# Noxious Weed Monitoring at the U.S. Air Force Academy- Year 4 Results

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On the cover: Common St. Johnswort (left) and Scotch thistle (right).

## EXECUTIVE SUMMARY

This report includes a summary of the results of the past four years of population monitoring of targeted noxious weeds at the US Air Force Academy ("the Academy"), emphasizing changes that were observed between 2007 and 2008.

In 2008 the sampling methodology of this project was adjusted based on analyses of the past three years' data, and the fieldwork was streamlined to focus resources on the most urgent weed management challenges. These changes included decreased emphasis on species that are of lesser management concern such as yellow toadflax, which have already occupied most available niches at the Academy and are beyond our ability to eradicate. Where necessary, methodological changes resulting from this shift in emphasis are also presented in this report. 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 ramossisima*), Russian knapweed (*Acroptilon repens*), Scotch thistle (*Onopordum acanthium*), and common St. Johnswort (*Hypericum perforatum*). 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 and spotted knapweed, 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.

To more directly address the potential impacts of noxious weeds and other competitive non-native species on rare species at the Academy, additional plots were established in 2008. To begin these efforts five permanent plots were established at occurrences of four different rare plant species (dwarf wild indigo (*Amorpha nana*), Rocky Mountain blazing star (*Liatris ligulistylis*), southern Rocky Mountain cinquefoil (*Potentilla ambigens*) and American currant (*Ribes americanum*)). Baseline data from these plots are included in this report.

Leafy spurge, musk thistle, Scotch thistle, and spotted knapweed continue to spread at the Academy and remain significant weed management challenges. There has been some success with myrtle spurge, common St. Johnswort, and Russian knapweed, but further work is needed to control and/or eradicate these species at the Academy.

## INTRODUCTION

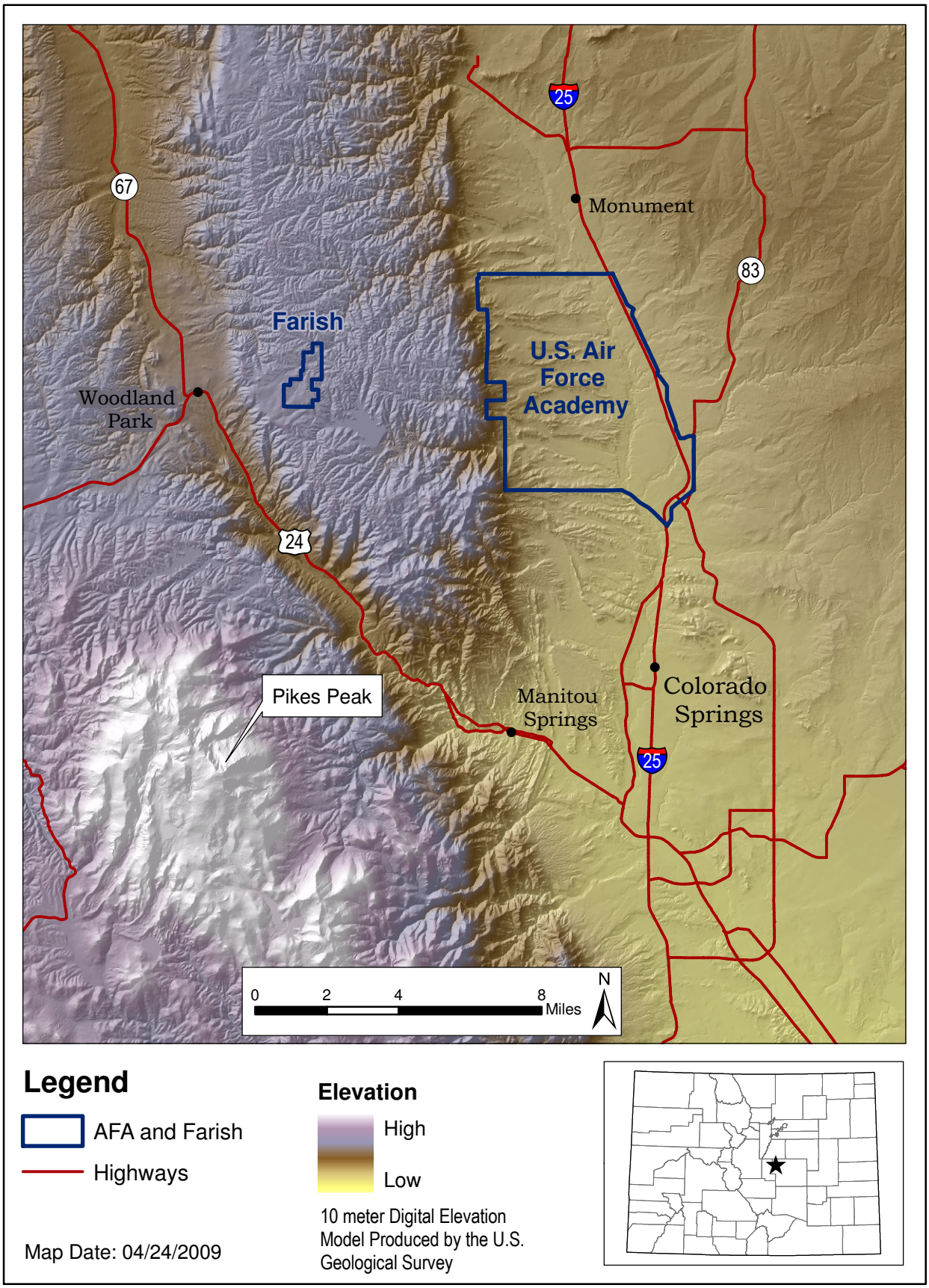
Weeds are known to alter ecosystem processes, degrade wildlife habitat, reduce biological diversity, reduce the quality of recreational sites, reduce the production of crops and rangeland forage plants, and poison livestock (Sheley and Petroff 1999). All of these impacts are occurring in Colorado (Colorado 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 biodiversity conservation locally and globally. The Academy has become increasingly insular and, like many military installations, it has become increasingly important for conservation as natural landscapes elsewhere in the area are developed and altered. In all, 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.

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 the Farish Memorial Recreation Area, El Paso County, Colorado.

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*), hoary cress (*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.

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 are presented in this report.

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 are summarized and presented in this report, and modifications and additions to previous methods are also detailed here.

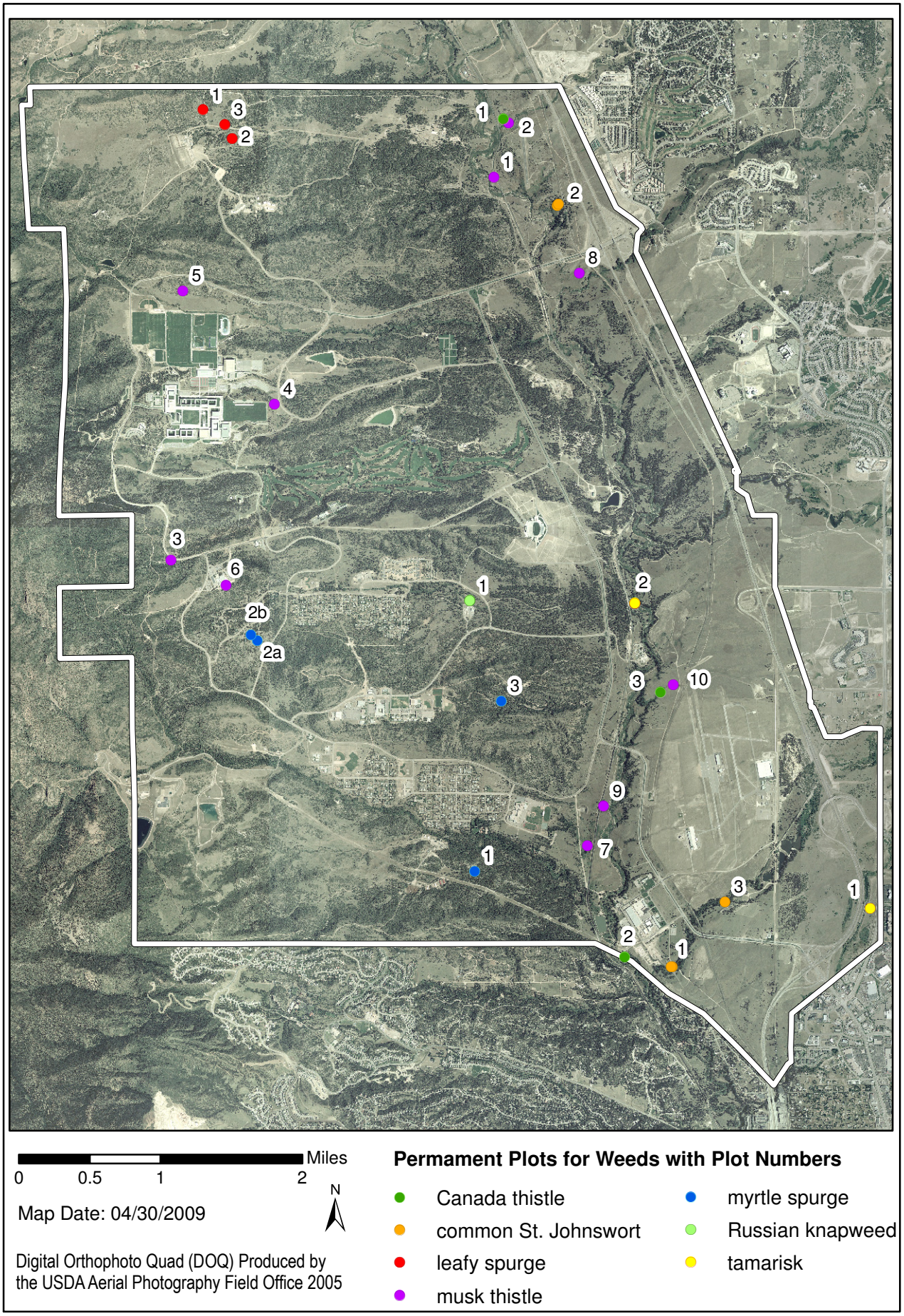
## METHODS

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 that 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 2008 as indicated by analysis of the first three years of monitoring data (Anderson and Lavender 2008b).

In 2008, 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 sampling methods used at permanent plots from 2005 through 2008.

| **Species** | **2005-2007 Sampling Methods** | **2008 Sampling Methods** |
|---|---|---|
| Russian Knapweed | *Transect/ photopoint/ photoplot/ perimeter mapping/ census* | *perimeter mapping/ census* |
| Whitetop | *Transect/ photopoint/ photoplot* | *Not a target in 2008* |
| Musk Thistle | *3 Photopoints* | *10 Photopoints* |
| Diffuse knapweed | *Belt Transects/ photopoints* | *Not a target in 2008* |
| Canada Thistle | *Transect/ photopoint/ photoplot* | *Transect/ photopoint/ photoplot* |
| Bull Thistle | *Photopoint* | *Not a target in 2008* |
| Fuller's Teasel | *Photopoint* | *Not a target in 2008* |
| Leafy Spurge | *Perimeter mapping/ survey transects/ photopoint* | *Perimeter mapping/ survey transects/ photopoint* |
| Common St. Johnswort | *Transect/ photopoint/ photoplot/ perimeter mapping* | *Photopoints and perimeter mapping* |
| Yellow Toadflax | *Transect/ photopoint/ photoplot* | *Not a target in 2008* |
| Myrtle Spurge | *Perimeter mapping/ census/ photopoint* | *Perimeter mapping/ census/ photopoint* |
| Tamarisk | *Perimeter mapping/ census/ photopoint if plants are found* | *Perimeter mapping/ census/ photopoint if plants are found* |




Map 2. Locations of all permanent monitoring plots sampled in 2008.

## *Natural Resource Based Weed Monitoring*

Few studies have focused on the impacts of weeds on rare plants (Thomson 2005). Controlling the impacts of invasive nonnative plants on rare and endemic plants is increasingly a management priority (Oostermeijer 2003). Weeds are ranked second only to habitat destruction among threats to biodiversity (Wilcove et al. 1998; Levine et al. 2003). Addressing these issues and concerns, monitoring plots were established in 2008 at the Academy at rare plant occurrences. Data from these plots are intended to connect rare plant conservation priorities at the Academy with weed management priorities by providing quantitative information about the relationship between location, abundance, and viability of weed and rare plant targets.

Baseline data were obtained at five locations representing four species of rare plants at the Air Force Academy (Table 2, Map 3). The purpose of these plots is to test the hypothesis that weeds are having negative impacts on rare plant species, are invading their occurrences, and diminishing their population size and viability through competition for resources (space, light, water, and nutrients). Determining the nature of interactions between noxious weed species and rare plants is important for natural resource conservation efforts at the Academy and Farish because of the rich flora of imperiled species supported in these areas. In these plots, target weed and competitive non-native species were mapped at the limit of accuracy of the GPS/ GIS equipment and censused. Weeds and competitive non-natives were mapped at each location where they were observed in close proximity to the rare plants. These species were primarily those targeted in this monitoring study and those listed in Spackman Panjabi and Decker (2007) but also included noteworthy non-native species that are known to be strong competitors and that are observed to form monocultures at the Academy.

Photopoints were sampled at each plot and will be resampled in future years. Photopoints are pictures that are retaken from the same position at each observation, and are typically taken to help elucidate changes to a plot. They are usually taken towards the horizon, rather than at the ground as is done for photoplots. Photopoints were established at all permanent plots. The camera was positioned directly above rebar monumentation marking the photopoint. Photos were shot using a tripod such that the lens aperature was 1.5 meters above the surface, and such that the sky occupied no more than ¼ of the photo. All photopoints were taken using an 8MP digital camera at a focal length equivalent to approximately 28mm on a film camera. Comparison of future years' data with the baselines obtained in 2008 may yield insights into the nature of these interactions and population trends of rare species at the Academy.

Table 2. Location **(NAD 83 CONUS UTM Zone 13)** of Natural Resource Based Monitoring Plots established in 2008.

Table 2 is not available

Map 3 is not available

## RESULTS AND RECOMMENDATIONS

As in previous years, climate continued to have a considerable influence over the cover and density of the target species. The 2008 growing season was characterized by below average precipitation in early summer followed by heavy precipitation later in summer resulting in above average precipitation in August and September (Table 3). The vegetation of the Academy, both weeds and native species, responded strongly to the heavy rains by growing and flowering profusely much later into summer than usual. Despite heavy late summer precipitation the total precipitation was still below average in 2008 due to the dry winter and spring.

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

Table 3. Summary data for monthly precipitation (in inches) at Colorado Springs, Colorado for water years from 2004 through 2008 (Colorado Climate Center 2009).

| Water Yr. | Data | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | 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** | **8.07** |
| | Average | 0.86 | 0.52 | 0.42 | 0.28 | 0.35 | 1.06 | 1.62 | 2.39 | 2.34 | 2.85 | 3.48 | 1.23 | 12.29 |
| | % of Ave. | 21 | 125 | 57 | 279 | 11 | 97 | 67 | 31 | 90 | 67 | 76 | 55 | 66 |
| | Accumulated | 0.18 | 0.83 | 1.07 | 1.85 | 1.89 | 2.92 | 4.00 | 4.73 | 6.83 | 8.74 | 11.39 | 12.07 | |
| | Average Accum. | 0.86 | 1.38 | 1.80 | 2.08 | 2.43 | 3.49 | 5.11 | 7.50 | 9.84 | 12.69 | 16.17 | 17.40 | |
| | % Ave. Accum. | 21 | 60 | 59 | 89 | 78 | 84 | 78 | 63 | 69 | 69 | 70 | 69 | |
| **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** | **11.08** |
| | Average | 0.86 | 0.52 | 0.42 | 0.28 | 0.35 | 1.06 | 1.62 | 2.39 | 2.34 | 2.85 | 3.48 | 1.23 | 12.29 |
| | % of Ave. | 56 | 15 | 71 | 86 | 11 | 23 | 6 | 34 | 35 | 155 | 101 | 123 | 90 |
| | Accumulated | 0.48 | 0.56 | 0.86 | 1.10 | 1.14 | 1.38 | 1.47 | 2.28 | 3.10 | 7.52 | 11.04 | 12.55 | |
| | Average Accum. | 0.86 | 1.38 | 1.80 | 2.08 | 2.43 | 3.49 | 5.11 | 7.50 | 9.84 | 12.69 | 16.17 | 17.40 | |
| | % Ave. Accum. | 56 | 41 | 48 | 53 | 47 | 40 | 29 | 30 | 32 | 59 | 68 | 72 | |
| **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** | **8.06** |
| | Average | 0.86 | 0.52 | 0.42 | 0.28 | 0.35 | 1.06 | 1.62 | 2.39 | 2.34 | 2.85 | 3.48 | 1.23 | 12.29 |
| | % of Ave. | 183 | 37 | 93 | 111 | 49 | 62 | 114 | 98 | 40 | 61 | 77 | 28 | 66 |
| | Accumulated | 1.57 | 1.76 | 2.15 | 2.46 | 2.63 | 3.29 | 5.14 | 7.49 | 8.43 | 10.17 | 12.86 | 13.20 | |
| | Average Accum. | 0.86 | 1.38 | 1.80 | 2.08 | 2.43 | 3.49 | 5.11 | 7.50 | 9.84 | 12.69 | 16.17 | 17.40 | |
| | % Ave. Accum. | 183 | 128 | 119 | 118 | 108 | 94 | 101 | 100 | 86 | 80 | 80 | 76 | |
| **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** | **10.43** |
| | Average | 0.86 | 0.52 | 0.42 | 0.28 | 0.35 | 1.06 | 1.62 | 2.39 | 2.34 | 2.85 | 3.48 | 1.23 | 12.29 |
| | % of Ave. | 29 | 19 | 93 | 164 | 54 | 91 | 24 | 14 | 22 | 10 | 124 | 404 | 85 |
| | Accumulated | 0.25 | 0.35 | 0.74 | 1.20 | 1.39 | 2.35 | 2.74 | 3.08 | 3.60 | 3.89 | 8.20 | 13.17 | |
| | Average Accum. | 0.86 | 1.38 | 1.80 | 2.08 | 2.43 | 3.49 | 5.11 | 7.50 | 9.84 | 12.69 | 16.17 | 17.40 | |
| | % Ave. Accum. | 29 | 25 | 41 | 58 | 57 | 67 | 54 | 41 | 37 | 31 | 51 | 76 | |

## *Acroptilon repens* (Russian Knapweed)

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

In 2008 Russian knapweed was treated with herbicide in the eastern portion of the large infestation near the Skills Development Center, but unfortunately very few of the stems were effectively sprayed. Because most of the stems are under coyote willows at this site, particular care is needed in herbicide application to ensure effective treatment of this species. Its distribution remains highly localized as of 2008 so it remains a high priority to eradicate this species at the Academy. The infestation occupied 103.7 square meters in 2008 in two polygons at the Skills Development Center. On the west side of the restored area 20 individuals remained extant in 2008 and on the east side of the restored area 137 remained extant.

Russian knapweed has been observed along Douglass Drive in 2005 and 2006. On July 14th, 2008, no plants were observed in this area during 20 minutes of searching along the ¼ mile stretch of Douglass Drive where they were previously documented.

## *Carduus nutans* (Musk Thistle)

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

Seven additional plots were established for musk thistle in 2008. Plot locations were randomly selected from a subset of the largest infestations detected in 2007 (Anderson and Lavender 2008b). Baseline data were obtained for each of the additional plots (Tables 4 and 5). Musk thistle remained extant at all three of the original plots for this species (Table 4). Recommendations for musk thistle include continuation of herbicide treatment of large infestations in 2009, and manual destruction of plants in smaller infestations and bag inflorescences if they contain ripe seed. These plots should be revisited in 2009.

Table 4. Summary of treatment at the ten musk thistle plots. Tx is shorthand for "treatment."

| Plot | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| **1** | no Tx | herbicide | no Tx | no Tx |
| **2** | no Tx | herbicide | no Tx | herbicide |
| **3** | herbicide | no Tx | herbicide | herbicide |
| **4** | | | | no Tx |
| **5** | | | | no Tx |
| **6** | | | | herbicide |
| **7** | | | | herbicide |
| **8** | | | | no Tx |
| **9** | | | | no Tx |
| **10** | | | | no Tx |

Table 5. Population size at each of the 10 plots for musk thistle in 2005-2008.

| Plot | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| **1** | 13 | 0 | 12 | 11 |
| **2** | 116 | 0 | 19 | 6 |
| **3** | 25 | 0 | 8 | 1 |
| **4** | | | | 1 |
| **5** | | | | 1 |
| **6** | | | | 10 |
| **7** | | | | 102 |
| **8** | | | | 212 |
| **9** | | | | 160 |
| **10** | | | | 500 |

## *Cirsium arvense* (Canada Thistle)

| 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.

A decline has been observed at all three permanent plots since 2005, although only plots 1 and 2 have been treated (Table 6). Some of the decline of Canada thistle at

these plots is probably due climate variation and hydrologic changes to these sites, as well as treatment. In 2008, most if not all of plot 1 had been treated with herbicide while no treatments had been applied in plots 2 and 3. Plot 1 was observed to be even wetter than it was in 2007, almost certainly due to the rising water table resulting from the upstream restoration of Black Forest Creek.

Cover of Canada thistle remained low at plots 1 and 2, and remained constant in 2008 with no significant change in cover in any plot compared with 2007 (Table 7, Figure 1).

It appears that the current hydrologic regime at most of plot 1 is now too wet for Canada thistle to thrive, although areas adjacent to this plot that were formerly drier may now become infested. Plot 2 and 3 are vulnerable to a resurgence of this species in favorable years for this species.

At plot 3, two probable southern Rocky Mountain cinquefoil plants were found in 2008 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*). Silky cinquefoil is often found with these species and may actually be a hybrid involving these species in its parentage. The southern 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 (Figure 2).

Table 6. Summary of treatment applications at the three permanent plots for Canada thistle. Tx is shorthand for "treatment."

| plot 1 | | | | plot 2 | | | | plot 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2005** | **2006** | **2007** | **2008** | **2005** | **2006** | **2007** | **2008** | **2005** | **2006** | **2007** | **2008** |
| no Tx | Herb-icide | no Tx | Herb-icide | no Tx | Herb-icide | no Tx | no Tx | no Tx | no Tx | no Tx | no Tx |

Table 7. Summary data from the three permanent monitoring plots for Canada thistle. P values are for paired T-tests.

| | | **2005** | **2006** | **2007** | **2008** |
|---|---|---|---|---|---|
| **Plot 1** | **average % cover** | 33.5 | 17.1 | 0.3 | 0.1 |
| | **sd** | 19.27 | 14.17 | 0.62 | 0.15 |
| | **P** | | 0.003 | <0.001 | 0.09 |
| **Plot 2** | **Average % cover** | 24.7 | 5.4 | 2.2 | 2.6 |
| | **sd** | 8.60 | 8.20 | 6.95 | 7.26 |
| | **P** | | <0.001 | 0.05 | 0.57 |
| **Plot 3** | **Average % cover** | 33.5 | 14.0 | 8.2 | 8.2 |
| | **sd** | 25.46 | 9.21 | 8.72 | 12.08 |
| | **P** | | 0.004 | 0.06 | 0.98 |

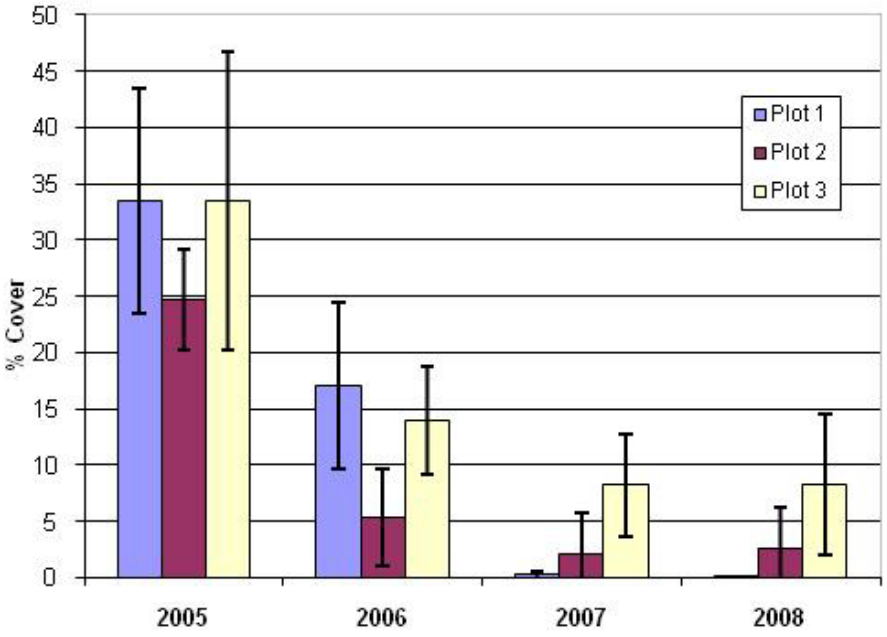



Figure 1. Summary of percent cover observations at the three permanent plots for Canada thistle from 2005 through 2008. Error bars indicate 90% confidence intervals around the mean.

Figure 2. Leaf of probable southern Rocky Mountain cinquefoil found at Plot 3 in 2008. Note typical silky hairs and regularly toothed leaflets which are typical and diagnostic for this species, but the decurrent blades connecting the terminal leaflets to one another.

Monitoring these sites will still be worthwhile for informing management decisions, particularly at plot 1 due to its proximity to the Black Forest Creek restoration project, and at plot 3 due to its proximity to southern Rocky Mountain cinquefoil.

## *Euphorbia esula* (Leafy Spurge)

| 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 |

The leafy spurge plots were sampled on August 8 before heavy rains began. The droughty conditions appeared to have resulted in poor growth of leafy spurge through early summer in the permanent plots.

At plot 2, herbicide has been applied aggressively every year to control leafy spurge (Table 8). From 2005 to 2007, leafy spurge spread rapidly into uninfested areas at this site. Efforts to spray it were locally effective here, but in any given year many stems evaded herbicide treatment and these became nodes from which the species spread in subsequent years. Overall, the area occupied and number of stems increased continuously from 2005 through 2007 despite treatment efforts (Tables 8 and 9). In 2008, considerably fewer stems were observed at this site but this may be partially due to drought. This plot had been partially treated in 2008 but many untreated stems were observed especially in the eastern portion of the plot. While density was much lower in 2008 the occupied area remained roughly the same suggesting that leafy spurge remains well entrenched at this site. Previously cleared areas are becoming infested once again at this site (Map 4).

Herbicide was probably applied to the largest infestation at plot 3 in 2008 although the poor condition of the plants in this plot 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.

The small infestation at plot 1 was not treated in 2005-2008, and no new infestations were detected at this plot in 2008.

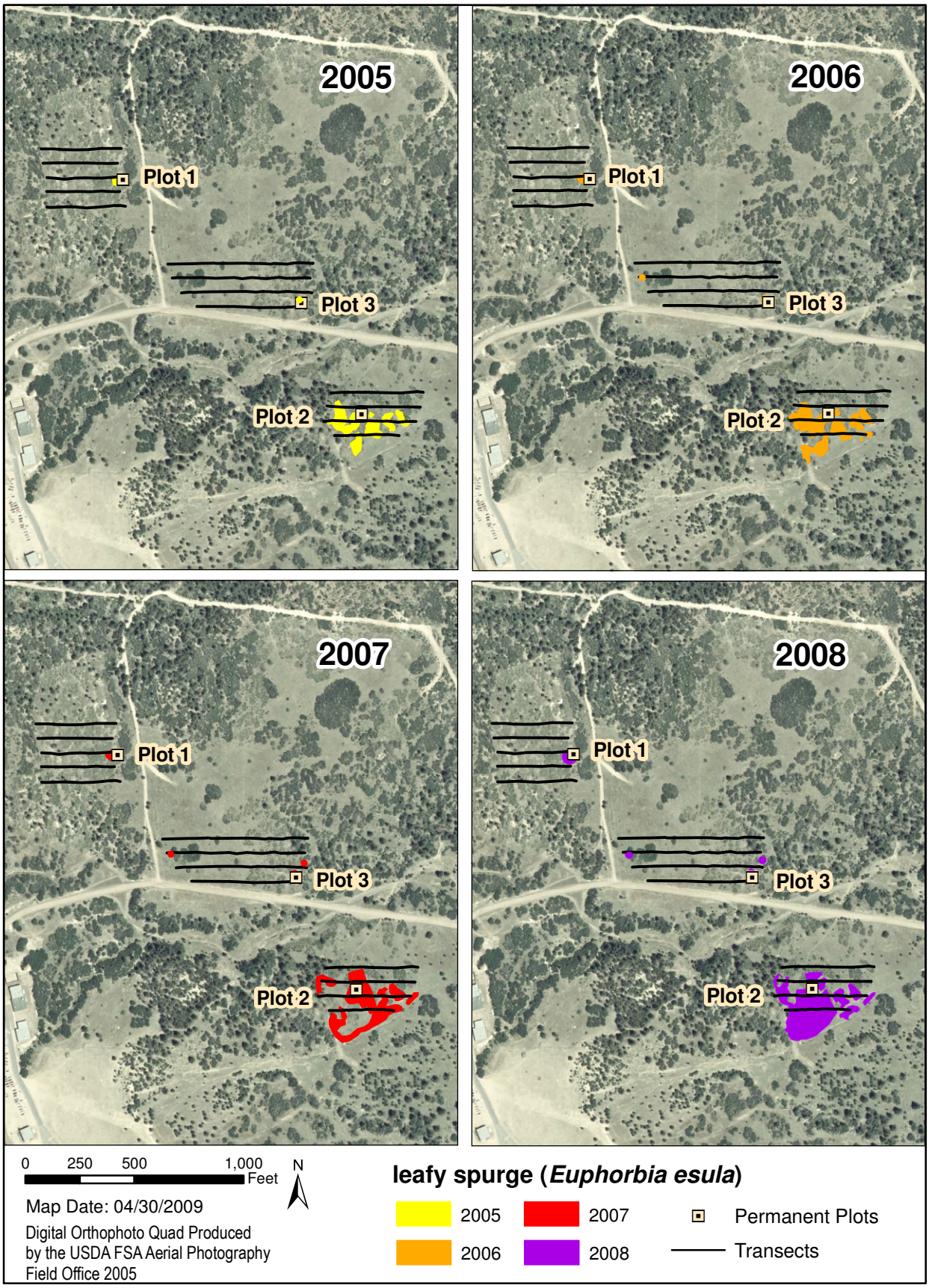
Table 8. Summary of treatment applications for the three leafy spurge plots from 2005-2008. Tx is shorthand for "treatment."

| plot 1 | | | | plot 2 | | | | plot 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | 2006 | 2007 | 2008 | 2005 | 2006 | 2007 | 2008 | 2005 | 2006 | 2007 | 2008 |
| no Tx | no Tx | no Tx | no Tx | Herb-icide | no Tx | Herb-icide | Herb-icide (in part) | no Tx | no Tx | Herb-icide (in part) | Herb-icide |

Table 9. Summary data from the three permanent plots for leafy spurge.

| | | Occupied Area ($m^2$) | N (ramets) | # patches |
|---|---|---|---|---|
| **Plot 1** | **2005** | 78 | 234 | 1 |
| | **2006** | 146 | 5840 | 1 |
| | **2007** | 129 | 5149 | 1 |
| | **2008** | 313 | 40 | 1 |
| **Plot 2** | **2005** | 2340 | 6097 | 6 |
| | **2006** | 3193 | 11130 | 7 |
| | **2007** | 4214 | 18156 | 4* |
| | **2008** | 5533 | 1076 | 5 |
| **Plot 3** | **2005** | 79 | 393 | 1 |
| | **2006** | 97 | 970 | 2 |
| | **2007** | 108 | 545 | 3 |
| | **2008** | 144 | 13 | 2 |

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




Map 4. Distribution of leafy spurge at the three permanent plots in 2005-2008.

## *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 |

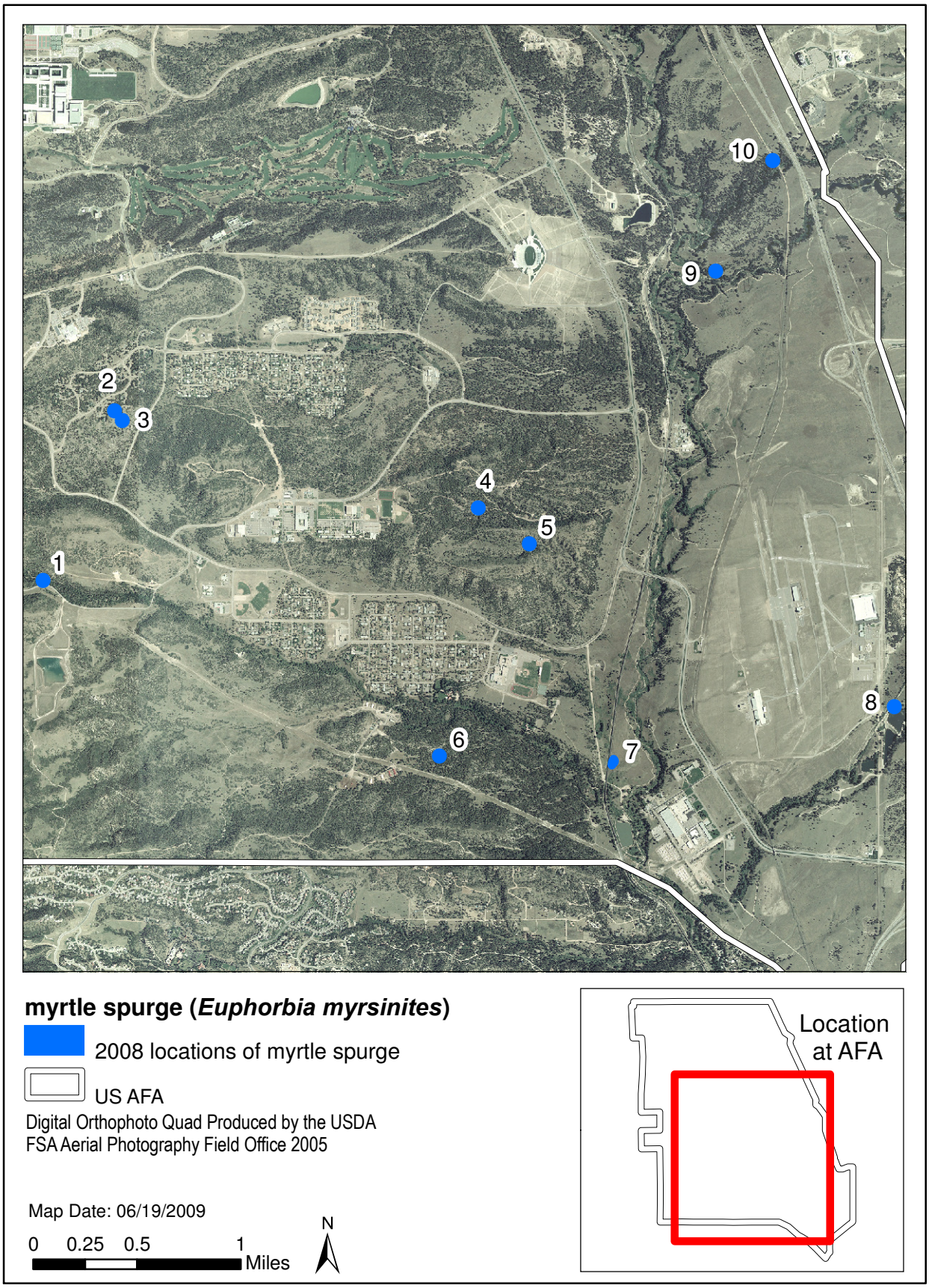
Myrtle spurge is the only noxious weed species at the Academy with List A status, mandating the eradication of this species wherever it is found (Colorado Department of Agriculture, Plant Industry Division 2005). Fortunately, Natural Resources Staff at the Academy identified the presence of myrtle spurge at an early stage of its invasion, and progress is being made towards its eradication. The three permanent plots for this species were established at the only known extant infestations in 2006, but there are now six additional infestations that are also being monitored (Map 5). The total area infested by myrtle spurge at the Academy was approximately 934 $m^2$ in 2008.

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 be sprouting 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.

Plot 2 is located at the southwestern edge of the housing in Douglass Valley behind 4176 Douglass Way, where two large patches are present. There was no evidence of treatment at this plot in 2006 or 2007. In 2006, myrtle spurge was found in a rockgarden 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 10). In 2008 large, reproductive plants remained at this location and no treatment was evident.

Plot 3 is located in the Archery Range area near Sumac Drive. It was treated with herbicide in 2005. 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.

Myrtle spurge is known from six additional sites at the Academy which vary in their current status and success of control:




Map 5. All known sites where myrtle spurge has been found at the Academy between 2005 and 2008. Numbers correspond to locations described in the text.

Table 10. Summary of all known infestations of myrtle spurge as of 2008. Numbers at left correspond to numbers in Map 5.

| | ***Site/ Location*** | ***2005*** | ***2006*** | ***2007*** | ***2008*** |
|---|---|---|---|---|---|
| 1 | Douglass Creek | 20-30 | 3 (pulled) | | |
| 2 | Plot 2- Douglass Valley Housing | | 72 | 122 | 120 |
| 3 | East Bank Monument Creek | | | 1 | 0 |
| 4 | Plot 3- Archery Range | | 25 | 41 | 24 |
| 5 | Archery Range- Community Center Drive | | | | 75 (sprayed) |
| 6 | Plot 1- East of Stables | | 142 | 97 | 146 |
| 7 | South of Electric Substation | | | | |
| 8 | Kettle Lake | | 1 (pulled) | 0 | 0 |
| 9 | Middle Fork Monument Creek | | | | 23 (pulled) |
| 10 | Santa Fe Trail | Pick-up Load | | 0 | 4 |

4. It was found at two sites along Douglass Creek adjacent to Douglass Drive in 2005, and 20-30 plants were pulled at that time. On June 8, 2006 the site was revisited, and another three plants were found and pulled. This site was not revisited in 2008.

5. It was found at Kettle Lake in 2005, where it was pulled that year. One plant was seen at the Kettle lake location on June 8, 2006 and was pulled; this site was revisited in 2007 and no plants were seen.

6. Myrtle spurge was discovered in 2005 along the Santa Fe trail. Natural Resources Staff dug up an entire pickup load of myrtle spurge that year. This treatment was very effective- when roots are fully excavated and the plants are taken away very little regrowth has been observed. Four plants were found at this site in 2008.

7. A site near the Archery Range off Community Center Drive was discovered and sprayed in 2008. Approximately 75 plants were observed at this site on July 15$^{th}$ 2008 after herbicide had been applied.

8. One previously unknown site was found on the east side of Monument Creek by Michelle Washebek in 2007 who pulled the one individual at the site. No plants were seen at this location in 2008.

9. At a previously known site south of the Middle Fork of Monument Creek, 23 plants were pulled by Brian Mihlbachler and David Anderson on July 15th 2008. Plants at this site had been pulled previously.

10. A large site was discovered in 2008 south of the substation off Community Center Drive.

It is likely that founder infestations of myrtle spurge will continue to crop up at the Academy. Continued annual monitoring is needed for this species to maintain vigilance and ensure that it is eradicated. All known infestations of this species should be revisited and assessed in 2009.

## *Hypericum perforatum* (Common St. Johnswort)

| Species | 2008 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 |

Some ongoing management efforts for common St. Johnswort at the Academy appear to have been quite effective. At plot 2 (Map 2), 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. It was detected at this roadside location in 2005 but was not seen for the past two years, indicating that persistent monitoring is required to ensure the eradication of infestations of this species.

At plots 1 and 3 (Map 2), biocontrol insects introduced by Michels et al. (2004) have had considerable local impacts on the density of common St. Johnswort (Figure 3). Additional infestations of common St. Johnswort were discovered along Kettle Creek in 2007, illustrating that this species is continuing to spread at the Academy (see Anderson and Lavender 2008a). The newly detected infestations were censused and perimeter mapped in 2008. In 2008 a total of 19 infestations of common St. Johnswort were mapped, occupying 3,999 square meters at the Academy. 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 2009 to inform support eradication efforts for this species.

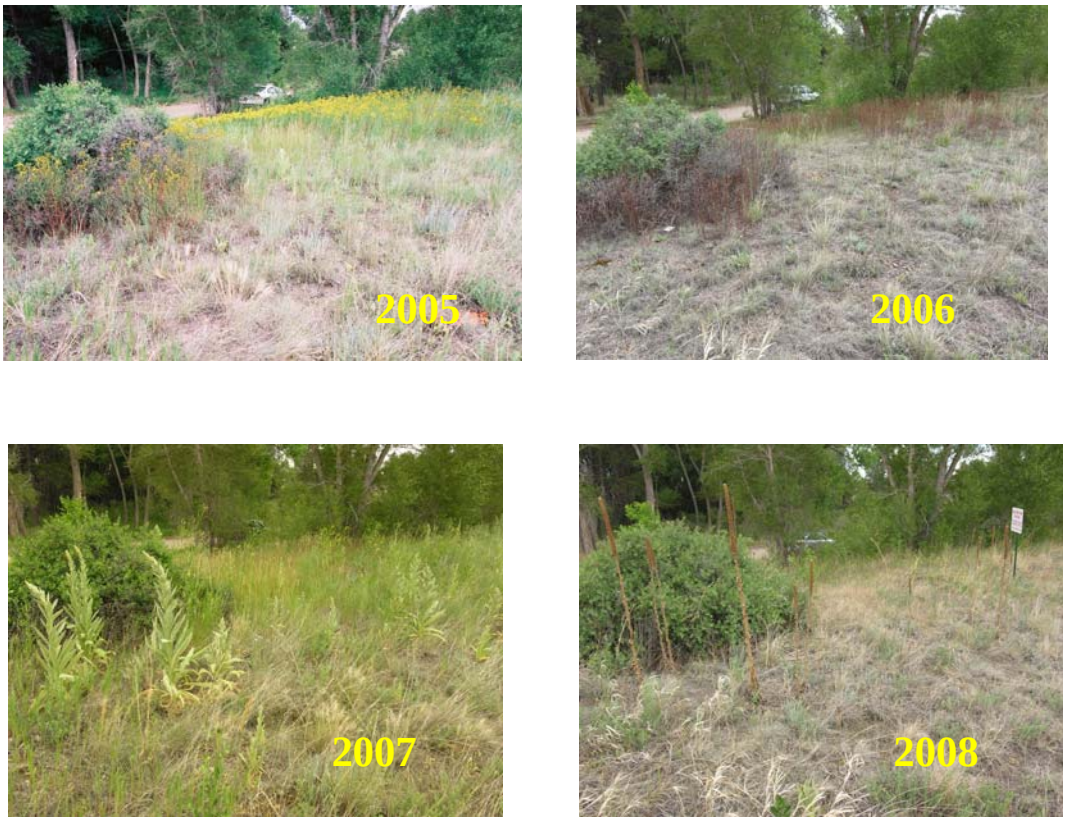


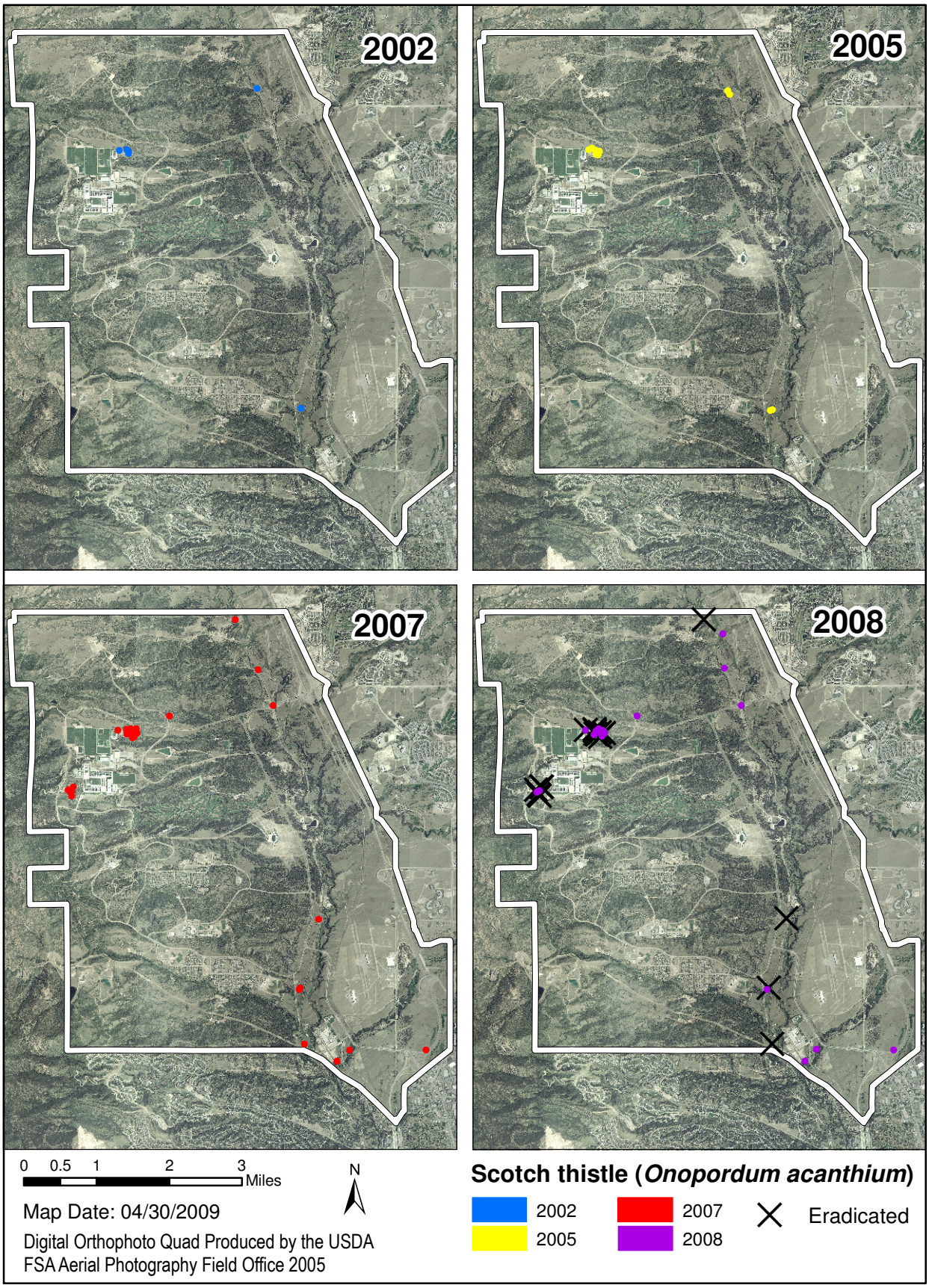

Figure 3. Photopoint 1a, showing progress in managing common St. Johnswort with biocontrol insects from 2005-2008. No common St. Johnswort was detected here in 2008.

## *Onopordum acanthium* (Scotch Thistle)

The population of Scotch thistle has increased from 2002 through 2008 at the Academy (Table 11, Map 6). Compared with 2007, occupied acres and number of individuals declined slightly in 2008. This is probably the result of a combination of aggressive treatment of infestations east of the athletic field complex and spring drought conditions. 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 over several years whether they were treated or not so it remains important to revisit and assess infestations after they have seemingly been eradicated.

Table 11. Summary data for Scotch thistle at the Academy from 2002-2008.

| | 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** | 1.13 | 140 | 25 |




Map 6. Extent of Scotch thistle in 2002 through 2008 at the Academy.

## *Natural Resource Based Weed Monitoring*

Noxious weed species pose a threat to the viability of rare plant occurrences at all five plots although the magnitude of the threat varies. Summary baseline data for these plots are compiled in Table 12, including the list of noxious weeds and other competitive non-native plant species mapped at each location. Details regarding each plot are described in the following sections.

Table 12. Summary baseline data for natural resource based monitoring plots in 2008.

| Rare Plant | Weed | Area ($m^2$) | % weeds within 10m | N for Rare Plants | Total $m^2$ of buffered Rare Plant |
|---|---|---|---|---|---|
| *Amorpha nana* | *Cirsium arvense* | 441.2 | 19.3% | 60 | 2289.7 |
| | *Linaria vulgaris* | 566.1 | 24.3% | | |
| | (all weeds, no overlap) | **624.1** | **27.3%** | | |
| *Liatris ligulistylis* | *Bromus inermis* | 76.2 | 24.4% | 23 | 312.6 |
| | *Linaria vulgaris* | 291.7 | 93.3% | | |
| | (all weeds, no overlap) | **291.8** | **93.4%** | | |
| *Potentilla ambigens* 1 | null | 0.0 | **0** | 7 | 2251.1 |
| *Potentilla ambigens* 2 | *Carduus nutans* | 2.8 | 0.9% | ~9600 | 312.6 |
| | *Centaurea diffusa* | 99.6 | 31.9% | | |
| | *Convolvulus arvensis* | 23.7 | 7.6% | | |
| | *Linaria vulgaris* | 6.1 | 1.9% | | |
| | *Onopordum acanthium* | 7.6 | 2.4% | | |
| | (all weeds, no overlap) | **118.9** | **38.0%** | | |
| *Ribes americanum* | *Dipsacus fullonum* | 503.3 | 14.5% | ~300 | 3471.4 |
| | *Lonicera tatarica* | 733.0 | 21.1% | | |
| | (all weeds, no overlap) | **1233.7** | **35.5%** | | |

### *Amorpha nana* (Dwarf Wild Indigo)

Dwarf wild indigo is Widespread throughout much of the midwest from southern Manitoba and Saskatchewan to Minnesota and northwest Iowa, from North Dakota to Oklahoma, west to Colorado and New Mexico. In Colorado it is known from Boulder, Jefferson, El Paso, and Las Animas Counties. The conservation status rank of dwarf wild indigo is G5 S2S3, indicating that it is globally common but imperiled in Colorado.

The occurrence at the Academy had not been seen since its discovery by Nan Lederer in 1993. In 2008 the occurrence of dwarf wild indigo was largely as described in 1993 and was found to remain extant and viable. At this location about 200 stems were found in a patch of grassland dominated by Arizona fescue (*Festuca arizonica*) and several dicot species.

Noxious weeds observed in the vicinity of dwarf wild indigo included Canada thistle and yellow toadflax, which were mapped in 2008 (Map 7). Neither of these species were mentioned in the 1993 account of this occurrence, so it is possible that they have invaded this site more recently. Smooth brome (*Bromopsis inermis*), a non-native, turf forming grass, is prevalent throughout most of this area but is not dominant within the occurrence of dwarf wild indigo. The presence of smooth brome nearby was also noted in 1993. This species is visible in the photopoint (Figure 4), making it possible to observe changes in the relative position of dwarf wild indigo and smooth brome in future years.

Figure 4. Photopoint for dwarf wild indigo. Red pinflags mark stems of dwarf wild indigo.

Map 7 is not available

### *Liatris ligulistylis* (Rocky Mountain Blazing Star)

Rocky Mountain blazing star (*Liatris ligulistylis*) is found across the northern US and in the plains provinces of Canada, and along the Rocky Mountains where it is typically found in moist meadows. Rocky Mountain blazing star is part of an interesting chapter of Colorado's natural history. At one time the Great Plains and Midwest were wetter and supported large contiguous tracts of woodlands, as well as Rocky Mountain blazing star and a suite of other woodland species. Now some of these species survive in Colorado in the Black Forest and in some areas of the Front Range but are now disjunct since the woodlands of the Plains have transitioned to prairie. These species are thus known collectively as woodland prairie relicts. The conservation status rank of Rocky Mountain blazing star in Colorado is G5? S1S2, indicating that it appears to be globally secure but is imperiled to critically imperiled in Colorado.

Rocky Mountain blazing star was discovered at the Academy in 2002 during the fieldwork to map the weeds of the Academy (Anderson et al. 2003). The small occurrence at the Academy is located in the Lehman Run drainage south of the main campus entrance.

Twenty five individuals were observed in 2008. Weeds and non-native species mapped within and adjacent to the occurrence include smooth brome and yellow toadflax (Figure 5, Map 8). Canada thistle was observed at this site in 2002 but was not seen within the immediate vicinity of Rocky Mountain blazing star in 2008.

Herbicide spraying occurred in 2008 in the immediate vicinity of the Rocky Mountain blazing star, raising concerns for potential impacts resulting from this activity. Fortunately the plants themselves were not sprayed but there has been considerable disturbance to this site from driving trucks through the area.

Figure 5. Photopoint for Rocky Mountain blazing star. Red pinflags mark clusters of stems of Rocky Mountain blazing star.

Map 8 is not available

## *Potentilla ambigens* (Southern Rocky Mountain Cinquefoil)

Extant occurrences of southern Rocky Mountain cinquefoil are currently known from Colorado and New Mexico. Historically, this species was collected at one location in Albany County, Wyoming in 1900 where it has not been seen since and is likely to have been extirpated (Anderson 2006). The conservation status of southern Rocky Mountain cinquefoil in Colorado is G3 S2, indicating that it is globally vulnerable and imperiled within the state of Colorado. The population at the Academy is therefore very important for maintaining the viability of this species.

**Plot 1**

This is the largest occurrence of southern Rocky Mountain cinquefoil at the Academy. The average density of this occurrence is 22 plants per square meter, based on 16 randomly placed $1m^2$ quadrats placed within the occurrence. Many plants were small and nonreproductive, but many large reproductive plants are present as well. The population size may be as high as 9,600 individuals at this location.

The persistence of this occurrence is the result of proactive management by Natural Resources Staff. This occurrence is near a degraded reach of Black Forest Creek. The course of Black Forest Creek had shifted as a result of channel degradation and was flowing through a portion of the occurrence. Considerable downcutting and rapid erosion threatened the entire occurrence of southern Rocky Mountain cinquefoil at this site. In 2006 many plants were falling into the channel as it widened and undercut the occurrence.

In 2007 ambitious efforts to restore this reach of Black Forest Creek began. The original creek channel to the north of the southern Rocky Mountain cinquefoil was regraded and stabilized. The new channel was filled and revegetated, resulting in some impacts to the occurrence at the edge of the channel (Figure 6). However, care was taken not to impact the unaffected plants and about half of the occurrence remains now. In 2008 it appears that the restoration efforts were highly successful with respect to southern Rocky Mountain cinquefoil.

The monitoring plot established at this site will allow for early detection and rapid response to weed invasion of the restored area and will detect changes in the footprint of southern Rocky Mountain cinquefoil at this site. Musk thistle, Canada thistle, and diffuse knapweed were all detected and mapped within the vicinity of this occurrence but no weeds were observed within 10 meters of the occurrence in 2008 (Map 9). Other competitive nonnative species observed at this site include sweet clover (*Melilotus* sp.), prickly lettuce (*Lactuca serriola*), cheatgrass (*Bromus tectorum*), mullein, flixweed (*Descurainia sophia*), smooth brome (*Bromopsis inermis*), crested wheatgrass (*Agropyron cristatum*), and pennycress (*Thlaspi arvense*).

Figure 6. Photopoint for southern Rocky Mountain cinquefoil plot 1. Vegetated area is in foreground to left; extant portion of southern Rocky Mountain cinquefoil occurrence is visible beyond.

Map 9 is not available

**Plot 2**

This occurrence of silky cinquefoil consists of a small population of seven large reproductive plants. The plants are on a gentle slope on a former floodplain bench of Black Forest Creek (Figure 7). Numerous noxious weeds are present within and adjacent to this occurrence (Scotch thistle, diffuse knapweed, Canada thistle, field bindweed, and yellow toadflax), all of which were mapped at this location (Map 10). Other competitive non-native species (crested wheatgrass, cheatgrass, smooth brome, and mullein) were also observed at this location and may also pose a threat to the viability of southern Rocky Mountain cinquefoil.

Figure 7. Photopoint for southern Rocky Mountain cinquefoil plot 2.

Map 10 is not available

## American Currant (*Ribes americanum*)

The occurrence of American current at the Academy is along Pine Creek where, despite altered hydrology, it is thriving. One noxious weed, Fuller's teasel, was mapped at this site (Figure 8, Map 11). In 2008 this species was present throughout the occurrence of American currant in low densities.

Tatarian honeysuckle (*Lonicera tartarica*) was also observed and mapped at this site in 2008. This species is not yet listed on Colorado's Noxious Weed List (Colorado Department of Agriculture Plant Industry Division 2005) but is listed in at least five other states (USDA NRCS 2009, Wisconsin Department of Natural Resources 2004). In other parts of the US it has been observed to form monocultures and outcompete native shrubs (Wisconsin Department of Natural Resources 2004). At Pine Creek hundreds of Tatarian honeysuckle individuals are present and the species has spread throughout much of the riparian area within the occurrence of American currant. These observations suggest that Tatarian honeysuckle may pose a significant threat to the viability of American currant at the Academy. This species is not yet widespread at the Academy or in Colorado but its presence in Pine Creek suggests that a rapid response may be warranted. It may be advisable at this time to add this species to the monitoring and mapping program at the Academy to facilitate rapid response management actions.

Figure 8. Photopoint for American currant. American currant is visible as very green foliage at center of the frame.

Map 11 is not available

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