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

Year 10

March 2015

NATURAL HERITAGE PROGRAM

COLORADO

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

Year 10

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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: Academy landscape view looking west P. Smith 2014; Middle: Musk thistle flower, CNHP, Bottom; Survey monitoring plot 2014 P. Smith.

EXECUTIVE SUMMARY

This report includes a summary of the results of the past ten years of population monitoring of targeted noxious weeds at the U.S. Air force Academy ("the Academy"), emphasizing changes that were observed between 2013 and 2014.

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 while the 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 2013 and 2014, 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*), dames rocket (*Hesperis matronalis;* mapped too late in 2014), common St. Johnswort (*Hypericum perforatum*), Dalmatian toadflax (*Linaria dalmatica* ssp. *dalmatic*), Tatarian honeysuckle (*Lonicera tatarica*), Scotch thistle (*Onopordum acanthium*), bouncingbet (*Saponaria officinalis*), and tamarisk (*Tamarix ramosissima*). Species with permanent plots include: whitetop (*Cardaria draba*; not updated in 2014), Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*; photo monitoring), diffuse and spotted knapweeds (*Centaurea diffusa* and *C. maculosa*), and leafy spurge (*Euphorbia esula*).

Summary data is provided below by individual species. Monitoring was not conducted at Farish in 2013 or 2014.

Summary of Findings:

- **Russian knapweed (*Acroptilon repens*):** In 2014, all the sites were visited and no confirmed occurrences were observed. A seedling that could be *Acroptilon repens* or *Centaurea* sp. was flagged.
- **Whitetop (*Cardaria draba*)**: In 2014, the plots were not sampled because the field season did not start until August. In 2013, seven plots were monitored. There was negligible spread of the plants but there was an increase in cover and density detected. A priority in 2015 will be to monitor these seven plots, and to add three more.
- **Musk thistle (*Carduus nutans*)**: In 2014, photo plot sampling showed a stable population.
- **Diffuse and spotted knapweeds (*Centaurea maculosa, C. diffusa*):** In 2014, 10 permanent plots were measured and knapweed populations are decreasing. The two Texas A&M biocontrol plots were discontinued after 2013. We suggest monitoring the biocontrol plots in 2015.
- **Canada thistle (*Cirsium arvense*)**: Eight permanent plots were measured in 2014. The results show decreases in the populations. The two Texas A&M biocontrol plots were discontinued after 2013. We suggest monitoring the biocontrol plots in 2015.
- **Houndstongue (*Cynoglossum officinale*)**: Areal survey is used to monitor this species. In 2014, a slight overall increase was noted with an increase in the number of shoots yet a

decrease in the area covered. One additional extant feature was recorded, but no new locations were discovered.

- **Leafy spurge (*Euphorbia esula*)**: Ten permanent plots were monitored in 2012-2014. In 2014, the populations were found to be stable to slightly decreasing in the permanent plots. The two Texas A&M biocontrol plots were discontinued after 2013.
- **Myrtle spurge (*Euphorbia myrsinites*)**: Thirty-four sites were visited in 2014 of which seven sites were extant. This data shows an overall increase from 2013, with more shoots and larger acreage but fewer extant features.
- **Yellow spring bedstraw (*Galium verum*)**: A single site was discovered in 2010 and appears to be eradicated as no new plants have been observed in 2012-2014. This is a good example of an early detection-rapid response model working well.
- **Dames rocket (*Hesperis matronalis*)**: This species was reported in 2012 at the Academy. It was visited in 2014 but too late in the season to collect reliable metrics and needs to be revisited in 2015.
- **Common St. Johnswort (*Hypericum perforatum*):** The overall trend has been downward since 2007, but in 2014 there was a slight increase in the number of shoots, area covered and 11 new sites.
- **Dalmatian toadflax (*Linaria dalmatica* ssp. *dalmatica*):** In 2014, seven individuals were observed at one extant feature where plants were treated in 2013. Overall, this represents a slight increase in the population and demonstrates the need for continued monitoring even after a couple of years.
- **Tatarian honeysuckle (*Lonicera tatarica*):** In 2014, five extant features were mapped and represented no change from 2013. Two of the locations identified in 2013 were eradicated, but two new extant features were discovered. There was a decrease in the number of individuals but an increase in occupied area resulting in a slight upward trend.
- **Scotch thistle (*Onopordum acanthium*):** 155 sites were visited in 2014, 74 were extant. From 2013 to 2014, there was an increase in extant features, occupied area and number of plants. There has been a steady increase since 2011.
- **Bounding bet (*Saponaria officinalis*):** Three distinct areas were visited in 2014. Portions of the original 2002 infestation are still extant, while no plants were observed at the two areas discovered in 2013. This represents a decrease from 2013 which had extant features at all three areas.
- **Tamarisk (*Tamarix ramosissima*):** One new site discovered in 2014 by AFA staff. The population is considered stable. A new plant is being discovered in a different location almost yearly.

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. CNHP botanists Katie Miller and Pam Smith worked tirelessly in the field to update the weed data. The work of Gerry Michels (Texas A&M) and his colleagues, especially Erin Parks, has also been valuable for this project. Tass Kelso and George Meantz generously provided the best bed and breakfast in Colorado Springs and endless thought provoking conversations about weeds over dinners and libations.

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INTRODUCTION

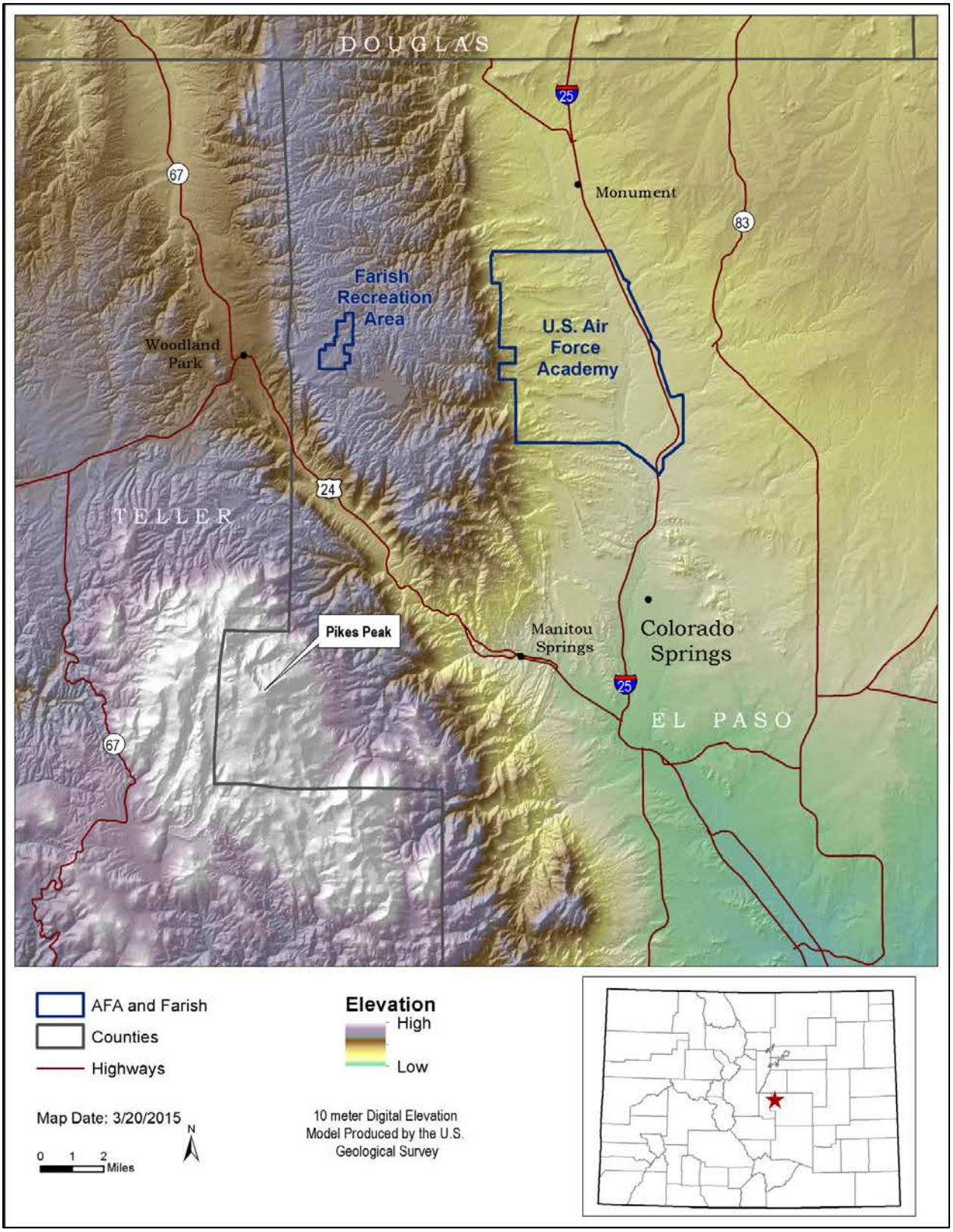
Many local governments now require public and private landowners to manage noxious weeds. The U.S. Air Force Academy (referred to herein as "the Academy") must conform to state (Department of Agriculture) and County (El Paso County) weed control regulations for noxious weeds (Code of Colorado Regulations 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 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 management. Natural areas can be defined as non-crop areas that contain native vegetation where the management includes the protection of these areas as well as to generate ecosystem services (Pearson & Ortega 2009). To successfully manage weeds in natural areas that contain a great variety of species is much more complex than in an agricultural area. Weed management in natural areas must also consider the management of the entire community and not just removal of individual weeds to be successful. A large extent of the landscape at the Academy would fall into the "natural areas" category which 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. 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 2008). The areas that support these elements must be considered in weed treatment strategies (Smith et al. 2015).

The Colorado Natural Heritage Program has been monitoring noxious weeds at the Academy for 10 years. The following report provides the results of the monitoring program.



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

This report represents the tenth year of surveys, sampling, and data analysis conducted by CNHP. 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, significant drought conditions suppressed the distribution of these two species. In 2003, populations exploded 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 report occurrences of myrtle spurge (*Euphorbia myrsinites*), an A List noxious weed. It is 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 was completed of the Academy and Farish with a total of 17 mapped species (Anderson and Lavender 2008a) which included three additional weed species not on the original weed 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 results of previous survey work (year 4 results) were presented with suggested modifications for future work (Anderson 2009). The recommendations from the year 4 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 was generated for spotted knapweed.
- **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 used, diffuse knapweed and whitetop (*Cardaria draba*) were not monitored. Begin annual mapping of Tatarian honeysuckle.
- **2012:** Collaboration with United States Fish & Wildlife Service (USFWS) and Texas A&M Agrilife Research Biocontrol Program resulted in: 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 perfoliatum*) monitoring plots; 3) biocontrol plots (Texas A&M) for Canada thistle (*Cirsium arvense*) and diffuse knapweed (*Centaurea diffusa*) are 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 AFA and Farish was completed mapping 22 weed species and an estimated 39% increase in area occupied (Rondeau and Lavender 2013).

- **2013:** Monitoring as in 2012, except Farish was not visited, and Canada thistle and dames rocket were not monitored. Diffuse knapweed and spotted knapweed hybridization was widespread. The two species (*Centaurea maculosa, C. diffusa* and hybrid forms) were lumped together for plot results.
- **2014:** Monitoring as in 2013, except that whitetop (*Cardaria draba*) plots were not visited and Canada thistle plots were visited. Dames rocket was mapped too late in the season. Whitetop and dames rocket are priorities in 2015.

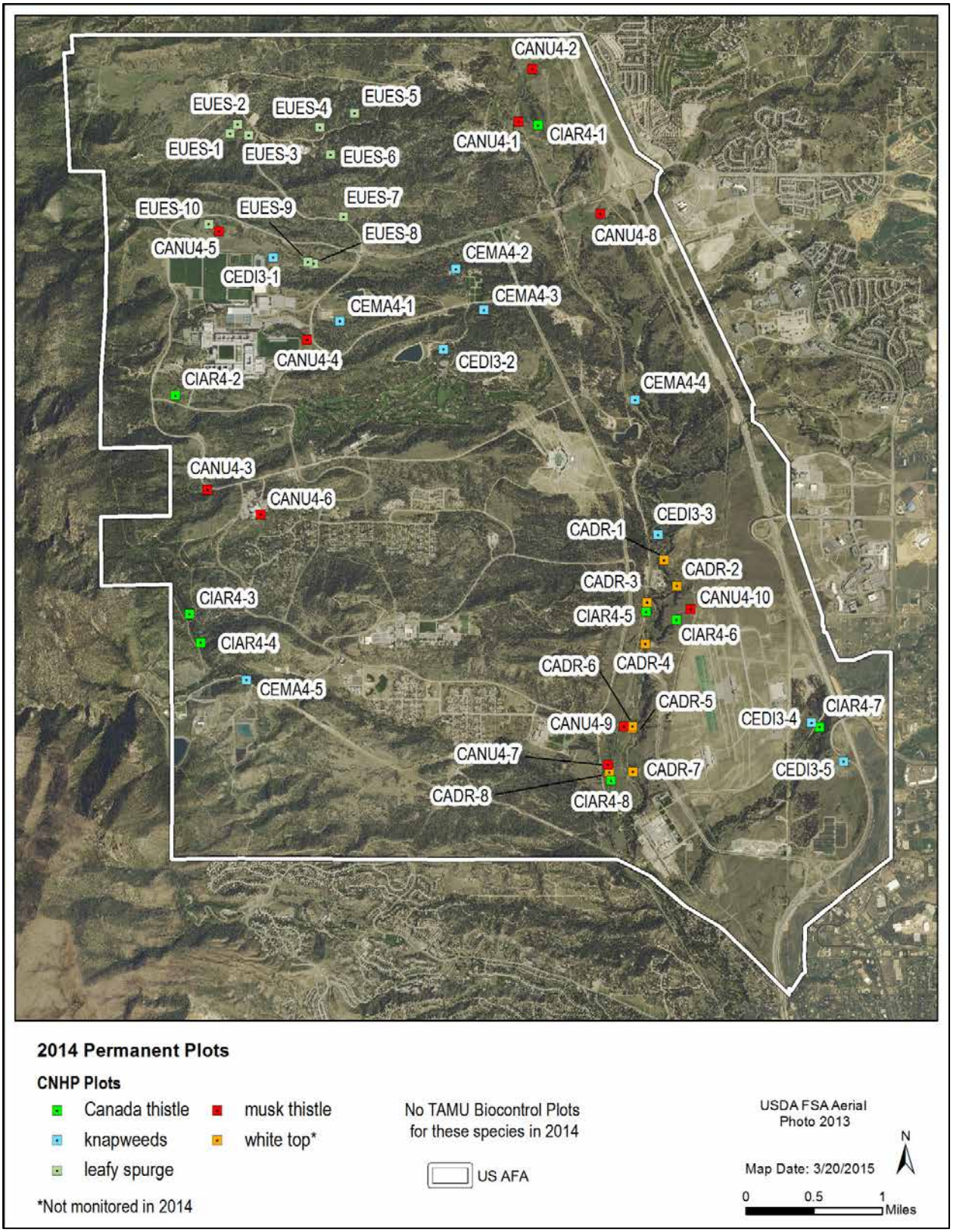
Methods

This project was undertaken 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 trend. The recommendations for the design and deployment of monitoring plots offered by Carpenter et al. (2004) were originally adhered to and subsequently modified as new information was collected. In 2012-2014, combinations of transect sampling, photoplots, and perimeter mapping and census were utilized in monitoring the 16 target noxious weed species (Table 1). Permanent plot locations are presented in Map 2. In order to closely align with the Texas A&M AgriLife biocontrol, we established 36 permanent plots utilizing the same methods as Michels et al. (2013) for: *Cardaria draba* (7), *Centaurea diffusa* (5), *C.maculosa* (5), *Cirsium arvense* (8) and *Euphorbia esula* (10). We randomly selected the plots, utilizing 2007 weed mapping data (Anderson and Lavender 2008a). Details for the methods used for collecting 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 *Cirsium arvense* and in 2014 we resampled all but *Cardaria draba*. Collecting data in subsequent years will allow us to analyze trend and treatment data.

Table 1. Summary of methods used for monitoring by CNHP in 2012-2014.

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

The 2013-2014 water year annual precipitation was 8% below average, however spring and summer precipitation were near average (Fig. 1). The annual average precipitation for the area is 16.3 inches (1961-1990). 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. Recent treatment areas at the Academy (2013) are depicted in Map 3 along with the location of the 2012 and 2013 biocontrol plots.

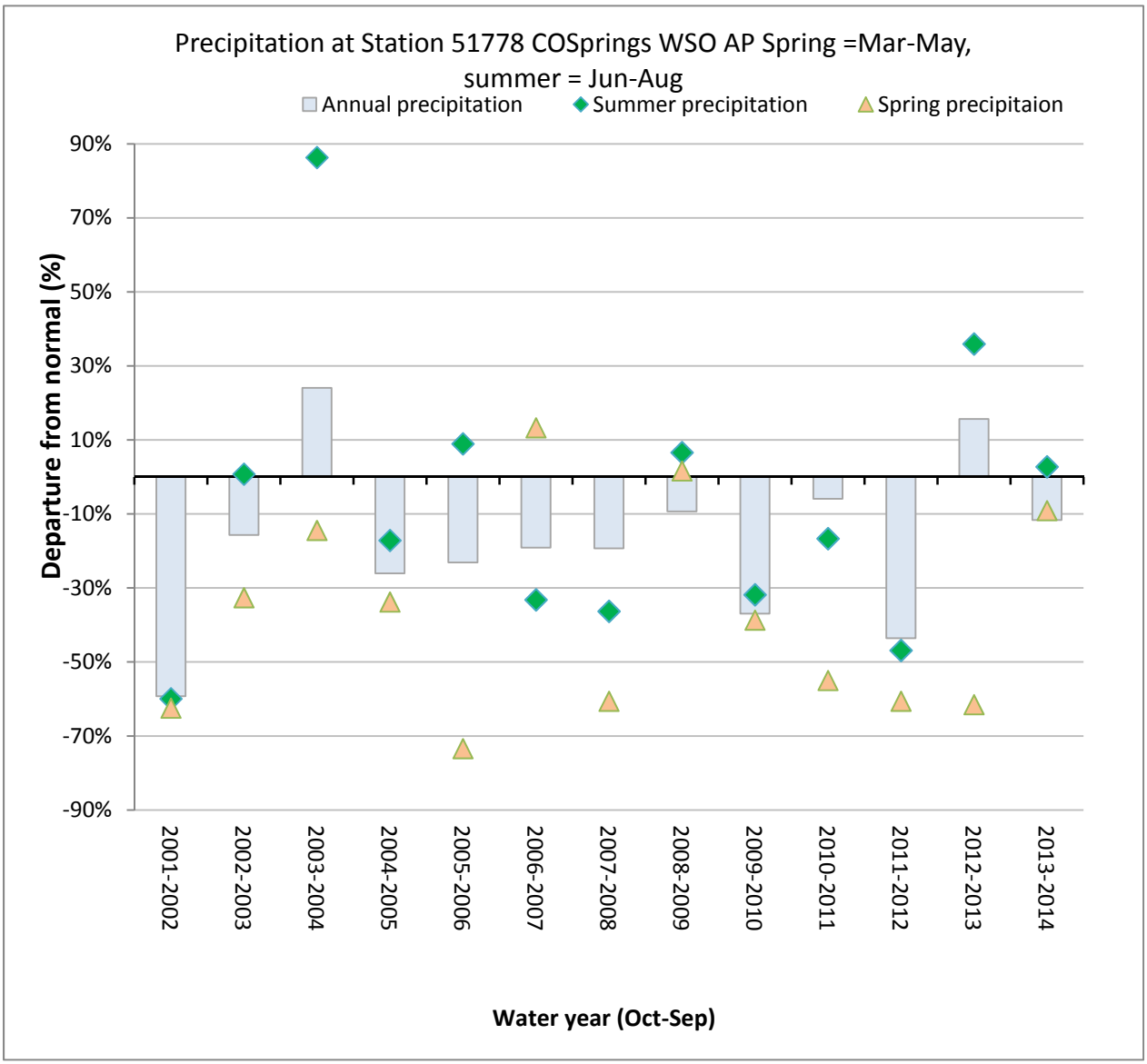
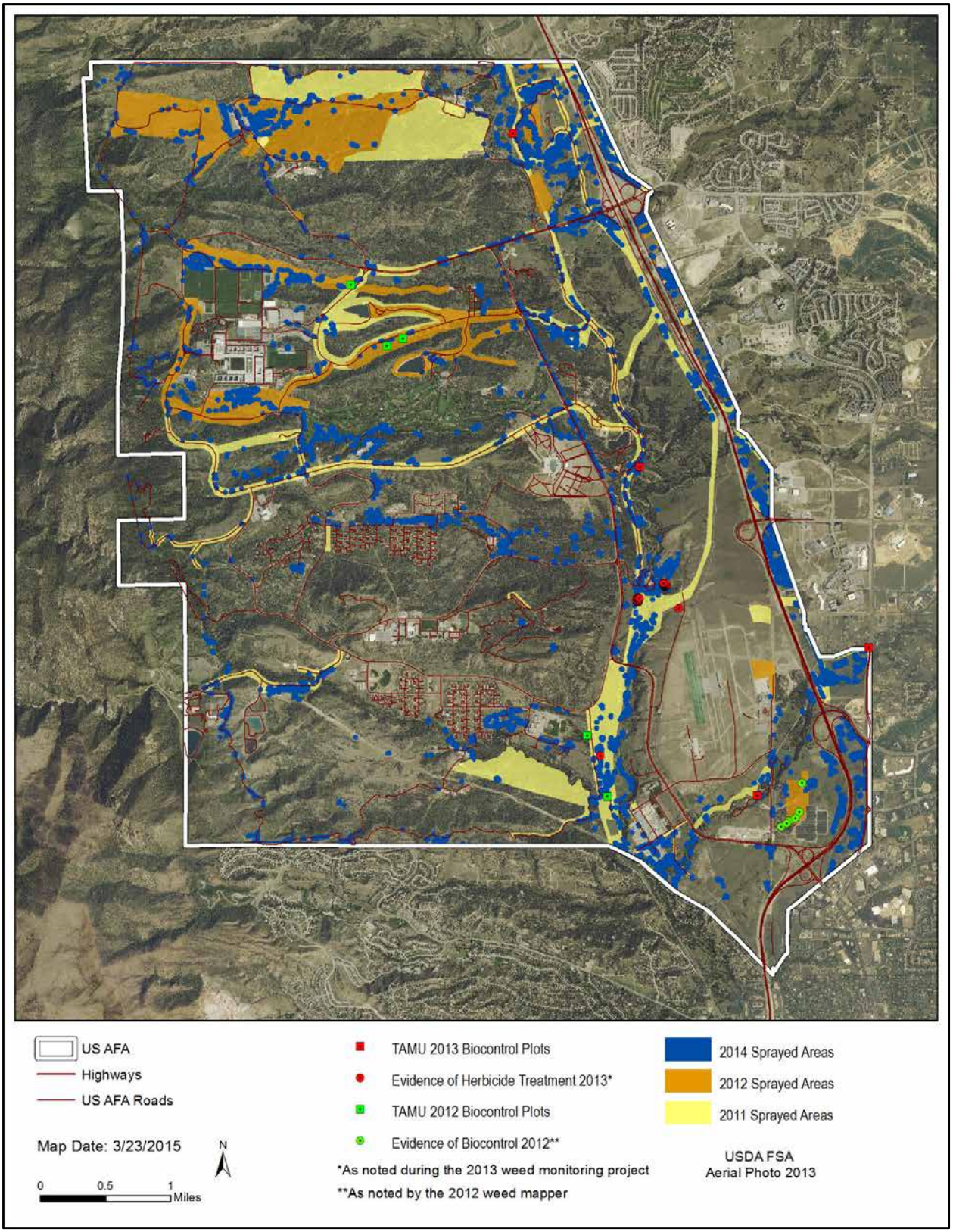


Figure 1. Summary data for annual precipitation by water year (October-September) at Colorado Springs, Colorado from 2002 through 2014 (Western Regional Climate Center 2014). Average annual precipitation (1961-1990) is 16.3 inches. Spring = March-May, Summer = June-August



Map 3. Recent treatment areas at the Academy.

Russian Knapweed (*Acroptilon repens*)

A small seeding with questionable ID was noted. This could be *Acroptilon repens* or *Centaurea* sp. Site was flagged and should be revisited immediately. Most of the new sites documented in 2012 have been successfully treated.

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).

2014 Results

All known sites were revisited in 2014 and no confirmed Russian knapweed plants were documented. One site had a small seedling that was too young to identify and appeared to be either *Acroptilon repens* or *Centaurea* sp. Between 2007 and 2014 the number of extant features and the number of individuals of Russian knapweed have fluctuated (Table 2, Figure 2 and Map 4).

Table2. Russian knapweed summary data, 2004-2014.

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

*ID is not confirmed only small basal leaves present (either *Centaurea* sp. or *Acroptilon repens*)

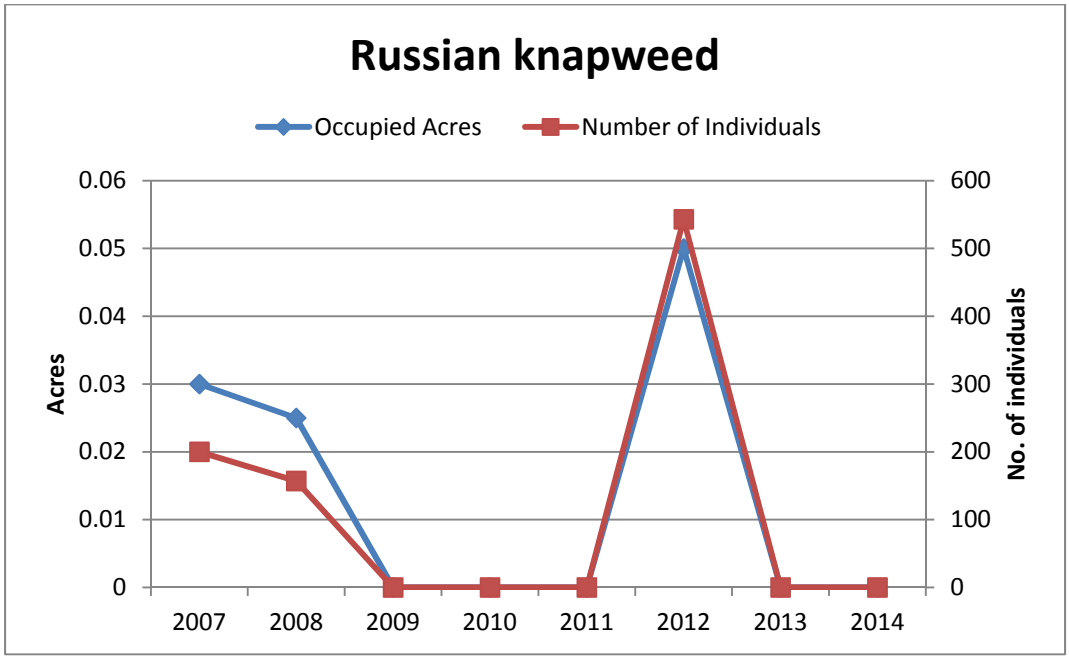
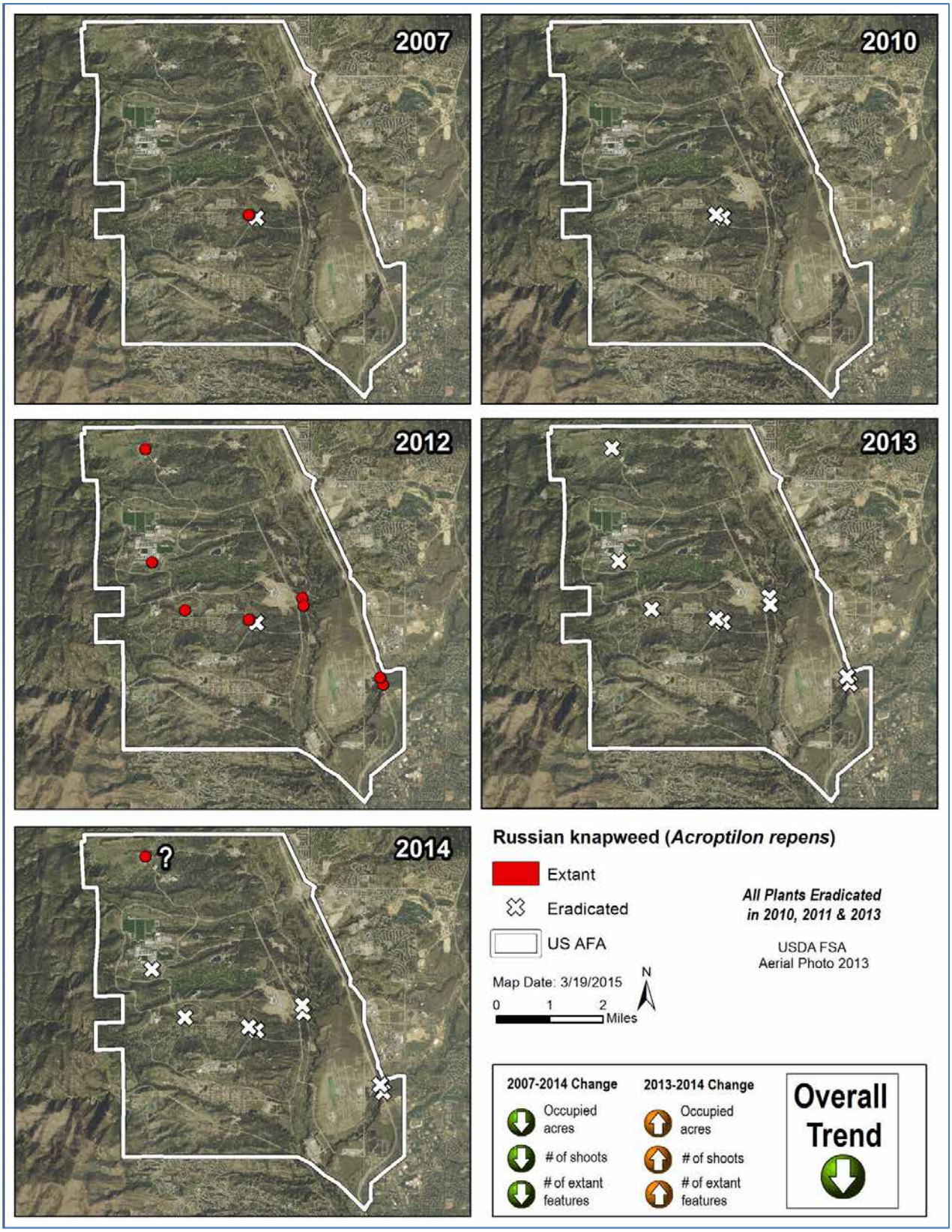


Figure 2. Russian knapweed trend, 2007-2014.

History of Sampling and Treatments:

- The first appearance of Russian knapweed was in 2004 and by 2007 there were two extant occurrences and 2 eradicated occurrences, all near Douglass Way (Map 4). By 2009, all of these occurrences were eradicated (Rondeau and Lavender 2012) and have not 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 (Map 4, Table 3 and Figure 2) 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 3).
- In 2013 all extant locations were treated (0.05 acres), and no live plants were observed in 2013 (Table 3 and Figure 2).



Map 4. Distribution of Russian knapweed at the Academy between 2007 and 2014.

Whitetop (*Cardaria draba*)

Not monitored in 2014. Monitoring in 2013 showed a slight increase in density and cover.

AFA Management Goals: Containment through chemical and mechanical treatments of large infestations 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

2014 Results

The known sites were not monitored in 2014 but are a priority for 2015. The populations were relatively stable between 2012 and 2013 (Table 3). The distribution remained steady and had not spread into new areas but there were increases in density and cover.

Table 3. Summary of whitetop permanent plots, 2012-2014.

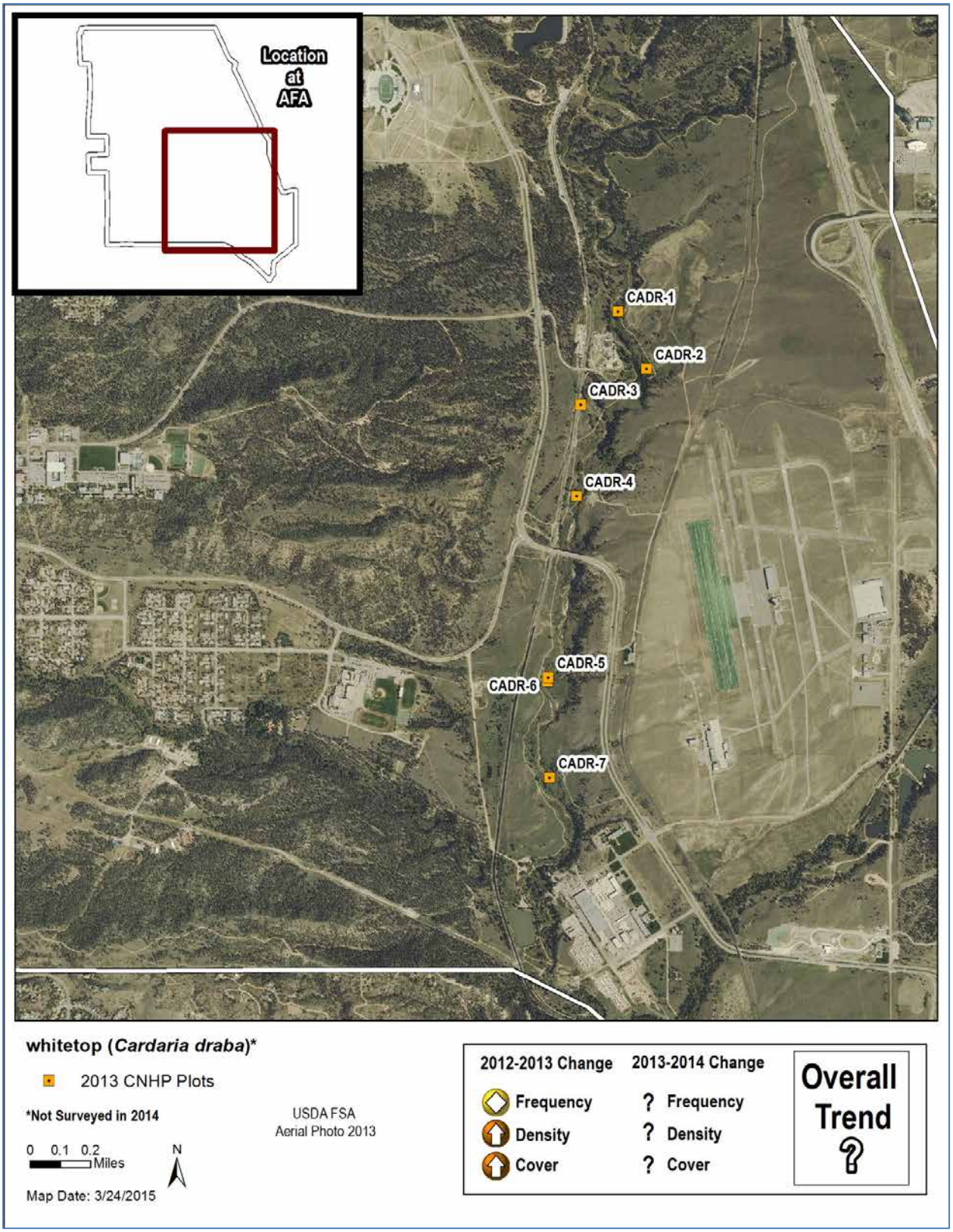
Permanent Plot Sampling Method					
Year	*Number of Plots Sampled*	*# Quadrats Sampled*	*# Shoots*	*AVG Height (cm)*	*Comments AVG# plants/plot*
2012	9	558	243	24.9	27/plot
2013	7	428	213	21.2	30/plot (2 of 7 plots treated)
2014	Not Sampled				

History of Sampling and Treatment:

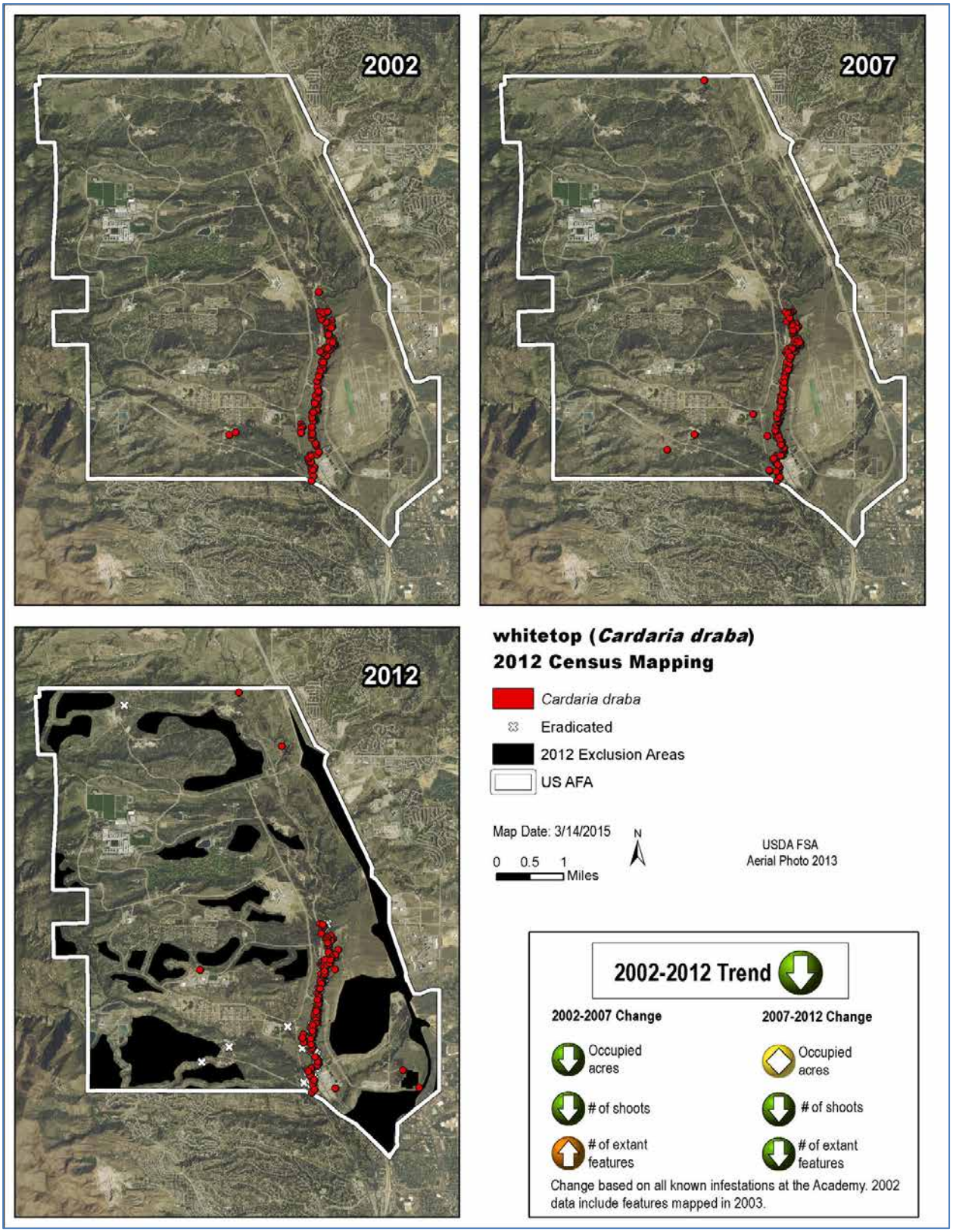
- 2007 - The first observed occurrence of whitetop. Specific details of sampling and treatment for 2004-2007 are in Anderson and Lavender (2008b).
- Due to the large number of mapped locations at AFA (Lavender and Rondeau 2013) we chose to monitor whitetop by randomly selecting sites from the 2007 dataset.
- In 2012, we randomly chose 8 sites that were known to have whitetop in 2007, and established 8 permanent plots (Map 5). We recorded density, cover, frequency, and height.
- In 2013 we re-sampled 7 of the 8 plots as one of the 2012 plots was not adequately marked and re-sampling was impossible. See Table 4 for summary data from each plot.
- The number of quadrats/plot (Frequency) that had whitetop present was stable between 2012 and 2013, with the overall average at 31 and 30, respectively (50% frequency; Table 4). We can infer that whitetop distribution remained steady and did not significantly spread into new areas.
- The average number of shoots/quadrat (Density) significantly increased from 2012 to 2013 from 12 to 15 shoots respectively (P= 0.007, one-tailed paired t-test). CADR-4 and CADR-6 were stable while all of the other plots increased. CADR-7 and CADR-2 had the largest increases (Table 4).
- The average cover of whitetop significantly increased from 2012 to 2013 from 4.8% to 7.5% respectively (P=0.037; one-tailed paired t-test). CADR-6 was the only plot that effectively remained stable. As with the density measure, CADR-7 increased more than any other plot, from 10.5% to 20% (Table 4).

Table 4. Whitetop detailed plot data, 2012-2013. *Treatment in 2013 (bolded and shaded) had little impact on data collection as it was applied just prior to sampling.

Permanent Plot Sampling Method						
Plot Name	*AVG Density 2012*	*AVG Density 2013*	*AVG Cover (%) 2012*	*AVG Cover (%) 2013*	*Quadrats with plants (%) 2012*	*Quadrats with plants (%) 2013*
CADR-1	27	30	12	13	81	82
CADR-2	7	**11**	6	**9**	65	**67**
CADR-3	1	**3**	0	**1**	21	**26**
CADR-4	7	8	2	5	52	50
CADR-5	9	12	2	3	37	39
CADR-6	5	4	1	1	26	26
CADR-7	31	37	11	20	65	61
AVG	**12**	**15**	**5**	**7**	**49**	**50**
SD	**12**	**13**	**5**	**7**	**22**	**21**



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*)

Number of plants observed at plots in 2014 slightly increased from 2013, but frequency decreased. Since 2008 there has been a significant downward trend.

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 – May.
- Plants die after seed set (CSU 2013a).
- Plants are impacted by drought.
- Seed longevity: 10 years (CCR 2014)

2014 Results

In 2014, 62 plants were observed which was very similar to the count observed in 2013 of 56. Frequency decreased in 2014. Two of the sampling plots were treated with herbicide in 2014 (Table 5). Herbicide spot treatments also observed on a non-target native plant: *Scrophularia lanceolata* at photo plot 2.

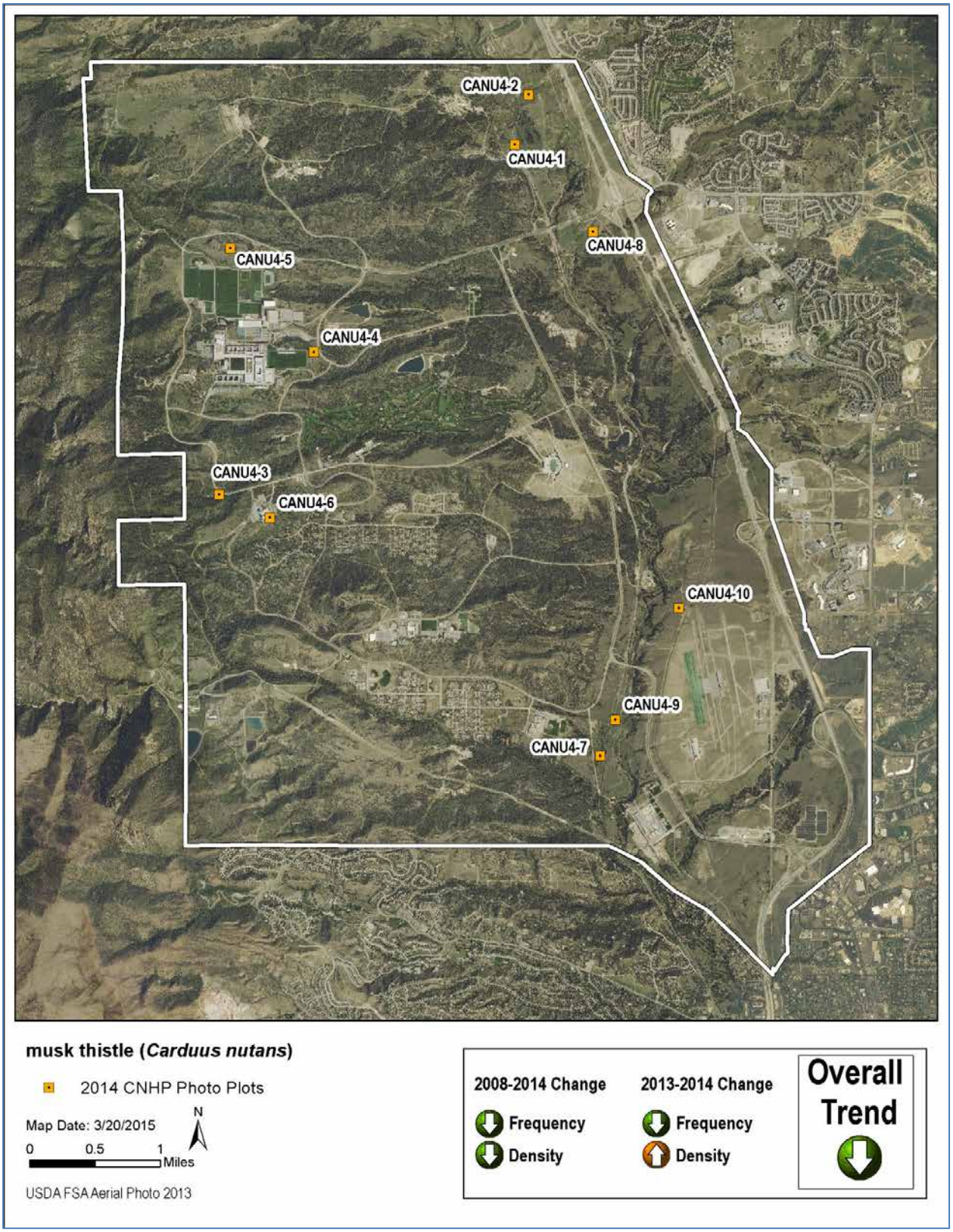
Table 5. Musk thistle population size at photo plots, 2008-2014. Bolded indicates plots that appear to have been treated.

Permanent Photo Plot Sampling Method							
Plot	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***
1	11	134	**9**	**7**	x	**7**	**40**
2	**6**	80	**5**	**160**	X?	0	**x***
3	**1**	**2**	**1**	**8**	--	1	0
4	1	63	**0**	**0**	--	0	0
5	1	27	**10**	0	--	6	**17**
6	**10**	45	**33**	3	--	2	4
7	**102**	**90**	**25**	**0**	x	**5**	0
8	212	**31**	**10**	**7**	--	7	0
9	160	**1**	**1**	**0**	--	0	0
10	500	--	**40+**	400	x	**28**	0
SUM	***1004***	***473***	***123***	***585***	***--***	***56***	***62***
Mar-June precipitation Diff from avg (inches)	***-4.28***	***0.78***	***-3.52***	***-4.25***		***-4.24***	***-1.43***

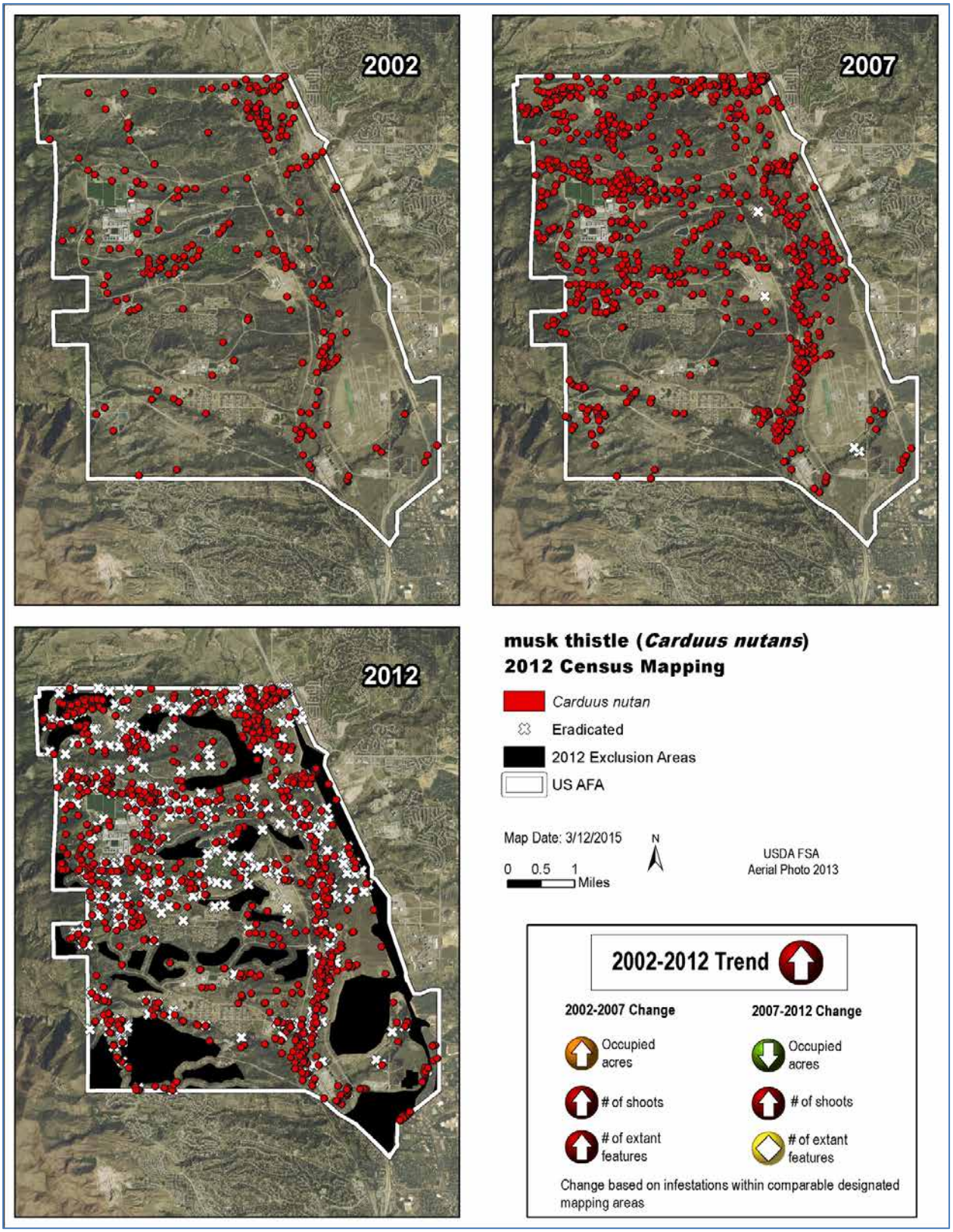
X* – treated *Scrophularia lanceolata* 2014

History of Sampling and Treatment:

- All ten plots were visited in 2008-2014 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 5).
- Precipitation patterns do not explain the decrease in plants noted. Musk thistle seeds require adequate surface soil moisture to germinate. In drought years, musk thistle may germinate, but will probably fail to survive due to lack of soil moisture in the 0-30 cm layer of the soil (Beck 1999 and Han 2012).



Map 7. 2014 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)

Plots show a decrease in all metrics.

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)

2014 Results

The average number of plants per plot in the 10 CNHP permanent plots decreased between 2012 and 2014, from 9 to 6 plants per plot. The biocontrol permanent plots also showed a decrease between 2012-2013, from 17 to 14 plants per plot (Table 6). Since the biocontrol plots were treated with herbicides in 2014, they were not monitored by Texas A&M (Michels et al. 2014).

Table 6. Summary of knapweed non-biocontrol and biocontrol permanent plots, 2012-2014.

Non-Biocontrol Permanent Plot Sampling Method					
Year	*Number of Plots Sampled*	*# Quadrats Sampled*	*# Shoots*	*AVG Height (cm)*	*AVG# Shoots/Plot*
2012	10	560	87	25.9	9/plot
2013	10	551	33	30.2	3/plot
2014	10	559	59	37.4	6/plot
Biocontrol Permanent Plot Sampling Method					
2012	4	163	51	34.0	17/plot
2013	3	114	41	33.7	14/plot
2014	Discontinued – herbicide application				

Trend. Treated and non-treated areas were similar with an overall stable trend. Four plots had an increasing trend of which one (CEDI3-5) had been treated with herbicide in 2015. This plot was only sprayed on the west side of the fence and while the area treated was weed free, the untreated area east of the fence had an increase in all of the metrics (Figure 3). Three plots remained stable, of which one (CEDI3-1) had been treated in 2012 and 2014. Three plots decreased of which one had been treated and two untreated. Plot CEDI3-1 is an interesting plot that clearly shows that spraying works but that incomplete spraying can still allow the population to increase.

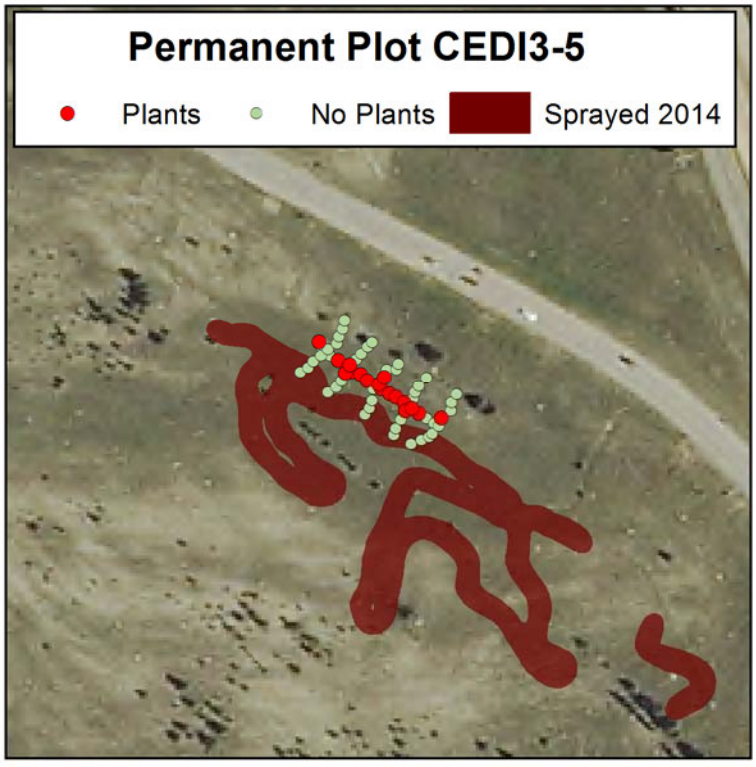


Figure 3. Incomplete spraying around plot CEDI3-5.

Frequency, or percent of quadrats with the plant present, is the best indicator of an expanding or contracting population. Density provides the average number of stems arising from the ground and cover describes how much area is occupied. While all of three metrics are susceptible to precipitation patterns, the least sensitive metric is frequency. The other two metrics, density and average cover, are more likely to be strongly correlated with annual precipitation values. We present all three metrics in Table 7 and graphically depict frequency in Figure 4.

Table 7. Knapweeds detailed plot data, 2012-2014. Proportion of quadrats (frequency) with knapweeds present and average density (plants/0.5m^2) and canopy cover. Bolded numbers indicate that the site was treated with herbicide. Colors indicate trend: red is an increase (I), orange is moderate increase (MI), yellow is stable (S), and green is a decrease (D). Change may vary due to rounding.

Plot Name	Quad w/ plant 2012	Quad w/ plant 2013	Quad w/ plant 2014	2012-2014 Change	Avg Dens 2012	Avg Dens 2013	Avg Dens 2014	Avg Cover (%) 2012	Avg Cover (%) 2013	Avg Cover (%) 2014	Overall Trend
CEDI3-1	**9%**	0%	2%	-7%	**0**	0.0	**0.03**	0.3	0.0	**0.4**	S?
CEDI3-2	**21%**	3%	6%	-15%	**1**	0.3	0.5	2.7	0.1	0.7	D
CEDI3-3	14%	7%	13%	-2%	0	0.3	0.5	1.4	0.5	3.8	MI
CEDI3-4	11%	21%	15%	5%	0	0.4	0.5	1.3	1.6	3.1	MI
CEDI3-5	14%	15%	**31%**	16%	1	0.6	**1.4**	3.3	2.3	**16.5**	I
CEMA4-1	23%	7%	27%	5%	2	0.1	1.0	1.7	0.3	5.3	MI
CEMA4-2	27%	0%	2%	-25%	2	0.0	0.05	2.2	0.0	0.4	D
CEMA4-3	3%	2%	2%	-2%	0	0.0	0.016	0.1	0.0	0.016	S
CEMA4-4	26%	8%	6%	-21%	2	1.3	0.4	6.2	1.3	1.1	D
CEMA4-5	2%	2%	0%	-2%	0	0.2	0.0	0.6	0.6	0.0	S
SK ploop3	**31%**				1			**4.4**			
SK ploop1	**37%**				**1**			**4.1**			
SK monck	**24%**	**43%**			**1**	**1.0**		**5.9**	**3.5**		
DK railroad	**56%**	**21%**			**3**	**0.4**		**16.0**	**1.7**		
DK hwy83		**100%**				**4.8**			**54.5**		
AVG	**21%**	**18%**	**10%**	**-5%**	**1.0**	**0.7**	**0.4**	**3.6**	**5.1**	**3.1**	D

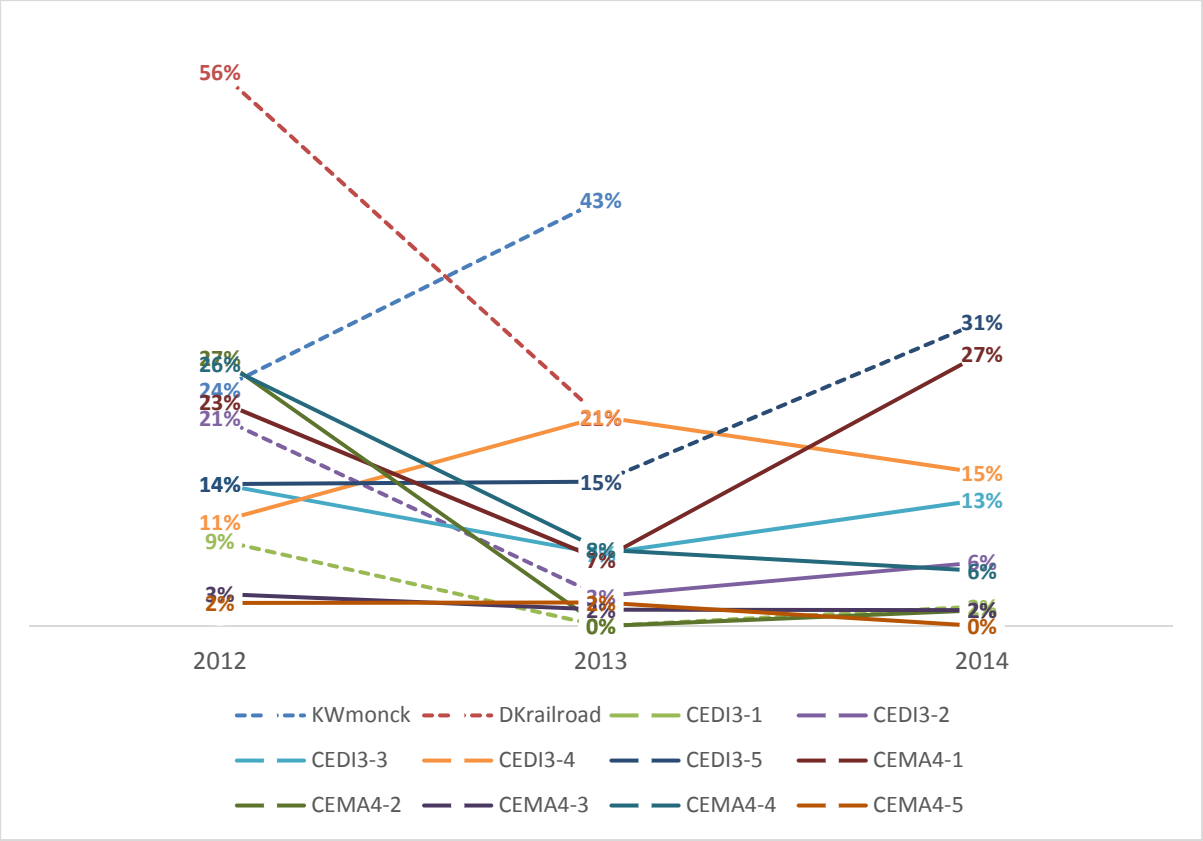
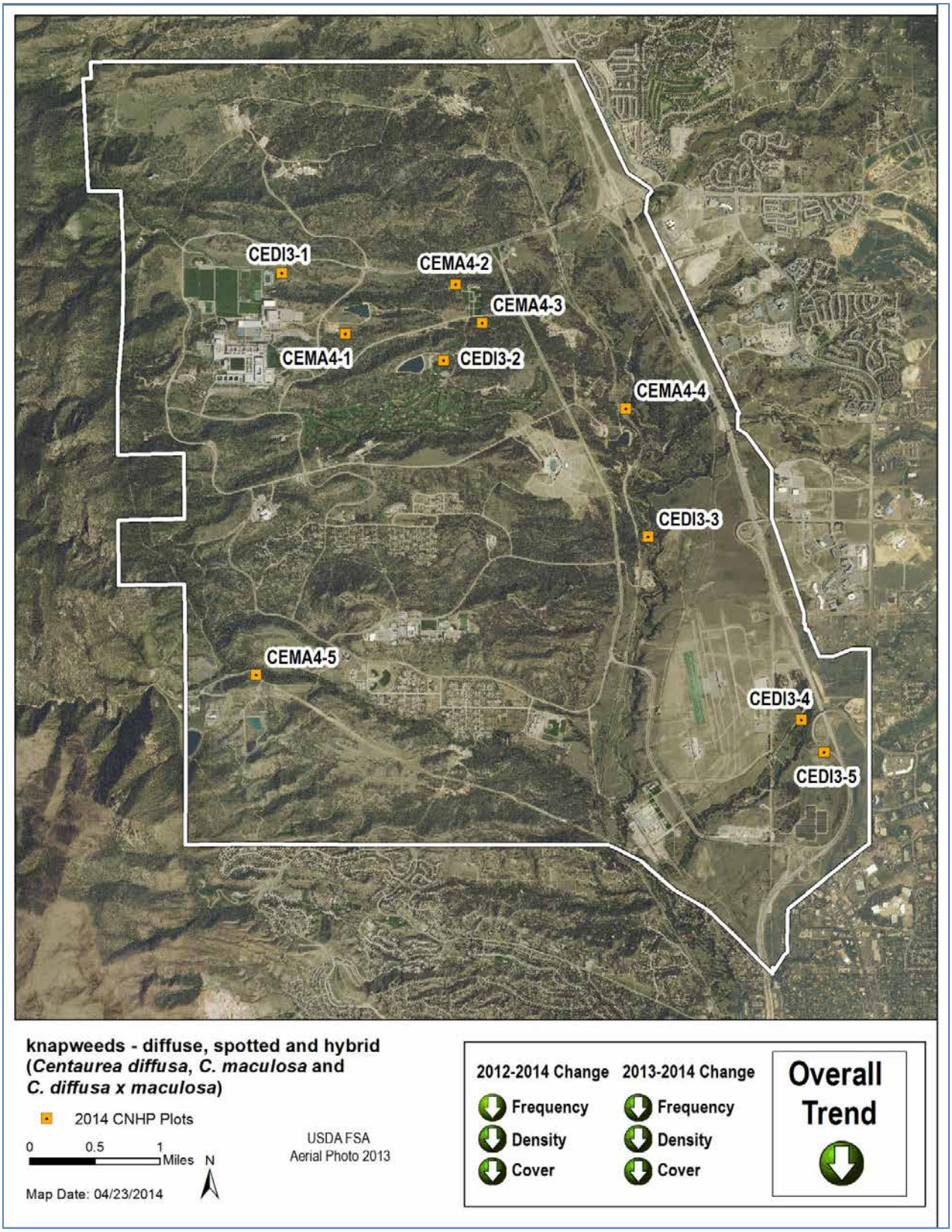


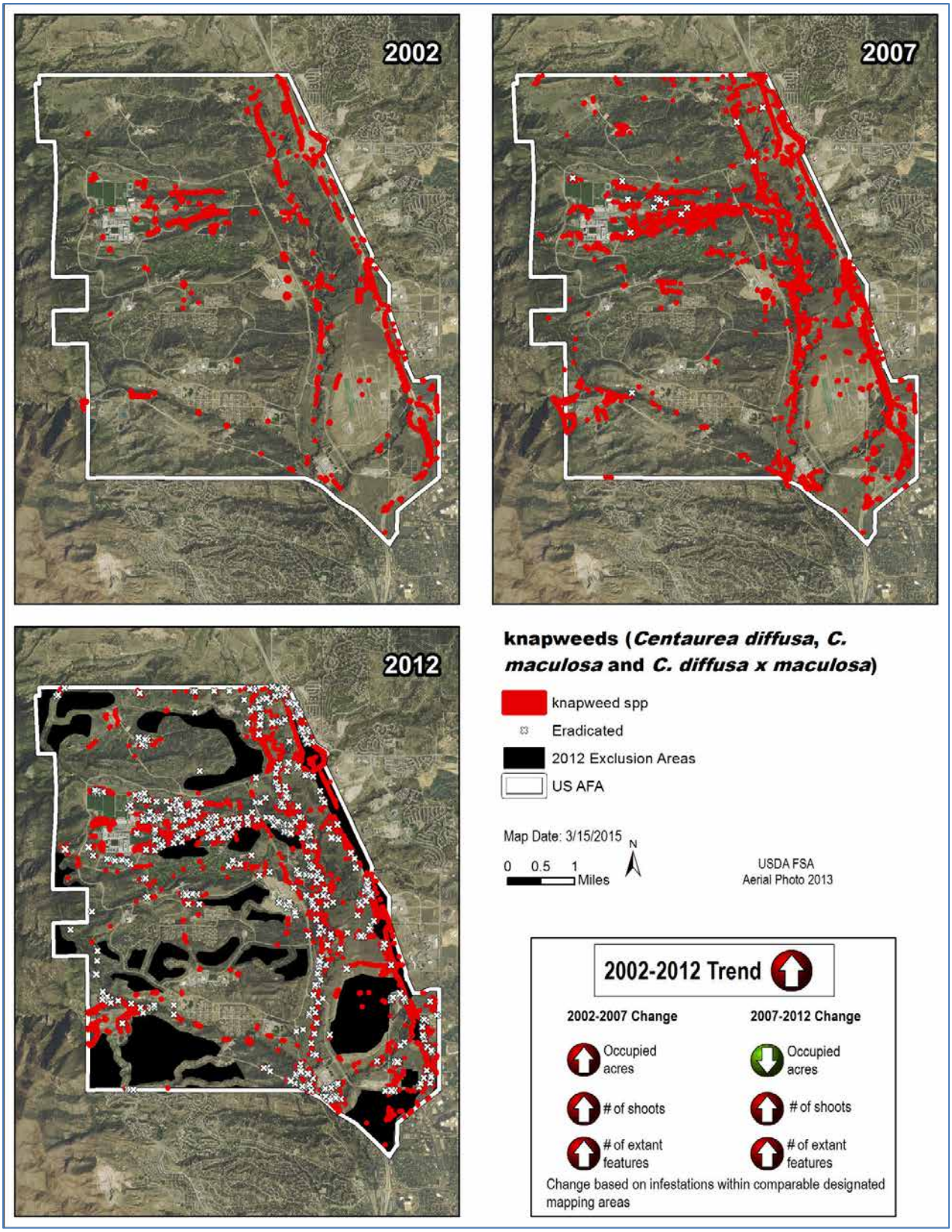
Figure 4. Knapweeds 2012-2014: Percent of quadrats/plot with knapweed. Dashed lines indicate herbicide treatment.

History of Sampling and Treatment:

- All 10 CNHP Permanent Plots were established in 2012.
- 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 broke). Additional years for both the treated and untreated plots should help tease apart the effectiveness of treatment.
- TAMU established a new biocontrol plot, DKhighway in 2013; not shown in this report. Therefore, in 2014 we will have 5 treated plots. If we were to randomly choose one of the non-treated plots and treat it with herbicide we would have a more balanced design that could help detect efficacies in treating knapweed. Another option would be to randomly treat two of the non-treated plots and establish a new untreated plot, which would balance it out so that we would have 7 treated and 7 non-treated (preferred).
- Although 2014 plot data show a decreasing trend, it is worth noting that in 2012 we conducted weed mapping of knapweeds (Map 10). Weed mapping showed nearly a six-fold increase in extant features since 2002 and a 53% increase since 2007. Density also increased significantly. (Lavender-Greenwell and Rondeau 2013).



Map 9. 2014 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 2014, all plot metrics indicate a downward trend.

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

State List: B

Photos: Left: Canada thistle plant at the AFA 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.

2014 Results

There was a decrease from 15 to 7 plants per plot in the permanent plots and a decrease in the biocontrol plots from 17 to 16 plants per plot, compared to 2012. The average height also decreased in both the biocontrol and non-biocontrol plots (Table 8).

Table 8. Summary of Canada thistle permanent plots, 2012-2014.

Non-Biocontrol Permanent Plot Sampling Method					
Year	*Number of Plots Sampled*	*# Quadrats Sampled*	*# Shoots*	*AVG Height (cm)*	*AVG# shoots/plot*
2012	8	416	117	43.0	15/plot
2013	Not Sampled by CNHP				
2014	8	411	56	35.6	7/plot
Biocontrol Permanent Plot Sampling Method					
2012	4	140	66	35.2	17/plot
2013	1	62	16	29.9	16/plot
2014	Discontinued – herbicide application				

The plots that had a biocontrol agent were not monitored in 2014. These plots should be monitored in subsequent years. Four of the five treated plots decreased while three of the untreated plots remained stable.

Frequency, or percent of quadrats with the plant present, is the best indicator of an expanding or contracting population. Density provides the average number of stems arising from the ground and cover describes how much area is occupied. While all of these metrics are susceptible to precipitation patterns the least sensitive metric is frequency. The other two metrics are more likely to be strongly correlated with annual precipitation values. We present all three metrics in Table 13 and graphically depict frequency in Figure 5.

Trend. The overall trend was stable to decreasing. Four plots were stable of which one was treated with herbicide in 2014. Four plots decreased of which three were treated and one untreated.

Table 9. Canada thistle detailed plot data, 2012-2014. Proportion of quadrats with Canada thistle present (frequency), average density (plants/0.5m^2) and canopy cover. Bolded numbers indicate that the site was treated with herbicide. Colors indicate trend: red is an increase (I), orange is moderate increase (MI), yellow is stable (S), and green is a decrease (D). Change may vary due to rounding.

Plot Name	Quad w/ plant 2012	Quad w/ plant 2013	Quad w/ plant 2014	2012-2014 Change	Avg Dens 2012	Avg Dens 2013	Avg Dens 2014	Avg Cover (%) 2012	Avg Cover (%) 2013	Avg Cover (%) 2014	Overall Trend
CIAR4-1	**21%**		**13%**	-8%	1.1		**0.4**	**2.2**		**1.3**	**D**
CIAR4-2	10%		9%	-1%	0.5		0.1	1.6		1.2	S
CIAR4-3	25%		19%	-6%	0.4		0.3	1.7		1.7	S
CIAR4-4	13%		**15%**	2%	0.2		**0.3**	0.7		**1.7**	**S**
CIAR4-5	42%		**10%**	-33%	1.8		**0.1**	7.4		**0.3**	**D**
CIAR4-6	66%		21%	-45%	3.9		0.5	13.6		3.4	D
CIAR4-7	16%		18%	2%	0.4		0.4	1.0		1.2	S
CIAR4-8	19%		**6%**	-13%	0.6		**0.1**	3.0		**1.3**	**D**
CTice1	**58%**				1.7			**7.1**			
CTice2	**100%**				8.8			**26.3**			
CTkettle	**24%**				0.7			**1.7**			
CTploop	**52%**				3.1			**8.5**			
AVG	**37%**		**14%**	**-0.1**	**1.9**		**0.3**	**6.2**		**1.5**	**D**

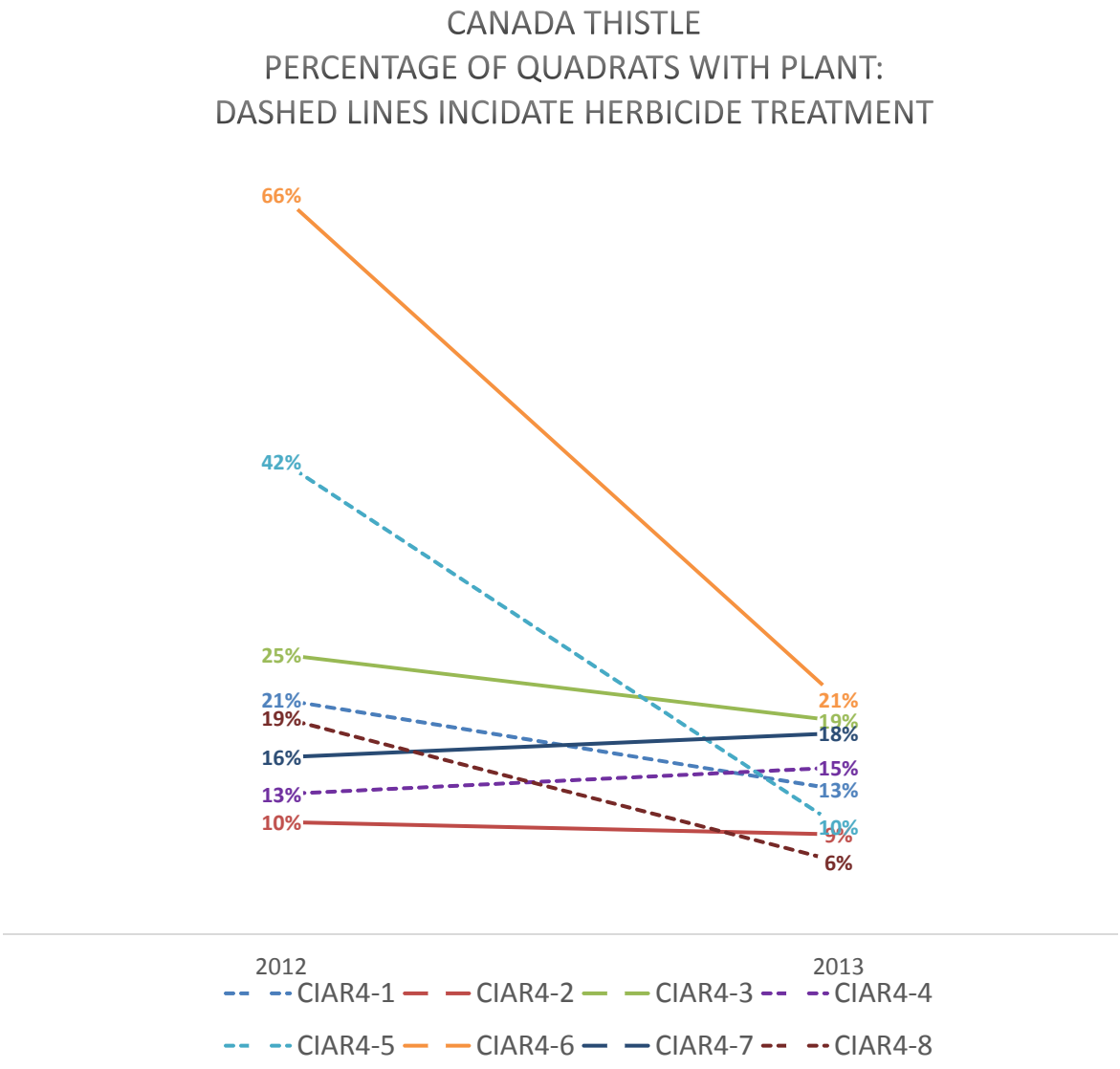
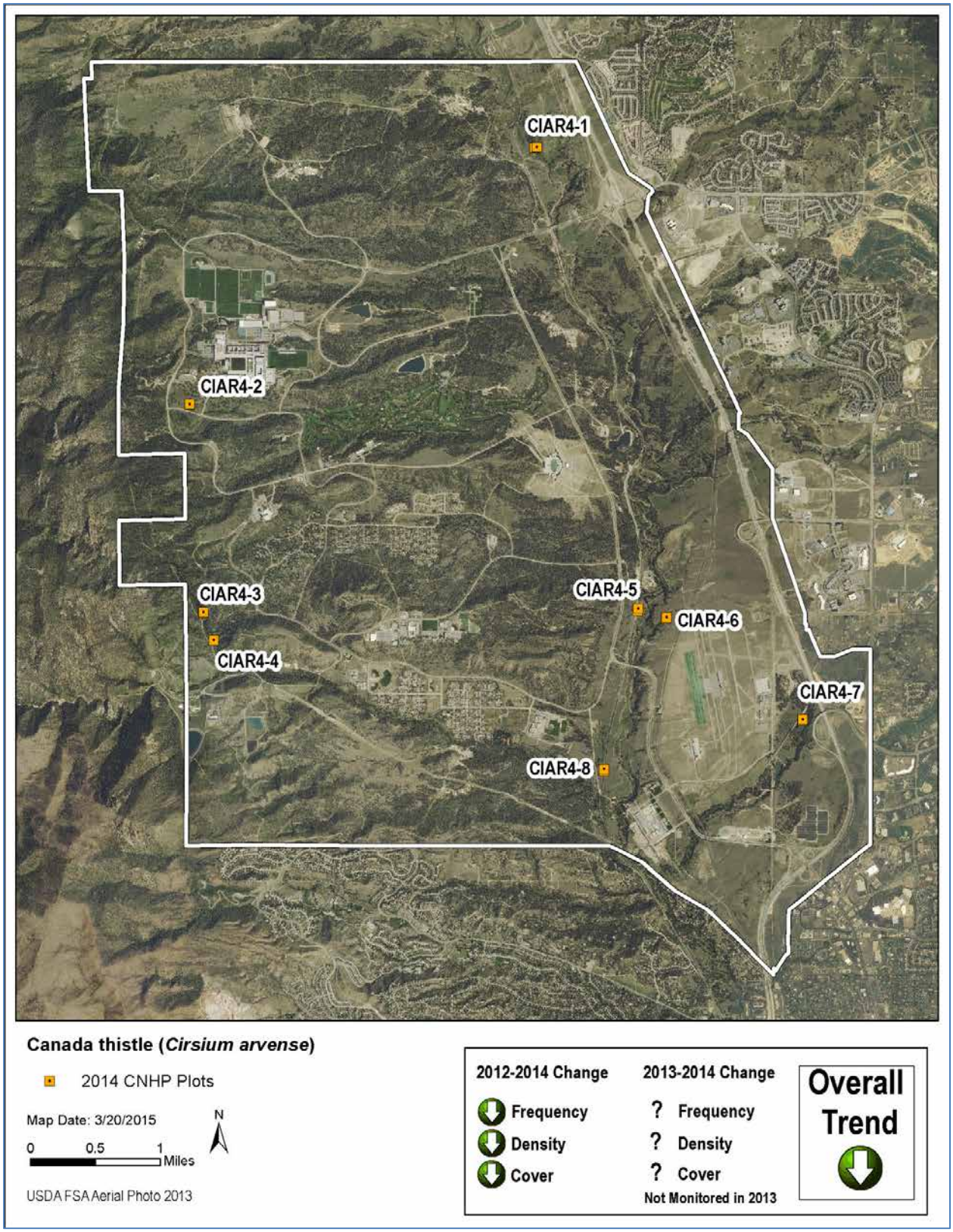


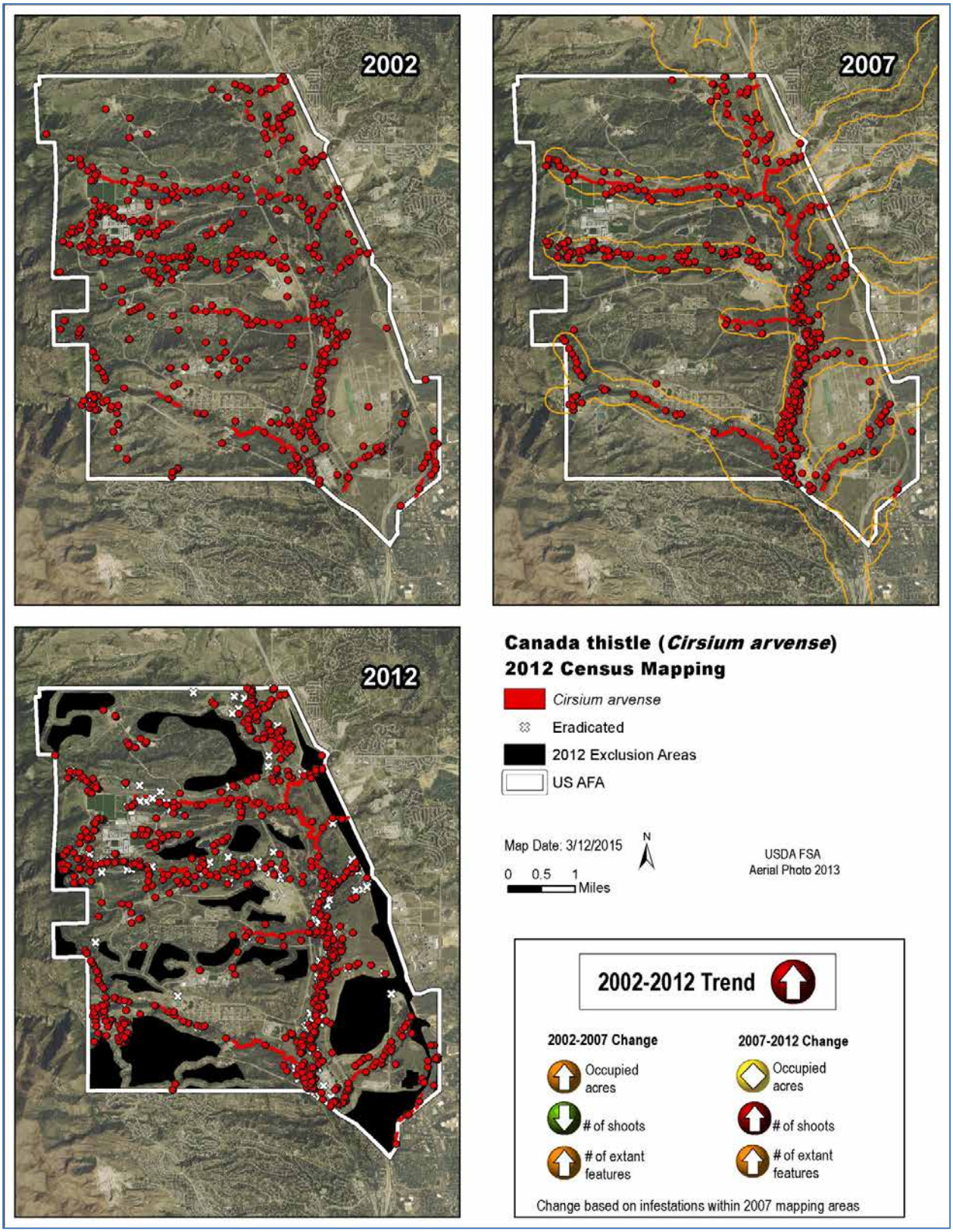
Figure 5. Canada thistle 2012-2014: Percent of quadrats/plot with Canada thistle. Dashed lines indicate herbicide treatment.

History of Sampling and Treatments:

- In 2012, 8 permanent plots were set up by CNHP.
- 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 (Map 12). Number of extant features and number of shoots significantly increased between 2007 and 2012 (Lavender-Greenwell and Rondeau 2013).



Map 11. 2014 Canada thistle plots at the Academy.



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

Houndstongue (*Cynoglossum officinale*)

Metrics are similar to 2009, when houndstongue was first discovered at AFA. Number of shoots doubled between 2013 and 2014, but distribution is holding.

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

State List: B

- Biennial
- Reproduction only by seed
- Flowers May-July
- Thick, black, woody taproot
- Forms rosette first year
- Seeds fall close to plant but Velcro©-like seeds allow transport by animals
- Seed longevity 3 years (CCR 2014)

Houndstongue seeds, photo BLM

Photo by M. DiTomaso, University of California - Davis

2014 Results

Since 2009, when the first population was observed at the AFA, the number of individuals and the number of mapped extant features of houndstongue have fluctuated (Table 14). The number of individuals ranged from a minimum of 11 (2010) to maximum of 102 (2014). The number of extant features ranged from 1 (2010) to 8 (2009 and 2014). Currently, there is the same number of extant features that were recorded in 2009, the number of individual plants observed were similar (95 in 2009 and 102 in 2014). The herbicide and hand pulling methods are not eliminating this plant but they may be keeping it from a rapid spread as it is still relatively localized. No new locations were discovered in 2014.

Table 10. Houndstongue summary data, 2009-2014. Bolded indicates treatment.

Census Mapping Method				
Year	*# Shoots*	*# Extant Features*	*# Eradicated Features*	*Occupied Area (m^2)*
2009	95	8	0	378
2010	11	1	6	78
2011	21	2	6	10
2012	**70**	**3**	9	**40**
2013	**48**	**7**	8	**218**
2014	102	8	8	170

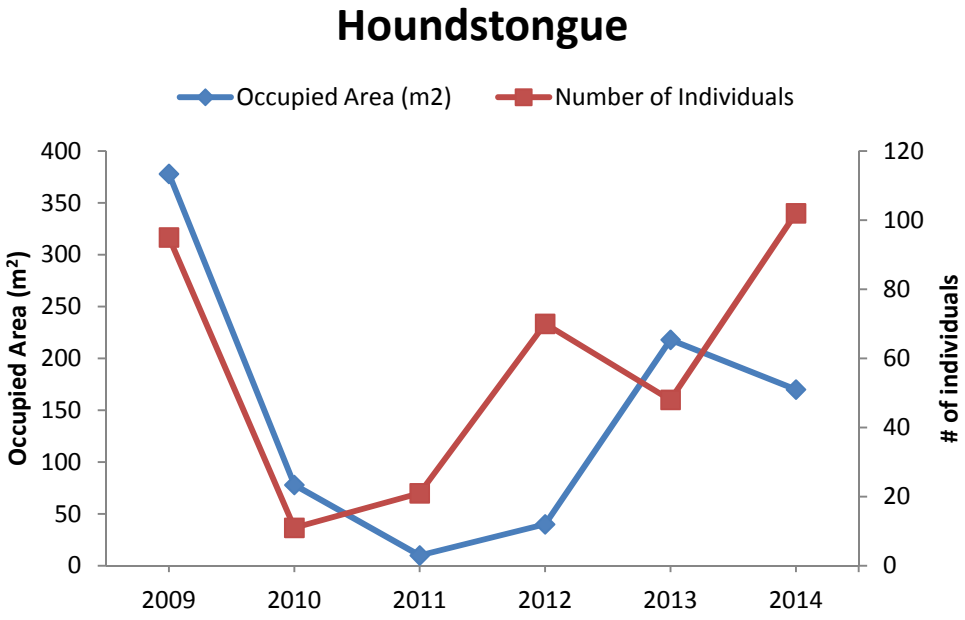
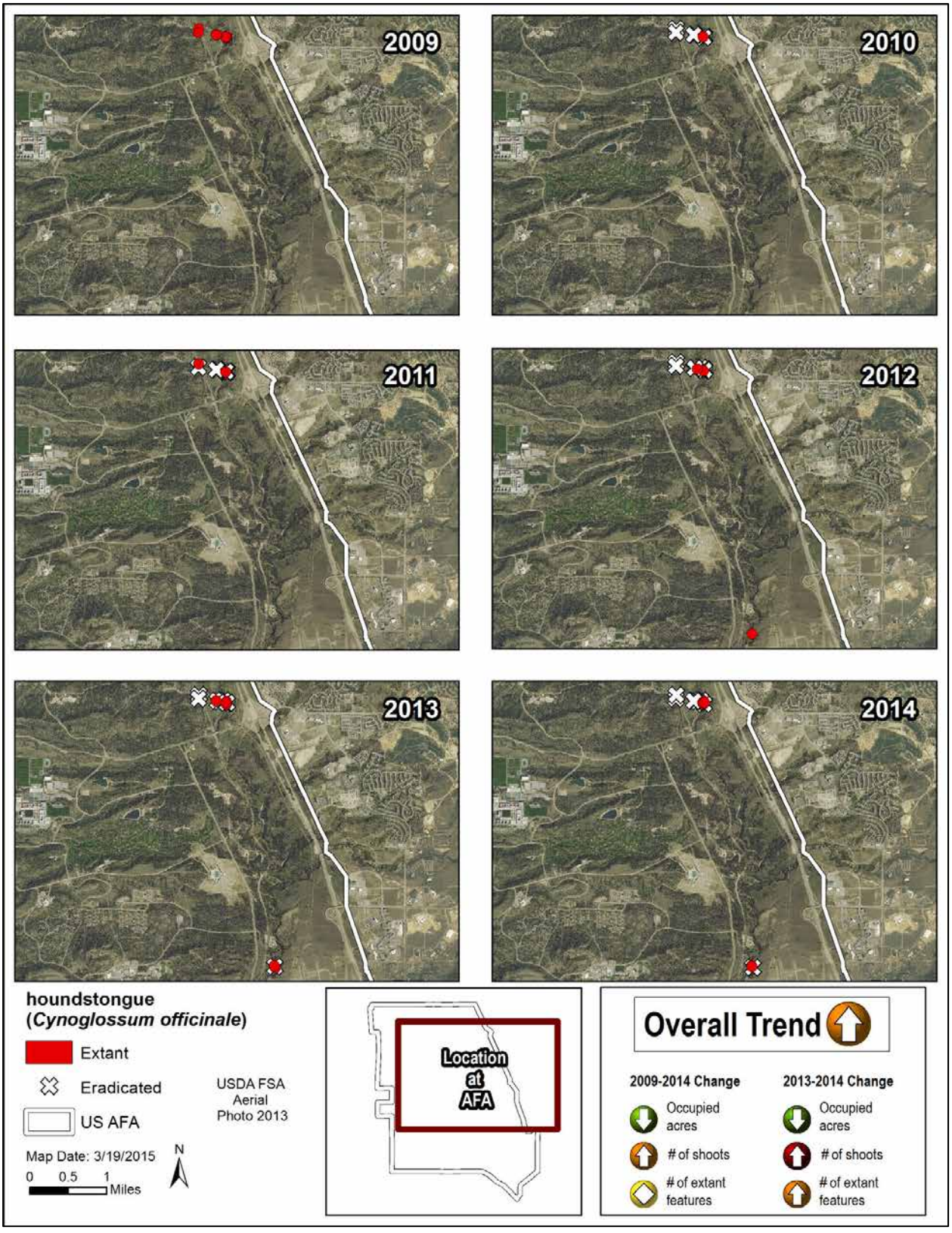


Figure 6. Occupied area (m^2) and number of individuals of houndstongue, 2009-2014.

History of Sampling and Treatment

- First population discovered in 2009 at AFA
- 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.



Map 13. Distribution of houndstongue at the Academy between 2009 and 2014.

Leafy Spurge (*Euphorbia esula*)

Plots are relatively stable, with a slight decreasing trend in 2014.

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

State List: B

- Perennial with extensive root system that can reach 15 feet in depth
- Reproduction from seed and root buds
- 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 AFA
- Grows very early in the spring
- Extremely difficult to control

Photo by Michelle Washebek

2014 Results

Between 2012 and 2014 there was a decrease in plants in both the biocontrol and non-biocontrol plots (Table 11). Treatments with herbicides are difficult to interpret because of partial treatments. More data is needed on treated and non-treated areas.

Table 11. Summary of leafy spurge permanent plots, 2012-2014.

Non-Biocontrol Permanent Plot Sampling Method					
Year	*Number of Plots Sampled*	*# Quadrats Sampled*	*# Shoots*	*AVG Height (cm)*	*AVG#/plot*
2012	10	600	171	32.0	17/plot (**8 plots possibly treated**)
2013	10	609	151	26.8	15/plot
2014	10	593	139	30.0	14/ plot
Biocontrol Permanent Plot Sampling Method					
2012	3			32.5	
2013	1			25.3	
2014	Discontinued – herbicide application				

Frequency, or percent of quadrats with the plant present, is the best indicator of an expanding or contracting population. Density provides the average number of stems arising from the ground and cover describes how much area is occupied. While all of these metrics are susceptible to precipitation patterns the least sensitive metric is frequency. The other two metrics are more likely to be strongly correlated with annual precipitation values. We present all three metrics in Table 12 and graphically depict frequency in Figure 7.

Trend. The overall trend was stable to a slight decrease. Five plots had an overall increasing trend (poor status) of which three had never been treated and one was partially treated in 2012. Two plots remained stable, of which neither had been treated. Three plots decreased of which all had been treated. In essence plots that were treated were more likely to decrease and plots that were not treated either remained stable or decreased. The one plot that was treated and increased was partially treated in 2012 and approx. ½ of the site is comprised of oaks thus plants amongst the oaks were not treated.

History of Sampling and Treatment

- 10 permanent plots established in 2012 (Map 14)
- Michaels et al. terminated biocontrol treatments in 2013
- In 2013 we recognized a need for more accurate treatment application data that includes area treated, date, and type of treatment.

Table 12. Leafy spurge detailed plot data, 2012-2014. Proportion of quadrats (aka frequency) with leafy spurge present and average density (plants/0.5m^2) and canopy cover. Bolded numbers indicate that the site was treated with herbicide. Colors indicate trend: red is an increase (I), orange is a moderate increase (MI), yellow is stable (S), and green is a decrease (D). Change may vary due to rounding.

Plot Name	Quad w/ plant 2012	Quad w/ plant 2013	Quad w/ plant 2014	2012-2014 Change	Avg Dens 2012	Avg Dens 2013	Avg Dens 2014	Avg Cover (%) 2012	Avg Cover (%) 2013	Avg Cover (%) 2014	Overall Trend
EUES-1	29%	35%	38%	9%	2	2.2	1.9	1.9	2.0	7.3	I
EUES-2	**40%**	3%	3%	-37%	**6**	0.0	0.0	**4.1**	0.1	0.1	**D**
EUES-3	**25%**	15%	34%	8%	**1**	0.6	1.6	**1.1**	0.4	0.8	**I**
EUES-4	27%	36%	29%	2%	1	1.4	1.5	1.3	1.3	4.0	I
EUES-5	31%	32%	27%	-3%	3	1.8	1.0	0.8	2.3	2.8	MI
EUES-6	35%	42%	45%	10%	2	1.9	2.1	2.0	2.3	5.2	I
EUES-7	11%	13%	15%	3%	0	0.4	0.7	0.2	0.7	3.3	I
EUES-8	**27%**	32%	**15%**	-13%	**2**	2.1	**0.5**	**2.1**	3.5	**1.1**	**D**
EUES-9	**43%**	21%	13%	-30%	**4**	1.9	0.3	**2.1**	1.4	0.7	**D**
EUES-10	18%	18%	15%	-3%	2	1.1	0.6	1.1	0.5	0.6	S
AVG	**29%**	**25%**	**23%**	**-5%**	**2.3**	**1.3**	**1.0**	**1.7**	**1.5**	**2.6**	**S / D**

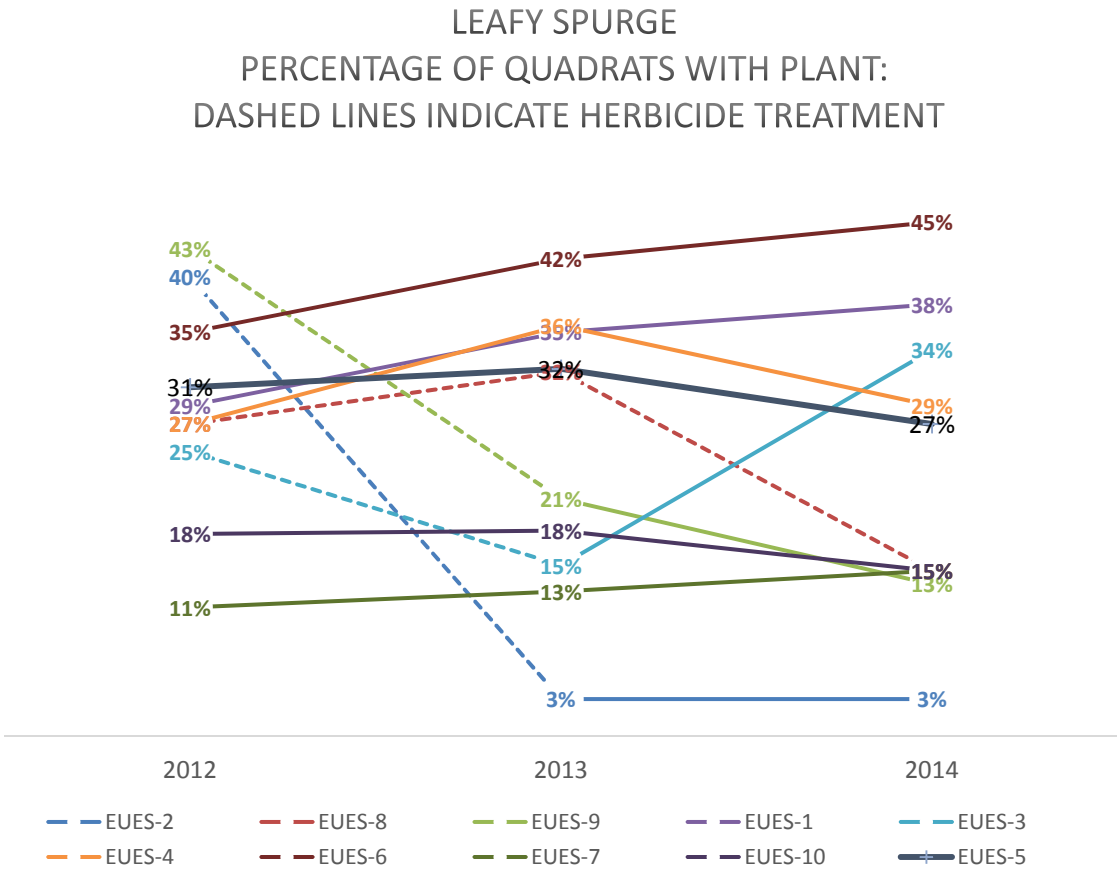


Figure 7. Percentage of quadrats/plot with leafy spurge 2012-2014. Herbicide treatments indicated by dashed lines.

Plot EUES-8 was partially treated. Figure 8 provides graphical representation of a plot that is partially treated.

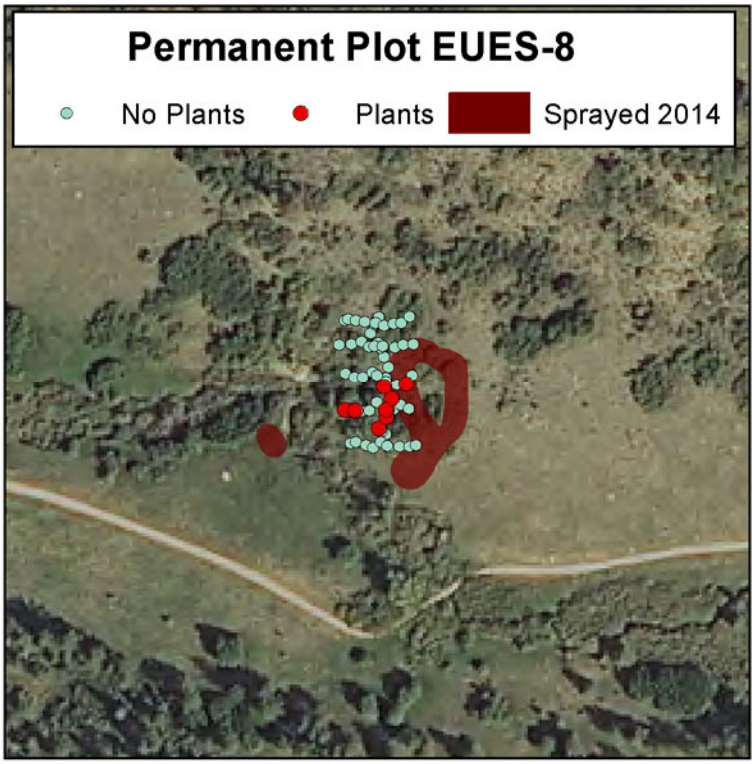
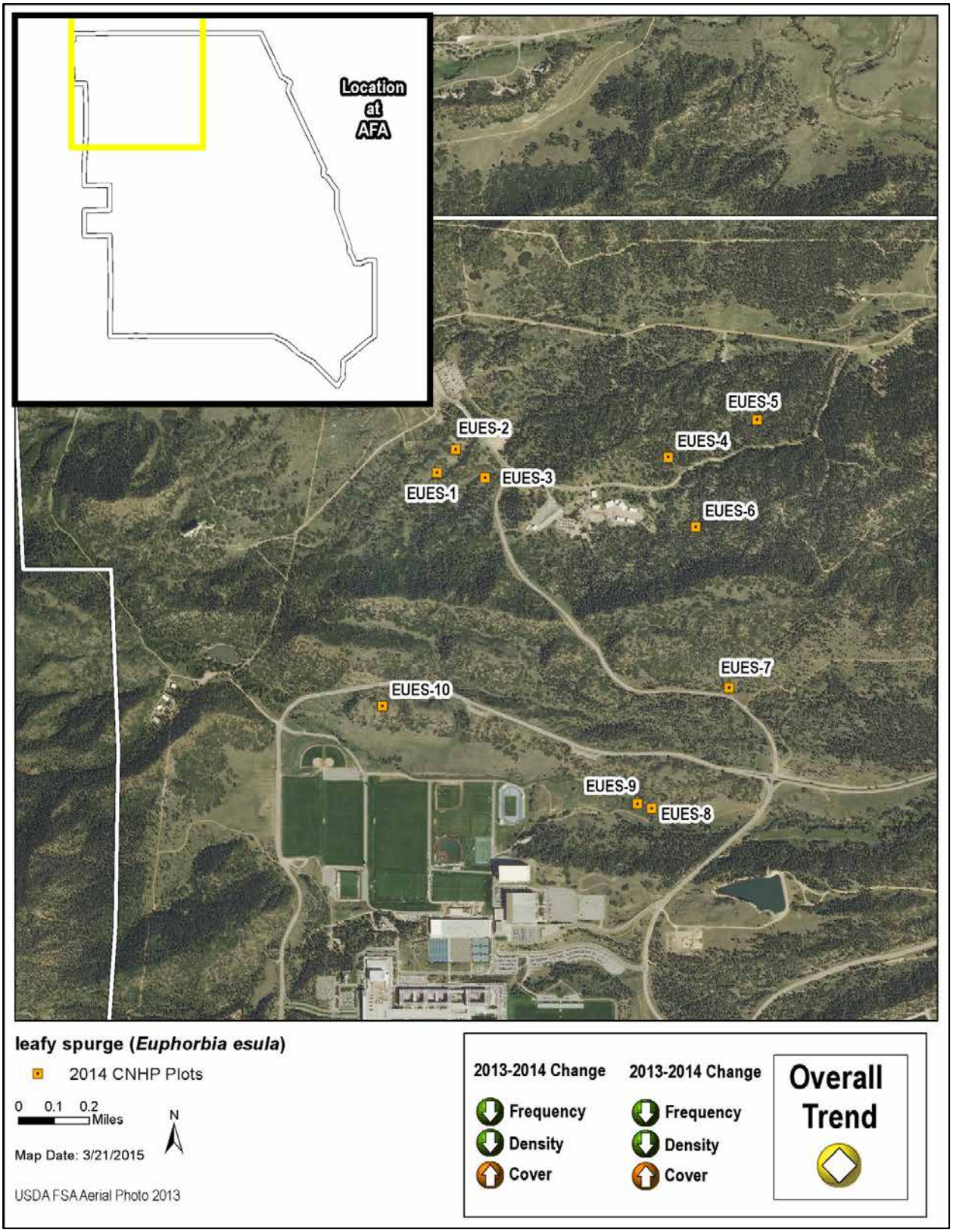
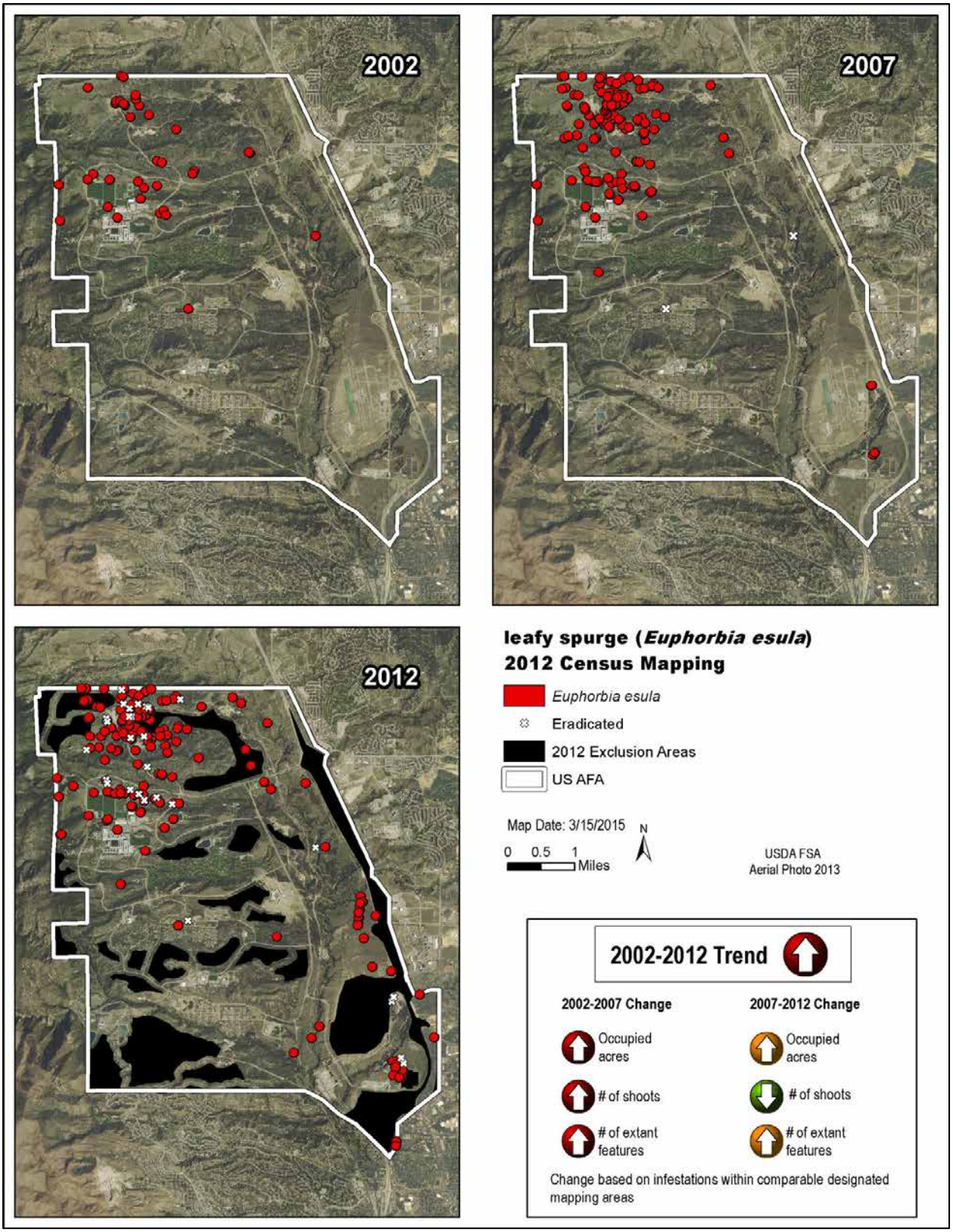


Figure 8. Incomplete spraying around plot EUES-8.



Map 14. 2014 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 continues to increase. Two new locations were documented in 2014.

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: Wikipedia Commons

Results: In 2014, 179 individuals were observed in 7 extant features occupying an estimated 0.7 acres of land. Extant features have ranged from 7-19 sites between 2005 and 2014 (Table 13 and Figure 9). 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 7-10 extant features and individuals ranging from 113-179.

Table 13. Myrtle spurge summary data, 2005-2014.

Census Mapping Method			
Year	*# shoots*	*# Extant Features*	*Occupied Acres*
2005	25	7	---
2006	243	10	---
2007	1021	7	0.18
2008	419	13	0.66
2009	464	12	2.4
2010	56	10	0.5
2011	57	12	0.25
2012	113	10	0.23
2013	129	19	---
2014	179	7	0.7

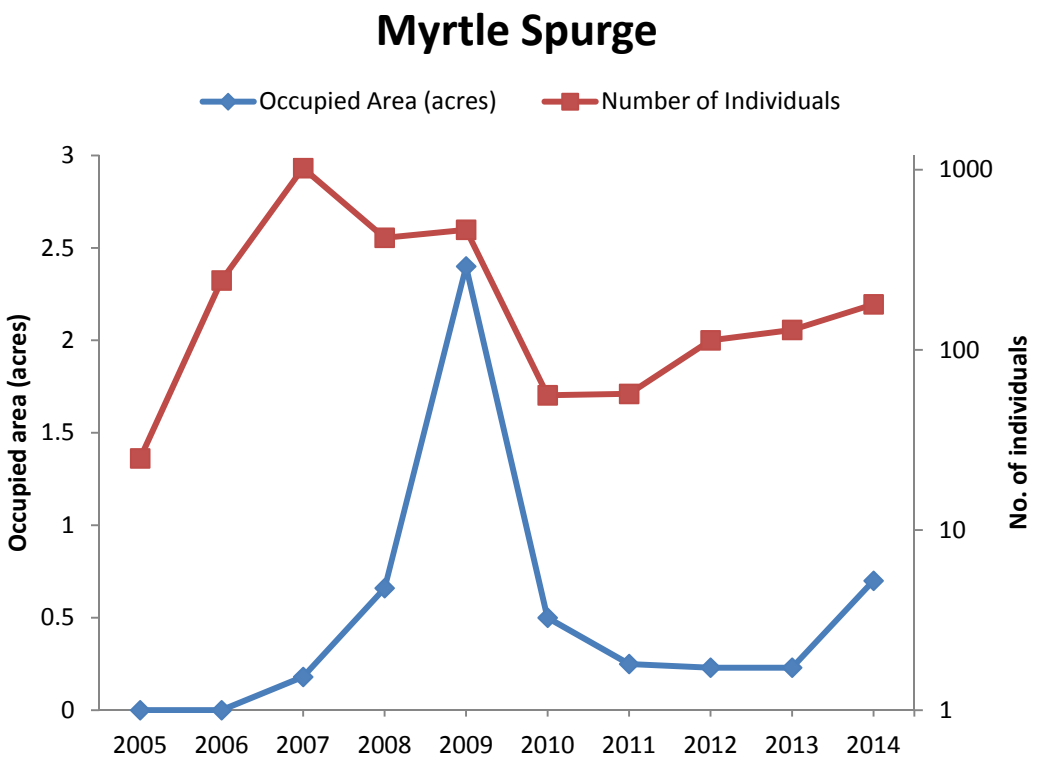
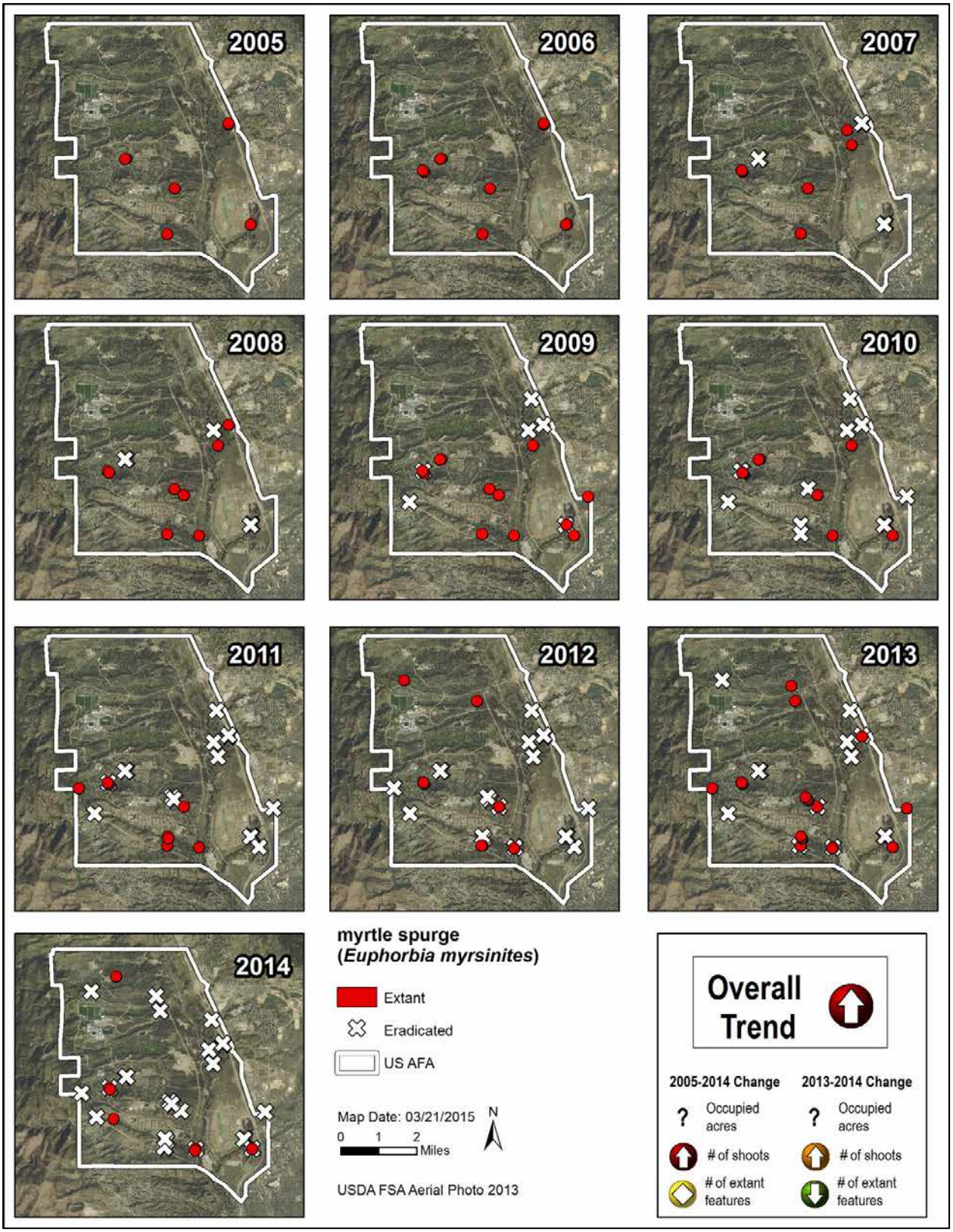


Figure 9. Myrtle spurge trend, 2005-2014.

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 7 sites and 25 individuals.
- Generally an upward trend, however much below the high number of approximately 1,000 individuals in 2007 (Table 13, Figure 8).



Map 16. Distribution of myrtle spurge at the Academy between 2005 and 2014.

Yellow Spring Bedstraw (*Gallium verum*)

Success! No plants observed in 2014. This species is potentially eliminated from the base.

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

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

Wikipedia photo

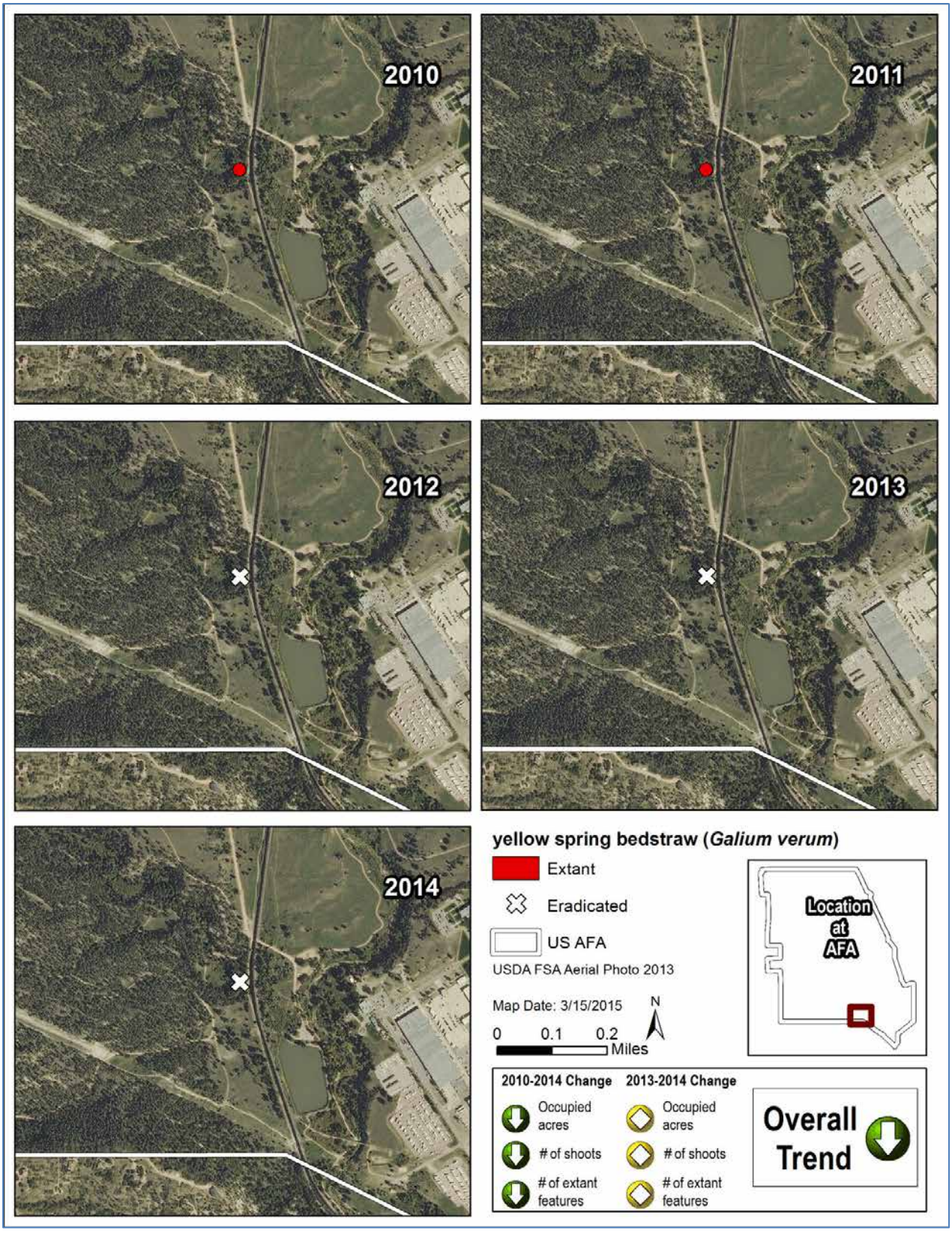
Results: No plants were observed in 2014 survey, and it has not been observed since 2011 (Table 14).

Table 14. Yellow spring bedstraw summary data, 2010-2014.

Census Mapping Method			
Year	*# Shoots*	*# Extant Features*	*Occupied Area (m^2)*
2010	700	1	28
2011	1	1	0
2012	0	0	0
2013	0	0	0
2014	0	0	0

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 m2 (0.01 acres). All plants were treated by the AFA.
- 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.



Map 17. Distribution of yellow spring bedstraw at the Academy between 2010 and 2014.

Dames Rocket (*Hesperis matronalis*)

A new site was discovered on the SW border of the Academy, but existing sites were surveyed too late in the season to collect reliable metrics.

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

State List: B

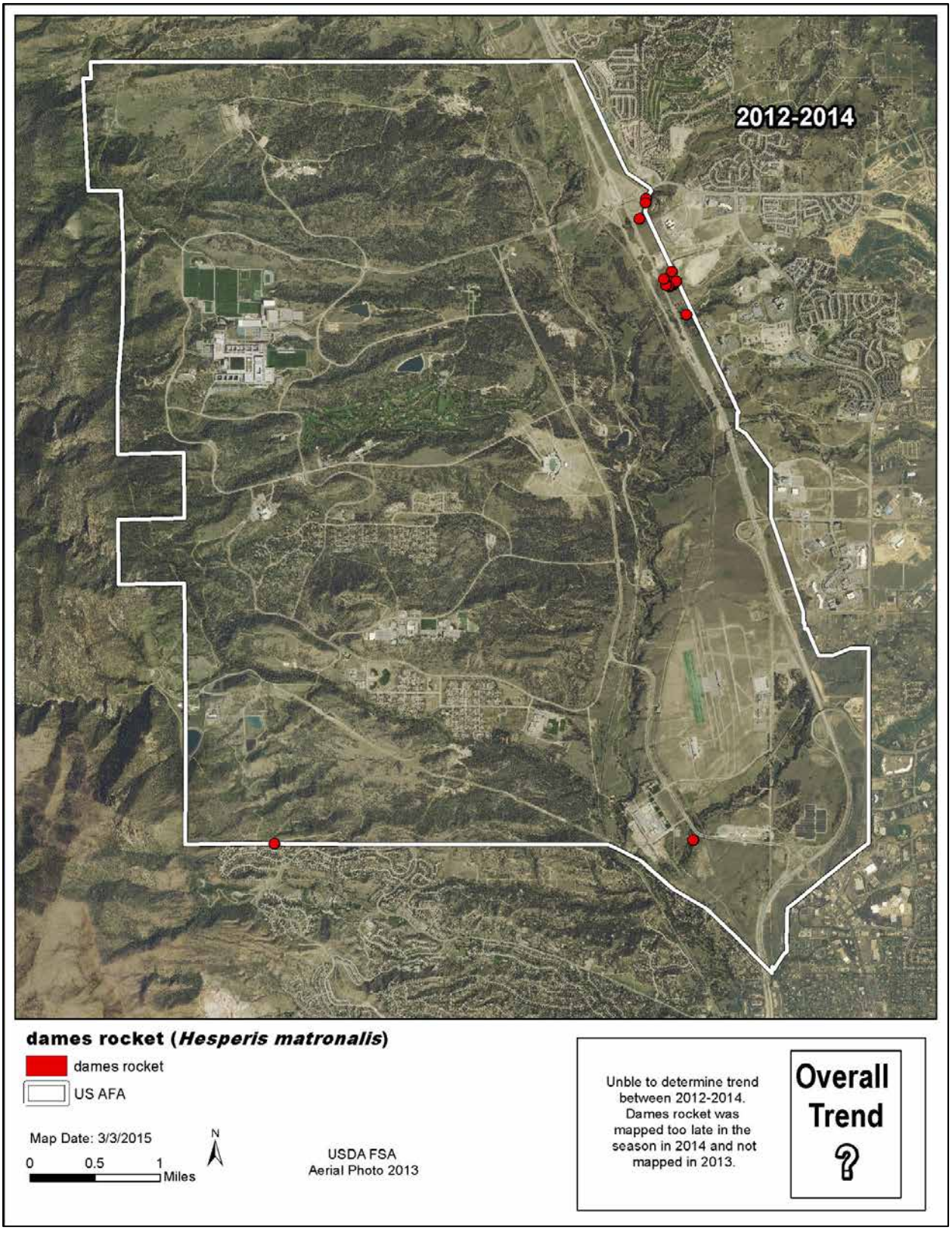
- Tall, showy short-lived perennial forb
- Garden escape
- Taproot and spreading secondary roots
- Reproduction only by seed
- Seeding late summer and fall with high number of seeds
- First year rosettes are green all winter and ready to grow early in the spring
- Seeds available to the public for horticulture
- Seed longevity is thought to be many years

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

Results: Most locations in 2014 appeared to be eradicated; however, these were surveyed too late in the growing season to reliably identify plants. Base personnel found a new location in June far from the original infestation site near I-25. We were unable to reliably document eradicated sites, so all known sites shown on Map 18 are presumed extant. Mapping will be a priority for 2015.

History of Sampling and Treatment:

- Dames 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.
- Dames rocket was not mapped in 2013.



Map 18. Mapped locations of dame's rocket at the Academy.

Common St. Johnswort (*Hypericum perforatum*)

Significant downward trend since 2007; however, there was a slight increase in all metrics in 2014, compared to 2013.

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+ yrs

Photo by Renee Rondeau

2014 Results

The number of extant features included 33 sites for 2014 which added 11 sites from 2013. This shows a slightly upward trend for the current year; however, the numbers of shoots are significantly smaller than in 2007. Figure 10 and Map 19 show the overall trend is downward. Flooding did prevent access to some of the known sites which were under water at the time of the surveys.

Table 15. Common St. Johnswort summary data, 2007-2014.

Census Mapping Method			
Year	*# Shoots*	*# Extant Features*	*Occupied Acres*
2007	44,647	8	0.86
2008	130,371	13	1.07
2009	95,883	21	2.02
2010	82,732	20	1.47
2011	87,128	26	1.44
2012	83,115	29	1.16
2013	2,621	22	0.85
2014	3,604	33	1.12

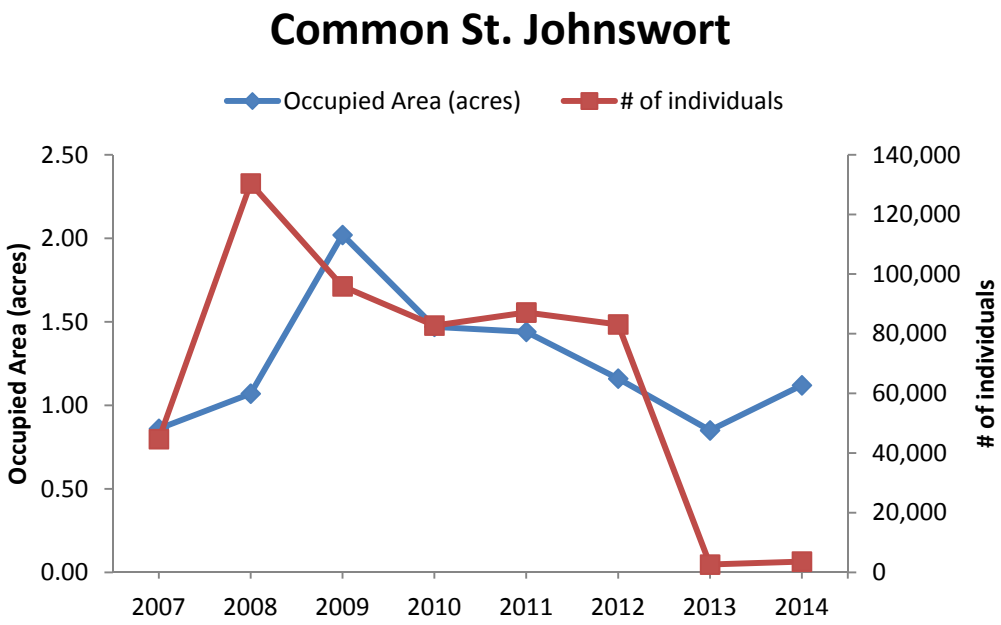
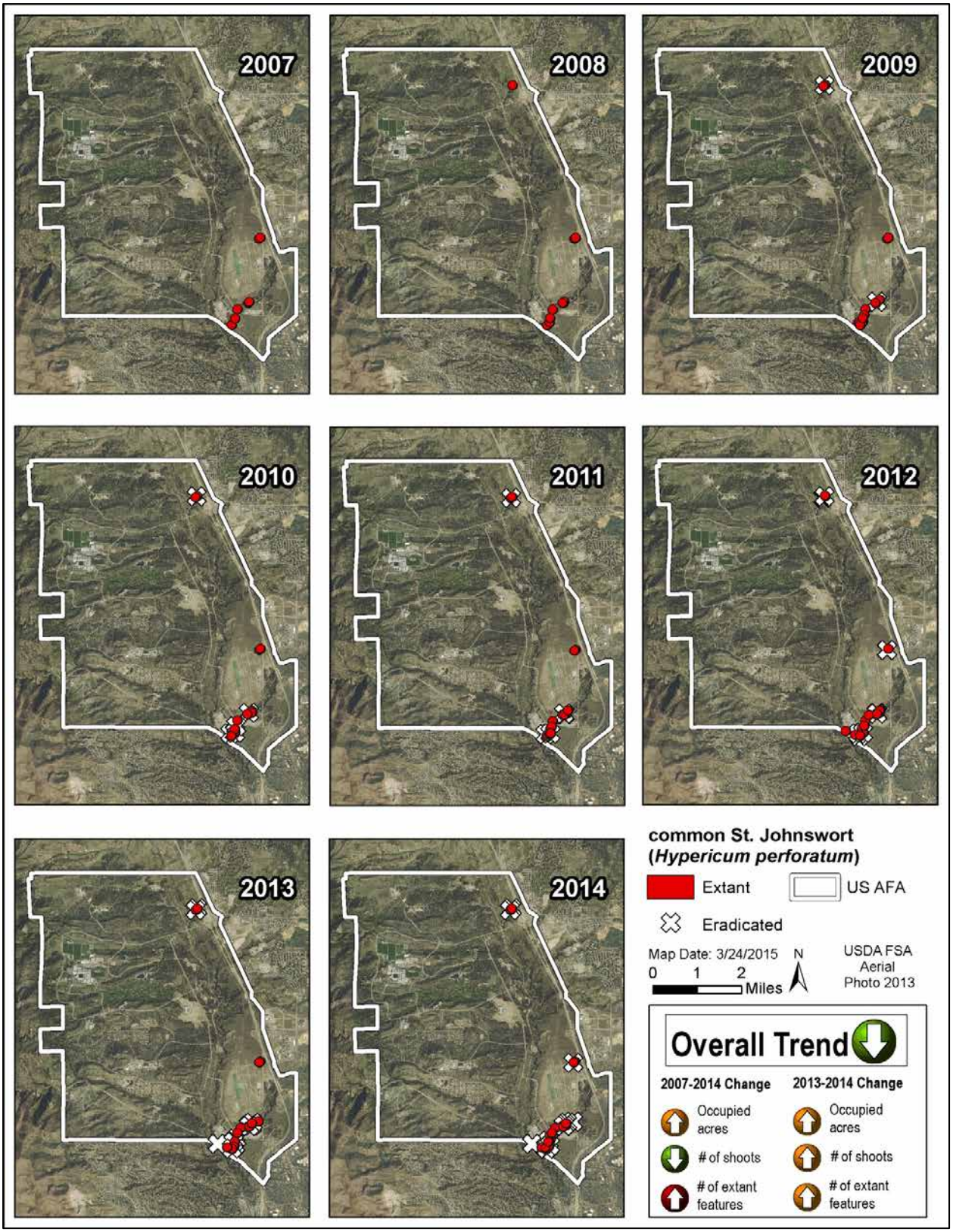


Figure 10. Occupied area (m^2) and number of individuals of common St. Johnswort, 2009-2014.

History of Sampling and Treatment:

- Common St. Johnswort was first monitored in 2007.
- The populations peaked in 2008-2009 (Table 21, Figure 10, Map 19).
- Biocontrol efforts were discontinued in 2010.
- A significant decline occurred in 2012-2103 due to management efforts.



Map 19. Distribution of common St. Johnswort at the Academy between 2007 and 2014.

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

The western population is still extant despite treatment in 2013.

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

2014 Results

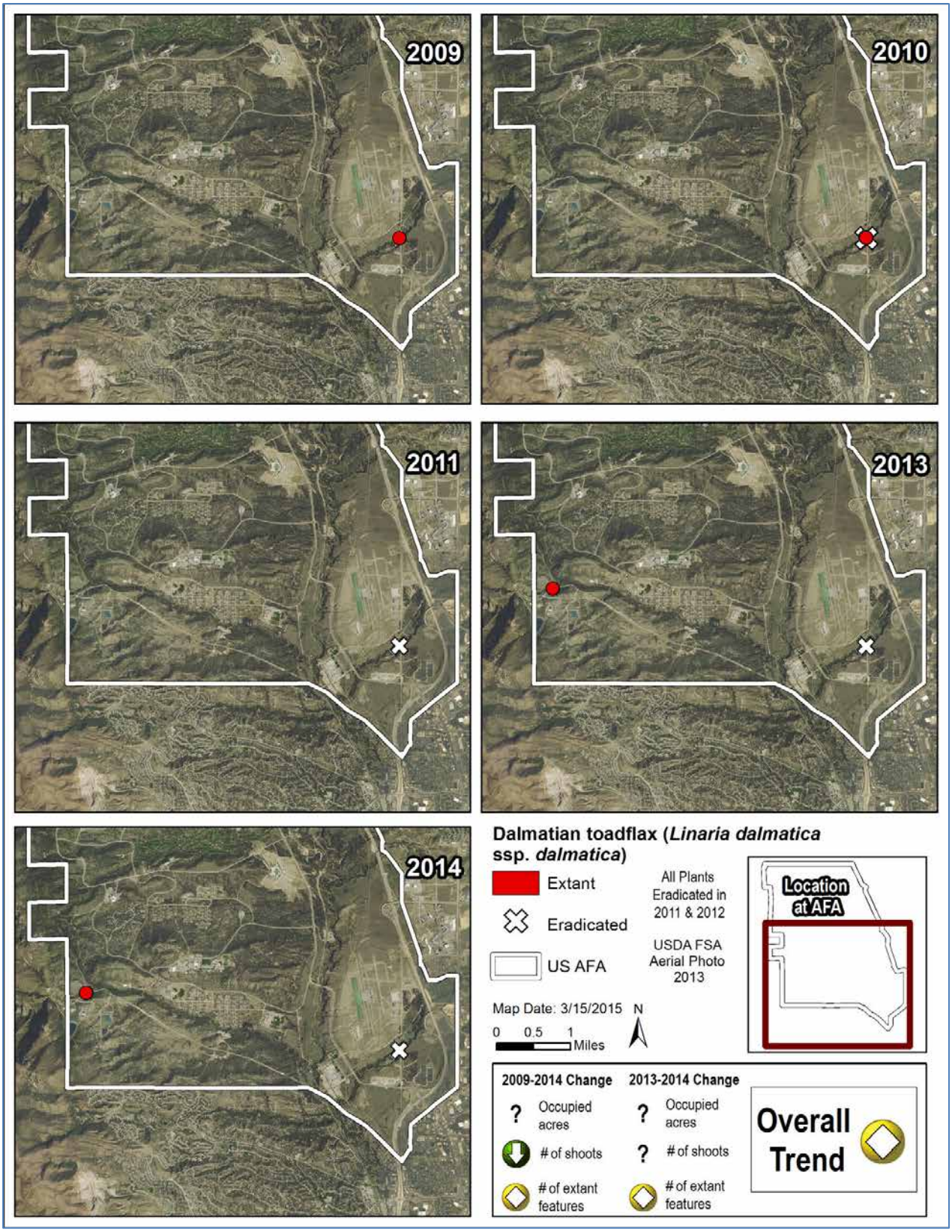
In 2014, seven individuals were observed at one extant feature that was treated in 2013 (Table 16). Overall, this represents a slight increase in the population since 2011 and demonstrates the need for continued monitoring even after a couple of years.

Table 16. Dalmatian toadflax summary data, 2007-2014. Bolded indicates treatment.

Census Mapping Method			
Year	*# Shoots*	*# Extant Features*	*Occupied Area (m^2)*
2009	10	1	---
2010	**107**	**2**	**203**
2011	0	0	0
2012	0	0	0
2013	---	**1**	---
2014	7	1	12.5

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 16).
- The AFA treated the 2010 sites and no plants were observed in 2011-2012.
- A new site was discovered in 2013 which was treated immediately.



Map 20. Distribution of Dalmatian toadflax at the Academy between 2009 and 2014.

Tatarian Honeysuckle (*Lonicera tatarica*)

Metrics were relatively stable between 2013 and 2014; however, plant has spread since it was first discovered in 2008.

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

State List: Not listed

- Tall shrub
- Commonly planted and escaping
- At the AFA one population is growing with a rare plant species, American currant

Photos: Wikipedia Commons

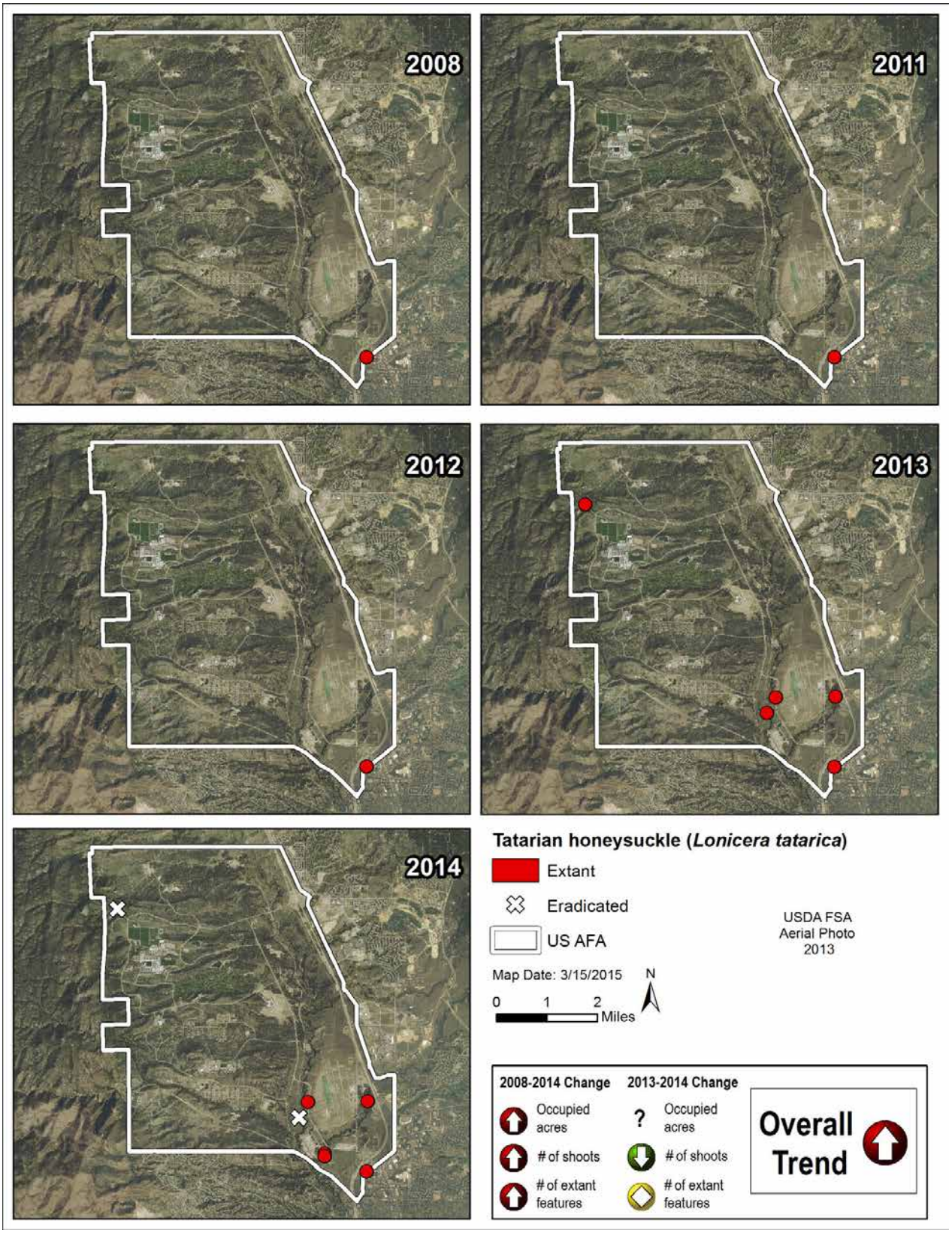
Results: In 2014, there were five extant features as in 2013 with seven fewer individuals (Table 17).

Table 17. Tatarian honeysuckle summary data, 2008-2014.

Census Mapping Method			
Year	*# Individuals*	*# Extant Features*	*Occupied Acres*
2008	First observations		
2012	30	1	0.15
2013	38	5	---
2014	31	5	0.21

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).



Map 21. Distribution of Tatarian honeysuckle at the Academy between 2008 and 2014.

Scotch Thistle (*Onopordum acanthium*)

Continues to increase.

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

2014 Results

The Scotch thistle population has been increasing steadily since 2010 and is approaching the high numbers observed in 2009 and 2007. Both pulling and herbicide treatments were used in the past (Table 18). Plants are reappearing after several years in many areas that were presumed eradicated.

Table 18. Scotch thistle summary data, 2002-2014.

Census Mapping Method			
Year	*# Shoots*	*# Extant Features*	*Occupied Acres*
2002	52	7	0.17
2005	137	12	0.42
2007	1307	36	1.30
2008	144	27	1.14
2009	1710	50	3.47
2010	669	61	0.66
2011	293	39	0.64
2012	889	66	0.30
2013	970	48	0.3?
2014	1,224	74	0.84

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 18, Figure 11, and Map 22).
- The population of Scotch thistle peaked in 2007 and 2009 with a decline in 2010.
- Scotch thistle has returned even if reduced over several years.

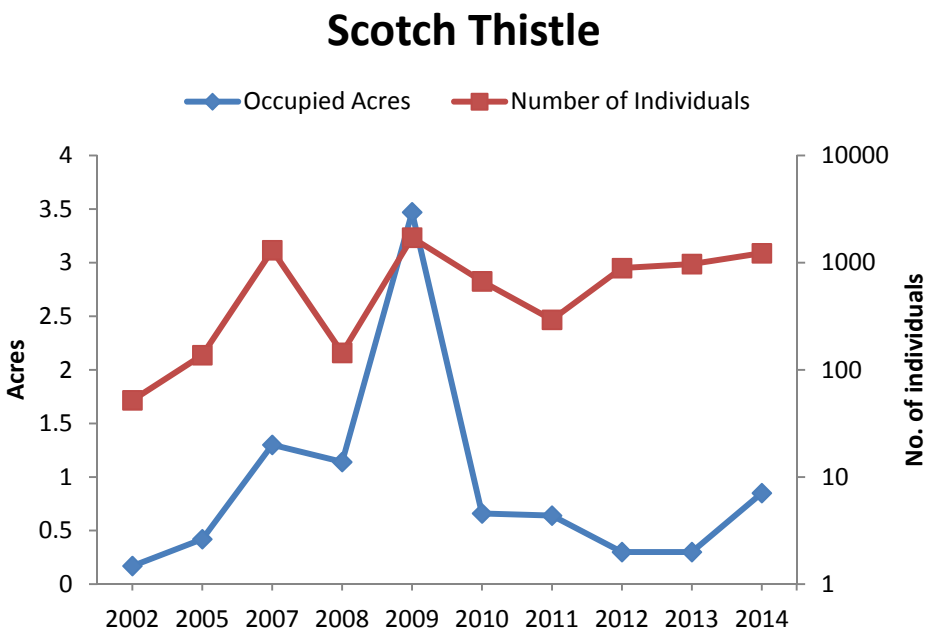
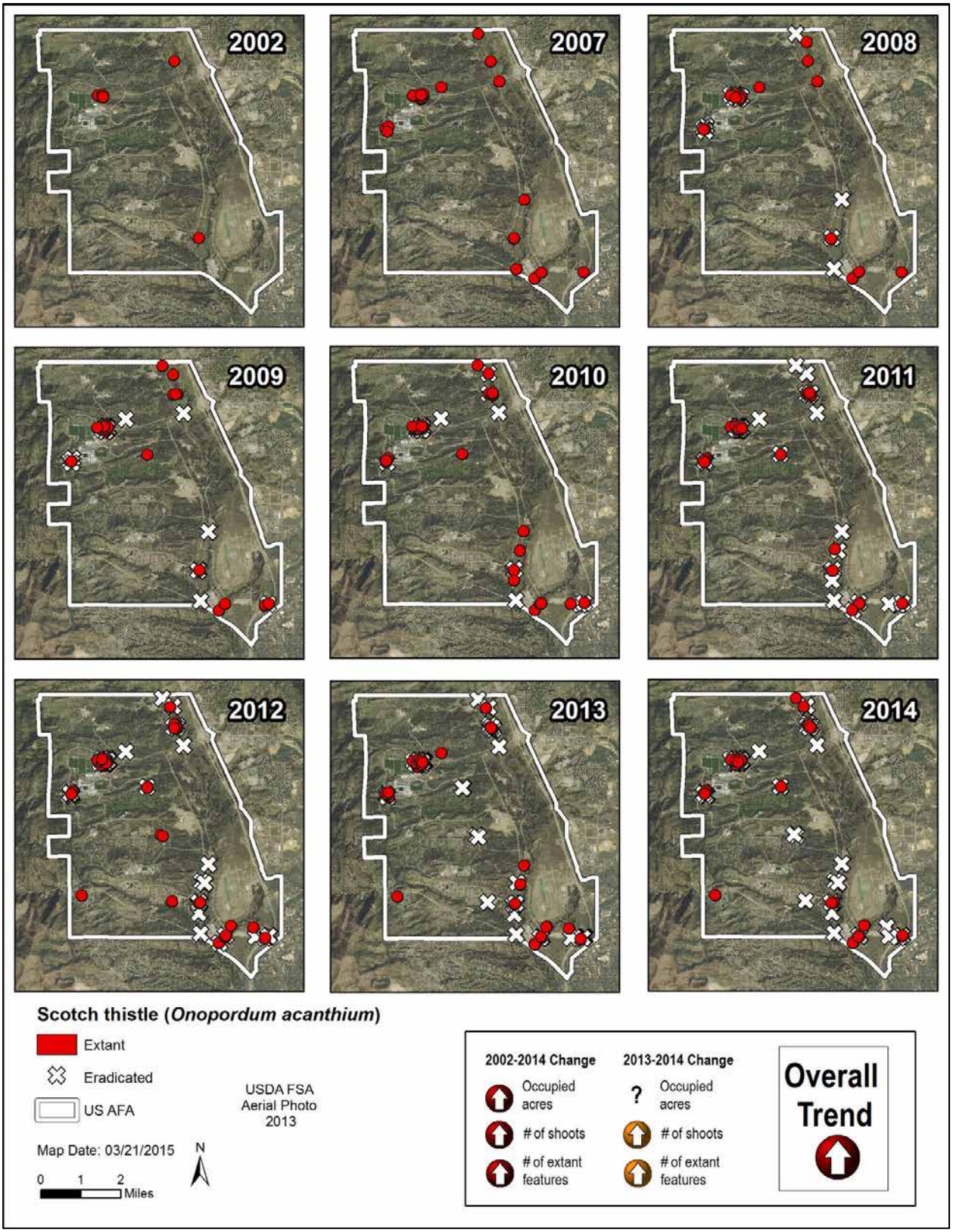


Figure 11. Occupied area (m^2) and number of individuals of Scotch thistle, 2009-2014.



Map 22. Distribution of Scotch thistle at the Academy between 2002 and 2014.

Bouncingbet (*Saponaria officinalis*)

Downward trend. All but two features were eradicated after treatment.

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

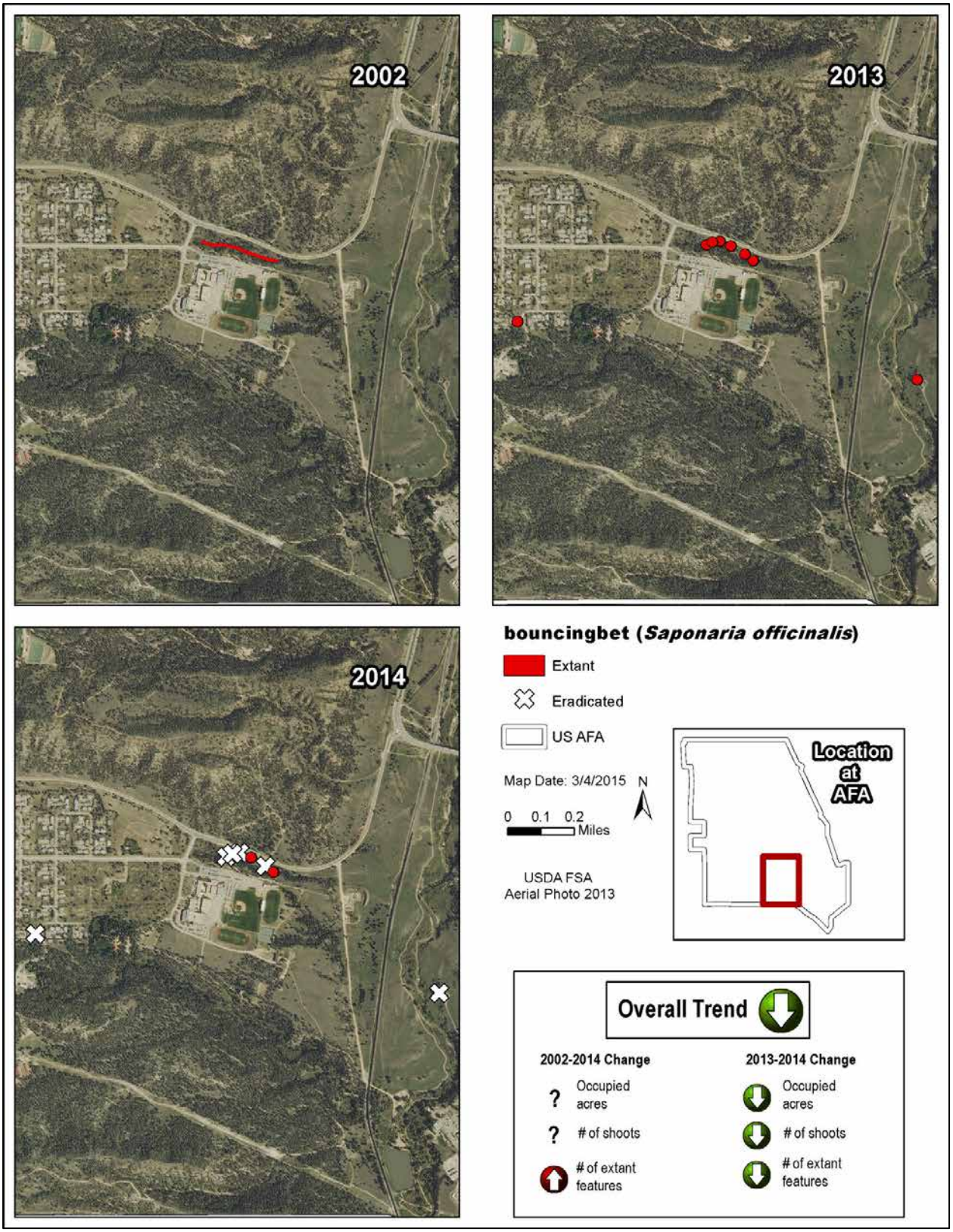
Results: In 2014, 42 individuals were observed in two locations. There were three locations that had been treated in 2013 (Table 19).

Table 19. Bouncingbet summary data, 2002-2014. Bolded indicates treatment.

Census Mapping Method			
Year	*# Shoots*	*# Extant Features*	*Occupied Acres*
2002	---	1	---
2013	42,092	**8**	0.50
2014	42	2	0.14

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 is still localized
- The 2013 locations were treated by the AFA.



Map 23. Distribution of bouncingbet at the Academy between 2002 and 2014.

Tamarisk (*Tamarix ramosissima*)

A new location several miles away from historical occurrences was found in 2014.

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)

2014 Results

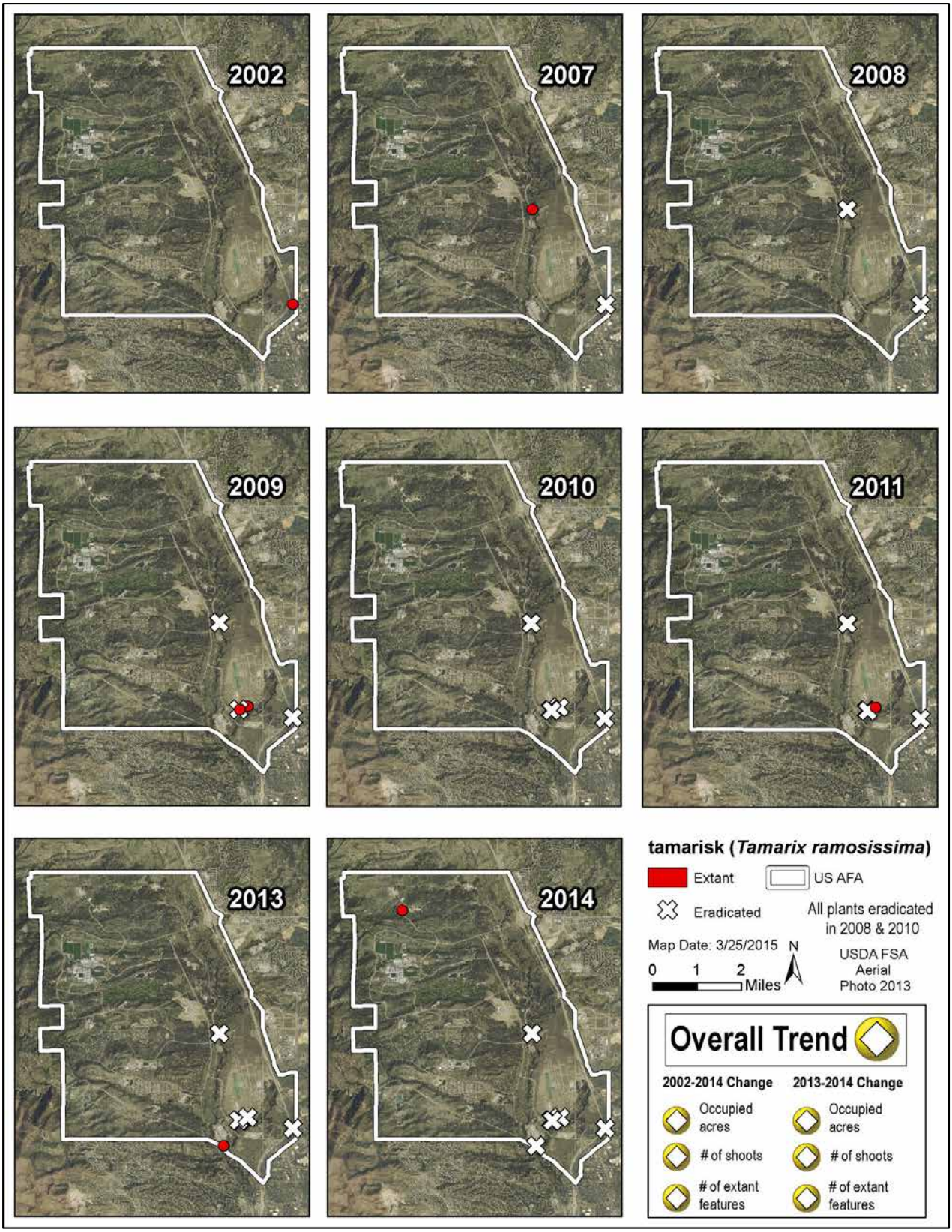
One plant was observed in 2014 and was immediately removed by the AFA (Table 20). Although no more than one or two individuals have been documented in any given year since 2002, the distribution of tamarisk is scattered around the base.

Table 20. Tamarisk summary data, 2002-2014.

Census Mapping Method			
Year	*# Shoots*	*# Extant Features*	*Occupied m^2*
2002	1	1	---
2007	1	1	---
2008	0	0	0
2009	2	2	---
2010	0	0	0
2011	1	1	---
2012	1	1	---
2013	1	1	---
2014	1	1	12.6

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.
- Continued rapid response efforts at the AFA have eliminated the individuals as they are found.



Map 24. Distribution of tamarisk at the Academy between 2002 and 2014.

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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
Russian knapweed	***Acroptilon repens***			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
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
yellow spring bedstraw	***Gallium verum***									M*	M	M	M	M
dames rocket	***Hesperis matronalis***											M*		PM
common St. Johnswort	***Hypericum perforatum***	M			M	M	M	M	M	M	M	M	M	M

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

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

APPENDIX B.

TRANSECT SURVEY PROTOCOLS FOR AFA 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)

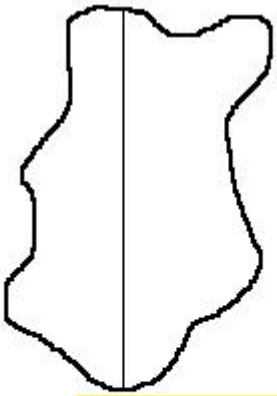
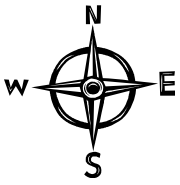


Fig. 1

0 m mark is south or west



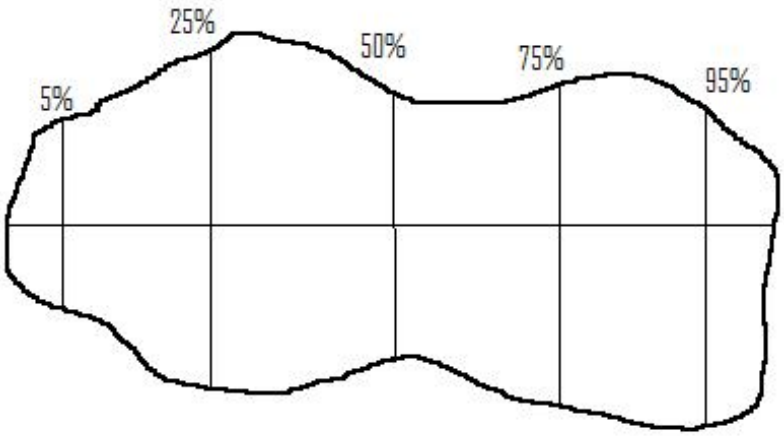


Fig. 2

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)

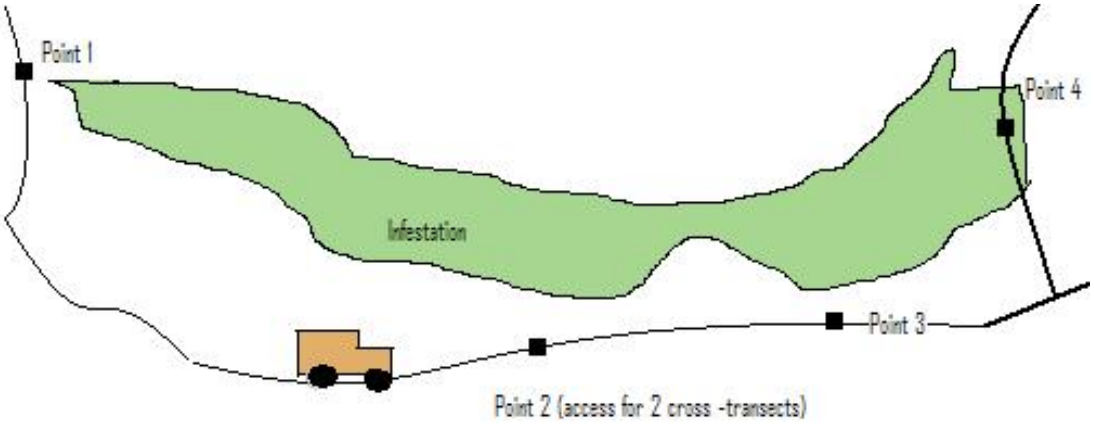

Point 1
Point 4
Infestation
Point 3
Point 2 (access for 2 cross -transects)

Fig. 3

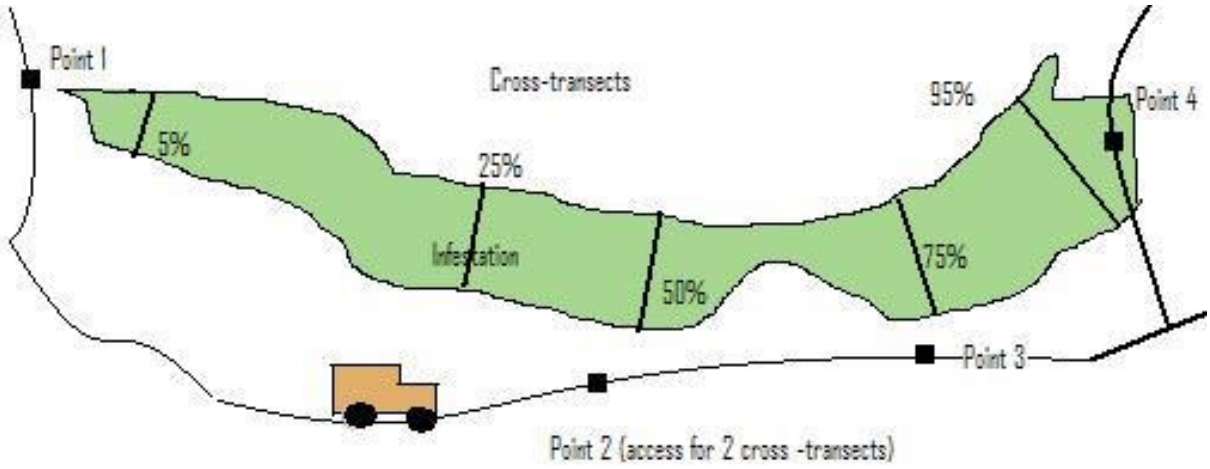

Point 1
Cross-transects
95%
Point 4
5%
25%
Infestation
50%
75%
Point 3
Point 2 (access for 2 cross -transects)

Fig. 4

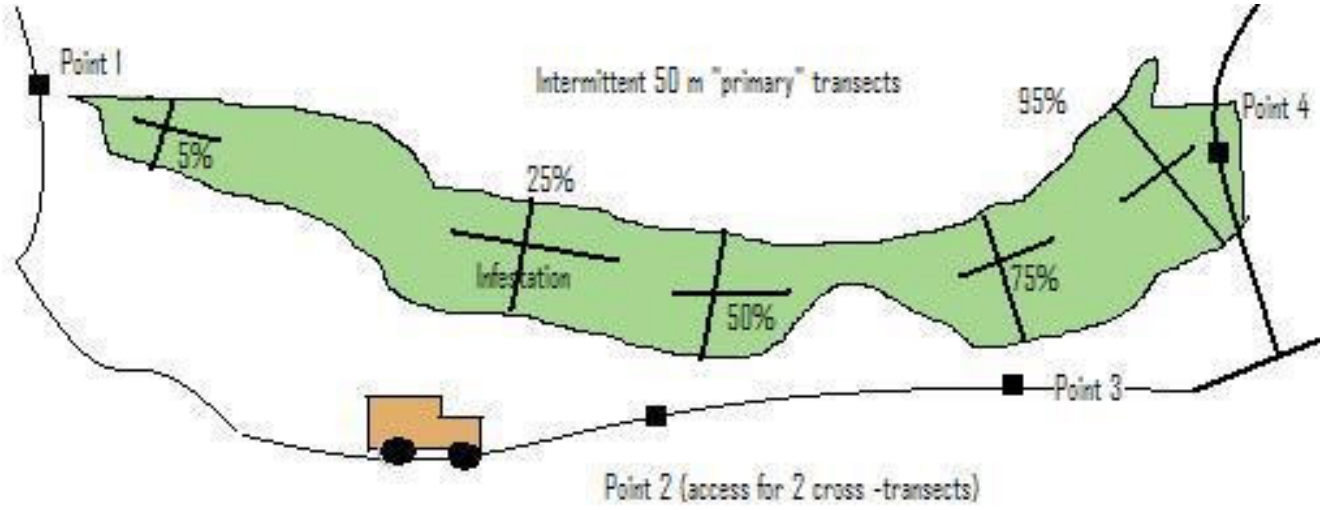


Fig. 5

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 10.0.3 (ESRI 1995-2011), 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 domain 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 technician had the option to document number of individuals or density as number of individuals per square meter. If density was noted, the number of individuals was calculated in the office based on the assigned density and the size of the infestation.

Weed data were stored in a master geodatabase in ArcGIS v10 (ESRI 1999-2010). 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

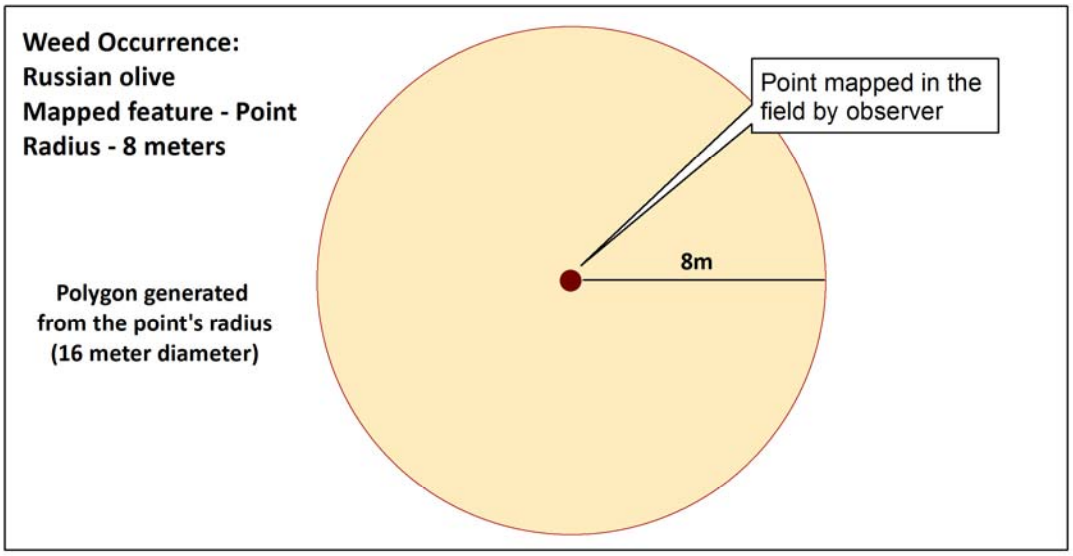
COUNTRY - Country

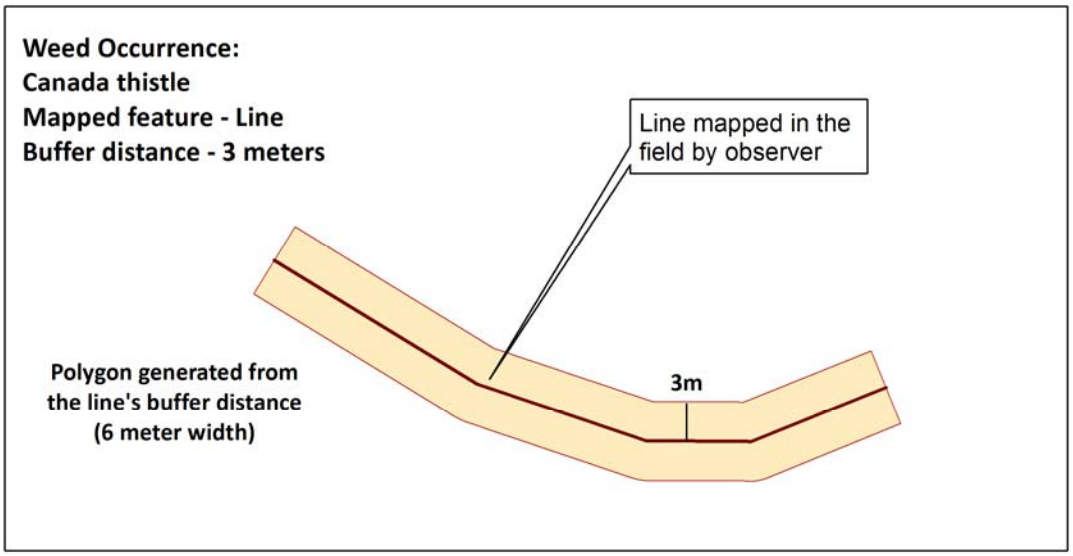
EXAMINER –Field observer

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 2014 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	NA	50	?	2
	2010	0	1	10	1	NA	20	2	NA	61	?	0
	2011	0	2	12	1	NA	26	0	1	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	1?	8	7	0	?	33	1	5	74	2	1
# of Erad. Features	2009	2	0	6	NA	NA	2	0	NA	34	?	3
	2010	4	6	12	0	NA	6	1	NA	30	?	5
	2011	4	6	16	0	NA	5	3	0	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
# of Shoots	2009	?	95	464	NA	NA	95,883	10	NA	1,710	?	2
	2010	0	11	56	700	NA	82,733	107	NA	669	?	0
	2011	0	21	57	1	NA	87,128	0	30	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	1	102	179	0	?	3,604	7	31	1,224	42	1

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	?	NA	3.47	?	<0.01
	2010	0	0.02	0.5	0.01	NA	1.47	0.50	NA	0.66	?	0
	2011	0	< 0.01	0.25	<0.01	NA	1.44	0	0.15	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	<.01?	0.04	0.7	0	?	1.12	<.01	0.21	0.84	0.14	<0.01