	335	20

In 2012, musk thistle was mapped in designated mapping areas only. The full scope of known infestations at Farish is detailed in Table 20. Increases may be due in part to inappropriate herbicide application at the wrong growth stage (Photo 3). See Recommendations for the Academy.

Table 20. All infestations of musk thistle at Farish.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	0.85	57	14	---
2007	2.77	1,269	44	1
2012	1.43	3,456	87	21
2017	12.48	568,697	357	21

Photo 3. Musk thistles with herbicide applied to bolted stems at Farish in 2017, Alyssa Meier, CNHP.



Map 13. Distribution of musk thistle at Farish from weed surveys (2002, 2007, 2012, and 2017).

Diffuse, Spotted and Hybrid Knapweeds (*Centaurea diffusa*, *C. stoebe*, & *C.* x *psammogena*)

Overall Trend: Increasing (plots stable)

Management Goals: Suppression

State List: B

Left photo: Diffuse Knapweed, Michelle Washebek, right photo: Spotted Knapweed (*Centaurea stoebe*) Wiki Commons 2015

- Short-lived non-creeping perennial, biennial, occasionally annual that spreads only by seeds
- Seeds germinate in the spring or fall and anytime during the growing season with disturbance (CSU 2013b)
- Environmental disturbance promotes invasion (CSU 2013b)
- Seed longevity: 8-10 years (Colorado Code of Regulations 2014)

2018 Overall Mapping Results

In 2018, there was a basewide survey of the knapweeds (spotted, diffuse and hybrid). Diffuse knapweed is by far the most common species at the Academy, with 78 percent of the occupied acres, while spotted knapweed occupies 21% and the hybrid with 1% occupied acres.

The data is reported below for all knapweeds and in separate sections for each of the three types of knapweeds. The monitoring results are reported for all knapweeds as it has been done previously. The coverage of knapweeds far exceeds all other noxious weed species at the base with an occupied area of 226.42 acres (Table 21). Canada thistle is the next highest with 104 occupied acres.

Table 21. All infestations of diffuse, spotted, and hybrid knapweeds at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
Hybrid	2.64	24,770	295	159
Spotted	49.29	480,136	864	278
Diffuse	179.74	1,536,010	2,588	659
All Knap	226.42	2,040,916	3,747	1,096

Diffuse Knapweed (*Centaurea diffusa*)

2018 Mapping Results

Diffuse knapweed followed a similar pattern as spotted knapweed; it increased between 2002 and 2007 mapping events but appears to have stabilized between 2007 and 2018 in occupied acres. The estimated number of shoots has stabilized between 2012 and 2018. The number of extant features has continued to increase from 2002 to 2018 (Tables 22 & 23, Map 14).

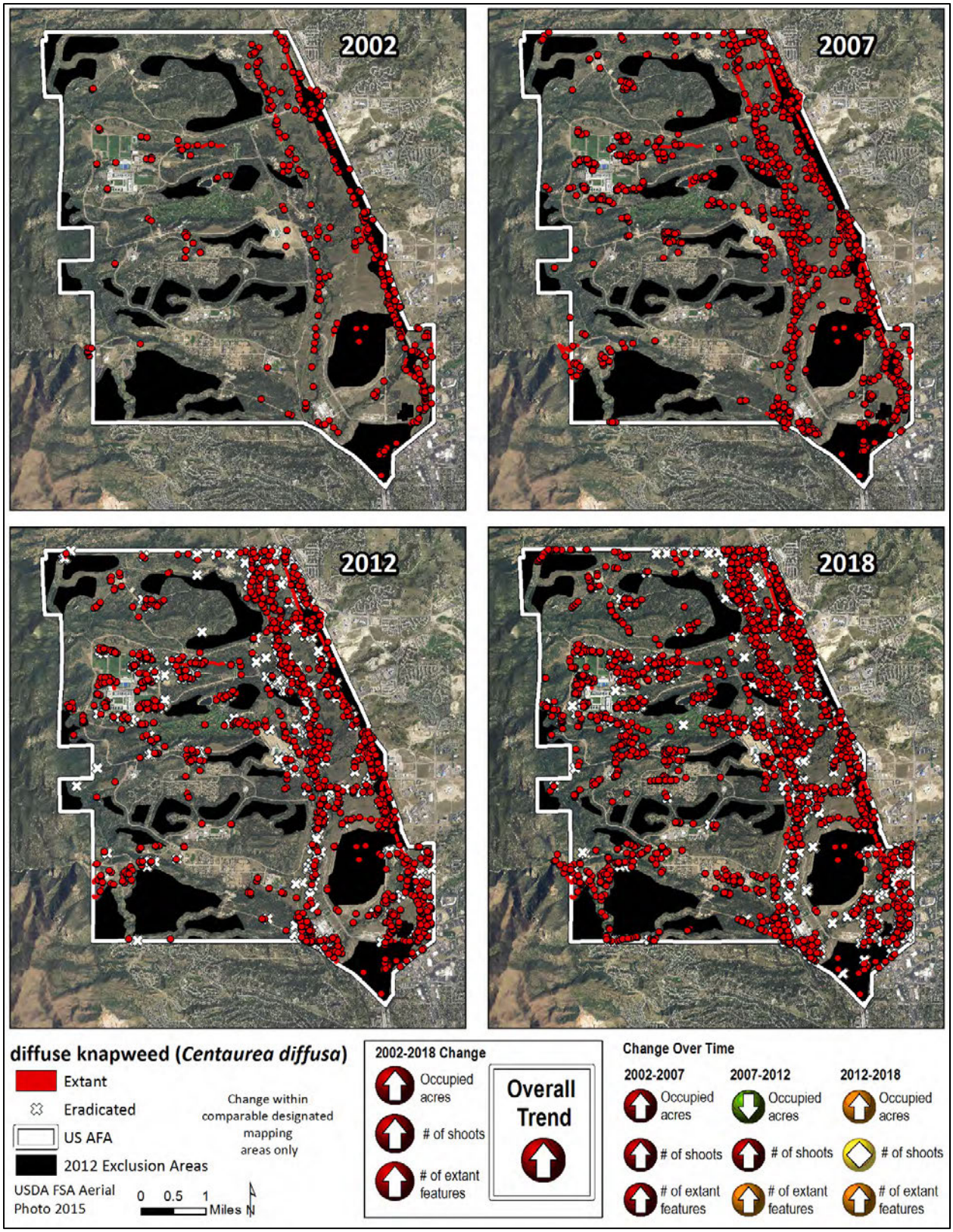
Table 22. Infestations of diffuse knapweed within comparable designated mapping areas at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	45.42	130,589	251	---
2007	119.86	394,197	913	0
2012	100.58	1,334,253	1,255	406
2018	158.41	1,423,367	2,407	630

In 2012, diffuse knapweed was mapped in designated mapping areas only. The full scope of known infestations is detailed in Table 23.

Table 23. All infestations of diffuse knapweed at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	56.37	141,805	328	---
2007	136.68	411,921	985	0
2012	117.41	1,352,457	1,329	406
2018	179.74	1,536,010	2,588	659



Map 14. Distribution of diffuse knapweed at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Spotted Knapweed (*Centaurea stoebe*)

2018 Mapping Results

Spotted knapweed increased between 2002 and 2007 mapping events but appears to have stabilized between 2007 and 2018 in occupied acres. The estimated number of shoots has stabilized between 2012 and 2018. The number of extant features has continued to increase from 2002 to 2018 (Tables 24 & 25, Map 15).

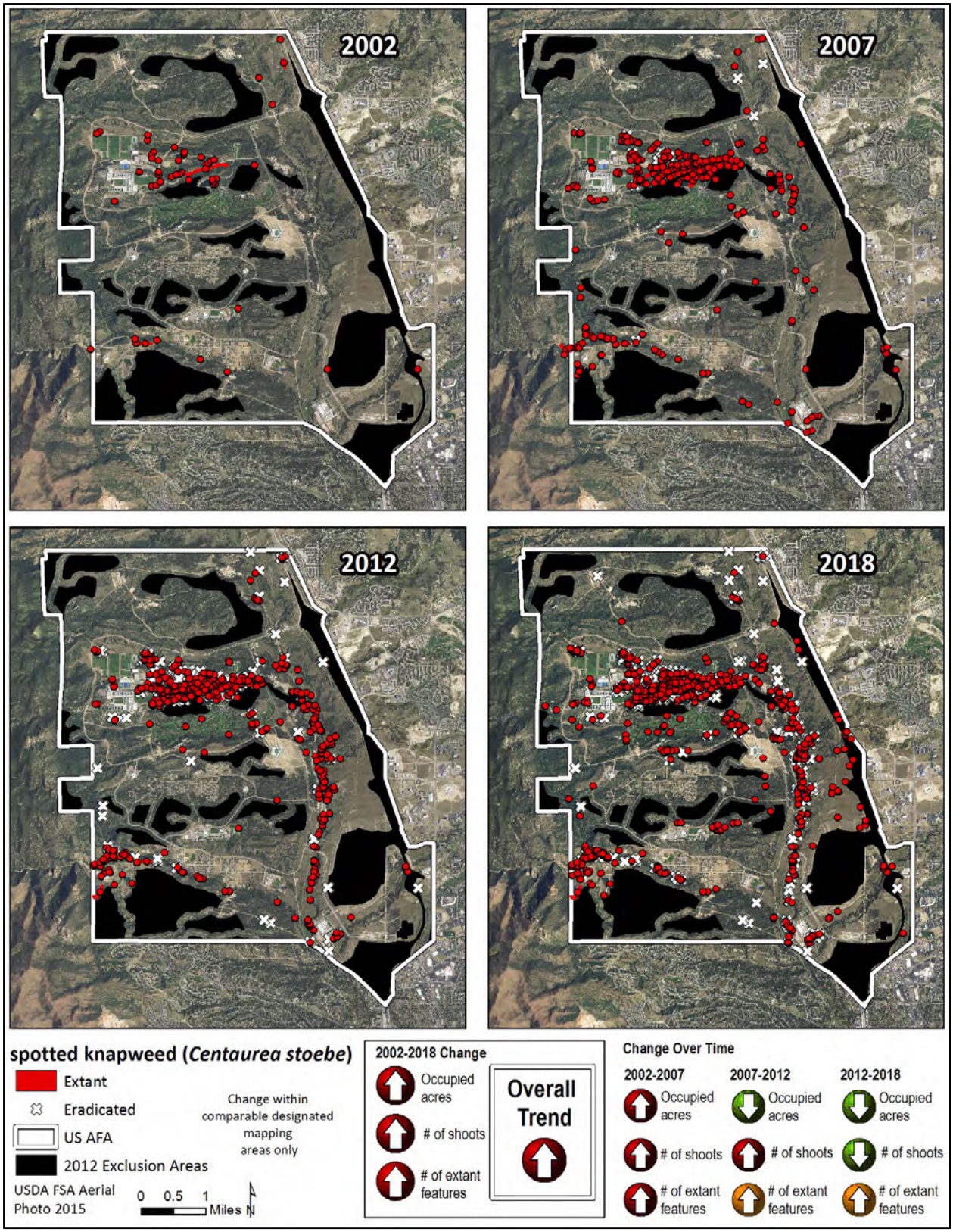
Table 24. Infestations of spotted knapweed within comparable designated mapping areas at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	4.67	3,485	54	---
2007	57.52	127,627	319	16
2012	53.02	543,144	565	156
2018	48.92	479,304	846	276

In 2012, spotted knapweed was mapped in designated mapping areas only. The full scope of known infestations is detailed in Table 25.

Table 25. All infestations of spotted knapweed at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	4.67	3,485	54	---
2007	57.58	127,836	323	16
2012	53.08	543,353	569	156
2018	49.29	480,136	864	278



Map 15. Distribution of spotted knapweed at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Hybrid Knapweed (*Centaurea* x *psammogena*)

2018 Mapping Results

The hybrid knapweeds were mapped with a similar occupied acres between 2007 and 2018 with a spike in 2012. The estimated number of shoots also spiked in 2012 with an overall increase since 2002. The numbers of extant features more than doubled between 2007 and 2012 and increased only slightly between 2012 and 2018 (Tables 26 & 27, Map 16).

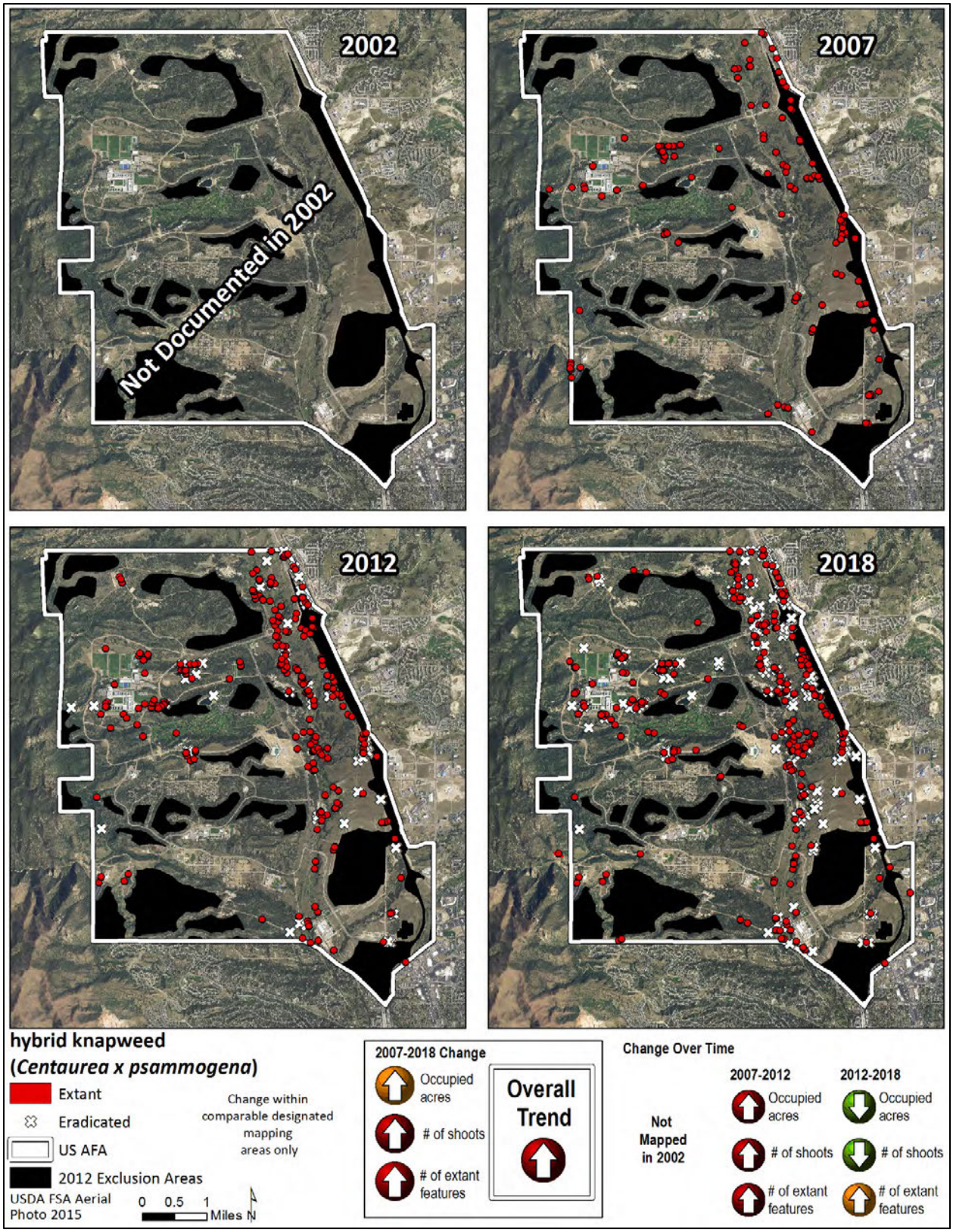
Table 26. Infestations of hybrid knapweeds within comparable designated mapping areas at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	1.75	2,810	118	---
2012	5.93	42,991	240	54
2018	2.42	22,110	279	155

In 2012, the hybrid knapweed was mapped in designated mapping areas only. The full scope of known infestations is detailed in Table 27.

Table 27. All infestations of hybrid knapweeds at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	1.8	2,922	125	---
2012	5.98	43,104	248	54
2018	2.64	24,770	295	159



Map 16. Distribution of hybrid knapweed at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Diffuse, Spotted, and Hybrid Knapweeds combined
2018 Mapping Results

The knapweeds at the Academy include diffuse and spotted knapweeds and their hybrid (*Centaurea* x *psammogena*). They cover the largest occupied area of all mapped noxious weeds with 226 occupied acres and an estimated two million shoots at 3,747 features (Table 21, Map 17). Knapweeds are very difficult to eradicate once they are established if follow-up plantings of native grasses and forbs are not part of an integrated management plan.

2018 Monitoring Results

Seven permanent knapweed plots were surveyed in 2018 (Map 18). The average number of shoots in the sampling plots has ranged from 17 to 66, the frequency has ranged from 6 to 36%, and the average knapweed height has ranged from 25-55 cm across all plots for 2012-2018 (Table 28). The data indicate an overall stable trend with a slight increase for frequency, a decrease in density and a stable percent cover for 2012-2018. The 2017-2018 data indicate a slight increase in frequency and percent cover, and an increase in density (Tables 29-31, Figure 10).

Table 28. Summary of knapweed permanent plot data, 2012-2018.

Non-Biocontrol Permanent Plot Sampling Method							
Year	*# Plots Sampled*	*# Quads Sampled*	*# quads with plants*	*Frequency (%)*	*Total # Shoots*	*AVG Height (cm)*	*AVG# Shoots/Plot*
2012	10	560	87	16	431	26	43
2013	10	551	33	6	168	30	17
2014	10	559	59	11	256	37	26
2015	9	496	71	14	296	45	33
2016	9	494	81	16	315	25	35
2017	9	499	112	21	483	38	54
2018	4	205	16	8	38	55	10
Biocontrol Permanent Plot Sampling Method							
2012	4	163	51	31	353	34	17
2013	3	114	41	36	116	34	39
2014	0	Herbicide applied to biocontrol plots					
2015	5	247	46	19	127	49	25
2016	3	185	35	19	127	26	42
2017	3	183	46	19	139	25	46
2018	3	183	42	23	200	31	66

Frequency (percent of quadrats with plants present) is the best indicator of an expanding or contracting population. Three of the 10 plots showed and increase since 2012 while the rest were stable. One biocontrol plot continues to show a decrease since 2012 with an increase from 2016-2018 (Table 29). The overall frequency is increasing slightly in the non-biocontrol plots (Figure 10) and it is stable to slightly decreasing in the biocontrol plots (Table 29).

Table 29. Frequency of knapweeds in permanent plots, 2012-2018. Frequency = % of quadrats with knapweeds. Bolded and shaded numbers indicate herbicide treatment. Colors indicate overall trend: yellow is stable or a change of <1 average standard deviation ASD; green represents a decrease of >1 ASD, and orange indicates an increase of >1 ASD. * indicates a change of >1 ASD for that year.

Plot Name	FREQ 2012 (%)	FREQ 2013 (%)	FREQ 2014 (%)	FREQ 2015 (%)	FREQ 2016 (%)	FREQ 2017 (%)	FREQ 2018 (%)	Average Frequency 2012-2018
CEDI3-1	**9**	0	**2**	7	7	5	---	5 (0-18)
CEDI3-2	**21**	3	6	Discontinued				
CEDI3-3	14	7	13	18	21	36*	---	18 (5-31)
CEDI3-4	11	21	15	15	13	20	23	17 (3-29)
CEDI3-5	14*	15*	**31**	42	47*	50*	Disc 2018	33 (20-46)
CEMA4-1	23	7*	27	31	41	53*	---	30 (17-43)
CEMA4-2	27*	0*	2	5	3	13	8	8 (0-20)
CEMA4-3	3	2	2	0	0	5	0	2 (0-14)
CEMA4-4	26*	8	6	6	8	11	---	11 (0-24)
CEMA4-5	2	2	0	0	0	0	5	1 (0-12)
AVG	**15**	**7**	**10**	**14**	**16**	**21**	**9**	**14**
SD	**9**	**7**	**10**	**14**	**18**	**19**	**9**	**13**
Biocontrol Plots								
SK ploop3	**31**	---	---	0	7	5	11	11 (0-31)
SK ploop1	**37**	---	---	5	11	23	10	17 (0-37)
DK railroad	**56**	**21***	---	48	39	48	48	43 (23-63)
DK hwy83	---	**100**	---	44	Discontinued			
KW monck	24	**43**	---	16	Discontinued			
AVG	**37**	**55**	**---**	**23**	**19**	**25**	**23**	**30**
SD	**12**	**33**	---	**20**	**17**	**18**	**18**	**20**

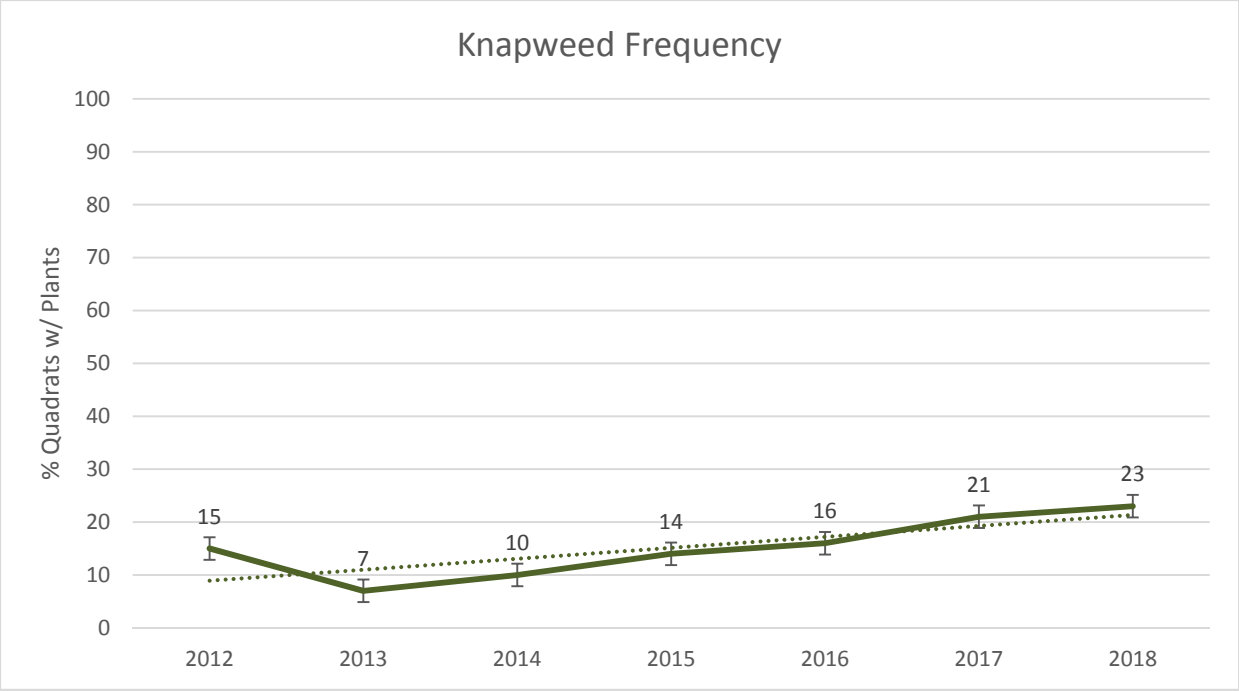


Figure 8. Knapweed frequency at non-biocontrol permanent plots, 2012-2018.

Density is calculated from the average number of stems arising from the ground in half meter quadrats and averaged for each plot; percent cover is an estimate of how much area is occupied within the half meter quadrats and averaged for the plot. Density and average cover are likely to be strongly correlated with annual precipitation values. The majority of the plots were stable to decreasing with less than 1 ASD difference from 2012-2018 with an increase from 2012 to 2018 in density and the percent cover was stable from 2012-2018 with a slight increase between 2017 and 2018 (Tables 30 & 31).

Table 30. Average density of knapweeds in permanent plots, 2012-2018. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: orange is an increase >1 average standard deviation (ASD), and yellow is stable). * indicates a change of >1 ASD for that year.

Plot Name	Density 2012	Density 2013	Density 2014	Density 2015	Density 2016	Density 2017	Density 2018	Average Density 2012-2018
CEDI3-1	**0.0**	0.0	**0.0**	0.10*	0.2	0.1	---	0.1 (0-0.8)
CEDI3-2	**1.0**	0.3	0.5	Discontinued				
CEDI3-3	0.0	0.3	0.5	0.5	0.6	1.1	---	0.5 (0-1.2)
CEDI3-4	0.0	0.4	0.5	0.6	0.7	0.5	0.5	0.5 (0-1.1)
CEDI3-5	1.0	0.6	**1.4**	2.4	2.4	3.3*	Disc 2018	1.9 (1.2-2.6)
CEMA4-1	2.0	0.1*	1.0	1.2	1.4	2.4*	---	1.4 (0.7-2.1)
CEMA4-2	2.0*	0.0*	0.1	0.1	0.1	0.4	0.3	0.4 (0-1.0)
CEMA4-3	0.0	0.0	0.0	0.0	0.0	0.1	0	0 (0-0.6)
CEMA4-4	2.0*	1.3	0.4	0.2	0.2	0.3	---	0.7 (0-1.4)
CEMA4-5	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0 (0-0.7)
AVG	**0.8**	**0.3**	**0.4**	**0.6**	**0.6**	**0.9**	**0.2**	**0.5**
SD	**0.9**	**0.4**	**0.4**	**0.7**	**0.8**	**1.1**	**0.2**	**0.6**

Biocontrol Plots								
SKploop3	1.0	---	---	0.0	0.1	0.1	0.2	0.3 (0-1.3)
SKploop1	1.0	---	---	0.1	0.2	0.6	0.6	0.5 (0-1.5)
DKrailroad	3.0	**0.4**	---	1.5	1.7	1.7	2.5	2.0 (1-3)
DKhwy83	---	**4.8**	---	0.6	Discontinued			
KWmonck	1.0	**1.0**	---	0.4	Discontinued			
AVG	**1.5**	**2.1**	**---**	**0.5**	**0.7**	**0.8**	**1.1**	**1.1**
SD	**0.9**	**1.9**	**---**	**0.5**	**0.9**	**0.7**	**1.0**	**1.0**

Table 31. Average % cover of knapweeds in permanent plots, 2012-2018. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: green represents a decrease of (>1 average standard deviation and yellow is stable. * indicates a change of >1 ASD for that year.

Plot Name	Cover (%) 2012	Cover (%) 2013	Cover (%) 2014	Cover (%) 2015	Cover (%) 2016	Cover (%) 2017	Cover (%) 2018	Average % Cover 2012-2017
CEDI3-1	0.3	0.0	**0.4***	0.9	0.1	0.1	---	0.3 (0-2.6)
CEDI3-2	2.7	0.1	0.7	Discontinued				
CEDI3-3	1.4	0.5	3.8	2.8	0.4	1.2	---	1.7 (0-4.0)
CEDI3-4	1.3	1.6	3.1	3.3	0.2	0.2	0.3	1.4 (0-3.4)
CEDI3-5	3.3*	2.3*	**16.5***	15.5*	1.0*	5.26	Disc 2018	7.3 (5.0-9.6)
CEMA4-1	1.7	0.3	5.3*	3.4	0.5	0.9	---	2.0 (0-4.3)
CEMA4-2	2.2	0.0	0.4	0.3	0.1	0.1	0.1	0.5 (0- 2.5)
CEMA4-3	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.1 (0-2.1)
CEMA4-4	6.2*	1.3	1.1	0.5	0.1	0.3	---	1.8 (0-4.1)
CEMA4-5	0.6	0.6	0.0	0.0	0.0	0.0	0.1	0.2 (0-2.2)
AVG	**2.0**	**0.7**	**3.1**	**3.0**	**0.2**	**0.9**	**0.1**	**1.4**
SD	**1.7**	**0.8**	**4.8**	**4.6**	**0.3**	**1.6**	**0.1**	**2.0**
Biocontrol Plots								
SKploop3	**4.4**	---	---	0.0	1.0	0.1	0.9	1.3 (0-7.4)
SKploop1	**4.1**	---	---	1.5	0.2	0.5	0.1	1.3 (0-7.4)
DKrailroad	**16.0***	**1.7**	---	7.8	0.1	0.8	2.0	4.7 (0-10.8)
DKhwy83	---	**54.5**	---	15.0	Discontinued			
KWmonck	**5.9**	**3.5**	---	5.6	Discontinued			
AVG	**7.6**	**19.9**	**---**	**6.0**	**0.4**	**0.5**	**1.0**	**5.9**
SD	**4.9**	**24.5**	**---**	**5.3**	**0.5**	**0.3**	**0.8**	**6.1**

Recommendations

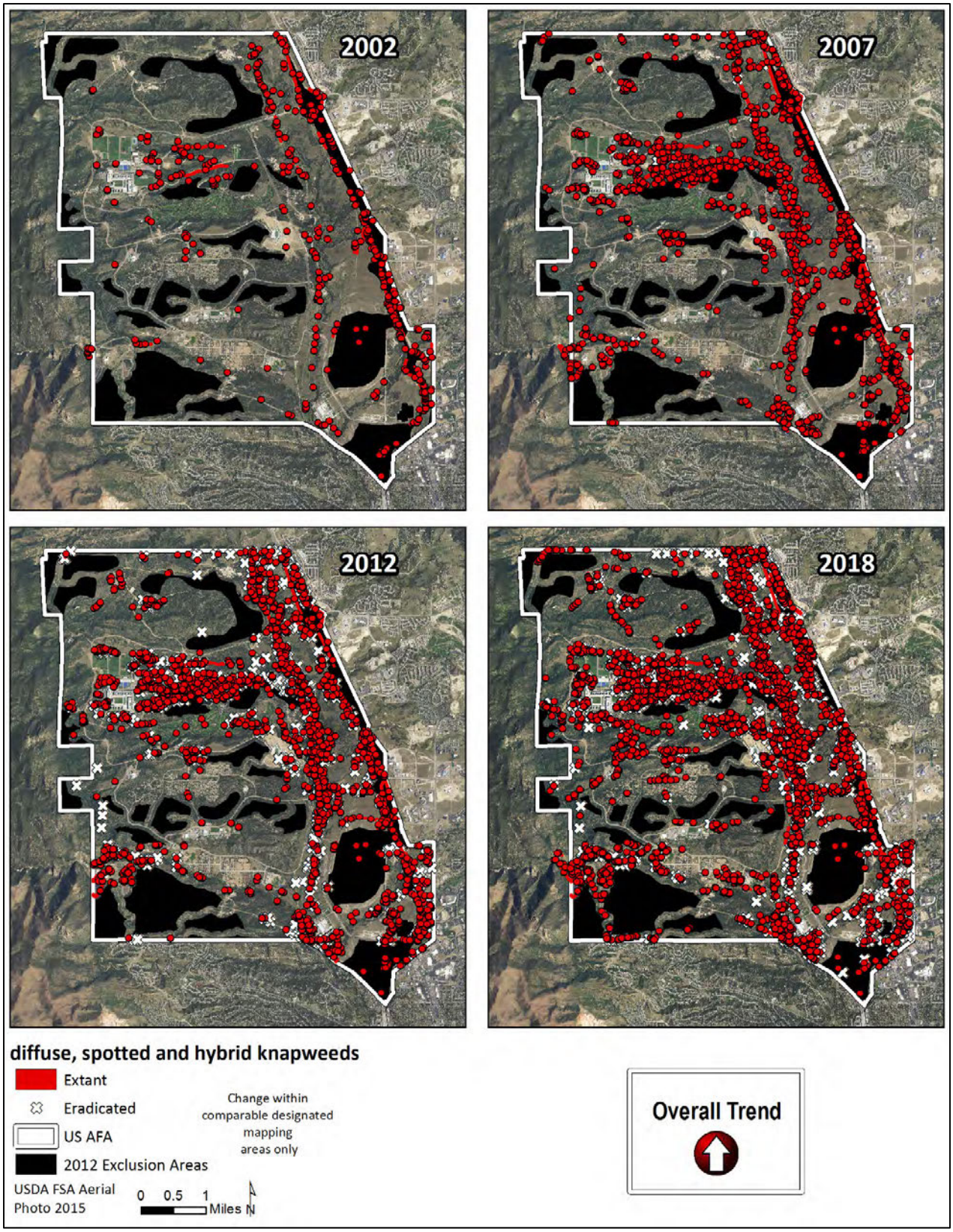
There has been a fairly aggressive chemical treatment program for knapweeds at the Academy; however, they continue to increase across the base. Consideration of a new treatment strategy for knapweeds using site plans is recommended. Recent research indicates herbicide treatments alone will not eliminate knapweeds (CSU 2013b) and if only chemical treatments are used to suppress plants the end result is an increase in weed cover (CSU 2013b, Pearson and Ortega 2009). To be most effective, treatments must not affect nearby native species or cause soil disturbances. Herbicides can cause soil disturbance by increasing bare ground, changing the pH and the balance of soil organisms, and impacting nearby native forbs and woody species (Nicholas et al. 2008). Partial treatments appear to be inevitable under current practices. If there is no plan to restore the

chemically or mechanically treated areas with native plantings, it may be prudent to discontinue herbicide applications in natural areas where native plants need to be protected (Smith et al. 2015). In addition, the presence of the native and rare (Colorado Natural Heritage Program tracked) plant species frostweed (*Crocanthemum bicknellii*) in monitoring plots needs to be considered. Frostweed is considered to be critically imperiled in Colorado with only a few known populations in the state.

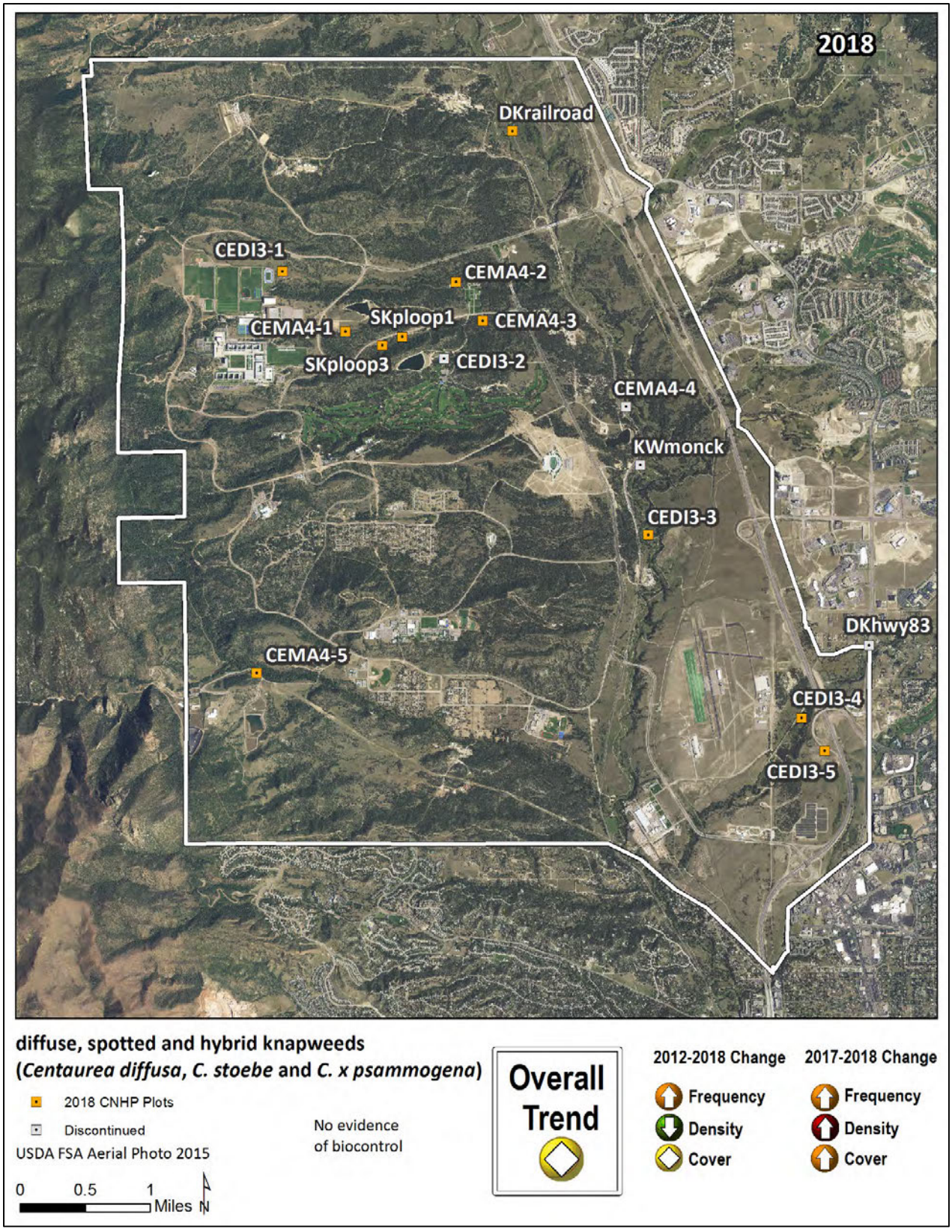
With the new scientific information, it is also clear that spraying dense stands of weeds with herbicides is not effective by itself. Replanting or restoration should be part of the plan to treat dense stands of weeds especially in wildlands.

History of Sampling and Treatment:

- Census mapping for knapweed distribution across the Academy property was conducted in 2002, 2007, and 2012.
- Ten CNHP permanent plots were established in 2012.
- In 2013, the diffuse and spotted knapweeds were combined into a hybrid swarm "knapweeds".
- In 2013, knapweeds, regardless of treatment, experienced a decrease in frequency, density, and cover, most likely due to the drought. (All of the 2013 plots were measured before the drought ended).
- TAMU established a new biocontrol plot, DK kwy83 in 2013.
- 2014 plot data show a decreasing overall trend, with the density showing a significant increase (Rondeau and Lavender-Greenwell 2013). All biocontrol plots were treated with herbicide and were not monitored by TAMU in 2014.
- In 2015, the plots were stable with a slight overall decrease. Only nine of the 10 plots were monitored (plot CEDI4-2 was incorporated into the nearby golf course). One plot (CEDI3-5) showed an increase despite being treated with herbicide. The biocontrol plots were all treated with herbicides and 2015 results show stable to slightly decreasing trends. One plot showed an overall decrease (DK hwy83) and KWmonck showed a slight decrease; this plot was impacted by wood dumping that buried about five percent of the plot and included six of the monitoring points for the plot in 2015.
- Frostweed (*Crocanthemum bicknellii*) was observed in monitoring plots in 2015 -2017. This species is considered to be critically imperiled in Colorado with only a few known populations in the state.
- In 2016, KWmonck and DK hwy83 were discontinued. The total number of plots surveyed was 12. The overall trend across all plots between 2012-2106 was stable to decreasing.
- In 2017, 12 total plots were surveyed with on overall stable trend. The biocontrol plot data will be kept separate for a couple of years because of the herbicide application observed in 2014.
- In 2018, seven of the 12 knapweed plots were monitored: CEDI -1 & 3, CEMA 1 & 4 were not monitored. CEDI 5 was discontinued because of issues keeping the permanent markers in place (plot was set up in a flood zone).



Map 17. Distribution of diffuse, spotted and hybrid knapweeds from basewide weed surveys (2002, 2007, 2012, and 2018).



Map 18. 2018 diffuse, spotted and hybrid knapweeds plots at the Academy.

Canada Thistle (*Cirsium arvense*)

Overall Trend: Increasing (plots stable-decreasing)

Management Goals: Suppression

State List: B

Photos: Left: Canada thistle plant at the Academy, CNHP. Upper right: Canada thistle in flower, CSU 2013c). Lower right: Canada thistle in seed by Jill Handwerk CNHP 2014.

- Perennial
- Horizontal and vertical root system
- Reproduction from root buds and seeds
- Seed longevity 22 years with deep burial promoting longevity (CSU 2013c)
- Susceptible to shading and inundation

2018 Overall Results

At the Academy and Farish, Canada thistle the mapping data shows the number of occupied acres, estimated number of shoots, and extant features are increasing compared to 2002. The permanent plot monitoring data show stable to decreasing trends for frequency, cover and density.

2018 Mapping Results at the Academy

Canada thistle is increasing across the base, with over 92 occupied acres and almost two million estimated shoots. The occupied acres are stable (slight increase) while the estimated number of shoots and extant features has increased since 2002-2007 (Tables 32 & 33, Map 19).

Table 32. Infestations of Canada thistle within comparable designated mapping areas at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	79.27	408,121	358	---
2007	90.68	379,992	543	0
2012	90.17	1,079,070	776	232
2018	92.35	1,718,919	1,126	401

Numbers derived from 2007 Canada thistle designated mapping areas

In 2007 and 2012, Canada thistle was mapped in designated mapping areas only. The full scope of known infestations is detailed in Table 33.

Table 33. All infestations of Canada thistle at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	101.36	529,103	543	---
2007	93.62	400,021	563	0
2012	95.95	1,169,173	963	232
2018	104.01	1,934,852	1,466	467

2018 Monitoring Results

Eight permanent plots were surveyed in 2018 for Canada thistle (two are biocontrol plots). The data from all plots indicate an overall stable to decreasing frequency, density and cover from 2012-2018 (Tables 34-37, Figure 11, Map 20).

Biocontrol agents have been observed in almost all the Canada thistle plots (not just the biocontrol plots). Biocontrol agents that form galls, necrotic leaf spots and browse by insects and animals have been observed consistently since 2015 when CNHP started making observations. In 2017, five of ten plots showed evidence of biocontrol and two in 2018 (Map 20).

Table 34. Summary of Canada thistle permanent plot data, 2012-2018.

Non-Biocontrol Permanent Plot Sampling Method							
Year	*# Plots Sampled*	*# Quads Sampled*	*#Quads w/plants*	*Frequency (%)*	*Total # Shoots*	*AVG Height (cm)*	*AVG# shoots/plot*
2012	8	416	117	27	502	43	63/plot
2013	Not Sampled						
2014	8	411	56	14	121	36	15/plot
2015	7	348	51	15	158	38	23/plot
2016	7	348	37	11	64	52	9/plot
2017	8	422	79	18	244	43	53/plot
2018	6	278	54	16	234	29	39/plot
Biocontrol Permanent Plot Sampling Method							
2012	4	140	66	47	329	35	17/plot
2013	1	62	16	26	44	30	16/plot
2014	Discontinued – herbicide application						
2015	1	50	6	12	12	19	12/plot
2016	2	91	4	4	12	39	6/plot
2017	2	97	5	5	6	10	3/plot
2018	2	97	7	13	19	33	10/plot

Table 35. Frequency of Canada thistle in permanent plots, 2012-2018. Frequency = % of quadrats with Canada thistle. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: green represents a decrease >1 average standard deviation and yellow is stable. * indicates a change of >1 ASD for that year.

Plot ID	FREQ 2012 (%)	FREQ 2013 (%)	FREQ 2014 (%)	FREQ 2015 (%)	FREQ 2016 (%)	FREQ 2017 (%)	FREQ 2018 (%)	Average Frequency 2012-2018
CIAR4-1	**21**	---	**13**	**8**	7	11	19	13 (2-24)
CIAR4-2	10	---	9	10	13	14	7	11 (0-22)
CIAR4-3	25	---	19	27	23	31	Disc	25 (14-36)
CIAR4-4	13	---	**15**	16	12	17	Disc	15 (4-26)
CIAR4-5	42*	---	**10**	6*	15	19	13	18 (7-29)
CIAR4-6	66*	---	21*	---	---	42	48	44 (33-55)
CIAR4-7	16	---	18	13	3	5	0	9(0-20)
CIAR4-8	19	---	**6**	**24***	5	8	6	11 (0-22)
AVG	**27**	**---**	**14**	**15**	**11**	**18**	**16**	**17**
SD	**18**	**---**	**5**	**7**	**7**	**12**	**16**	**11**
Biocontrol Plots								
CTice1	**58***	---	---	---	0*	0*	0*	19 (14-24)
CTploop	**52***	---	---	12*	8*	9*	13*	19 (14-24)
CTice2	**100**	Discontinued						
CTkettle	**24**	26	Discontinued					
AVG	**55**	**---**	---	**12**	**4**	**5**	**7**	**17**
SD	**3**	---	---	---	**6**	**5**	**7**	**5**

Discontinued

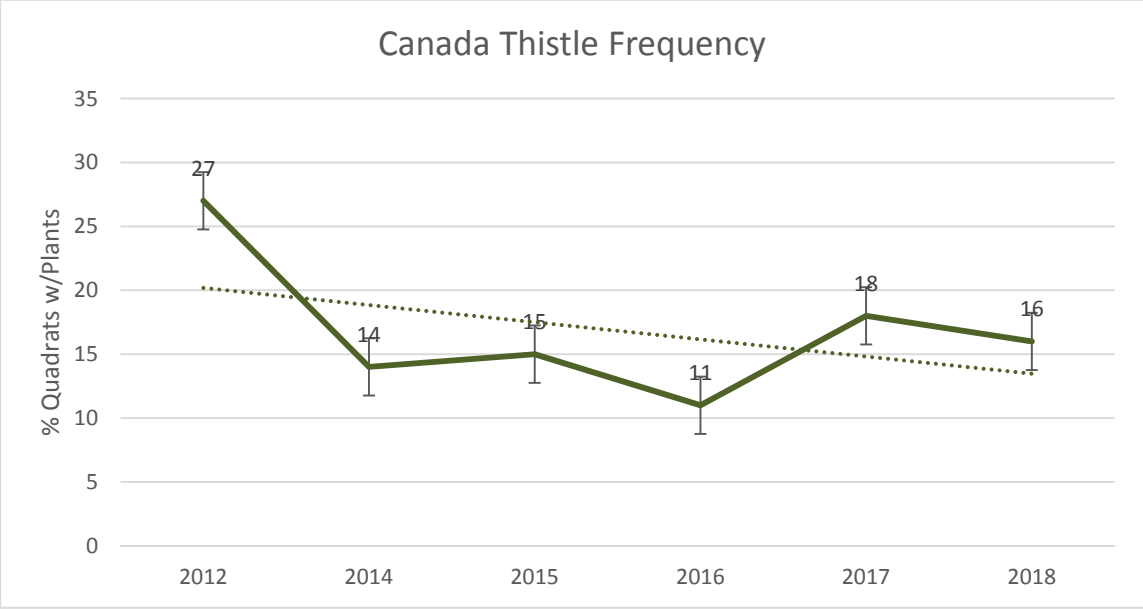


Figure 9. Canada thistle frequency at permanent plots, 2012-2018.

Density is calculated from the number of stems arising from the ground in half meter quadrats and averaged for each plot; percent cover is an estimate of how much area is occupied within the half meter quadrats and averaged for the plot. Five of the eight plots showed a decrease in density from 2012-2018 and remained stable from 2017-1018. Six of the eight plots showed a decrease in average percent cover from 2012-2017 and all plots were stable from 2017-2018 (Tables 36 & 37).

Table 36. Average density of Canada thistle in permanent plots, 2012-2018. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: yellow is stable with less than 1 average standard deviation (ASD), and green is a decrease indicating >1 ASD. * indicates a change of >1 ASD for that year.

Plot Name	Density 2012	Density 2013	Density 2014	Density 2015	Density 2016	Density 2017	Density 2018	Average Density 2012-2018
CIAR4-1	**1.1**	---	**0.4**	**0.3**	0.2	0.2	0.7	0.5 (0-1.1)
CIAR4-2	0.5	---	0.1	0.1	0.1	0.2	0.2	0.2 (0-0.8)
CIAR4-3	0.4	---	0.3	0.4	0.4	0.4	Disc	0.4 (0-0.9)
CIAR4-4	0.2	---	**0.3**	0.5	0.2	0.3	Disc	0.3 (0-0.8)
CIAR4-5	1.8*	---	**0.1**	0.1	0.2	0.5	0.4	0.5 (0-1.1)
CIAR4-6	3.9*	---	0.5*	---	---	2.4	2.7	2.4 (1.8-3.0)
CIAR4-7	0.4	---	0.4	0.3	0.1	0.1	0*	0.2 (0-0.8)
CIAR4-8	0.6	---	**0.1**	**1.2***	0.1	0.2	0.1	0.4 (0-1.0)
AVG	**1.1**	**---**	**0.3**	**0.4**	**0.1**	**0.5**	**0.7**	**0.5**
SD	**1.2**	**---**	**0.2**	**0.4**	**0.1**	**0.7**	**0.9**	**0.6**
BioControl								
CTice1	**1.7***	---	---	---	0*	0*	0*	0.4 (0.1-0.7)
CTploop	**3.1***	---	---	0.2*	0.2*	0.1*	0.4*	0.8 (0.5-1.1)
CTice2	**8.8**	Discontinued						
CTkettle	**0.7**	0.7	Discontinued					
AVG	**2.4**	**---**	**---**	**0.2**	**0.1**	**0.1**	**0.2**	**0.6**
SD	**0.7**	**---**	**---**	**---**	**0.1**	**0.1**	**0.2**	**0.3**

Table 37. Average % cover of Canada thistle in permanent plots, 2012-2018. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: yellow is stable with <1 average standard deviation (ASD), and green is a decrease indicating >1 ASD. * indicates a change of >1 ASD for that year.

Plot Name	Cover (%) 2012	Cover (%) 2013	Cover (%) 2014	Cover (%) 2015	Cover (%) 2016	Cover (%) 2017	Cover (%) 2018	Average Cover (%) 2012-2018
CIAR4-1	**2.2**	---	**1.3**	**1.1**	0.1	0.2	3.1*	1.3 (0.1-2.7)
CIAR4-2	1.6	---	1.2	0.6	0.1	0.1	0.2	0.6 (0-2.0)
CIAR4-3	1.7	---	1.7	2.2	0.5	0.3	Disc	1.3 (0-2.8)
CIAR4-4	0.7	---	**1.7**	1.2	0.3	0.2	Disc	0.8 (0-2.3)
CIAR4-5	7.4*	---	**0.3**	0.3	0.2*	0.2*	0.4	1.7 (0.3-3.1)
CIAR4-6	13.6*	---	3.4*	---	---	5.3*	2.3*	6.2 (5.8-7.6)
CIAR4-7	1.0	---	1.2	1.1	0.0*	0.1	0*	0.6 (0-2.0)
CIAR4-8	3.0*	---	**1.3**	**0.6**	0.1	0.1	0.1	0.9 (0-2.3)
AVG	**3.9**	**---**	**1.5**	**1.0**	**0.2**	**0.8**	**1.0**	**1.4**
SD	**4.2**	**---**	**0.8**	**0.5**	**0.2**	**1.7**	**1.2**	**1.4**
Biocontrol Plots								
CTice1	**7.1***	---	---	---	0.2	0*	0*	2.4 (0-5.8)
CTploop	**8.5***	---	---	2.3	0*	0.1	0.1	2.7 (0-6.1)
CTice2	**26.3**	Discontinued						
CTkettle	**1.7**	2.4	Discontinued					
AVG	**10.9**	**---**	**---**	**---**	**0.2**	**0.1**	**0.1**	**2.8**
SD	**10**	**---**	**---**	**---**	**0.1**	**0.1**	**0.1**	**2.3**

Recommendations

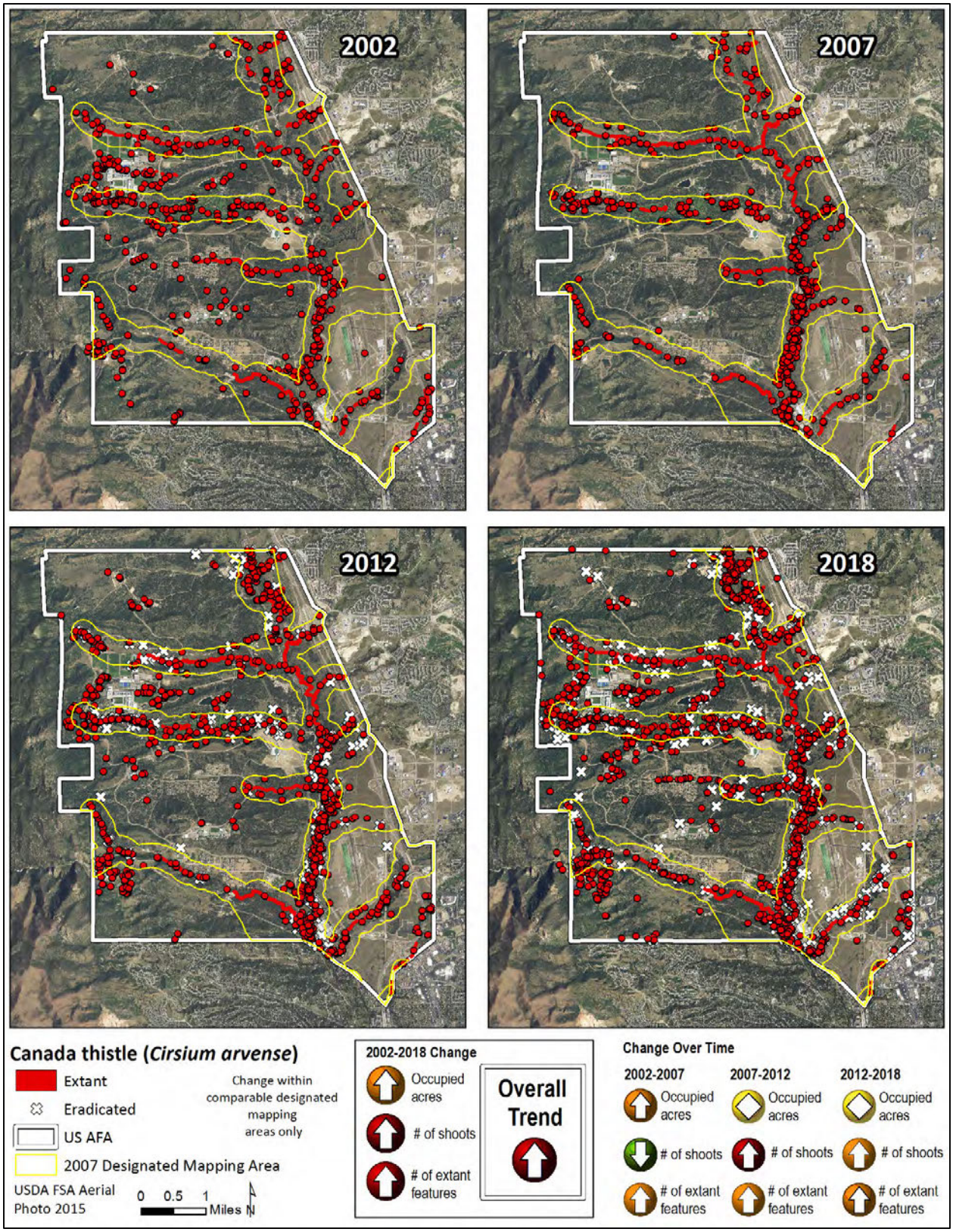
Consider a site plan before attempting to control Canada thistle in wildlands at the Academy. The protection of the rare amphibian species and rare plant species should be considered in future management since both were documented in the Canada thistle weed plots in previous years. A state vulnerable, Colorado species of concern, USFS and BLM sensitive amphibian species, Northern Leopard Frog (*Lithobates pipiens*), was noted in one of the Canada thistle monitoring plots (CIAR4-7) in 2015 and in the Jack's Valley seep area in 2018. An uncommon plant species (CNHP watchlist) carrion-flower (*Smilax lasioneura*) was also observed in this plot in 2015.

It should be noted when considering future treatments of Canada thistle that a number of studies are indicating that herbicides used in wildlands have not been successful at controlling Canada thistle without some other integrated management strategy (CSU 2013c, Pearson et al. 2016). A study in Rocky Mountain National Park demonstrated that weed management practices including both chemical and mechanical treatments resulted in impacts to soils, soil biota and native plant species that were as damaging as the impacts from the Canada thistle (Pritekel et al. 2006). This calls into question the use of herbicides or any treatments that damage soils in systems where the protection of native vegetation is critical. Encouraging the biocontrol activities and protecting the surrounding landscape from disturbances while monitoring for expansion combined with a site plan for any active management are highly recommended for areas with SWMAs. This will help document what is working to decrease weeds. Since most activities that impact the above ground

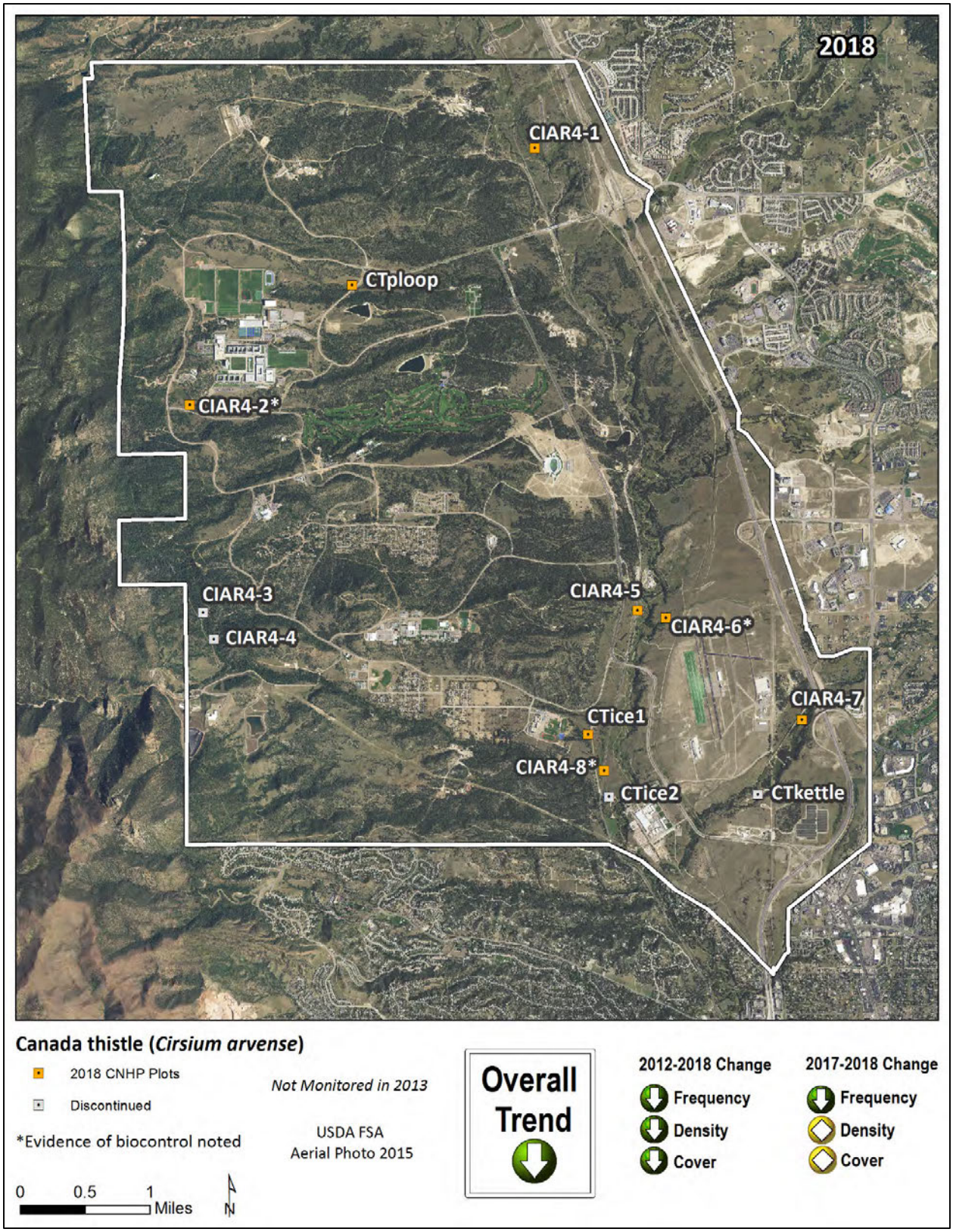
portions of the plant cause the underground root buds to be stimulated the actual footprint of Canada thistle can increase with treatments and may be best left untreated if there is no plan for restoration in dense areas.

History of Sampling and Treatments:

- In 2012, eight permanent plots were set up by CNHP.
- Census mapping for Canada thistle distribution across the Academy property was conducted in 2002, 2007, and 2012.
- Plots were monitored in 2012 and 2014.
- Although 2014 plot data trends are decreasing, it is worth noting that in 2012 we conducted weed mapping of Canada thistle. The number of extant features significantly increased between 2007 and 2012 (Lavender-Greenwell and Rondeau 2013).
- All plot metrics indicated a stable to decreasing trend from 2012-2015. Seven of eight permanent plots were monitored with the exception of CIAR4-6 (flooded); one biocontrol plot (CTploop) was added by CNHP in 2015. Biocontrol and insect and animal browse were noted on Canada thistle in six plots. A tracked amphibian species (Northern Leopard Frog) and a CNHP watchlisted plant species (carrion-flower) were both observed in Canada thistle monitoring plots in 2015. Plots were partially treated with herbicide.
- All metrics indicated a decreasing to stable trend for 2016. Seven of eight plots were sampled with CIAR4-6 flooded for the second year in a row. CTploop biomonitoring plot was monitored and a new plot CTice1 was added to bring the total plot number to 10 to strengthen statistics. CTice2 and CTkettle are discontinued. Both biomonitoring plots showed a decrease for all metrics greater than one average standard deviation from 2012-2016. Biocontrol organisms were noted in 7 plots in 2016 compared to only three in 2015. No plots were treated with herbicide in 2016.
- In 2017, 10 plots were monitored and show an overall decreasing trend compared to 2012. Five plots showed evidence of biocontrol organisms.
- In 2018, there was basewide noxious weed mapping and eight permanent plots were monitored for Canada thistle. Two plots were discontinued in the forested area on the west side as the vegetation was getting too dense to use the monitoring plot method that is suited to grasslands or shrublands.



Map 19. Distribution of Canada thistle at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).



Map 20. 2018 Canada thistle plots at the Academy.

2017 Canada Thistle Mapping Results at Farish

Farish was surveyed in 2017. The latest survey shows a large increases since 2002 (Tables 38 & 39, Map 21). Treatments should not be attempted without a site plan as they can make the weed footprint larger especially in natural areas.

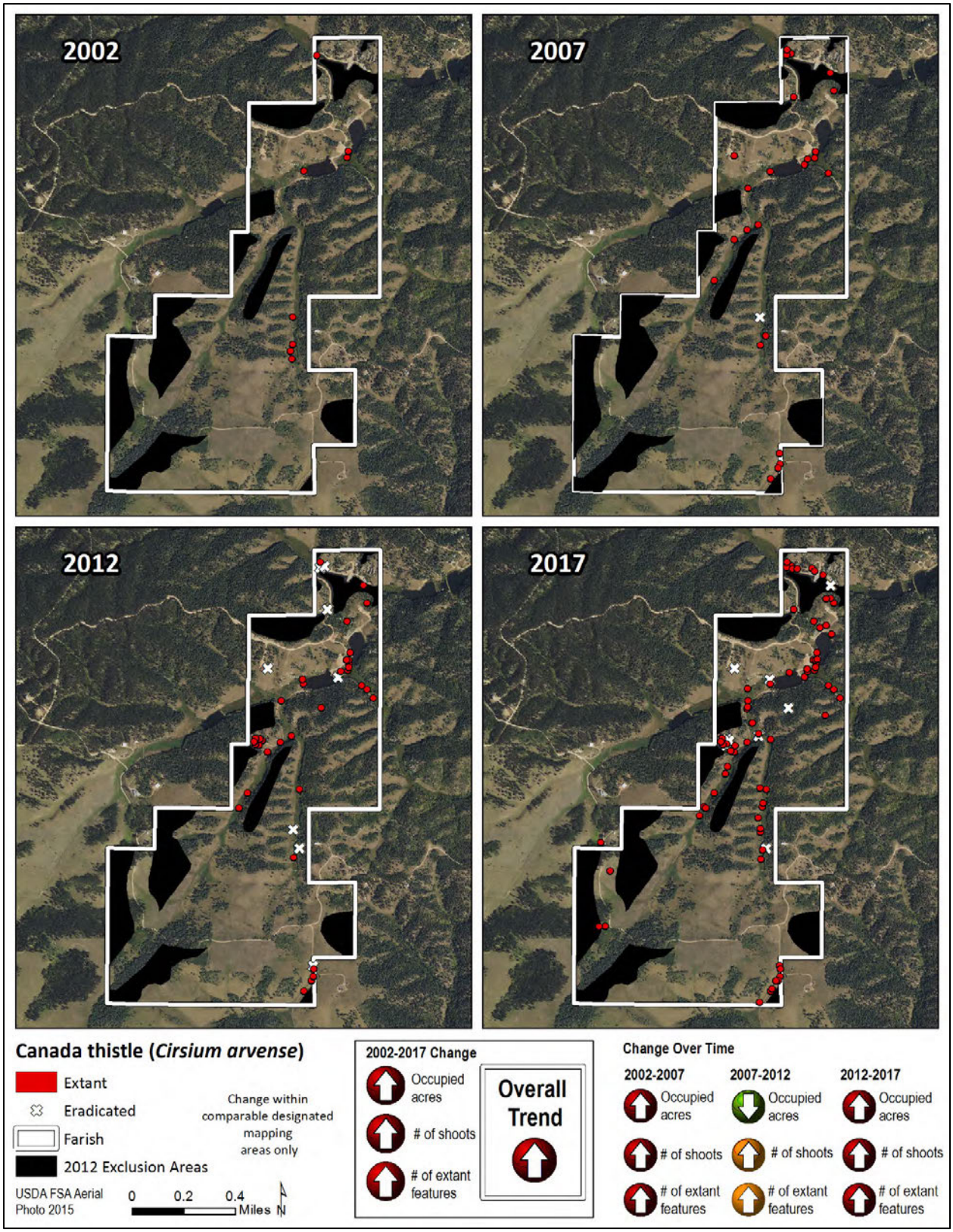
Table 38. Infestations of Canada thistle within comparable designated mapping areas at Farish.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	0.23	3,488	8	---
2007	1.55	14,734	23	1
2012	1.27	24,082	35	8
2017	3.95	169,584	72	9

In 2012, Canada thistle was mapped in designated mapping areas only. The full scope of known infestations at Farish is detailed below.

Table 39. All infestations of Canada thistle at Farish.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	0.23	3,488	8	---
2007	1.56	14,785	24	1
2012	1.28	24,132	36	8
2017	3.96	169,599	74	10



Map 21. Distribution of Canada thistle at Farish from weed surveys (2002, 2007, 2012, and 2017).

Bull Thistle (*Cirsium vulgare*)

Overall Trend: Increasing

Management Goals: Suppression

State List: B

Photo: http://www.kingcounty.gov/environment/animalsAndPlants/noxious-weeds/weed-identification/bull-thistle.aspx

- Biennial (annual), to 6ft. tall
- Reproduction by seed
- Often confused with native thistles
- Seed longevity is thought to be relatively long
- Clipped flower heads can still produce seeds
- Lower leaves with white hairs, upper surface has spines.
- Taproot to 2 ft.

Photo: Bull thistle at the Academy, Michelle Washebek, CNHP

2018 Mapping Results

The number of bull thistle shoots and extant features have increased since 2002 (Tables 40 & 41, Map 22). Spring and summer precipitation are correlated with occupied acres showing a decrease since 2007 and 2003 and an increase in 2018 (Figure 12).

Table 40. Infestations of bull thistle within comparable designated mapping areas at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002†	5.54	596	73	---
2007	6.42	4,347	128	0
2012	1.19	4,089	207	79
2018	3.96	14,982	407	170

†2002 values from field notes, not adequately mapped in GIS

In 2012, bull thistle was mapped in designated mapping areas only. The full scope of known infestations is detailed in Table 41.

Table 41. All infestations of bull thistle at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002†	5.54	596	73	---
2007	6.46	4,412	131	0
2012	1.23	4,154	210	79
2018	4.04	15,656	417	171

†2002 values from field notes, not adequately mapped in GIS

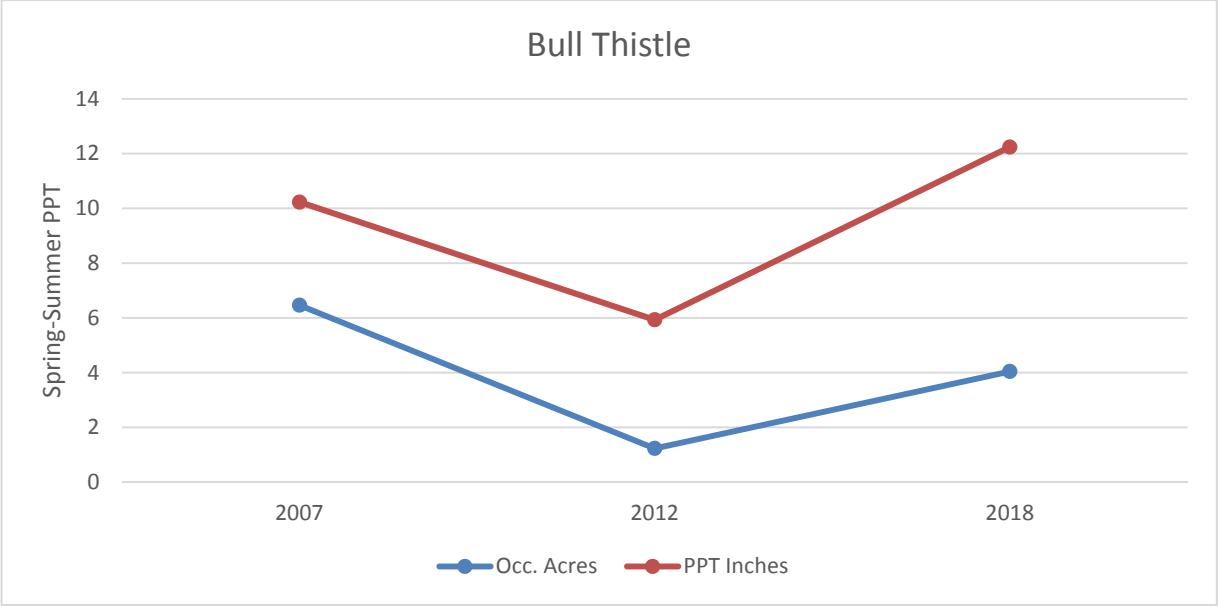


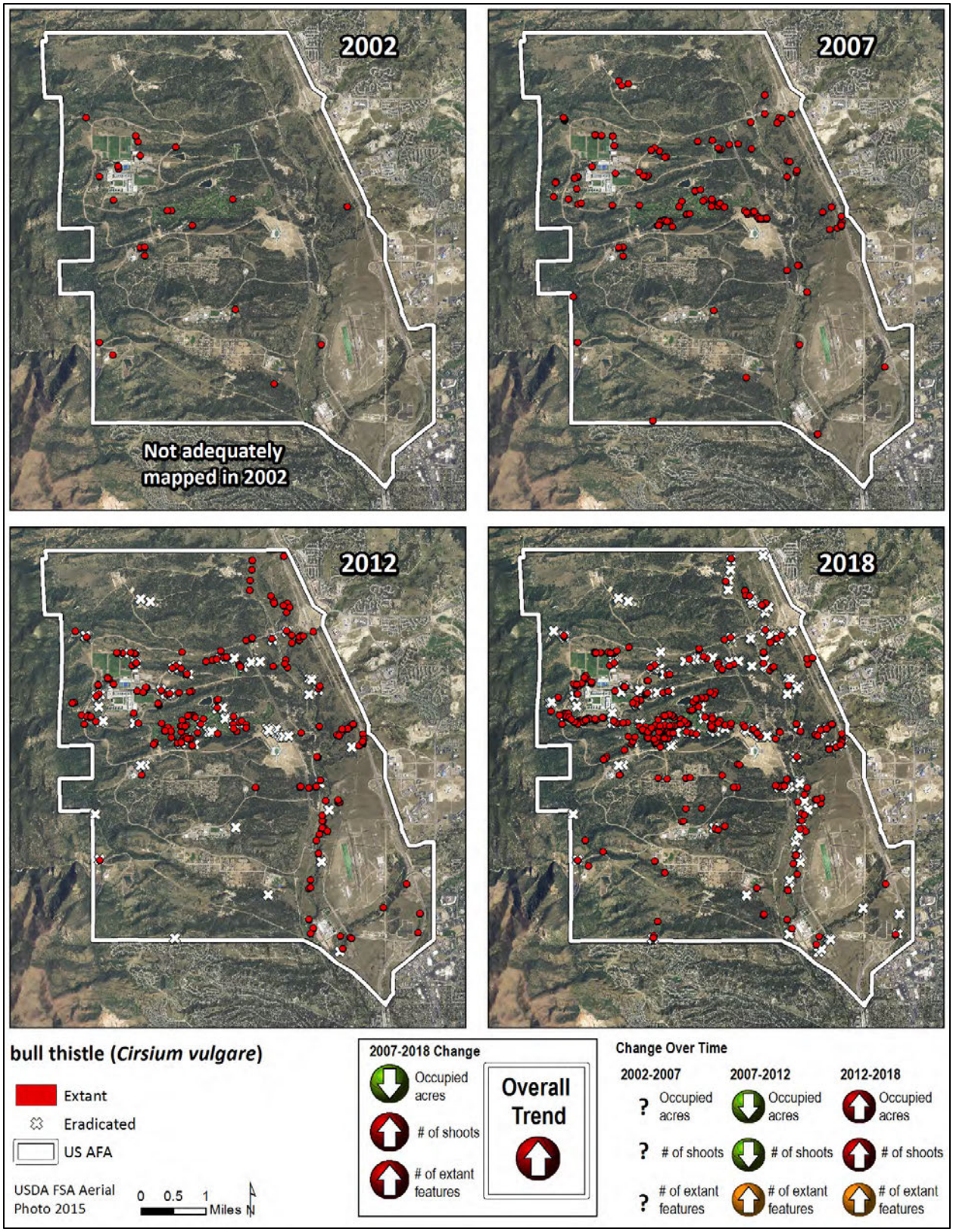
Figure 10. Comparison of spring-summer precipitation and occupied acres of bull thistle at the Academy.

Recommendations

Years that have wet spring and summer rains tend to show increases in populations. This species is can be treated by severing the plant below the root crown (cut below the soil surface). The best time to do this is in the spring or before the plants bolt. Bolted stems need to be removed if they have flower or seed heads. Since these plants are often found in moist to wet habitats, this is the preferred method. Chemical treatments in wetlands are not recommended, especially in the undeveloped areas of the Academy. Riparian areas are a disturbance dominated habitat especially at the Academy where unnatural flows occur along many of the major drainages that provide a constant source of seeds from the east and west sides of the Academy. Even if control could be achieved in a single year, the chance of reintroduction is exceedingly high in these areas. If treatments are to occur, they should have a site plan with a focus on what the site will look like when the treatment is undertaken, why it needs to occur and the follow-up and monitoring activities that will occur. In addition, the site should be a workable sized area with considerations for re-seeding as necessary and the utilization of techniques appropriate for wetlands.

History of Sampling and Treatment:

- Bull thistle was mapped as part of the basewide surveys in 2002, 2007, 2012 and 2018. Portions of its distribution in 2002 were only captured in field notes and not mapped.



Map 22. Distribution of bull thistle at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Houndstongue (*Cynoglossum officinale*)

Overall Trend: 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, photo BLM

Photo by M. DiTomaso, University of California - Davis

2018 Mapping Results

Houndstongue has been increasing in occupied acres, estimated number of shoots and in the number of mapped features since it was first discovered in 2009. There was a significant increase in the number of shoots and number of mapped features since the last basewide survey with most of the features located along Monument Creek (Table 42, Figure 13, Maps 23 & 24).

Table 42. All infestations of houndstongue at the Academy.					
	Occupied Acres	**Estimated Number of Shoots**	**Total Number of Features Visited**	**Number of Extant Features**	**Number of Eradicated Features**
2002	---	---	---	---	---
2007	---	---	---	---	---
2009	0.09	95	8	8	0
2010	0.02	11	7	1	6
2011	<0.01 (10 m²)	21	8	2	6
2012	0.01	70	12	3	9
2013	0.05	48	15	7	8
2014	0.04	102	16	8	8
2015	0.20	534	31	22	11
2016	0.20	480	36	22	14
2017	0.41	787	37	26	13
2018	0.51	4,514	71	50	22

Basewide weed mapping performed during shaded years.

Houndstongue was found in wetland areas that also contain a number of rare plant species. In addition, all features were mapped within the boundaries of the Special Weed Management Areas (SWMAs) delineated in the weed management plan (Smith et al. 2015).

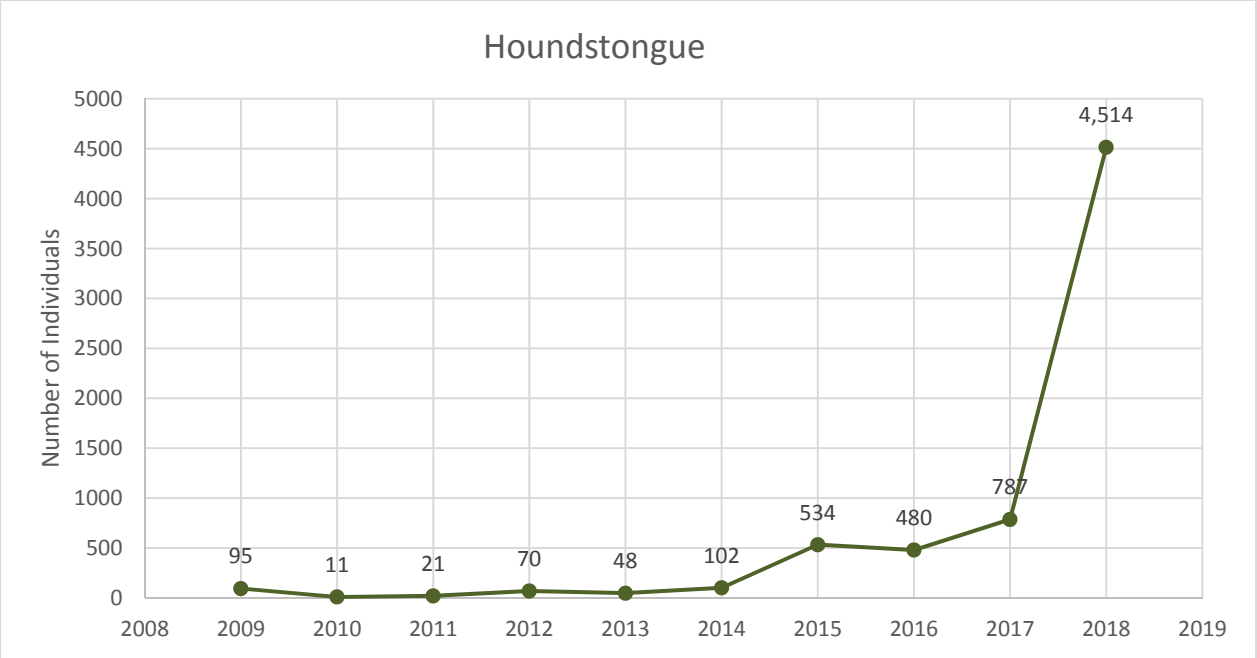


Figure 11. Number of houndstongue individuals, 2009-2018.

Recommendations

Overall, the numbers of individuals continue to climb despite treatments. Therefore, the first recommendation is to look as some individual sites to see what treatments are working (mechanical vs. herbicide) and look at the disturbance regime.

According to a number of studies (Nicholas et al. 2008, Norris 1999, Pritekel et al. 2006), if the focus is solely on the removal of a target weed species without consideration of impacts of the treatment on the surrounding vegetation, soils and fauna, the treatments will likely be unsuccessful and could create more problems. Herbicide treatments may also be contributing to the increases in numbers we are seeing. One of the problems previously identified at the Academy has been overkill at treated sites, where adjacent plants are being injured and/or killed and surrounding soils are being left in a disturbed state post treatment. In addition, when bare soil is exposed in the treatment areas noxious weed species start to occupy the area. The soil damage and an increase in weeds, likely due to herbicide treatment in a wet meadow containing rare plants at the Academy, is shown in Photo 4. The disturbance of intact native species increases the likelihood of increasing the weed species footprint in this wetland. The first rule in weed treatment is to protect intact surrounding areas from disturbance.

Photo 4. Area treated in a wet meadow for houndstongue. Treated area left bare soils and has new sprouts of houndstongue and other non-native species and noxious weeds including Canada thistle and common mullein. P. Smith 2015.

Observations at the treated sites also reveal that many plants, especially rosettes, were overlooked at treatment sites perhaps because they were not recognized and/or because they are tucked underneath nearby dense vegetation. The rosettes are hard to recognize and can be different sizes throughout the summer. Treatments at the inappropriate time of year when the plants are in fruit or flower will also lead to ineffective control if the plants are not handled properly.

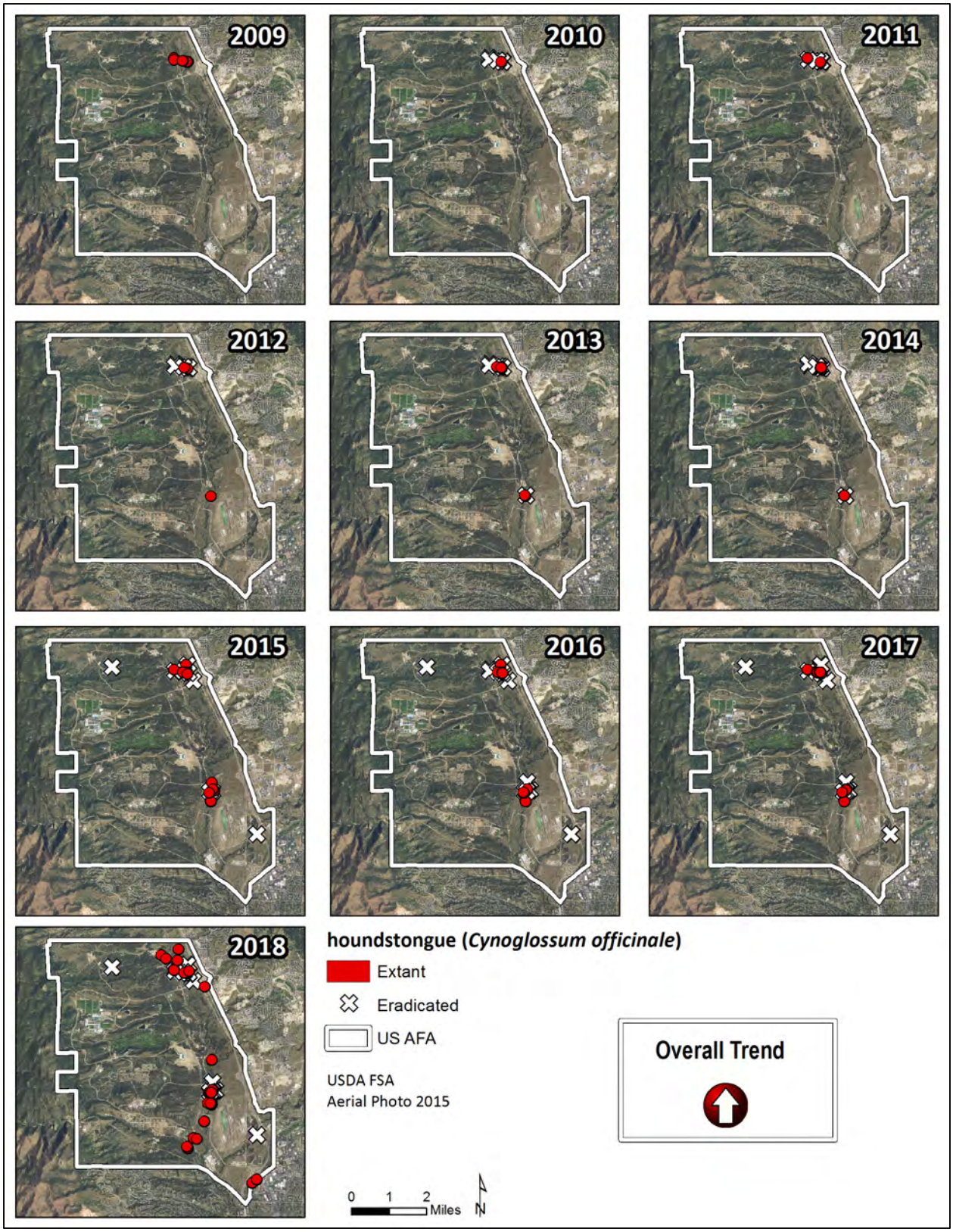
Since all the known houndstongue sites are within the designated Special Weed Management Area (SWMA) delineated in the 2014 Weed Management Plan (Smith et al. 2015) site plans for known locations should be created before any more chemical or mechanical treatments occur to track what is occurring at these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

Summary of Recommendations

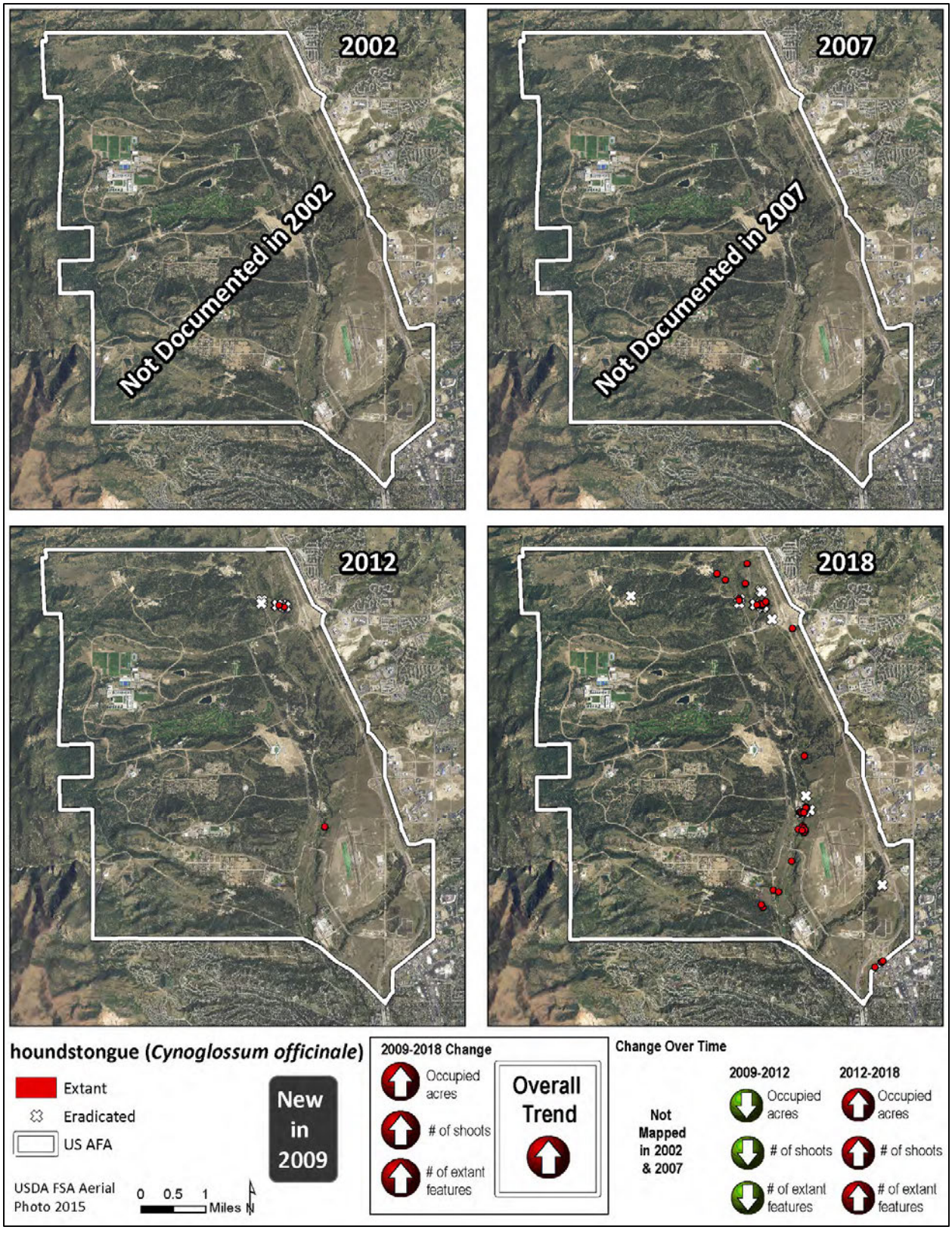
1. Protect intact habitats from disturbances (off road vehicles, unnecessary soil disturbances from chemical herbicide or manual treatments).
2. Mechanical removal is recommended (CDA 2019a). The root can be severed about an inch below the soil surface at the rosette stage before the plant bolts and produces flowers and/or seeds. If flowers or seed heads are present, remove the top portion of the plant. These tops should be placed in a black plastic bag and removed from the site. The black plastic bags should be left in the sun for a month to make sure the seeds are killed before discarding in the trash. Since this plant is a biennial, it dies after it produces flowers/fruits. Removal of the top portion causes less soil disturbance than digging the taproots.
3. Areas where soil area greater than a square foot is left bare should be planted with a native seed mix at the appropriate time.
4. Sites should be carefully surveyed under dense vegetation at the known sites for rosettes.
5. Follow-up monitoring should be conducted yearly. Seed longevity is relatively short compared to other species (five years) and should continue for at least five years after no plants were found. Observations should be made on the condition of the treatment site: notes on whether noxious weeds moving into the site or smooth brome, is biodiversity increasing or decreasing, bare soil presence etc.
6. Herbicide use is not recommended. If it is the manager's choice, only utilize herbicides that are legal for wildlands and wetlands. A precise spot application to rosettes making sure that wetland applications are made with wetland appropriate herbicide and that floodplains and intermittently inundated areas are considered to be wetlands. Make sure all applicators can recognize rare plants and the rosette stage of houndstongue.
7. Create a site plan before an area is treated. Houndstongue is a biennial species that often will work itself out of a system if the disturbance pressures are released. Years that have wet spring and summer rains tend to show increases in populations.

History of Sampling and Treatment

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



Map 23. Distribution of houndstongue at the Academy between 2009 and 2018.



Map 24. Distribution of houndstongue at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Common Teasel (*Dipsacus fullonum*)

Overall Trend: Increasing

Management Goals: Suppression

State List: B

- Biennial
- Reproduction by seed
- Flowers July-September
- Seeds viable for 2 years
- Grows to 6 feet tall
- Taproot to 2 feet - (CWMA 2018)

Photo: Jack's Valley 2018 P. Smith

Close-up by D. Gordon E. Robertson, CC BY-SA 3.0
https://commons.wikimedia.org/w/index.php?curid=8007987

Rosette

https://extension.umass.edu/landscape/weeds/dipsacus-fullonum

2018 Mapping Results

Common teasel increased in the number of extant features and numbers of shoots but appears to be stable to decreasing in occupied acres (Table 43). This biennial species is found in moist soils mostly along Monument, Kettle, and Pine Creeks on the east side of the Academy (Map 25).

Table 43. All infestations of common teasel at the Academy.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	18.33	1,693	35	---
2007	10.51	53,454	181	---
2012	9.26	116,595	319	65
2018	11.27	123,921	364	185

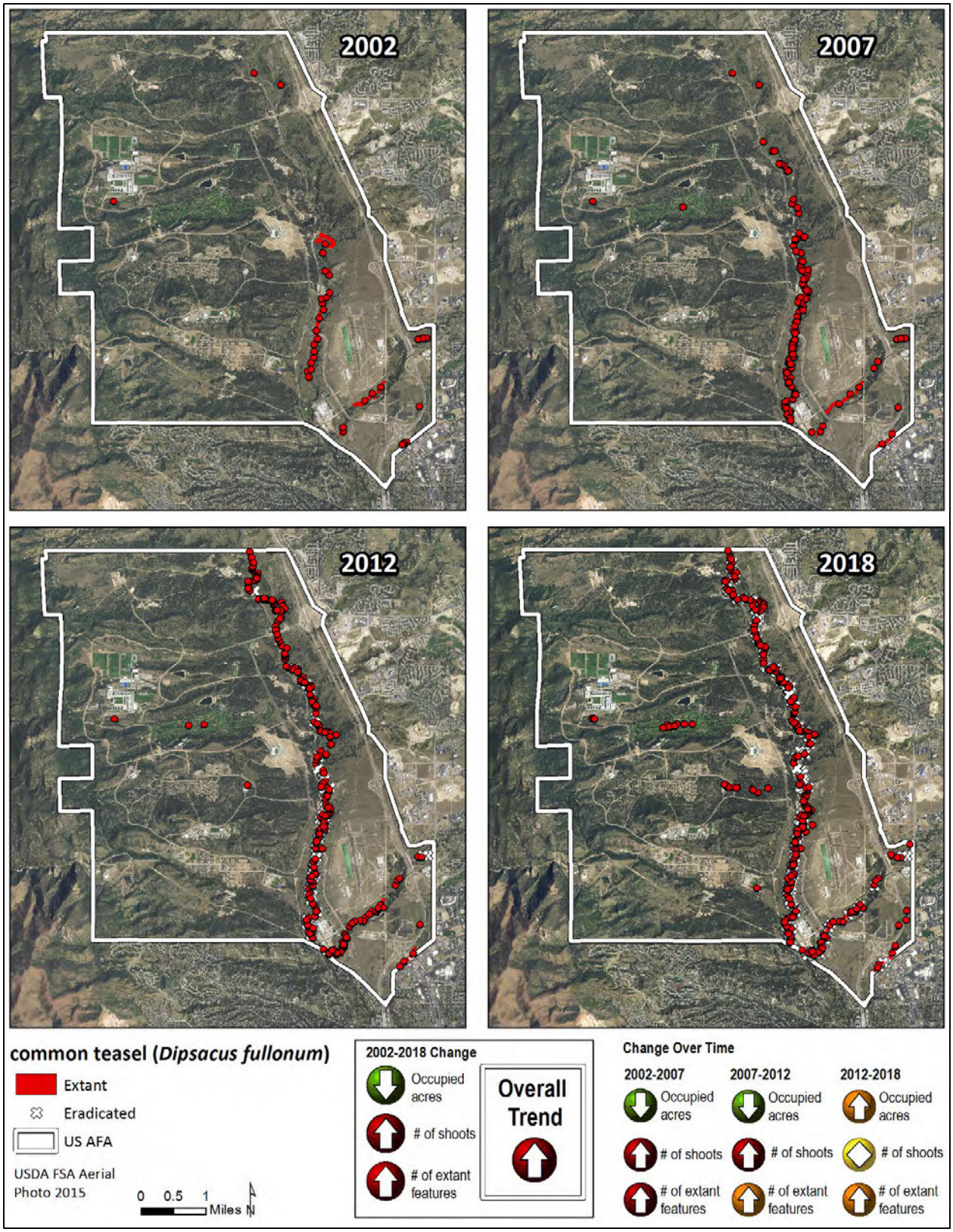
Common teasel has dense cover in patches along drainages at the Academy. Biennials tend to phase out of natural areas as long as the soil is not continually disturbed. Some locations near drainages are subjected to frequent flooding and disturbances. Flooding events, pulling, and herbicide treatments that impact soils will keep the area in an early seral stage that favors the establishment of weeds like common teasel. Published studies indicate that treated teasel patches tend to be much less biodiverse than they were pre-treatment. The presence of teasel does not necessarily mean impacts to native species. However, the impacts of removing the teasel, especially since the current cover is high, could be more disturbing to the surrounding vegetation than leaving the teasel in place. The moisture gradient is very important in determining the extent to which this plant will be able to move into an adjacent area and should be considered in a site plan before treatments occur.

Recommendations

The Colorado Department of Agriculture recommendations for treating teasel infestations indicate that mechanical methods are best for infestations smaller than 1/2 acre. Depending on the density, replanting with native species may be necessary. Any treatment should consider not harming other native plants present, ecology and site condition. Sever roots below the soil surface during the first year before the plant stores energy (rosette stage) and in the second year before seed production. Flower heads must be collected, bagged, and disposed of or destroyed; seeds will mature and germinate if left on the ground. All chemicals recommended are for pastures and rangelands, none are recommended for wildlands (CDA 2019). Treatments should start at the perimeter. Follow-up monitoring should occur within a couple of months of initial treatments. A site plan with specific tasks for what the treatment will entail and the expected outcomes and monitoring timelines should be in place before moving forward with treatments.

History of Sampling and Treatment

- Common teasel was mapped as part of the basewide surveys in 2002, 2007, 2012 and 2018.



Map 25. Distribution of common teasel at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Russian Olive (*Elaeagnus angustifolia*)

Overall Trend: Decreasing

Management Goals: Containment

State List: B

- Multi-stemmed shrub/tree (40ft)
- Deep roots
- Nitrogen-fixer
- Reproduction by seed and post injury sprouting, suckers
- Seeds viable for 3 years
- Ornamental escape/planted
- LEAVES ARE ALTERNATE (look-a-likes are opposite)

2018 Mapping Results

The basewide survey data indicate the occupied acres, numbers of shoots and extant features are decreasing at the Academy (Tables 44 & 45, Map 26).

Table 44. Infestations of Russian olive within comparable designated mapping areas at the Academy.				
	Occupied Acres	**Estimated Number of Shoots**	**Number of Extant Features**	**Number of Eradicated Features**
2002†	38.70	1,079	216	---
2007	13.30	531	89	129
2012	10.80	557	154	173
2018	6.78	632	95	262

† 2002 values are sums of 2002 and 2003 mapping

In 2012, Russian olive was mapped in designated mapping areas only. The full scope of known infestations is detailed in Table 45..

Table 45. All infestations of Russian olive at the Academy.				
	Occupied Acres	**Estimated Number of Shoots**	**Number of Extant Features**	**Number of Eradicated Features**
2002†	49.77	1,344	275	---
2007	18.96	641	117	156
2012	16.27	689	193	200
2018	6.91	653	108	322

† 2002 values are sums of 2002 and 2003 mapping

Recommendations

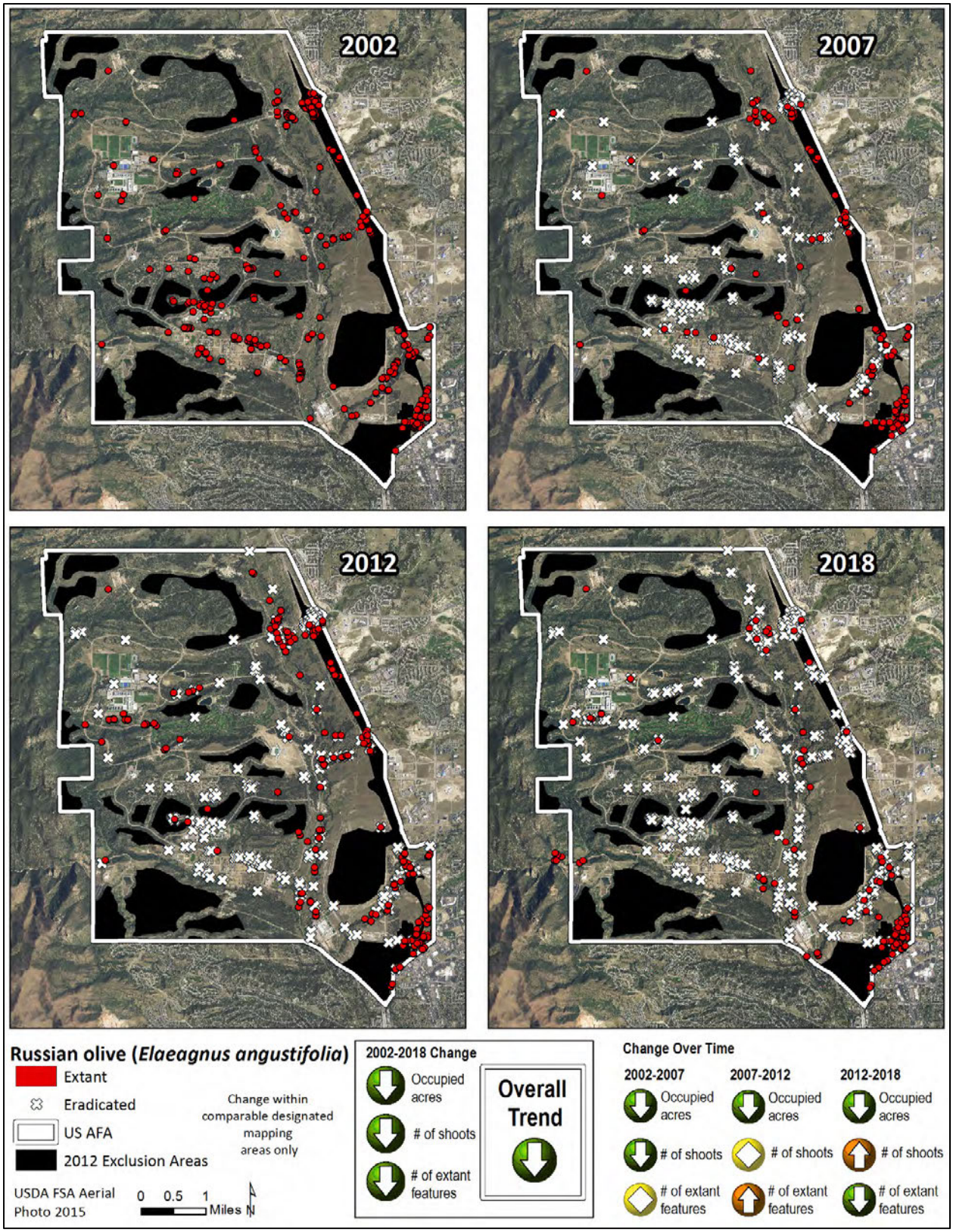
Make sure look-a-likes are not being targeted for treatment.

Shepherdia argentea by Paul Rothrock
http://swbiodiversity.org/seinet/imagelib/search.php?imagetype=all&phuid=5334&submitaction=search

Forestiera pubescens at Kettle Creek

History of Sampling and Treatment

- Russian olive was mapped as part of the basewide surveys in 2002, 2007, 2012 and 2018.
- Extreme drought in 2002 followed by relatively average precipitation in 2003 necessitated a second year of mapping in 2003.



Map 26. Distribution of Russian olive at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Leafy Spurge (*Euphorbia esula*)

Overall Trend: Increasing (plots decreasing)

Management Goals: Containment

State List: B

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

Photo by Michelle Washebek

2018 Overall Results (Academy and Farish)

At the Academy leafy spurge occupied acres, estimated number of shoots, and extant features are increasing compared to 2002. At Farish, a single population on nearby private land has increased, but it has not crossed the fence line. The permanent plot monitoring data show a stable to decreasing trend.

2018 Mapping Results at the Academy

The mapping results show an overall increasing trend for leafy spurge at the Academy since 2002 for occupied acres, estimated number of shoots and number of extant features. However, since 2007, the numbers of shoots have been decreasing and the occupied acres have stabilized (Tables 46 & 47, Map 27).

Table 46. Infestations of leafy spurge within comparable designated mapping areas at the Academy.				
	Occupied Acres	**Estimated Number of Shoots**	**Number of Extant Features**	**Number of Eradicated Features**
2002	0.91	28,338	32	---
2007	7.58	336,337	152	2
2012	10.64	275,713	204	30
2018	11.16	227,961	214	78

In 2012, leafy spurge was mapped in designated mapping areas only. The full scope of known infestations is detailed below in Table 47.

Table 47. All infestations of leafy spurge at the Academy.				
	Occupied Acres	**Estimated Number of Shoots**	**Number of Extant Features**	**Number of Eradicated Features**
2002	1.09	35,387	38	---
2007	8.21	372,666	162	2
2012	11.97	327,018	215	30
2018	11.77	230,883	224	80

2018 Monitoring Results

Ten permanent monitoring plots were surveyed in 2018 for leafy spurge. The data shows a stable trend for both frequency and density, and a decrease for cover from 2012-2018 (Tables 48-50, Figure 14, Map 28). The overall results continue to indicate a natural decline may be occurring which is further supported by the presence of biocontrol organisms at 50-70% of the plots (2017-2018).

Table 48. Summary of leafy spurge permanent plot data, 2012-2018.

Non-Biocontrol Permanent Plot Sampling Method							
Year	*# Plots Sampled*	*# Quads Sampled*	*# quads with plants*	*Frequency (%)*	*Total # Shoots*	*AVG Height (cm)*	*AVG# shoots/plot*
2012	10	600	171	29	1,234	32.0	123/plot
2013	10	609	151	25	676	26.8	68/plot
2014	10	593	139	23	664	30.0	66/ plot
2015	10	595	120	20	534	38.2	53/plot
2016	10	573	159	28	679	33.4	68/plot
2017	10	563	172	31	644	33.4	64/plot
2018	10	555	283	28	511	24.6	51/plot

Frequency (percent of quadrats with the plant present) is the best indicator of an expanding or contracting population and is the least sensitive to precipitation patterns. The frequency has remained stable from 2012-2018. Eight of the plots showed no differences greater or less than one average standard deviation over five sampling years and one plot decreased and one increased (Table 49, Figure 14).

Table 49. Frequency of leafy spurge in permanent plots, 2012-2018. Frequency = % quadrats with leafy spurge. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: yellow is stable <1 average standard deviation (ASD) and green is a decrease (>1 ASD). * indicates a change of >1 ASD for that year.

Plot Name	FREQ 2012 (%)	FREQ 2013 (%)	FREQ 2014 (%)	FREQ 2015 (%)	FREQ 2016 (%)	FREQ 2017 (%)	FREQ 2018 (%)	Average FREQUENCY 2012-2018
EUES-1	**29**	35	38	30	39	58*	39	38 (27-49)
EUES-2	**40***	3	3	2	8	19	15	13 (2-24)
EUES-3	**25**	15	**34**	13*	30	30	28	25 (14-36)
EUES-4	**27**	36	29	19	26	30	26	28 (17-39)
EUES-5	**31**	32	27	32	30	24	24	29 (18-40)
EUES-6	**35**	42	45	40	45	47	42	42 (31-53)
EUES-7	11	13	15	15	29	29	26	20 (9-31)
EUES-8	**27**	32	**15**	24	24	29	24	25 (14-36)
EUES-9	**43***	21	13*	22	34	35	40	30 (19-41)
EUES-10	18	18	15	5	17	15	19	16 (5-27)
AVG	**29**	**25**	**23**	**19**	**28**	**32**	**28**	**26**
SD	**9**	**12**	**13**	**11**	**11**	**12**	**9**	**11**

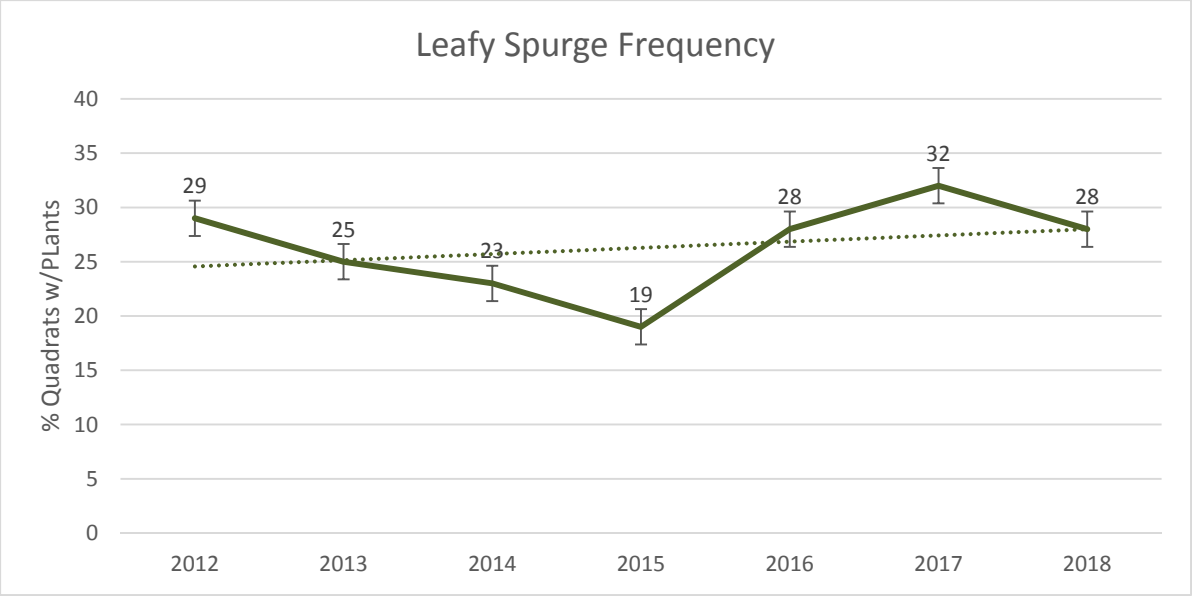


Figure 12. Leafy spurge frequency at 10 permanent plots, 2012-2018.

The overall trend was stable for density with seven plots stable for overall average density 2012-2018 and three plots showing decreases (Table 50). Density is calculated from the average number of stems arising from the ground in half meter quadrats and averaged for each plot. The percent cover is an estimate of how much area is occupied within the half meter quadrats and averaged for the plot. The average percent cover shows an overall decrease for 2012-2018 with eight plots showing a decrease and two plots remaining stable (Table 51).

Table 50. Average density of leafy spurge in permanent plots, 2012-2018. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: yellow is stable (less than 1 standard deviation) and green is a decrease (>1 standard deviation). * indicates a change of >1 ASD for that year.

Plot Name	Density 2012	Density 2013	Density 2014	Density 2015	Density 2016	Density 2017	Density 2018	Average Density 2012-2018
EUES-1	**2**	2.2	1.9	2.4	1.4	2.6	1.1	1.9 (1.2-2.6)
EUES-2	**6***	0.0*	0.0*	0.1*	0.1*	0.7	0.7	1.1 (0.4-1.8)
EUES-3	**1**	0.6	**1.6**	0.8	1.2	1.3	1.4	1.1 (0.4-1.8)
EUES-4	**1**	1.4	1.5	0.4	0.8	1.0	0.6	1.0 (0.3-1.7)
EUES-5	**3***	1.8	1.0	1.1	1.0	0.7	0.8	1.3 (0.6-2.0)
EUES-6	**2**	1.9	2.1	1.2	2.1	1.8	1.4	1.8 (1.1-2.5)
EUES-7	0*	0.4	0.7	0.4	1.1	1.1	0.5	0.6 (0-1.3)
EUES-8	**2**	2.1	**0.5**	1.7	1.7	1.2	1.3	1.5 (0.8-2.2)
EUES-9	**4***	1.9	0.3*	0.6*	1.6	1.1	1.1	1.5 (0.8-2.2)
EUES-10	2*	1.1	0.6	0.3	1.0	0.6	0.5	0.9 (0.2-1.6)
AVG	**2.3**	**1.3**	**1.0**	**0.9**	**1.2**	**1.2**	**1.0**	**1.3**
SD	**1.6**	**0.7**	**0.7**	**0.7**	**0.6**	**0.6**	**0.3**	**0.7**

Table 51. Average % cover of leafy spurge in permanent plots, 2012-2018. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: yellow is stable (less than 1 standard deviation) and green is a decrease (>1 standard deviation). * indicates a change of >1 ASD for that year.

Plot Name	Cover (%) 2012	Cover (%) 2013	Cover (%) 2014	Cover (%) 2015	Cover (%) 2016	Cover (%) 2017	Cover (%) 2018	Average % Cover (2012-2018)
EUES-1	**1.9**	2.0	7.3*	1.6	0.7*	0.8*	0.7*	2.1 (1.3-2.9)
EUES-2	**4.1***	0.1	0.1	0.1	0.1	0.3	0.2	0.7 (0-1.5)
EUES-3	**1.1**	0.4	**0.8**	0.3	0.6	0.5	0.3	0.6 (0-1.4)
EUES-4	**1.3**	1.3	4.0*	0.5	0.3*	0.4	0.3*	1.2 (0.4-2.0)
EUES-5	**0.8**	2.3*	2.8*	1.5	0.4	0.2*	0.2*	1.2 (0.4-2.0)
EUES-6	**2.0**	2.3	5.2*	1.6	0.7*	0.5*	0.6*	1.8 (1.0-2.6)
EUES-7	0.2	0.7	3.3*	0.9	0.4	0.5	0.3	0.9 (0.1-1.7)
EUES-8	**2.1**	3.5*	**1.1**	2.5	0.8	0.4*	0.1*	1.5 (0.7-2.3)
EUES-9	**2.1***	1.4	0.7	0.8	0.3	0.7	0.4	0.9 (0.1-1.7)
EUES-10	1.1	0.5	0.6	0.2	0.3	0.2	0.2	0.4 (0-1.2)
AVG	**1.7**	**1.5**	**2.6**	**1.0**	**0.5**	**0.5**	**0.3**	**1.2**
SD	**1.0**	**1.0**	**2.3**	**0.7**	**0.2**	**0.2**	**0.2**	**0.8**

Rare Plants

Two CNHP tracked rare plant species were documented in the plots in 2016-2018, the Rocky Mountain phacelia (*Phacelia denticulata)* was documented in (EUES-10) and the plains frostweed (*Crocanthemum bicknelli*) was observed in EUES 4 and 5 (Photo 5). The Rocky Mountain phacelia is considered to be globally vulnerable and is a regional endemic species (G3/S3) and is fully tracked by the Colorado Natural Heritage Program. This plant is only known from three states in the western U.S. The plains frostweed is a state critically imperiled (G5/S1) species known from only a few locations in the state.

Photo 5. Plains frostweed (left) and Rocky Mountain phacelia (right).

Recommendations

1) Herbicide should not be applied to leafy spurge plots. The two plots that were not treated in 2012 do not appear to be different from treated plots.
2) Consider monitoring for other leafy spurge locations for the presence of biocontrol agents. Populations appear to be declining naturally, monitoring is recommended to prevent disturbance.
3) Herbicide application is not recommended for leafy spurge populations without site plans, not only in the monitoring plots, but in the vicinity as the biocontrol organisms are present and active. In addition, the monitoring data shows the biocontrol organisms are working as the six year monitoring trend is showing stable to decreasing trends. Evidence of biocontrol was noted in eleven quadrats at six different plot locations in 2016 and at seven plots in 2017 and five plots in 2018. The biocontrol organisms were frequently noted by Michels and the TAMU crew who were specifically seeking them out at appropriate emergence times. These organisms are likely contributing to observed decreases and perhaps the reason the populations are stable to decreasing (Michels 2014).

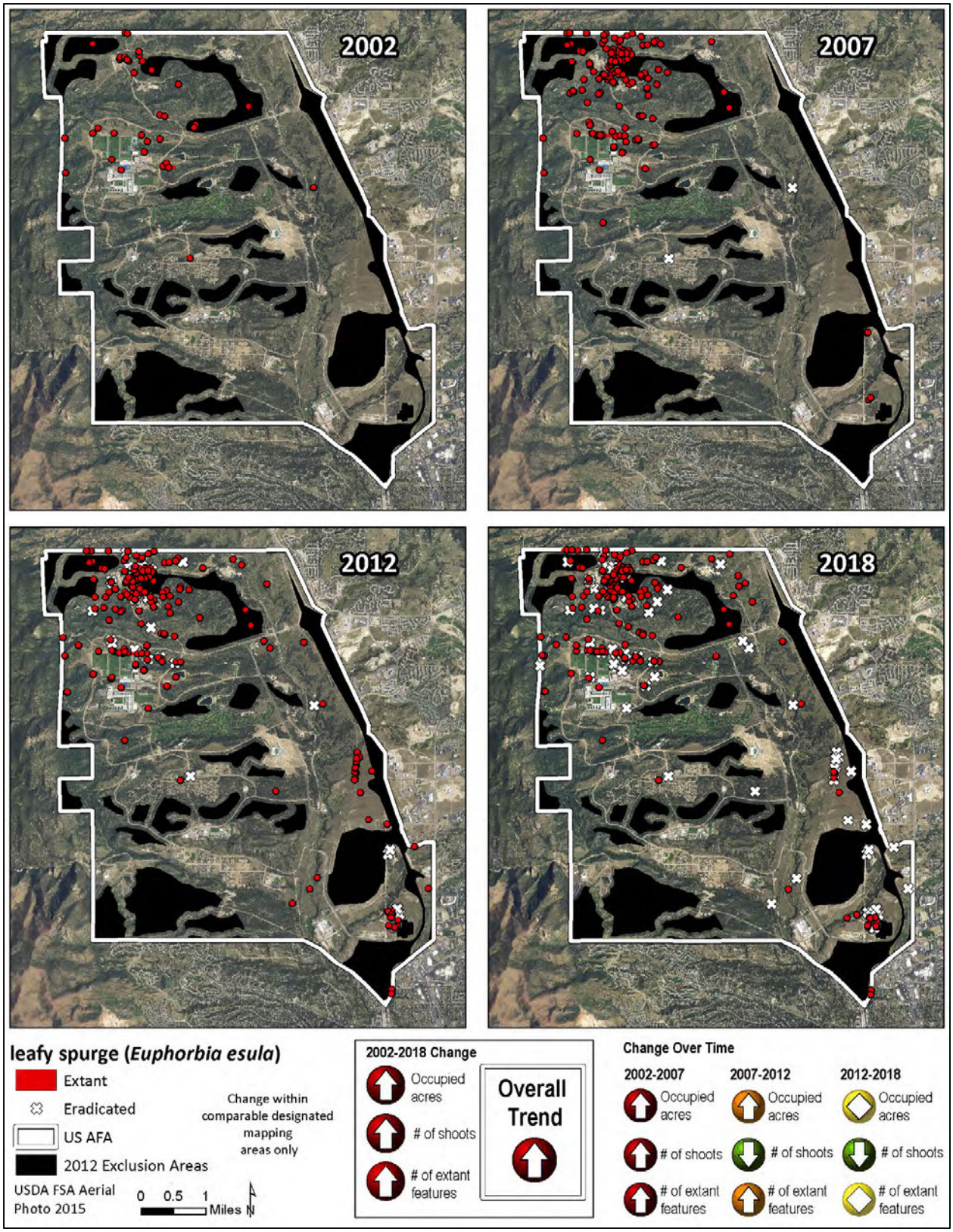
A study in Rocky Mountain National Park demonstrated that leafy spurge management practices including both chemical and mechanical treatments resulted in impacts to soils, soil biota and native plant species that were as damaging as the impacts from the leafy spurge itself (Pritekel et al. 2006). This calls into question the efficacy of treating these plants in systems where you need to protect native vegetation. Continued monitoring of these plots will be important for looking at treatment effects at the Air Force Academy since the untreated plots are showing stable to downward trends but census mapping since 2002 shows an increasing trend (Map 16). A greenhouse study conducted in 2008 (Nicholas et al.) showed that leafy spurge seedling growth was lower in spots that had native species compared to soils that had smooth brome. This further brings home the point that disturbance of the soils will encourage the growth of leafy spurge or other non-native species. Protecting areas with native plant cover from disturbance (including herbicides) should be a priority to protect soil chemistry and to prevent leaving bare spots where smooth brome often moves in.

Photo 6. Leafy spurge plants with damage to apical parts of plants in 2016. Photo: Pam Smith.

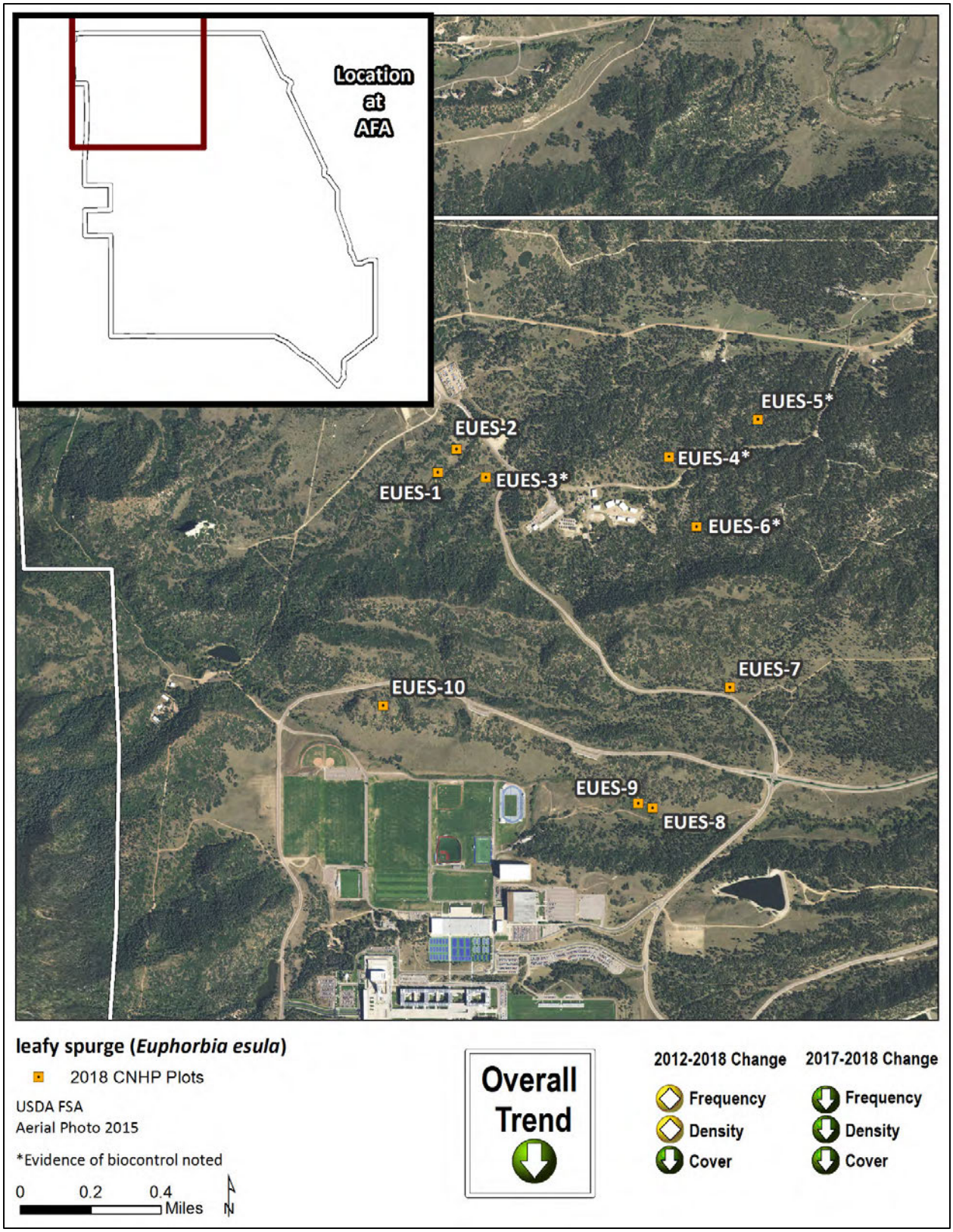
Protocols for treating weeds in the vicinity of rare plants has been developed by the State of Colorado (Mui and Panjabi, 2016), and should be considered for management activities in the areas designated by Smith et al. (2015) as SWMAs. These areas should be considered for site plans in 2018.

History of Sampling and Treatment

- Ten permanent plots were established in 2012.
- Census mapping for leafy spurge distribution across the Academy property was conducted in 2002, 2007, and 2012.
- Michaels et al. terminated biocontrol treatments in 2013.
- In 2013, a need was recognized for more accurate treatment application data that includes area treated, date, and type of treatment.
- In 2015, all non-biocontrol treatment plots were visited. Rare plants (*Phacelia denticulata*) were noted in EUES 10.
- In 2016, all ten plots were visited. There was a decrease in the percent cover of leafy spurge while the frequency and density were stable 2012-2016. No plots were treated with herbicide. Rare plants (*Phacelia denticulata*) were again noted in plot EUES 10. Evidence of biocontrol organisms causing impacts to flowering plants was noted in six plots at a total of eleven quadrats.
- In 2017, all ten plots were visited. Gambel's oak are continuing to encroach on the plots. Leafy spurge seems to be declining without treatments. Another rare plant species was located in EUES 4 & 5 (*Crocanthemum bicknellii*). Evidence of biocontrol is common and found in the majority of plots over multiple years, animal browse has also been frequently observed.
- In 2017, no leafy spurge was mapped at Farish.
- In 2018, basewide mapping at the Academy showed an overall increase from 2002. 10 plots were monitored in 2018 showing stable to declining populations of leafy spurge and active biocontrol.



Map 27. Distribution of leafy spurge at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).



Map 28. 2018 leafy spurge plots at the Academy.

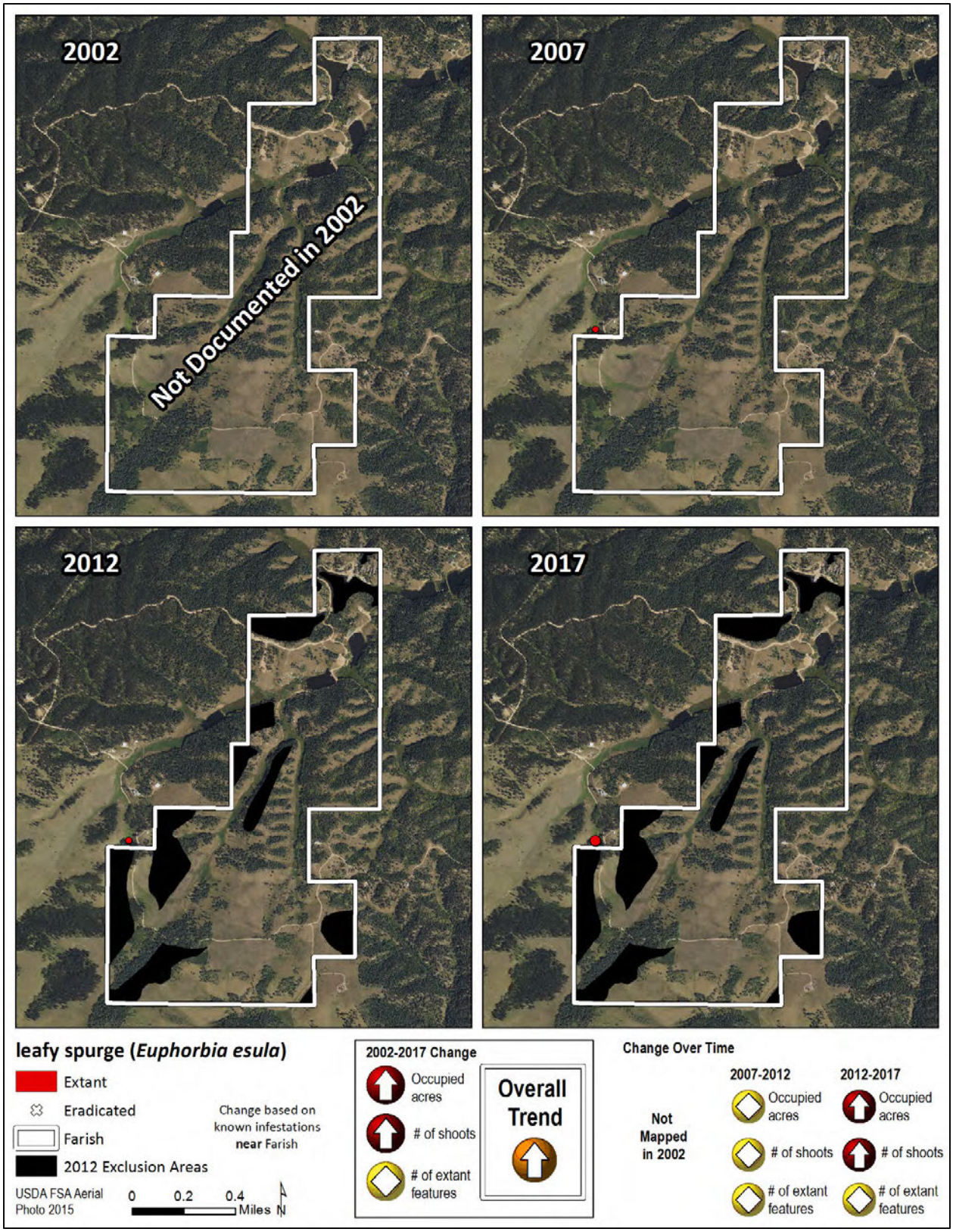
2017 Leafy Spurge Mapping Results at Farish

For over 10 years, leafy spurge has been observed near Farish on private property. Although the number of individuals has increased over time and the occurrence has crept closer to the fence line, it has not moved onto the property (Photo 7, Table 52, Map 29).

Table 52. Infestations of leafy spurge near Farish.

	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	0.03	113	1	0
2012	0.03	113	1	0
2017	0.31	94,248	1	0

Photo 7. Leafy spurge near the border of Farish (left) and private property (right) in 2017, Alyssa Meier, CNHP



Map 29. Distribution of leafy spurge near Farish from weed surveys (2002, 2007, 2012, and 2017).

Myrtle Spurge (*Euphorbia myrsinites*)

Overall Trend: Increasing

Management Goals: Rapid Response

State List: A

- Evergreen perennial
- Reproduction by seeds which are projected 15 feet from plant by seed pods
- Plant is allelopathic
- Milky sap is an irritant
- Planted in gardens and readily escapes
- Possibly spread by birds at AFA due to random widely spread small occurrences
- Seed longevity 8 years
- Easily removed by hand (CWMA 2017a)

Photo: Dave Anderson

Photo: Wikimedia Commons

2018 Mapping Results

Overall, the mapping results show myrtle spurge is increasing across the Academy. The occupied acres (2007-2018), estimated number of shoots and the number of extant features have increased since 2005 despite rapid response efforts. The total number of mapped features has steadily increased since 2005 from seven to 26 (with 35 features potentially eradicated) (Table 53, Maps 30 & 31). However, between 2017 and 2018 there has been a decrease in occupied areas, estimated numbers of shoots although the number of extant features has remained almost the same (Table 53).

Table 53. All infestations of myrtle spurge at the Academy.

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

Basewide weed mapping performed during shaded years.

The number of individuals has fluctuated from 25 to 1,021 since 2005, with the highest number of individuals reported in 2007 (Table 53). The trend for the last six years shows a range of 7-26 extant features and individuals ranging from 129-501. However, the overall trend is decreasing with a large increase since 2016 and a large decrease between 2017 and 2018 (Figure 15). The new features mapped in 2017 were largely in the vicinity of known locations of myrtle spurge (Maps 30 & 31).

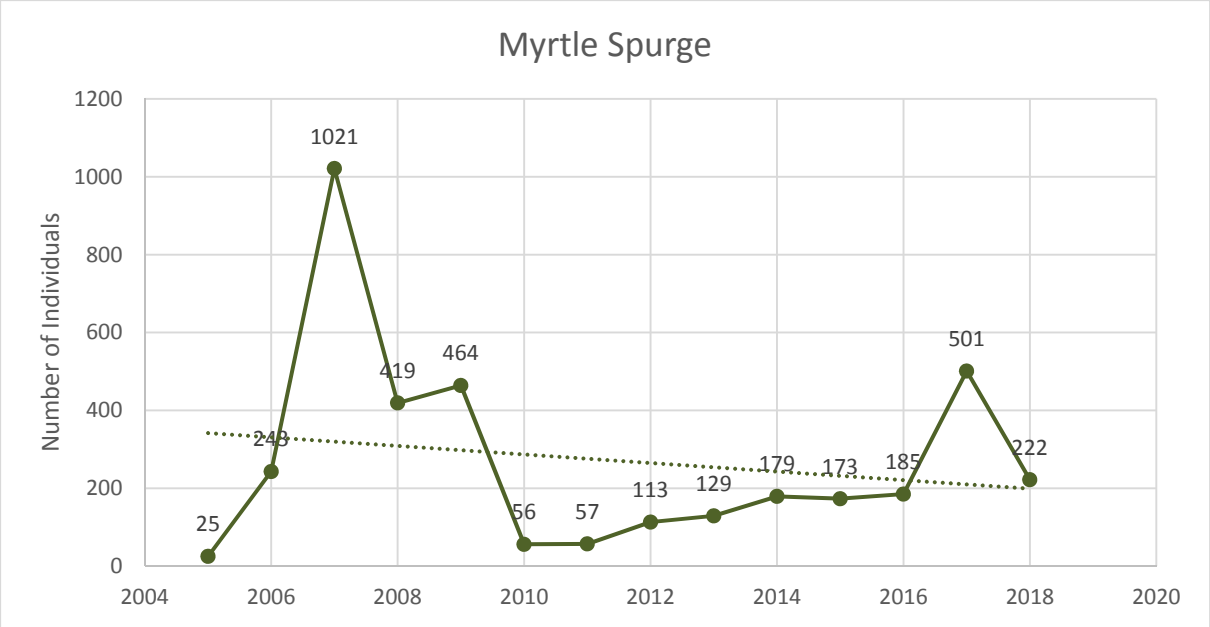


Figure 13. Myrtle spurge trend, 2005-2018.

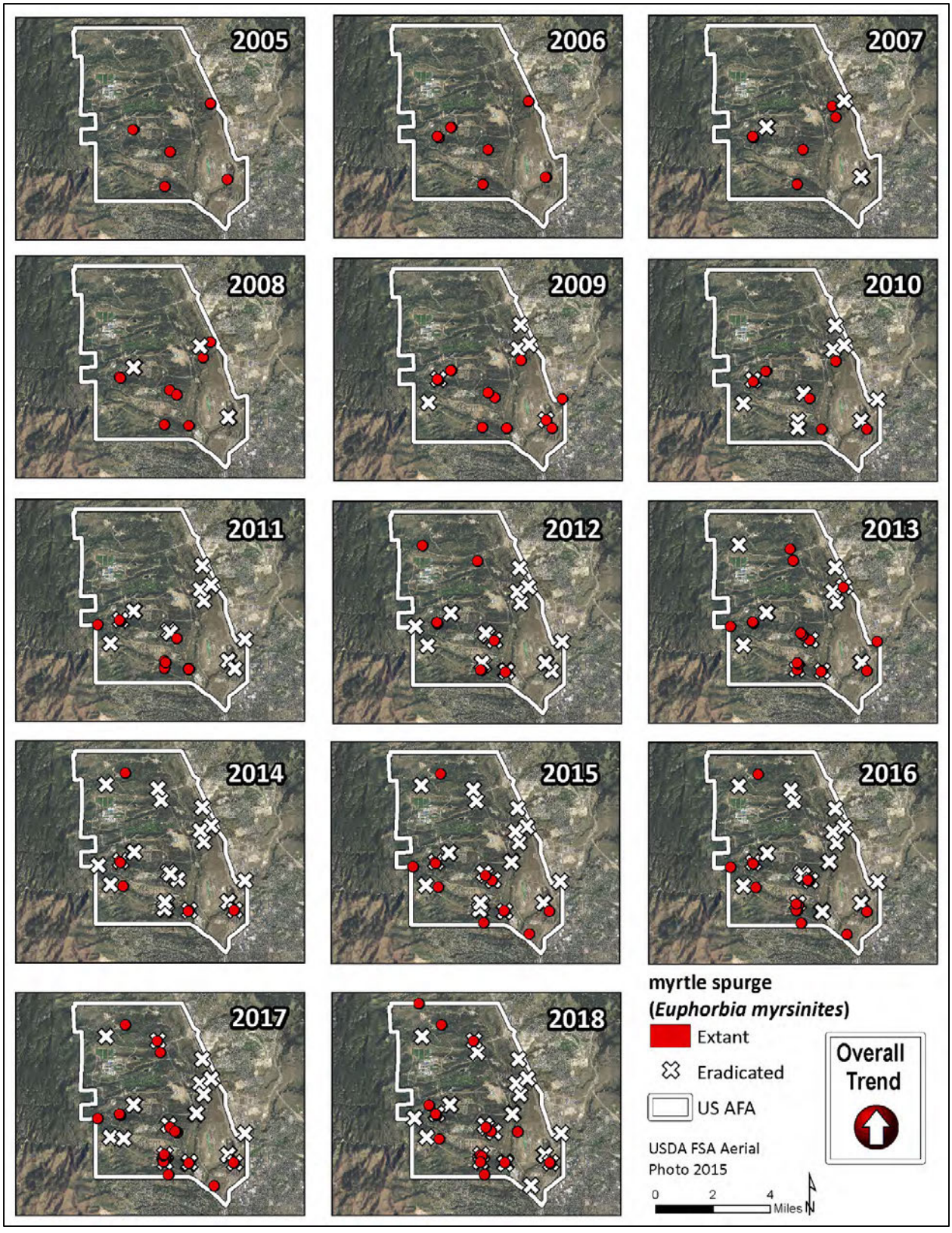
Recommendations

Visiting sites early in the season is recommended before the plants set seed. There are several reasons that myrtle spurge continues to be found at treated locations. The most likely reason is that the seed source is still present and too much soil disturbance is resulting from herbicides. Early removal before seed set will help to reduce the seed bank in the soil. More precise herbicide application needs to occur otherwise pulling is the best method. When the surrounding plants are inadvertently targeted cheat grass and other weeds are filling in the site (Photo 8). Myrtle spurge blooms as early as March in Colorado (CWMA 2018). Continue to monitor all known mapped or reported features for sprouts annually.

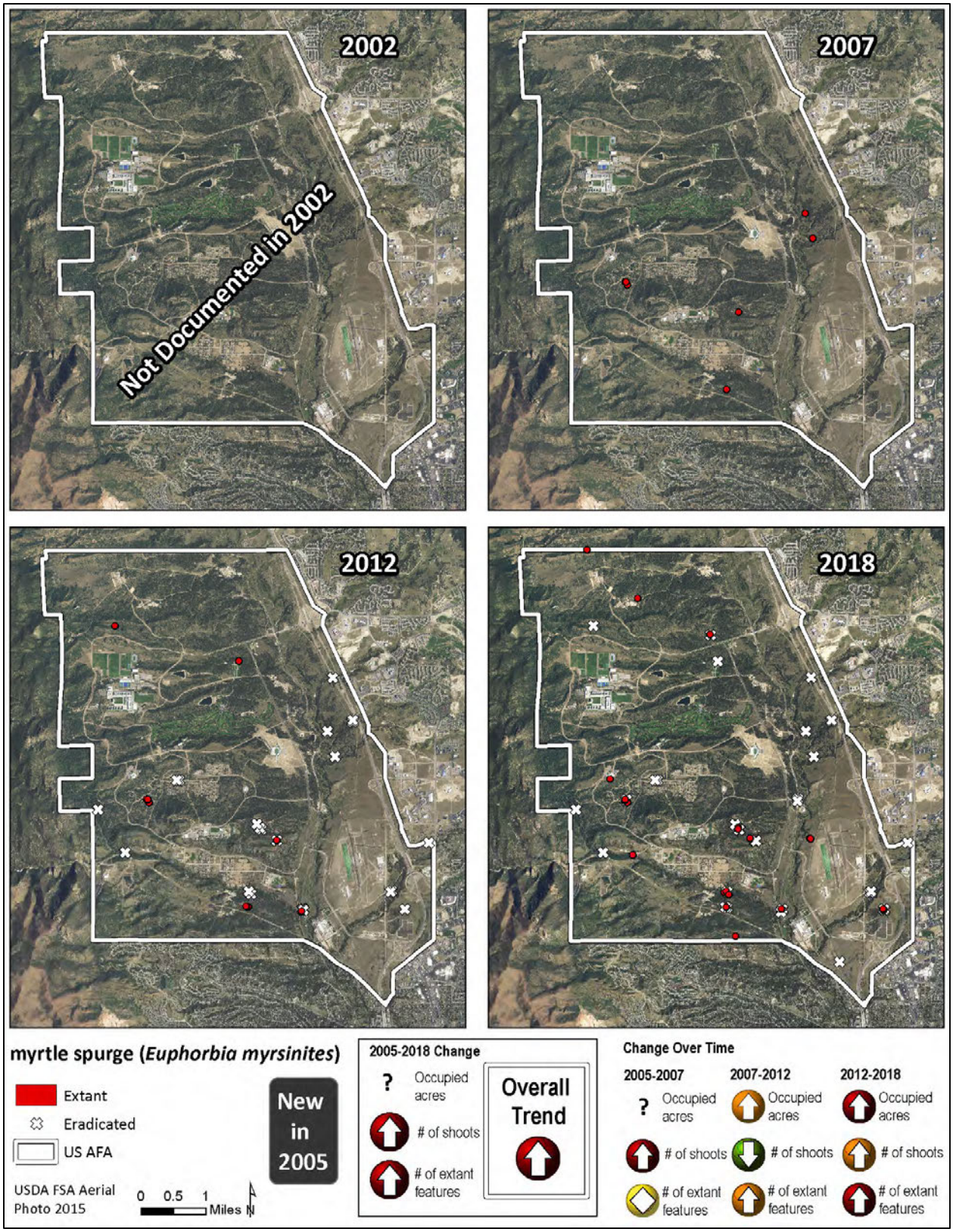
Photo 8. Treated myrtle spurge site with myrtle spurge returning; right side: smooth brome tillers moving into treated area (P. Smith 2016).

History of Sampling and Treatment:

- Natural Resources Staff at the Academy identified the presence of myrtle spurge in 2005 at an early stage of its invasion with seven sites and 25 individuals.
- In 2007, the highest number of plants (1,021) was documented for myrtle spurge.
- 2008-2016 yearly increases in the number of individuals.
- In 2016, 185 individuals were observed at 17 extant features.
- In 2017, we saw an increase in plants at or near known sites from 185 individuals in 2016 to 501 in 2017.
- In 2018, a basewide mapping effort showed myrtle spurge has spread across the entire property and continues to be found even in treated areas.



Map 30. Distribution of myrtle spurge at the Academy between 2005 and 2018.



Map 31. Distribution of myrtle spurge at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Yellow Spring Bedstraw (*Gallium verum*)

Overall Trend: Decreasing (Increasing 2017-2018)

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

2018 Mapping Results

Yellow spring bedstraw is a garden escape that was first documented in 2010, it was treated and then found again 2015 and 2018 at the single monitoring point (Table 54, Figure 16, Maps 32 & 33). All plants and root parts were removed by CNHP staff in 2015 and no plants were found in 2016 or in 2017. The seed longevity of this plant is not known. Large boulders and some landscaping and flooding have changed the area dramatically since 2015. Although this plant is not on the State of Colorado noxious weed list, it is a garden escape that has been shown to be aggressive at the Air Force Academy and throughout southern Canada and the northern U.S. It is a rhizomatous perennial plant that does well in dry soils. It is found on the edge of a disturbed riparian area with many native shrubs and herbs at the Academy (see photo above).

Table 54. All infestations of yellow spring bedstraw at the Academy.

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

Basewide weed mapping performed during shaded years.

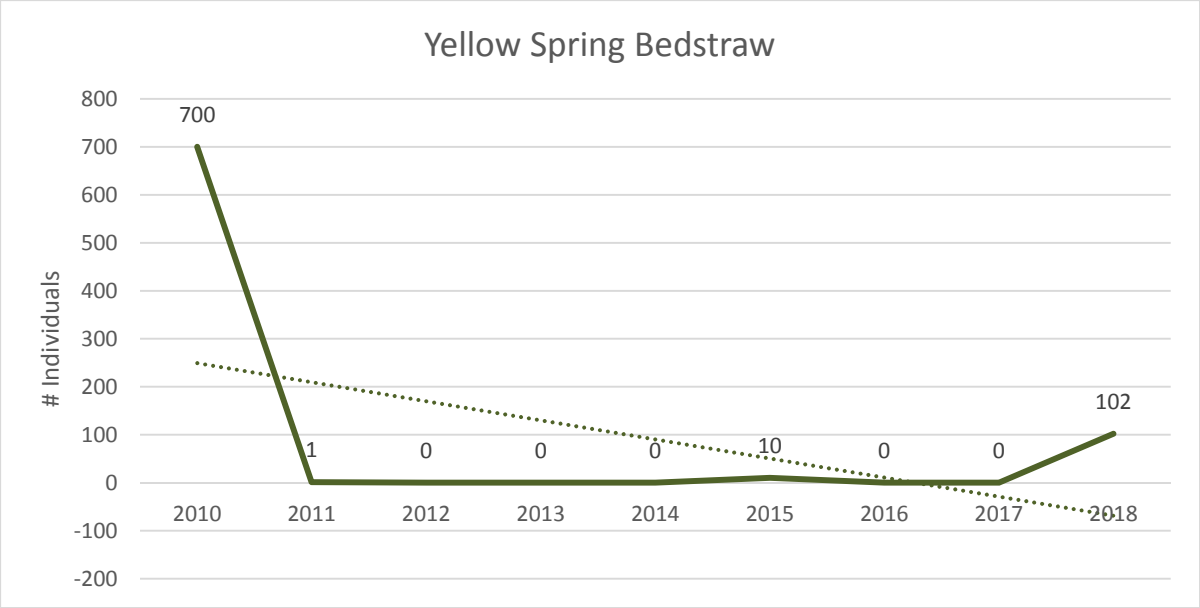


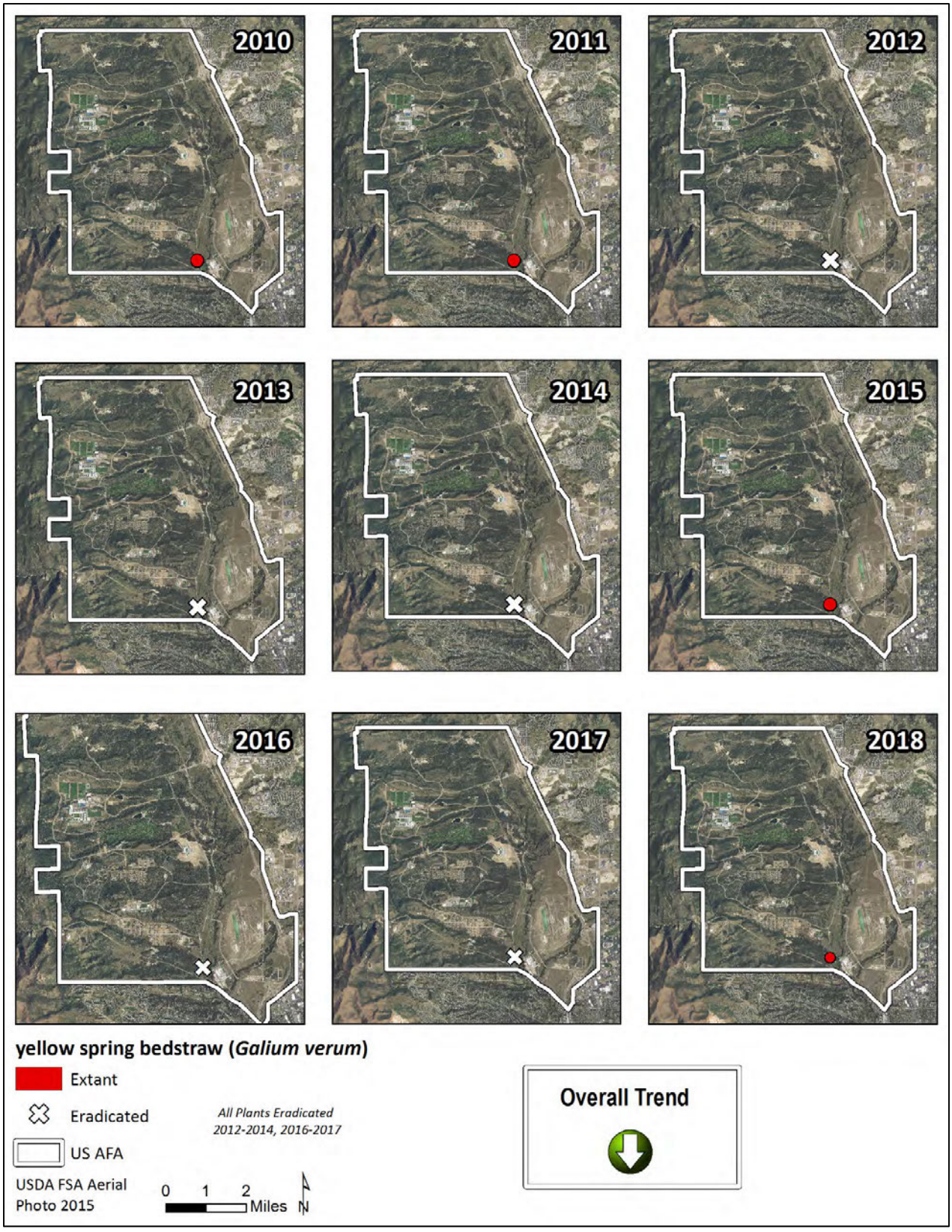
Figure 14. Yellow spring bedstraw trend, 2010-2018.

Recommendations

Continue to monitor the area for yellow spring bedstraw and remove when detected. Put this species on a watch list for future weed mapping efforts. Keep records of treatments and photograph the site if possible.

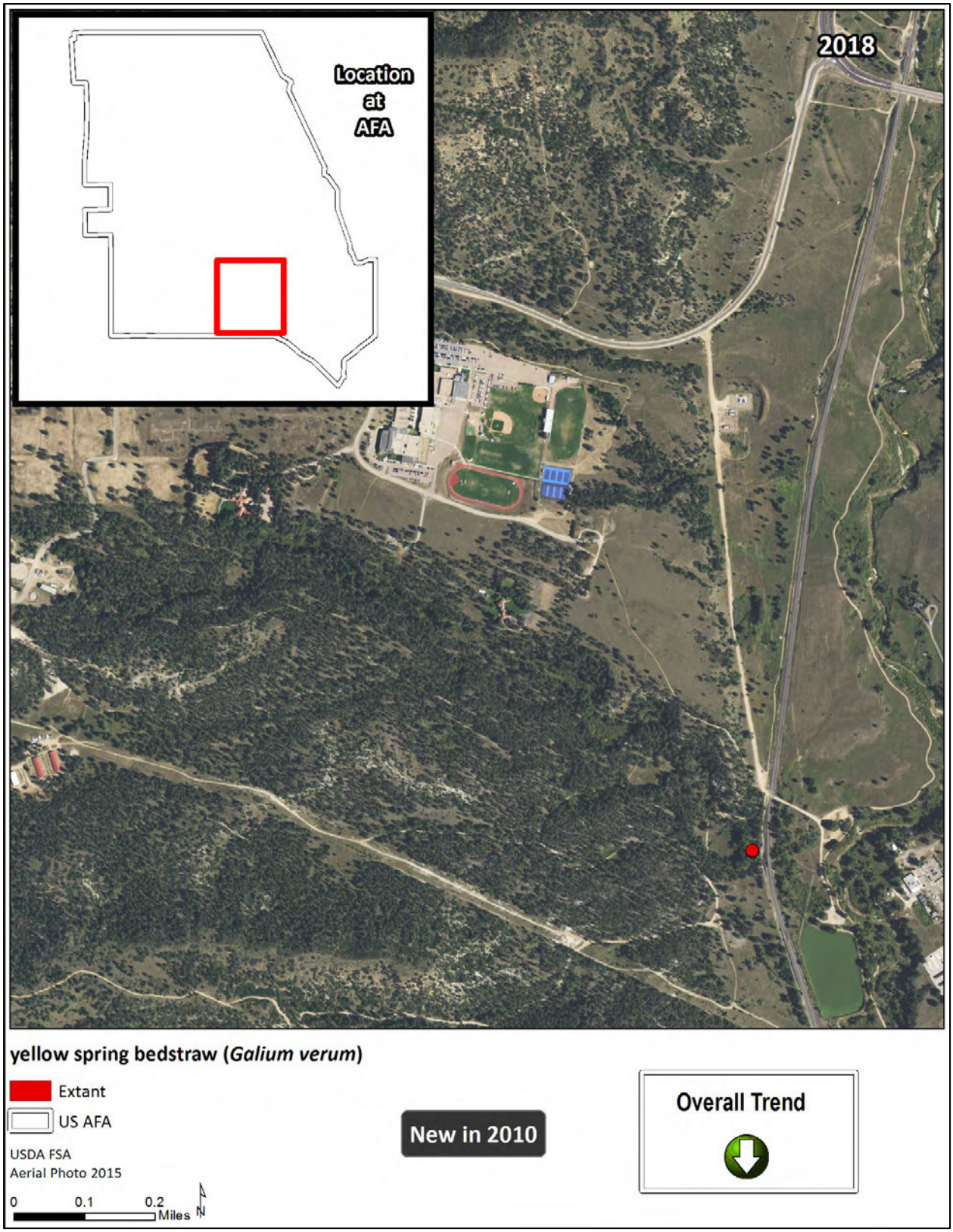
History of Sampling and Treatment:

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



Map 32. Distribution of yellow spring bedstraw at the Academy between 2010 and 2018.

Map 33. Distribution of yellow spring bedstraw at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).



Map 34. Close-up of yellow spring bedstraw at the Academy in 2018.

Dame's Rocket (*Hesperis matronalis*)

Overall Trend: Decreasing

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 2017b)

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

2018 Mapping Results

Dame's rocket was first documented in 2012 with 12 mapped features. Although, the numbers of plants are greatly reduced (665 from 16,871) there has been an increase since 2015. All of these locations have previously been treated with herbicides. There were no new locations mapped in 2018 (Table 55, Maps 35 & 36).

Table 55. All infestations of dame's rocket at the Academy.

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

† Base personnel found a new location with 130 individuals in June 2014 on the south boundary of the Academy far from the original infestation site near I-25. This site was not accessible in 2015-2016 (gated road) and assumed extant.

Basewide weed mapping performed during shaded years.

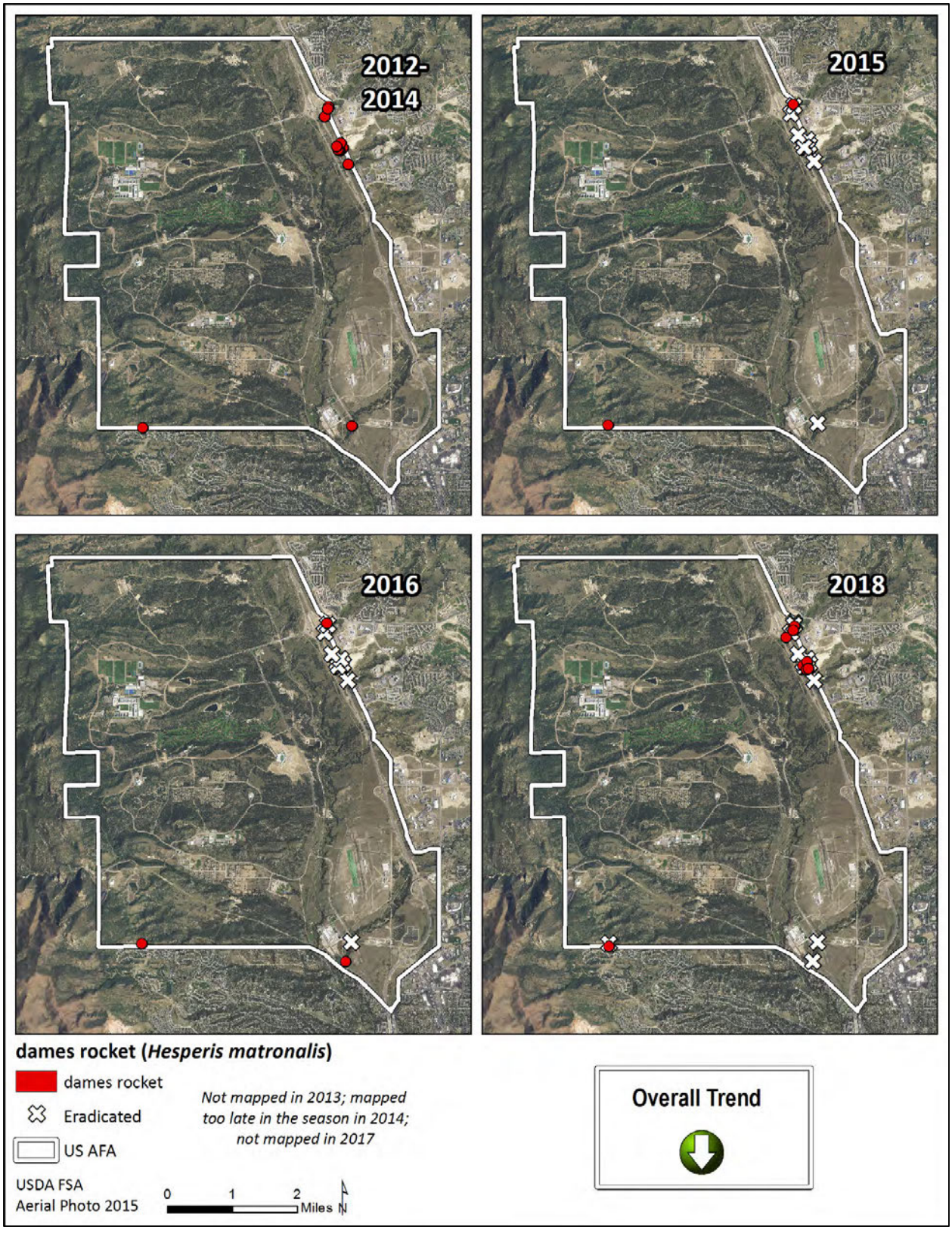
Recommendations

Getting to plants before seed set is considered to be essential. Cutting flowering tops is recommended as well as manual removal. Herbicides are only recommended for late fall when native plants are dormant and the basal parts of the dame's rocket are susceptible to the chemical (glyphosate recommended). The number one priority is not to disturb nearby intact vegetation during any type of treatment - https://sewisc.org/invasives/invasive-plants/63-dames-rocket, https://sewisc.org/invasives/invasive-plants/63-dames-rocket). The applicator will need to recognize the rosettes (or have them flagged by CNHP). For small infestations of consider manual removal of plants with follow-up monitoring. Continuous herbicide treatments have the potential to exacerbate weed invasions and open up the area to more or different weed species. Rare plants, wetlands, and intact prairie uplands were located within the areas being treated. Because the seed longevity is quite long, all of the sites should be monitored for multiple years. Any future herbicide applications need to be done with a site plan that will require a more precise application method, herbicides that are acceptable at the proper stage (fall rosettes) and make sure chemicals are appropriate for wetlands and floodplains, and continued follow-up monitoring after any type of treatment.

History of Sampling and Treatment:

- Dame's rocket was first discovered in 2012, near I-25. The 2012 mapping project (Rondeau and Greenwell 2013) documented 0.18 occupied acres with 16,871 shoots in 14 locations.

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



Map 35. Distribution of dame's rocket at the Academy between 2012 and 2018.

Map 36. Distribution of dame's rocket at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Orange Hawkweed (*Hieracium aurantiacum*)

Overall Trend: Increasing (New in 2018 at Farish)

Management Goals: Eradication

State List: A

Photo: Pam Smith CNHP, Sept 2018 Farish

- Perennial
- Reproduction by seed, rhizomes and stolons
- Flowers June-August
- Native look-a-like is orange agoseris (*Agoseris aurantica*)
- Seeds are viable for seven years
- 100 to 1,000 seeds/plant (CWMA 2018)

2018 Mapping Results

Approximately 200 plants with some in flower were found just a few meters off the campground road (Table 56, Map 37). The area was photographed and location data was taken (this was not part of the weed survey). A plan is in place for springtime manual treatments.

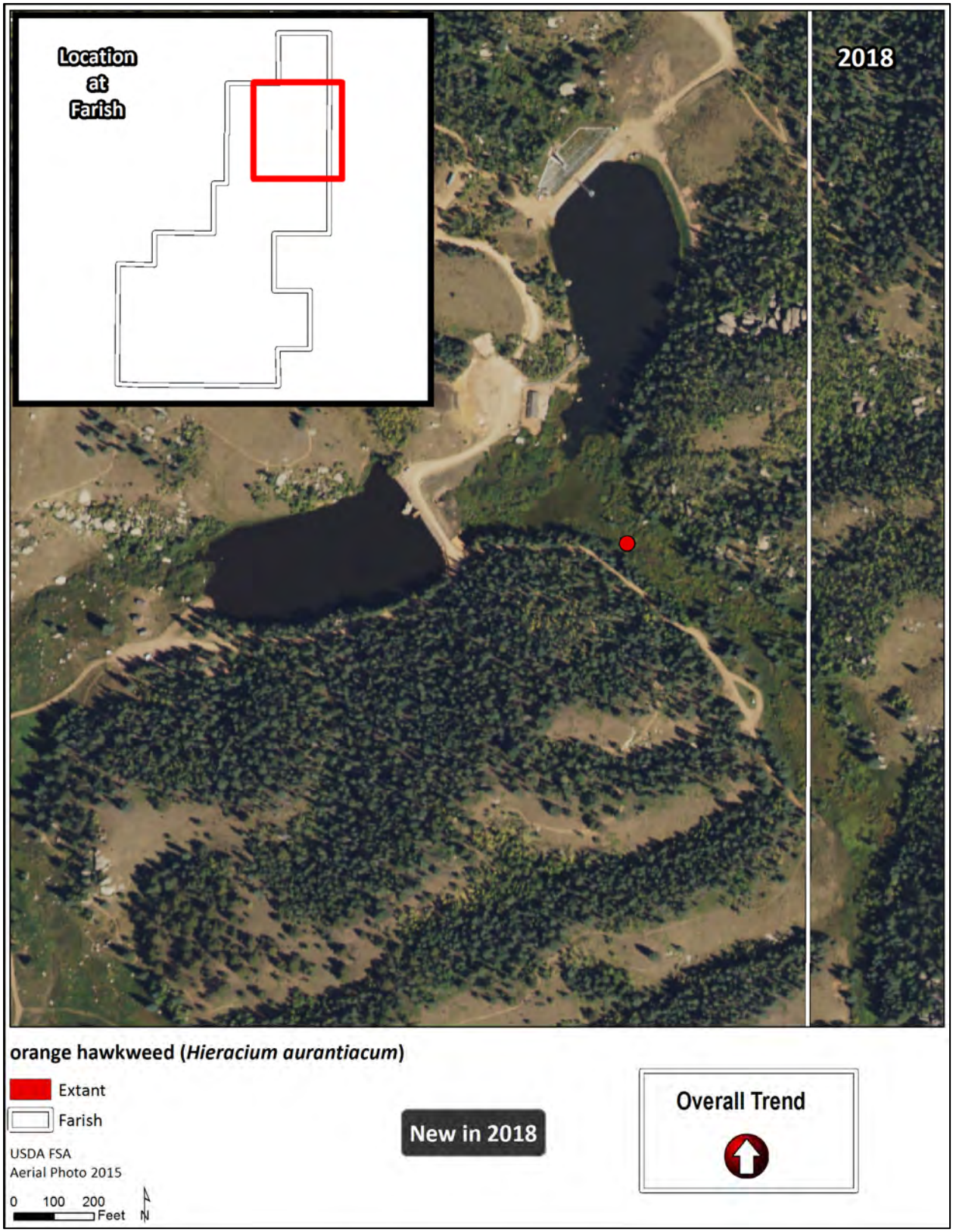
Table 56. All infestations of orange hawkweed at Farish.				
	Occupied Acres	Estimated Number of Shoots	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2017	---	---	---	---
2018	0.01	200	1	0

Recommendations

A site plan has been written for treatment at this site which includes hand removal of the plants making sure to get as much of the roots as possible. Repeated monitoring within the season will also occur as part of the site plan by CNHP. The site plan is included as a separate attachment. All treatments are recommended for spring and small areas like this one are ideal for a mechanical treatment. Surveys in the vicinity for more plants will also occur. There are plans for making sure there is minimal soil disturbance and disturbance to nearby native vegetation.

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.



Map 37. Close-up of orange hawkweed at Farish in 2018.

Common St. Johnswort (*Hypericum perforatum*)

Overall Trend: Moderate Increase

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

2018 Mapping Results

In 2018, basewide mapping showed an increase in the number of individuals and mapped features while the occupied acres remained relatively stable. Since 2012, there has been a large reduction in the number of plants, but the number of extant features has remained relatively stable between 22-33 sites until 2017 (Table 57, Figure 17, Maps 38 & 39). Flooding and biocontrol appears to have contributed to the declines in the number of shoots in some areas over the years.

Table 57. All infestations of common St. Johnswort at the Academy.

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

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

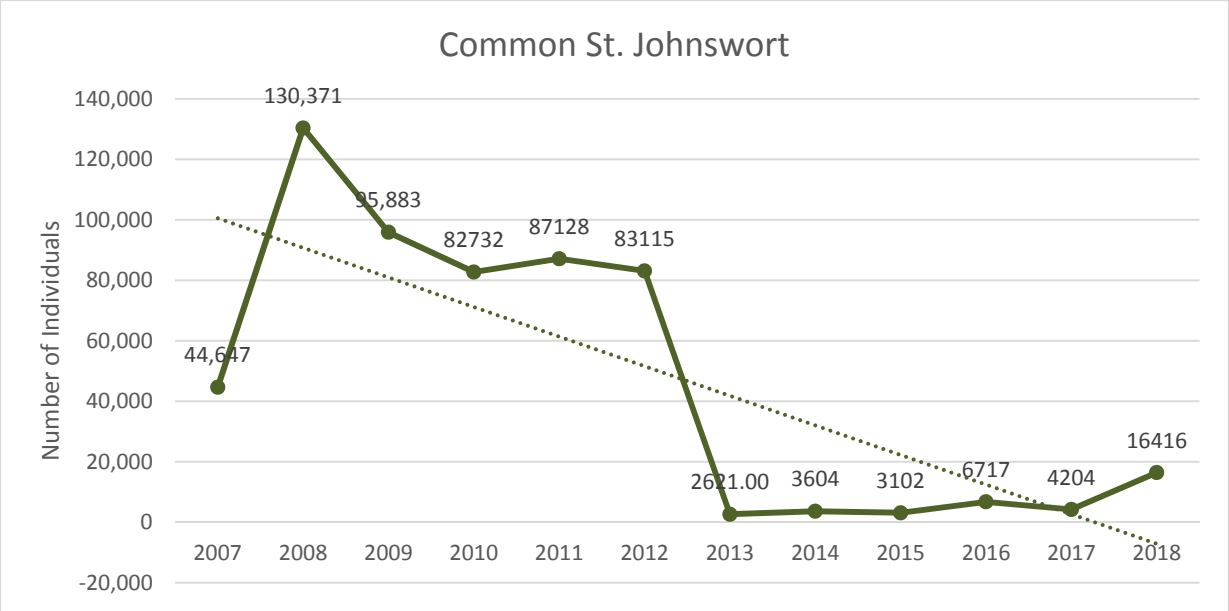


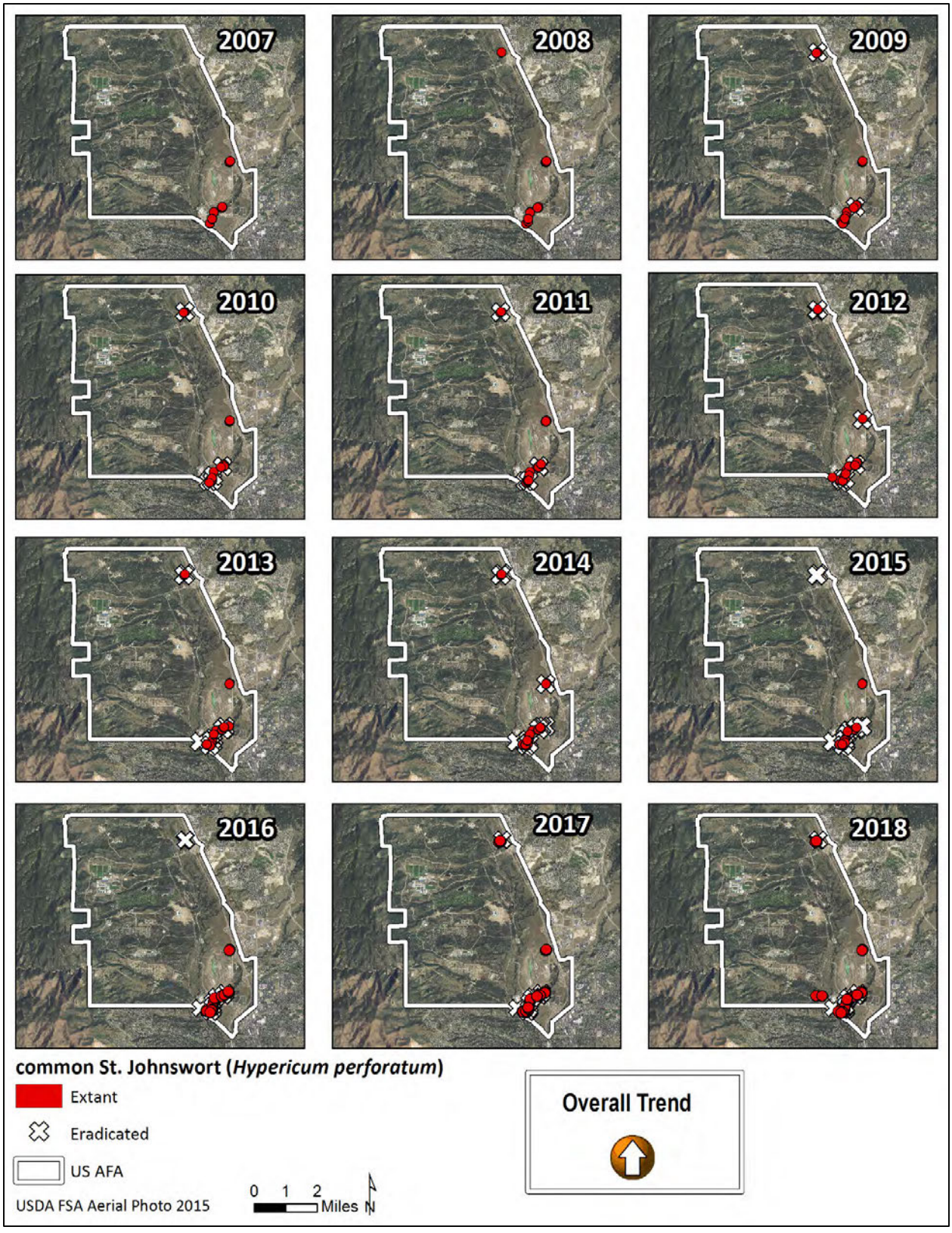
Figure 15. Number of individuals and extant features of common St. Johnswort, 2009-2018.

Recommendations

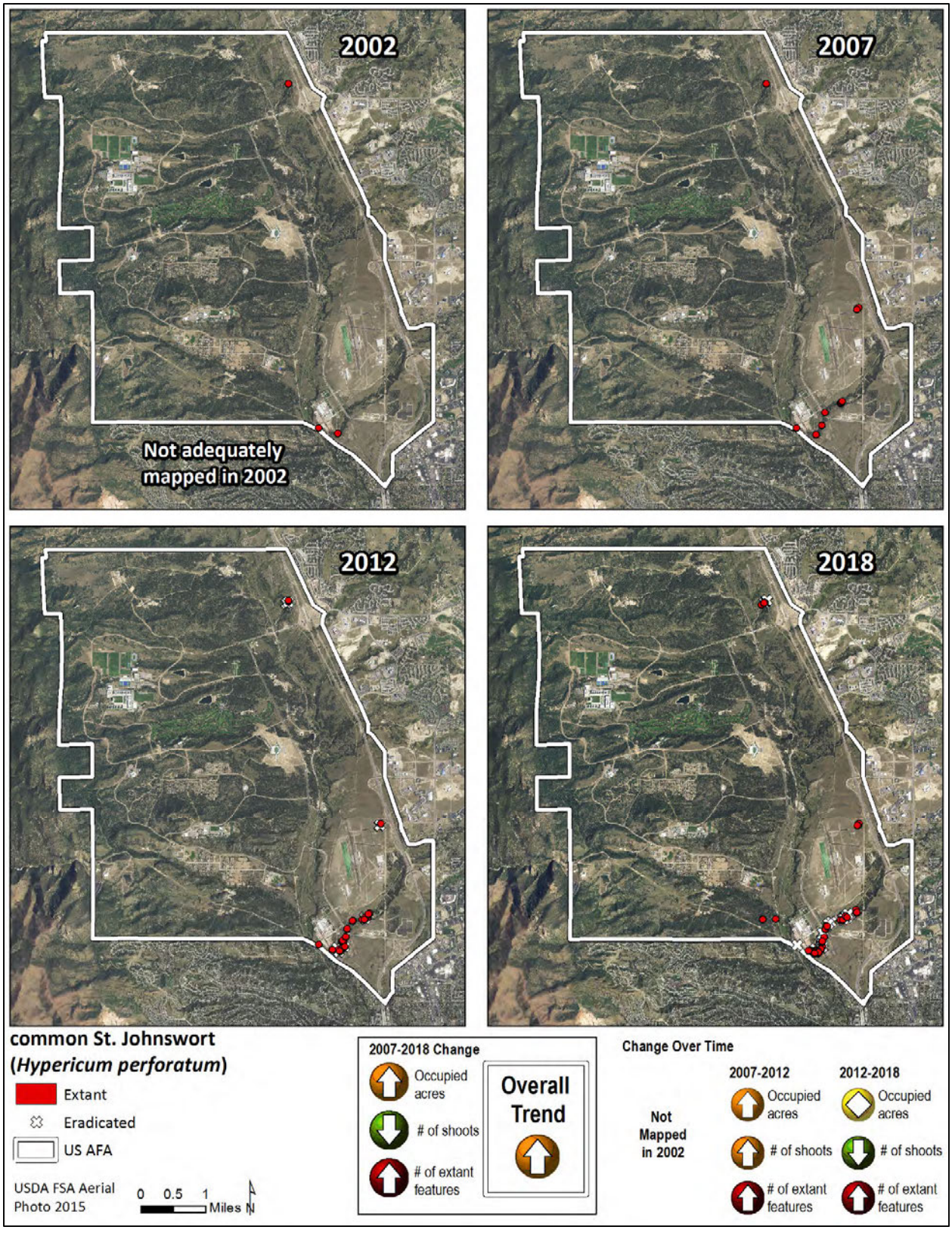
Large numbers of plants are removed during flooding events and washed downstream. In addition, biocontrol organisms are present and active at the Academy. These two elements have kept the numbers individuals at fairly low levels.

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.



Map 38. Distribution of common St. Johnswort at the Academy between 2007 and 2018.



Map 39. Distribution of common St. Johnswort at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Perennial Pepperweed (*Lepidium latifolium*)

Overall Trend: Increasing (New in 2018)

Management Goals: Eradication, Rapid Response

State List: B

Photo: Kate Wright CNHP 2018 at the Academy

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

2018 Mapping Results

This was the first year perennial pepperweed has been mapped at the Academy. There were 213 individuals in two separate features (Table 58). The plants are located in NE Jack's Valley and near I-25 in the southeast part of the Academy (Map 40).

Table 58. All infestations of perennial pepperweed at the Academy.				
	Occupied Acres	**Estimated Number of Shoots**	**Number of Extant Features**	**Number of Eradicated Features**
2002	---	---	---	---
2007	---	---	---	---
2012	---	---	---	---
2018	0.02	213	2	0

Recommendations

Rapid response treatments should include a site plan to document actions, photos and follow-up activities. The most important aspect of treating this species is not to disturb the surrounding vegetation. Herbicide treatments alone do not work, a combination of mechanical, herbicide and plantings are necessary (Young et al 2002). For 2019, the treatments will be either mechanical or a combination of mechanical and chemical depending upon observations in the spring or early summer of 2019 and in consultation with the herbicide applicator. If herbicides are necessary the plants will be flagged by CNHP botanists.

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.
- It was found at two locations on opposite ends of the base. Over 90% of total shoots were documented in the southern occurrence.

Map 40. Distribution of perennial pepperweed at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Dalmatian Toadflax (*Linaria dalmatica*)

Overall Trend: Moderate Increase

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)

2018 Mapping Results

In 2017, at Kettle Pond # 1 there were 480 plants pulled and in 2018 there were 52 individuals mapped at the same location. In 2016, only one plant was observed which shows the need for yearly monitoring for the rapid response species at the Academy. The other three locations visited had no plants (Table 59, Figure 18, Maps 41 & 42).

Table 59. All infestations of Dalmatian toadflax at the Academy.

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

Basewide weed mapping performed during shaded years.

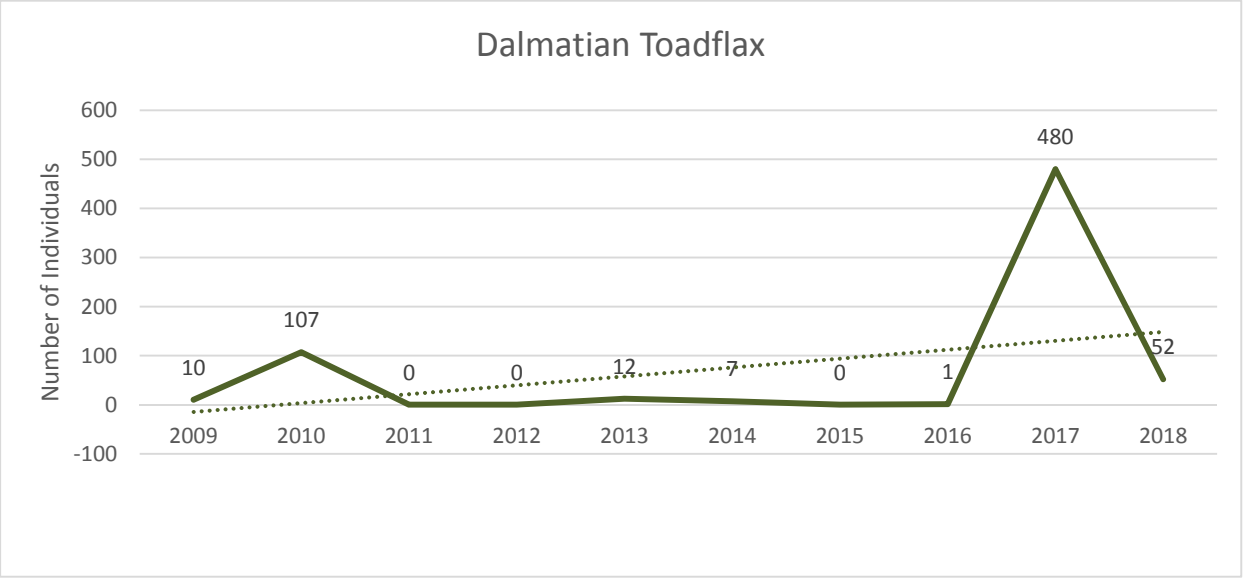


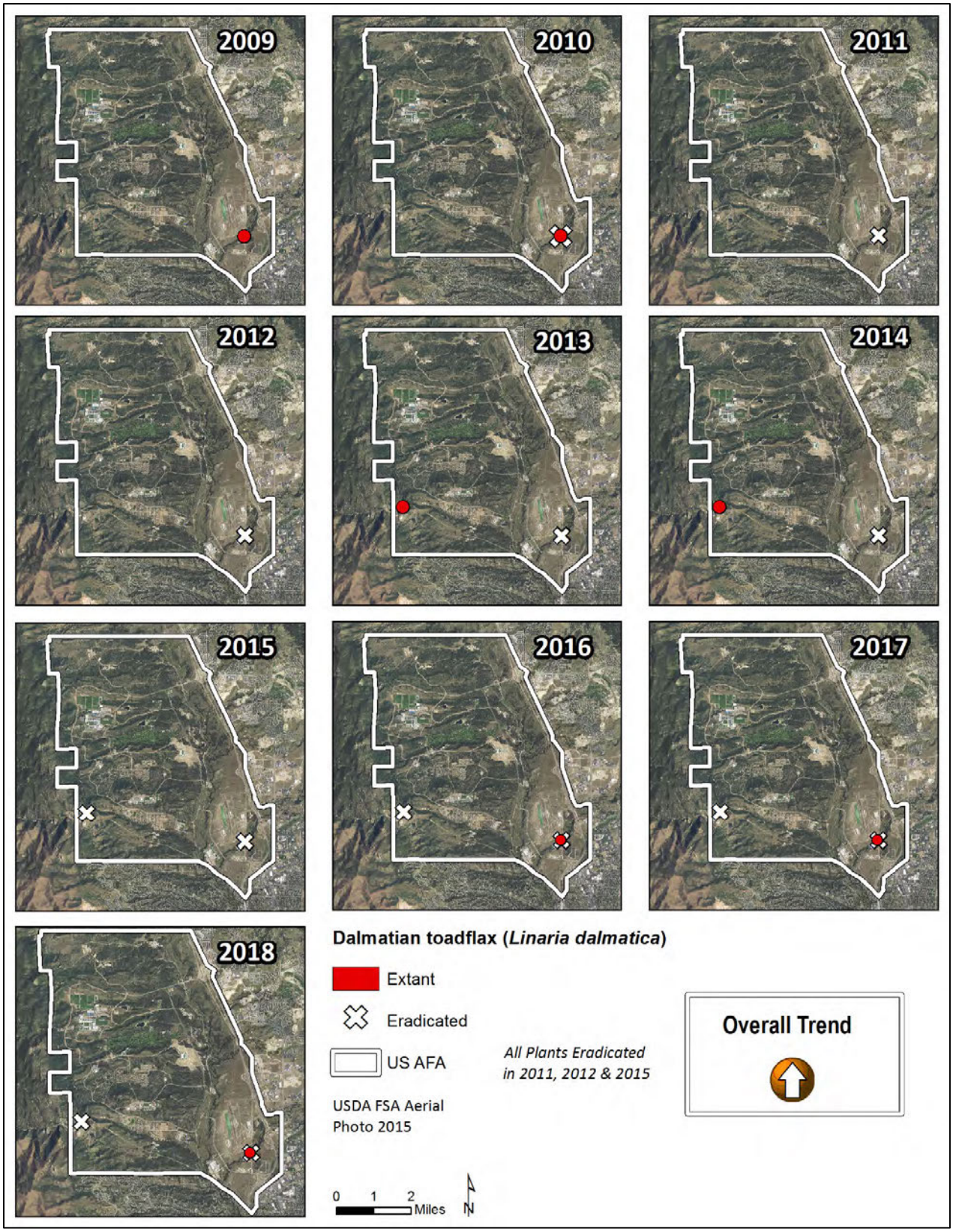
Figure 16. Number of individuals and extant features of Dalmatian toadflax, 2009-2018.

Recommendations

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

History of Sampling and Treatment:

- Dalmatian toadflax was discovered at the Academy in 2009 with one occurrence found near Kettle Lake #1 near the boat ramp. The occurrence consisted of a small number of plants.
- In 2010, two patches were mapped by CNHP with 107 shoots that covered approximately 203 m^2 (0.05 acres). The original infestation was eradicated, but two new infestations were found very close by, just north of the original occurrence.
- The Academy treated the 2010 sites and no plants were observed in 2011-2012.
- A new site on the western side of the Academy was discovered in 2013 which was treated immediately. This was far away from the previous infestations on the east side of the Academy near Kettle Lake #1.
- In 2014, seven plants were observed at the western known site, they were hand pulled and have not returned as of 2016 survey.
- In 2015, no plants were observed at the four known sites and no new infestations were found.
- In 2016, one individual was found (and pulled) at the original site at Kettle Lake #1 near the boat ramp.
- In 2017, there was a significant increase in a single year in the number of individuals the Kettle Lake #1 site where one plant was observed in 2016. All plants were removed by CNHP.
- In 2018, 52 plants were observed at the Kettle Lake #1 site and at no other locations.



Map 41. Distribution of Dalmatian toadflax at the Academy between 2009 and 2018.

Map 42. Distribution of Dalmatian toadflax at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Yellow toadflax (*Linaria vulgaris*)

Overall Trend: Widespread, comprehensive mapping not feasible

Management Goals: Monitoring/Suppression

State List: B

Photos: Yellow toadflax at the Academy. Michelle Washebek 2007.

- Perennial
- Reproduction by seed and creeping roots
- Flowers June – September
- May hybridize with Dalmatian toadflax
- Biological controls are present at the Academy

2017 Mapping Results at Farish

Seven large occurrences of yellow toadflax were mapped at Farish, ranging from 0.17 acre to 0.70 acre, for a total of 2.86 acres (Photo 9, Map 43).

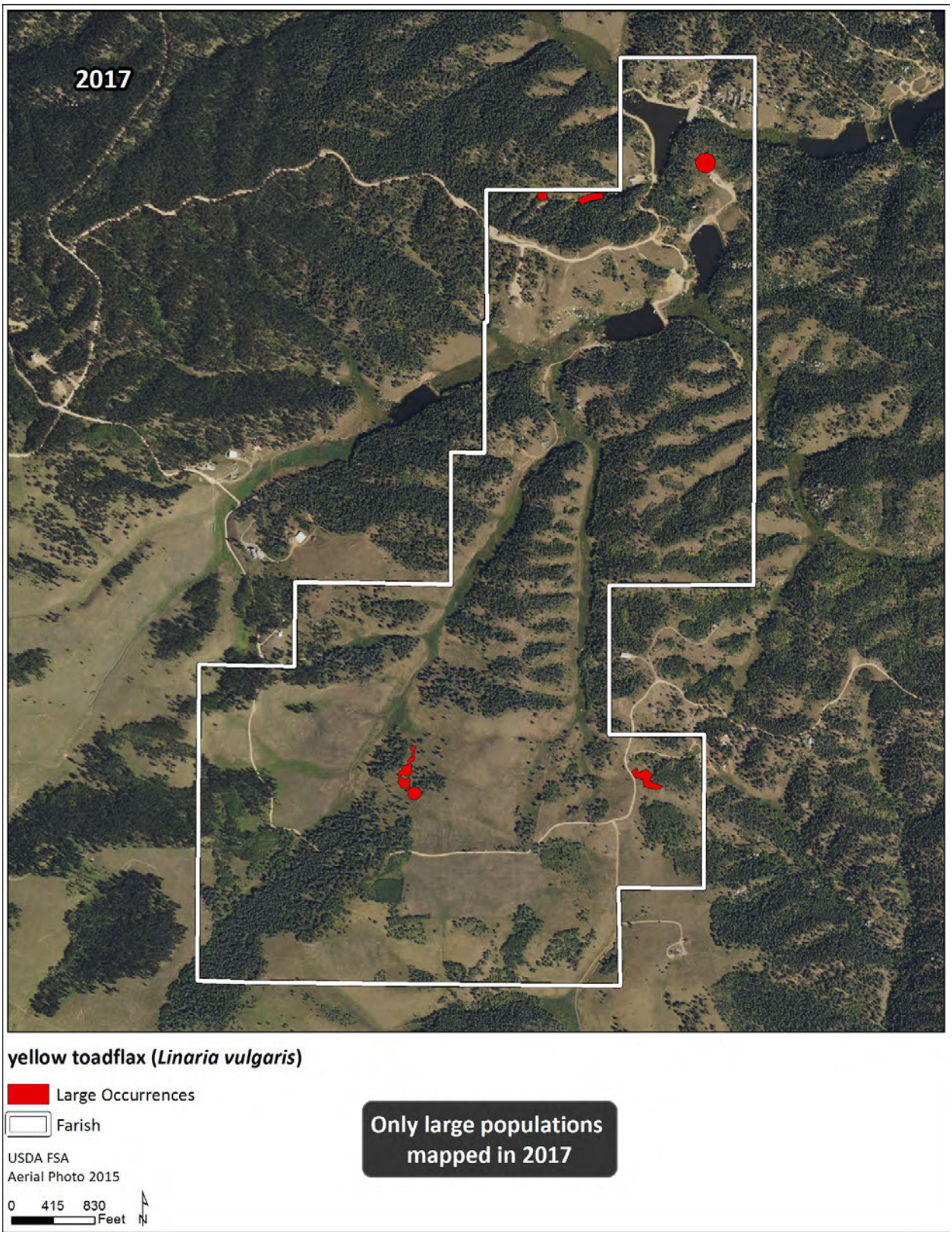
Photo 9. Yellow toadflax mixed with musk thistle in Farish natural areas 2017, Alyssa Meier, CNHP.

Recommendations

Toadflax species are extremely difficult to control once they have become established, preventing infestations into new areas is the most important management option. Biocontrol, which is present, is likely the best alternative due to the distribution of toadflax. Any soil disturbances for building or in landscapes should be monitored for new toadflax occurrences. Management to control it must consider the possibility of succession to an equally undesirable species when plants are removed (FEIS 2019). All herbicides recommended by Colorado Department of Agriculture are for rangelands and pasturelands only and not for wildlands (http://www.colorado.gov/ag/weeds).

History of Sampling and Treatment:

- Comprehensively mapped during the 2002 basewide weed survey.
- In 2007, mapped only within high priority conservation areas (CNHP's Monument Creek potential conservation area) due to its widespread distribution.
- In 2012, distribution was not mapped. Instead, sample sites were identified and presence/absence was documented.
- In 2017, only large occurrences greater than ¼ acre in size were mapped at Farish.
- In 2018, basewide mapping was not feasible at the Academy due to the cover and difficulty mapping this species which grows mixed within very dense stands of vegetation.



Map 43. Large occurrences of yellow toadflax at Farish in 2017.

Tatarian Honeysuckle (*Lonicera tatarica*)

Overall Trend: 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

Photos: Wikimedia Commons

2018 Mapping Results

In 2018, there were 35 extant features with a total of 132 individuals observed (Table 60). The number of extant features has increased since 2008 (Table 60, Map 44 & 45). Some features represent mature trees (~25) that were missed in previous surveys and do not necessarily indicate an expansion. At least two areas include sprouting individuals at treated sites.

Table 60. All infestations of Tatarian honeysuckle at the Academy.					
	Occupied Acres	Estimated Number of Shoots	Total Number of Features Visited	Number of Extant Features	Number of Eradicated Features
2002	---	---	---	---	---
2007	---	---	---	---	---
2008†	0.15	20	1	1	0
2012†	0.15	20	1	1	0
2013	0.18	28	5	5	0
2014	0.21	31	7	5	2
2015	0.40	48	10	9	1
2016	0.24	22	12	8	4
2017	0.24	8	9	6	3
2018	0.60	132	40	35	5

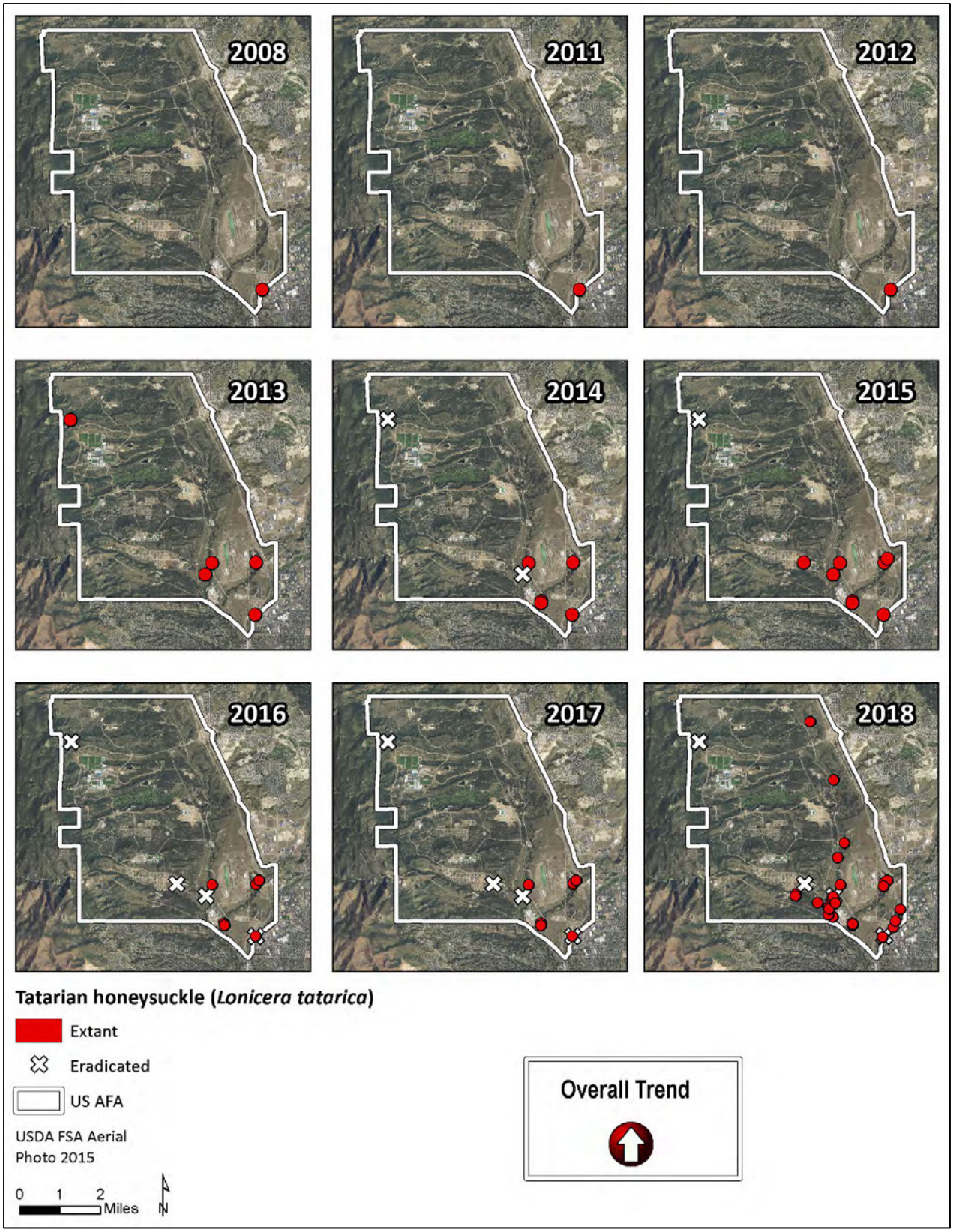
Basewide weed mapping performed during shaded years. † Number of shoots at the original site documented in 2008 was previously reported to be 30 individuals, an estimate from a distance. This site was visited in 2014 for an actual count of 20.

Recommendations

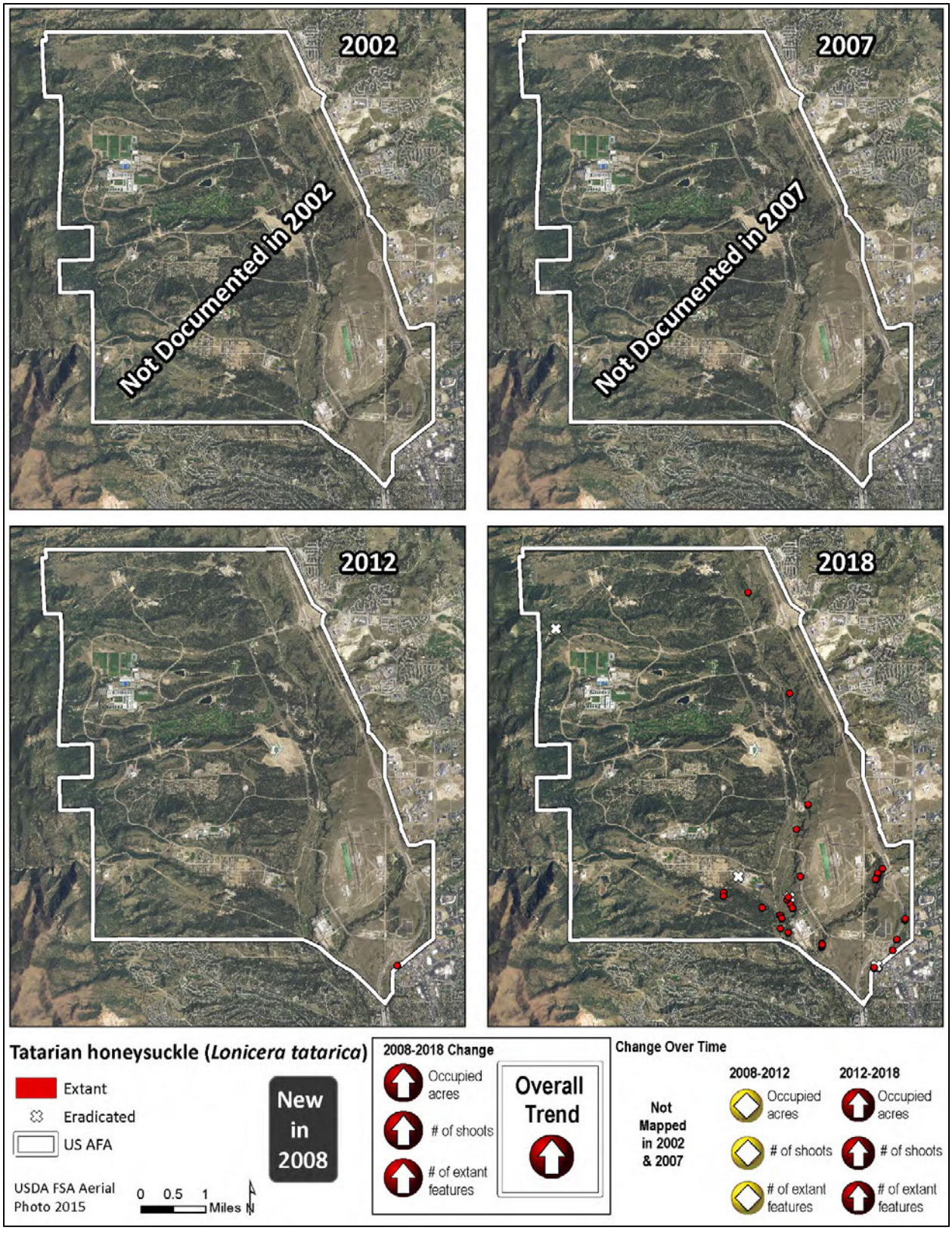
Continue to monitor known sites as sprouting is common after treatment.

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.



Map 44. Distribution of Tatarian honeysuckle at the Academy between 2008 and 2018.



Map 45. Distribution of Tatarian honeysuckle at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Scotch Thistle (*Onopordum acanthium*)

Overall Trend: Increasing

Management Goals: Containment

State List: B

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

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

2018 Mapping Results

Scotch thistle has been increasing across the Academy since it was first mapped in 2002. In 2018, almost 2,000 individuals were observed at 275 features (Table 61, Figure 19, Maps 46 & 47). Although, there were new mapped features, most of them were in the vicinity of known locations. The occupied area for the scotch thistle is increasing since 2010 but less than in 2009. Precipitation seems to be correlated with cover (Figure 20).

Table 61. All infestations of Scotch thistle at the Academy.

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

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

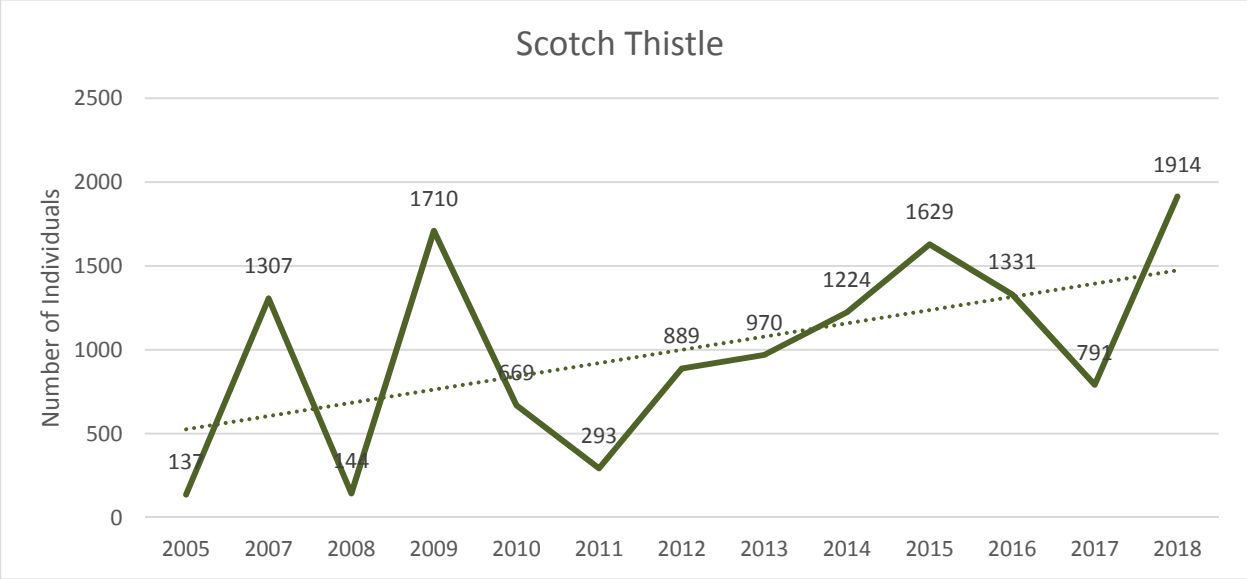


Figure 17. Number individuals and extant features of Scotch thistle, 2005-2018.

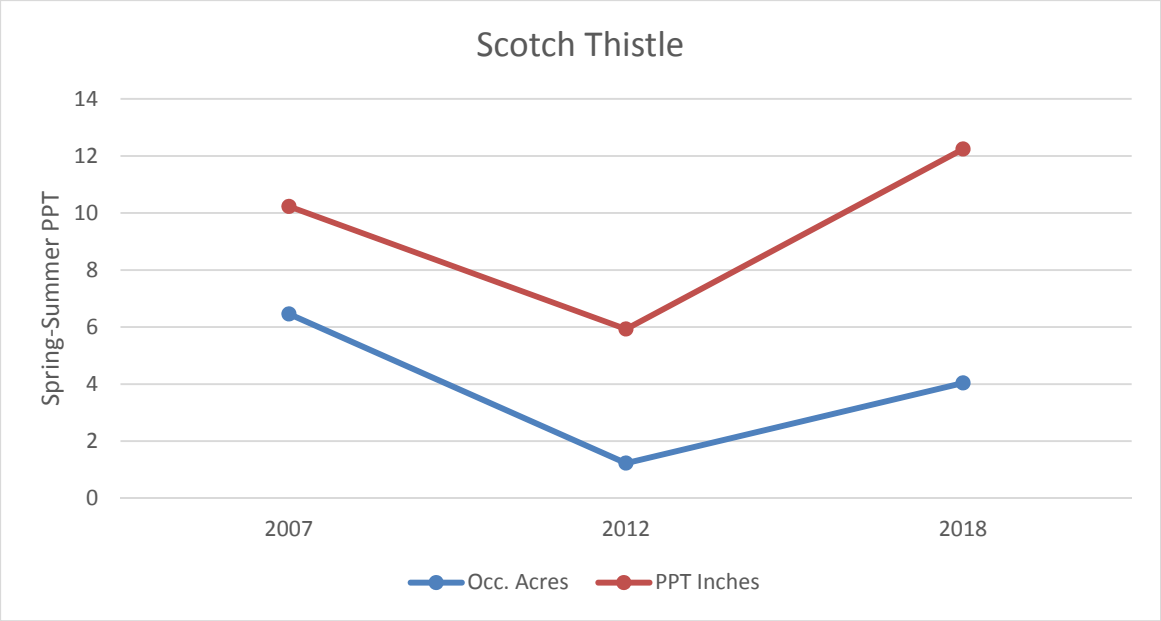


Figure 18. Comparison of spring-summer precipitation and occupied acres of Scotch thistle at the Academy.

Recommendations

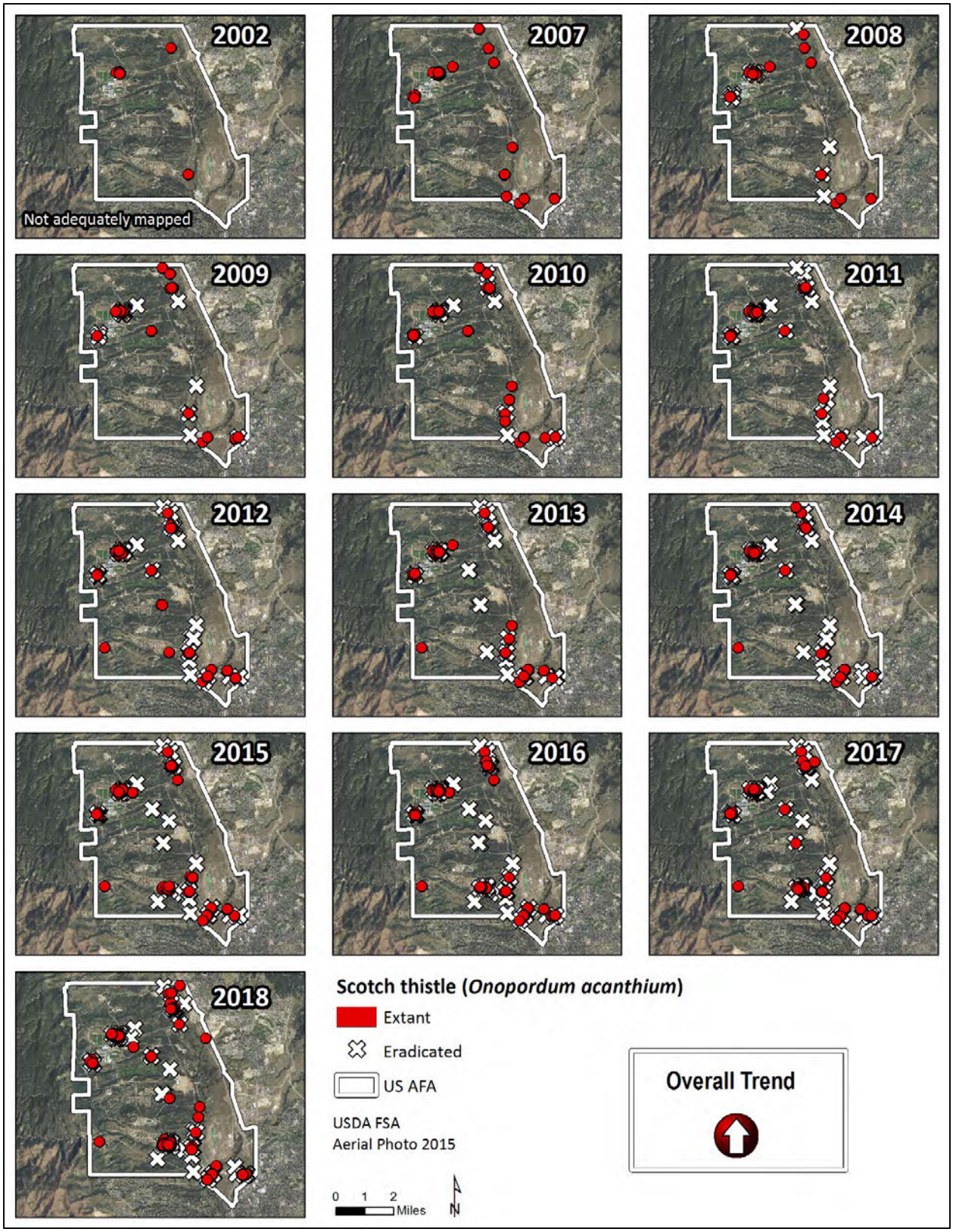
Despite years of active management, both the number of mapped features and the number of individuals are increasing, even in areas with multiple years of treatment at a single location. It is time to re-evaluate the treatment method as it does not appear to be providing successful results. A site plan for each of the treatment sites is recommended to help document what is occurring and what methods are helping or harming the removal of this species. Site assessments will take into consideration a variety of aspects of treatment that may be impairing success including: partial treatments, treating the proper growth stage and avoiding chemical overspray that leaves bare soil which impacts the native plants that could potentially help to provide competition. The ground disturbances associated with the chemical treatments as well as the inappropriate growth stage being treated are likely causing increases (Photo 10). The effects to local flora and fauna, water quality and soil microorganisms that result from excessive use of chemicals is also problematic. The site plan could include alternate options for treatments. Protecting existing vegetation in the grasslands is so important in keeping weeds from spreading. Removing the seed source is considered a key aspect of treating this species. Herbicides are only one tool and should not be used exclusively for control of this species.

Removing new sprouts early in the spring is far less damaging to soils than other treatments. Once plants have bolted they are much more difficult to treat without excessive soil disturbances.

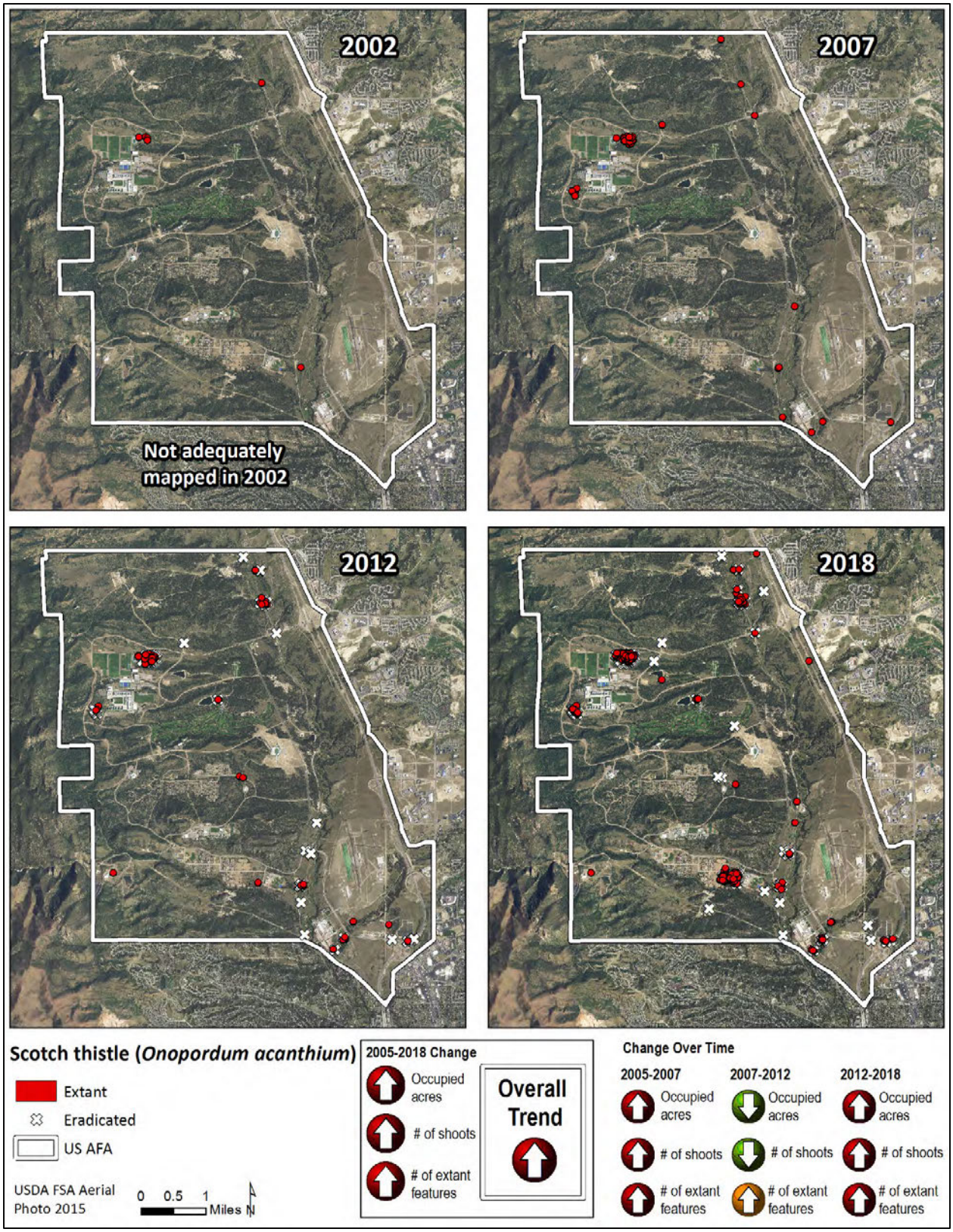
Photo 10. Photo of herbicide treated Scotch thistles showing overspray areas with bare soil and repopulation with other noxious weeds including houndstongue and cheatgrass. Photo: P. Smith 2015.

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 there fewer individuals counted.
- In 2018, the basewide mapping showed 275 extant sites with almost 2,000 individuals observed.



Map 46. Distribution of Scotch thistle at the Academy between 2002 and 2018.



Map 47. Distribution of Scotch thistle at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Bouncingbet (*Saponaria officinalis*)

Overall Trend: Decreasing (Increasing 2017-2018)

Management Goals: Eradication

State List: B

- Perennial
- Self-fertile
- Reproduction from seeds
- Colony former
- Blooms summer-fall
- Seed longevity is unknown (CDA 2016)

Photo: ct.botanicalsociety.org

Photo: Leaves of mature plant, missouristate.edu

2018 Mapping Results

The first basewide survey for bouncingbet was conducted in 2018. It was first documented in notes during the 2002 weed survey then added to the monitoring program and mapped on the Academy in 2013. Since 2013, it has decreased in cover and estimated number of shoots (Table 62). In 2013, a total of 42,092 plants at 8 features, with one location containing 37,699 individuals (estimate based on density). A dramatic decline occurred in 2014 with only 42 plants at two sites; by 2015, 608 plants were mapped at eight features. The total number of extant features has increased from 2 in 2014, to 26 in 2018 (Table 62, Figure 21). The new features are located along Pine Creek in the southeast and along Monument Creek (Maps 48 & 49).

Table 62. All infestations of bouncingbet at the Academy.

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

Basewide weed mapping performed during shaded years.

One of the most interesting observations for 2016 through 2018 is that nearly every single mature plant that was in the flower stage had the flowers or parts of the plants browsed by ungulates (Photo 11).

Photo 11. Browsed bouncingbet flower tops in 2016. Photo: P. Smith

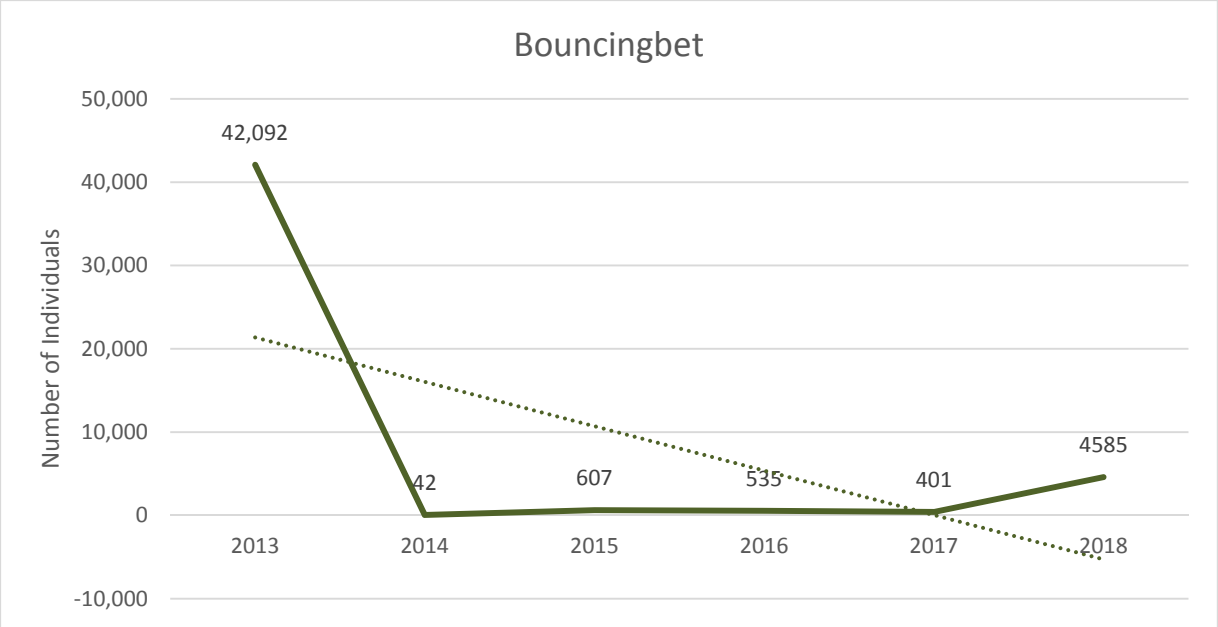


Figure 19. Number of individuals for bouncingbet, 2013-2018.

Recommendations

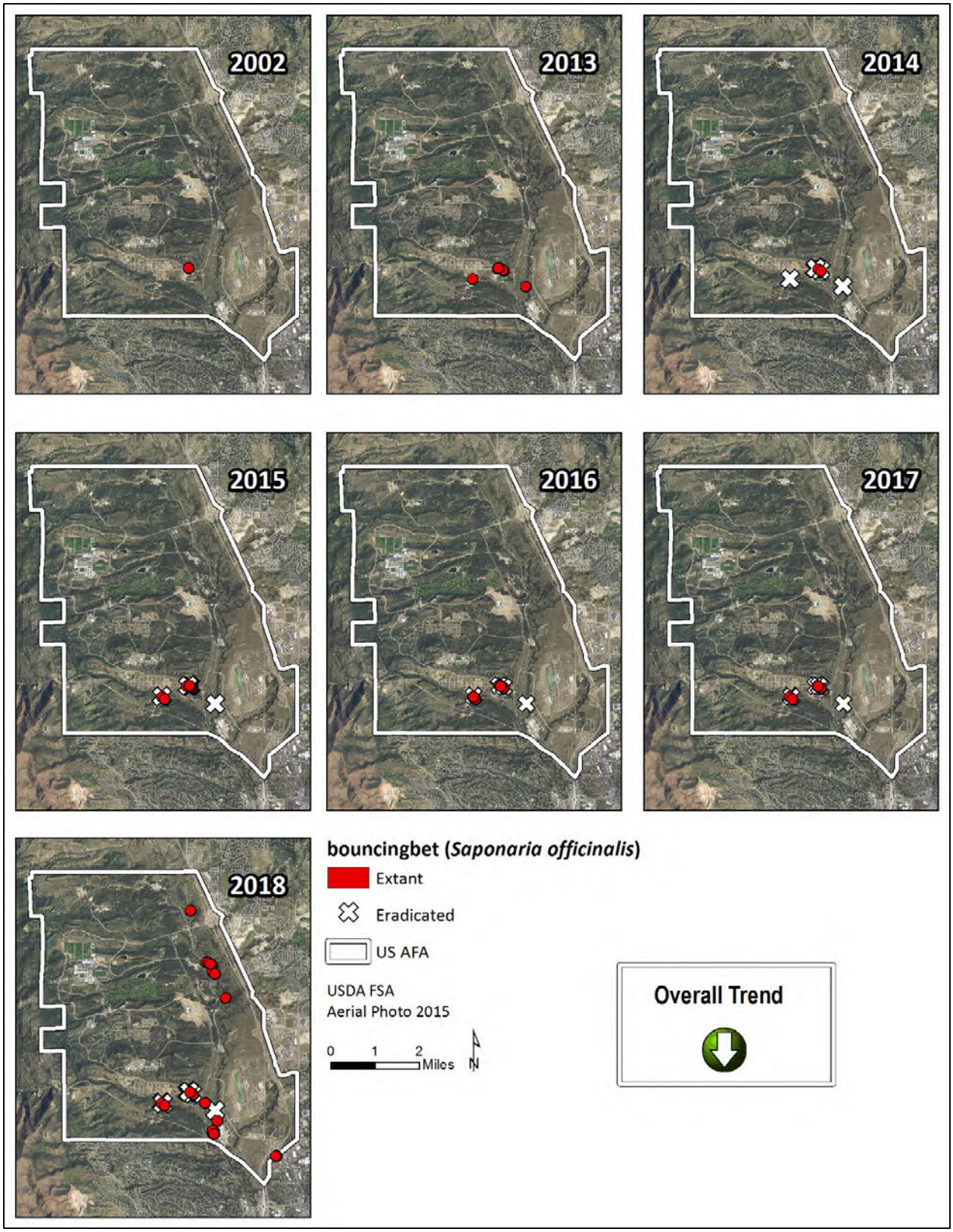
Herbicides appear to be suppressing this species for a few years. However, most of the treated areas have re-sprouting bouncingbet, cheatgrass (List C), smooth brome (a rhizomatous non-native grass) or bare ground at herbicide treated sites (Photo 12). Smooth brome is difficult to control once it becomes established and is not a good cover for wildlands. Cheatgrass indicates recently disturbed soils in treatment areas.

The most important aspect of keeping weeds contained is not to disturb the surrounding native plant species and leave bare soil. Since animals are grazing the bouncingbet in a significant way, we recommend discontinuing herbicide treatments. Continue to monitor all known sites for the next few years to determine if a reduction in plant production is occurring naturally. Always be on the lookout for new populations. A site plan would help focus treatments and results for a more successful outcome by reducing non-target damage to native plants and soils.

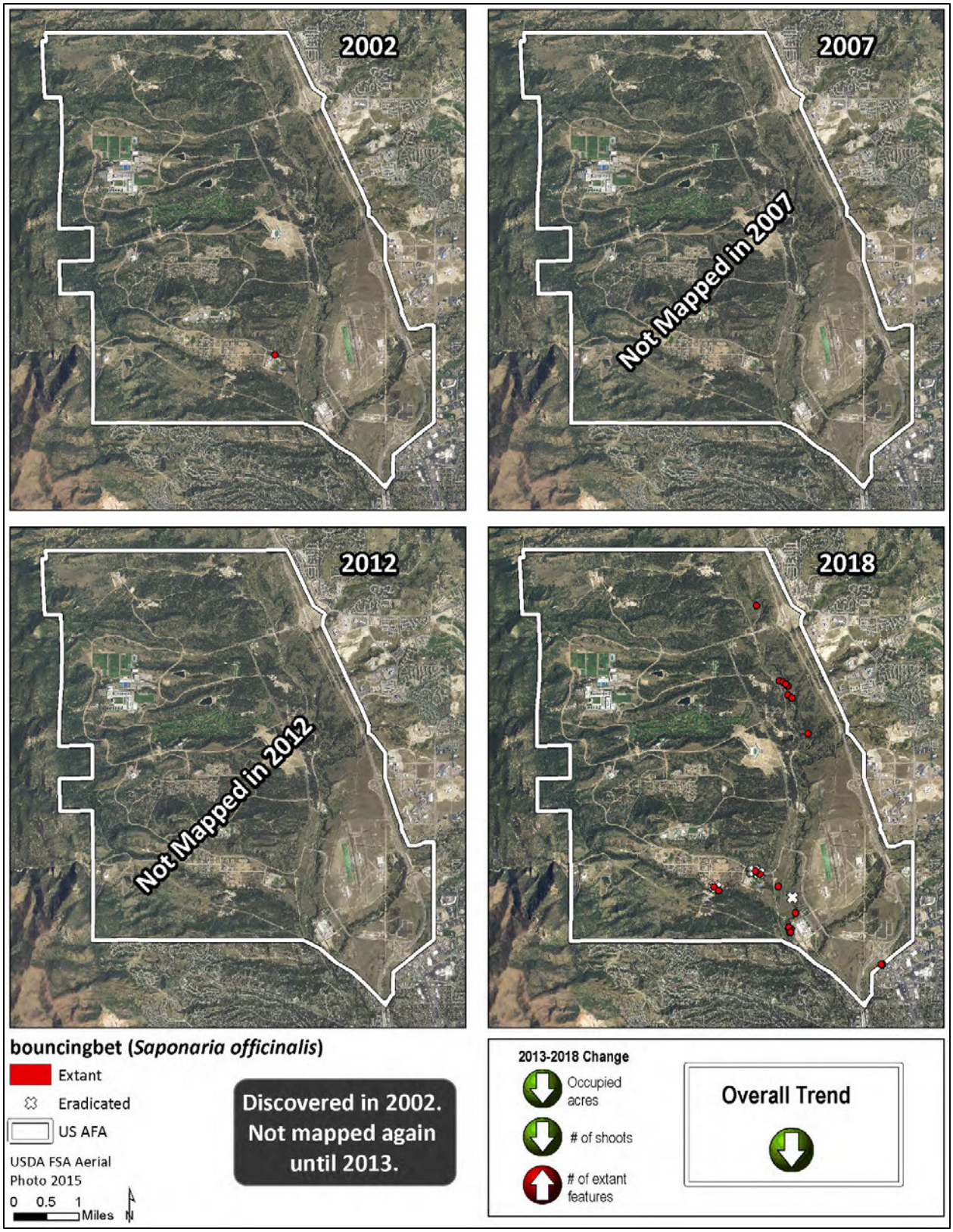
Photo 12. Bouncingbet herbicide treatment area with bouncingbet returning and cheatgrass filling in bare soils left by overspray in drainage area.

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 in the population of bouncingbet since it was first mapped in 2013, and an increase in mapped features that include locations along Monument and Pine Creeks.



Map 48. Distribution of bouncingbet at the Academy between 2002 and 2018.



Map 49. Distribution of bouncingbet at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Salt Cedar (*Tamarix ramosissima*)

Overall Trend: Moderate Increase

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 2018)
- Provides habitat for nesting birds (USFS 2016)

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

2018 Mapping Results

Salt cedar was found at two locations in 2018 at the Academy (Table 63, Maps 50 & 51). One individual has been mapped in NW Jack's Valley for five years in a row. The other individual was first observed in the NE section of Jack's Valley in 2018 and was treated by Academy staff (pers. comm. Brian Mihlbachler (2018).

Table 63. All infestations of salt cedar at the Academy.

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

Basewide weed mapping performed during shaded years.

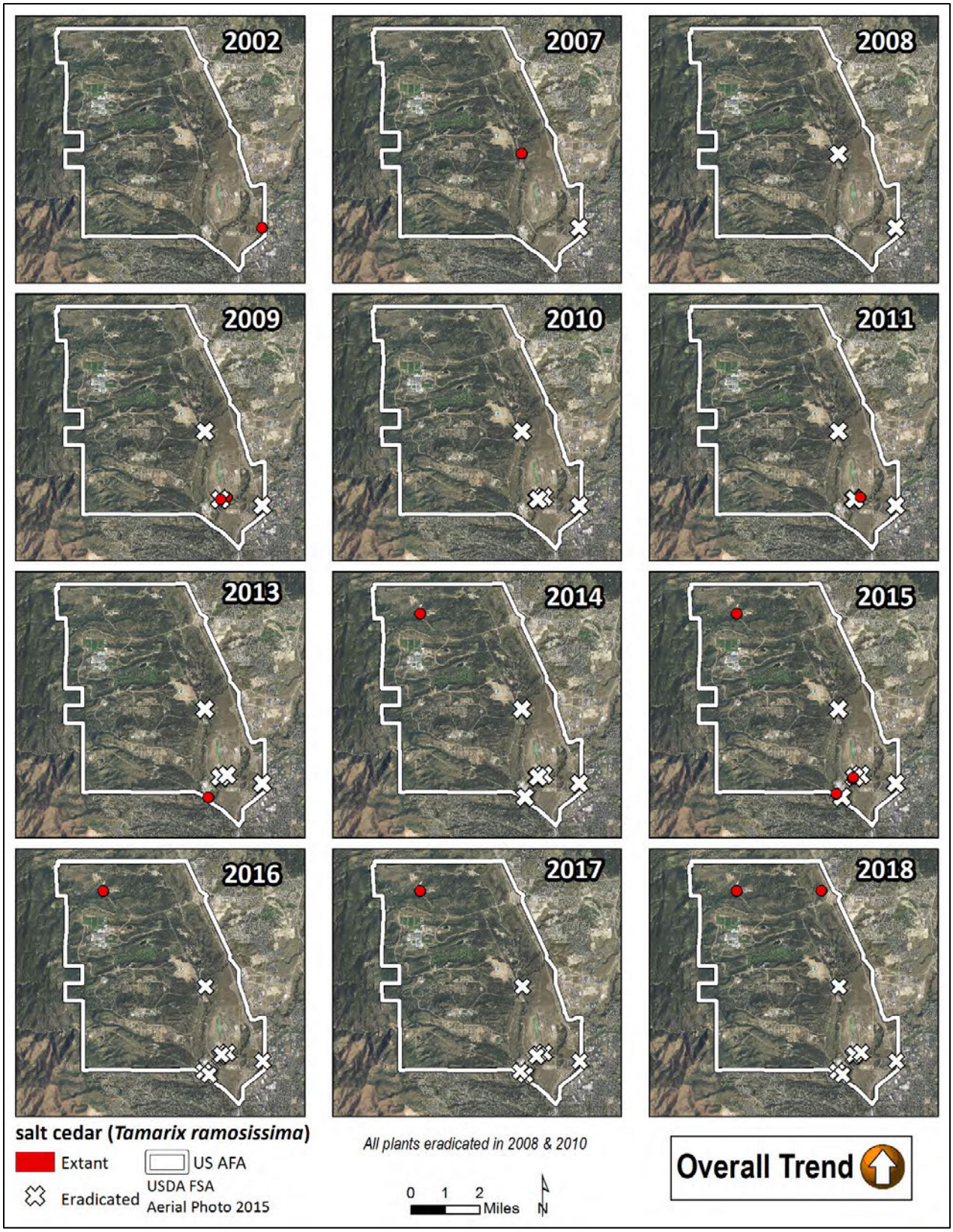
Recommendations

Since the known population includes less than 10 individuals (one individual with 7 sprouts), we recommend a cut-stump method for treatment. For this method to be effective, plants are cut as close to the ground as possible (within 5 cm). According to Colorado Natural Areas BMPs for salt cedar, herbicide should be applied immediately (within seconds) to the cut since as the wound will heal quickly and decrease the amount of herbicide that will be translocated into the stump (CPW 2013). Herbicide should be applied around the perimeter of the cut stump or stems. The two herbicides recommended by Colorado State Parks for this method are triclopyr and imazapyr. Follow-up monitoring is recommended. If bare soil or soil disturbance occurs, new plantings of

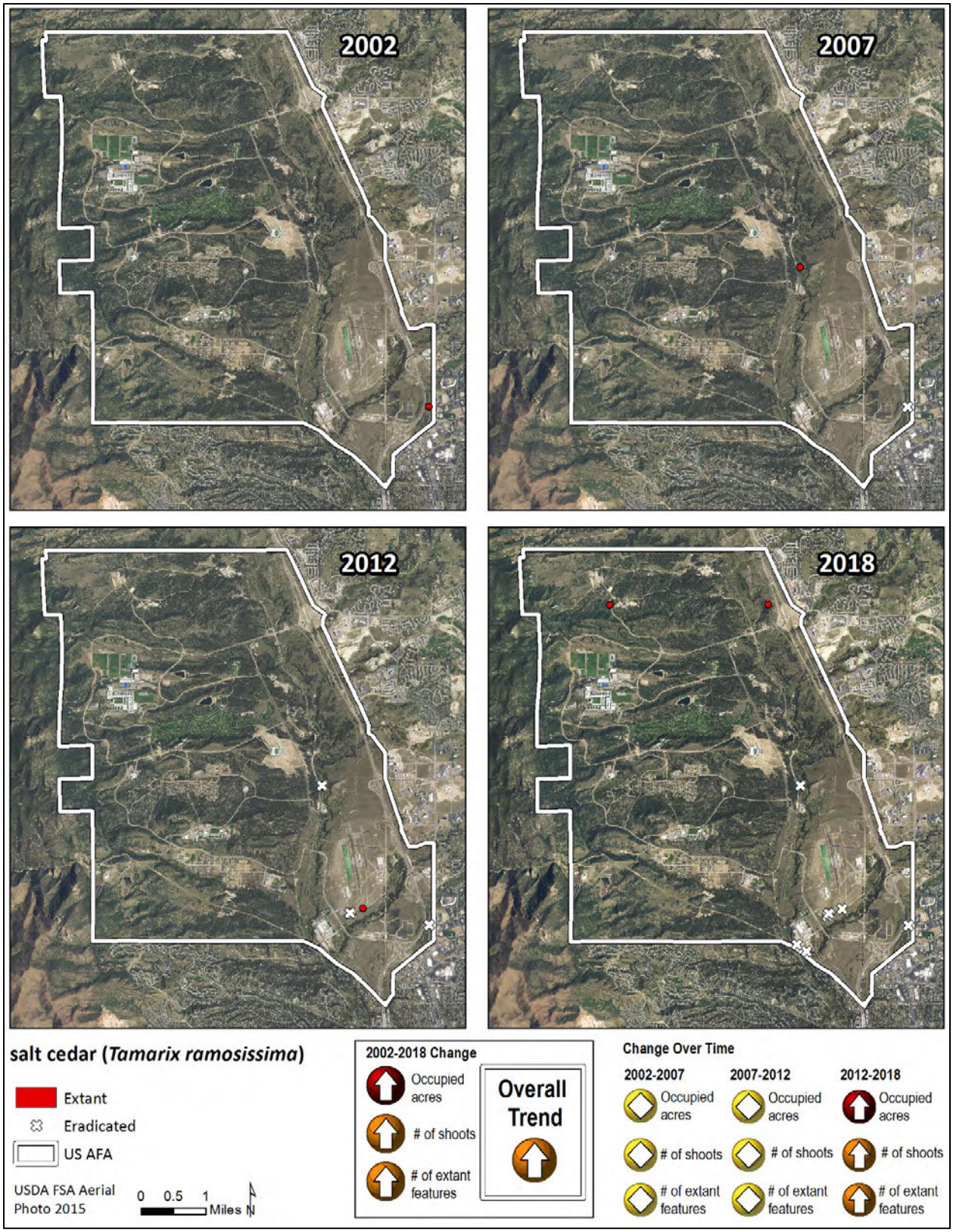
native shrubs and forbs are recommended. Follow-up monitoring for sprouts within a year is recommended (CPW 2013). Salt cedar can spread both by seed and vegetatively. Continued monitoring at the Academy is recommended at the known sites and throughout the Academy, especially in ditches and riparian areas.

History of Sampling and Treatment:

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



Map 50. Distribution of salt cedar at the Academy between 2002 and 2018.



Map 51. Distribution of salt cedar at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

Scentless Chamomile (*Tripleurospermum perforatum*)

Overall Trend: Increasing (New in 2016)

Management Goals: Rapid Response – Kettle 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 2017c, CWMA 2018)

2018 Mapping Results

Scentless chamomile was first observed in 2016, and the first basewide mapping occurred in 2018. The mapping data show there are 117 extant features, consisting of 2,530 individuals which occupy 0.41 acres (Table 64). The scentless chamomile was first mapped in the Kettle Creek drainage and in 2018, it was found all along Monument Creek drainage (Maps 52 & 53).

Table 64. All infestations of scentless chamomile at the Academy.

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

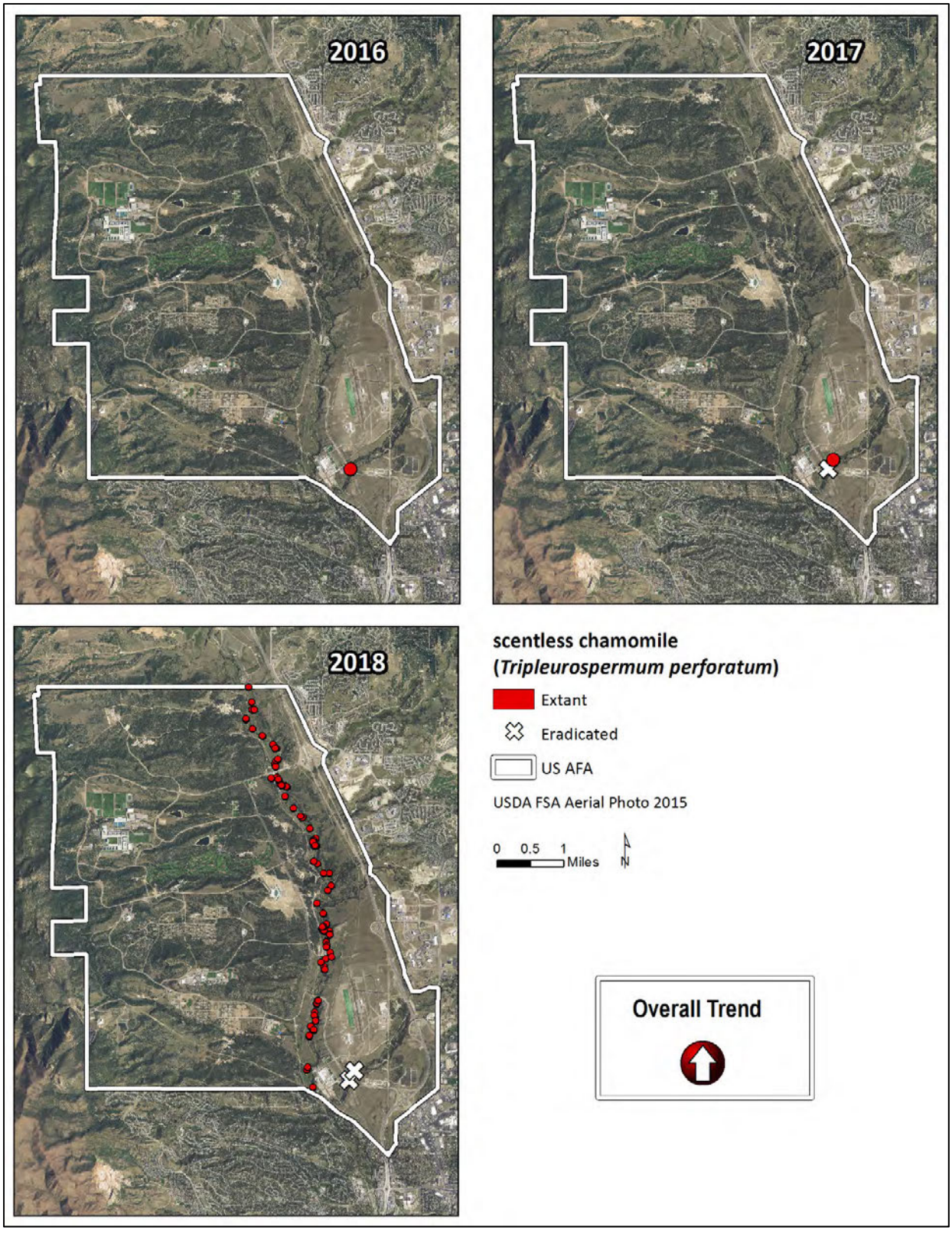
Basewide weed mapping performed during shaded years.

Recommendations

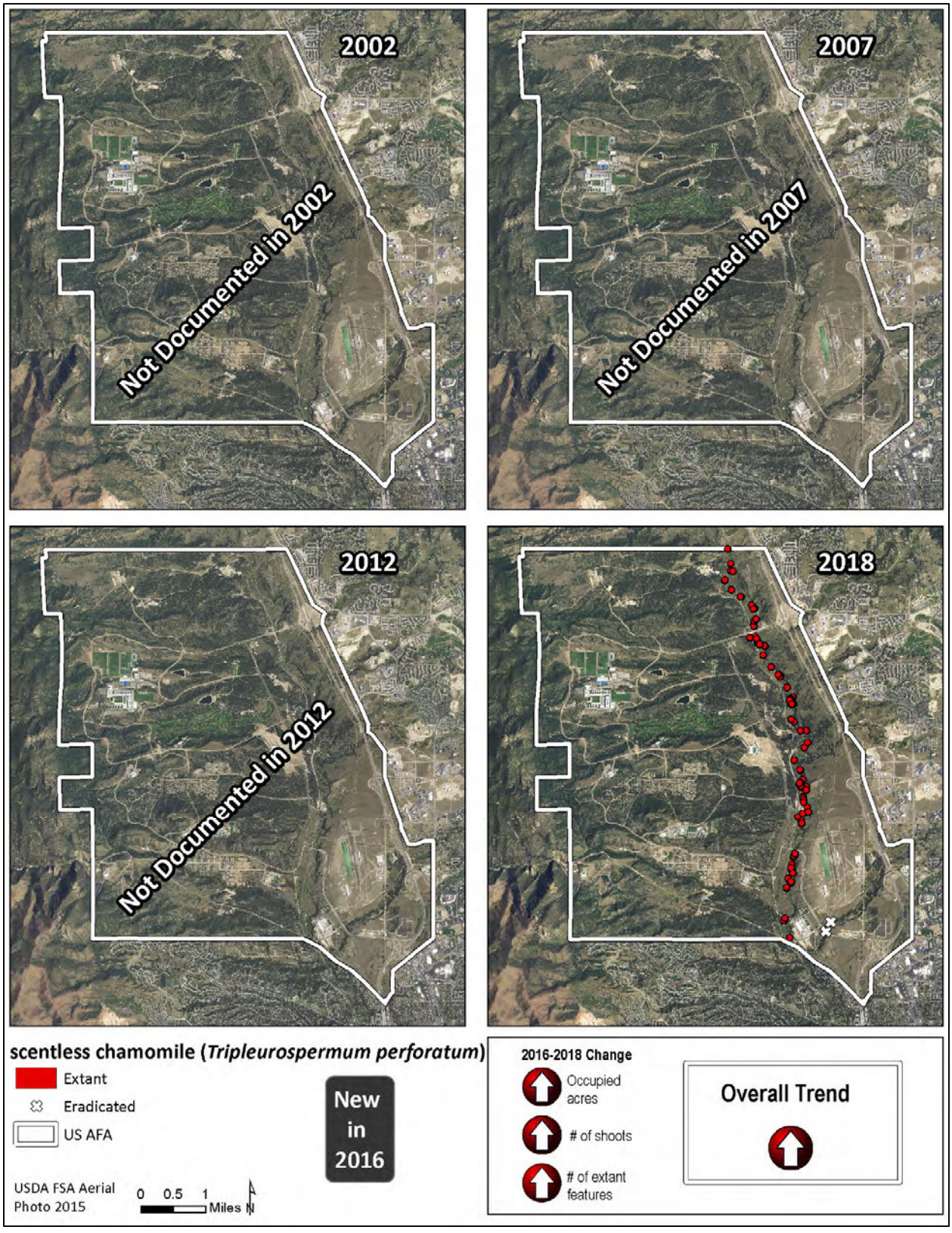
The number of plants observed in 2018 along Monument Creek (>2,500) is large enough that rapid response actions are not likely practical. In addition, even if there was the man-power and resources to eliminate this plant from the Monument Creek drainage, there appears to be a constant seed source from drainages that come into the Academy on the east side. Since the seed source is likely going to be a continuous problem from the east, it may be better to use Academy resources on something else. Therefore, rapid response is currently only recommended for the Kettle Creek drainage on the east side or any other small drainages where scentless chamomile is discovered in small numbers. A diligent attempt to find plants while the invasion is new are worthwhile in the smaller drainages. For local rapid response in Kettle Creek, we recommend mechanical removal. The sandy sediment allows for easy removal with the roots intact. All plants will need to be carried out and discarded as they flower and fruit continuously. Recently flooded areas can be surveyed on foot. The plants are likely to turn up in the other small drainages at the Academy. Spending time training technicians and staff to recognize scentless chamomile and to pull plants as they are found is recommended in smaller drainages.

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.



Map 52. Distribution of scentless chamomile at the Academy between 2016 and 2018.



Map 53. Distribution of scentless chamomile at the Academy from basewide weed surveys (2002, 2007, 2012, and 2018).

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. 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.

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 2016. Colorado Department of Agriculture, Colorado State University Scotch thistle fact Sheet Rev 11/16. https://www.colorado.gov/agconservation/Factsheets/ScotchThistleFactSheet.pdf Accessed 4/7/2017.

CDA 2019. Colorado Department of Agriculture, Colorado State University Common Teasel Fact Sheet Rev 11/16. https://drive.google.com/file/d/1z6ZJBmGlTO0tkeGGp4Tk1x3U6pV64OQ3/view . Accessed 6/3/2019.

CDA 2019a. 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.

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

CSU 2013. Colorado State University Extension: Colorado Noxious Weed Fact Sheets Russian thistle. Website accessed 3/2015. http://extension.colostate.edu/topic-areas/natural-resources/identification-and-management-of-kochia-and-russian-thistle-6-314/

CSU 2013a. Colorado State University Extension: Colorado Noxious Weed Fact Sheets Musk thistle. Website accessed 01/2018: http://extension.colostate.edu/topic-areas/natural-resources/musk-thistle-3-102/

CSU 2013b. Colorado State University Extension: Colorado Noxious Weed Fact Sheets Diffuse and Spotted Knapweed. Website accessed 01/2018. http://extension.colostate.edu/docs/pubs/natres/03110.pdf

CSU 2013c. Colorado State University Extension: Colorado Noxious Weed Fact Sheets: Canada thistle. Website accessed 01/2018 http://extension.colostate.edu/topic-areas/natural-resources/canada-thistle-3-108/

Colorado State University Extension. 2016. http://www.ext.colostate.edu/sam/weeds.html

CWMA. 2018. Colorado Weed Management Association, Noxious Weeds of Colorado 13th Edition.

CWMA. 2017. Colorado Weed Management Association. Leafy Spurge, Euphorbia esula. Website accessed 2017: http://www.cwma.org/LeafySpurge.html

CWMA. 2017a. Colorado Weed Management Association. Myrtle Spurge, Euphorbia myrsinites. Website accessed 2017: www.cwma.org/myrtlespurge.html

CWMA. 2017b. Colorado Weed Management Association. Dame's rocket, Hesperus matronalis. Website accessed 2017: www.cwma.org/DamesRocket.html

CWMA. 2017c. Colorado Weed Management Association. Scentless chamomile, Tripleurospermum perforatum) Website accessed 2017: www.cwma.org/DamesRocket.html

Interagency Workgroup. 2016. Wetland Restoration, Creation, and Enhancement. A Guide for the Public. NOAA, EPA, and others. http://www.habitat.noaa.gov/pdf/pub_wetlands_restore_guide.pdf

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.

Michels, G.J., E. Parks, K. Miller and K. Davis. 2014. Biological Control of Noxious Weeds on Federal Installations in Colorado and Wyoming- Consolidated 2004 Report. Bushland, TX: Texas A&M AgriLife Research.

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

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

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

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

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

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. 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.

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

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., 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.

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

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

USDA-NRCS 2002. Smooth Brome (Bromus inermis) Plant Fact Sheet: Accessed April, 2017. https://plants.usda.gov/factsheet/pdf/fs_brin2.pdf

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

USFS Fire Effects Information System (FEIS) 2019 *Linaria* spp. www.fs.fed.us/database/feis/plants/forb/linspp/all.html#MANAGEMENT%20CONSIDERATIONS

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

USFS-USDA 2014b. Department of Agriculture Forest Service. Field Guide for Managing Dalmatian

and Yellow Toadflaxes in the Southwest. Southwest Region TP-R3-16-06. September 2014. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410111.pdf

WU 2018. Weather Underground Colorado Springs Weather History for KCOS https://www.wunderground.com/history/airport/KCOS/

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

Western Regional Climate Center. 2015. Monthly Climate Summaries. Reno, NV. Accessed via the Internet at: www.wrcc.dri.edu.

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 MAPPING AND 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
Russian knapweed (*Acroptilon repens*)			M*	M	M	M	M	M	M	M	M	M	M	M	M	M	M
garlic mustard (*Alliaria petiolata*)																	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
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
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
yellow spring bedstraw (*Gallium verum*)									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
Dame's rocket (*Hesperis matronalis*)											M*		PM	M	PM		M
common St. Johnswort (*Hypericum perforatum*)	M			M	M	M	M	M	M	M	M	M	M	M	M	M	M
perennial pepperweed *(Lepidium latifolium)*																	M*
Dalmatian toadflax (*Linaria dalmatica*)								M*	M	M	M	M	M	M	M	M	M
yellow toadflax (*Linaria vulgaris*)	M					PM					PM						PM
Tatarian honeysuckle (*Lonicera tatarica*)							M*			M	M	M	M	M	M	M	M
Scotch thistle (*Onopordum acanthium*)	M			M	M	M	M	M	M	M	M	M	M	M	M	M	M
Bouncingbet (*Saponaria officinalis*)	M*											M	M	M	M	M	M
Salt cedar (*Tamarix ramosissima*)	M					M	M	M	M	M	M	M	M	M	M	M	M
scentless chamomile (*Tripleurospermum perforatum*)															M*	M	M

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)

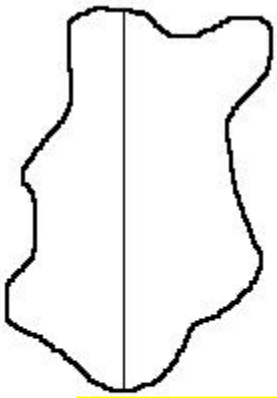
Materials for SURVEY ONLY:
Quadrat 50 x 50 cm (2)
50 m survey tape (minimum of 2, however 3 can also work well.
GPS unit, with the current year's shapefile for data entry

Standard survey procedure:

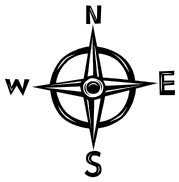
- The technique outlined here will apply to the majority of sites
- The general concept is to aim for a 50 m transect through the center of weed infestation. Sometimes it may be necessary to do a shorter transect in order to stay within the habitat. Ideally, the 25 m long bisecting transects have the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



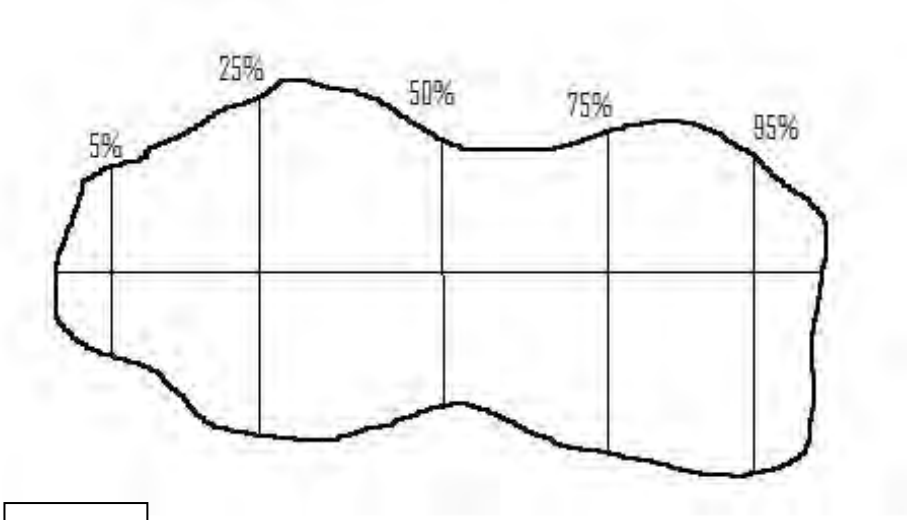


Fig. 2

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.

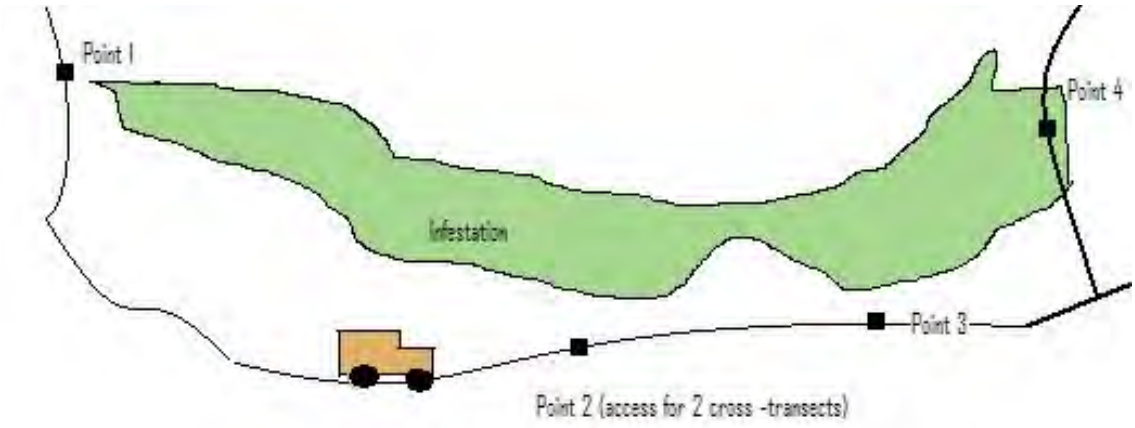

Point 1
Point 4
Infestation
Point 3
Point 2 (access for 2 cross -transects)

Fig. 3

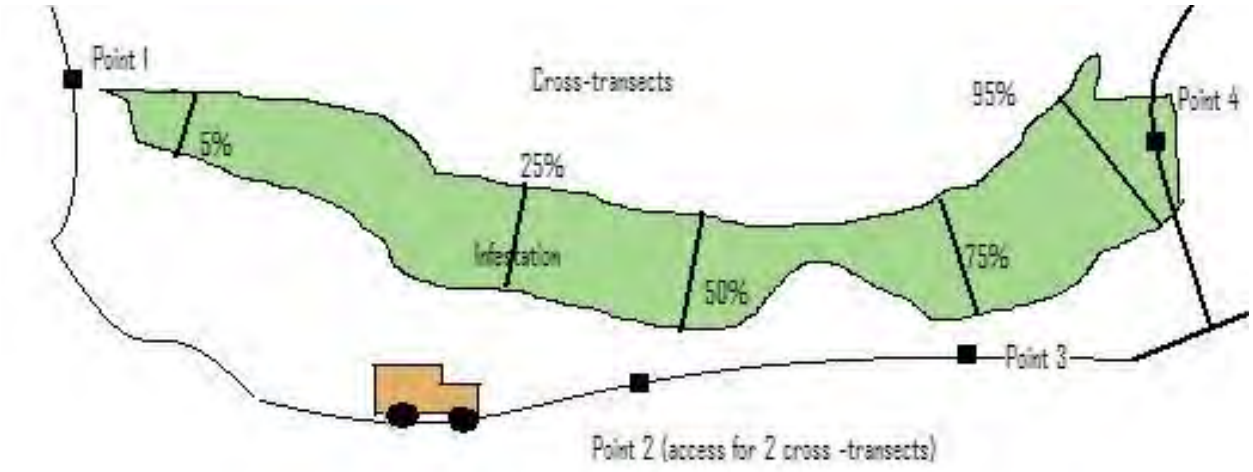

Point 1
Cross-transects
95%
Point 4
5%
25%
Infestation
50%
75%
Point 3
Point 2 (access for 2 cross -transects)

Fig. 4

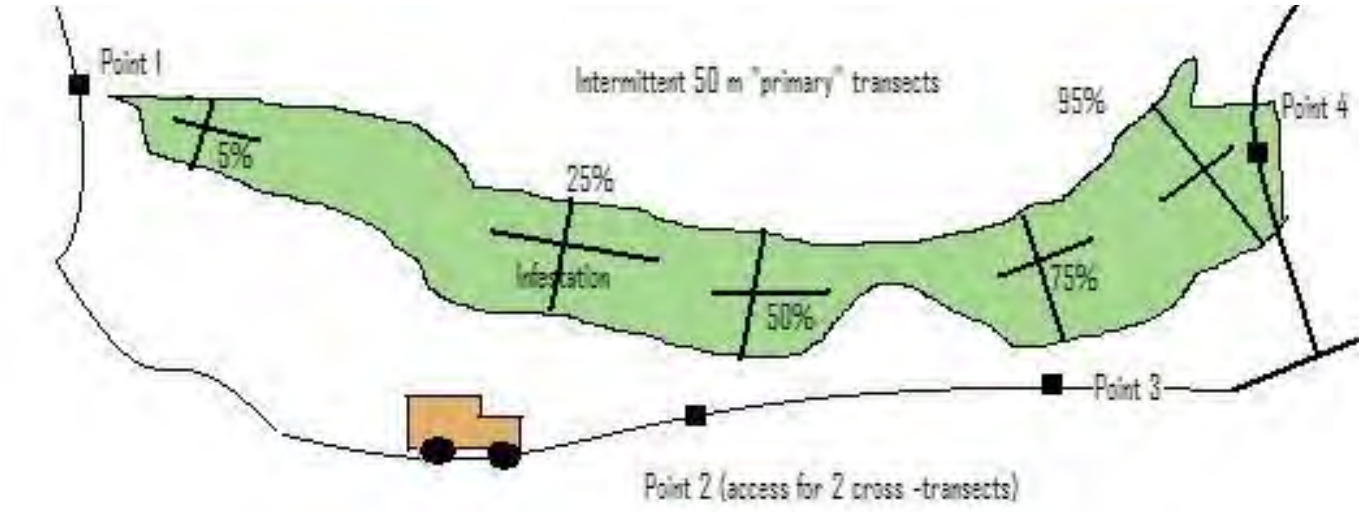


Fig. 5

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.

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

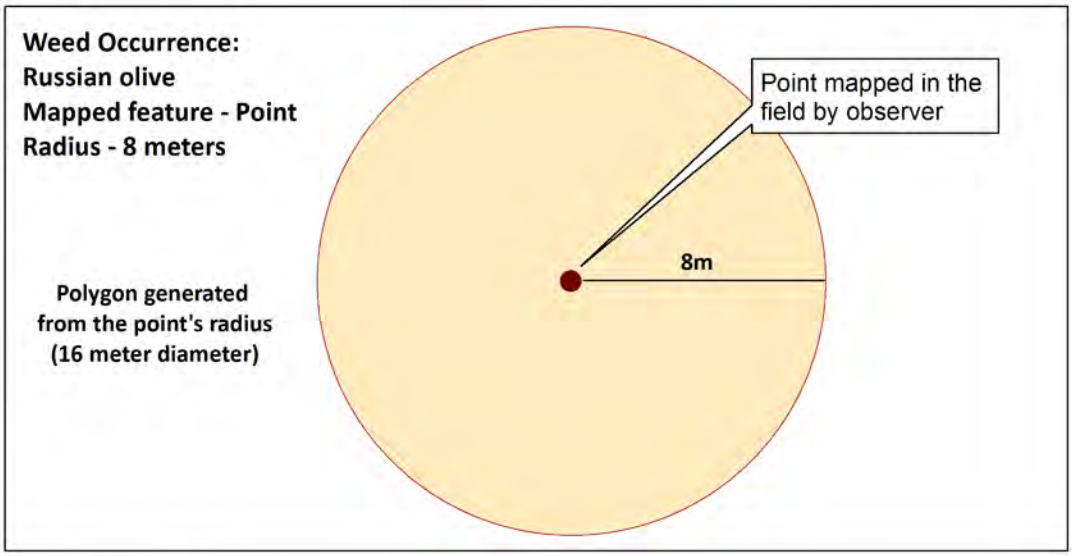
COUNTRY - Country

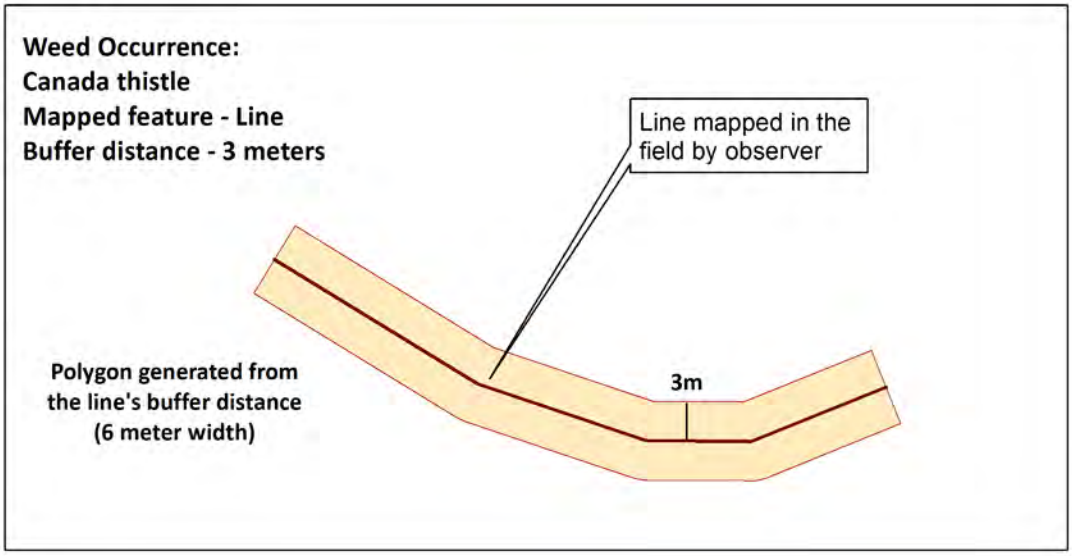
EXAMINER –Field observer

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: