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

Year 11

May 2016

COLORADO NATURAL HERITAGE PROGRAM

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

Year 11

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May 2016

CNHP's mission is to preserve the natural diversity of life by contributing the essential scientific foundation that leads to lasting conservation of Colorado's biological wealth.

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Front Cover: Top: Dame's rocket P. Smith 2015; Middle: Canada thistle with lady bug P. Smith 2015, CNHP, Bottom; Survey monitoring plot 2015 P. Smith.

EXECUTIVE SUMMARY

This report includes a summary of the results of the past eleven years of population monitoring of targeted noxious weeds at the U.S. Air force Academy ("the Academy"), emphasizing changes that were observed between 2012 and 2015.

Weed species were monitored utilizing two methods, a complete census (areal mapping), and permanent plots, depending on the species. Areal monitoring was conducted on species that are considered to have a high probability of suppression or eradication. Species monitored with permanent plots are considered to have a low probability for containment but are being selectively managed. Of the 16 total species on the monitoring list for 2015, areal mapping is used for 11 species and permanent plots are used for five species. Areal mapping species include: Russian knapweed (*Acroptilon repens*), houndstongue (*Cynoglossum officinale*), myrtle spurge (*Euphorbia myrsinites*), yellow spring bedstraw (*Galium verum*), dame's rocket (*Hesperis matronalis*), common St. Johnswort (*Hypericum perforatum*), Dalmatian toadflax (*Linaria dalmatica* ssp. *dalmatica*), Tatarian honeysuckle (*Lonicera tatarica*), Scotch thistle (*Onopordum acanthium*), bouncingbet (*Saponaria officinalis*), and tamarisk (*Tamarix ramosissima*). Species with permanent plots include: whitetop (*Cardaria draba*), Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*; photo monitoring), diffuse and spotted knapweeds (*Centaurea diffusa* and *C. maculosa*), and leafy spurge (*Euphorbia esula*).

A summary of recommendations and a summary of findings are provided below. Monitoring was not conducted at Farish in 2012-2015 but it is scheduled for 2016.

Summary of Recommendations:

- Baseline plots are needed as part of the monitoring surveys. Ideally, 50 -100% of monitoring plots should be left as baseline plots which are free from herbicide and other control efforts. This would provide data to determine the impacts of treatments (including biocontrol) versus weather condition impacts. Without baseline plots, monitoring data will not provide the information needed to make the monitoring effort worthwhile.
- Healthy ecosystems are the best defense against weeds. Herbicide applications should be targeted to roadsides and away from sensitive areas with rare plants and diverse native species unless a site specific treatment plan is in place for proposed treatment areas where natural resources need protection. Such a plan would include minimal and precise herbicide application and immediate follow-up replanting of native species (Smith et al. 2015).
- A workshop in winter or early spring, with the staff at the Academy and the contractor who treats weeds, is recommended to enhance communication and information sharing and reduce impacts to native species. Native species are being directly impacted by weed management activities. Recognizing some of the rare species that are on the base as well as some of the target weeds in different growth stages can be reviewed in a workshop with a CNHP botanist.

Monitoring 2015 Summary of Findings

Status	Name	Common Name	Comment
	*Acroptilon repens*	Russian knapweed	Potentially eradicated. No new features mapped in 2015, no extant features.
	*Cardaria draba*	Whitetop	Permanent plot data shows plants are stable. Ten plots monitored.
	*Carduus nutans*	Musk thistle	Photo plots show significant overall decrease since 2008, slight increase 2013-2015.
	*Centaurea maculosa, C diffusa,* & hybrids	Spotted and diffuse knapweeds	Permanent plot data show a stable to slight decrease. Fourteen plots surveyed (9 + 5 biocontrol plots).
	*Cirsium arvense*	Canada thistle	Permanent plots show stable to slight decrease. Eight plots monitored. Evidence of biocontrol and rare plants/animals in plots.
	*Cynoglossum officinale*	Houndstongue	Increase in number of mapped features, and increase in number of individuals at extant features.
	*Euphorbia esula*	Leafy spurge	Permanent plot data show stable to slight decrease. Ten plots monitored. Rare plants found in two plots. Evidence of biocontrol.
	*Euphorbia myrsinites*	Myrtle spurge	Stable to slight increase. 2007-2013 decrease, slight increase in 2014-2015.
	*Gallium verum*	Yellow spring bedstraw	Increase. No plants observed 2012-2014, 10 plants in 2015.
	*Hesperis matronalis*	Dame's rocket	A dramatic decrease since 2012. A rare plant species was documented in treatment area.
	*Hypericum perforatum*	Common St. Johnswort	Significant decrease since 2007, largely attributed to biocontrol.
	*Linaria dalmatica ssp. dalmatica*	Dalmatian toadflax	Decrease, no plants observed at all known sites in 2015.
	*Lonicera tatarica*	Tatarian honeysuckle	Increase since 2008. Increase 2013-2015 due to re--sprouting of treated individuals.
	*Onopordum acanthium*	Scotch thistle	Increase since 2008. Mapped features increased due to new survey areas and the number of individuals increased.
	*Saponaria officinalis*	Bouncingbet	Dramatic reduction in number of individuals since 2013.
	*Tamarix ramosissima*	Tamarisk	Currently, there are less than 10 occurrences in four locations, which is an increase since 2002 when only 1 occurrence was known.

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 2015. Field assistance from CNHP volunteer Dominik McLaren and CSU work-study student Alyssa Meier to update the weed data this year. Special thanks to Karin Decker at CNHP for editing and critique.

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INTRODUCTION

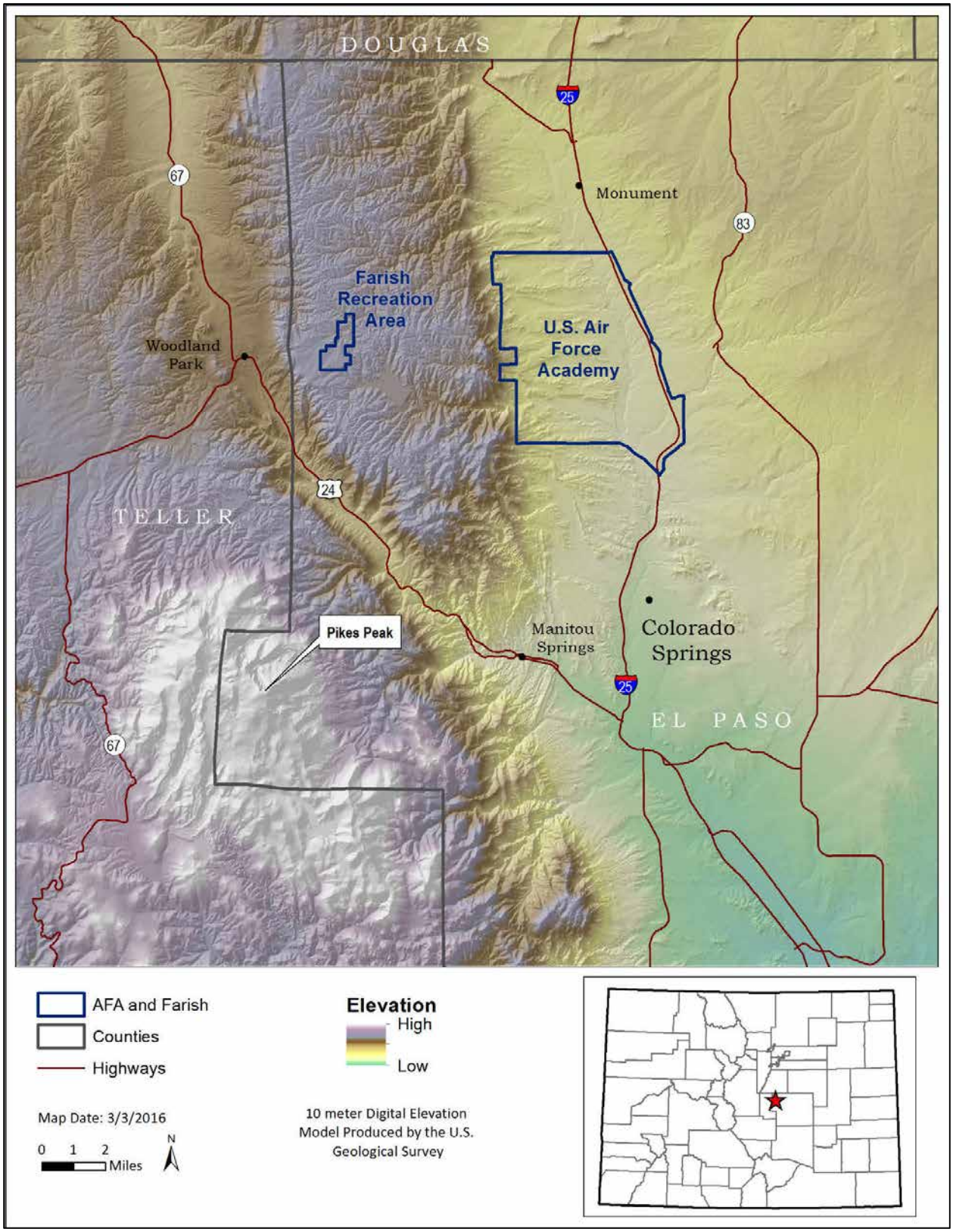
Many local governments now require public and private landowners to manage noxious weeds. The U.S. Air Force Academy (referred to herein as "the Academy") must conform to state (Department of Agriculture) and County (El Paso County) weed control regulations for noxious weeds (Code of Colorado Regulations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

The Academy has also established management objectives for weed control in order to remain compliant 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.

Many of the guidelines for controlling noxious weeds (including herbicide label instructions) are often based on agricultural landscapes and not 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 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 falls into the "natural areas" category and includes important wetland features. The Academy and Farish Outdoor Recreation Area 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. 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 the site. The Academy is critically important for the conservation of the listed Threatened Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (Siemers et al. 2012, Colorado Natural Heritage Program 2015).

The Colorado Natural Heritage Program has been monitoring noxious weeds at the Academy for 11 years. The following section summarizes the results of the monitoring program to date. This document focuses on the eleventh year of surveys, sampling, and data analysis conducted by CNHP.



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

Timeline of Weed Mapping and Monitoring at the Academy

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.

- **2002-2003:** Approximately 4,000 weed populations were mapped at the Academy and Farish, with 14 species on the target list (Anderson et al. 2003).
- **2003:** Whitetop (*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, and this 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 permanent monitoring plots. 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. Myrtle spurge was added to the target weed list.
- **2007:** The second weed map of the Academy and Farish was completed, with a total of 17 mapped species (Anderson and Lavender 2008a), including three additional weed species not on the original map.
- **2008:** Based on previous year's data, protocols were adjusted for the 2008 surveys. Tatarian honeysuckle (*Lonicera tatarica*) was discovered at the Academy.
- **2009:** The recommendations from the year 4 monitoring results were applied and two additional species were mapped: houndstongue (*Cynoglossum officinale*) and Dalmatian toadflax (*Linaria dalmatica* ssp. *dalmatica*). A total of 13 species were targeted. A habitat suitability model for spotted knapweed was produced.
- **2010:** We did not monitor diffuse knapweed (*Centaurea diffusa*). Yellow spring bedstraw (*Gallium verum*) was discovered at the Academy and mapped.
- **2011:** Updated monitoring protocols were used; diffuse knapweed and whitetop (*Cardaria draba*) were not monitored. The annual mapping of Tatarian honeysuckle began.
- **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 responsibility for the leafy spurge (*Euphorbia esula*) and common St. Johnswort (*Hypericum perforatum*) monitoring plots; 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 whitetop (*Cardaria draba*) and leafy spurge (*Euphorbia esula*); and 5) the third weed mapping effort 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 maculosa, C. diffusa* and hybrid forms) were lumped together for plot results.
- **2014:** Monitoring was the same as in 2013, except that whitetop (*Cardaria draba*) plots were not visited and Canada thistle plots were visited. Dame's rocket was mapped too late in the season. Whitetop and dame's rocket were prioritized for 2015.
- **2015:** Monitoring was the same as in 2014, except that whitetop (*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.

METHODS

The objective of this project was to evaluate the effectiveness of ongoing management of noxious weeds at the Academy in order to determine whether weed management objectives are being met and to determine trends. 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. In 2012-2015, combinations of transect sampling, photo plots, and perimeter mapping and census were used to monitor the 16 target noxious weed species (Table 1). Permanent plot locations are shown in Map 2. In order to closely align with the Texas A&M (TAMU) AgriLife biocontrol, we established 36 permanent plots using the methods of Michels et al. (2013). Plot numbers were whitetop (7), diffuse knapweed (5), spotted knapweed (5), Canada thistle (8), and leafy spurge (10). Plots were randomly selected, utilizing 2007 weed mapping data (Anderson and Lavender 2008a). Details of the methods used to collect density, cover, height, reproductive stage, number of flowers, and flower width at each of the permanent plots are in Appendix B. In 2013, we resampled all but Canada thistle, and in 2014 we resampled all but whitetop. For all plots we calculated average density, average cover, and frequency (% quadrats with plants).

The sampling in 2015 included all permanent plots listed above with the addition of 3 plots for whitetop added in 2015 following methods in Anderson and Lavender (2008a). Canada thistle biocontrol plot CTploop was added and CIAR4-6 permanent plot was not sampled in 2015, so that the total remained 8 plots.

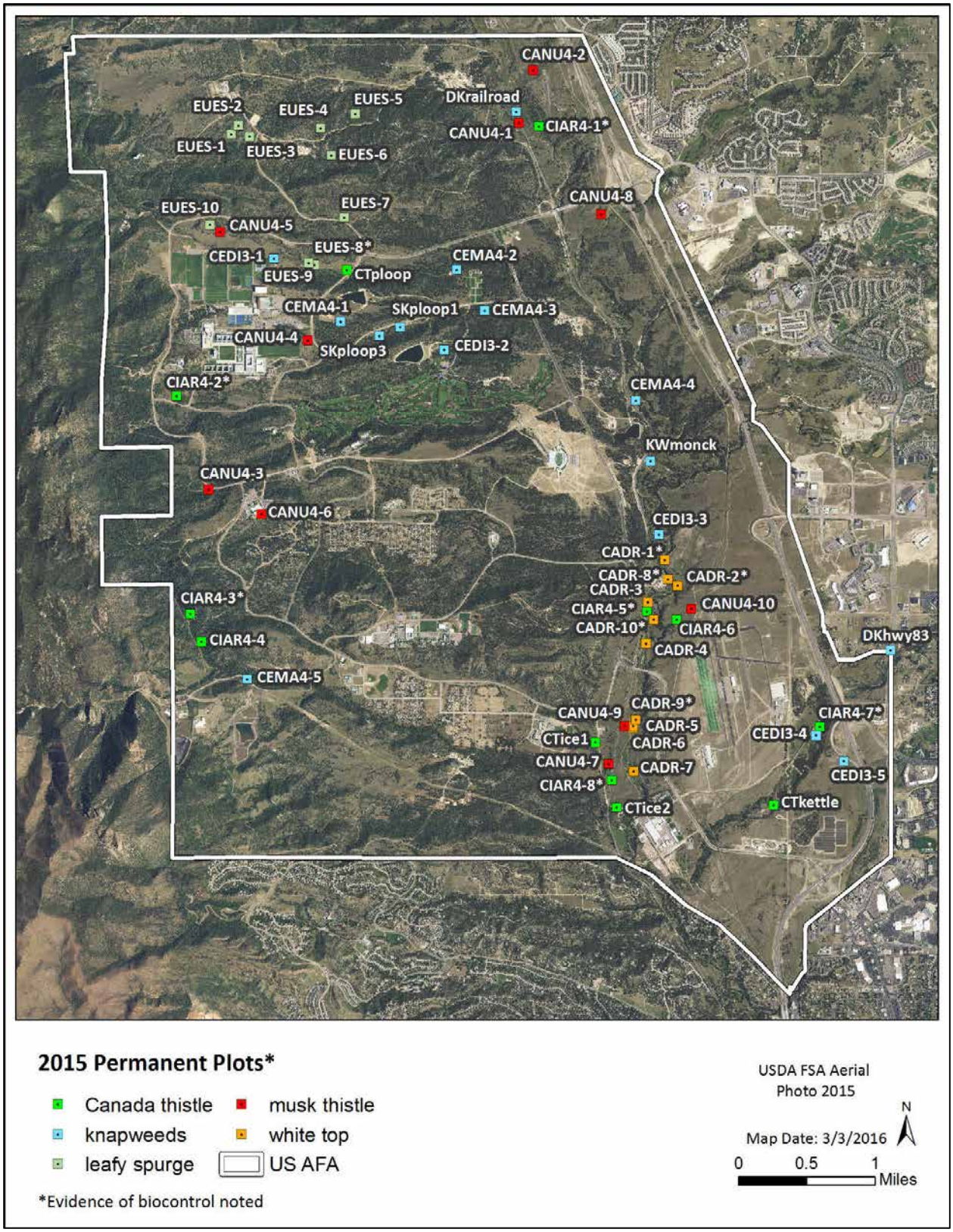
Biocontrol introductions by Texas A&M AgriLife were discontinued in 2015 since most of the populations of weeds at the Academy were determined to be too small to support biocontrol agents at this time. However, some of the noxious weed populations have the potential to grow to the point

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. All five Texas A&M biocontrol plots for knapweed and a single plot for Canada thistle were re-established for continued monitoring.

Table 1. Summary of methods used for monitoring by CNHP in 2012-2015.

Latin Name	*Common Name*	*2012 Methods**	*2013 Methods**	*2014 Methods**	*2015 Methods**
Acroptilon repens	Russian knapweed	M	M	M	M
Cardaria draba	Whitetop	PP	PP	---	PP
Carduus nutans	Musk thistle	M	PP (photo plots)	PP (photo plots)	PP (photo plots)
Centaurea diffusa, C. maculosa and hybrid	Diffuse, spotted knapweeds	PP	PP	PP	PP
Cirsium arvense	Canada thistle	PP	---	PP	PP
Cynoglossum officinale	Houndstongue	M	M	M	M
Euphorbia esula	Leafy spurge	PP	PP	PP	PP
Euphorbia myrsinites	Myrtle spurge	M	M	M	M
Galium verum	Yellow spring bedstraw	M	M	M	M
Hesperis matronalis	Dames rocket	M	---	PM	M
Hypericum perforatum	Common St. Johnswort	M	M	M	M
Linaria dalmatica spp. *dalmatica*	Dalmatian toadflax	M	M	M	M
Lonicera tatarica	Tatarian honeysuckle	M	M	M	M
Onopordum acanthium	Scotch thistle	M	M	M	M
Saponaria officinalis	Bouncingbet	M	M	M	M
Tamarisk ramosissima	Tamarisk	M	M	M	M

*Shading indicates monitoring activities: PP = permanent plots, M = mapped, PM = partially mapped



Map 2. Locations of permanent monitoring plots for weeds at the Academy.

RESULTS AND RECOMMENDATIONS

Annual precipitation can be a helpful indicator for interpreting weed monitoring data. Higher precipitation years often result in increased weed numbers for that year. The yearly total for 2015 was 25.25 inches which is over 60% above the average annual precipitation (1961-1990) of 16.2 inches. In 2015, the 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). The majority of 2015 rainfall for Colorado Springs was received during the spring months, with lesser amounts during the summer months which were also above normal (Figure 1).

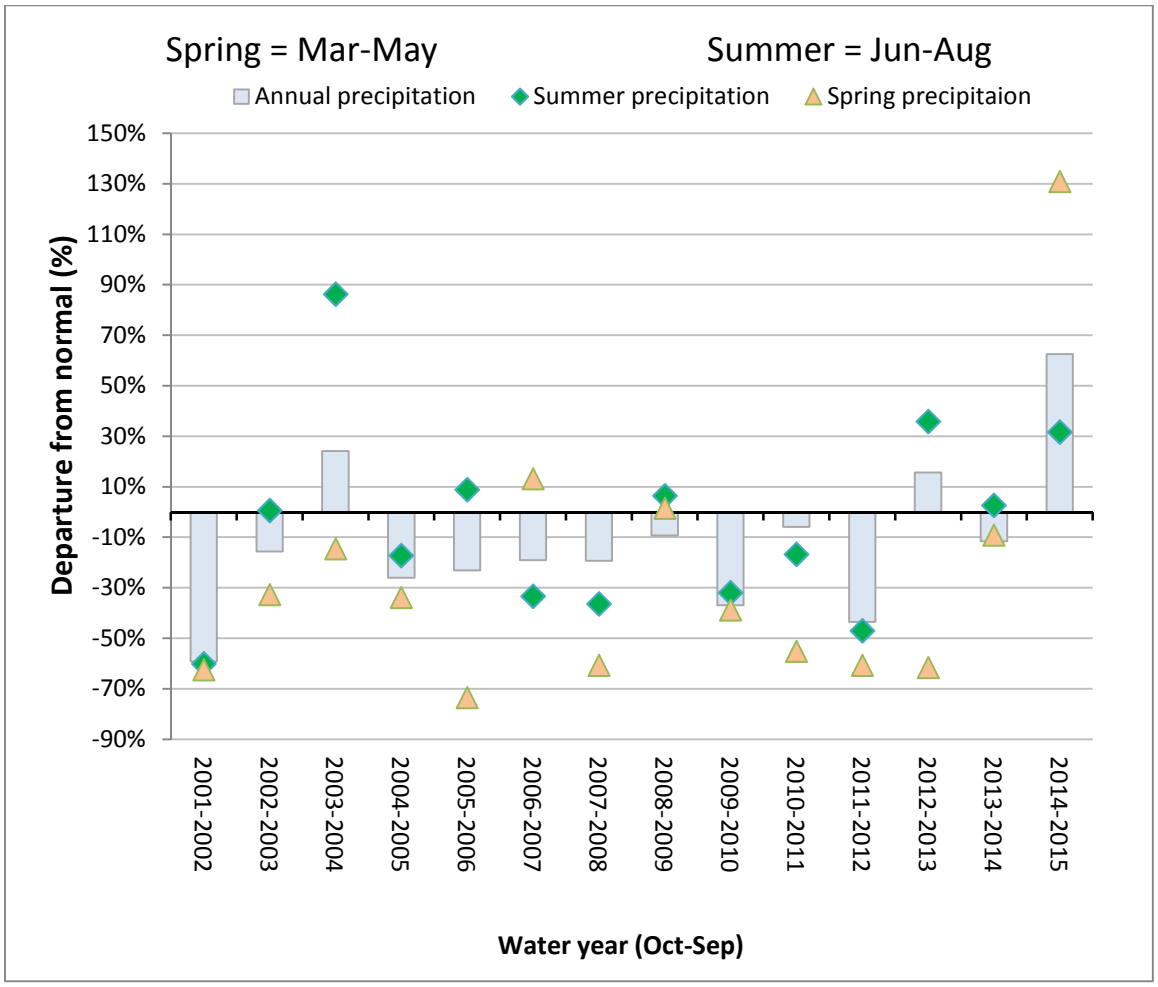


Figure 1. Summary data for annual precipitation by water year (October-September) at Colorado Springs, Colorado from 2002 through 2015 (Western Regional Climate Center 2014 and Weather Underground History 2015). Average annual precipitation (1961-1990) is 16.3 inches. Spring = March-May, Summer = June-August

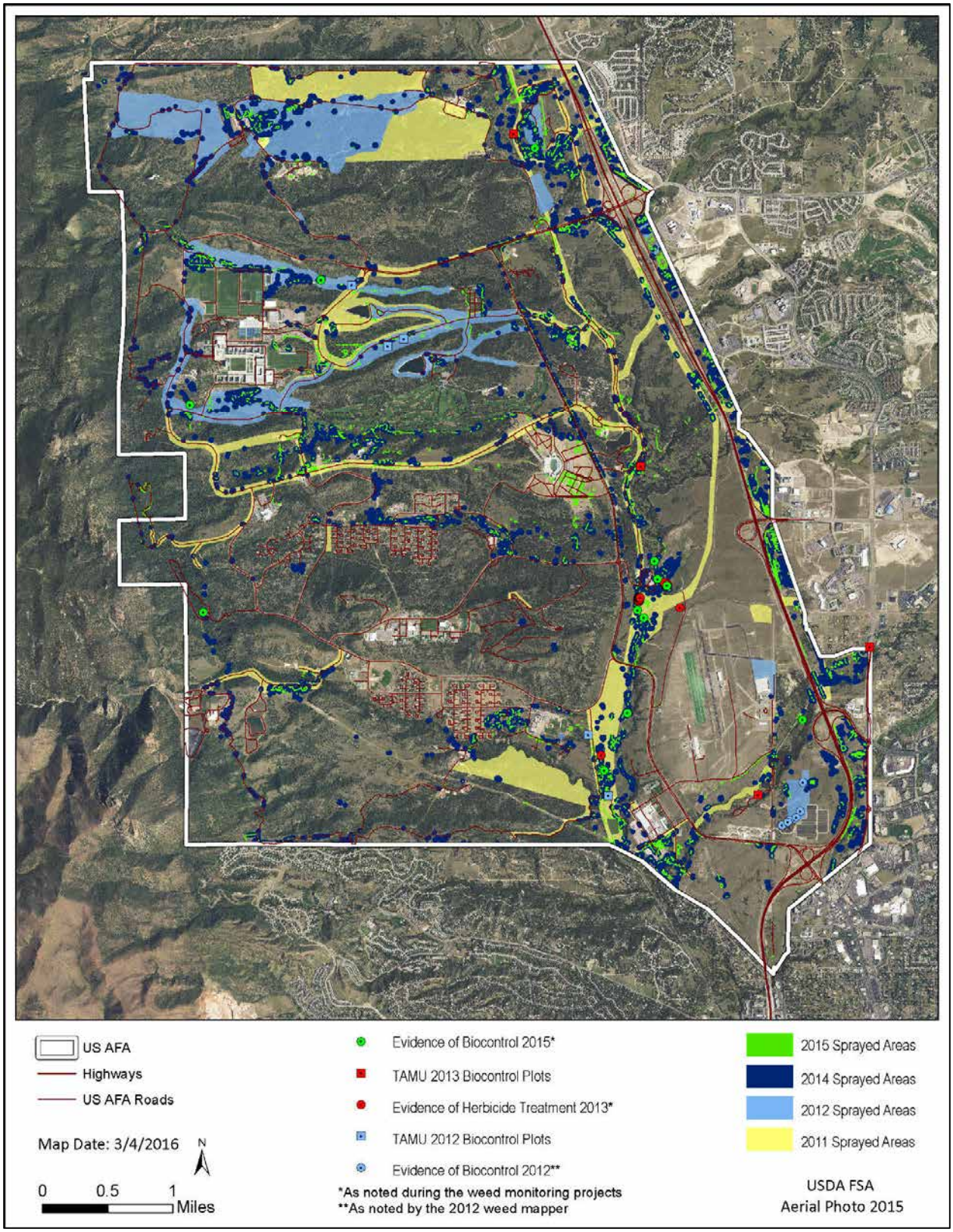
The results for 16 monitored weed species indicate that five species show a decreasing trend, five species show an increasing trend, five species show a stable or stable to slightly increasing or decreasing trend, and one species, Russian knapweed (*Acroptilon repens*) is considered to be

potentially eradicated. Results specific to each target noxious weed species are summarized in the following sections. See Appendix A-D for additional information on methods and results. (Recently treated areas at the Academy are shown in Map 3.)

Recommendations as weed management at the Academy moves forward include securing baseline control monitoring plots that are not subjected to weed treatments. At least half of the plots should not be treated and detailed records should be kept on the plots that are treated. Control plots are necessary to interpret the weed data that is being collected. A second recommendation is to continue to improve communications between staff and contractors to ensure proper identification of target weed species, identification of wetland habitats and rare plant species known to occur within a number of the study plots and other areas at the Academy, and to interpret the monitoring results. A yearly meeting with CNHP and weed treatment staff and contractors is a good way to open lines of communication and share information. Ongoing communication is critical because in some instances, the disturbances caused by weed treatments appear to encourage the growth of noxious weeds and smooth brome. In addition, some of the weed management occurring at the Academy is in natural areas where the native vegetation needs to be protected and/or in the vicinity of rare plants, native plant communities, and animals of conservation concern. Protocols for treating weeds in the vicinity of rare plants are currently being developed by the State of Colorado (Mui 2016, pers. comm. 21 February). CNHP has been involved in the development of the protocols and some of the recommendations have been incorporated into this report. 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.

Recommendation Summary:

- Avoid herbicide application to monitoring plots without a study plan. A GIS shapefile will be provided to the weed contractor(s) and technicians to avoid plots.
- Utilize only spot herbicide applications in Special Weed Management Areas (Smith et al. 2015) if herbicides are used.
- Host a yearly weed workshop for updates and improved communication for contractors and staff.
- Site plans are recommended for natural areas before weed control methods are initiated that include a site description with a species list, the proposed method of treatment(s) and a description of the follow-up monitoring and restoration activities.
- Utilizing herbicides for multiple years in the same location should be avoided. The coverage of smooth brome into the natural areas seems to be increasing in areas where herbicides have been repeatedly utilized at the same locations.



Map 3. Recent treatment areas at the Academy.

Russian Knapweed (*Acroptilon repens*)

Potentially eradicated; all sites with no extant features observed between 2013-2015.

AFA Management Goals: Eradication through continued monitoring and rapid response with mechanical and chemical treatments

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).

2015 Results

During the 2015 survey, eleven of the twelve known sites were surveyed and no Russian knapweed plants were observed (Table 2, Figure 2 and Map 4). The occurrence located south of the athletic fields in a gated high security area was not surveyed (no plants were observed there in 2014). Monitoring of the known sites should continue for at least two more years based on herbicide residue time and seed longevity of this species. Rapid response and early detection is a viable method for any newly detected populations to maintain a "potentially eradicated" status at the Air Force Academy.

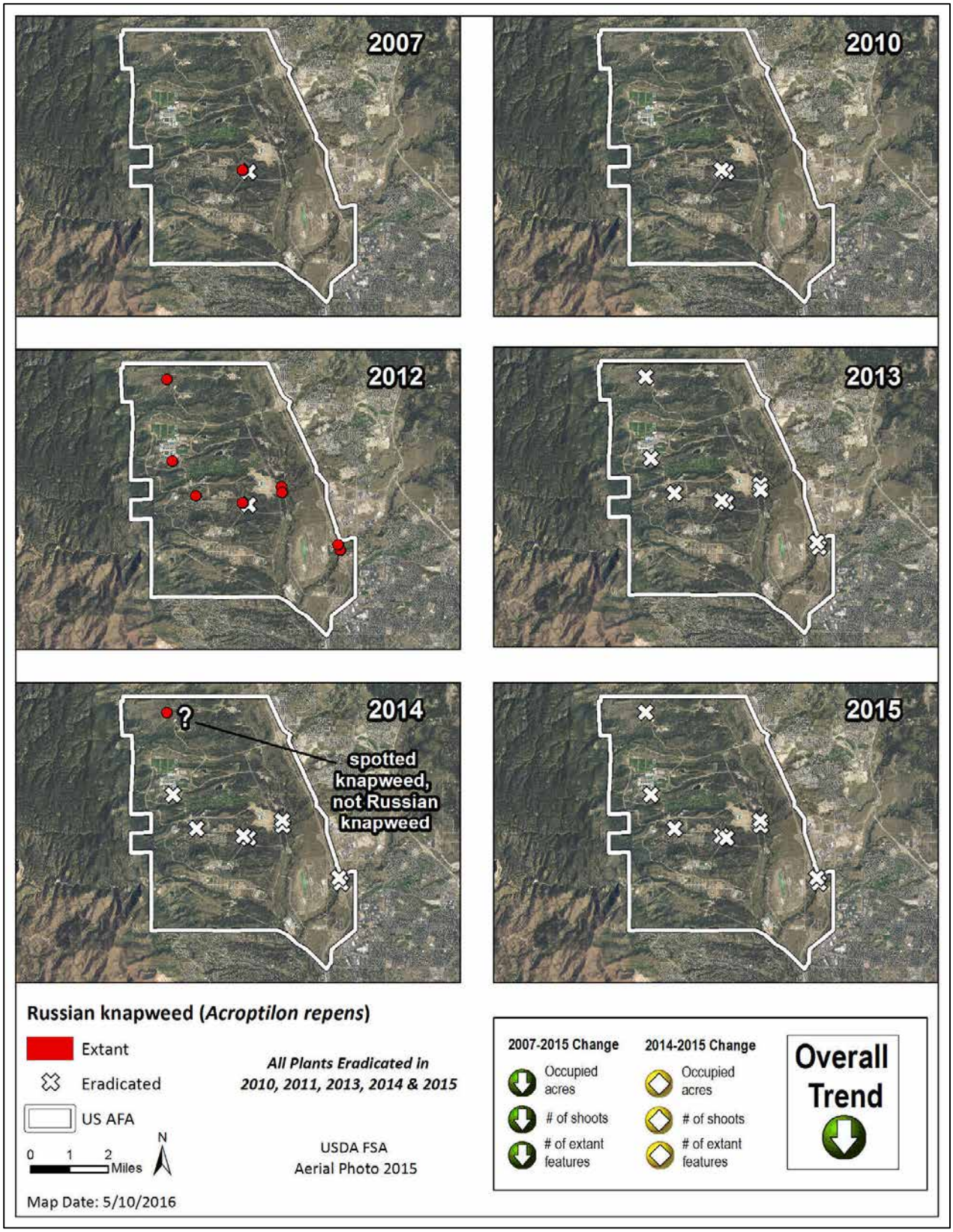
Table 2. Russian knapweed summary data, 2004-2015.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2004	---	3	0	---
2005	---	2	1	---
2007	200	2	2	0.03
2008	157	2	2	0.025
2009	---	2	2	---
2010	0	0	4	0
2011	0	0	4	0
2012	543	10	4	0.05
2013	0	0	12	0
2014	0	0	11	0
2015	0	0	12	0

Figure 2. Number of Russian knapweed individuals and mapped features, 2007-2015.

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 (Map 4). 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 (Table 2).
- 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.



Map 4. Distribution of Russian knapweed at the Academy between 2007 and 2015.

Whitetop (*Cardaria draba*)

Monitoring 2012 - 2015 showed the plot populations stable to slightly decreasing.

AFA Management Goals: Containment through chemical and mechanical treatments of large infestations as necessary and monitoring for new satellite populations.

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 (CCR 2014).

Photo by Michelle Washebek

2015 Results

All seven permanent plots were surveyed and three new plots were established in 2015, bringing the total number of monitoring plots to 10, to improve statistical analyses (Map 5). Based on our monitoring data it appears that whitetop populations are stable to slightly decreasing (Map 6). The average number of plants per plot was lower than 2012 or 2013 (Table 3). Herbicide applied in 2013 to two plots was done later in the season after monitoring in 2013 and may have contributed to the reduction in the number of shoots observed in one plot in 2015 (the permanent plots were not monitored in 2014). Herbicide treatments in 2015 occurred in one plot (CADR-10) in April before the plot was established.

Table 3. Summary of whitetop permanent plot data, 2012-2015.

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	7	433	186	43	4,317	38	617
2015 (new)	3	185	87	47	1,298	42	433

*Herbicide was applied to CADR-2 and CADR-3 after 2013 sampling.

The frequency (the percent of quadrats within each plot with plants) ranged from 21-82% across all years, with an overall average of 48%. Standard deviation (SD) is a measure of variance from the mean and was similar during 2012-2015, ranging from 19-22%. If there was a change greater than the average SD from year to year within the same plot, the change was considered to be an increase or a decrease. CADR-2 was the only plot that showed such a change (decrease) (Table 4, Figure 3). Both CADR-2 and CADR-3 were treated with herbicide in 2013. However, CADR-3 did not show a decrease and remained stable. Three newly established plots were similar to the existing seven plots with a slightly lower average number of shoots (Table 3).

Table 4. Frequency of whitetop 2012-2015 in permanent plots. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: yellow is stable less than one standard deviation (21%), and green represents a decrease of more than one standard deviation.

Plot Name	% Quadrats w/ Plants 2012	% Quadrats w/ Plants 2013	% Quadrats w/Plants 2015	Overall Trend 2012-2105
CADR-1	81	82	82	
CADR-2	65	**67**	16	
CADR-3	21	**26**	24	
CADR-4	52	50	40	
CADR-5	37	39	41	
CADR-6	26	26	29	
CADR-7	65	61	68	
CADR-8*	---	---	43	---
CADR-9*	---	---	45	---
CADR-10*	---	---	**53**	---
AVG	**49**	**50**	**44**	**48**
SD	**22**	**21**	**19**	**21**

*Plots established in 2015

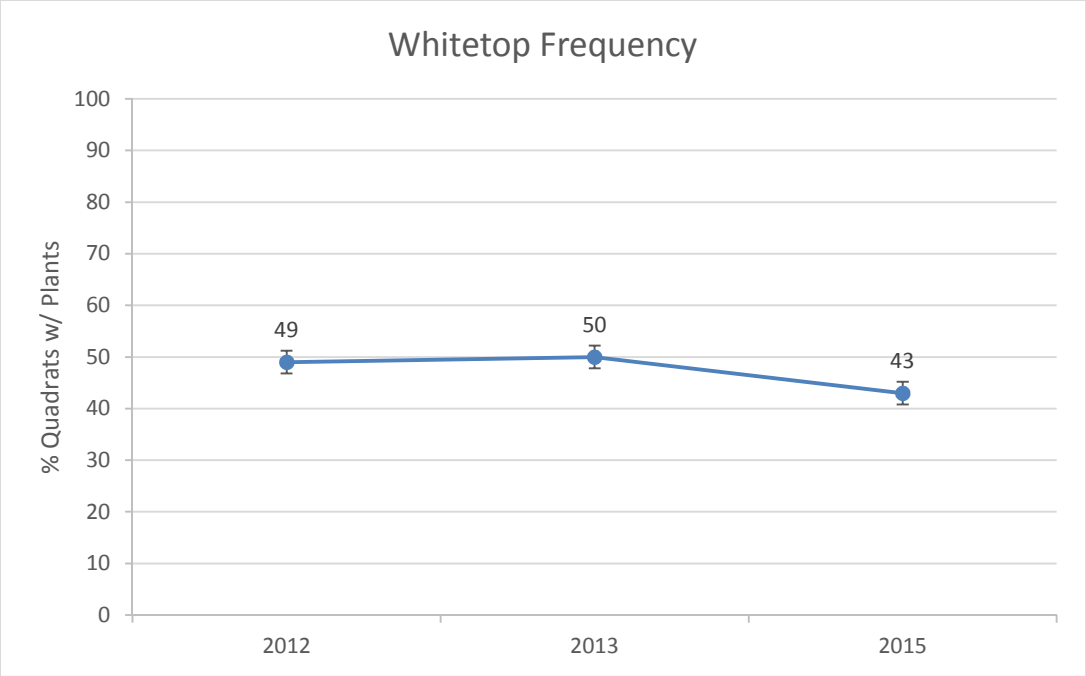


Figure 3. Whitetop 2012-2015: Percent of quadrats/plot with whitetop at seven permanent plots.

The density is calculated as the average number of shoots per quadrat. In 2015, all of the monitoring plots had lower average densities except CADR-4 which increased by 1.5 standard deviation. The average % cover for each quadrat remained stable.

Table 5. Average density and average % cover of whitetop in permanent plots, 2012-2015. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: yellow is stable with less one standard deviation, green represents a decrease of more than one standard deviation and red indicates a change greater than one standard deviation.

Plot Name	*AVG Density 2012*	*AVG Density 2013*	*AVG Density 2015*	*Overall Trend 2012-2015*	*AVG Cover (%) 2012*	*AVG Cover (%) 2013*	*AVG Cover (%) 2015*	*Overall Trend 2012-2015*
CADR-1	27	30	12		12	13	11	
CADR-2	7	**11**	1		6	**9**	1	
CADR-3	1	**3**	1		0	**1**	1	
CADR-4	7	8	24		2	5	3	
CADR-5	9	12	8		2	3	6	
CADR-6	5	4	3		1	1	3	
CADR-7	31	37	20		11	20	18	
CADR-8	---	---	10	---	---	---	11	---
CADR-9	---	---	5	---	---	---	5	---
CADR-10	---	---	**7**	---	---	---	**6**	---
AVG	**12**	**15**	**9**	**12**	**5**	**7**	**7**	**6**
SD	**12**	**13**	**8**	**11**	**5**	**7**	**5**	**6**

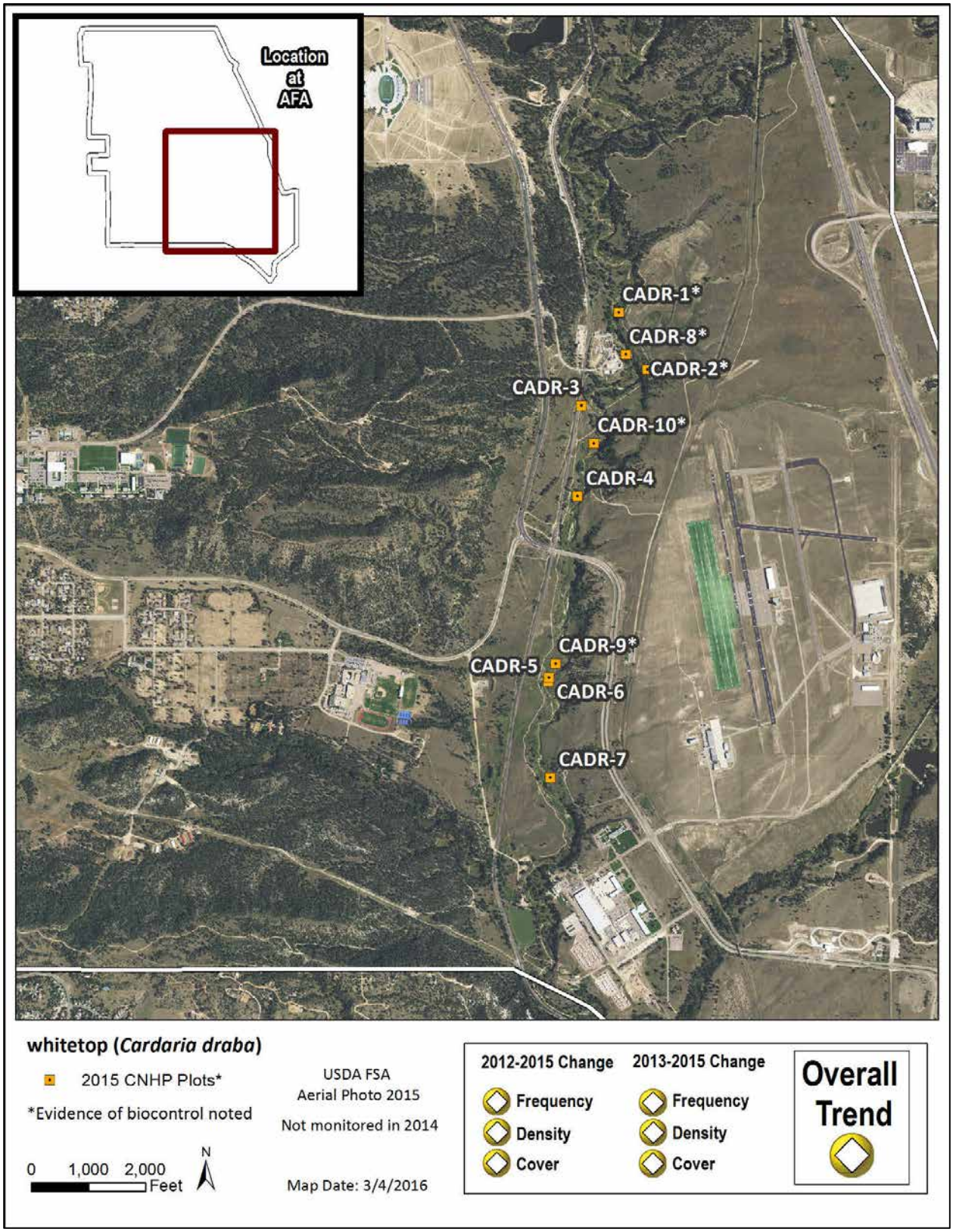
Whitetop, like many deep-rooted perennial species, is difficult if not impossible to control once it has become established. It is thought that targeting newly established satellite populations is more effective for control, while the established populations should be monitored for expansion (USFS 2014). There is no evidence that herbicide treatments from 2013 were successful in controlling whitetop, since there was a decrease in one of the treated plots but not the other. CADR-1 and CADR-7 showed decreases larger than one standard deviation for density and were not treated while two treated plots were stable. CADR-4 showed an increase in density of greater than one standard deviation with the average cover and frequency remaining stable.

There are no state-approved biocontrol organisms currently available for whitetop. However, insect damage was observed in half of the plots in 2015 (Map 6). This is an important consideration in the management of this difficult to control species as weed species can naturally decline over time (Norris 1999). Continued monitoring can help determine if this is occurring at the Academy.

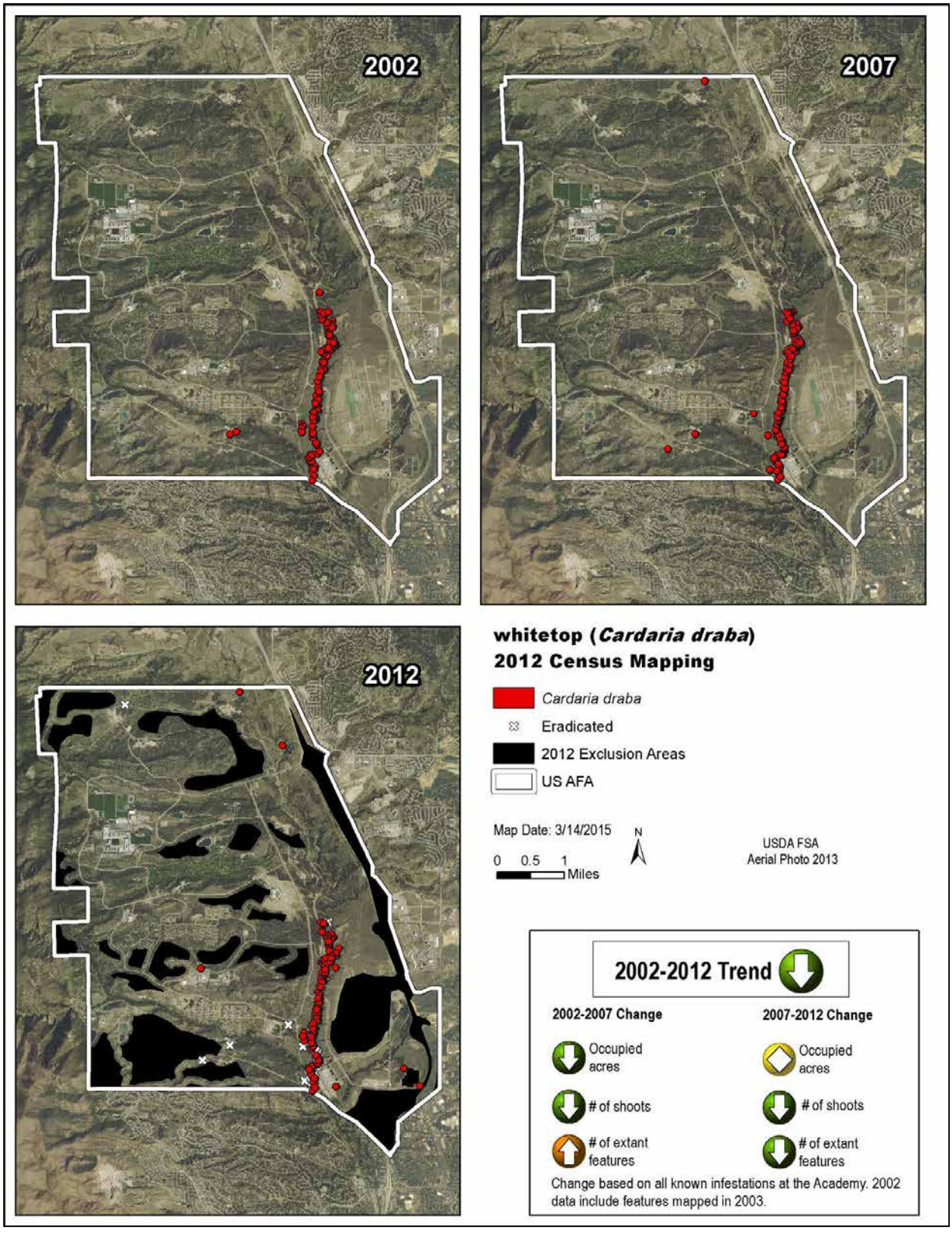
A backpack hand-held sprayer or wick method are recommended for natural areas if chemical treatments are used (only recommended for satellite populations), especially in areas known to contain resources of conservation concern and where the native vegetation needs to be protected or where smooth brome is in the vicinity (Smith et al. 2015). The most important consideration for this species is to determine if populations are expanding, stable or naturally decreasing. Census mapping for whitetop was conducted in 2002, 2007, and 2012, and showed a decreasing trend (Map 6). 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 and intact soils.

History of Sampling and Treatment:

- In 2002, whitetop was mostly concentrated along Monument Creek in the south half of the Academy (Anderson et. al. 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 whitetop in 2007 were used to establish eight permanent plots (Map 5).
- Census mapping for whitetop distribution across the Academy property was conducted in 2002, 2007, and 2012 (Map 6).
- In 2013, seven of the eight plots were monitored (Table 4). Frequency was stable between 2012 and 2013 (Table 4, Figure 3), density increased from 2012 to 2013. The average cover of whitetop increased from 2012 to 2013 (Table 5). Herbicide was applied after monitoring in 2013 to plots 2 and 3.
- 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 (Table 5).



Map 5. 2013 whitetop plots at the Academy.



Map 6. Distribution of whitetop at the Academy in 2002, 2007 and 2012.

Musk Thistle (*Carduus nutans*)

Overall there has been a significant decrease since photo plots were initiated in 2008, with slight increases observed from 2013-2015.

AFA Management Goal: Suppression through mechanical, chemical, and biological treatments with continued monitoring.

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 (CCR 2014).

2015 Results

In 2015, which was a very favorable year for musk thistle across the state, the population at the Academy increased from 62 to 98 individuals. The increase over the last three years has been slight and overall the numbers of individuals are much lower than those observed in 2008 when the photo plots were originally set up (Table 6, Figure 4). Spring and early summer precipitation was significantly higher than the average for Colorado Springs in 2015 (Figure 1, p. 7) and could have contributed to the increase since 2013. Herbicide treatments were observed on a non-target native plant: lanceleaf figwort (*Scrophularia lanceolata*) two years in a row (2014 and 2015) at CANU-2.

Table 6. Musk thistle population size at photo plots, 2008-2015. Bolded and shaded indicates plots that appear to have been treated.

Plot	*2008*	*2009*	*2010*	*2011*	*2013*	*2014*	*2015*
CANU-1	11	134	**9**	**7**	**7**	**40**	34
CANU-2	**6**	80	**5**	**160**	0	x*	10*
CANU-3	**1**	**2**	**1**	**8**	1	0	2
CANU-4	1	63	**0**	**0**	0	0	3
CANU-5	1	27	**10**	0	6	**17**	**7**
CANU-6	**10**	45	**33**	3	2	4	0
CANU-7	**102**	**90**	**25**	**0**	**5**	0	6
CANU-8	212	**31**	**10**	**7**	7	0	0
CANU-9	160	**1**	**1**	**0**	0	0	4
CANU-10	500	--	**40+**	400	**28**	0	32
SUM	**1004**	**473**	**123**	**585**	**56**	**62**	**98**
Mar-June precipitation Diff from avg (inches)	***-4.28***	***0.78***	***-3.52***	***-4.25***	***-4.24***	***-1.43***	***+8.64***

X* – treated *Scrophularia lanceolata* 2014/2015

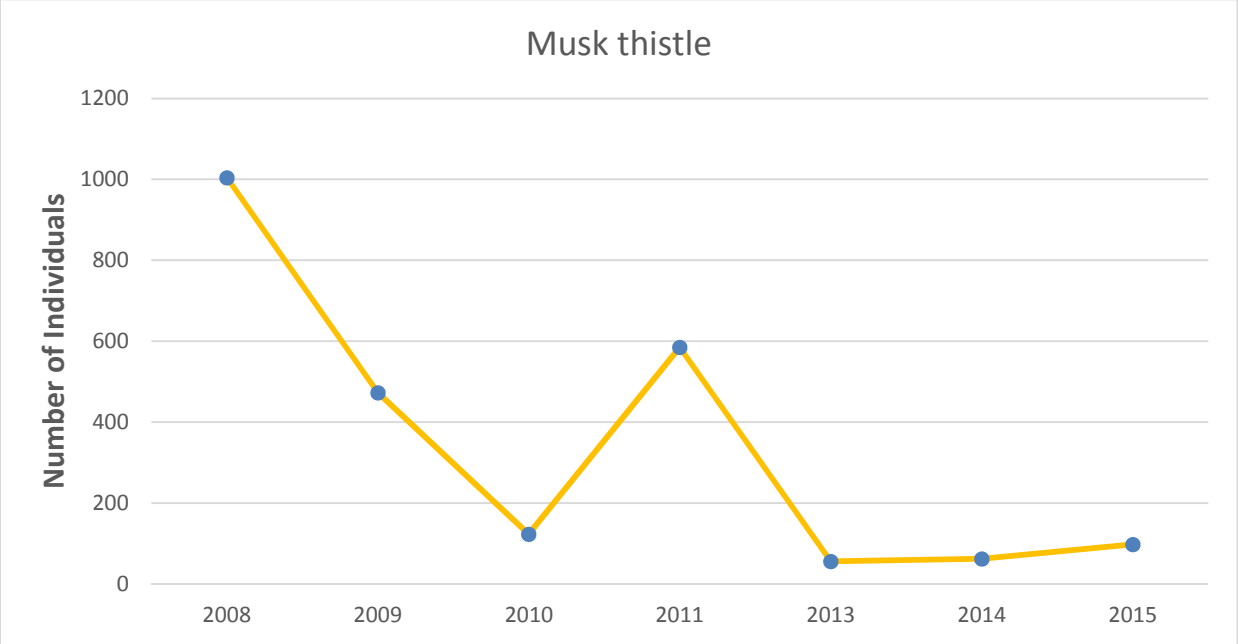


Figure 4. Musk thistle counts at 10 photo plots, 2008-2015.

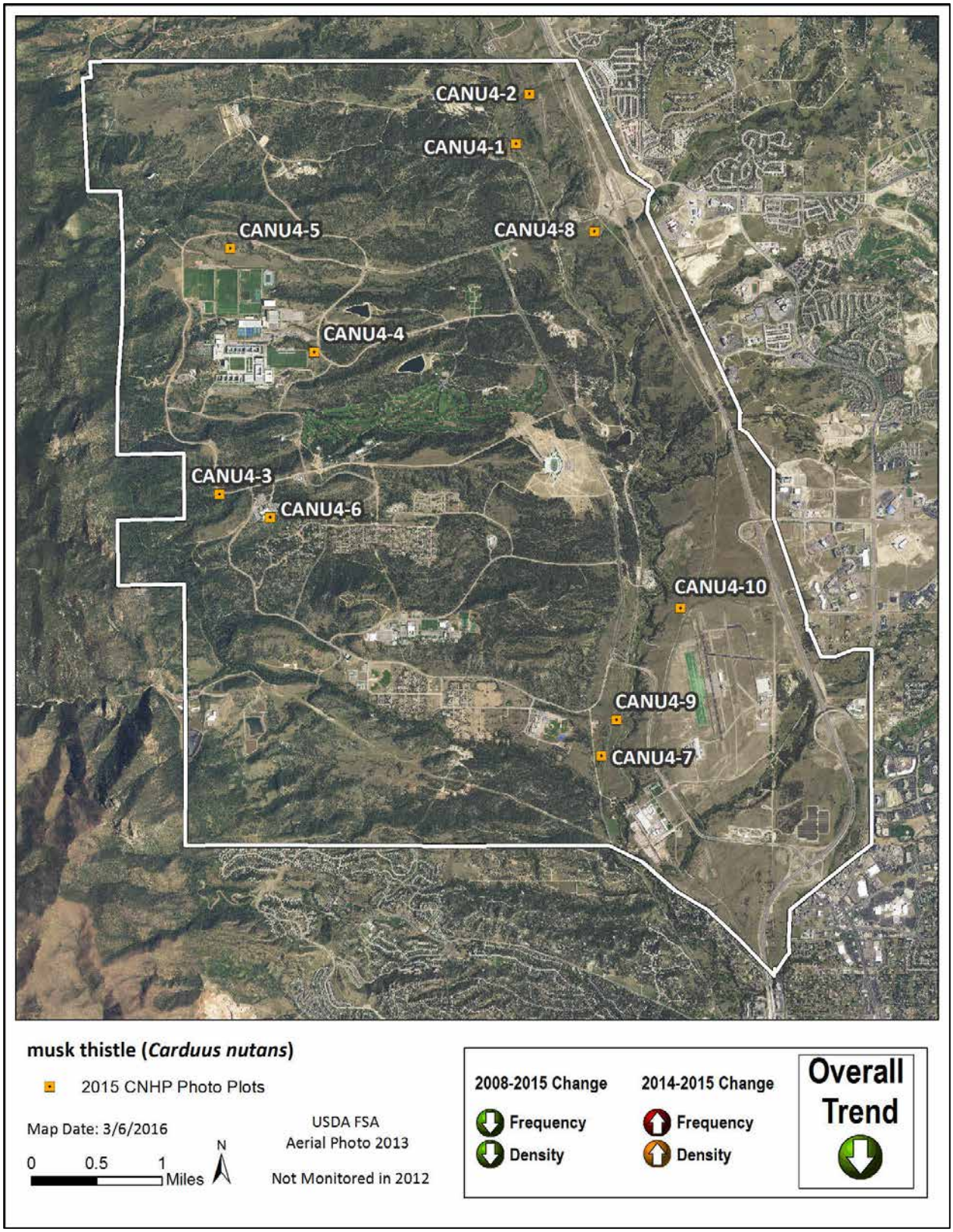
Future treatments should not include broadcast herbicide applications in areas with native vegetation. Spot treatments at rosette stage are acceptable. Plot CANU-7 has been treated every year with herbicides and there has been a reduction in musk thistle plants. However, there has also been a dramatic decrease in native species including native grasses and herbs, which are being replaced by smooth brome, a non-native aggressive grass species (Photo 1). The result is a significant 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. Precise spot application of herbicides is recommended for the natural areas to avoid non-target damage which allows other species to enter the system. Repeated herbicide applications over multiple consecutive years are not recommended.

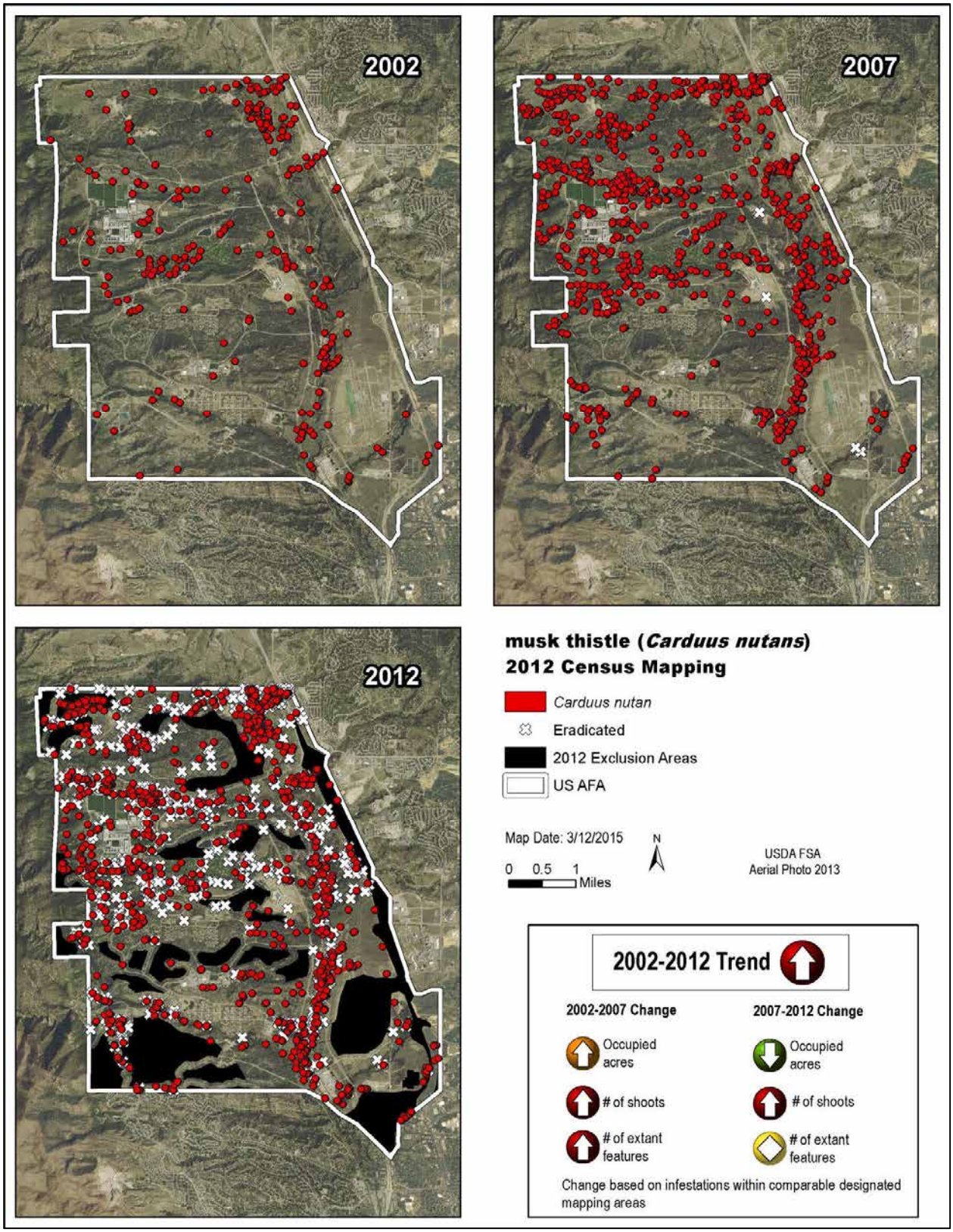
Photo 1. CANU-7 plot was treated with herbicide five years in a row. There was a reduction from 120 musk thistle to 6 plants in 2015. However, the native grasses and forbs present in 2008 have been replaced with a non-native aggressive grass – smooth brome.

History of Sampling and Treatment:

- All ten plots were visited in 2008-2015 with the exception of 2012 (Map 7).
- All plots have been treated at least once if not multiple times with herbicides based on our field observations (Table 6).
- Census mapping for musk thistle distribution across the Academy property was conducted in 2002, 2007, and 2012 (Map 8).
- 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.
- Distribution of musk thistle was mapped in 2002, 2007, and 2012 (Map 8).



Map 7. 2015 musk thistle plots at the Academy.



Map 8. Distribution of musk thistle at the Academy in 2002, 2007, and 2012.

Spotted and Diffuse Knapweeds (*Centaurea maculosa, C. diffusa, &* hybrids)

Permanent plots show plant populations are stable to slightly decreasing. Rare plant species were located in two monitoring plots.

AFA Management Goal: Containment through monitoring and mechanical, chemical, and biological treatments.

State List: B

Left photo: Diffuse Knapweed, Michelle Washebek, right photo: Spotted Knapweed (*Centaurea maculosa*) 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 2013).
- Environmental disturbance promotes invasion (CSU 2013)
- Seed longevity: 8-10 years (CCR 2014).

2015 Results

All of the data indicate an overall decrease in plants between 2012 and 2015. Herbicide treatments did not always correspond with reductions in plants. Continued monitoring will reveal if herbicide is suppressing growth or if there is continued reduction of plants. The rare (Colorado Natural Heritage Program tracked) plant species frostweed (*Crocanthemum bicknellii*) was located in two of

the monitoring plots. This species is considered to be critically imperiled in Colorado with only a few known populations in the state.

One of the monitoring plots (CEDI3-2) has been discontinued because it has been developed into the nearby golf course. Thus, in 2015 only nine permanent plots were monitored instead of 10. All biocontrol plots were monitored in 2015, and all were reported to have been treated with herbicide in 2014 with partial treatments reported in 2013. Biocontrol plot KWmonck has been used as a dump for wood debris and six of the monitoring points (quadrat locations) on the plot were buried. DKhwy83 had a drainage installed through the plot several years ago. The total number of shoots in the sampling plots decreased across all plots when compared to 2012 for both the biocontrol and non-biocontrol sampling plots (Table 7). The average knapweed height has been increasing across all plots since 2012, while the frequency (average number of plots with plants) has been stable to decreasing (Table 7).

Table 7. Summary of knapweed permanent plot data, 2012-2015.

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	25.9	43/plot
2013	10	551	33	6	168	30.2	17/plot
2014	10	559	59	11	256	37.4	26/plot
2015	9	496	71	14	296	44.6	33/plot
Biocontrol Permanent Plot Sampling Method							
2012	4	163	51	31	353	34.0	17/plot
2013	3	114	41	36	116	33.7	39/plot
2014	0	Herbicide applied to biocontrol plots					
2015	5	247	46	19	127	48.8	25/plot

Frequency (percent of quadrats with the plant present) is the best indicator of an expanding or contracting population. Treated and non-treated areas were similar in frequency of knapweed, with an overall stable trend. In 2014, four plots had an increasing trend; one of these four (CEDI3-5), had been treated with herbicide in 2014. In 2015, CEDI3-5 was the only plot to show a 10% or greater increase since 2012. Five plots were stable; one of these (CEDI3-1) had been treated in 2012 and 2014. Two plots, neither of which appear to have been treated, showed an overall decrease with a difference of 10% or more (Table 8 & Figure 5).

Table 8. Knapweeds 2012-2015: Percent of quadrats/plot with knapweeds. Frequency = proportion of quadrats with knapweeds. Bolded and shaded numbers indicate herbicide treatment. Colors indicate trend: yellow is stable or less than one average standard deviation (10%), and green represents a decrease of more than one standard deviation, and red indicates an increase of greater than 1 standard deviation.

Plot Name	FREQUENCY 2012	FREQUENCY 2013	FREQUENCY 2014	FREQUENCY 2015	Overall trend 2012-2015
CEDI3-1	**9%**	0%	**2%**	7%	
CEDI3-2	**21%**	3%	6%	*	Discontinued
CEDI3-3	14%	7%	13%	18%	
CEDI3-4	11%	21%	15%	15%	
CEDI3-5	14%	15%	**31%**	42%	
CEMA4-1	23%	7%	27%	31%	
CEMA4-2	27%	0%	2%	5%	
CEMA4-3	3%	2%	2%	0%	
CEMA4-4	26%	8%	6%	6%	
CEMA4-5	2%	2%	0%	0%	
AVG	**15%**	**7%**	**10%**	**14%**	**12%**
SD	**8.6**	**6.5**	**10.4**	**13.6**	**10%**
Biocontrol Plots					
SK ploop3	**31%**	---	---	0%	
SK ploop1	**37%**	---	---	5%	
KW monck	**24%**	**43%**	---	16%	
DK railroad	**56%**	**21%**	---	48%	
DK hwy83		**100%**	---	44%	
AVG BioC	**37%**	**55%**	**---**	**23%**	**38%**
SD BioC	**11.9**	**33.2**	---	**19.8**	**22%**

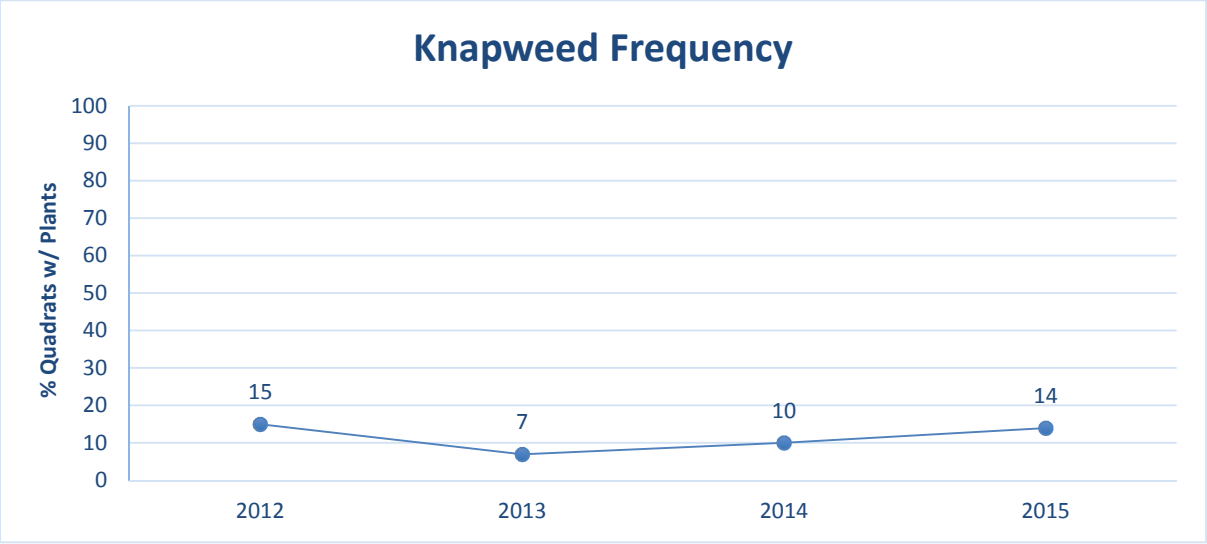


Figure 5. Knapweeds 2012-2015: Percent of quadrats/plot with knapweeds.

Density is calculated as the average number of stems arising from the ground, and cover is an estimate of how much area is occupied. Density and average cover are likely to be strongly correlated with annual precipitation values. The only plot to show an increase of greater than 10% was the partially treated plot CEDI3-5. The majority of the plots were stable with less than a 5% difference (Table 9). All biocontrol plots were treated with herbicide between 2012-2015 with DKrailroad and Dkhwy83 showing decreases in overall trends (i.e. differences of %5 or greater) between 2012 and 2015.

Table 9. Average density and average % cover of knapweeds from plot data in 2012-2015. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: red is an increase (>1 standard deviation), yellow is stable, and green is a decrease (> 1 standard deviation).

Plot Name	Avg Dens 2012	Avg Dens 2013	Avg Dens 2014	Avg Dens 2015	Overall Trend	Avg Cover (%) 2012	Avg Cover (%) 2013	Avg Cover (%) 2014	Avg Cover (%) 2015	Overall Trend 2012-2015
CEDI3-1	**0**	0.0	**0.03**	0.10		0.3	0.0	**0.4**	0.9	
CEDI3-2	**1**	0.3	0.5	---	Disc	2.7	0.1	0.7	---	Disc
CEDI3-3	0	0.3	0.5	0.5		1.4	0.5	3.8	2.8	
CEDI3-4	0	0.4	0.5	0.6		1.3	1.6	3.1	3.3	
CEDI3-5	1	0.6	**1.4**	2.4		3.3	2.3	**16.5**	15.5	
CEMA4-1	2	0.1	1.0	1.16		1.7	0.3	5.3	3.4	
CEMA4-2	2	0.0	0.05	0.11		2.2	0.0	0.4	0.3	
CEMA4-3	0	0.0	0.016	0.0		0.1	0.0	0.016	0.0	
CEMA4-4	2	1.3	0.4	0.2		6.2	1.3	1.1	0.5	
CEMA4-5	0	0.2	0.0	0.0		0.6	0.6	0.0	0.0	
AVG	**0.8**	**0.3**	**0.4**	**0.6**	**0.5**	**2.0**	**0.7**	**3.1**	**3.0**	**1.8**
SD	**0.9**	**0.4**	**0.4**	**0.7**	**0.6**	**1.7**	**0.8**	**4.8**	**4.6**	**3.0**
Biocontrol Plots										
SK ploop3	1	---	---	0.0		**4.4**	---	---	0.0	
SK ploop1	**1**	---	---	0.1		**4.1**	---	---	1.5	
KW monck	**1**	**1.0**	---	0.4		**5.9**	**3.5**	---	5.6	
DK railroad	**3**	**0.4**	---	1.5		**16.0**	**1.7**	---	7.8	
DK hwy83	---	**4.8**	---	0.6		---	**54.5**	---	15.0	
AVG BioC	**1.5**	**2.1**	**---**	**0.5**	**1.4**	**7.6**	**19.9**	**---**	**6.0**	**9.0**
SD BioC	**0.9**	**1.9**	**---**	**0.5**	**1.1**	**4.9**	**24.5**	**---**	**5.3**	**12.0**

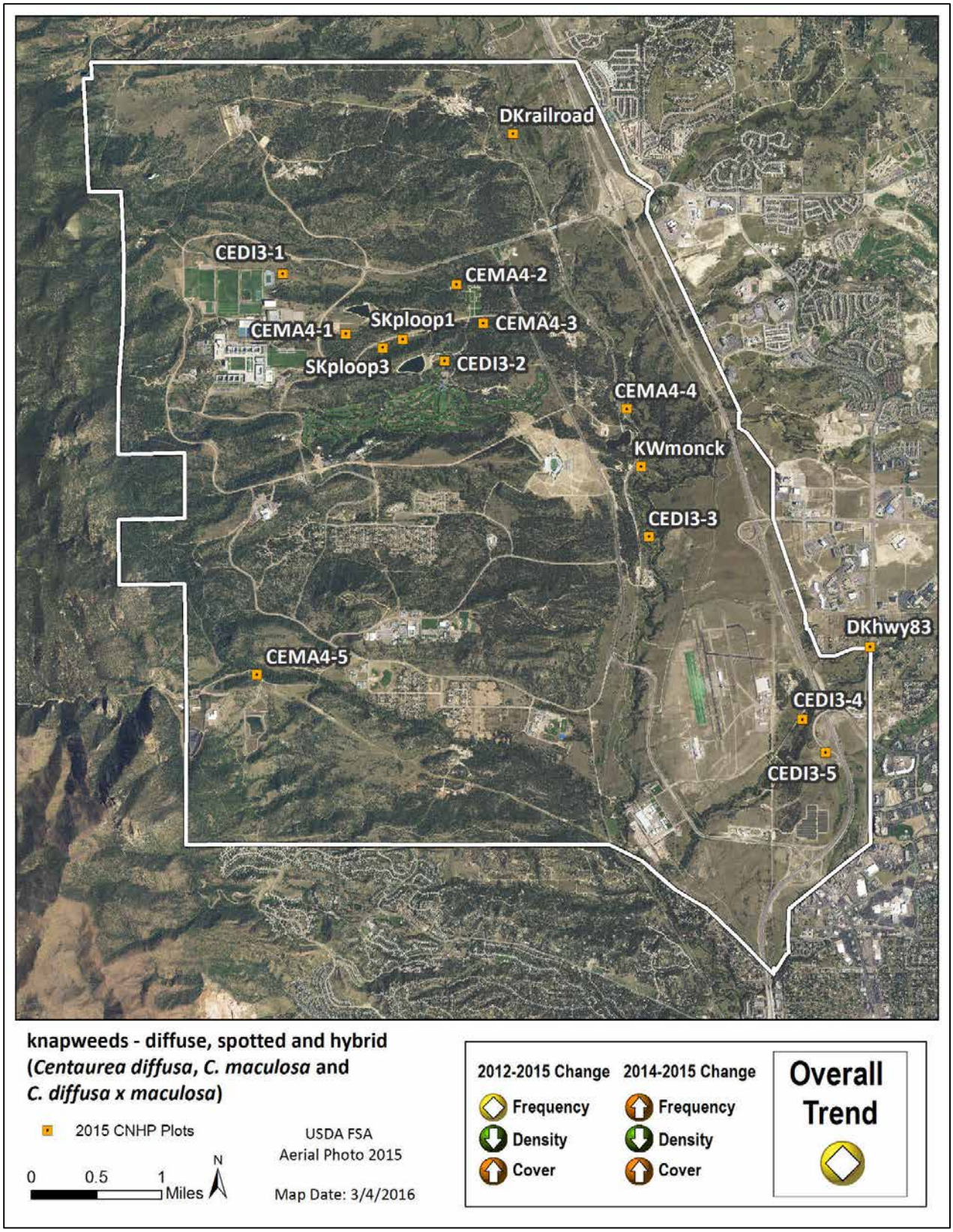
For future treatments, we recommend at least half of the plots be left untreated to serve as baseline plots to assist in determining whether the treatments are working, or if any reductions or increases may be due to weather conditions instead. Partial treatments of plots and disturbance of

monitoring plots are confounding the interpretation of the plot data and also appear to increase knapweeds.

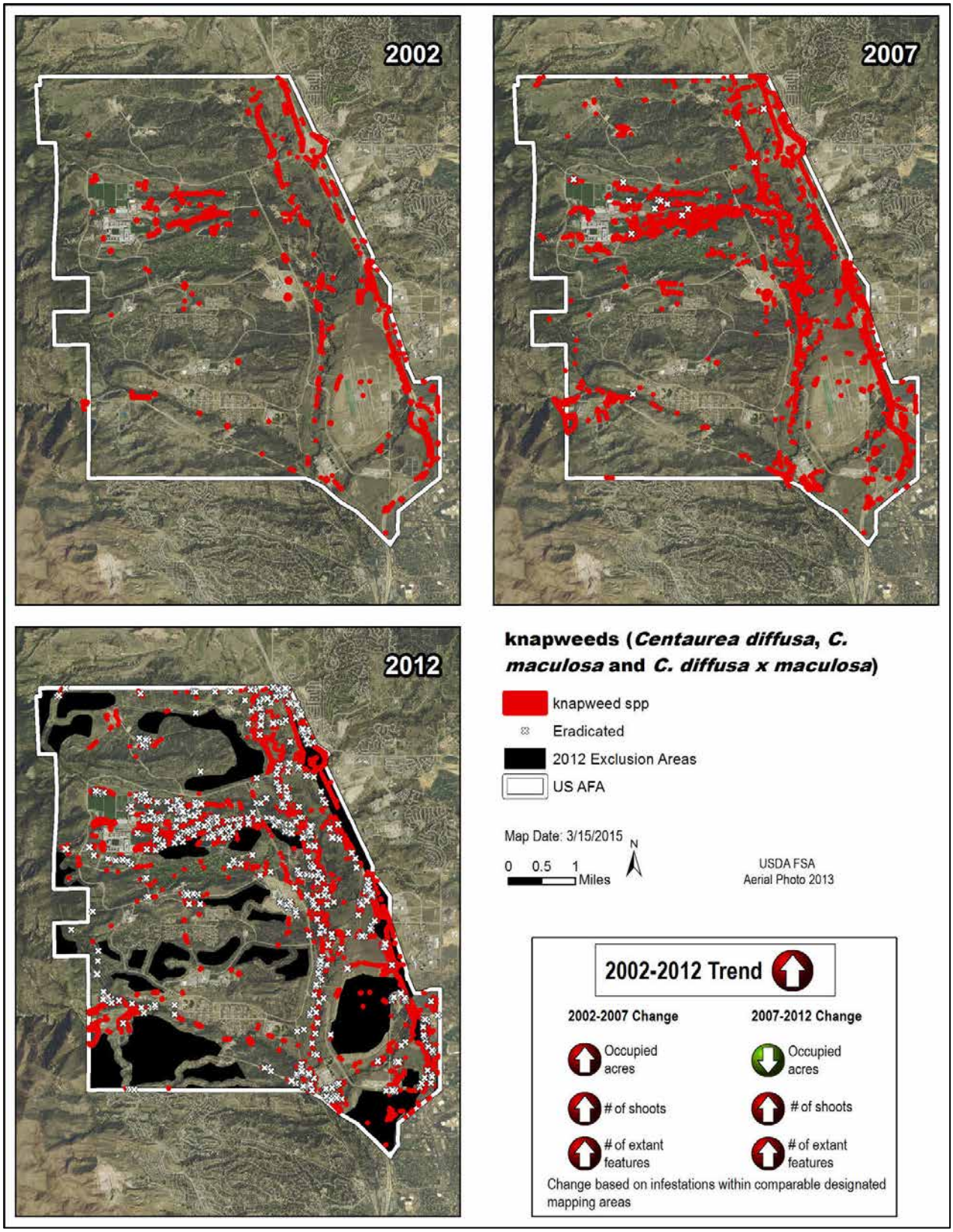
Consideration of a new treatment strategy for knapweeds that includes a site plan stating the goal of the treatment is suggested. Recent research indicates herbicide treatments alone will not eliminate knapweeds (Beck 2013). In addition, treatments have been shown to cause an increase in other weeds or knapweeds themselves over time (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 (Larson 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).

History of Sampling and Treatment:

- All 10 CNHP permanent plots were established in 2012 (Map 9).
- Census mapping for knapweed distribution across the Academy property was conducted in 2002, 2007, and 2012 (Map 10).
- In 2013, the diffuse and spotted knapweeds were combined into a hybrid swarm "knapweeds".
- 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.
- Distribution of knapweeds was mapped in 2002, 2007, and 2012 (Map 10).



Map 9. 2015 knapweed (diffuse, spotted and hybrid) plots at the Academy.



Map 10. Distribution of knapweeds (diffuse, spotted and hybrid) at the Academy in 2002, 2007, and 2012.

Canada Thistle (*Cirsium arvense*)

Between 2012 and 2015, all plot metrics indicate an overall stable to decreasing trend. Biocontrol organisms are present in permanent plots. A rare amphibian species was noted in the monitoring plots.

AFA Management Goals: Suppression through monitoring, chemical and biological treatments.

State List: B

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

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

2015 Results

There was an overall decrease in frequency, while the average density and average percent cover between 2012 and 2015 were largely stable. The average height also decreased in both the biocontrol and non-biocontrol plots (Tables 10-12). The biocontrol plots were treated with herbicides in 2014. 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. An uncommon plant species (CNHP watchlist) carrion-flower (*Smilax lasioneura*) was also observed in this plot.

One of the permanent plots (CIAR4-6) was not monitored in 2015 because it was under water. Before herbicides were used on the biocontrol plots the populations appeared to be decreasing between 2012 and 2013 (Table 10). The single biocontrol plot surveyed in 2015 shows a lower average number of shoots per plot (Table 10). Biocontrol agents that formed galls were present on three of the permanent plots (CIAR4-1, CIAR4-2, CIAR4-3) and were also observed at the biocontrol plot CTploop) in 2015. Leaf browse by insects and animals and necrotic spots were noted on Canada thistle in plots CIAR4-2, CIAR4-3, CIAR4-5, CIAR-8 and CTploop in 2015.

Table 10. Summary of Canada thistle permanent plot data, 2012-2015.

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	28	502	43.0	63/plot
2013	Not Sampled						
2014	8	411	56	14	121	36	15/plot
2015	7	348	51	15	158	38	23/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

Frequency (percent of quadrats with the plant present) can be a good measure of an expanding or contracting population. All plots showed an overall decreasing to stable trend for frequency (Table 11 and Figures 6). The frequency is indicating an overall stable to slightly decreasing trend. Figure 7 illustrates the variation within individual plots by year from 2012-2015. Plots treated with herbicide do not appear to decline more or less than plots that were not treated. CTkettle was stable after herbicide application, CIAR-6 frequency declined significantly with no herbicide application and CIAR4-5 appears to have increased between 2014 and 2015 after treatment.

Table 11. Canada thistle 2012-2015: Percent of quadrats/plot with Canada thistle. 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).

Plot Name	FREQUENCY 2012	FREQUENCY 2013	FREQUENCY 2014	FREQUENCY 2015	Overall Trend 2012-2015
CIAR4-1	**21%**	---	**13%**	**8%**	
CIAR4-2	10%	---	9%	10%	
CIAR4-3	25%	---	19%	27%	
CIAR4-4	13%	---	**15%**	16%	
CIAR4-5	42%	---	**10%**	6%	
CIAR4-6	66%	---	21%	**	
CIAR4-7	16%	---	18%	13%	
CIAR4-8	19%	---	**6%**	**24%**	
AVG	**27%**	---	14%	15%	19%
SD	**17.5**	---	5.0	6.9	10
Biocontrol Plots					
CTice1	**58%**	---	---	---	---
CTice2	**100%**	---	---	---	---
CTkettle	**24%**	26%	---	---	
CTploop	**52%**	---	---	12%	
AVG BioC	**59%**	**26%**	---	**12%**	
SD BioC	**27.2**	---	---	---	---

** Plot was flooded in 2015

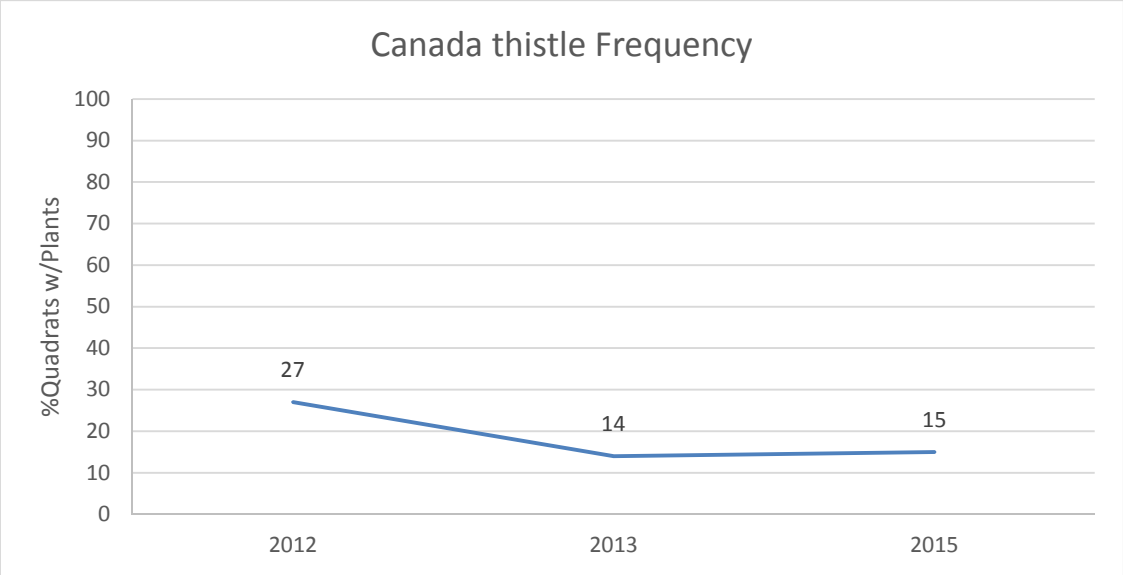


Figure 6. Canada thistle 2012-2015: Percent of quadrats/plot with Canada thistle.

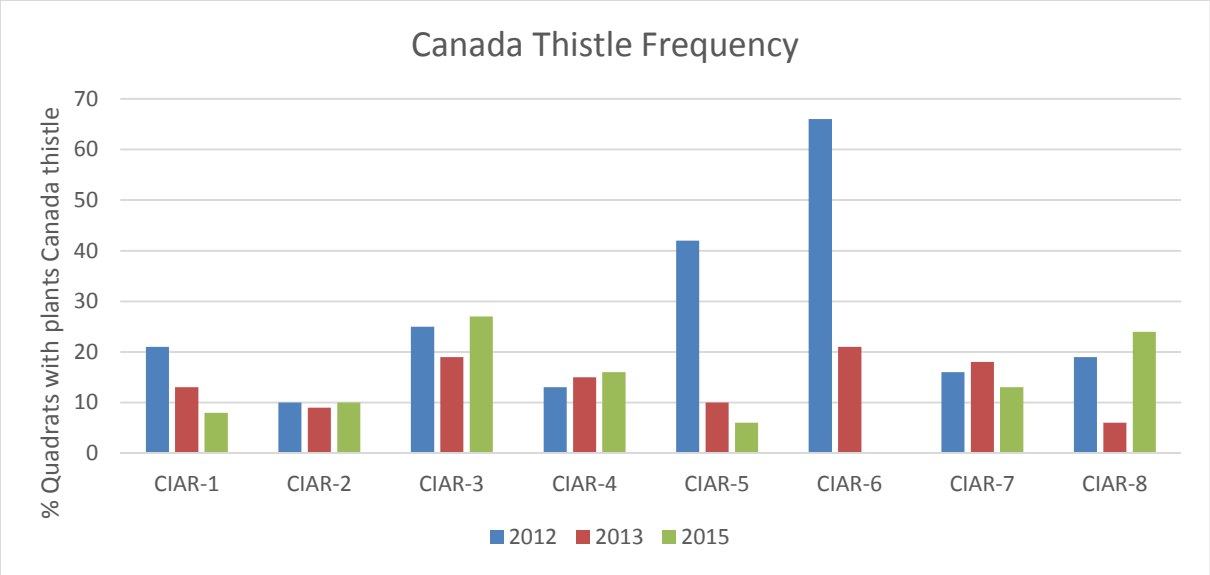


Figure 7. Percent of quadrats by individual plot 2012-2015 with Canada thistle.

Density represents the average number of stems arising from the ground within an area and percent cover is an estimate of how much area is occupied. These two metrics are likely to be strongly correlated with annual precipitation values. This year was an exceptionally wet with levels of precipitation much higher than normal in May and June. Average density and average % cover were stable to decreasing across all plots (Table 12). The results from next year may be impacted by the rainfall increase in 2015 and depending on the timing and life stage of the plants when the rain event occurred as well as the precipitation levels in 2016. The upcoming year could show an increase in density.

Table 12. Average density and average % cover of Canada thistle 2012-2015. Bolded and shaded numbers indicate that the site was treated with herbicide. Colors indicate trend: yellow is stable with less than 1 standard deviation, and green is a decrease indicating more than 1 standard deviation.

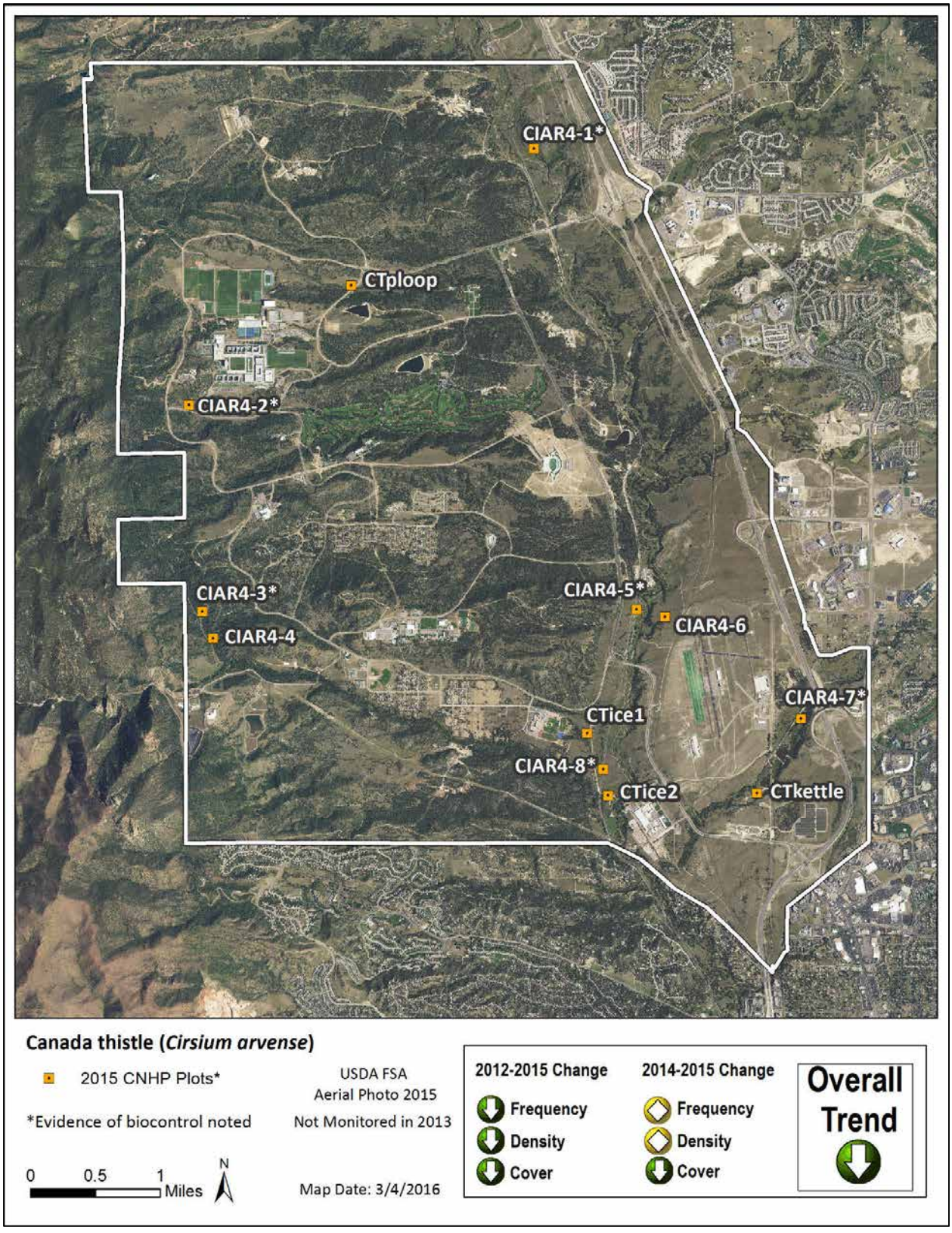
Plot Name	Avg Dens 2012	Avg Dens 2013	Avg Dens 2014	Ave Dens 2015	Overall Trend 2012-2015	Avg Cover (%) 2012	Avg Cover (%) 2013	Avg Cover (%) 2014	Avg Cover (%) 2015	Overall Trend 2012-2015
CIAR4-1	**1.1**	---	**0.4**	**0.3**		**2.2**	---	**1.3**	**1.1**	
CIAR4-2	0.5	---	0.1	0.1		1.6	---	1.2	0.6	
CIAR4-3	0.4	---	0.3	0.4		1.7	---	1.7	2.2	
CIAR4-4	0.2	---	**0.3**	0.5		0.7	---	**1.7**	1.2	
CIAR4-5	1.8	---	**0.1**	0.1		7.4	---	**0.3**	0.3	
CIAR4-6	3.9	---	0.5	---		13.6	---	3.4	---	
CIAR4-7	0.4	---	0.4	0.3		1.0	---	1.2	1.1	
CIAR4-8	0.6	---	**0.1**	**1.2**		3.0	---	**1.3**	**0.6**	
AVG	**1.1**	**---**	**0.3**	**0.4**	**0.6**	**3.9**	**---**	**1.5**	**1.0**	**2.1**
SD	**1.2**	**---**	**0.2**	**0.4**	**0.6**	**4.2**	**---**	**0.8**	**0.5**	**1.8**
Biocontrol Plots										
CTice1	**1.7**	---	---	---	---	**7.1**	---	---	---	---
CTice2	**8.8**	---	---	---	---	**26.3**	---	---	---	---
CTkettle	**0.7**	0.7	---	---		**1.7**	2.4	---	---	
CTploop	**3.1**	---	---	0.2		**8.5**	---	---	2.3	
AVG	**3.6**	---	**---**	**---**	**---**	**10.9**	**---**	**---**	**---**	**---**
SD	**3.1**	**---**	**---**	**---**	**---**	**10**	**---**	**---**	**---**	**---**

It should be noted when considering future treatments of Canada thistle that 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. Continued monitoring of these plots will be important in looking at the effects at the Air Force Academy because the untreated plots are showing stable to downward trends without herbicide application and biocontrol organisms are present and active. The protection of the rare amphibian species and uncommon plant species present should also be considered in future management since both were documented in the Canada thistle weed plots.

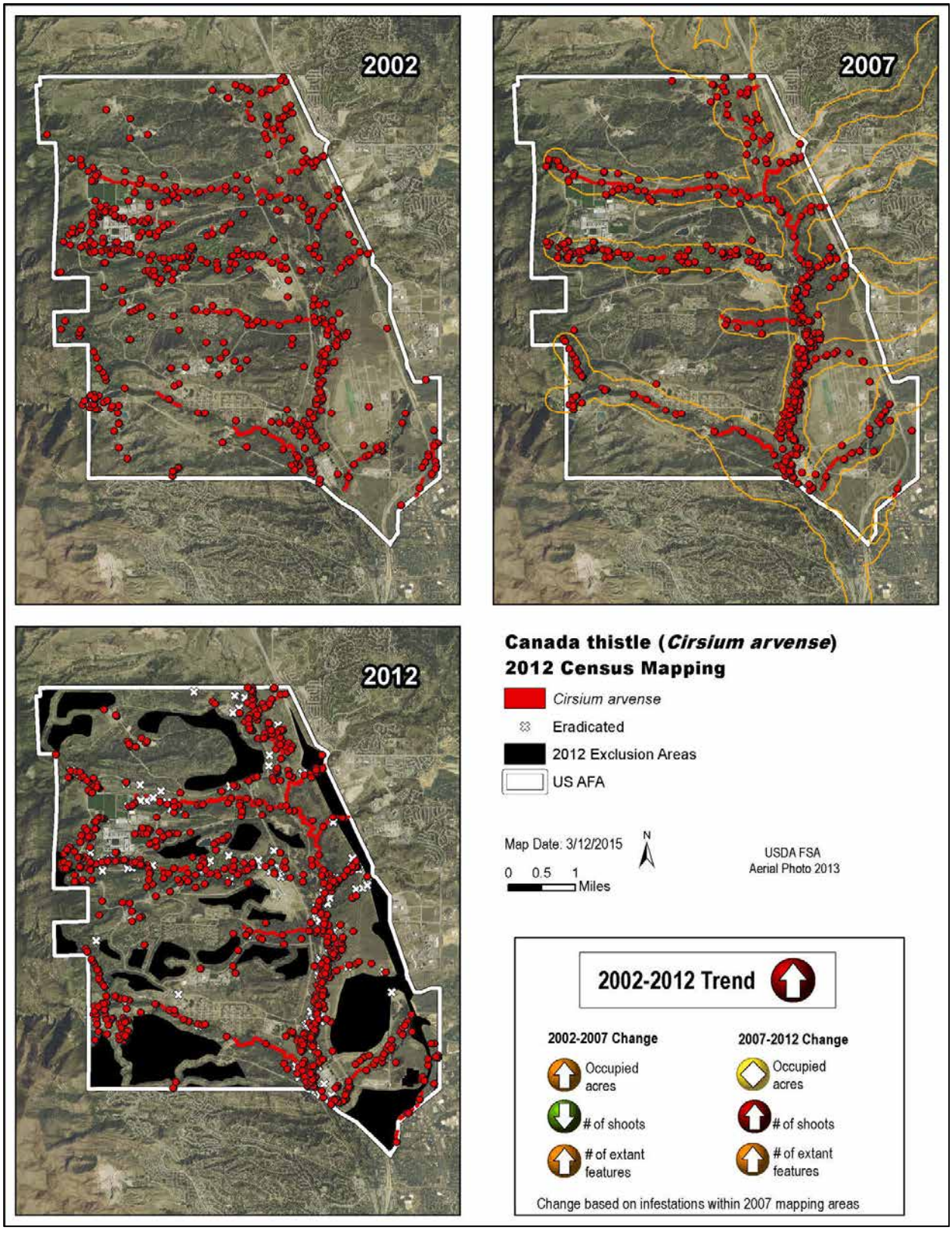
Herbicide treatments in 2015 included treatments for the monitoring plots. Therefore, no solid statements can be made. For clearer results, it is imperative to either leave all plots untreated and look for natural population trends or treat half of the plots completely and with thorough treatment records. This will allow for accurate interpretation of treatments or natural trends.

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 (Map 12).
- 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 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 (Map 11). 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.



Map 11. 2015 Canada thistle plots at the Academy.



Map 12. Distribution of Canada thistle at the Academy in 2002, 2007, and 2012.

Houndstongue (*Cynoglossum officinale*)

A substantial increase was noted between 2014 and 2015 due to 10 new mapped locations, as well as increases at existing features.

Rare plant species are located near or within populations of houndstongue.

AFA Management Goals: Eradication through continued monitoring and rapid response with mechanical and chemical treatments.

- 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 (CCR 2014).

Houndstongue seeds, photo BLM

Photo by M. DiTomaso, University of California - Davis

2015 Results

Fourteen new locations were mapped in 2015 by CNHP (Table 13). In 2014, there were a total of 16 mapped locations with 102 individuals at eight extant sites. In 2015, at the same 16 locations, 266 individuals were mapped at 12 extant sites. In total, there were 534 individuals mapped at 22 extant features. This represents an increase in both the number of sites and in the number of individuals since 2014 and an overall increase compared to 2009-2014 (Figure 8). 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).

Table 13. Houndstongue summary data, 2009-2015. Bolded and shaded indicates treatment.

Census Mapping Method				
Year	***# Shoots***	***# Extant Features***	***# Eradicated Features***	***Occupied Area (m^2)***
2009	95	8	0	0.09
2010	11	1	6	0.02
2011	21	2	6	<0.01 (10 m^2)
2012	**70**	**3**	9	**0.01**
2013	**48**	**7**	8	**0.05**
2014	102	8	8	0.04
2015	534	22	11	0.20

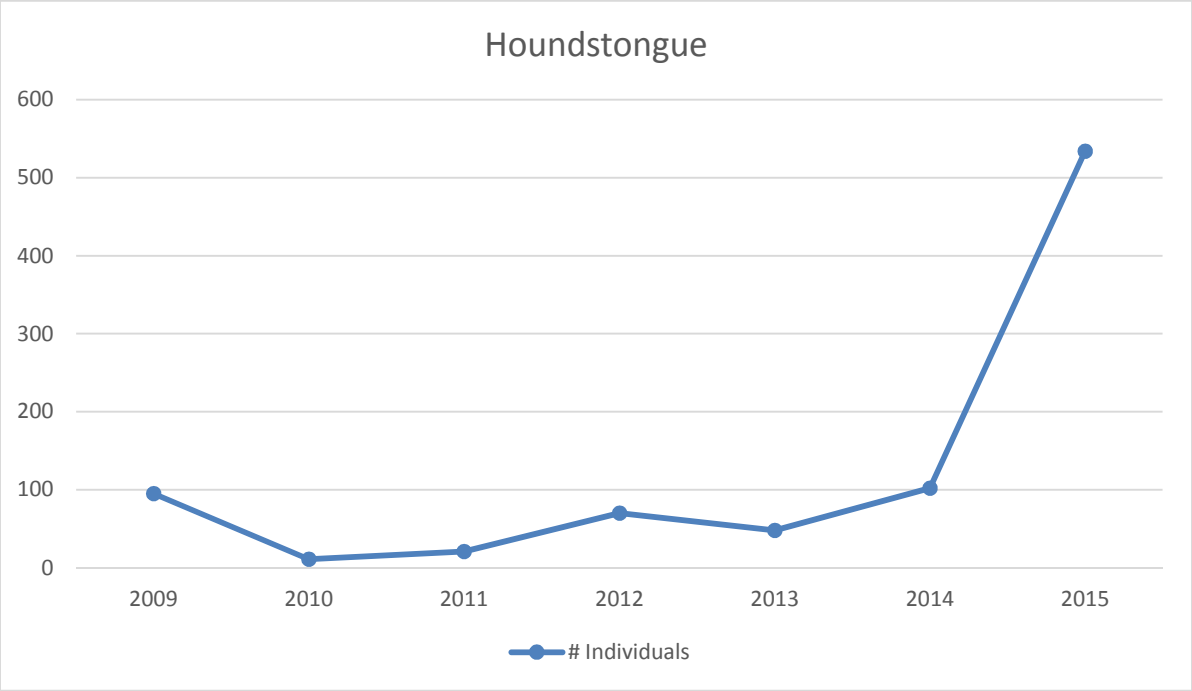


Figure 8. Number of houndstongue individuals 2009-2015.

New BMPs (Best Management Practices) are currently under development by the State of Colorado Department of Agriculture to look at weed treatment in natural areas and near sensitive species. One of the methods recommended currently in Washington State BMPs is to only use herbicide if all other methods have failed and to only use a spot application to individual plants to avoid negative impacts to soils, and native plants: http://www.seattle.gov/parks/projects/BMP/chapter5.pdf. Photo 2 demonstrates damage and an increase in weeds due to herbicide treatment in a wet meadow containing rare plants at the Air Force Academy. The disturbance of intact native species increases the likelihood of increasing the weed species in this wetland.

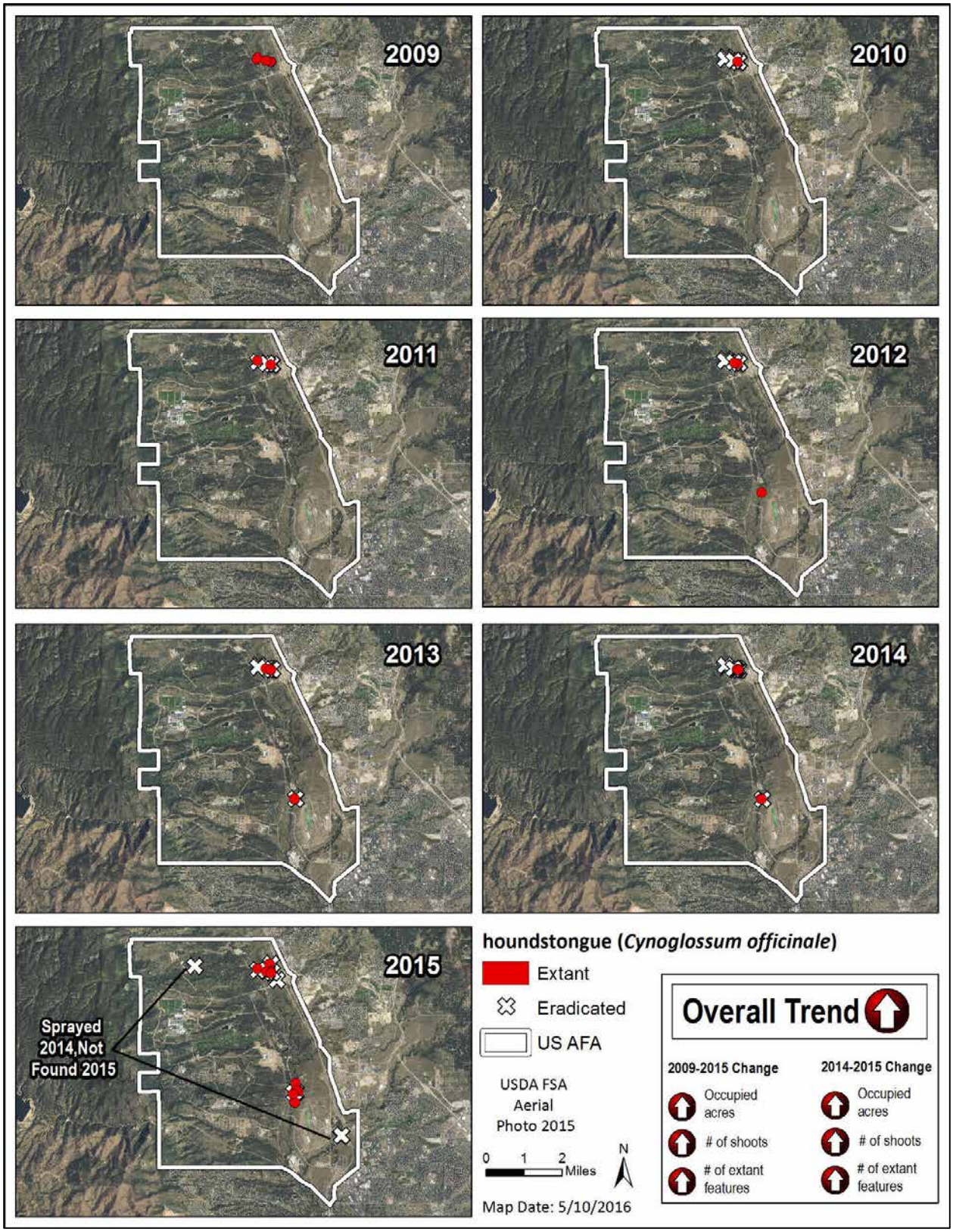
Photo 2. Area treated in a wet meadow for houndstongue. Treated area left bare soils and has new sprouts of houndstongue and other non-native species and noxious weeds including Canada thistle and common mullein. P. Smith 2015

The treatments for houndstongue have included both mechanical and chemical methods. For SWMAs, mechanical is probably the least damaging to the surrounding soils if done at the right time of year and when soils are moist. Chemical applications appear to be opening up soils to invasion in the wet areas and may be exacerbating the spread. Recommendations are to pull rosettes when the

soil is damp and to avoid herbicide treatments. Many of the new sprouts are under dense shrubs and in thick vegetation.

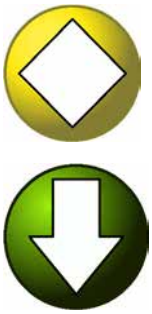
History of Sampling and Treatment

- First populations discovered in 2009 at the Academy
- In 2012 a new site was located south of the existing known sites.
- 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.
- 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 (Map 13).



Map 13. Distribution of houndstongue at the Academy between 2009 and 2015.

Leafy Spurge (*Euphorbia esula*)



Plots are stable, with a decreasing trend. A rare plant species was observed in a monitoring plot in 2015.

AFA Management Goals: Containment through continued monitoring, precise chemical, or biological treatments

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.

Photo by Michelle Washebek

2015 Results

A comparison of data between 2012 and 2015 shows an overall decrease in the number of shoots in the non-biocontrol plots (Table 14). Two plots (EUES-7 and 10) have not been treated with herbicides; all the other plots have been treated. These untreated plots also show stable or decreasing numbers of plants over all four years. In addition, there were 7 individuals of a rare plant, Rocky Mountain phacelia (*Phacelia denticulata)* documented in one of the untreated plots (EUES-10) in 2015. 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 US.

Table 14. Summary of leafy spurge permanent plot data, 2012-2015.

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

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. Five of the plots have stayed relatively stable (±5%) over four sampling years while five plots have decreased (>10% decrease, Table 15, Figure 9).

Table 15. Leafy spurge 2012-2015: percent of quadrats/plot with leafy spurge. 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).

Plot Name	FREQUENCY 2012	FREQUENCY 2013	FREQUENCY 2014	FREQUENCY 2015	Overall Trend (2012-2015)
EUES-1	**29%**	35%	38%	30%	
EUES-2	**40%**	3%	3%	2%	
EUES-3	**25%**	15%	**34%**	13%	
EUES-4	**27%**	36%	29%	19%	
EUES-5	**31%**	32%	27%	32%	
EUES-6	**35%**	42%	45%	40%	
EUES-7	11%	13%	15%	15%	
EUES-8	**27%**	32%	**15%**	24%	
EUES-9	**43%**	21%	13%	22%	
EUES-10	18%	18%	15%	5%	
AVG	**29%**	**25%**	**23%**	**19%**	**247%**
SD	**9.1**	**11.8**	**12.6**	**11.3%**	**11.2**

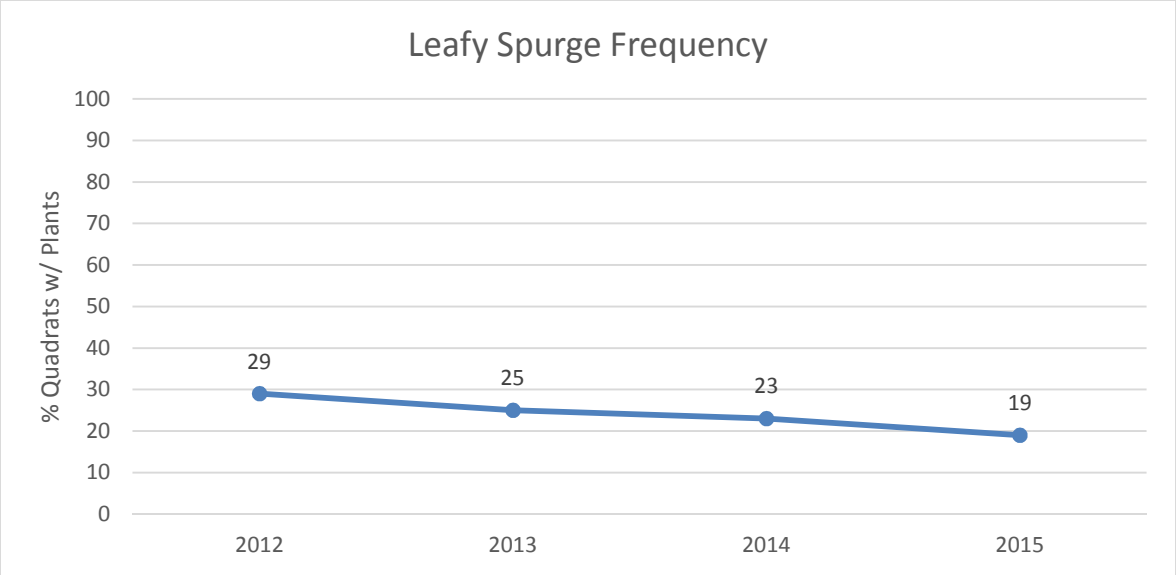


Figure 9. Leafy spurge 2012-2015: percent of quadrats/plot with leafy spurge.

Density is calculated from the average number of stems arising from the ground in the half meter quadrats while percent cover is an estimate of how much area is occupied within the half meter quadrats. Density and cover tend to be more susceptible to precipitation patterns than frequency. The overall trend was stable for both the average density and average percent cover (Table 16). This is interesting because it was an exceptionally wet spring and early summer in Colorado Springs (Table 1 p. 7).

Table 16. Average density and average % cover of leafy spurge 2012-2015. 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).

Plot Name	Avg Dens 2012	Avg Dens 2013	Avg Dens 2014	Avg Dens 2015	Overall Trend (2012-2015)	Avg Cover (%) 2012	Avg Cover (%) 2013	Avg Cover (%) 2014	Avg Cover (%) 2015	Overall Trend (2012-2015)
EUES-1	**2**	2.2	1.9	2.4		**1.9**	2.0	7.3	1.6	
EUES-2	**6**	0.0	0.0	0.1		**4.1**	0.1	0.1	0.1	
EUES-3	**1**	0.6	**1.6**	0.8		**1.1**	0.4	**0.8**	0.3	
EUES-4	**1**	1.4	1.5	0.4		**1.3**	1.3	4.0	0.5	
EUES-5	**3**	1.8	1.0	1.1		**0.8**	2.3	2.8	1.5	
EUES-6	**2**	1.9	2.1	1.2		**2.0**	2.3	5.2	1.6	
EUES-7	0	0.4	0.7	0.4		0.2	0.7	3.3	0.9	
EUES-8	**2**	2.1	**0.5**	1.7		**2.1**	3.5	**1.1**	2.5	
EUES-9	**4**	1.9	0.3	0.6		**2.1**	1.4	0.7	0.8	
EUES-10	2	1.1	0.6	0.3		1.1	0.5	0.6	0.2	
AVG	**2.3**	**1.3**	**1.0**	**0.9**	**1.4**	**1.7**	**1.5**	**2.6**	**1.0**	**1.7**
SD	**1.6**	**0.7**	**0.7**	**0.7**	**0.9**	**1.0**	**1.0**	**2.3**	**0.7**	**1.3**

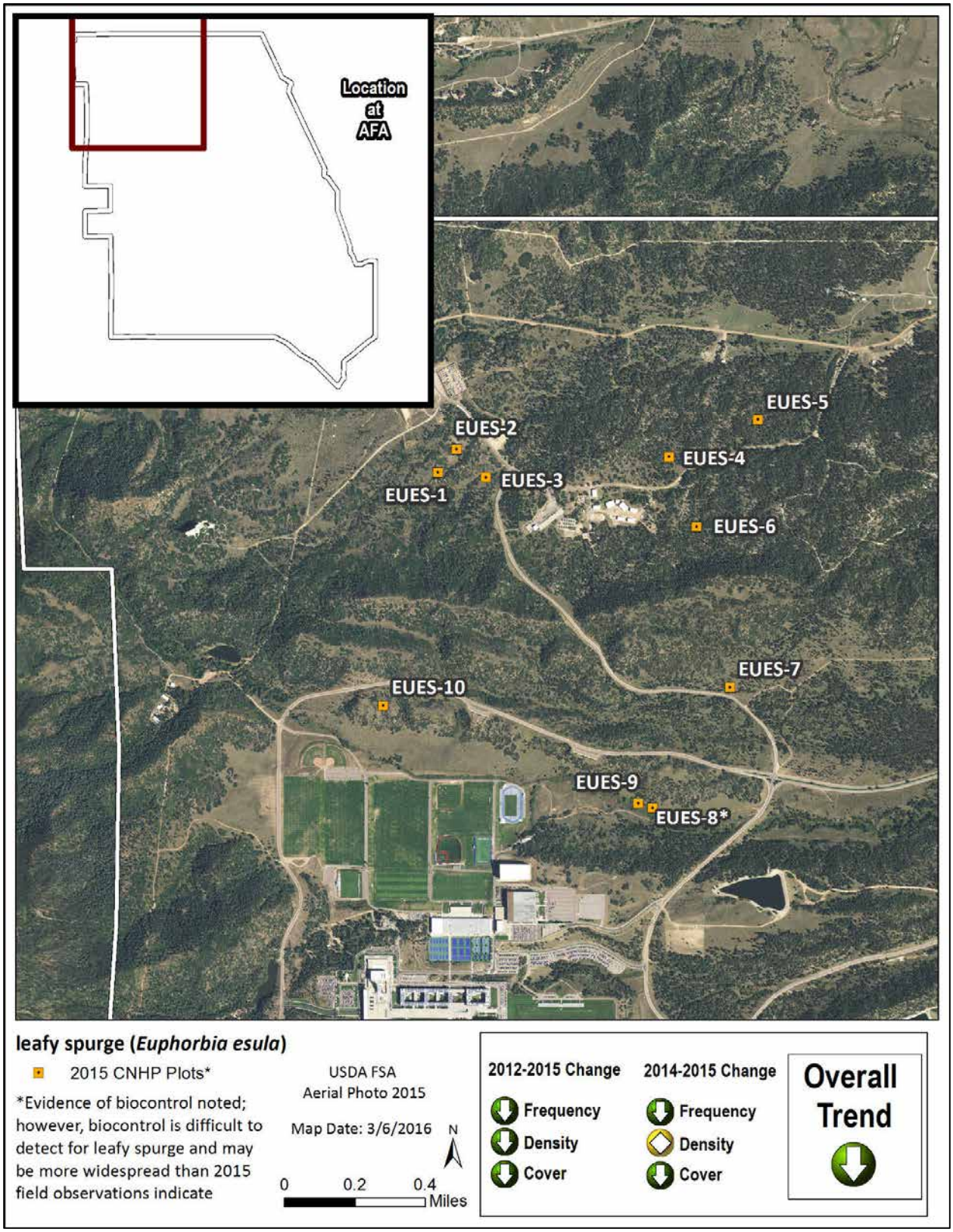
Recommendations are to continue to leave plots EUES-7 and EUES-10 untreated and add three additional untreated plots to have at least a total of five treated and five untreated plots for future monitoring. It should be noted when considering future treatments of leafy spurge that a study in Rocky Mountain 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. A greenhouse study conducted in 2008 (Nicholas et al.) showed that leafy spurge seedling growth was lower in pots 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. The best protection is to protect areas with native plant cover from disturbance keeping in mind that herbicides disturb soils by changing soil chemistry and leaving bare spots.

In addition, a CNHP tracked rare plant species was found in EUES-10, where there were seven individuals of Rocky Mountain phacelia (*Physaria denticulata*) observed. This species is considered to be globally vulnerable (G3/SU) because it is a regional endemic known from eight counties in Colorado, two in Wyoming, and one in New Mexico. Protocols for treating weeds in the vicinity of rare plants are currently being developed by the State of Colorado (Mui, 2016, pers. comm. 21 February), and should be considered in future planning. If treatments are to continue, only a precise spot application of an herbicide should be used to minimize soil damage and damage to the surrounding native species (Smith et al. 2015). We suggest the Academy staff continue to leave plot EUES-10 untreated as a control plot for the monitoring survey. This plot has shown a natural decrease in frequency of leafy spurge since it was monitored in 2012 (Table 15).

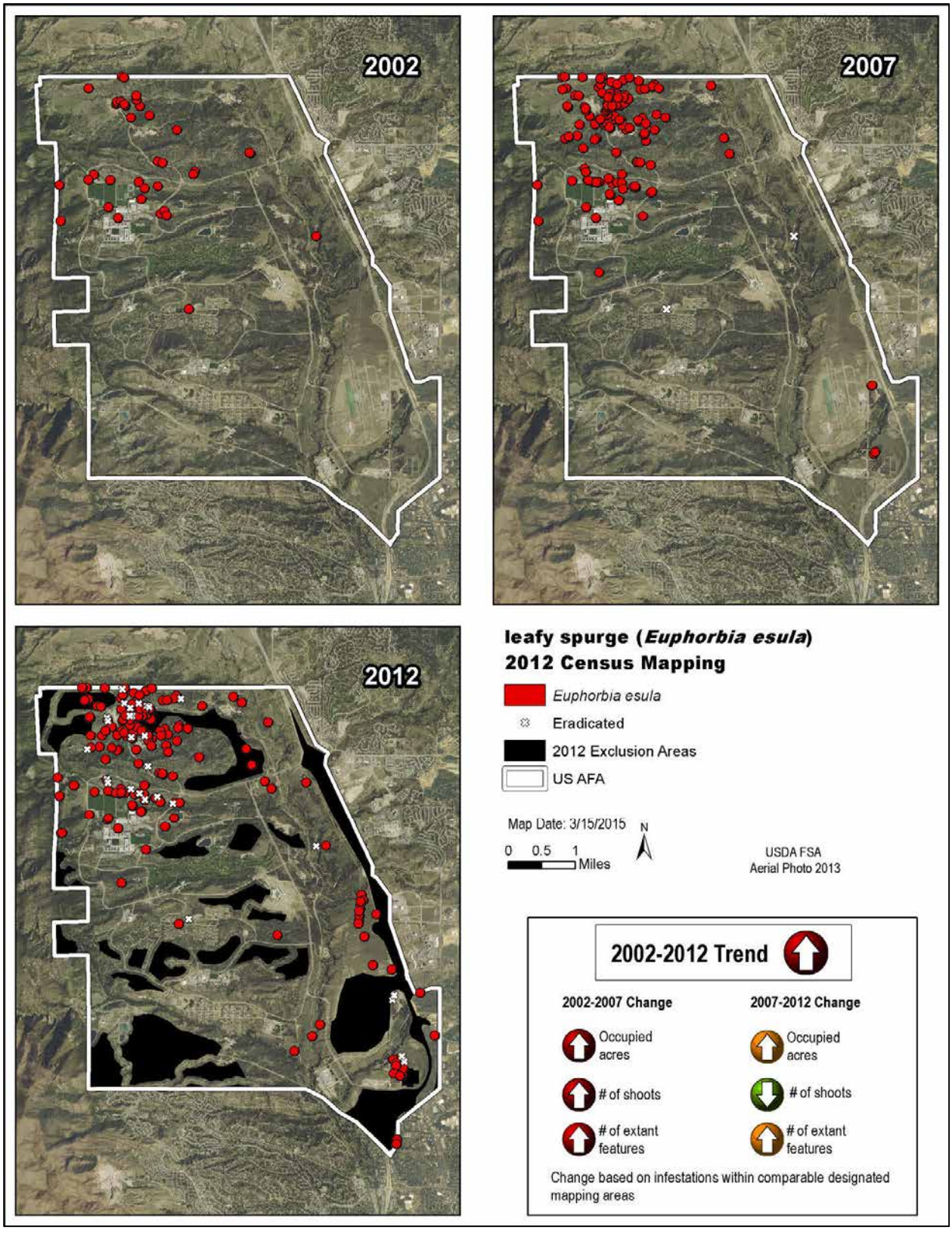
Biocontrol organisms were observed during the plot monitoring visit in 2015 (EUES-8). The biocontrol organisms were frequently noted by Michels and the TAMU crew who were specifically seeking them out at appropriate emergence times. These organisms are likely contributing to observed decreases.

History of Sampling and Treatment

- Ten permanent plots were established in 2012 (Map 14).
- Census mapping for leafy spurge distribution across the Academy property was conducted in 2002, 2007, and 2012 (Map 15).
- 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.

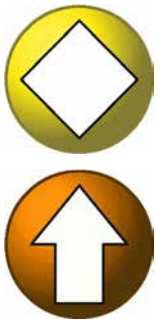


Map 14. 2015 leafy spurge plots at the Academy.



Map 15. Distribution of leafy spurge at the Academy in 2002, 2007, and 2012.

Myrtle Spurge (*Euphorbia myrsinites*)



Myrtle spurge populations are currently stable with an overall increasing trend.

AFA Management Goals: Eradication through continued monitoring and rapid response with mechanical and chemical treatments

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.
- Appears to be spread by birds at AFA due to random widely spread small occurrences.
- Seed longevity 8 years.

Photo: Dave Anderson

Photo: Wikimedia Commons

Results: In 2015, 173 individuals were observed at 14 extant features. In 2014, 179 individuals were observed in seven extant features occupying an estimated 0.7 acres of land. Extant features have ranged from 7-19 between 2005 and 2015 (Table 17, Figure 10). The number of individuals has fluctuated from 25 to 1,021, with the highest number of individuals reported in 2007. The trend for the last three years shows a range of 7-19 extant features and individuals ranging from 129-173.

Table 17. Myrtle spurge summary data, 2005-2015.

Census Mapping Method				
Year	*# shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2005	25	7	0	---
2006	243	10	0	---
2007	1,021	7	6	0.18
2008	419	13	5	0.66
2009	464	12	6	2.4
2010	56	10	12	0.5
2011	57	12	16	0.25
2012	113	10	25	0.23
2013	129	19	12	---
2014	179	7	27	0.7
2015	173	14	26	1.04

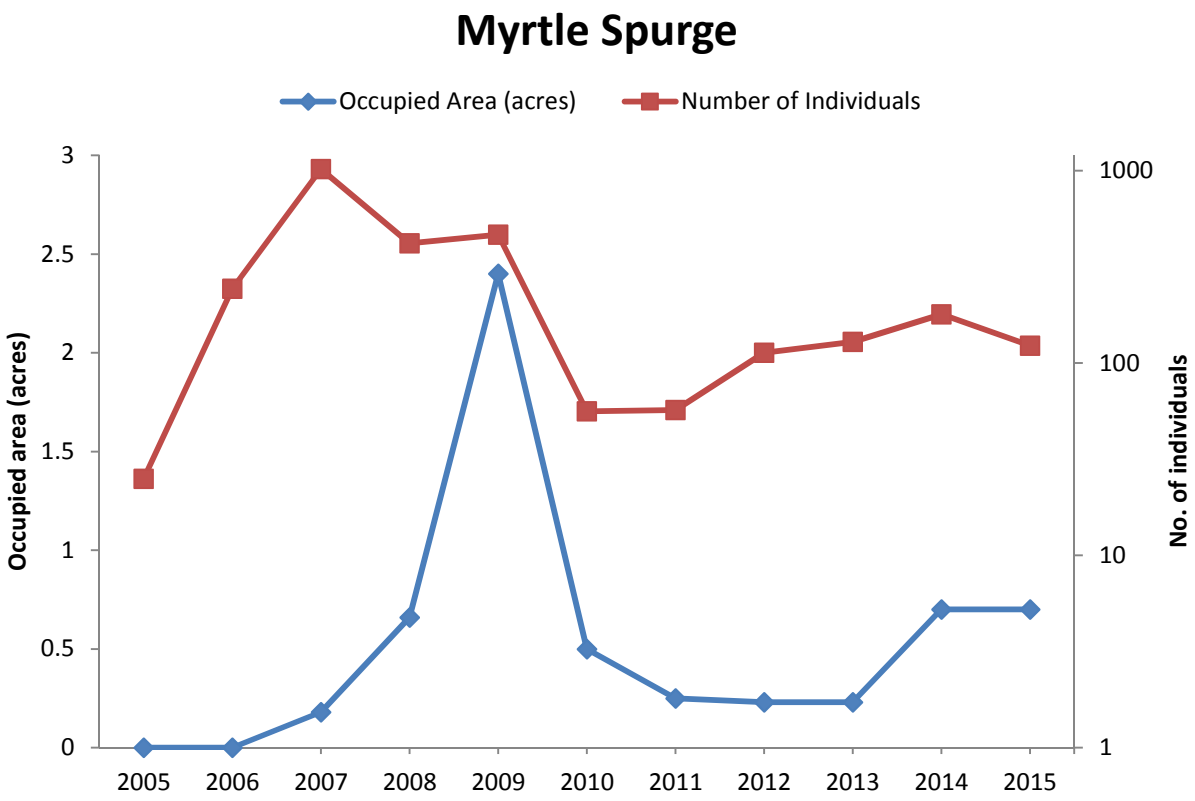
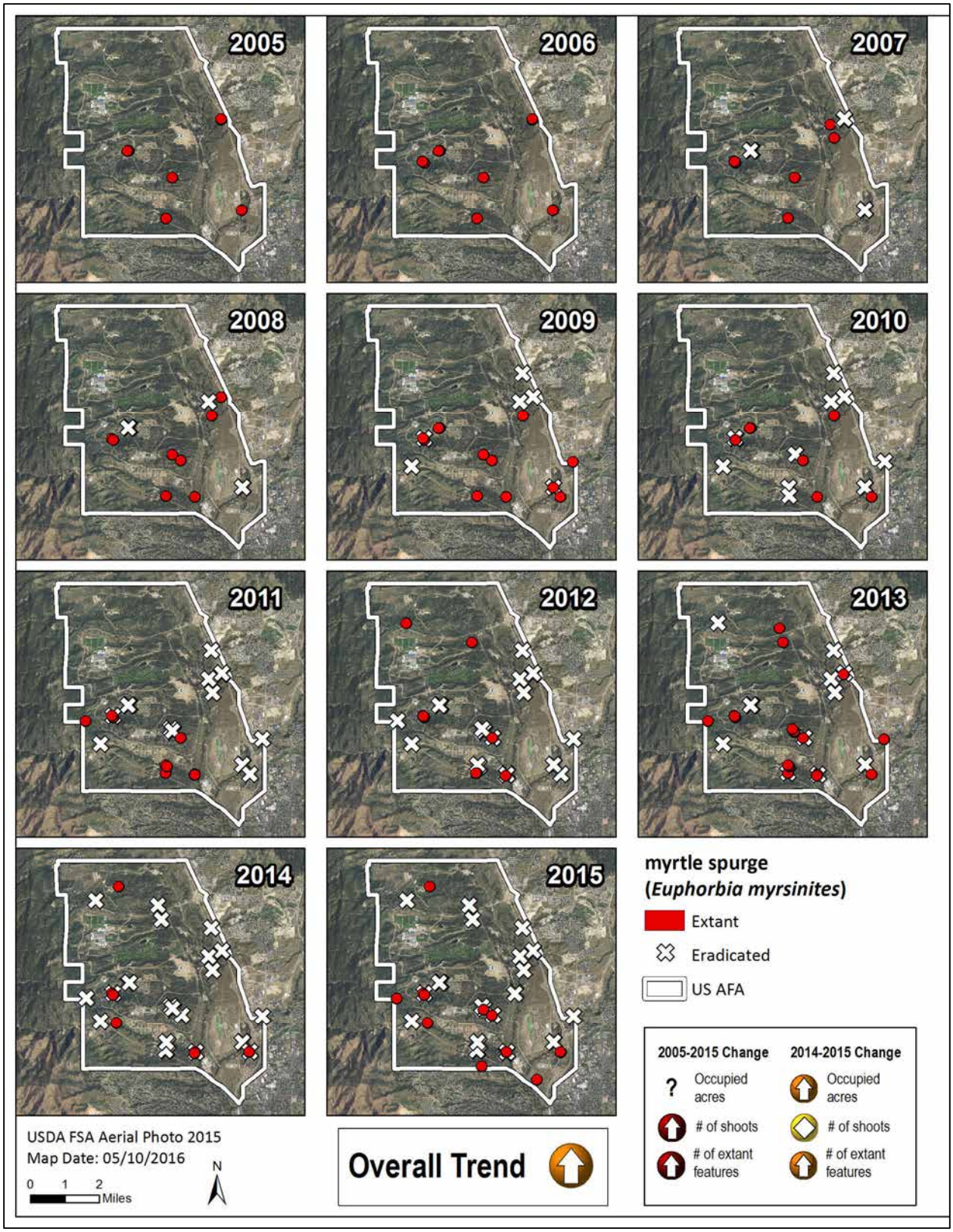


Figure 10. Myrtle spurge trend, 2005-2015.

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.
- 2005-2015 generally an upward trend (Map 16); however 2015 is much below the high number of approximately 1,000 individuals in 2007 and populations are relatively stable between 2014 and 2015. (Table 16, Figure 10).



Map 16. Distribution of myrtle spurge at the Academy between 2005 and 2015.

Yellow Spring Bedstraw (*Gallium verum*)

10 plants were observed at the known location after it was thought to be eliminated from the base (2012-14).

AFA Management Goals: Eradication through continued monitoring and rapid response.

State List: Not listed

- 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

Results

For the first time since 2011, plants were found in 2015 at the single monitoring point (Table 18, Map 17). All plants and root parts were removed by CNHP staff. The seed longevity of this plant is not known. This site and the immediate vicinity should be monitored frequently for at least four more years. Rapid response and early detection methods are appropriate for this species. 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. Mechanical removal is an appropriate method.

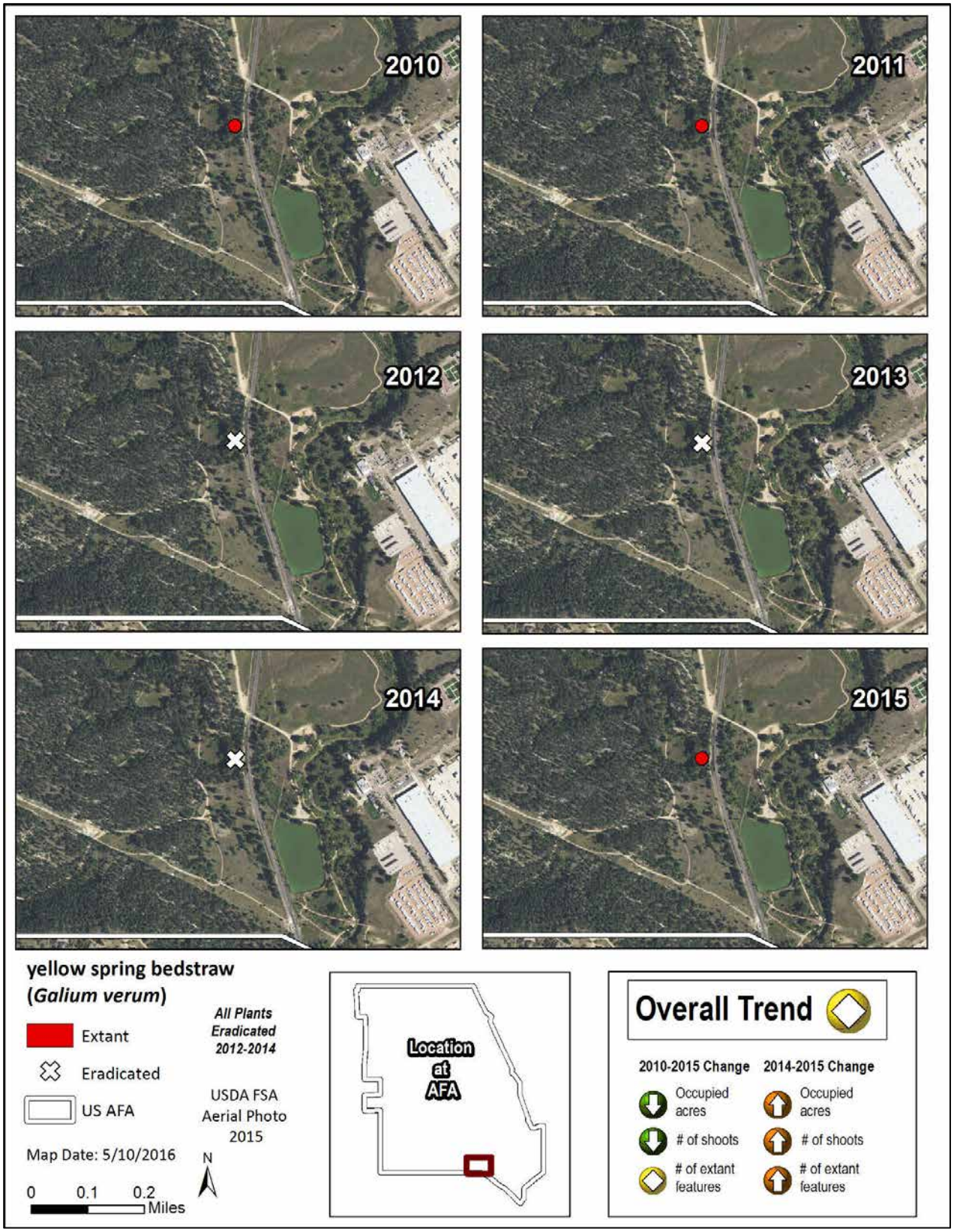
Table 18. Yellow spring bedstraw summary data, 2010-2015.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2010	700	1	0	<0.01 (28 m^2)
2011	1	1	0	<0.01 (3.1 m^2)
2012	0	0	1	0
2013	0	0	1	0
2014	0	0	1	0
2015	10*	1	0	<0.01 (3.1 m^2)

*All plants manually treated at the time of observation by CNHP.

History of Sampling and Treatment:

- This species was discovered at the Academy in 2010 with one occurrence found near Ice Lake (Map 17). 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 2013 and 2014.
- In 2015, 10 new plants were discovered at the known site and manually removed.



Map 17. Distribution of yellow spring bedstraw at the Academy between 2010 and 2015.

Dame's Rocket (*Hesperis matronalis*)

Two extant populations were documented in 2015 out of 14 known locations. Since 2012, there has been a dramatic decrease in the number of plants at these 14 sites.

A rare plant occurrence was documented in the vicinity of treatment area.

AFA Management Goals: Eradication through continued monitoring and rapid response with mechanical and chemical treatments

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 thought to be many years.

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

Results

Two out of 14 populations discovered in 2012 were still extant and included 280 plants (Map 18). This is a dramatic decrease since 2012, when the number of plants reached almost 17,000 (Table 19). Photos 3 &4 show four partially killed dame's rocket plants with a dead four meter square patch of an adjacent dead native shrub, skunkbush sumac (*Rhus trilobata*). Recommendations for this area would be to ensure herbicides are wetland compatible and that a more precise method is used to spray. For small infestations of 20 or fewer plants, consider manual removal of plants. The potential to exacerbate weed invasions is much greater in areas where native plants were impacted by herbicides or mechanical removal of plants. Rare plants, wetlands, and intact prairie uplands were located within the areas being treated.

Table 19. Dame's rocket summary data, 2010-2015.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2012	16,871	14	0	0.83
2013*	---	---	---	---
2014*	---	---	---	---
2015	280	2**	14	0.08

*Dame's rocket was not surveyed in 2013, and was surveyed too late in the season in 2014 to accurately estimate the population.

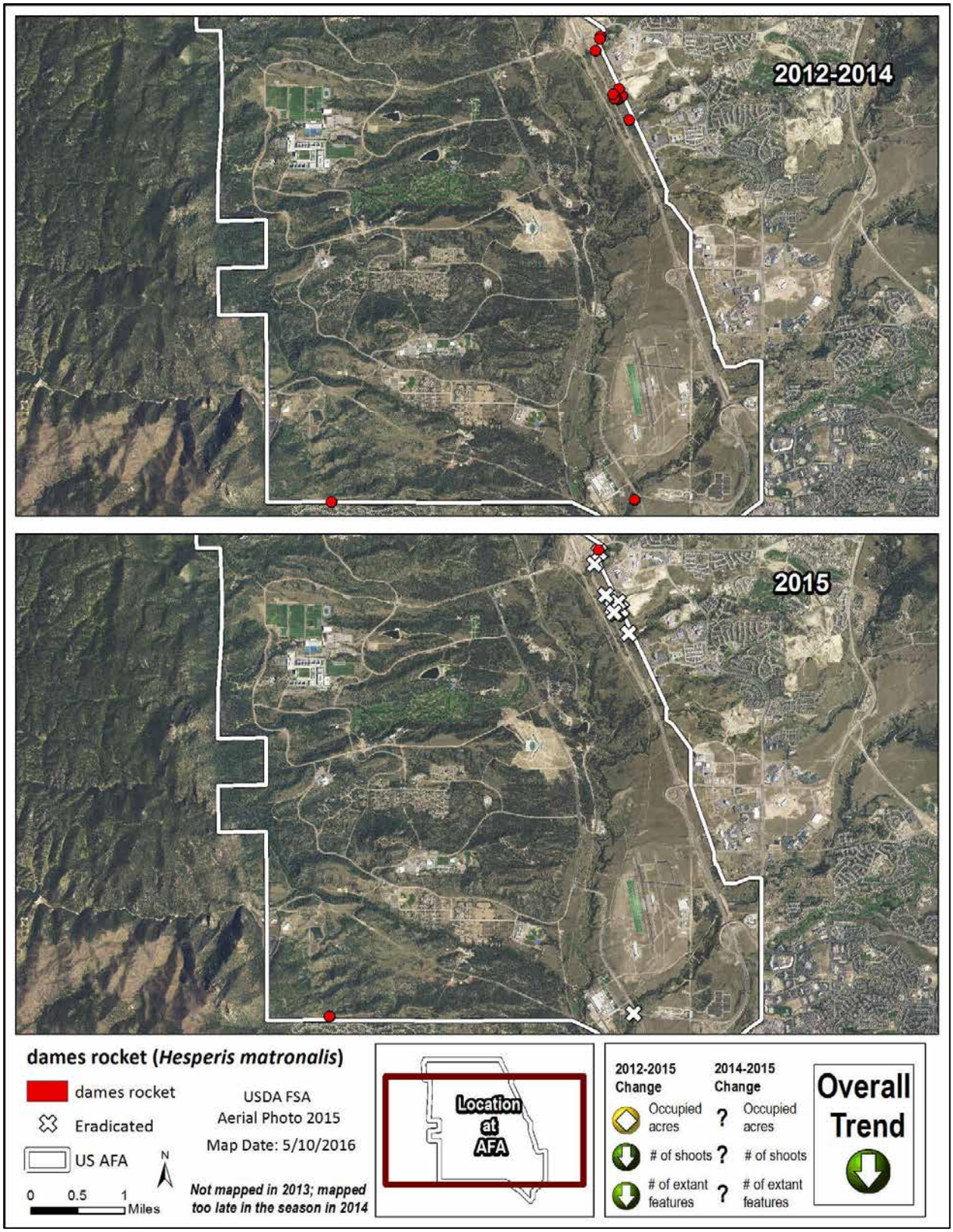
**Base personnel found a new location with 130 individuals in June 2014 on the south boundary of the Academy far from the original infestation site near I-25. This site was not accessible in 2015 (gated road) and assumed extant.

Photo 3. A patch of dead skunkbush sumac (*Rhus trilobata*) shrubs behind four partially treated dame's rocket plants (red circle).

Photo 4. Close-up photo (red circle Photo 2) of partially killed dame's rocket plants in front of dead native sumac shrubs. P. Smith 2015

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 (Map 18). 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.



Map 18. Mapped locations of dame's rocket at the Academy between 2012 and 2015.

Common St. Johnswort (*Hypericum perforatum*)

Significant downward trend since 2007; slight decreases 2013-2015.

AFA Management Goals: Containment through continued monitoring and treatment with biological, mechanical and chemical control methods.

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

Results

In 2015, the number of extant features was 27, which is a slight decrease from 33 individuals in 2014. The number of shoots observed also decreased slightly (Table 20). Since 2012, there has been a large reduction in the number of plants, but the number of extant features has remained relatively stable (Table 20 and Figure 11). The flooding that has been occurring over the last two years has contributed to some of the decline in the number of shoots.

Table 20. Common St. Johnswort summary data, 2007-2015.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2007	44,647	8	0	0.86
2008	130,371	13	0	1.07
2009	95,883	21	2	2.02
2010	82,733	20	6	1.47
2011	87,128	26	5	1.44
2012	83,115	29	10	1.16
2013	2,621	22	21	0.85
2014	3,604	33	19	1.12
2015	3,102	27	29	1.27

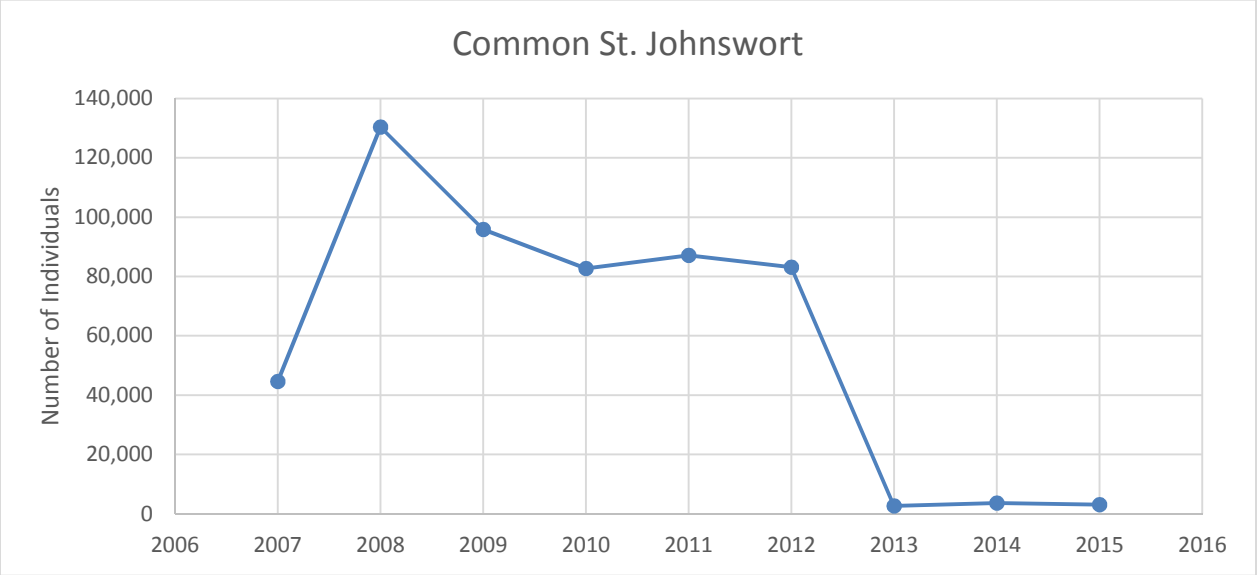
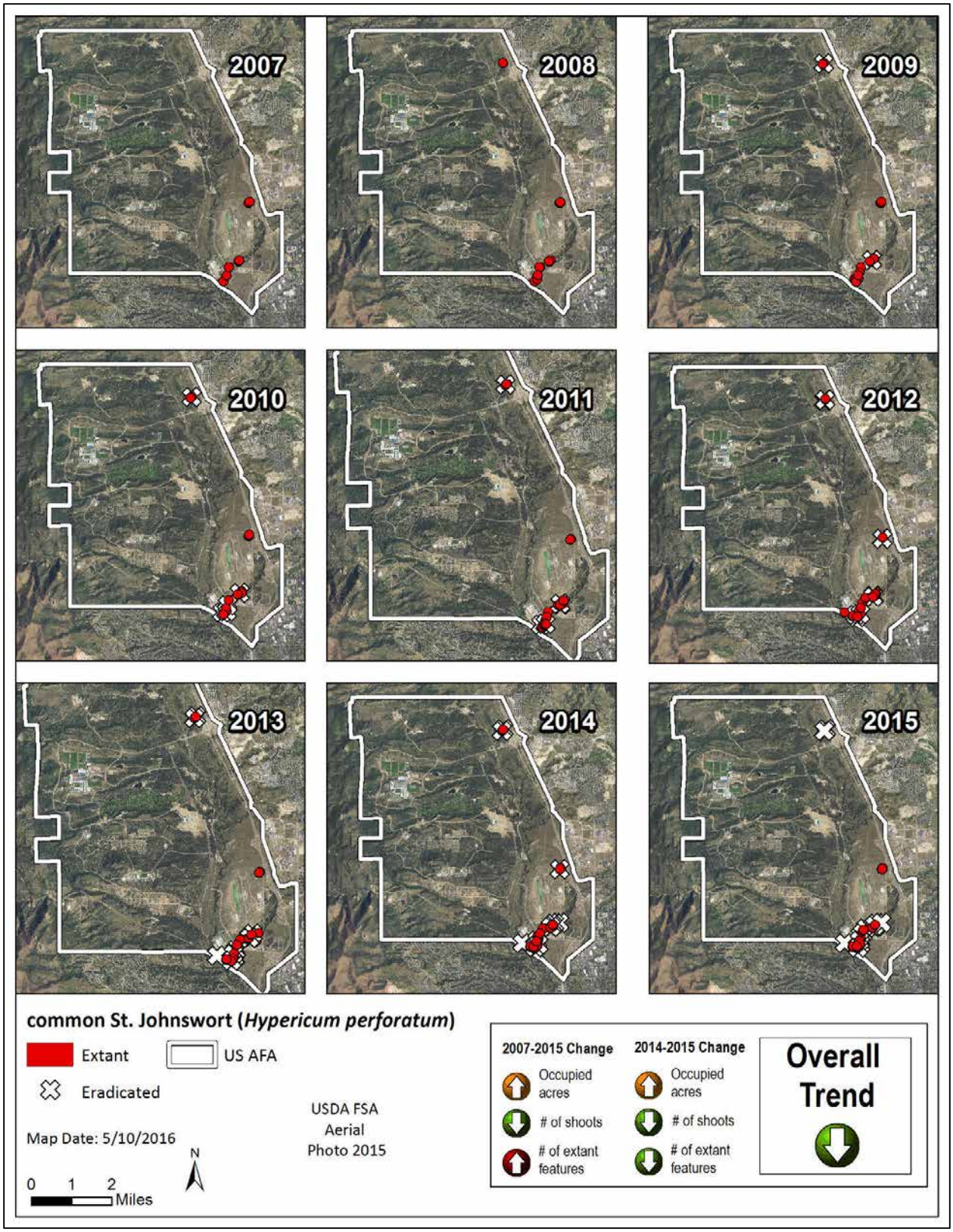


Figure 11. Number of individuals and extant features of common St. Johnswort, 2009-2015.

History of Sampling and Treatment:

- Common St. Johnswort was first monitored in 2007.
- The populations peaked in 2008-2009 (Table 20, Figure 11, Map 19).
- Biocontrol efforts were discontinued in 2010.
- A significant decline occurred in 2012-2013.
- The number of extant features and occupied acres have remained relatively stable since 2012.



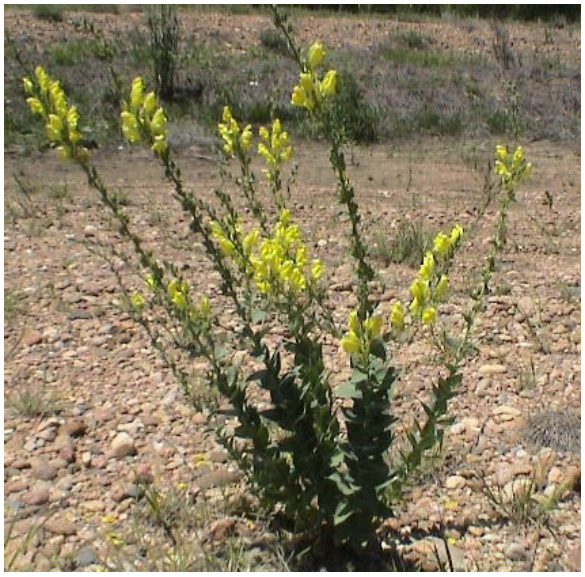
Map 19. Distribution of common St. Johnswort at the Academy between 2007 and 2015.

Dalmatian Toadflax (*Linaria dalmatica* ssp. *dalmatica*)

No plants were observed at the four known locations and no new sites were documented in 2015.

AFA Management Goals: Eradication through continued monitoring and rapid response with chemical treatment

State List: B



Photos: Colostate.edu

- 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.

Results

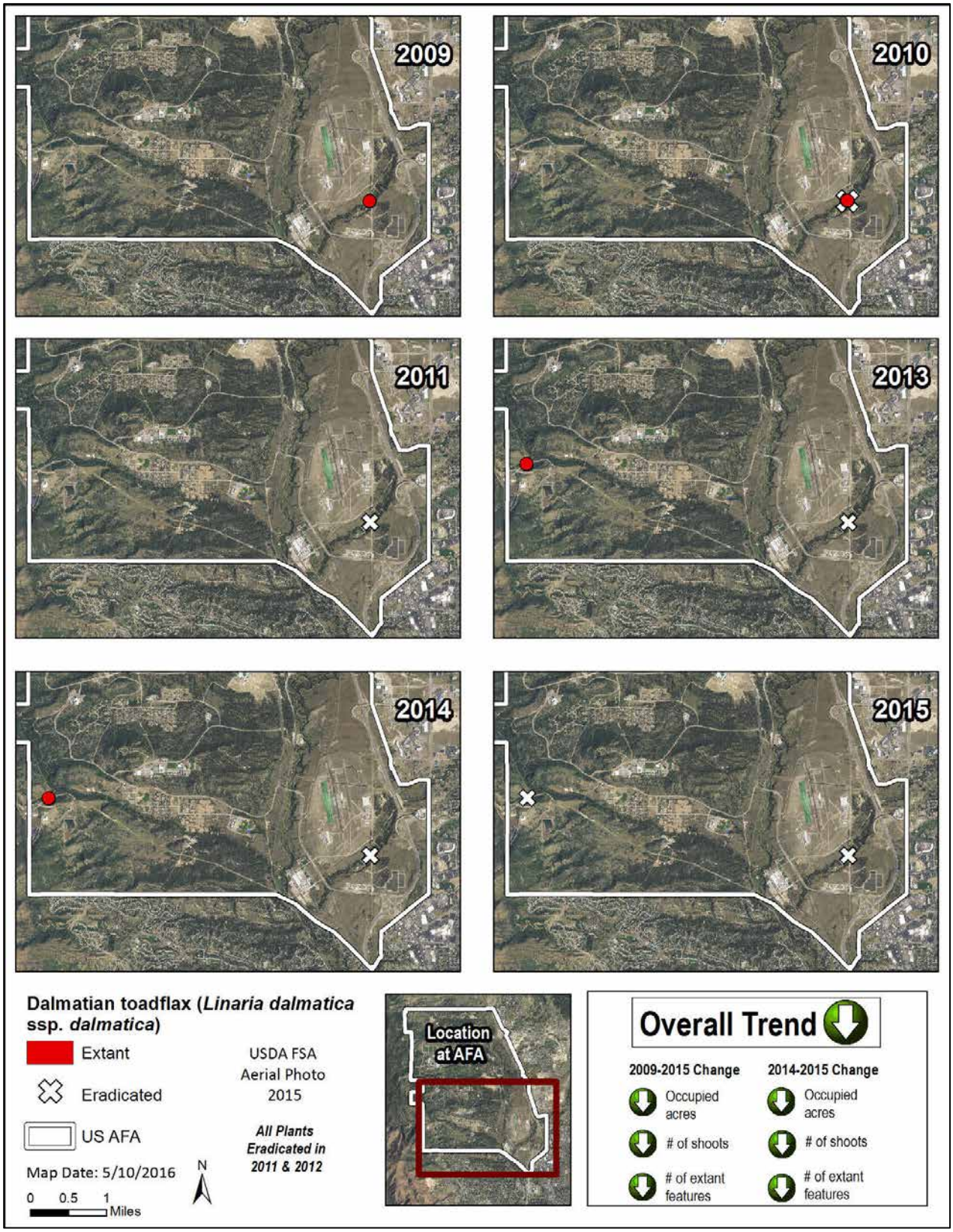
In 2015, no individuals were observed at any of the four known locations (Table 21). However, seven plants were noted in 2014 which demonstrates the need for continued monitoring.

Table 21. Dalmatian toadflax summary data, 2007-2015. Bolded and shaded indicates treatment.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2009	10	1	0	---
2010	**107**	**2**	1	**0.50**
2011	0	0	3	0
2012	0	0	3	0
2013	**12**	**1**	3	**---**
2014	7	1	3	<0.01 (12.5 m^2)
2015	0	0	4	0

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 (Map 20) with 107 shoots that covered approximately 203 m^2 (0.05 acres -Table 21). 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.
- In 2015, no plants were observed at the four known sites and no new infestations were found.



Map 20. Distribution of Dalmatian toadflax at the Academy between 2009 and 2015.

Tatarian Honeysuckle (*Lonicera tatarica*)

The new extant features include two sites with mature shrubs that represent stable populations and two sites that include expanding populations at treatment sites in 2015.

AFA Management Goals: Containment through continued monitoring, mechanical and chemical treatments

State List: Not listed

- 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

Results: In 2015, there were nine extant features with 28 individuals observed. The original site documented in 2008, which has 20 individuals, was not visited in 2015, but was included in the total number of individuals (48) in 2015 (Table 22). Earlier reports from 2008 and 2012 estimated 30 individuals at the original site. However, an actual count of 20 was documented in 2014. The overall increase in 2015 is represented by 17 additional individuals and four additional extant sites compared to 2014 (Map 21). The increases are occurring at treatment sites where the trees are sprouting and spreading (Mihlbachler, 2016, pers. comm. 12 May). Continued monitoring and care

not to increase disturbances when treating is important because dense thickets can result in disturbed conditions.

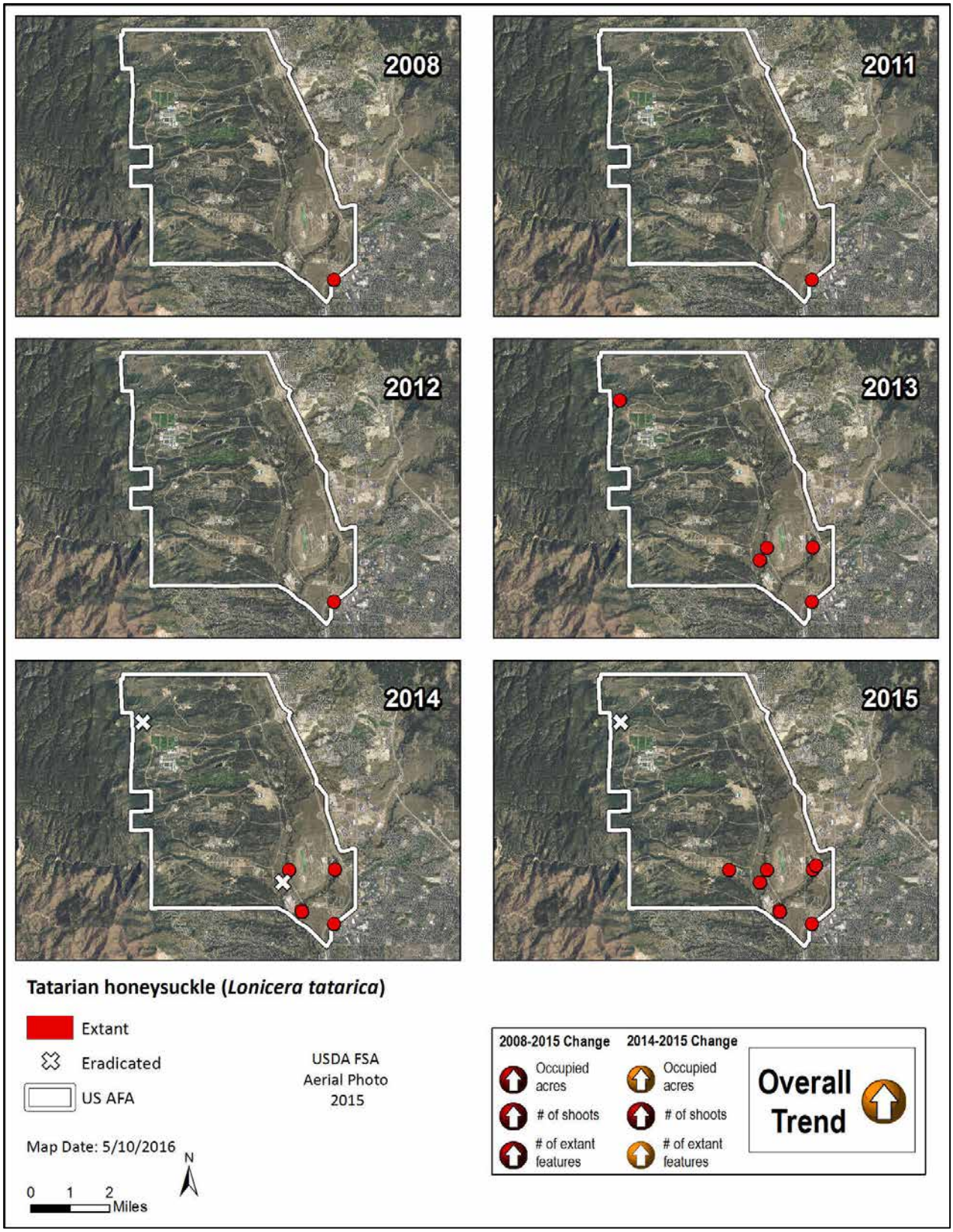
Table 22. Tatarian honeysuckle summary data, 2008-2015.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2008	20*	1	0	0.15
2012	20*	1	0	0.15
2013	28	5	0	0.18
2014	31	5	2	0.21
2015	48	9	1	0.40

*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. The original site was not revisited in 2015, and assumed to be extant with 20 individuals.

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 0.015 acres with approximately 30 individuals at one site in 2012.
- In 2013, four new locations were documented with eight individuals (Map 21). 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.



Map 21. Distribution of Tatarian honeysuckle at the Academy between 2008 and 2015.

Scotch Thistle (*Onopordum acanthium*)

Overall the trend is increasing 2002-2015. There was a decline in the number of individuals with an increase in the number of mapped features from 2014-2015

AFA Management Goals: Containment through continued monitoring, mechanical and biological treatments

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.

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

Results

In 2015, there were 157 extant features out of a total of 233 that were visited. This is more than twice the number of mapped Scotch thistle features reported in 2014, with 74 out of a total of 155 sites with Scotch thistle. There were new survey areas added in 2015 (Table 23, Figure 12). In some areas treatments were impacting the surrounding areas leaving bare open soils, cheatgrass was filling in the chemically disturbed sites. Rosettes of Scotch thistle were often missed in the treatments and other noxious weeds were observed growing in treated areas (Photos 4 & 5).

Table 23. Scotch thistle summary data, 2002-2015.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2002	52	7	0	0.17
2005	137	12	0	0.42
2007	1307	36	0	1.30
2008	144	27	17	1.14
2009	1,710	50	34	3.47
2010	669	61	30	0.66
2011	293	39	56	0.64
2012	889	66	73	0.30
2013	970	48	85	---
2014	1,224	74	81	0.84
2015	1,629	157	76	1.60

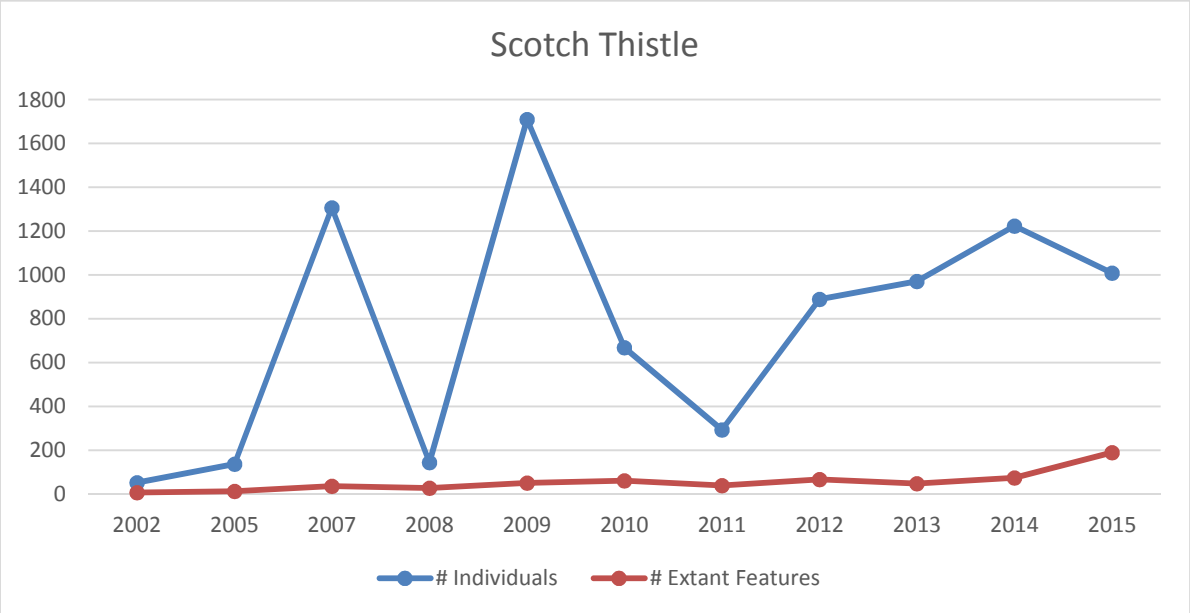


Figure 12. Number of Scotch thistle individuals and Extant Features, 2009-2015.

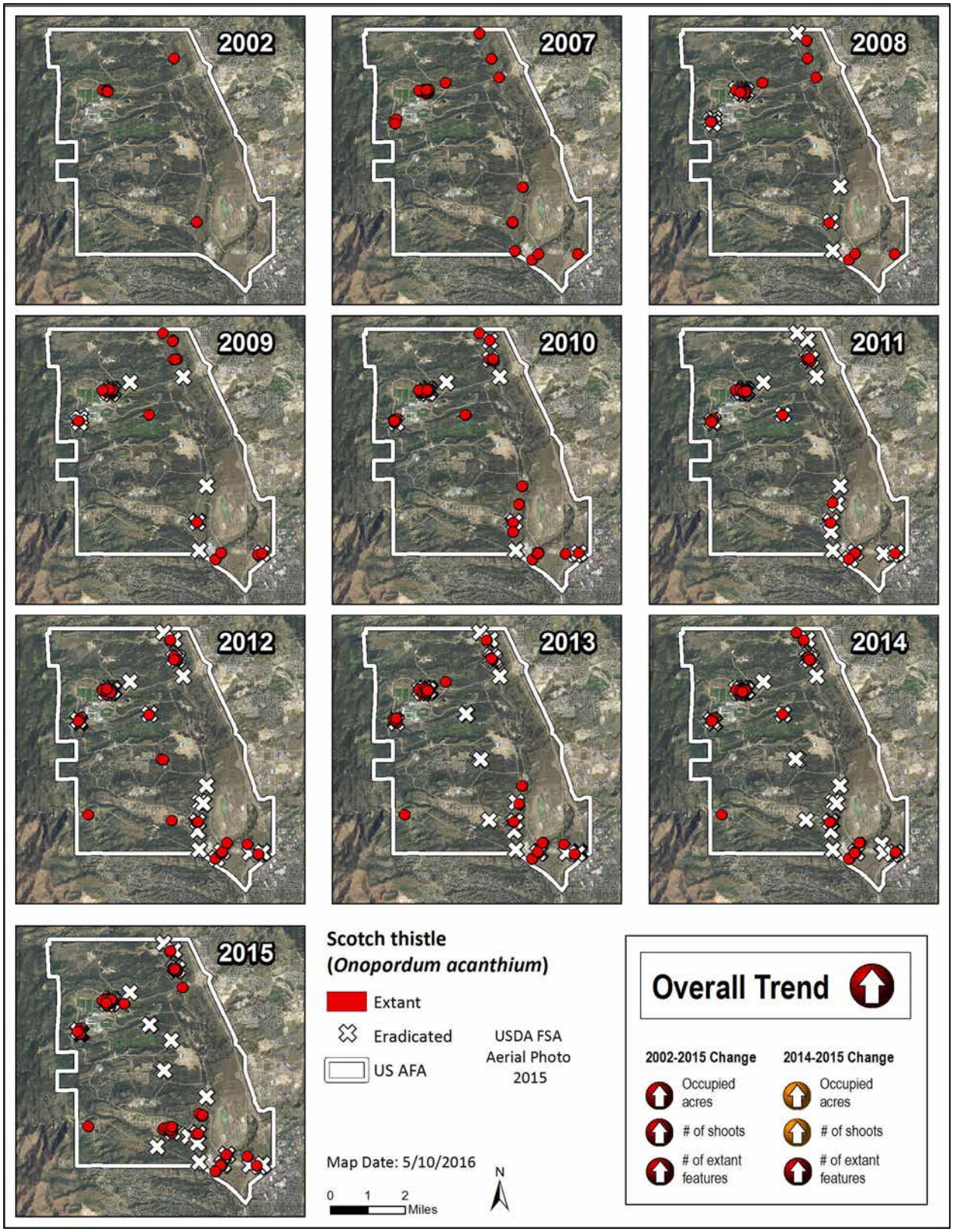
Photo 4. Photo of herbicide treated Scotch thistles showing overspray areas with bare soil and repopulation with other noxious weeds including houndstongue and cheatgrass. Photo: P. Smith 2015.

Photo 5. Chemically treated Scotch thistle area showing dense growth of annual weeds likely resulting from soil disturbance caused by herbicide application. Photo: P. Smith 2015.

Recommendations are to target the rosettes of the Scotch thistle plants and limit non-target damage to surrounding soils by using a precise spot application. Manual forms of treatment including severing the plant just below the root crown before the plants flower and go to seed should be considered as well. Spraying mature heads is not recommended for biennial species as the plant is going to die anyway. Treating plants when they are most susceptible to herbicides (pre-flower) without disturbing the surrounding habitat is key to a successful treatment that does not create more weed habitat.

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 (Table 23, Figure 12, and Map 22).
- 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. Using methods that precisely target Scotch thistle at the appropriate growth phase will help treatment be more effective.



Map 22. Distribution of Scotch thistle at the Academy between 2002 and 2015.

Bouncingbet (*Saponaria officinalis*)

Overall Downward trend 2013-2015. But slight upward trend between 2014 -2015.

AFA Management Goals: Eradication through continued monitoring and rapid response with mechanical and chemical treatments.

State List: B

- Perennial.
- Self-fertile.
- Reproduction from seeds.
- Colony former.
- Blooms summer-fall.
- Seed longevity is unknown.

Photo: ct.botanicalsociety.org

Photo: Leaves of mature plant, missouristate.edu

Results

Since 2013, there has been a dramatic reduction in the number of bouncingbet shoots. All eight mapped features were treated with herbicides in 2013. In 2014, two features had plants and the total number of individuals was 42. In 2015, 11 sites were monitored with eight extant features. The total number of individuals observed went from 42 in 2014, to 608 in 2015. In 2013 the

numbers of shoots were over 40,000 at eight monitoring sites (Table 24, Figure 13). Herbicides appear to be suppressing this species for a few years. Most of these areas have smooth brome (a rhizomatous non-native grass) that is replacing the bouncingbet. Smooth brome is difficult to control once it becomes established.

Table 24. Bouncingbet summary data, 2002-2015. (Bolded and shaded indicates treatment.)

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2002	---	1	0	---
2013	42,092	**8**	0	**0.50**
2014	42	2	6	0.14
2015	608	8	5	0.09

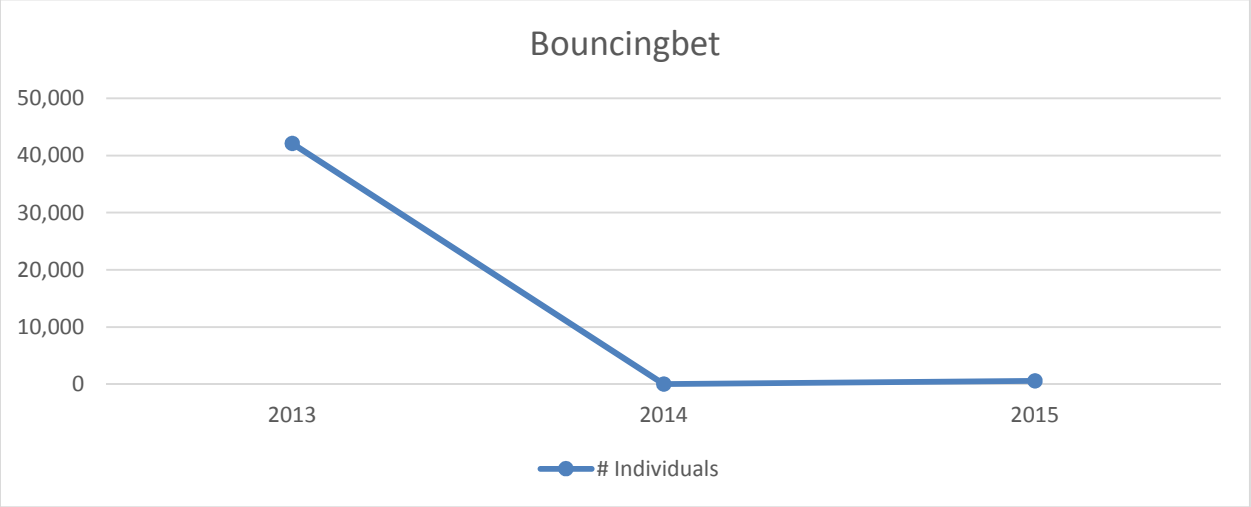
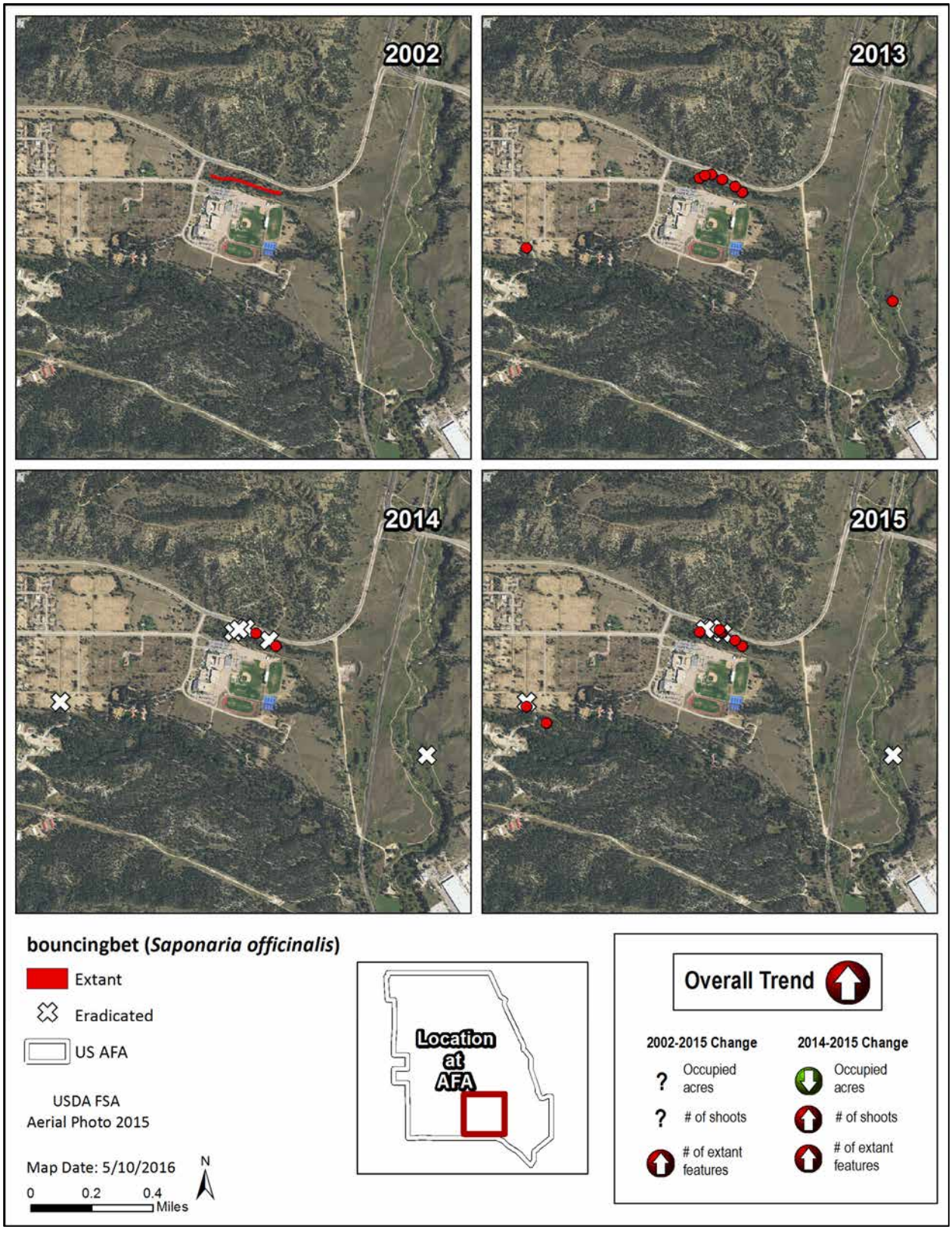


Figure 13. Number of individuals for bouncingbet 2013-2105.

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 (Map 23), 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.



Map 23. Distribution of bouncingbet at the Academy between 2002 and 2015.

Tamarisk (*Tamarix ramosissima*)

Increased number of plants and extant mapped features in 2015.

AFA Management Goals: Eradication through continued monitoring and rapid response with mechanical and chemical treatments

State List: B

- Reproduction by roots, submerged stems and seeds.
- Seed longevity <1 year.

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

Results

In 2015, a new monitoring site was located on the south side of the airport, and was visited with Dr. Brian Mihlbachler (USFWS). This new site brings the total monitoring sites to nine with four extant and five extirpated sites for future monitoring (Table 25).

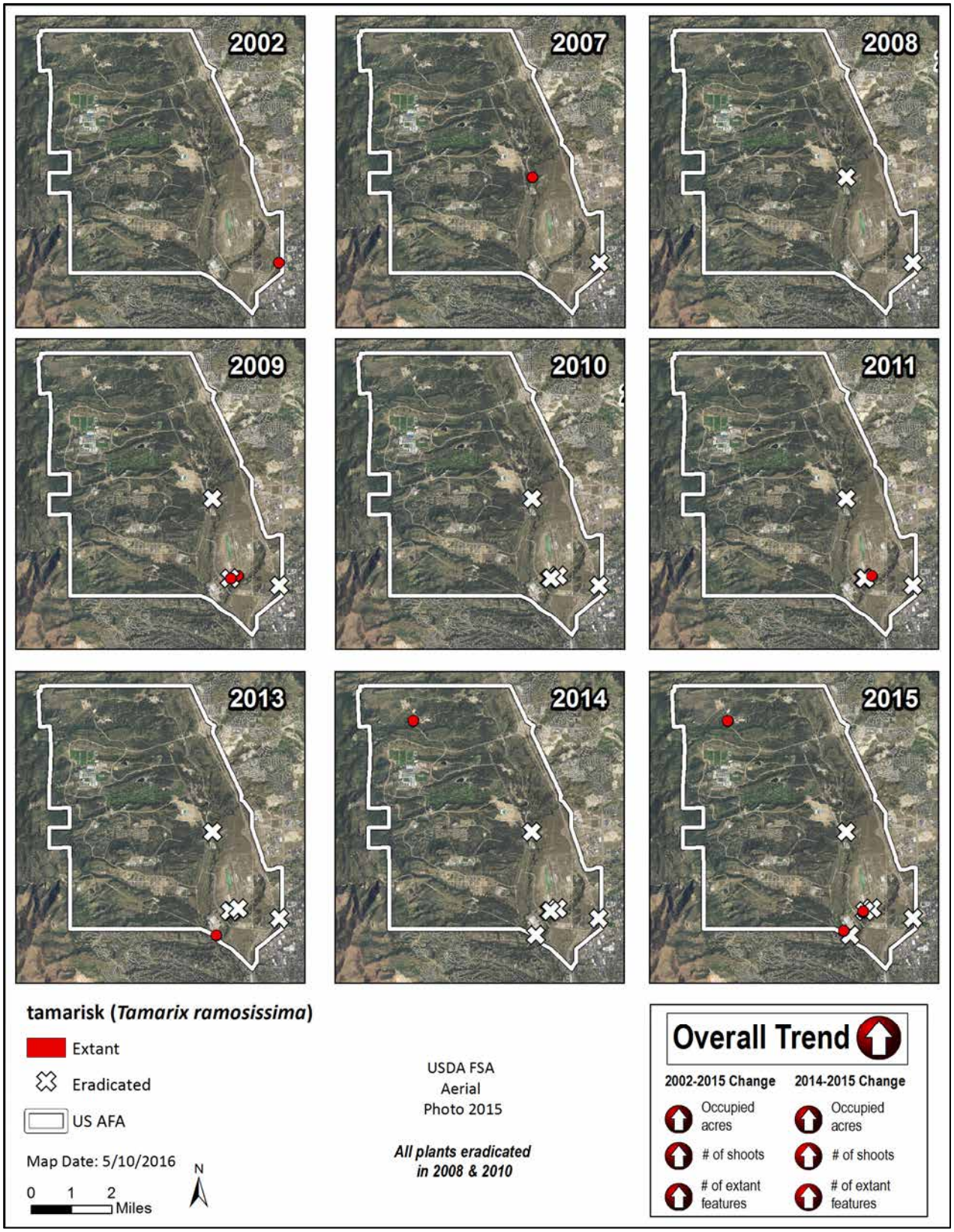
Table 25. Tamarisk summary data, 2002-2015.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Acres*
2002	1	1	0	<0.01 (3.14 m^2)
2007	1	1	1	<0.01 (3.14 m^2)
2008	0	0	1	0
2009	2	2	3	<0.01 (6.28 m^2)
2010	0	0	5	0
2011	1	1	4	<0.01 (3.14 m^2)
2012	1	1	4	<0.01 (3.14 m^2)
2013	1	1	5	<0.01 (3.14 m^2)
2014	1	1	6	<0.01 (12.6 m^2)
2015	6	4	5	.03

Since the known population includes fewer than 10 individuals, 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 tamarisk, herbicide should be applied immediately (within one minute) to the cut since the wound will heal quickly and decrease the amount of herbicide that will be translocated into the stump (CNAP 2005). 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 (CNAP 2005). Tamarisk can spread both by seed and vegetatively. Continued monitoring at the Academy is recommended at the known and throughout the Academy, especially in ditches and riparian areas.

History of Sampling and Treatment:

- Tamarisk was known from five separate sites between 2002 and 2013 (Map 24).
- 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 tamarisk plants in 2015.



Map 24. Distribution of tamarisk at the Academy between 2002 and 2015.

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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.

Common Name	Scientific Name	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Russian knapweed	***Acroptilon repens***			M*	M	M	M	M	M	M	M	M	M	M	M
Siberian peashrub	***Caragana arborescens***											M			
whitetop	***Cardaria draba***	M	M				M					M			
musk thistle	***Carduus nutans***	M					M					M			
diffuse knapweed	***Centaurea diffusa***	M					M					M			
diffuse / spotted knapweed hybrid	***C. diffusa x maculosa***				M*		M					M			
spotted knapweed	***Centaurea maculosa***	M			M	M	M					M			
Canada thistle	***Cirsium arvense***	M					PM					M			
bull thistle	***Cirsium vulgare***	M					M					M			
field bindweed	***Convolvulus arvensis***	M					M								
hounds - tongue	***Cynoglossum officinale***								M*	M	M	M	M	M	M
Fuller's teasel	***Dipsacus fullonum***	M					M					M			
Russian olive	***Elaeagnus angustifolia***	M	PM		PM		M					M			
leafy spurge	***Euphorbia esula***	M					M					M			
myrtle spurge	***Euphorbia myrsinites***				M*	M	M		M	M	M	M	M	M	M
yellow spring bedstraw	***Gallium verum***									M*	M	M	M	M	M
dames rocket	***Hesperis matronalis***											M*		PM	M

Common Name	Scientific Name	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
common St. Johnswort	***Hypericum perforatum***	M			M	M	M	M	M	M	M	M	M	M	M
Dalmatian toadflax	***Linaria dalmatica ssp. dalmatica***								M*	M	M	M	M	M	M
yellow toadflax	***Linaria vulgaris***	M					PM					PM			
Tatarian honeysuckle	***Lonicera tatarica***							M*			M	M	M	M	M
Scotch thistle	***Onopordum acanthium***	M			M	M	M	M	M	M	M	M	M	M	M
Bouncingbet	***Saponaria officinalis***	M*											M	M	M
tamarisk	***Tamarix ramosissima***	M					M	M	M	M	M	M	M	M	M

M = mapped, PM = partially mapped, * indicates year discovered

APPENDIX B. TRANSECT SURVEY PROTOCOLS FOR THE ACADEMY UTILIZED FOR BIOCONTROL AND NON-BIOCONTROL PLOTS FOR WHITETOP, 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)

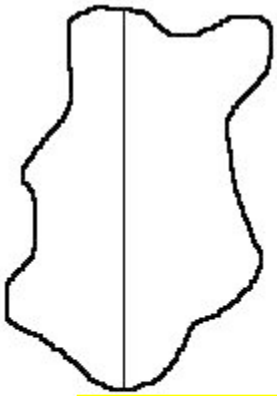
Materials for SURVEY ONLY:
Quadrat 50 x 50 cm (2)
50 m survey tape (minimum of 2, however 3 can also work well.
GPS unit, with the current year's shapefile for data entry

Standard survey procedure:

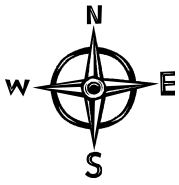
- The technique outlined here will apply to the majority of sites
- The general concept is to aim for a 50 m transect through the center of weed infestation. Sometimes it may be necessary to do a shorter transect in order to stay within the habitat. Ideally, the 25 m long bisecting transects have the 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. 7)

Fig. 1



0 m mark is south or west



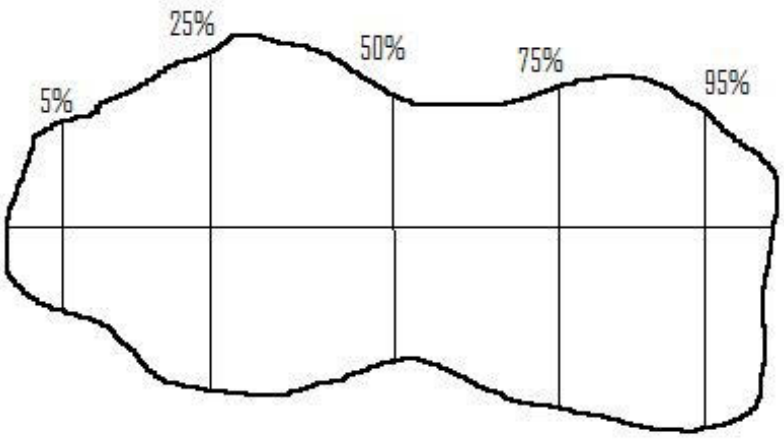


Fig. 2

0 m mark is south or west

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

- For sites deemed unmappable because of vas 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. (Fig. 7)

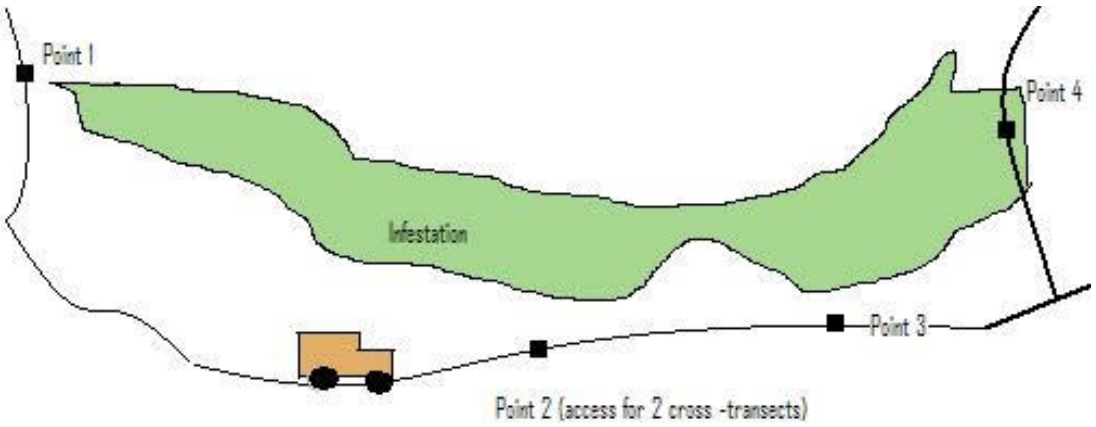

Point 1
Point 4
Infestation
Point 3
Point 2 (access for 2 cross -transects)

Fig. 3

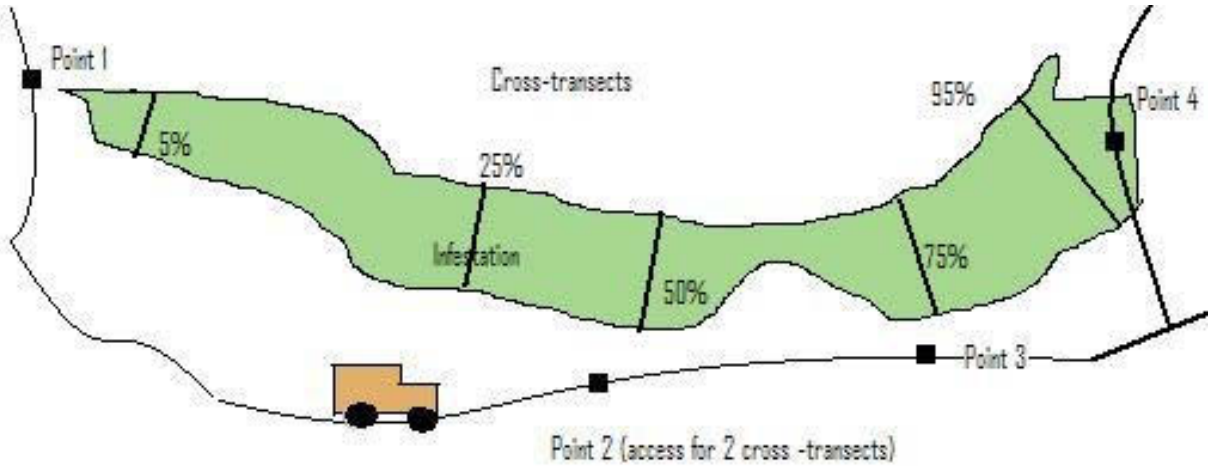

Point 1
Cross-transects
95%
Point 4
5%
25%
Infestation
50%
75%
Point 3
Point 2 (access for 2 cross -transects)

Fig. 4

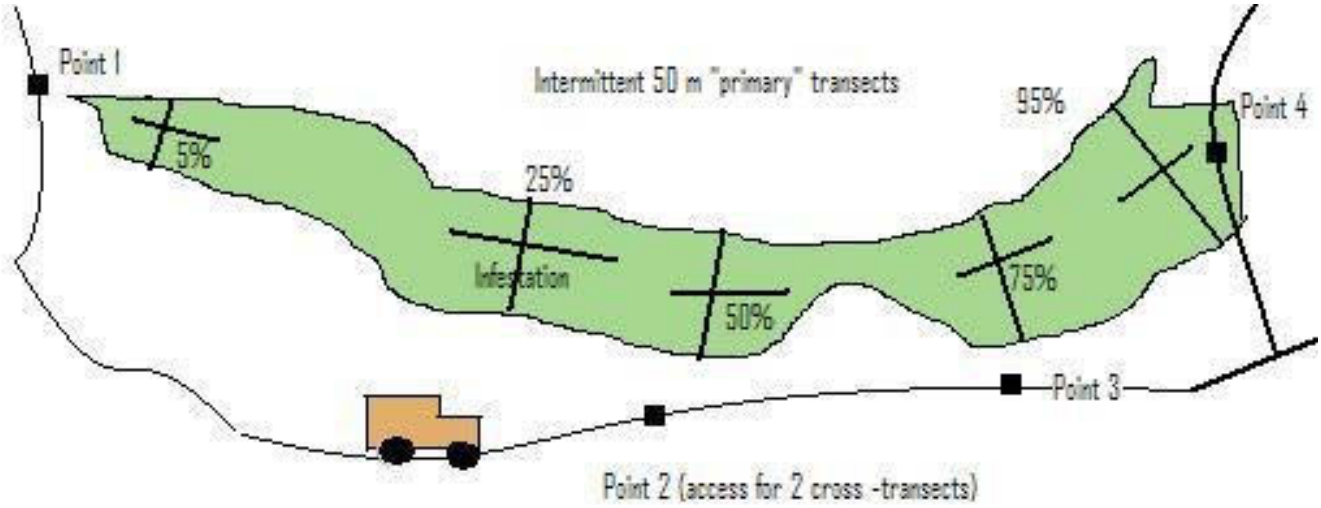


Fig. 5

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

All weed infestations were mapped in the field using ArcPad version 10.2 (ESRI 1995-2015), a portable version of GIS software that allows the user to create and edit spatial data remotely using a tablet computer. ArcPad was installed on a Trimble Yuma rugged tablet with a Windows 7 operating system and a built-in GPS receiver module. The Yuma tablet has improved display capabilities, a rugged exterior to withstand adverse weather conditions, a stable operating system and hard drive, and a larger screen to help with navigation and data collection. The configuration of a built-in GPS receiver module prevented reoccurring loose connections that were problematic during previous weed mapping efforts. According to Trimble specifications (http://www.trimble.com/mappingGIS/yuma_rugged_tablet.aspx?dtID=technical_specs) the GPS is generally accurate to within 2-5m using SBAS (Satellite-Based Augmentation System). To ensure data accuracy during the collection process, SBAS was activated and warning systems were enabled in ArcPad to notify the user when the PDOP (Positional Dilution of Precision) exceeded 6 and the EPE (Estimated Probable Error) exceeded 8. Twenty points were averaged at each location, and 10 vertices were averaged for lines and polygons.

Weeds were mapped as points, lines or polygons. Linear features were mapped as lines and assigned a buffer width to estimate area. Irregularly shaped features greater than approximately 900 square meters (30m x 30m) 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, infestations 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 keep track of 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 2011 NAIP digital orthophoto quad for reference. Attributes were collected using customized field forms, designed to minimize user error by maximizing look-up tables and field auto-population techniques. One free text field was maintained to document any observations deemed important, such as nearby significant species or difficulties incurred in a specific area (e.g., dense oak thickets affecting the ability to map features or estimate individuals). The field botanist 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 based on the assigned density and the size of the infestation.

Weed data were stored in a master geodatabase in ArcGIS v10.2 (ESRI 1999-2015). 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

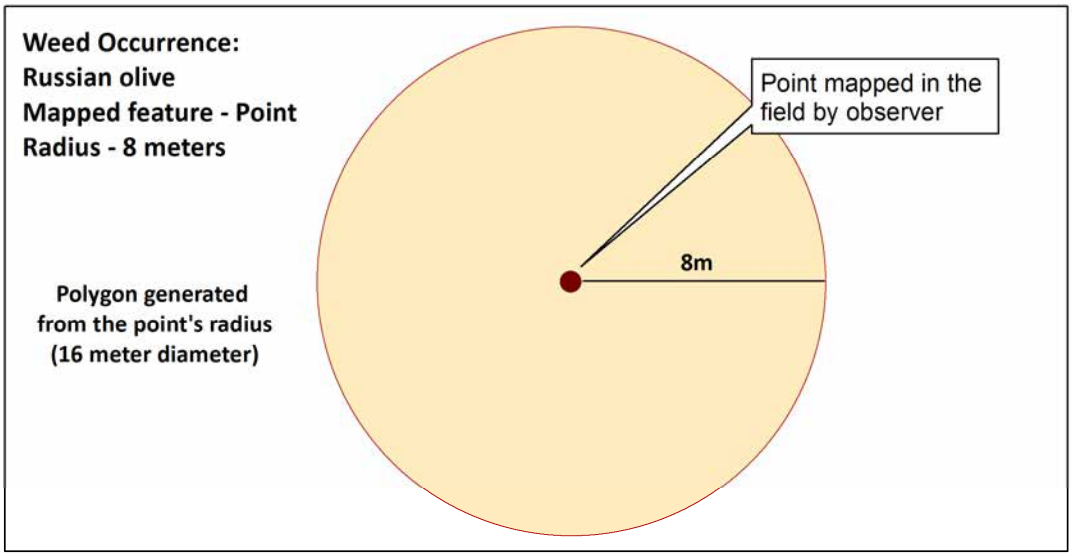
COUNTRY - Country

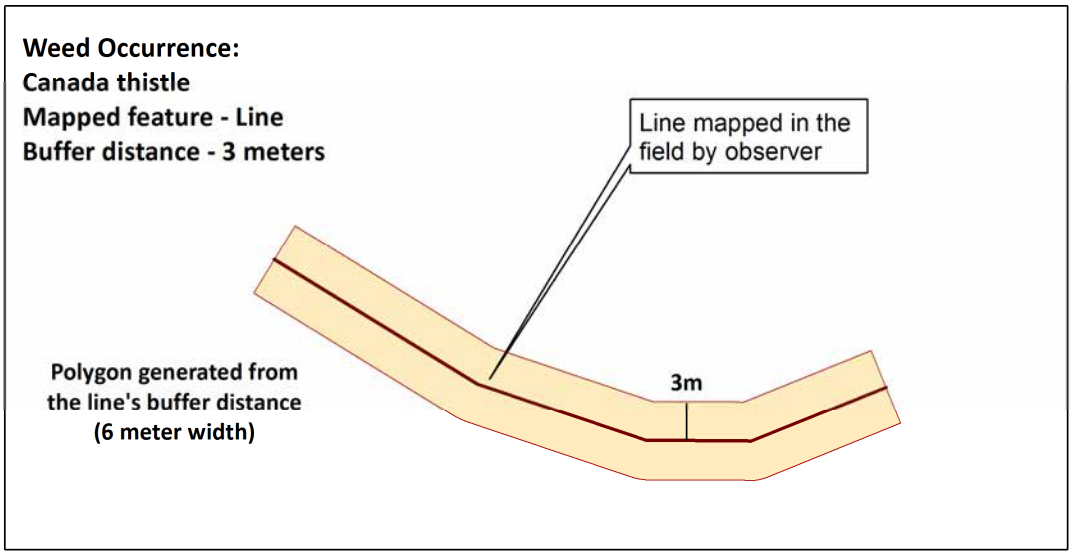
EXAMINER –Field observer

MAPAGENCY – Mapping agency

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

Buffered points and lines were converted to polygons in the final weed geodatabase. See examples below.





APPENDIX D. ALL MAPPED WEEDS IN 2015 IN COMPARISON TO 2009-2014

Metric	Year	*Acroptilon repens*	*Cynoglossum officinale*	*Euphorbia myrsinites*	*Galium verum*	*Hesperis matronalis*	*Hypericum perforatum*	*Linaria dalmatica spp. dalmatica*	*Lonicera tatarica*	*Onopordum acanthium*	*Saponaria officinalis*	*Tamarix ramosissima*
# of Extant Features	2009	2	8	12	NA	NA	21	1	?	50	?	2
	2010	0	1	10	1	NA	20	2	?	61	?	0
	2011	0	2	12	1	NA	26	0	?	39	?	1
	2012	10	3	10	0	14	29	0	1	66	?	1
	2013	0	7	19	0	?	22	1	5	48	8	1
	2014	0	8	7	0	?	33	1	5	74	2	1
	2015	0	22	14	1	2	27	0	9	157	8	4
# of Erad. Features	2009	2	0	6	NA	NA	2	0	?	34	?	3
	2010	4	6	12	0	NA	6	1	?	30	?	5
	2011	4	6	16	0	NA	5	3	?	56	?	4
	2012	4	9	25	1	0	10	3	0	73	?	4
	2013	12	8	12	1	?	21	3	0	85	0	5
	2014	11	8	27	1	?	19	3	2	81	6	6
	2015	12	11	26	0	14	29	4	1	76	5	5
# of Shoots	2009	?	95	464	NA	NA	95,883	10	?	1,710	?	2
	2010	0	11	56	700	NA	82,733	107	?	669	?	0
	2011	0	21	57	1	NA	87,128	0	?	293	?	1
	2012	543	70	113	0	16,871	83,115	0	30	889	?	1
	2013	0	48	129	0	?	2,621	12	38	970	42,092	1
	2014	0	102	179	0	?	3,604	7	31	1,224	42	1
	2015	0	534	173	10	280	3,102	0	48	1,629	608	6

Metric	Year	*Acroptilon repens*	*Cynoglossum officinale*	*Euphorbia myrsinites*	*Galium verum*	*Hesperis matronalis*	*Hypericum perforatum*	*Linaria dalmatica spp. dalmatica*	*Lonicera tatarica*	*Onopordum acanthium*	*Saponaria officinalis*	*Tamarix ramosissima*
Occ. Acres	2009	?	0.09	2.4	NA	NA	2.02	?	?	3.47	?	<0.01
	2010	0	0.02	0.5	0.01	NA	1.47	0.50	?	0.66	?	0
	2011	0	< 0.01	0.25	<0.01	NA	1.44	0	?	0.64	?	<0.01
	2012	0.05	0.01	0.23	0	0.83	1.16	0	0.15	0.3	?	<0.01
	2013	0	0.05	?	0	?	0.85	?	0.18	?	0.50	<0.01
	2014	0	0.04	0.7	0	?	1.12	<.01	0.21	0.84	0.14	<0.01
	2015	0	0.20	1.04	<0.01	0.08	1.27	0	0.40	1.60	0.09	0.03