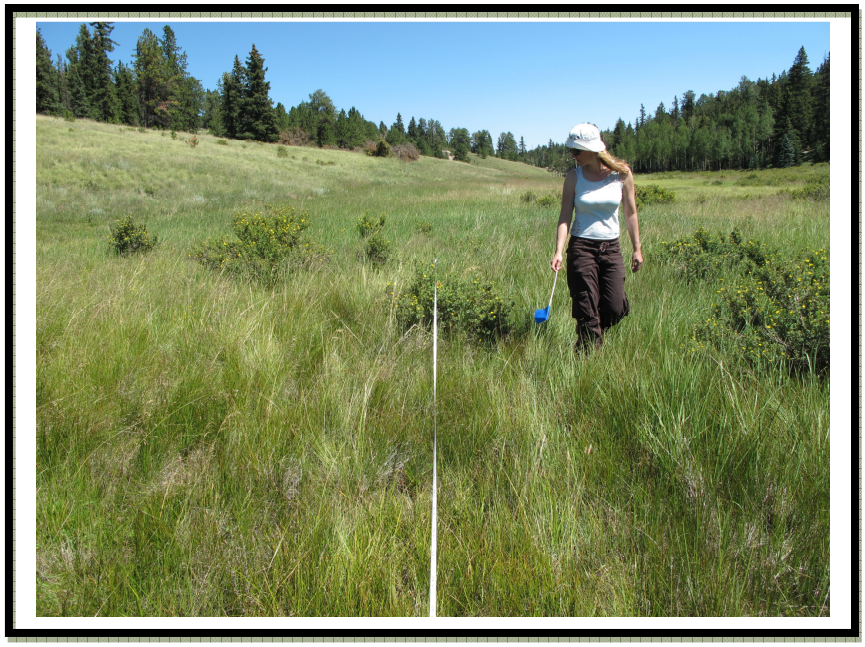
Noxious Weed Monitoring at the U.S. Air Force Academy- Year 7 Results



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On the cover: Amy Lavender at Farish Canada thistle plot 8 Aug 10, 2011.

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EXECUTIVE SUMMARY

This report includes a summary of the results of the past seven years of population monitoring of targeted noxious weeds at the US Air Force Academy ("the Academy"), emphasizing changes that were observed between 2010 and 2011.

In 2009 the sampling methodology of this project was adjusted based on analyses of the past four years' data, and the fieldwork was streamlined to focus resources on the most urgent weed management challenges. In 2011 our sampling methodology was nearly identical to 2009. Management of all noxious weed species at the Academy is important and all are integrated into weed monitoring efforts at the Academy, but the periodicity of sampling for some species has been shifted from every year to every two to five years depending on the species.

Increased emphasis has been given to species for which relatively inexpensive management efforts have a high probability of success. The primary species in this category are myrtle spurge (*Euphorbia myrsinites*), tamarisk (*Tamarix ramosissima*), Russian knapweed (*Acroptilon repens*), Scotch thistle (*Onopordum acanthium*), common St. Johnswort (*Hypericum perforatum*), houndstongue (Cynoglossum officinale), Dalmatian toadflax (*Linaria genistifolia* ssp. *dalmatica*), and yellow bedstraw (*Galium verum*). These species are still relatively uncommon at the Academy and can still reasonably be eradicated or controlled, and also pose a significant risk to the natural resource values of Academy if they continue to spread. A complete census and GIS mapping of all infestations of these species has been conducted annually. Others, including leafy spurge, spotted knapweed, and whitetop, pose an equal threat to the natural resource values of the Academy but their current high abundance precludes an annual census; nonetheless these species continue to be a high priority for management and monitoring.

In addition to monitoring AFA, we set up 23 permanent plots at Farish Memorial Recreation Area. Canada thistle, yellow toadflax, and musk thistle plots were randomly selected from the 2007 weed survey. These permanent plots will allow a better resolution on the control or spread of these noxious weeds.

We will be coordinating with Texas A&M's biocontrol program in 2012 to better integrate biocontrol and herbicide treatment into future monitoring at AFA.

The highlights of 2011 monitoring are listed below.

- **Russian knapweed:** aggressive spraying has *extirpated* the few known populations; however, continued monitoring is necessary to assure that this species is permanently eliminated from the Academy.
- **Musk thistle:** many of the ten plots at AFA were treated however the number of individuals increased over that of 2010. The Farish plots suggest a decline of this species at Farish.
- **Canada thistle:** cover increased in areas where untreated at AFA. The Farish plots suggest a decline of this species at Farish.

- **Leafy spurge:** plot 2 has the largest infestation and biocontrol did not appear to have significant affect. In 2011 part of this infestation was treated with an herbicide. The number of individuals significantly declined. Herbicide treatment should be continued on this plot in 2012.
- **Myrtle spurge:** the aggressive treatment, including herbicide treatment and direct pulling, is having a positive impact. The Academy-wide population and locations decreased from 0.5 to 0.25 acres; however it has not been eradicated.
- **St. Johnswort:** Herbicide treatment occurred on eight of the sites and the number of individuals significantly declined in six of these. Overall, the 2011 occupied area and number of individuals remained similar to 2010. We believe that a few more years of herbicide treatment will have a significant impact. We recommend that CNHP joins the weed sprayer in the field in 2012 so that a more thorough herbicide treatment can occur. Most of the occurrences are within the Kettle Creek floodplain thus careful attention is needed when applying herbicides.
- **Scotch thistle:** occupied acres remained similar to 2010 however the number of individuals decreased from 669 in 2010 to 293 in 2011. On-going weed management is critical for this species.
- **Spotted knapweed:** this species has reached high numbers; we did not conduct any monitoring on this species however we intend to conduct an herbicide vs. biocontrol study in 2012. We will utilized the predicted models developed in 2009 to develop the study in collaboration with Texas A&M.
- **Tamarisk:** continued management and monitoring is necessary, but as of 2010, treatments appear to be keeping this species under control as only one plant was found and removed.
- **Houndstongue and Dalmatian toadflax:** these two species were new to the list and mapped and censused in 2009. An aggressive treatment in 2010 had positive impacts and in 2011 the Dalmatian toadflax was eradicated however houndstongue is still present and will need continued herbicide or pulling treatments.
- **Yellow bedstraw:** This weed was discovered at one area in 2010 and immediately treated with an herbicide. In 2011 one plant was observed and pulled. Rapid response while the infestation is localized is very effective.
- **Yellow toadflax:** Mixed results at Farish plots suggest this species may be eradicated from one site while increasing at other sites. Our observations at Farish noted that this plant is frequent, although cover is seldom high. The Parry's oatgrass rare plant community at Farish has a high frequency and low cover of the toadflax and it is poised to spread and increase in cover when the "right" opportunity arises.

INTRODUCTION

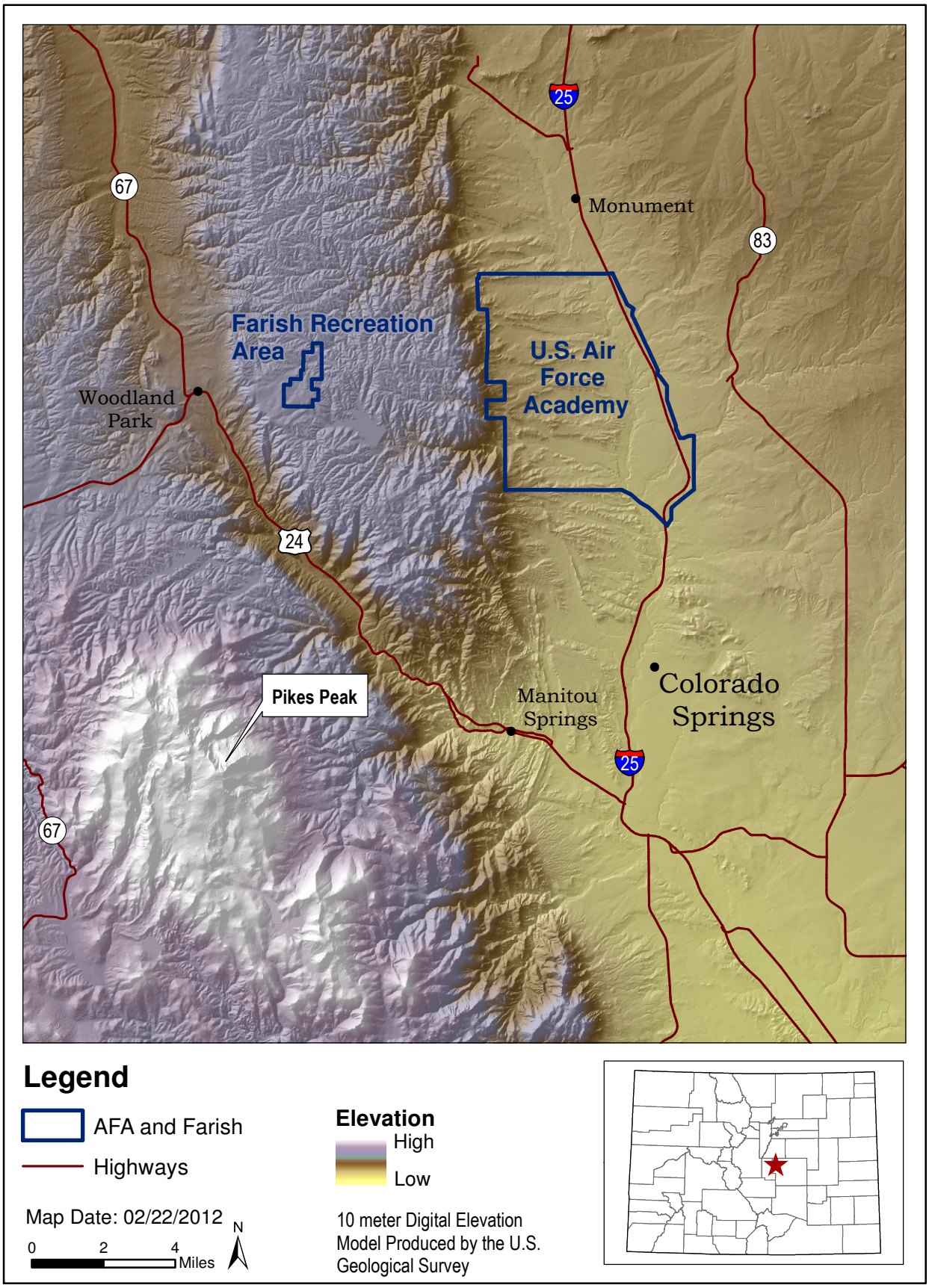
Weeds are known to alter ecosystem processes, degrade wildlife habitat, reduce biological diversity, reduce the quality of recreational sites, reduce the production of crops and rangeland forage plants, and poison livestock (Sheley and Petroff 1999). All of these impacts are occurring in Colorado (Colorado Department of Agriculture 2001). In recognition of their enormous detriments to our society and environment, 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 (Colorado Department of Agriculture Plant Industry Division 2005) and county (El Paso County 2007) weed control regulations for noxious weeds. The Academy has also established management objectives for weed control in order to remain compliant with local weed regulations.

The Academy and the Farish Outdoor Recreation Area ("Farish") are near Colorado Springs, Colorado (Map 1) and are important for local and global biodiversity conservation. The Academy has become increasingly insular and, like many military installations, increasingly important for conservation as natural landscapes elsewhere in the area are developed and altered. In total, at least 30 plants, animals, and plant communities of conservation concern are found at the Academy and Farish, including 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 (Spackman-Panjabi and Decker 2007, Colorado Natural Heritage Program 2008). The Academy is critically important for the conservation of the listed threatened Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (Colorado Natural Heritage Program 2008). Noxious weeds threaten the viability of conservation targets by competing for resources and altering the structure and function of the ecosystems they invade. They also increase the cost while diminishing the likelihood of success of restoration efforts.

History of Weed Mapping and Monitoring at the Academy

In 2002 and 2003, the Colorado Natural Heritage Program (CNHP) mapped selected noxious weeds found at the Academy and Farish (Anderson et al. 2003). The project was undertaken to provide the U.S. Air Force Academy Department of Natural Resources with information on noxious weeds to serve as the basis for development of a formal Integrated Weed Management Plan, and to meet the requirements of a comprehensive management plan. In 2002, 3,936 infestations were mapped for 14 target species at the Academy and Farish, and additional infestations were mapped in 2003 (Anderson et al. 2003).

In 2004, an integrated noxious weed management plan was developed based largely on the results of the weed mapping exercise (Carpenter et al. 2004). The purpose of this plan is to guide the management of noxious weeds at the Academy and Farish in the most efficient and effective manner. This plan supports the 2003-2008 *Integrated Natural Resources Management Plan* for the Academy. The plan set weed management objectives and recommended weed management protocols for the



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

Academy and Farish. The plan also underscored the importance of monitoring weed infestations as a means of measuring the effectiveness of management practices, and recommended monitoring protocols.

Weed management priorities have been set for the Academy and Farish that are based primarily on four factors: 1) current status on State and County noxious weed lists, 2) current prevalence at the Academy or Farish and cost effectiveness of management, 3) potential invasiveness, and 4) the threat posed to significant natural resources (Anderson et al. 2003, Carpenter et al. 2004, Spackman-Panjabi and Decker 2007). For example, myrtle spurge is given a high priority for management due to its status as a List A species, for which eradication is required by state law. However, common St. Johnswort is also given a high priority for management; although State and County weed management statutes do not require eradication of this species, its distribution at the Academy is localized and eradication is feasible at present. This species is also a threat to significant natural resources at the Academy.

In 2005, a monitoring program for 13 species of noxious weeds Russian knapweed (*Acroptilon repens*), whitetop (*Cardaria draba*), musk thistle (*Carduus nutans*), diffuse knapweed (*Centaurea diffusa*), spotted knapweed (*Centaurea maculosa*), Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), Fuller's teasel (*Dipsacus fullonum*), Russian olive (*Elaeagnus angustifolia*), leafy spurge (*Euphorbia esula*), common St. Johnswort (*Hypericum perforatum*), yellow toadflax (*Linaria vulgaris*), and Scotch thistle (*Onopordum acanthium*)) was established at the Academy. Of the 13 species targeted for monitoring in this study, 12 are species that had been mapped in 2002 and 2003. A total of 14 species were mapped in 2002 and 2003, but two species (Tamarisk, *Tamarix ramosissima,* and field bindweed, *Convolvulus arvensis*) were not targeted for monitoring. Tamarisk was not targeted for monitoring because the single plant discovered in 2002 had been destroyed and there had been no new reports of this species at the Academy. Field bindweed was not targeted for monitoring because it occurs sporadically in relatively small infestations in a limited area of the Academy, mostly near infrastructure. Russian knapweed was discovered at the Academy in 2004, so it was not mapped in 2002 and 2003 but is included as a monitoring target because of its legal status and invasiveness.

In 2006, all permanent monitoring plots established in 2005 were resampled. A fourteenth species, myrtle spurge (*Euphorbia myrsinites*) was added to this study because it is listed on Colorado's A List of noxious weeds, and eradication of this species is required under state law (Colorado Department of Agriculture 2005). It was discovered at the Academy in 2005 by Natural Resources staff. In 2007, the monitoring plots were sampled a third time. The first three years of data from this project were analyzed and presented in the 2009 report (Anderson et al. 2009).

In 2007 CNHP completed a weed map of the Academy and Farish, completely revising the baseline weed survey completed in 2002 and 2003 for most target species (Anderson and Lavender 2008a). Data from this study were complementary to the ongoing monitoring project.

Weed monitoring also continued in 2007. The first three years of monitoring data were analyzed and the results were used to adjust the monitoring protocols and

priorities in subsequent years of monitoring. The report for 2007 (Anderson and Lavender 2008b) includes specific recommendations for continued weed monitoring that were followed in 2008. The results of 2008's field work were summarized and presented in the year-4 report, and modifications and additions to previous methods were detailed (Anderson et al. 2009).

In 2009, we applied the recommendations from the year-4 results (Rondeau et al. 2010). Two additional species were mapped in 2009: houndstongue (*Cynoglossum officinale)* and Dalmatian toadflax (*Linaria genistifolia* ssp. *Dalmatica).* A total of 46,468 m^2 (11.48 acres) of infestations were mapped for 14 target species in 2009.

In 2010 and 2011, we primarily mirrored 2009 methods; however, we did not monitor diffuse knapweed nor whitetop (Cardaria draba). A total of 16,102 m^2 (3.98 acres) of infestations were mapped for 10 target species in 2011.

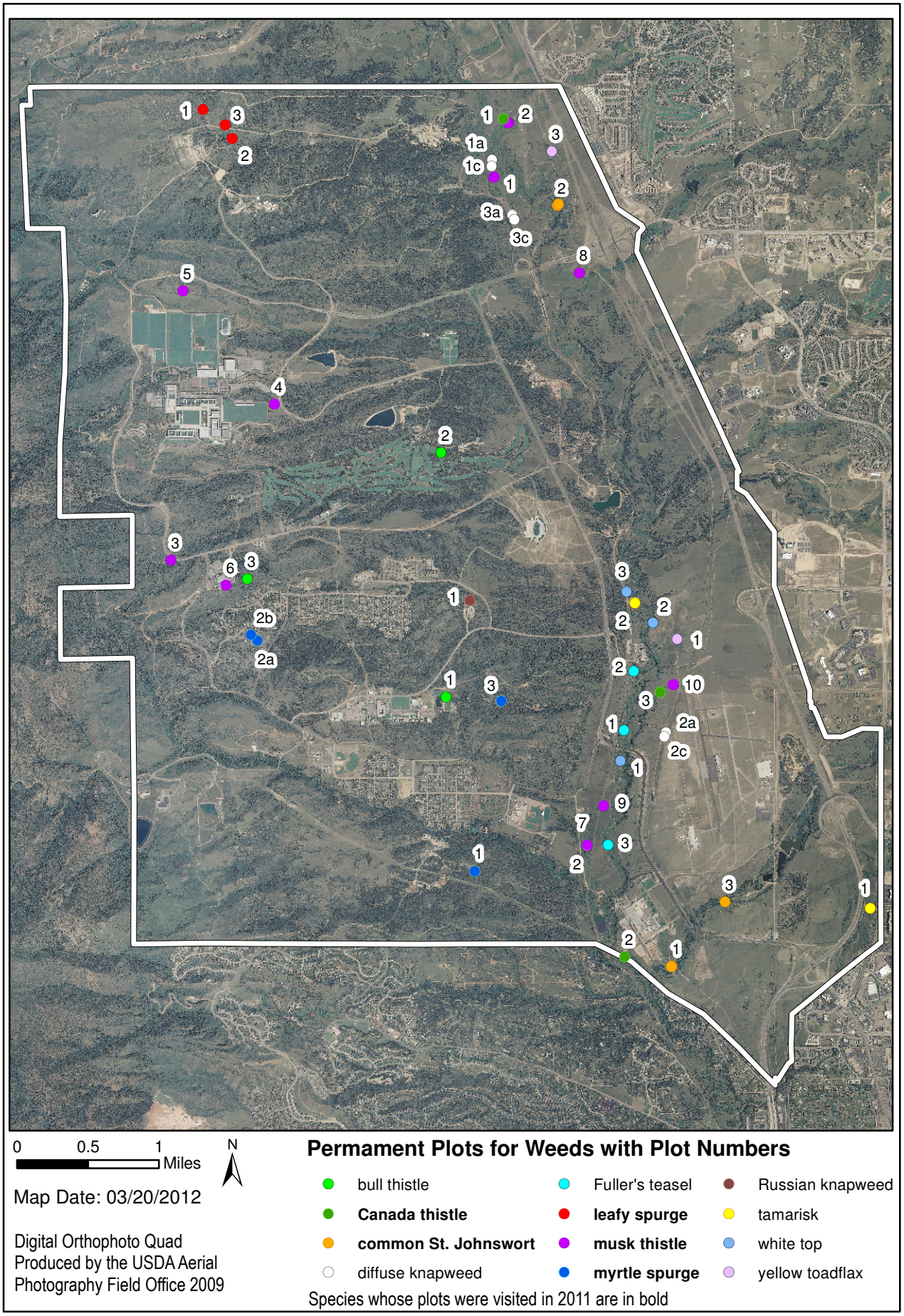
METHODS

This project was undertaken to evaluate the effectiveness of ongoing management of noxious weeds at the Academy, and to determine whether weed management objectives are being met. The recommendations for the design and deployment of monitoring plots offered by Carpenter et al. (2004) were adhered to closely in this study. The monitoring program at the Academy has utilized a combination of permanent plots and census techniques, as recommended by Carpenter et al. (2004). Adjustments were made to these methods in 2009 as indicated by analysis of the first four years of monitoring data (Anderson et al. 2009).

In 2010, combinations of transect sampling, photoplots, photopoints, survey transects, perimeter mapping, and census were utilized in monitoring the target noxious weed species. These methods have been described in detail in Anderson and Lavender (2006) and Anderson and Lavender (2007). Details on which methods were utilized for each target species are presented in Table 1. Permanent plot locations are presented in Map 2.

Table 1. Summary of methods used for sampling, mapping, and modeling in 2010 and 2011.

Species	2010 Sampling Methods	2011 Sampling Methods
Russian knapweed	*Perimeter mapping/ census*	*perimeter mapping/ census*
Spotted knapweed	*Ground-truthed predicted occurrence model*	*Not sampled*
Whitetop	*Belt transects/photopoints*	*Not sampled*
Musk thistle	*10 Photopoints/ estimated size*	*10 Photopoints / estimated size*
Diffuse knapweed	*Not sampled*	*Not sampled*
Canada thistle	*Transect/photopoints/photoplot*	*Transect/ photopoints/ photoplot*
Scotch thistle	*Perimeter mapping/census*	*Perimeter mapping/census*
Bull thistle	*Not a target in 2010*	*Not a target in 2011*
Fuller's teasel	*Not a target in 2011*	*Not a target in 2011*
Leafy spurge	*Perimeter mapping/survey transects/photopoint*	*Perimeter mapping/ survey transects/ photopoint*
Common St. Johnswort	*Photopoints/quadrats and perimeter mapping*	*Photopoints/ quadrats and perimeter mapping*
Yellow toadflax	*Perimeter mapping/census*	*Perimeter mapping/census*
Houndstongue	*Perimeter mapping/census*	*Perimeter mapping/census*
Myrtle spurge	*Perimeter mapping/census/photopoints*	*Perimeter mapping/ census/ photopoints*
Tamarisk	*Perimeter mapping/ census*	*Perimeter mapping/ census*
Yellow bedstraw	*1st observation in 2010; perimeter mapping/census*	*Not observed*
Dalmatian toadflax	*Not sampled*	*Set up 10 permanent transects at Farish*



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

RESULTS AND RECOMMENDATIONS

The 2010 growing season was relatively dry with only 52% of the average precipitation (Table 2). The non-growing months were 40% drier than average at just 10.3 inches vs. the normal 17.4 inches (Table 2).

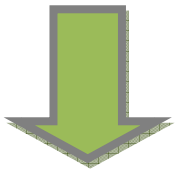
Results specific to each target noxious weed species and for the natural resource based monitoring plots are summarized in the following sections. See Appendix A for additional information.

Table 2. Summary data for monthly precipitation (inches) at Colorado Springs WSO station 51778 for water year. Average precipitation is for 1949-2011 (http://ccc.atmos.colostate.edu).The growing months (summer) are shaded.

Water Yr.	Data	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Summer Total	Annual Total
2004-2005	**Monthly Precip.**	**0.18**	**0.65**	**0.24**	**0.78**	**0.04**	**1.03**	**1.08**	**0.73**	**2.10**	**1.91**	**2.65**	**0.68**	**9.15**	**12.07**
	Average	0.78	0.45	0.32	0.29	0.31	0.88	1.36	2.12	2.27	2.87	2.93	1.24	12.79	**15.82**
	% of Ave.	0.23	1.44	0.75	2.69	0.13	1.17	0.79	0.34	0.93	0.67	0.90	0.55	72%	76%
2005-2006	**Monthly Precip.**	**0.48**	**0.08**	**0.30**	**0.24**	**0.04**	**0.24**	**0.09**	**0.81**	**0.82**	**4.42**	**3.52**	**1.51**	**11.17**	**12.55**
	Average	0.78	0.45	0.32	0.29	0.31	0.88	1.36	2.12	2.27	2.87	2.93	1.24	12.79	**15.82**
	% of Ave.	0.62	0.18	0.94	0.83	0.13	0.27	0.07	0.38	0.36	1.54	1.20	1.22	87%	79%
2006-2007	**Monthly Precip.**	**1.57**	**0.19**	**0.39**	**0.31**	**0.17**	**0.66**	**1.85**	**2.35**	**0.94**	**1.74**	**2.69**	**0.34**	**9.91**	**13.20**
	Average	0.78	0.45	0.32	0.29	0.31	0.88	1.36	2.12	2.27	2.87	2.93	1.24	12.79	**15.82**
	% of Ave.	2.01	0.42	1.22	1.07	0.55	0.75	1.36	1.11	0.41	0.61	0.92	0.27	77%	83%
2007-2008	**Monthly Precip.**	**0.25**	**0.10**	**0.39**	**0.46**	**0.19**	**0.96**	**0.39**	**0.34**	**0.52**	**0.29**	**4.31**	**4.97**	**10.82**	**13.17**
	Average	0.78	0.45	0.32	0.29	0.31	0.88	1.36	2.12	2.27	2.87	2.93	1.24	12.79	**15.82**
	% of Ave.	0.32	0.22	1.22	1.59	0.61	1.091	0.29	0.16	0.23	0.101	1.471	4.0081	85%	83%
2008-2009	**Monthly Precip.**	**0.14**	**0.25**	**0.15**	**0.09**	**0.04**	**0.45**	**1.52**	**2.39**	**2.91**	**3.82**	**1.84**	**1.2**	**13.68**	**14.80**
	Average	0.78	0.45	0.32	0.29	0.31	0.88	1.36	2.12	2.27	2.87	2.93	1.24	12.79	**15.82**
	% of Ave.	0	0.56	0.47	0.31	0.13	0.511	1.12	1.13	1.28	1.331	0.628	0.9677	107%	94%
2009-2010	**Monthly Precip.**	**0.36**	**0.45**	**0.67**	**0.12**	**0.49**	**0.55**	**1.26**	**0.82**	**0.34**	**2.67**	**2.47**	**0.09**	**7.65**	**10.29**
	Average	0.78	0.45	0.32	0.29	0.31	0.88	1.36	2.12	2.27	2.87	2.93	1.24	12.79	**15.82**
	% of Ave.	0.46	1	2.09	0.41	1.58	0.625	0.93	0.39	0.15	0.93	0.843	0.0726	60%	65%
2010-2011	**Monthly Precip.**	**0.43**	**0.07**	**0.07**	**0.11**	**0.14**	**0.54**	**0.68**	**0.71**	**0.31**	**4.90**	**1.49**	**5.91**	**14.00**	**15.36**
	Average	0.78	0.45	0.32	0.29	0.31	0.88	1.36	2.12	2.27	2.87	2.93	1.24	12.79	**15.82**
	% of Ave.	0.55	0.16	0.22	0.38	0.45	0.614	0.5	0.33	0.14	1.707	0.509	4.7661	109%	97%

Acroptilon repens (Russian knapweed)

Species	Sampling Methods
Russian knapweed	*perimeter mapping and census at all locations*



Russian knapweed has not been observed for three years (2009-2011). ***SUCCESS***

In 2009 Russian knapweed was treated with herbicide in the eastern portion of the large infestation near the Skills Development Center, it appears that the treatment was successful as we did not locate any individuals in 2010 or 2011.

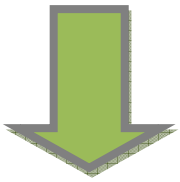
Russian knapweed was observed along Douglass Drive in 2005 and 2006 but not 2008-2011.

We recommend annual visits to these sites by AFA weed contractors and a follow up site visit by CNHP.

Carduus nutans (tusk thistle)

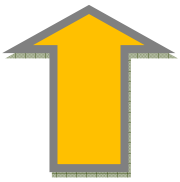
Species	Sampling Methods	Plots 1-10
Musk thistle	*Photopoint*	1 photopoint per plot

Treated



Number of individuals declined in treated plots.

Untreated



Number of individuals generally increased in untreated plots.

Ten of the ten established plots were revisited in 2011 (see Map 2 for locations). Photos were repeated from the permanent rebar and plants that occur within the frame of the photo were counted (Tables 3 and 4). Four plots were treated with herbicide prior to sampling and plot 2 was treated after we sampled. Number of individuals increased significantly in plots 2 and 10, both untreated, and decreased significantly in plots 5, 6, and 7 (Table 4). This suggests that musk thistle is killed when treated with herbicide and that the spraying has successfully reduced the population size of musk thistle at AFA. Recommendations for musk thistle include continuation of herbicide treatment of large infestations in 2012, and manual destruction of

plants in smaller infestations and bag inflorescences if they contain ripe seed. All 10 plots should be revisited in 2012.

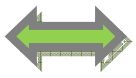
Table 3. Musk thistle plot and associated treatment. Tx is shorthand for "treatment."

Plot	2005	2006	2007	2008	2009	2010	2011
1	no Tx	herbicide	no Tx	no Tx	No Tx	herbicide	herbicide
2	no Tx	herbicide	no Tx	herbicide	No Tx	herbicide	No Tx
3	herbicide	no Tx	herbicide	herbicide	herbicide	herbicide	No Tx
4				no Tx	No tx	herbicide	No Tx
5				no Tx	No tx	herbicide	No Tx
6				herbicide	No tx	herbicide	No Tx
7				herbicide	herbicide	herbicide	herbicide
8				no Tx	herbicide	herbicide	herbicide
9				no Tx	herbicide	herbicide	herbicide
10				no Tx	Not visited	herbicide	No Tx

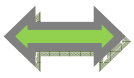
Table 4. Musk thistle population size at 10 plots, 2005-2010. Bolded numbers were treated plots.

Plot	2005	2006	2007	2008	2009	2010	2011
1	13	**0**	12	11	134	**9**	**7**
2	116	**0**	19	**6**	80	**5**	160
3	**25**	0	**8**	**1**	**2**	**1***	8
4				1	63	**0**	0
5				1	27	**10***	0
6				**10**	45	**33**	3
7				**102**	**90**	**25**	**0**
8				212	**31**	**10**	**7**
9				160	**1**	**1**	**0**
10				500	Not visited	**40+**	400

Cirsium arvense (Canada thistle)



Plot 1(**not treated**) slight increase in y11



Plot 2 (**not treated**) was stable in y11

Plot 3 (**untreated**) increased in y11

Species	Sampling Methods	Plot 1	Plot 2	Plot 3

Canada thistle	*Transect/ photopoint/ photoplot*	50 m transect, 20 quadrats, 5 photoplots, 2 photopoints	50 m transect, 20 quadrats, 5 photoplots, 2 photopoints	50 m transect, 20 quadrats, 5 photoplots, 2 photopoints

Canada thistle is one of the most abundant noxious weeds at the Academy, second only to yellow toadflax in occupied area (Anderson and Lavender 2008a). Along with yellow toadflax, it is one of two species that is only targeted for management within high priority conservation areas.

Canada thistle percent cover and related precipitation for all three plots over all sampled years are graphed in Figure 1.

Plot 1 is in the Black Forest stream restoration project that began in 2008 and the combination of herbicide treatment (Table 5) with an increase in water table has drastically reduced Canada thistle cover from 33% in 2005 to just 4% in 2011 (Table 6).

Plot 2 is in a Monument Creek meadow below the RV parking lot and Civil Engineering Picnic Area. This plot was treated in multiple years and the Canada thistle went from 25% cover in 2005 to 0% in 2010 and 2011 (Tables 6 and 7). It appears that while the herbicide successfully decreased Canada thistle it allowed the exotic monocot, smooth brome, to drastically increase from 22% cover in 2005 to 64% cover in 2010 (Table 7, Figure 3). In 2010, a new power line was erected near plot 2.

Plot 3 has never been treated and Canada thistle has varied from a high of 33% in 2005 to a low of 8% in 2007 and 2008, perhaps due to precipitation variation. In 2011 Canada thistle had 24% cover, an increase over 2010 (Tables 7 and 8).

At plot 3, two probable Southern Rocky Mountain cinquefoil plants were found in 2008 and 2009, just north of the transect. Previously this site has been searched for Southern Rocky Mountain cinquefoil due to the abundance of wooly cinquefoil (*Potentilla hippiana*) and beautiful cinquefoil (*P. pulcherrima*). Southern Rocky Mountain cinquefoil is often found with these species and may actually be a hybrid involving these species in its parentage. The Rocky Mountain cinquefoil at this site has somewhat uncharacteristic leaves which have been seen in other occurrences at the Academy but apparently nowhere else, with decurrent blades on the leaflets.

We suggest that in 2012, Plot 3 remain as is, that is, not treated, while Plot 1 and 2 remain under treatment. This is a small sample size and because Plot 1 underwent a drastic restoration project the sample size is even smaller than it appears. If time and funding in 2012 permits, we suggest adjusting the sampling design to 10 plots and collaborating with Texas A&M in order to understand the trend of this species.

Table 5. Canada thistle treatment applications at the three permanent plots, 2005-2011. Tx is shorthand for "treatment."

Plot	2005	2006	2007	2008	2009	2010	2011
1	no Tx	herbicide	no Tx	herbicide	no Tx	herbicide	herbicide
2	no Tx	herbicide	no Tx	no Tx	herbicide	herbicide	No Tx
3	no Tx	no Tx	no Tx	no Tx	no Tx	No Tx	No Tx

Table 6. Canada thistle cover (%) from the three permanent monitoring plots, 2005-2011. Summer precipitation is for May-September.

	Plot 1	Plot 2	Plot 3	Summer Precipitation (in)
2005	33.5	24.7	33.5	8.07
2006	17.1	5.4	14	11.08
2007	0.3	2.2	8.2	8.06
2008	0.1	2.6	8.2	10.43
2009	0.5	1.5	13.7	12.16
2010	2	0	18	6.39
2011	4	0	24	14.0

Table 7. Canada thistle, smooth brome and snowberry cover (%) for Plot 2.

	2005	2006	2007	2008	2009	2010	2011
Canada thistle	25	5	2	3	2	0	0
Smooth brome	22	12	24	11	40	64	54
Snowberry	16	11	11	10	14	12	22

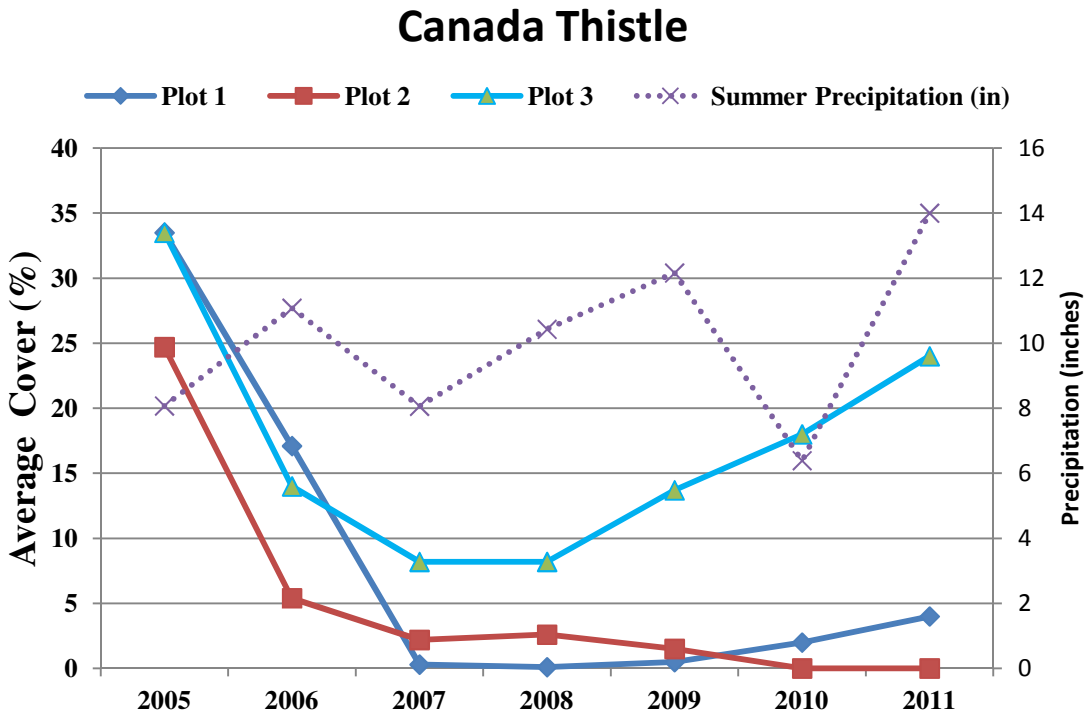


Figure 1. Canada thistle cover (%) for three permanent plots from 2005-2011 and the associated summer precipitation (May-September).

Euphorbia esula (leafy spurge)

Plot 1. Occupied area remained nearly the same as 2009. **No treatment.**

Plot 2. Occupied area remained similar to 2010; no. of ramets significantly decreased in 2010; **Herbicide treatment.**

Plot 3. Occupied area was nearly identical to 2010; no. of ramets increased. **Herbicide treatment.**

Species	Sampling Methods	Plot 1	Plot 2	Plot 3
Leafy spurge	*Perimeter mapping/ survey transects*	Perimeters mapped, 5 E-W survey transects spaced 20m apart	Perimeters mapped, 4 E-W survey transects spaced 20m apart	Perimeters mapped, 4 E-W survey transects spaced 20m apart

Over the course of this study 2005-2011, leafy spurge plots have experienced herbicide and biocontrol treatments as well as no treatment. The plot that has never been treated is the only plot that has not expanded while the other two treated plots had increased, regardless of treatment type. However, in 2011 plot 2 was treated with herbicide in addition to the biocontrol and there was a significant decrease in number of individuals.

Plot 2 has the largest population of the three plots (Table 9, Figure 2 and 3, Map 3). At plot 2, a biocontrol agent was released in 2005 and herbicide treatment only occurs outside of the plot (personal communication with Brian Mihlbachler, 2010). From 2005 to 2010, leafy spurge spread into uninfested areas at this site. In 2010, the occupied area grew by another 378 m^2 (0.09 acres) and the number of ramets drastically increased from 295 in 2009 to 27,653 in 2010. This site has become challenging to monitor because it continues to grow. Overall, the area occupied and number of stems increased continuously from 2005 through 2008 despite treatment efforts, and was stable in 2009 but increased again in 2010 (Tables 8 and 9). In 2011 the site was treated with an herbicide and although the total area changed very little, the number of individuals had a significant drop from 27,653 in 2010 to 1,980 in 2011. It appears that the herbicide treatment was more successful than the biocontrol treatment.

Herbicide was applied to the largest infestation at plot 3 in 2007-2010, although the poor condition of the plants in this plot in 2008, due to drought, made it difficult to tell. No plants were seen at the small founder infestation on the west side of this plot. An infestation of white top was observed at this site in 2008 that is the first known infestation of this species in Jack's Valley. This plot has been fairly stable since 2009 however there was an increase in the number of individuals in 2010, but this is still a small population.

The small infestation at plot 1 was not treated in 2005-2011, and no new infestations were detected at this plot in 2011, better yet, the occupied area remained stable at 100 m^2 (0.025 acres) and the number of ramets slightly declined from 150 to 135 (Table 9, Figure 2).

Table 8. Leafy spurge treatment applications for the plots from 2005-2010. Tx is shorthand for "treatment".

Plot	2005	2006	2007	2008	2009	2010
1	no Tx	no Tx	no Tx	no Tx	no Tx	No tx
2	biocontrol	biocontrol	biocontrol	biocontrol	biocontrol	Herbicide
3	no Tx	no Tx	Herbicide (in part)	Herbicide (in part)	Herbicide	No tx

Table 9. Leafy spurge summary data from the three permanent plots. Summer precipitation is May-September. Bolded numbers indicate that the plot was treated with herbicide in that year. Plot 2 had a biocontrol treatment started in 2005. Summer precipitation is for May-September.

		Occupied Area (m^2)	N (ramets)	# patches	Summer Precipitation (in)
Plot 1	**2005**	78	234	1	8
	2006	146	5,840	1	11
	2007	129	5,149	1	8
	2008	313	40	1	10
	2009	100	200	1	12
	2010	100	150	1	6
	2011	100	135	1	14
Plot 2	**2005**	2,340	6,097	6	8
	2006	3,193	11,130	7	11
	2007	4,214	18,156	4*	8
	2008	5,533	1,076	5	10
	2009	5,373	295	4	12
	2010	5,751	27,653	4	6
	2011	**5,778**	**1,980**	**5**	**14**
Plot 3	**2005**	79	393	1	8
	2006	97	970	2	11
	2007	**108**	**545**	**3**	**8**
	2008	**144**	**13**	**2**	**10**
	2009	**185**	**11**	**3**	**12**
	2010	**185**	**23**	**3**	**6**
	2011	185	74	3	14

* In 2007, several smaller patches grew and amalgamated into four larger patches at plot 2.

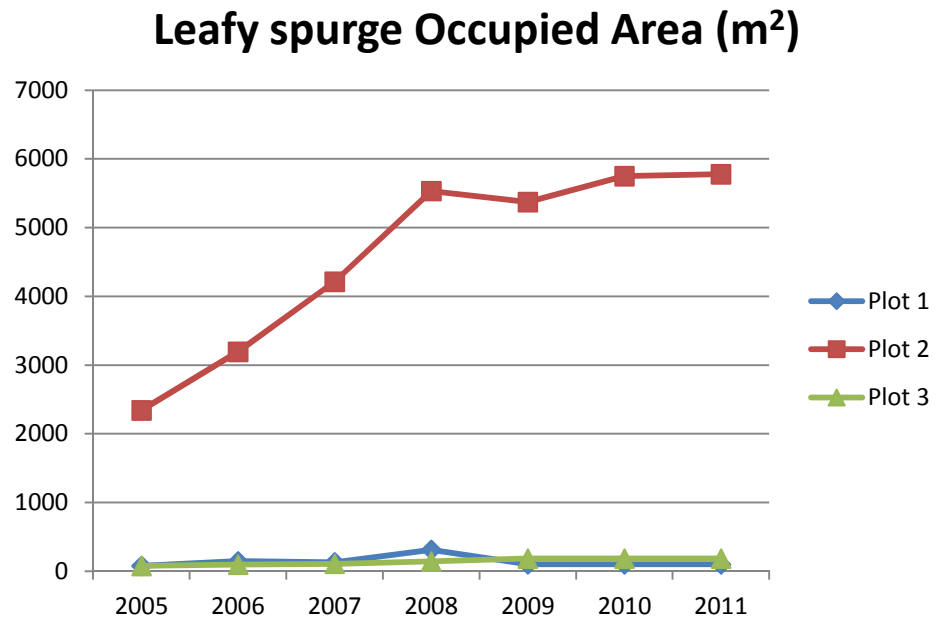


Figure 2. Occupied area of leafy spurge at three plots 2005-2011.

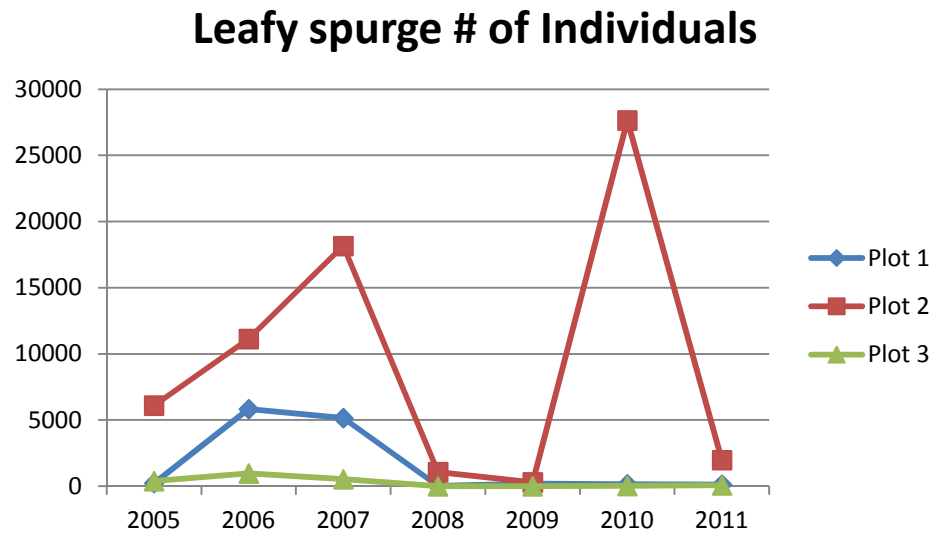
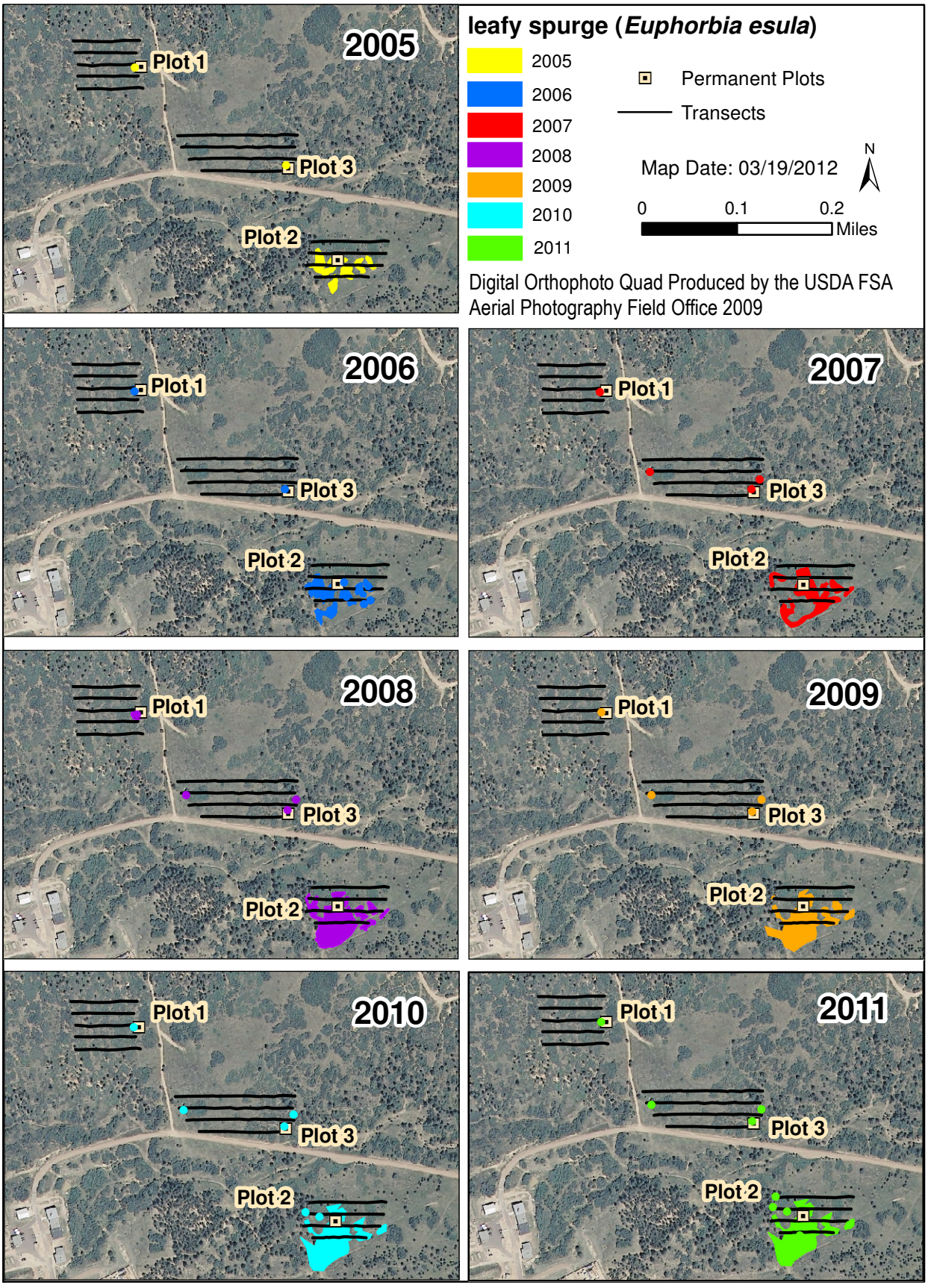
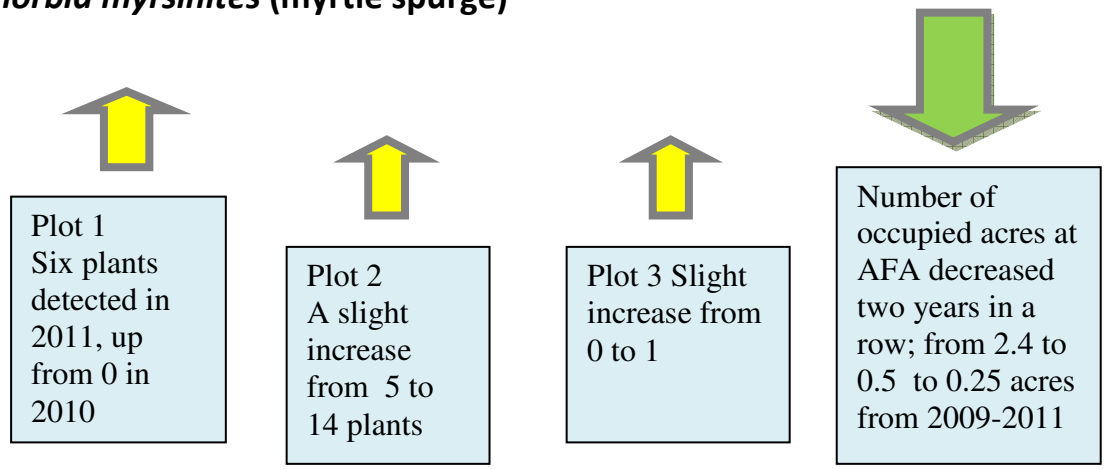


Figure 3. Number of individuals (ramets) of leafy spurge at three plots 2005-2011.



Map 3. Distribution of leafy spurge at the three permanent plots between 2005 and 2011.

Euphorbia myrsinites (myrtle spurge)



Species	Sampling Methods	Plot 1	Plot 2	Plot 3	Additional locations
Myrtle spurge	*Perimeter mapping/ census/ photopoint*	Perimeter mapping, census, 1 photopoint	Perimeter mapping, census, 2 photopoints	Perimeter mapping, census, 1 photopoint	Perimeter mapping, census, photos

Myrtle spurge is on the noxious weed list, A status, mandating the eradication of this species wherever it is found (Colorado Department of Agriculture, Plant Industry Division 2005). Fortunately, Natural Resources Staff at the Academy identified the presence of myrtle spurge at an early stage of its invasion, and some progress is being made towards its eradication (Table 10, Figure 4, and Map 4). See Appendix A for information about each location depicted on the map. The three permanent plots for this species were established at the only known extant infestations in 2006, but there are now 9 additional infestations that are also being mapped (Map 4). The total area infested by myrtle spurge at the Academy in 2011 was 1017 m^2 (0.25 acres) with a total of 57 individuals at 12 locations; this is a slight reduction in overall area from 2010 however the number of known extant locations increased from 10 to 12, potentially indicating a spread of this species. The number of individual's remains low (56) and was nearly identical to 2010. (Table 10 and Figure 4).

AFA's efforts at eradicating this species is keeping this species in check and this kind of effort (spraying and pulling) needs to continue in future years.

Table 10. Myrtle spurge summary data.

	2005	2006	2007	2008	2009	2010	2011
No. of individuals	25	243	261	419	464	56	57
Area (m^2)				2,678	9,643	2,203	1,017
Area (acres)				0.66	2.4	0.5	0.25
Extant locations				13	12	10	12
Eradicated locations				1	6	12	16

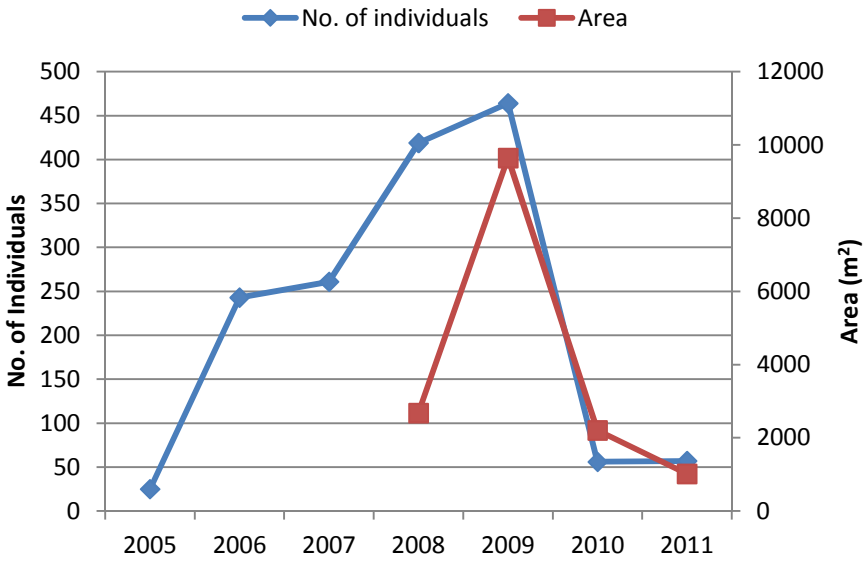
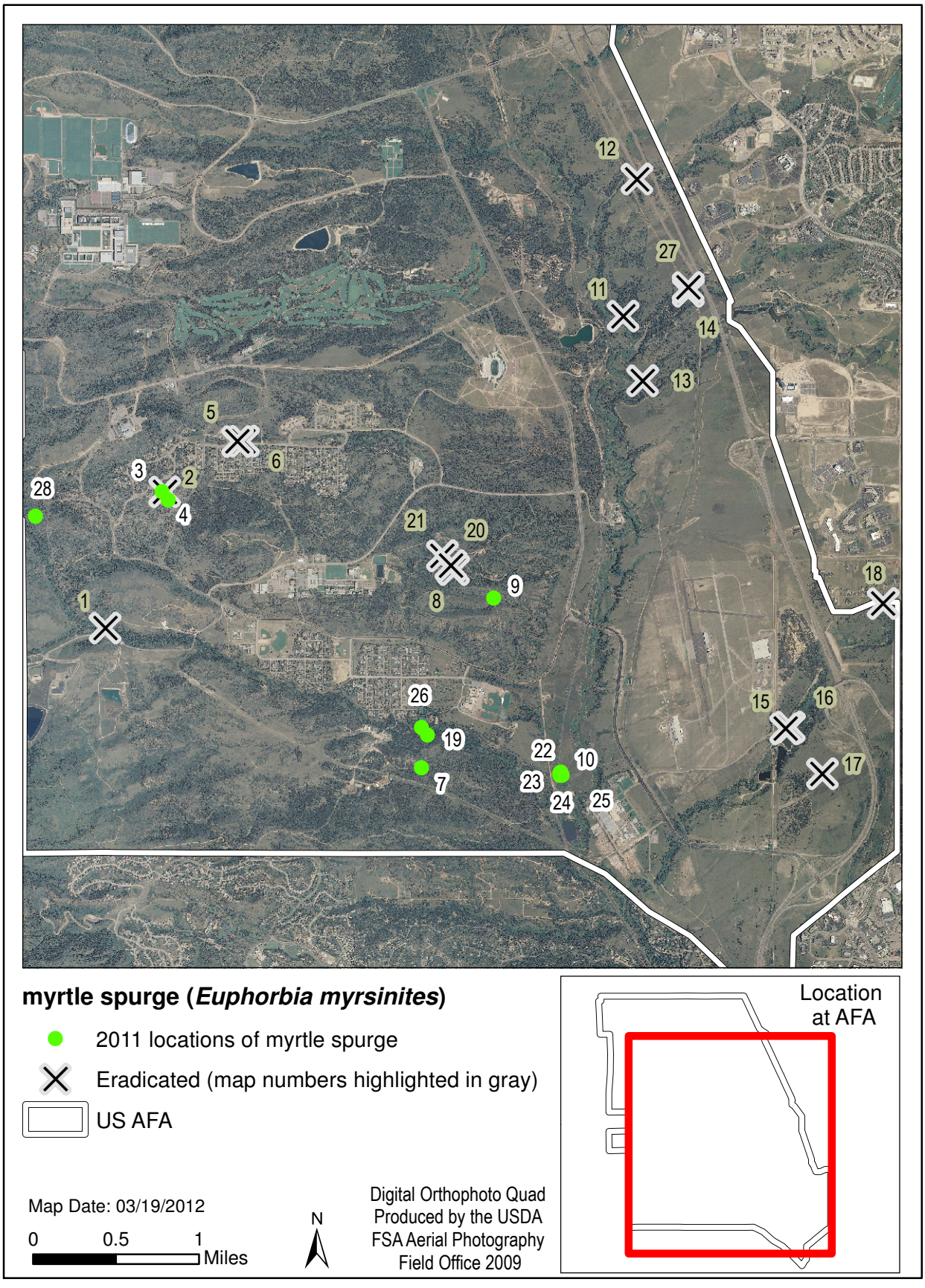


Figure 4. Number of individuals and occupied area for myrtle spurge 2005-2011.



Map 4. All known sites where myrtle spurge has been found at the Academy between 2005 and 2011. Numbers correspond to the locations described in the Appendix.

The following paragraphs summarize the permanent plot data depicted in Table 11. Plot 1 is located east of the stables in a dense stand of ponderosa pines that is being thinned. Aggressive measures were taken in 2005 and 2006 to eradicate this infestation by pulling and excavating plants. This reduced the density but many small plants were found in 2007 that may have sprouted from seeds or from rootstock that remained underground after the 2006 treatment. In 2008 myrtle spurge was once again abundant at this site (N=146) and the site had not been treated. No flowering individuals were observed in 2008 but some flowering stalks were present. A beetle tree was felled upslope and dragged through the N edge of the infestation. In 2009, plants were pulled, however 10 plants were still present when we monitored this site in August. In 2010 no plants were observed and in 2011 six plants were observed, thus indicating that the seed bank is alive and well. We recommend continued monitoring of this site as seeds may survive in the soil bank for years.

Plot 2 is located at the southwestern edge of the housing in Douglass Valley behind 4176 Douglass Way, where two large patches were documented in past years. There was no evidence of treatment at this plot in 2006 or 2007. In 2006, myrtle spurge was found in a rock garden adjacent to the two large patches where the resident said they had dug up four plants from behind their house and planted it; the resident voluntarily removed the plants after realizing it is a noxious weed. In 2007, another lone individual was found between two houses just east of the northernmost patch; the plant was pulled. The number of individuals at this plot increased considerably from 2006 to 2007 (Table 11). In 2008 large, reproductive plants remained at this location and no treatment was evident. In 2009 restoration occurred in part of this site, with drill seedling of *Lolium* and *Avena*; 21 seedlings were visible. The other area at this site did not have any treatment and had 70 individuals (See Appendix A). The AFA continues to treat this site and by August of 2010 only 5 small plants were noted and 11 small plants were noted in 2011 . Continued diligence is necessary to completely eradicate this species from the site.

Plot 3 is located in the Archery Range area near Sumac Drive. It was treated with herbicide in 2006. This was somewhat successful, but again there were numerous small plants sprouting from seed or rootstock in 2007. In 2008 this site was partially treated. Many senescent plants as well as withered native dicots were observed but many individuals remained untreated here. In 2009, seven plants were pulled on July 10. In August of 2010 no plants were observed. One small plant was observed and pulled in 2011.

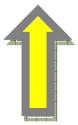
Table 11. Myrtle spurge population size at sampled plots 2006-2011. Bolded numbers indicate that it was treated.

Plots	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Plot 1- East of Stables	**142**	**97**	146	**10**	**0**	6
Plot 2- Douglass Valley Housing	72	122	120	**91**	**5**	**14**
Plot 3- Archery Range	**25**	41	**24**	**7**	**0**	**1**

Hypericum perforatum (common St. Johnswort)

Plot 1
Decreased from 3550 individuals in 2010 to 50 in 2011 (herbicide used)

Plot 2
Remained nearly identical to 2010 with 5 vs 6 individuals (no tx)



Plot 3
Increased in no. of individuals and area over 2009. (some of the area was sprayed and some had beetles).

All locations
Occupied area and no. of individuals remained similar to 2010.

Species	2009 Sampling Methods	Plot 1	Plot 2	Plot 3	Other sites
Common St. Johnswort	*photopoint/ census/ perimeter mapping*	2 photopoints, perimeter mapping	3 photopoints, perimeter mapping	2 photopoints, perimeter mapping	Perimeter mapping and census

In 2011, compared to 2010, there was very little change in number of individuals or occupied area for the all locations (Table 12 and 13; Figure 5 and Map 5), however the number of extant locations increased from 20 to 26. The monitored plots had mixed results with Plot 1 decreasing, plot 2 staying the same, and plot 3 increasing (Table 12). Plot 1 had an active herbicide treatment whereas plots 2 and 3 were not treated. What appeared to be effective management for St. Johnswort in 2007 and 2008 was reversed in 2009 when number of individuals and occupied area increased, however in 2010 this species was knocked back probably due to a more aggressive herbicide treatment. Although an even more aggressive herbicide treatment occurred in 2010 the population is still holding steady. Number of individuals and occupied area remained similar in 2011 compared to 2010 from 82,724 to 87,128 individuals and 1.5 acres to 1.4 acres. Thus we consider this to be stable and may be a positive sign but since the number of patches increased from 20 to 26 we believe this species still has the ability to increase if due diligence is not maintained. We recommend an aggressive herbicide treatment.

Plot 1 along south Kettle Creek (Map 2 and Figure 5) was sprayed in 2010 and 2011 and this significantly reduced the number of individuals and occupied area. No beetles were present in 2010 or 2011. A nearby occurrence adjacent to the old road bed wasn't sprayed in 2010 but was in 2011 and it declined in 2011.

At plot 2, the furthest north occurrence, (Map 2), a broadleaf herbicide was applied sometime in the summer or fall of 2005 after the baseline data were obtained at this site. No evidence of common St. Johnswort was found at this site in 2006 and 2007. In 2008 a small patch was detected along the road adjacent to the large infestation, however the original site was still free of St. Johnswort. In 2009 another small location approx. 0.1 miles southwest was detected and the original site had 3 plants in 2009 (Table 12). In 2010 and 2011 this site remained nearly identical as 2009 (Table 14).

At plot 3, middle Kettle Creek, (Map 2), biocontrol insects introduced by Michels et al. (2004) had considerable local impacts on the density of common St. Johnswort in previous years but not so in 2009 , 2010 or 2011; both number of individuals and area increased in 2010 (Table 12).

In 2011, 8 out of the 26 known locations were sprayed. The herbicide treatment negatively impacted the number of individuals in most cases (Table 14).

Additional infestations of common St. Johnswort were discovered along Kettle Creek in 2011 however some patches were eradicated, illustrating that this species still has the potential to spread at the Academy (Table 14, Map 5 and Figure 5). Based on these observations, it appears timely now to use herbicide to eradicate small founder infestations along Kettle Creek and on the roadside infestation at plot 2. It will be necessary to continue perimeter mapping and census of the entire population of this species in 2012 to inform eradication efforts for this species.

Table 12. St. Johnswort summary for permanent plots, 2005-2011.

		2008	2009	2010	2011
plot 1	no. of ind	0	17,261	3,550	50
	area (sq m)	0	230	71	71
plot 2	no. of ind	0	3	5	6
	area (sq m)				
plot 3	no. of ind	56,439	68,368	69,559	76,090
	area (sq m)	1,128	1,709	1,739	1,902

Table 13. St. Johnswort summary data for AFA, 2007-2010.

Year	Occupied Area (m^2)	# of individuals	# of patches
2007	3,491	44,647	8
2008	4,341	130,371	13
2009	8,192	95,883	21
2010	5,945	82,732	20
2011	5,817	87,128	26

Table 14. Number of individuals in areas treated with herbicide. Herbicide treatment occurred in 2011.

	2010	2011	Difference
1	10	60	10
2	600	30	-570
3	8	0	-8
4	300	20	-280
5	4,270	3,559	-711
6	800	400	-400
7	7,370	6,330	-1,040
8	69,559	76,090	6,531

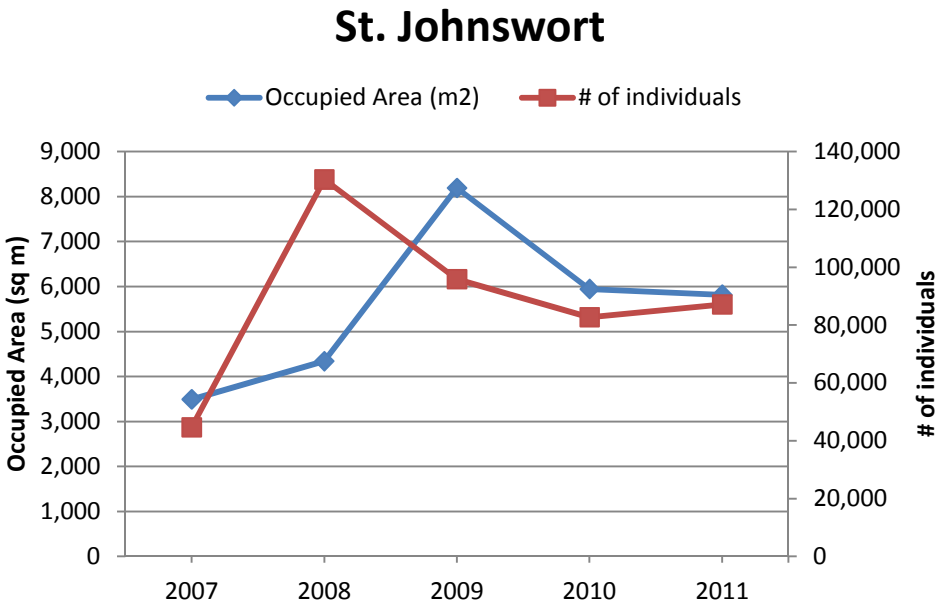
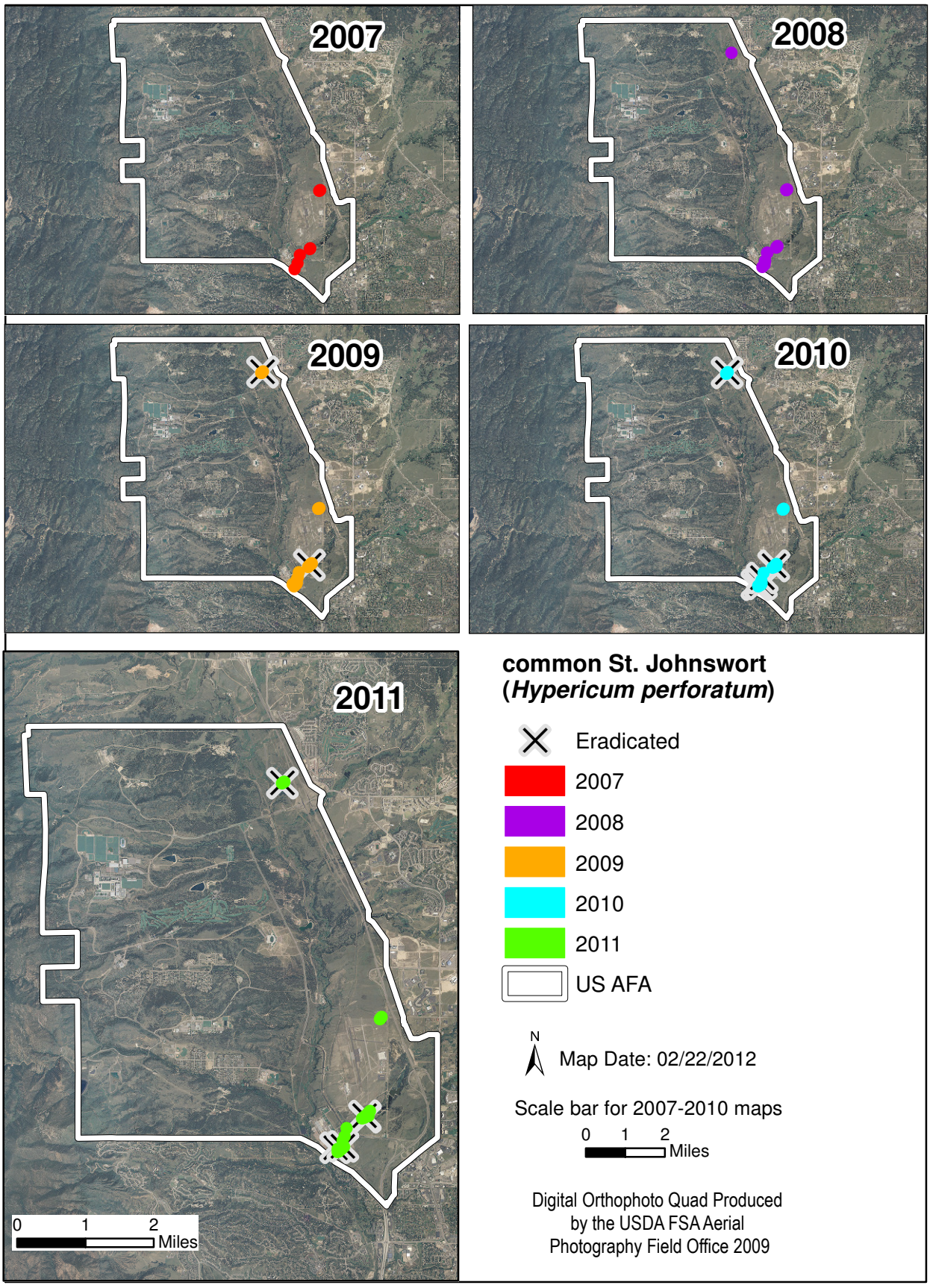
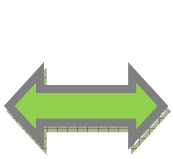


Figure 5. St. Johnswort occupied area and number of individuals for all mapped locations on AFA, 2007-2011.



Map 5. Distribution of common St. Johnswort at the Academy between 2007 and 2011.

Onopordum acanthium (Scotch thistle)



Occupied acres remained stable compared to 2010.

Number of individuals **decreased** 56% between 2010 and 2011 from 669 to 293.

The population of Scotch thistle had increased from 2002 through 2009 at the Academy (Table 15, Map 6, Figure 6), however in 2010 there was a significant decrease in occupied acres and number of individuals, most likely due to an active herbicide treatment. Compared with 2009, occupied acres drastically decreased by over 80% from 3.5 acres to 0.66 acres (Table 15). The number of individuals also decreased since 2009 from 1710 to 669 (Table 15). This downward trend continued in 2011 and although the occupied acres remained stable the number of individuals declined 56% from 669 individuals in 2010 to 293 in 2011. The number of locations also declined from 61 in 2010 to 39 in 2011. It may still be possible to eradicate this species through a coordinated and consistent program of treatment. Where treatments have been carefully applied, reproductive success is limited. However, most infestations observed at the Academy have remained viable, even if reduced, over several years whether they were treated or not, so it remains important to revisit and assess infestations after they have seemingly been eradicated.

We recommend a continuation of the aggressive herbicide treatment for this species in 2012.

Table 15. Scotch thistle summary data at the Academy, 2002-2011.

	Occupied Acres	Number of Individuals	Number of Mapped Features
2002	0.17	52	7
2005	0.42	137	12
2007	1.30	1,307	36
2008	1.14	144	27
2009	3.47	1,710	50
2010	0.66	669	61
2011	0.64	293	39

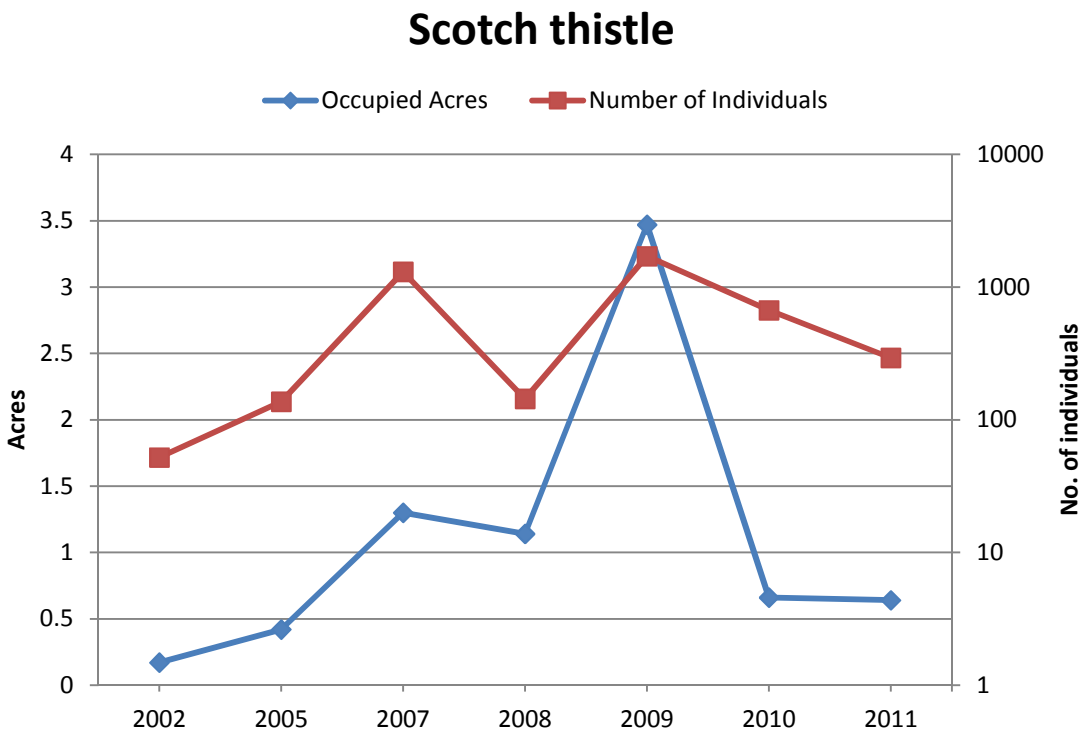
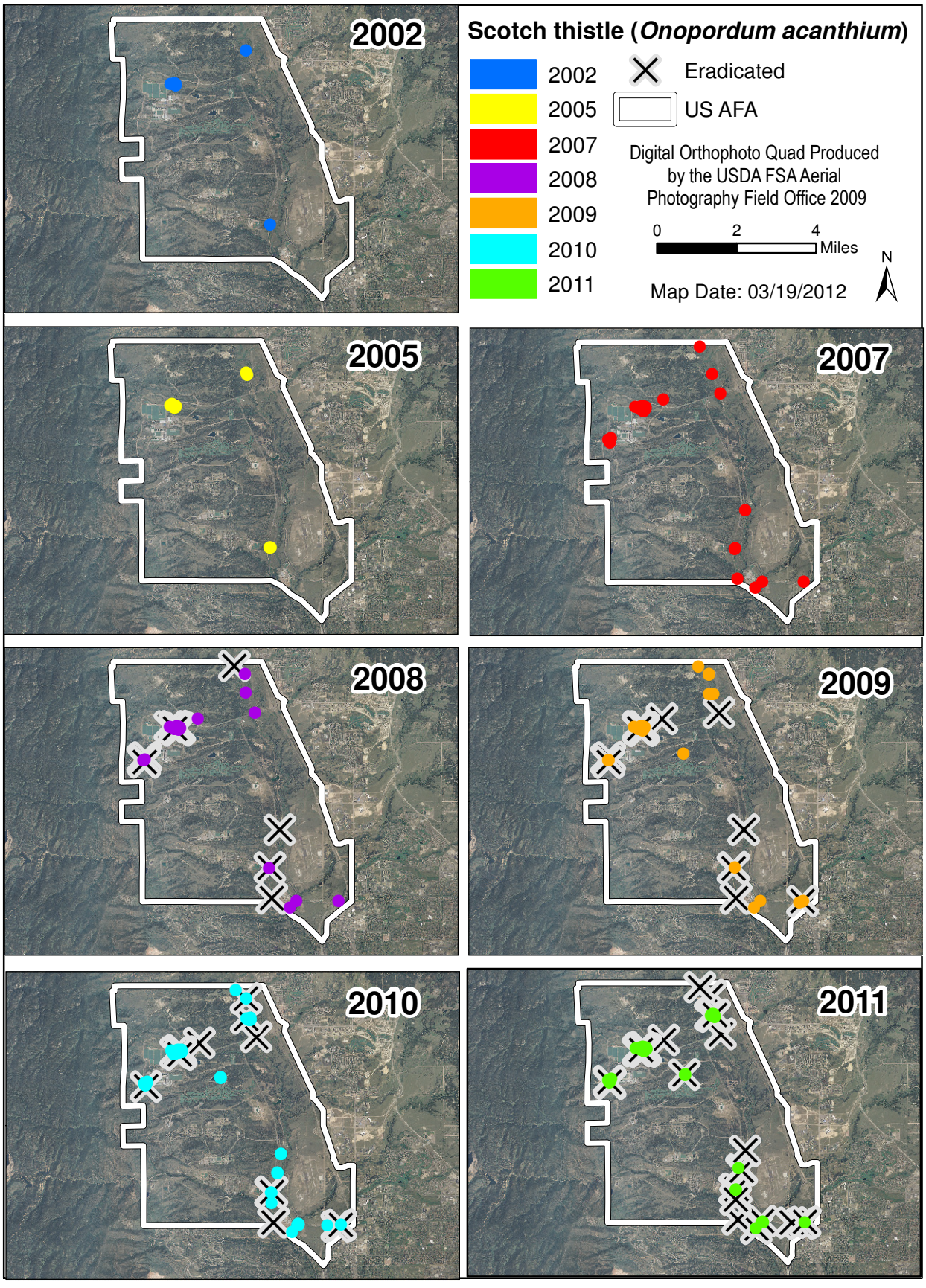
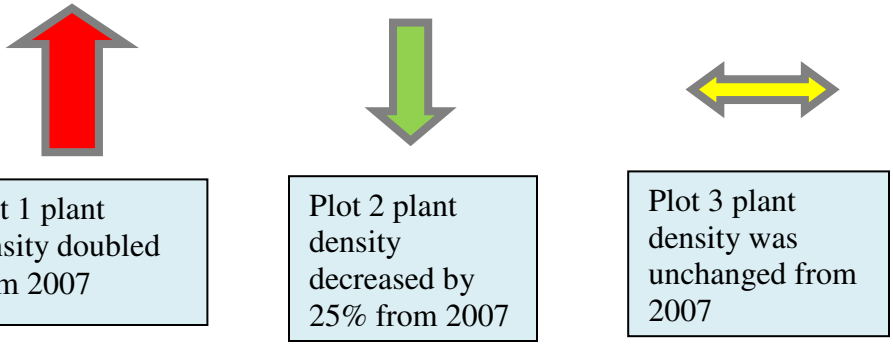


Figure 6. Scotch thistle, Academy-wide, occupied area and number of individuals from 2002-2011.



Map 6. Distribution of Scotch thistle at the Academy between 2002 and 2011.

Centaurea diffusa (diffuse knapweed)



Plot 1 plant density doubled from 2007

Plot 2 plant density decreased by 25% from 2007

Plot 3 plant density was unchanged from 2007

Species	Sampling Methods	Plot 1	Plot 2	Plot 3
Diffuse knapweed	*Belt Transects/ photopoints*	4 25 m belt transects, each divided into five segments, 2 photopoints	4 25 m belt transects, each divided into five segments, 2 photopoints	4 25 m belt transects, each divided into five segments, 2 photopoints

NOT SAMPLED IN 2012. In 2009 density (plants/m^2) of diffuse knapweed increased in plot 1, decreased in plot 2 and was stable in plot 3. Plot 1 has seen the most drastic change in density, steadily increasing since 2006 (Table 16 and Figure 7). Plot 2, near the runway, was repeatedly mowed and decreased by nearly 25%. In 2006 a strip along the west side of plot 3 was mowed prior to sampling in 2007, which evidently resulted in a considerable reduction of density at this location compared with 2006 (Figure 7). Mowing, though impractical for most knapweed infestations, may be an effective means of managing this species at the Academy along the railroad right-of-way and roadsides. The railroad appears to be a major corridor for the dispersal of diffuse knapweed throughout the Academy, so intensive management of infestations there may provide benefits base-wide.

Table 16. Summary data from permanent monitoring plots for diffuse knapweed.

		2005	2006	2007	2009
Plot 1	**Average density (plants/m²)**	1.02	0.92	9.83	19.67
	SD	0.29	1.41	9.59	9.89
	N (*C. diffusa*)	153	138	1,475	2,950
	N (hybrids)	0	19	24	73
Plot 2	**Average density (plants/m²)**	6.85	6.44	12.73	8.3
	SD	8.32	5.98	12.16	7.50
	N (*C. diffusa*)	771	966	1,909	1,237
	N (hybrids)	0	92	160	8
Plot 3	**Average density (plants/m²)**	2.68	5.68	2.05	2.08
	SD	0.89	4.35	2.77	2.69
	N (*C. diffusa*)	302	809	292	300
	N (hybrids)	0	27	1	8

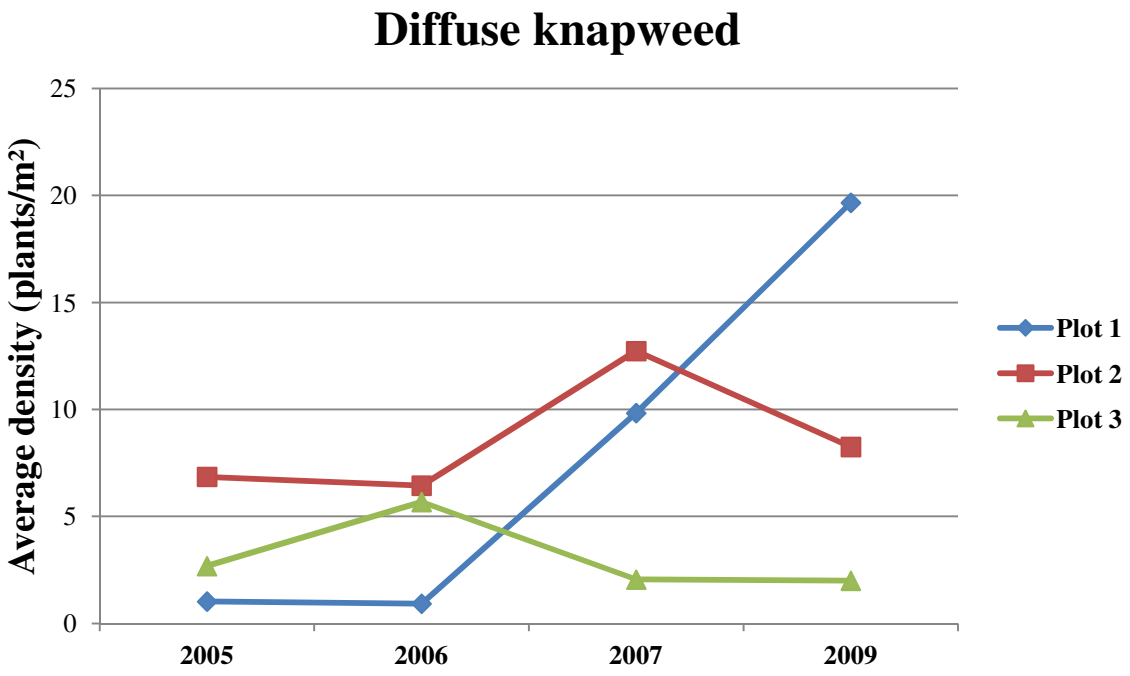
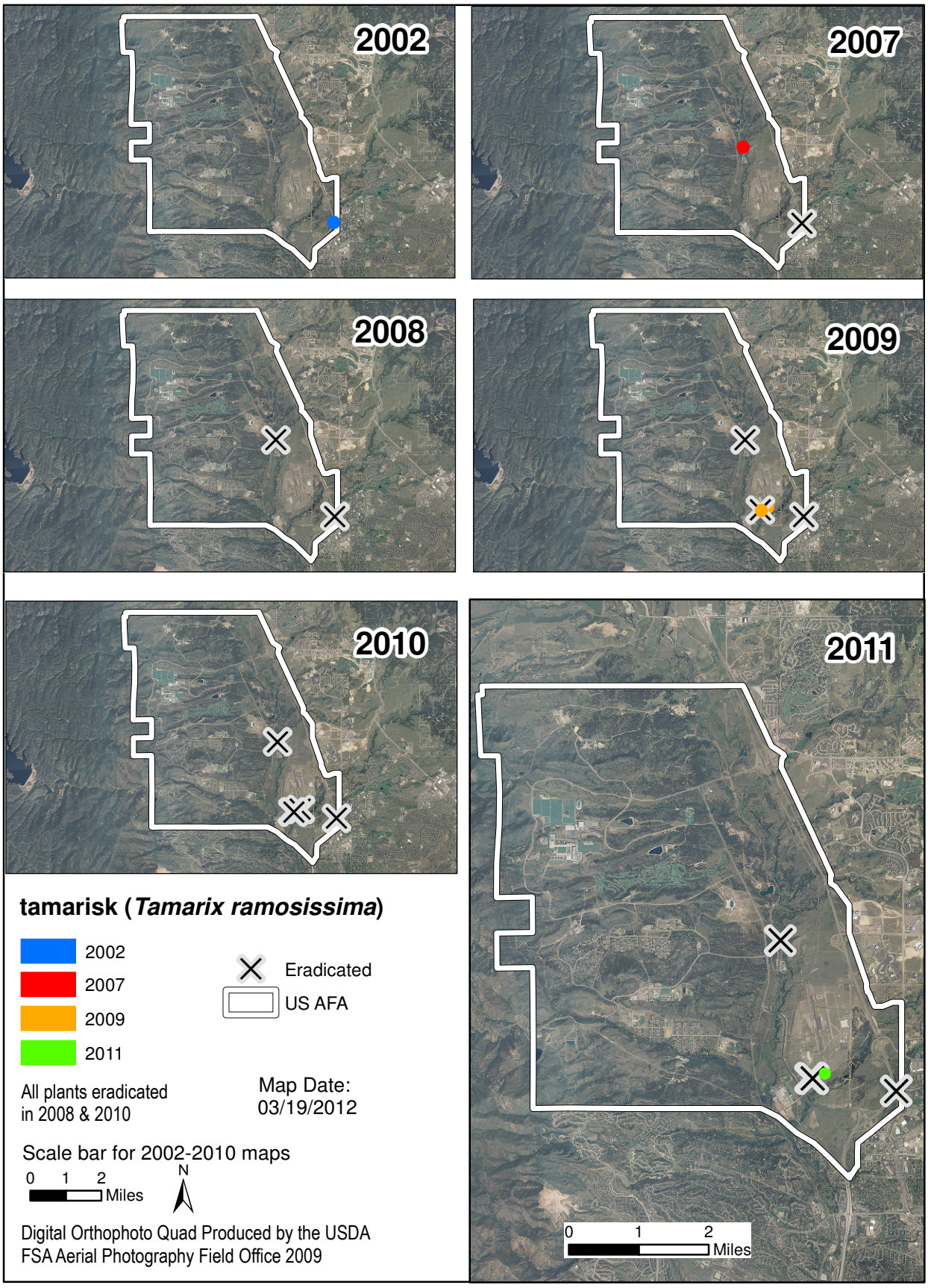


Figure 7. **Diffuse knapweed average density for three permanent plots from 2005-2009.**

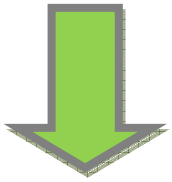
Tamarix ramossisima (Tamarisk)

Tamarisk was present at one of the visited sites therefore the eradication efforts are nearly successful but continued management is required. (Map 7).



Map 7. Distribution of tamarisk at the Academy between 2002 and 2011.

*Cynoglossum officinale (*houndstongue*)*



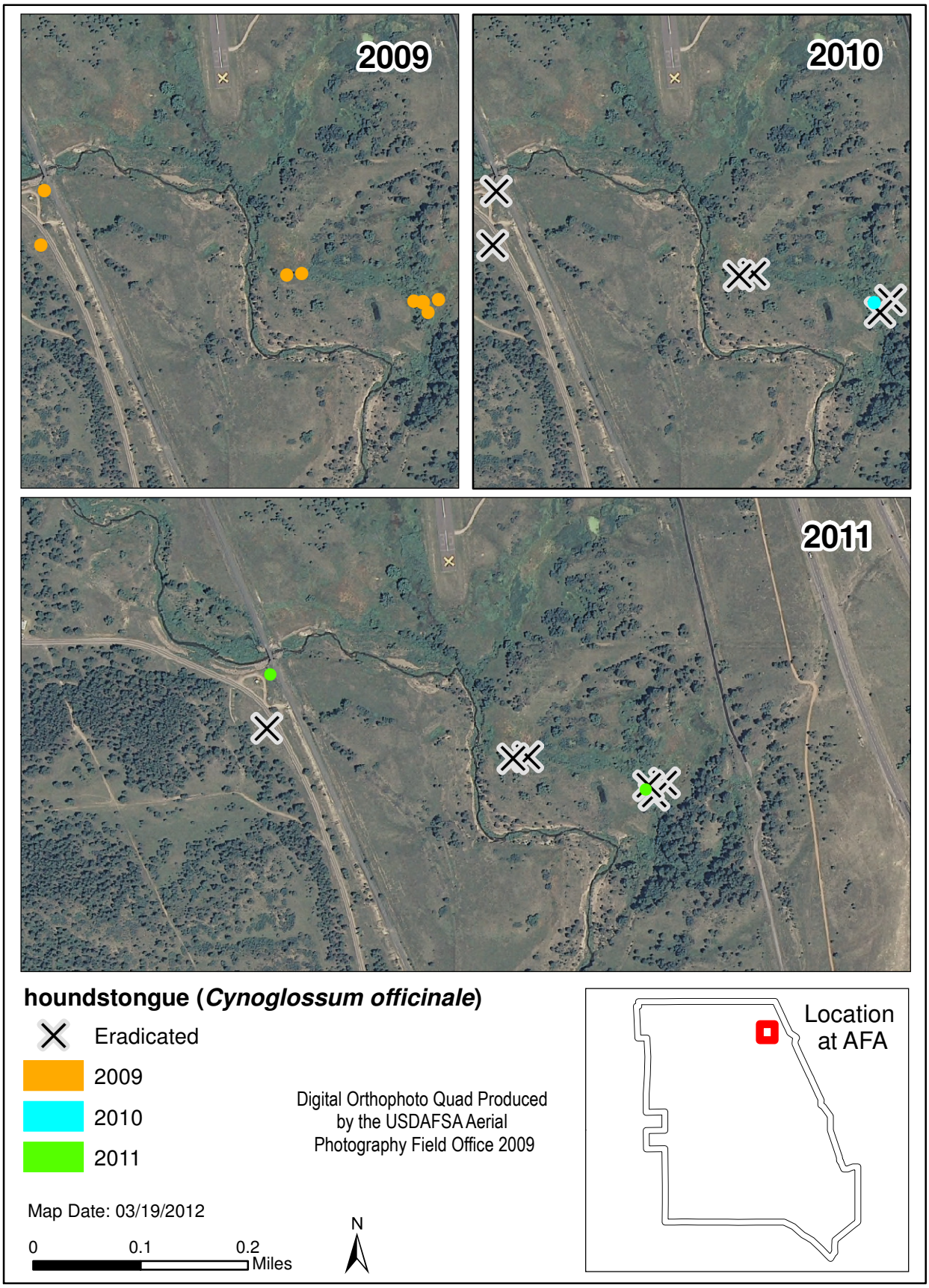
Occupied acres **decreased** over 80% since 2010; 78 m^2 to 10 m^2.

Number of individuals **increased** from 11 in 2010 to 21 in 2011

Houndstongue was treated with herbicide in 2010 and 2011 and the success in a decreased number of occupied area was notable. However the plants did reproduce from seeds and the number of individuals increased in 2011 as did the number of mapped features (Table 17, Map 8). These plants had fruits on them thus it is likely that the seed bank has been populated. We recommend continued monitoring and rapid response to any new populations.

Table 17. Houndstongue summary data, 2009-2011.

	Occupied Area (m^2)	Number of Individuals	Number of Mapped Features
2009	378	95	8
2010	78	11	1
2011	10	21	2



Map 8. Distribution of houndstongue at the Academy between 2009 and 2011.

*Linaria genistifolia ssp. dalmatica (*Dalmatian toadflax*)*

This species 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 we mapped two patches (Map 9), counted 107 individuals that covered approximately 203 m^2 (0.05 acres) (Table 18). The AFA sprayed the plants in 2010 and in 2011 no plants were observed. This is an excellent example of early detection and treatment leads to success.

Table 18. Dalmatian toadflax summary data, 2009-2011.

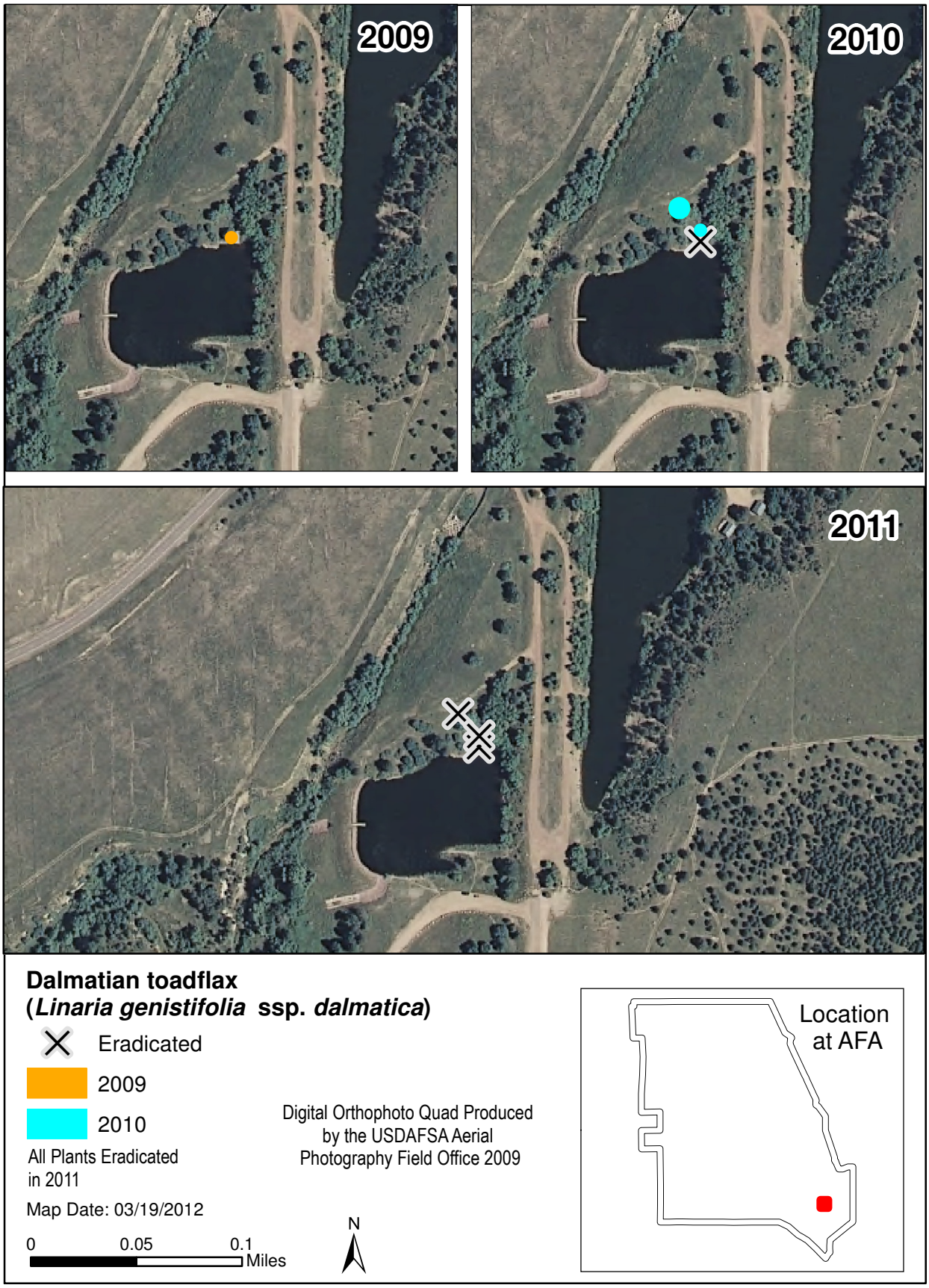
	Occupied Area (m^2)	Number of Individuals	Number of Mapped Features
2009		10	1
2010	203	107	2
2011	0	0	0

Gallium verum (yellow spring bedstraw)

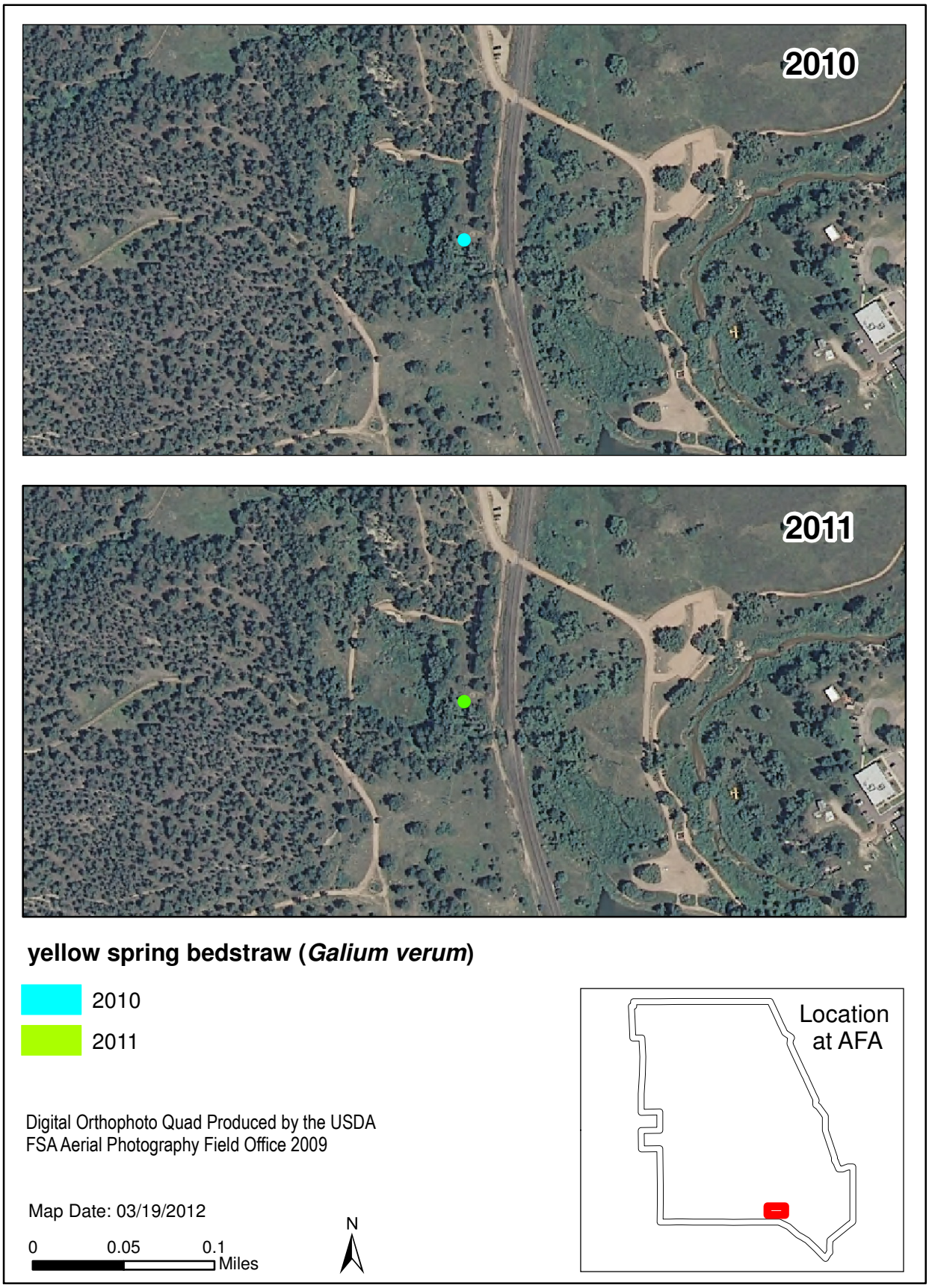
This species was discovered at the Academy in 2010 with one occurrence found near Ice Lake (Map 10). The occurrence consisted of 700 individuals in 28 m^2 (0.01 acres). The AFA immediately eradicated it however this species can be very aggressive and warrants multiple visits and rapid responses. We visited this site in 2011 and located and pulled one individual. This is another great example of how early detection and treatment can lead to success. We recommend continued vigilance at this site.

Lonicera tatarica (Tatarian honeysuckle)

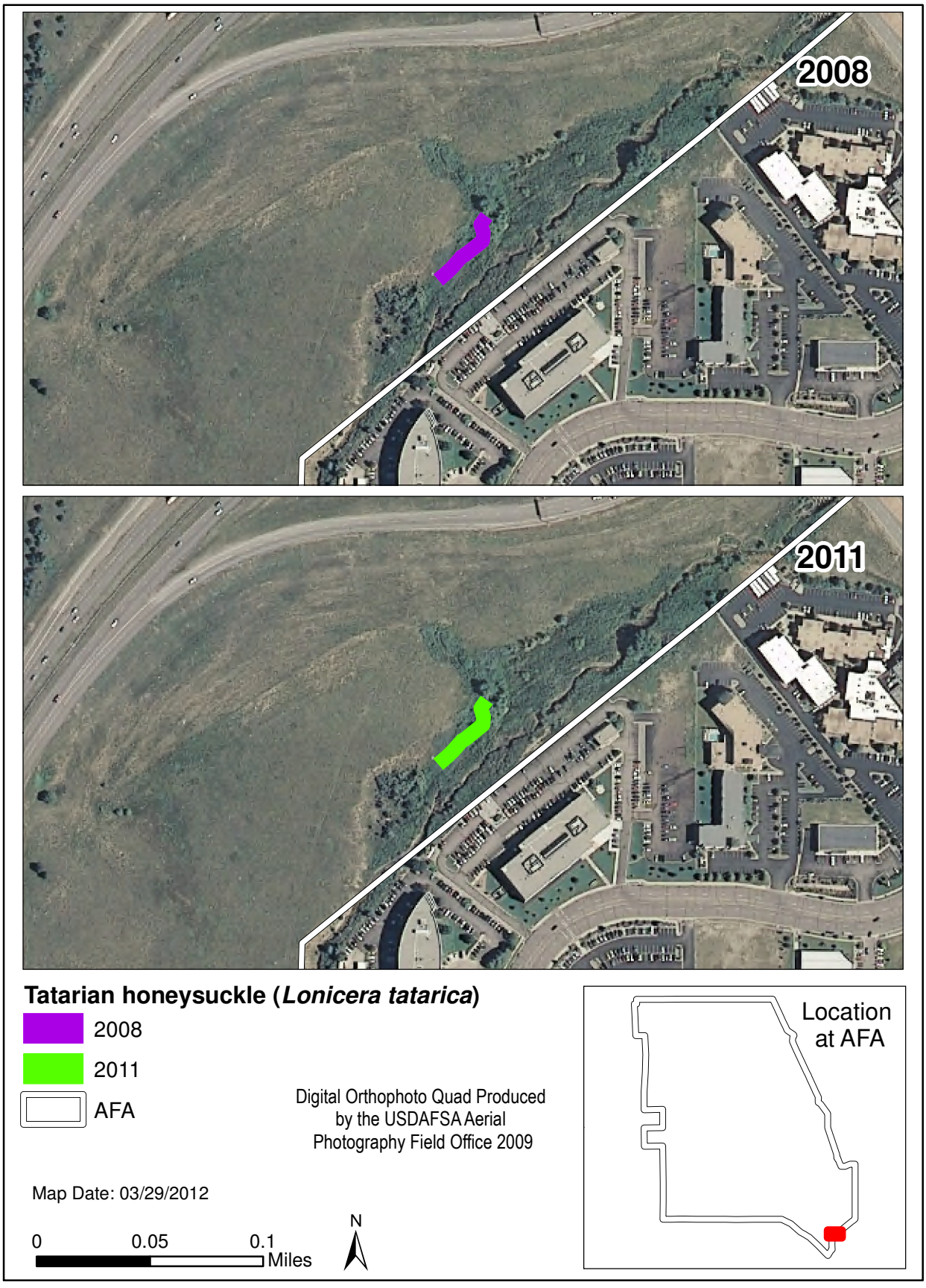
This species was first discovered at the Academy in 2008, embedded with the state rare plant, *Ribes americanum*. The invasion of *Lonicera tatarica* is a concern due to its potential to dominate the site at the exclusion of the rare currant. Since this site is sensitive to herbicide spraying, pulling plants is likely the best way to control this infestation. Weed technicians should be informed of the presence of the rare plant prior to pulling weeds. Plants may need to be pulled for three to five years to fully eradicate the honeysuckle, but success is high if the weed is targeted early on in its establishment and the site is monitored annually for resprouting (Batcher and Stiles 2000).



Map 9. Distribution of Dalmatian toadflax at the Academy in between 2009 and 2011.



Map 10. Distribution of yellow spring bedstraw at the Academy in 2010 and 2011.



Map 11. Distribution of Tatarian honeysuckle at the Academy in 2008 and 2011.

FARISH WEED MONITORING

Conducted August 9-11, 2011

The primary monitoring question: Has musk thistle, Canada thistle, and yellow toadflax cover increased since the 2007 weed mapping project.

Methods. The 2007 Farish weed data (Anderson and Lavender 2008) was used to randomly select locations of *Carduus nutans* (musk thistle), *Cirsium arvensis* (Canada thistle), and *Linaria vulgaris* (yellow toadflax) to establish permanent plots in 2011. We used an ArcGIS extension to randomly select 10 points for each species, at least 20 m from a road and at least 100 m from each other (only for one species at a time). We chose these points from the 1-5% cover class as it is much easier to detect an increase from the 1-5% cover class than from the 5-25% cover class. The Canada thistle is the only species that did not have many points in the low cover class thus we chose the 5-25% cover class for this species. Four of the Canada thistle plots were too close to the road so we ended up with 6 plots. All other species had 10 plots. (See map).

Carduus nutans (musk thistle) 10 plots at 1-5% cover
Cirsium arvensis (Canada thistle) 6 plots at 5-25% cover
Linaria vulgaris (yellow toadflax) 10 plots at 1-5% cover

Once in the field we had to remove plots since we were unable to locate these weed infestations (most likely due to proximity of a small road that was not noticeable from the office); therefore, we ended up with 9 musk thistle, 5 Canada thistle, and 9 yellow toadflax plots.

We collected cover data from a 20m transect using the point-intercept method. A point was taken at every 20 cm, starting at 0.2m mark, i.e. 100 points/plot. The plot was laid out in the shape of a cross with 4-5m lines radiating out from a center point. This formed a 10 m^2 plot.

Setting up the 10m^2 plot: Using a Trimble Yuma tablet with ArcPad 8, we navigated to each random point. A 3 foot long ½" diameter rebar was hammered into the ground to denote the center of the plot (a permanent marker). A pin flag was tossed to generate a random starting direction and 4-5m tapes were laid out, each at 90 degrees from the other (We used a Brunton SM360LA Sightmaster compass; precise to 1/2 degree). To facilitate the process of laying out the tapes we laid the second tape at 180 degrees from the first tape and then we placed a homemade t-cross on the center rebar to quickly guide us to laying out the two perpendicular tapes (see photo). Each end point was marked with a 3/8" 3 foot long rebar. When taking down the plot we removed all but the center rebar and one end rebar (generally the end rebar that we left was in the direction least likely to be seen).

Data collection: We calculated percent cover by denoting the presence of the weed at 100 points (25/line, starting at the 0.2 m mark and placing a point every 20 cm). The actual percentage was placed into one of 8 cover classes:

Cover Class Score	Description	Percent Cover (%)
0	None	0
1	Trace*	0.1-0.9
2	Low	1-5
3	Low-Moderate	6-10
4	Moderate	11-25
5	Moderate-High	26-50
6	High	51-75
7	Very High	76-100

*If the weed was in the 10 m^2 plot but not present on the point intercept mark we marked the weed as having a Cover Class Score 1 (Trace). All other cover class scores were developed from actual percent captured from point intercept count. Comments about community type and other weeds were recorded

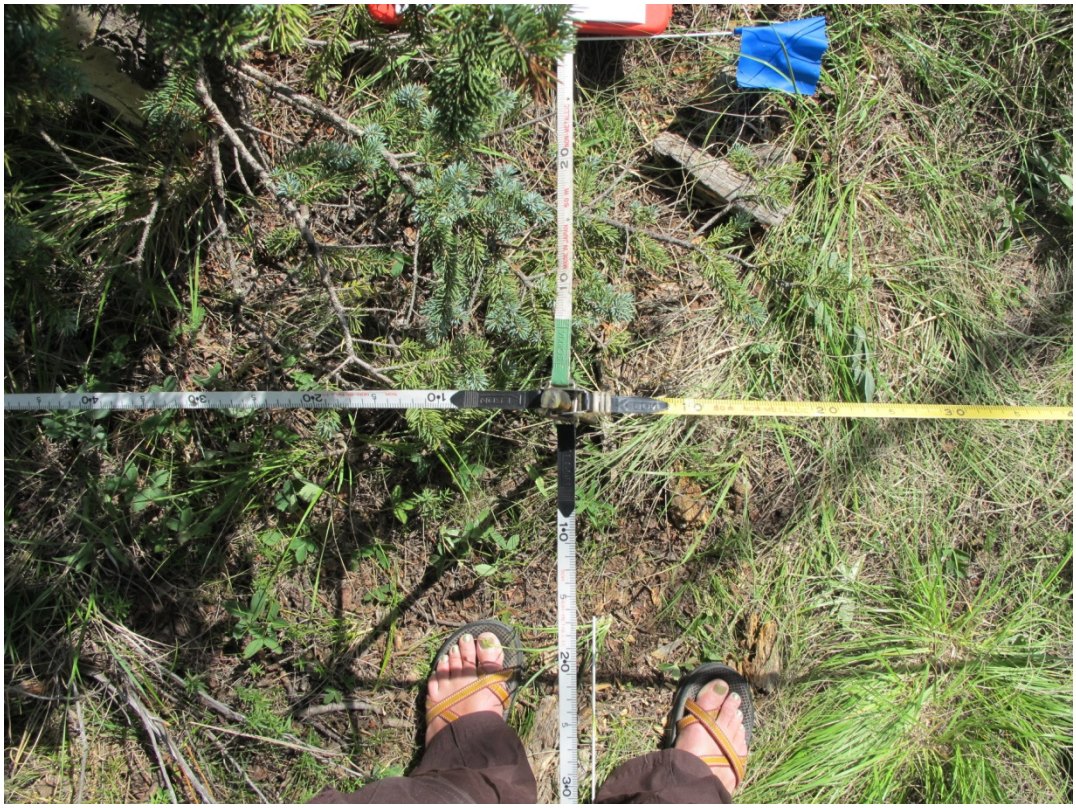
Photos: Using a Canon G11 with a 6.1-30.5 mm (1:2.8-.5) lens always zoomed to widest angle, i.e., 6.1 or the equivalent of 35 mm) we took at least three photos at each plot, all from the center mark. The first photo was looking straight down at the ground so that you could see all four tapes. An object was placed below the 50 cm mark on the tape that was facing up and the upper edge of the photo just takes in this object (note that because the tapes are high up on the rebar there is an optical illusion and it often looks like the object is at somewhere between 20-40 cm). Two landscape photos were also taken and the direction and time of all photos were noted.
Data recording: Data was recorded in ArcPad 8 as well as on a paper form.

Results and General Comments.
Canada thistle (n=5). All but one plot had less than 5% cover in 2011 whereas all of the 2007 plots had at least 5% cover. **Canada thistle decreased in cover since 2007.**
Musk thistle (n=9). Six plots had 0% and 3 plots had less than 2% cover. **We believe musk thistle is stable or potentially declining.**
Yellow toadflax (n=9). Four sites had 0% cover in 2011, three sites had 1-2% cover, and two sites had 8-9% cover. This means that 22% of the plots nearly doubled in cover since 2011, while 33% remained stable, and 44% decreased. We believe that yellow toadflax has been spreading at Farish although our data indicates mixed results. The 2012 weed mapping project will be more definitive on the spread of this plant. We observed this species in many areas as we traversed Farish.

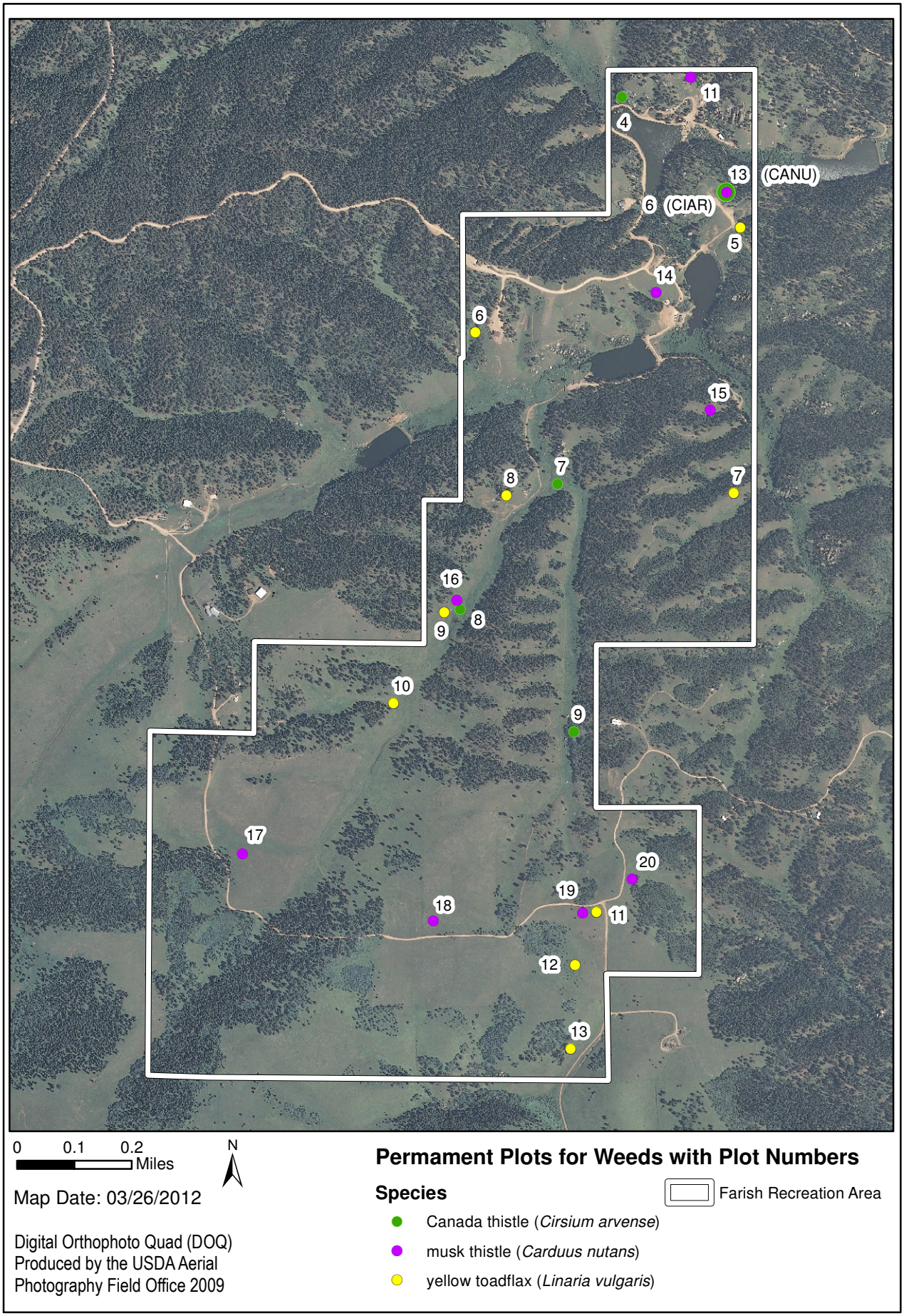
In some places, the weeds mapped in 2007 at Farish were shifted about 5m from the actual infestation we saw in 2011. This shifting was intermittently noticed and it is unclear why this occurred. In some instances, it appeared to be a natural shift, with evidence of dead plants in the plot and live plants nearby. Two locations in particular, CANU #15 and LIVU #7, seemed to be spatially offset with no natural explanation. These two plots occur near each other on the northeastern portion of Farish. Perhaps the accuracy of the GPS unit affected those two plot locations when they were mapped in 2007. We did have several moments of erratic GPS readings at Farish in 2011 probably due to terrain, canopy cover and cloudy weather. We don't feel that this perceived shifting affects the trend described above for the three weeds.

Suggestions for future monitoring: If the 2012 mapping project locates additional Canada thistle sites we should set up new permanent plots, in order to increase the sample size. A summary of past treatments for these species/sites at Farish from 2008-2011 would be useful. We might want to set up another four yellow toadflax and five musk thistle sites that would be selected from the 2012 data set. It may be that yellow toadflax spends a lot of energy spreading and once it has spread it has the potential to increase cover in favorable years. This weed could be problematic for the Parry's oatgrass (*Danthonia parryi*) community (G3S3) as it is present in low cover in all of the *Danthonia parryi* sites that we documented.

The smooth brome grasslands are probably fairly resistant to new weeds. These smooth brome meadow were probably Parry's oatgrass meadows prior to disturbance.
Musk thistle does not appear to spread as easily as yellow toadflax but it also seems to be persistent. Spraying this weed when the plant has flowers is probably not doing much good—check. The current spray regime appears to miss the young plants.
We recommend monitoring these established sites once/5 years unless management believes they have significantly altered the species.



See Excel spreadsheet in Appendix A for 2011 data.



Map 12. Locations of all permanent monitoring plots for weeds at Farish Recreation Area.

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Appendix A.

Myrtle Spurge Table

Map number refers to Map 4 within this document.

Map Number	Date	No of Individuals	Area (sq m)
1	8/3/2011	0	0
2	8/18/2011	0	0
3	8/18/2011	11	308
4	8/18/2011	14	242
5	8/18/2011	0	0
6	8/18/2011	0	0
7	8/3/2011	6	216
8	9/8/2011	0	0
9	9/8/2011	1	102
10	7/27/2011	3	3
11	9/8/2011	0	0
12	9/8/2011	0	0
13	9/8/2011	0	0
14	9/7/2011	0	0
15	7/28/2011	0	0
16	7/28/2011	0	0
17	7/28/2011	0	0
18	7/13/2010	0	0
19	7/13/2011	2	78
20	9/8/2011	0	0
21	9/8/2011	0	0
22	7/27/2011	1	3
23	7/27/2011	1	3
24	7/27/2011	4	28
25	7/27/2011	1	3
26	7/29/2011	12	28
27	9/7/2011	0	0
28	8/26/2011	1	3
Total		57	1018

All mapped weeds in 2011 in comparison to 2009 and 2010.

SPECIES	Extant			Eradicated			# of individuals		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
Acroptilon repens	2	0	0		4	4	0	0	0
Cynoglossum officinale	8	1	2		6	6	95	11	21
Euphorbia esula*	15	8	9		0	0	506	27,826	2,189
Euphorbia myrsinites	9	10	12		12	16	464	56	57
Galium verum		1	1		0	0		700	1
Hypericum perforatum	20	20	26		6	5	95,883	82,733	87,128
Linaria genistifolia spp. dalmatica	2	2	0		1	3		107	0
Lonicera tatarica			1			0			30
Onopordum acanthium	49	61	39		30	56	1,710	669	293
Tamarix ramosissima	6	0	1		5	4		0	1

Farish Musk Thistle Plots

Species	Plot no.	Date	Photo time	Photo Dir (ground, L, L)	Total (%) 2011	2011 Cover Category	2007 Cover Category	2007 # Individuals	2007 Buffer distance (m)	2007 area (sq m)	Other sp cover/comments
Canu	**11**	**8/9/2011**	**1813**	**244, 150, 64**	**1**	**2**	**2**	**31**	**10**	**314.16**	
Canu	**13**	**8/9/2011**	**1633**	**180, 180, 270**	**0**	**1**	**2**	**2**	**1**	**3.14**	**same point as Ciar 6; this plot probably increased since 2007 but not a lot**
Canu	**14**	**8/11/2011**	**1312**	**283, 283, 193**	**0**	**1**	**2**	**21**	**10**	**314.16**	**only center rebar left; mumo grassland**
Canu	**15**	**8/11/2011**	**1121**	**56, 56, 146**	**0**	**1**	**2**	**2**	**1**	**3.14**	**choke cherry/mumo/artfri; we observed some 10 canu in one clump by the trail therefore it has increased since 2007 but the GPS coordinates were off enough that the point was off and none of the transects crossed it.**
Canu	**16**	**8/10/2011**	**1220**	**162, 162, 252**	**1**	**2**	**2**	**5**	**5**	**78.54**	**Dapa community**
Canu	**17**	**8/10/2011**	**940**	**140, 140, 230**	**0**	**0**	**2**	**5**	**4**	**50.27**	**smooth brome community**
Canu	**18**	**8/10/2011**	**1350**	**121, 121, 301**	**0**	**0**	**2**	**6**	**4**	**50.27**	**smooth brome community**
Canu	**19**	**8/10/2011**	**1708**	**262, 172, 352**	**0**	**1**	**2**	**4**	**5**	**78.54**	**Fear/smooth brome/mixed forb**
Canu	**20**	**8/10/2011**	**1735**	**205, 205, 115**	**2**	**2**	**2**	**17**	**7**	**153.94**	**nodding brome community; sprayed**

Farish Canada Thistle plots.

Species	Plot no.	Date	Photo time	Photo Dir (ground, L, L)	Total (%) 2011	2011 Cover Category	2007 Cover Category	2007 # Individuals	2007 Buffer distance (m)	2007 area (sq m)	Other sp cover/comments
Ciar	**4**	**8/9/2011**	**1900**	**343, 343, 163**	**1**	**2**	**3 and 4**	**49.98**	**4**	**50.27**	
Ciar	**6**	**8/9/2011**	**1633**	**180, 180, 270**	**5**	**2**	**3 and 4**	**312.36**	**10**	**314.16**	**same point as Canu13; Livu and Canu in plot 1%)**
Ciar	**7**	**8/11/2011**	**907**	**176, 176, 356**	**3**	**2**	**3 and 4**	**312.36**	**10**	**314.16**	**moist meadow; mixed forb/grass/livu**
Ciar	**8**	**8/10/2011**	**1158**	**105, 105, 115??**	**3**	**2**	**3 and 4**	**312.36**	**10**	**314.16**	**moist meadow with Deschampsia ceaespitosa**
Ciar	**9**	**8/10/2011**	**1422**	**215, 305, 125**	**0**	**0**	**3 and 4**	**199.91**	**8**	**201.06**	**Aspen/Danthonia community; livu present; no ciar**

Farish Yellow Toadflax plots.

Species	Plot no.	Date	Photo time	Photo Dir (ground, L, L)	Total (%) 2011	2011 Cover Category	2007 Cover Category	2007 # Individuals	2007 Buffer distance (m)	2007 area (sq m)	Other sp cover/comments
Livu	5	8/9/2011	1535	190, 190, 100	0	1	2	562.24	6	113.10	small patches of livu at 60 & 150 degrees
Livu	6	8/11/2011	1241	180, 180, 270	0	1	2	449.79	6	113.10	Dapa/Potentilla fruticosa community
Livu	7	8/11/2011	1158	130, 220, 40	0	1	2	224.90	6	113.10	Muhlenbergia montana/Festuca arizonica; livu in plot but not on lines
Livu	8	8/11/2011	938	164, 164, 344	1	2	2	937.07	10	314.16	Pipo/Dapa community
Livu	9	8/10/2011	1117	92, 92, 182, 272	8	3	2	337.35	6	113.10	Danthonia parryi community
Livu	10	8/10/2011	1020	155, 155, 245	9	3	2	1,349.38	12	452.39	Dapa community
Livu	11	8/10/2011	1647	246, 156, 66	2	2	2	2,186.50	10	314.16	mixed forbs
Livu	12	8/10/2011	1604	245, 155, 335	2	2	2	1,518.05	9	254.47	smooth brome community
Livu	13	8/10/2011	1515	245, 155, 335	0	1	2	4,216.82	15	706.86	Danthonia parryi community; livu in plot