Biological Control of Noxious Weeds on Federal Installations in Colorado and Wyoming

Air Force Academy
Buckley Air Force Base
Fort Carson Military Post
Rocky Flats National Wildlife Refuge
F. E. Warren Air Force Base

G. J. Michels, J r., H. L. Lindon, , Nathanel (J J ,) Engel, Brian Mulhern, Sundhya Solanki, Erin Jones and Chanda Henne

Texas AgriLife Research
2301 Experiment Station Road
Bushland, Texas 79012

2008 Consolidated Report
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On the cover: Close up of saltcedar (Tamarix) flowers taken from Section 36 at Fort Carson. Over 10,000 Diorhabda elongata beetles were released at the site this summer. Photo credit: Erin Jones.
Introductory Notes

As of 2008, the biological control of noxious weeds project has been going on for twelve years at Ft. Carson Military Post (FTC), nine years at Air Force Academy (AFA), eight years at Rocky Flats National Wildlife Refuge (RF), six years at Buckley Air Force Base (BAF), and five years at F. E. Warren Air Force Base (WAB). As stated in previous years, the program’s focus is threefold:

1. Establish approved insects and mites for control of various federal- and state-listed noxious weeds at various sites within the five locations.
2. Redistribute established insects and mites to additional weed infestations.
3. Monitor the reduction in weed infestations through GPS mapping of infestation perimeters and plant measurements that include density, height, and other variables.

Though this summer marked a transitional period where a new project coordinator has stepped in to take over the project, every effort has been made to maintain the continuity of the program. The focus this year was on conducting the vegetation monitoring when insect populations were at their peak and plants had reached the flowering stage. This change in the monitoring protocol was made to ensure that sampling would be better timed to more accurately reflect the current populations of plant and insect species.

To accomplish this goal, sentinel sites were selected to represent each insect and plant type and sites were sampled weekly. When plants and insects were determined to be at their peak, the sentinel site and all other sites of that plant species were mapped. Ideally, sentinel sites continued to be monitored until insect populations declined for two consecutive weeks. To further streamline the data taking process, changes were made to the number of samples taken at a site, with 30 quadrats sampled in sentinel sites and 10 points sampled in all other sites. In 2008 we continued monitoring the progress of sites in all four stages of control (new, young, populations in consistent decline and “crashed”) as well as seeking out potential new sites. Due to limited resources this summer, both in labor and insect availability, we focused on marking out new sites only and will begin mapping them and performing additional insect releases next summer if agents are available.

Finally, you will notice the return this year of data on the infestation of field bindweed by the bindweed mite Aceria malherbae (Table 8). Biocontrol efforts on this mite began in 2006 and additional releases were made in 2008 from mites harvested in Amarillo, TX. We hope to continue with mite introductions, mowing to distribute the mites, and monitoring infestations at all the installations with field bindweed sites.
Navigating the 2008 Report

Figure 1 illustrates the locations of noxious weed biological control work over the past eleven years. For the 2008 season we have focused on five installations, Air Force Academy, Buckley Air Force Base, Fort Carson Military Post, Rocky Flats National Wildlife Refuge, and F. E. Warren Air Force Base. Table 1 presents an overview of the general trends in noxious weed intensity and growth over the past year. Table 2 provides a quick reference to the changes in weed population parameters, density and height, on a site-by-site basis for each of the participating installations. Sites discontinued in 2008 were not included in this quick summary table.

Beginning on page 13, we present the supplementary laboratory and field data collection from 2006 and 2008 that helps us to assess the establishment efficacy and damage potential of released bio-agents. Table 3 represents the results of knapweed seedhead collections in 2008 quantifying populations of the seed-feeders Larinus minutus, Metzneria paucipunctella, Urophora affinis and U. quadrifasciata. Tables 4 and 5 contain information about Atheta sp. establishment and Table 7 describes the success of the control of St. John’s wort at the Air Force Academy. As mentioned in the introductory notes, Table 8 contains data on field bindweed infestations across four installations. In previous years a comparison of establishment levels of toadflax stem-borer, Mecinus janthinus, from the previous field season were included in this section. Results from the 2007 field season are missing because we did not have an opportunity to collect toadflax stems this spring, results of the 2008 field season will be included in next year’s report.

In the remainder of this consolidated report, we discuss the details of activities at the various locations in alphabetical order, beginning with the Air Force Academy and ending with F. E. Warren Air Force Base. As in previous reports, this format provides a written narrative of the key observations and activities at each location, followed by tabular material with historic site data, plant parameter changes, and biocontrol agent release and recovery records. Additionally, maps and graphs of individual infestations provide detailed information on the current distribution of and changes to a weed’s density and height throughout its monitoring history.

Characteristics of each weed infestation (i.e. total area covered, density of infested patches, height of plants, seedhead production, etc.) are summarized within the initial table for each installation. Plant density measurements are taken from counts of individual stems/plants within a given number of 0.5m² quadrat samples (n). The additional table presented for each installation identifies which biological control agents have been released and recovered at a given site to date. Due to the changes in sampling protocol this year, sentinel sites were monitored several times in the season and therefore bio-agents had a better chance of being detected than in previous years when only one survey was conducted. The species recovery tables therefore reflect data from both sentinel site visits and data from species counted during site mapping.

Just as they were last year, the current year’s weed density and height estimates are then presented in detail as colorful maps illustrating the distribution of each plant parameter within an infestation’s perimeter. The maps are generated using a Geographic Information Systems (GIS) technique called spatial interpolation based on the data collected at various points sampled throughout an infestation. For each weed infestation we present the following maps:
a) Perimeter of the Infestation – we present a map of the current area infested by a particular weed, superimposed over both the previous year’s infestation extent and cumulative area covered by the weed throughout all previous monitoring years

b) Weed Density – the interpolation map represents the variation in weed density across its infestation area in 2008

c) Weed Height – the interpolation map displays the variation in plant maximum height (a proxy measurement for weed vigor or quality) across the current year’s infestation

In addition to weed parameter distribution maps, we provide graphs showing the change in plant density and height over the duration of our biocontrol release and monitoring activities. Error bars in the graphs represent the 95% confidence interval (p=0.05). Where the top error bar for a given year does not overlap the bottom error bar for another year, or vice versa, the change is statistically significant.

All maps and graphs presented in our annual consolidated reports are generated from georeferenced data, obtained in the field using GPS-enabled data collectors. All of the data collected on weed infestation perimeters, plant density and height, bio-agent release and detection up to the 2007 field season are contained within a geodatabase. Using this information, we are able to analyze data both statistically and spatially, along with converting data to visual maps, using GIS. In order to provide our cooperating installations with the opportunity to utilize the data we have collected to meet their own planning and analysis needs, we are making these comprehensive geodatabases available to you. Information for the 2008 field season will be incorporated into the database in the winter of 2008 and distributed to our cooperators at the meeting in 2009. Photopoint photos for all years available will also be incorporated into the database this winter. The information contained within each geodatabase is compatible with ArcGIS products; however, individual database, or .dbf files, can be viewed as standalone tables in MS Excel. These data will also be supplemented by the raw plant dissection and insect observation information that was used to produce Tables 3-8.
General Trends in 2008

Of the sites monitored in both 2007 and 2008, the overall trend across all species and all installations was a decrease in both plant density and plant height (Table 1). The majority of sites showing a decrease in density were not significantly less dense than last summer (16 sites out of 21) whereas a little over half of the sites that showed a decrease in height had plants that were significantly shorter than last year (18 sites out of 31). The only species that had more than two sites with an increase in either parameter was spotted knapweed, with three sites having significant increases in density, three sites with a non-significant increase in density and two sites with a non-significant increase in height. Only one site, Monument Trail Road at the Air Force Academy, had an increase (non-significant) in both parameters. The overall decline in density and plant robustness may be attributed to a long dry spell during the late spring and summer. The number of bio-agents observed was also low, and in some sites non-existent, which may be linked to the lack of precipitation as well. According to the National Oceanic and Atmospheric Administration (NOAA), the average precipitation in the Colorado Springs area over the period from June 3rd to the end of August was from 0 up to 4.5 inches lower than normal. Two agents that were particularly successful this year despite the dry weather were Larinus minutus and Rhinocyllus conicus, the latter of which self-dispersed to sites on Air Force Academy, Buckley Air Force Base, Fort Carson Military Post and Rocky Flats National Wildlife Refuge.

Each installation also had several sites where the area and density of weeds were reduced to such low levels that accurate mapping was not possible. Though in the past sites that had diminished weed populations have rebounded to mappable levels in subsequent years, it is encouraging to see so many sites reduced to a few scattered plants. There were four sites at the Air Force Academy, one at Buckley Air Force Base, three at Fort Carson Military Post, two at Rocky Flats National Wildlife Refuge and five at F.E. Warren Air Force Base that were unmappable due to low density.

This summer we were not able to make as many insect releases as we had planned due to low insect numbers at established sites. However, one bio-agent that we had in abundant supply was the field bindweed mite Aceria malherbae. A large number of infested runners were collected from a site in Amarillo, Texas, and distributed to 11 previously-established field bindweed sites at Buckley Air Force Base, Fort Carson Military Post, and Rocky Flats National Wildlife Refuge. The addition of infected runners combined with mowing of the sites to redistribute the mite should increase the efficacy of this bio-agent. As mites become established at sites on each of the bases these sites can then serve as nurseries to distribute the mite to other Field Bindweed patches on the installation.

As always, please send us any comments you may have regarding either our biocontrol efforts or the reporting format. We appreciate the continued opportunity to carry on this important work.
Figure 1. Map showing the federal installations in Colorado and Wyoming on which noxious weed biological control efforts are being/have been made by Texas AgriLife Research.
Table 1. Overall summary of the trends in noxious weed parameter changes, 2007-2008, at the five participating installations in Colorado and Wyoming.

<table>
<thead>
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<th>Noxious Weed</th>
<th>Parameter</th>
<th>Significant decrease</th>
<th>Decrease</th>
<th>Significant increase</th>
<th>Increase</th>
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<td><strong>10</strong></td>
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1Significance level, $p=0.05$
Table 2. Details of the changes in noxious weed parameters, 2007-2008, at Air Force Academy (AFA), Buckley Air Force Base (BAF), Fort Carson Military Post (FTC), Rocky Flats National Wildlife Refuge (RF), and F. E. Warren Air Force Base (WAB). Sites that were monitored only one of these years are not included in the summary.

<table>
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<th>Site</th>
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<th>Parameter</th>
<th>Annual Change</th>
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<td>decrease</td>
</tr>
<tr>
<td>FTC</td>
<td>ARA II</td>
<td>Canada Thistle</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>FTC</td>
<td>Duckpond</td>
<td>Canada Thistle</td>
<td>Density</td>
<td>increase</td>
</tr>
<tr>
<td>FTC</td>
<td>Duckpond</td>
<td>Canada Thistle</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>FTC</td>
<td>Wildlife</td>
<td>Musk Thistle</td>
<td>Density</td>
<td>increase</td>
</tr>
<tr>
<td>FTC</td>
<td>Wildlife</td>
<td>Musk Thistle</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>FTC</td>
<td>Gun Club</td>
<td>Diffuse Knapweed</td>
<td>Density</td>
<td>decrease</td>
</tr>
<tr>
<td>FTC</td>
<td>Gun Club</td>
<td>Diffuse Knapweed</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>FTC</td>
<td>Fuel Site</td>
<td>Spotted Knapweed</td>
<td>Density</td>
<td>increase</td>
</tr>
<tr>
<td>FTC</td>
<td>Fuel Site</td>
<td>Spotted Knapweed</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>FTC</td>
<td>Turkey Creek</td>
<td>Spotted Knapweed</td>
<td>Density</td>
<td>increase</td>
</tr>
<tr>
<td>FTC</td>
<td>Turkey Creek</td>
<td>Spotted Knapweed</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>RF</td>
<td>Lindsay Ranch</td>
<td>Canada Thistle</td>
<td>Density</td>
<td>decrease</td>
</tr>
<tr>
<td>RF</td>
<td>Lindsay Ranch</td>
<td>Canada Thistle</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>RF</td>
<td>South Fence Transects</td>
<td>Dalmatian Toadflax</td>
<td>Density</td>
<td>increase</td>
</tr>
<tr>
<td>RF</td>
<td>South Fence Transects</td>
<td>Dalmatian Toadflax</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>RF</td>
<td>North Buffer Transects</td>
<td>Diffuse Knapweed</td>
<td>Density</td>
<td>decrease</td>
</tr>
<tr>
<td>RF</td>
<td>North Buffer Transects</td>
<td>Diffuse Knapweed</td>
<td>Height</td>
<td>increase</td>
</tr>
<tr>
<td>WAB</td>
<td>Black Powder Road</td>
<td>Leafy Spurge</td>
<td>Height</td>
<td>decrease</td>
</tr>
<tr>
<td>WAB</td>
<td>Black Powder Road</td>
<td>Leafy Spurge</td>
<td>Density</td>
<td>decrease</td>
</tr>
</tbody>
</table>

at p=0.05 * indicates parameters are significantly different, ns indicates no significant difference
Summary of 2008 Laboratory and Field Support Efforts

In addition to weed mapping and monitoring efforts on federal installations, our program performs a number of surveys/studies to support the assessment of biological control efficacy. These analyses include biocontrol insect surveys in the field and dissection of plant materials from bio-agent release areas, generally conducted in the fall and winter after the field season. Summaries of the population densities of various biological control agents that are presented in this section include the following:

- Knapweed seedhead occupants, collected after the 2008 field season (Table 3)
- Comparative spring collections of *Aphthona* beetle populations found at mapped leafy spurge infestations during peak beetle emergence in 2004, 2005, 2006, 2007 and 2008 (Table 5).
- Comparative spring collections of *Aphthona* populations found at supplementary leafy spurge release sites in 2006, 2007 and 2008, from which 10 random sweeps were taken to collect the beetles in lieu of mapping the sites (Table 6).
- Comparative spring collections of *Chrysolina* beetle populations found at mapped St. John’s wort infestations during peak beetle emergence in 2004, 2005, 2006, 2007 and 2008 (Table 7).

Discussions of the bio-agent establishment and damage reported in these tables will take place within the subsequent sections for individual installations.
Table 3. Knapweed seedhead dissections from sampled plants in 2008 at Air Force Academy (AFA), Fort Carson Military Post (FTC) and Rocky Flats National Wildlife Refuge (RF), identifying the proportion of knapweed seedheads attack (%) and the seed-feeding agents responsible.

<table>
<thead>
<tr>
<th>Installation Abbreviation</th>
<th>Sample Site Name</th>
<th>n</th>
<th>Percent Heads Attacked</th>
<th>Seedheads with Biological Control Agents (%)</th>
<th>L. minutus</th>
<th>U. affinis</th>
<th>U. quadrifasciata</th>
<th>M. paucipunctella</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFA Bike Trail¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFA Deadman’s Creek¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFA Highway 83</td>
<td></td>
<td>300</td>
<td>86</td>
<td>30</td>
<td>33</td>
<td>6</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>AFA New Monument Creek</td>
<td></td>
<td>198</td>
<td>33</td>
<td>1</td>
<td>26</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>AFA Monument Trail Road</td>
<td></td>
<td>197</td>
<td>86</td>
<td>16</td>
<td>56</td>
<td>17</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>AFA NPWR¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFA Old Monument Creek</td>
<td></td>
<td>200</td>
<td>78</td>
<td>45</td>
<td>11</td>
<td>0.5</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>AFA Parade Loop (combined)</td>
<td></td>
<td>192</td>
<td>42</td>
<td>0.5</td>
<td>20</td>
<td>17</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>AFA Water Treatment Plant</td>
<td></td>
<td>200</td>
<td>79</td>
<td>19</td>
<td>24</td>
<td>0</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>FTC Fuel Site¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTC Gun Club¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTC Hazmat¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTC Turkey Creek¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF N Buffer Transects</td>
<td></td>
<td>100</td>
<td>95</td>
<td>19</td>
<td>32</td>
<td>24</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

Note: The columns containing the percentages of seedheads attacked by respective insect species will not necessarily sum to the “percent heads attacked” column, as there are often multiple insects/species found per seedhead.

¹ Not sampled this year
Table 4. Knapweed root dissections from sampled plants in 2008 at Air Force Academy (AFA), Fort Carson Military Post (FTC) and Rocky Flats National Wildlife Refuge (RF), identifying the proportion of knapweed roots attack (%) and the root-feeding agents responsible.

<table>
<thead>
<tr>
<th>Installation Abbreviation</th>
<th>Site Name</th>
<th>n</th>
<th>Percent Roots Attacked</th>
<th>Roots with Biological Control Agents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C. achates</td>
</tr>
<tr>
<td>AFA</td>
<td>Bike Trail$^1$</td>
<td>1</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td>AFA</td>
<td>Deadman’s Creek$^1$</td>
<td>1</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>AFA</td>
<td>Highway 83</td>
<td>70</td>
<td>34</td>
<td>10</td>
</tr>
<tr>
<td>AFA</td>
<td>New Monument Creek</td>
<td>20</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>AFA</td>
<td>Monument Trail Road</td>
<td>39</td>
<td>39</td>
<td>3</td>
</tr>
<tr>
<td>AFA</td>
<td>NPWR$^1$</td>
<td>1</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>AFA</td>
<td>Old Monument Creek</td>
<td>38</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>AFA</td>
<td>Parade Loop (combined)</td>
<td>47</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td>AFA</td>
<td>Water Treatment Plant</td>
<td>51</td>
<td>47</td>
<td>10</td>
</tr>
<tr>
<td>FTC</td>
<td>Fuel Site$^1$</td>
<td>1</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>FTC</td>
<td>Gun Club$^1$</td>
<td>1</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>FTC</td>
<td>Hazmat$^1$</td>
<td>1</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>FTC</td>
<td>Turkey Creek$^1$</td>
<td>1</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>RF</td>
<td>N Buffer Transects$^2$</td>
<td>8</td>
<td>75</td>
<td>62</td>
</tr>
</tbody>
</table>

Note: The columns containing the percentages of roots attacked by respective insect species will not necessarily sum to the “percent roots attacked” column, as there are often multiple insects/species found per root.

$^1$ Not sampled this year
$^2$ Extremely low knapweed density
Table 5. Proportion of sampled leafy spurge 0.5m² quadrats populated by *Aphthona* species biological control agents, as identified through sweep net captures in 2004-2008 at mapped sites from Air Force Academy (AFA), Buckley Air Force Base (BAF) and F. E. Warren Air Force Base (WAB). The number of quadrat samples taken at a site is indicated by n.

<table>
<thead>
<tr>
<th>Installation Abbreviation</th>
<th>Site Name</th>
<th>2008 Sweeps</th>
<th>2007 Sweeps</th>
<th>2006 Sweeps</th>
<th>2005 Sweeps</th>
<th>2004 Sweeps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>% Infested</td>
<td>n</td>
<td>% Infested</td>
<td>n</td>
<td>% Infested</td>
</tr>
<tr>
<td>AFA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deadman’s Trail</td>
<td>33</td>
<td>27</td>
<td>32</td>
<td>28</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>Douglass School</td>
<td>12</td>
<td>0</td>
<td>30</td>
<td>17</td>
<td>43</td>
<td>0</td>
</tr>
<tr>
<td>FERL</td>
<td>10</td>
<td>0</td>
<td>50</td>
<td>22</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>North FERL</td>
<td>71</td>
<td>21</td>
<td>--</td>
<td>--</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Interior</td>
<td>11</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Runway</td>
<td>31</td>
<td>19</td>
<td>45</td>
<td>47</td>
<td>28</td>
<td>86</td>
</tr>
<tr>
<td>South Fence</td>
<td>10</td>
<td>40</td>
<td>30</td>
<td>17</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Southwest Williams Lake</td>
<td>10</td>
<td>0</td>
<td>31</td>
<td>19</td>
<td>34</td>
<td>44</td>
</tr>
<tr>
<td>Williams Lake</td>
<td>19</td>
<td>16</td>
<td>56</td>
<td>43</td>
<td>45</td>
<td>2</td>
</tr>
<tr>
<td>Black Powder Road</td>
<td>27</td>
<td>0</td>
<td>129</td>
<td>50</td>
<td>96</td>
<td>27</td>
</tr>
<tr>
<td>Control</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>64</td>
<td>23</td>
</tr>
<tr>
<td>Nature I</td>
<td>--</td>
<td>--</td>
<td>60</td>
<td>8</td>
<td>54</td>
<td>6</td>
</tr>
<tr>
<td>Nature II</td>
<td>--</td>
<td>--</td>
<td>62</td>
<td>39</td>
<td>54</td>
<td>56</td>
</tr>
</tbody>
</table>

1 Site initiated in 2006
2 Site initiated in 2005
3 Site initiated in 2004
Table 6. Comparison of establishment rates at additional *Aphthona* species biological control release sites at Buckley Air Force Base (BAF) and F. E. Warren Air Force Base (WAB) *in years following mass introduction in 2005*. Insects were released at these sites, but infestation perimeters have not been mapped. Instead, 10 random leafy spurge 0.5m² quadrats have been sampled at each release location in 2006-2008.

<table>
<thead>
<tr>
<th>Installation Abbreviation</th>
<th>Sample Site Name</th>
<th>2008 Sweep Samples</th>
<th>2007 Sweep Samples</th>
<th>2006 Sweep Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>% Quadrats Infested</td>
<td>% Quadrats Infested</td>
<td>% Quadrats Infested</td>
</tr>
<tr>
<td></td>
<td></td>
<td># Insects/quadrat</td>
<td># Insects/quadrat</td>
<td># Insects/quadrat</td>
</tr>
<tr>
<td>BAF North Runway 1</td>
<td>10</td>
<td>1</td>
<td>60</td>
<td>3</td>
</tr>
<tr>
<td>BAF North Runway 2</td>
<td>0</td>
<td>--</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>BAF North Runway 3</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>WAB Black Powder 1</td>
<td>0</td>
<td>--</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>WAB Black Powder 2</td>
<td>50</td>
<td>2</td>
<td>100</td>
<td>18</td>
</tr>
<tr>
<td>WAB Black Powder 3</td>
<td>90</td>
<td>5</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>WAB Black Powder 4</td>
<td>20</td>
<td>1.5</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>WAB Black Powder 5</td>
<td>0</td>
<td>--</td>
<td>10</td>
<td>0.1</td>
</tr>
<tr>
<td>WAB Black Powder 6</td>
<td>0</td>
<td>--</td>
<td>10</td>
<td>0.1</td>
</tr>
<tr>
<td>WAB Bridge I</td>
<td>20</td>
<td>1</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>WAB Bridge II</td>
<td>20</td>
<td>2</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>WAB Nature III</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>WAB Nature IV</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>WAB Propane</td>
<td>67</td>
<td>2</td>
<td>80</td>
<td>5</td>
</tr>
</tbody>
</table>

1 Initial release of *Aphthona* species beetles made in 2007.

2 Supplementary release of *Aphthona* species beetles made in 2007 (following the insect establishment survey).
Table 7. Proportion of sampled St. John’s wort 0.5m² quadrats populated by *Chrysolina* species biological control agents at Air Force Academy, as identified through visual counts in 2004-2008. The number of quadrat samples taken at a site is indicated by n.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>2008 Insect Counts</th>
<th>2007 Insect Counts</th>
<th>2006 Insect Counts</th>
<th>2005 Insect Counts</th>
<th>2004 Insect Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>% Infested</td>
<td>n</td>
<td>% Infested</td>
<td>n</td>
</tr>
<tr>
<td>Kettle Creek</td>
<td>39</td>
<td>31</td>
<td>47</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Midway Kettle Creek</td>
<td>34</td>
<td>3</td>
<td>32</td>
<td>44</td>
<td>30</td>
</tr>
<tr>
<td>Santa Fe</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

*Note: The Santa Fe site was not sampled in 2006, 2007 or 2008, as there were not enough plants left at this site to sample.*
Table 8. Proportion of sampled Field Bindweed 0.5m² quadrats populated by biological control agent *Aceria malherbae* at Air Force Academy (AFA), Buckley Air Force Base (BAF), and Fort Carson Military Post (FTC) as identified through random sampling in 2006-2008. The number of quadrat samples taken at a site is indicated by n.

<table>
<thead>
<tr>
<th>Installation Abbreviation</th>
<th>Sample Site Name</th>
<th>2008 Sample n</th>
<th>% Infested</th>
<th>2007 Sample n</th>
<th>% Infested</th>
<th>2006 Sample n</th>
<th>% Infested</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFA</td>
<td>Stadium ²</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>AFA</td>
<td>FERL ¹</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>BAF</td>
<td>Breckenridge</td>
<td>10</td>
<td>30</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>BAF</td>
<td>FW1 ⁴,⁶</td>
<td>10</td>
<td>40</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>BAF</td>
<td>FW2 ⁴,⁶</td>
<td>10</td>
<td>70</td>
<td>20</td>
<td>0</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>BAF</td>
<td>FW3 ⁵</td>
<td>10</td>
<td>50</td>
<td>10</td>
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<td>10</td>
<td>0</td>
</tr>
<tr>
<td>BAF</td>
<td>NE Gate ¹ ⁵,⁶</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>BAF</td>
<td>NE Gate ² ⁵</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>BAF</td>
<td>NE Gate ³ ⁵</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
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Table 8. Proportion of sampled Field Bindweed 0.5m² quadrats populated by biological control agent *Aceria malherbae* at Air Force Academy (AFA), Buckley Air Force Base (BAF), and Fort Carson Military Post (FTC) as identified through random sampling in 2006-2008. The number of quadrat samples taken at a site is indicated by n.

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¹ Denotes sites where mites were released in 2000  
² Denotes sites where mites were released in 2001  
³ Denotes sites where mites were released in 2004  
⁴ Denotes sites where mites were released in 2005  
⁵ Denotes sites where mites were released in 2006  
⁶ Denotes sites where mites were released in 2008
Air Force Academy

Nineteen noxious weed infestations were mapped at Air Force Academy this year over a total area of 2.70 ha (6.66 acres). Two additional sites, Stadium and FERL field bindweed, were not mapped. Instead, random sampling was conducted to detect the presence of bio-agents on these two sites. Though the total area of infestation decreased almost threefold from last year’s 8.6 ha, it is still an increase from 2006’s total area of 1.78 ha. Eleven out of the twenty sites saw a decrease in area, results that are consistent with an overall decrease in height and density of weeds both at the Air Force Academy (Table 2) and throughout all the installations monitored this summer (Table 1). Mapped and monitored sites this year included four Canada thistle sites over 0.19 ha (0.47 acres), four leafy spurge sites over 0.37 ha (0.91 acres), six knapweed sites over 1.89 ha (4.67 acres) two St. John’s wort sites over 0.13 ha (0.33 acres) and two Yellow toadflax sites over 0.12 ha (0.29 acres). Of the 17 sites that were surveyed in both 2007 and 2008, 15 saw a decrease in height (11 sites with significant changes) while only ten sites had a decrease in density (with only one site significantly less dense). See Table 10 for a year by year summary of each site including area, density, height, and where applicable, seedhead number and size.

As in previous years, the six knapweed sites mapped in 2008, covering 1.89 ha of land, comprised the largest percentage (70%) of the total area mapped at the Air Force Academy this year. This majority held despite the Total Parade Loop site being reduced by 94%, the largest reduction in area of any site (Figure 3; Table 10). The dramatic expansion and decline of this site over the course of two growing seasons illustrates the dynamic and often stochastic nature of plant populations, underscoring the need for long term monitoring. One explanation for the large reduction in the knapweed populations may be the strong attack in 2007 of seedheads and roots by several species of biocontrol agents. This year also seemed to be a particularly favorable one.
for the bio-agent *Larinus minutus*, as a large numbers of insects were observed at all the knapweed sites on the base. *L. minutus* were recovered at each of the knapweed sites every time they were sampled, and recoveries continue to be made at sites where the insect has self-dispersed (i.e. Highway 83). The insects were so numerous that we were able to use the three AFA sites as nursery sites and sent about 250 insects to Dr. Tim Kring, Professor of Entomology at the University of Arkansas, to use in a new biocontrol program for knapweed in northern and central Arkansas. Enough samples of seedheads and roots were taken this year from knapweed sites to analyze the percent heads and roots attacked by plant-boring insects (Tables 3 and 4). Almost every insect was present at each site with few exceptions (i.e. *U. quadrifasciata* at Water Treatment Plant). Overall, *Agapeta zoegana* had the largest population (or second largest) population at all sites except New Monument Creek. The population of Agapeta zoegana was an unexpected but pleasant surprise. This biocontrol agent was not previously found in large numbers, but seems to now be well established at the Academy.

Figure 3. Photopoint of Parade Loop II in 2007 (left) and 2008 (right). Though the photo in 2008 was taken after flowering, the plants appear smaller and less robust than last year’s plants.

Just as with the knapweeds, it was also a bad year for populations of yellow toadflax; the plants remained small throughout the growing season and many plants were withered and dry by early August (Figure 4). No *Gynnetron antirrhini* were observed on any of the four sites during mapping, though a total of 21 insects were observed at the Ice Lake Road II sentinel site from 30 May to 14 July. There were no *Mecinus janthinus* agents observed at any of the toadflax sites, though they have been observed in sites at the Air Force Academy in the past three years the insects have not been able to successfully establish a self-sustaining population. Some species of insects were observed this season that had either not been observed before or only observed in low numbers. Galls of the Canada thistle feeder *Urophora cardui* were observed at the Kettle Lake and Parade Loop sites where they had not been seen previously (Figure 4). The Parade Loop site in particular was had many galls. Many thistle plants also exhibited “window-paneing” from *Cassida rubiginosa*, though few adult insects were observed (Figure 4). FERL North had *Aphthona* sp. releases in 2005 and we are now beginning to recover *A. nigriscutis* and *A. cyparissiae*. The observation of these insects may be the result of the new
sentinel site monitoring protocol. Sentinel sites were visited multiple times throughout the growing season allowing us to observe insects that emerge at different times over the course of the summer that would have been missed if the site were only sampled once.

Figure 4. Photo of an U. cardui gall on a Canada thistle plant at the Kettle Lake site (left). This photo was taken in the first week of August. Much evidence of C. rubiginosa was seen at the thistle sites in the form of “window-paneing” on the leaves, though few adults were observed (Right, bottom). Yellow toadflax plants remained small and un-flowered through early August (right, top).

There were six sites monitored in previous years that were not monitored this year. As in 2006 and 2007, the Ice Lake Road musk thistle and Santa Fe St. John’s wort sites had only a few plants with not enough left to monitor. The newly-created Bike Trail diffuse knapweed site also had plants that were too few and scattered to monitor effectively. This site was created last summer to serve as a nursery site for L. minutus and Cyphocleonus achates removed from other sites slated to be sprayed with herbicide in fall of 2007. The sudden influx of bio-agents may have been responsible for this site’s rapid decline. The NPWR spotted knapweed site was destroyed by construction this summer. However, the FERL North site, (destroyed last year) came back stronger this year with an area almost twice as large as in 2006, though plant density was half of what it was in the first year. The Deadman’s Creek spotted knapweed site, which is usually not mapped but randomly sampled for insects, was not sampled this year.

No insect releases were made at the Air Force Academy this year. Though the redistribution of Aceria anthocoptes from a thistle site at Fort Carson Military Post was planned, no mites were observed this summer. The bindweed mite Aceria malherbae was distributed from a site in Amarillo, Texas to other military installations in Colorado. These sites will
hopefully serve as nursery sites in the coming years that we can use to distribute mites to sites at the Air Force Academy. No new sites were established this summer either, though some sites (i.e. Kettle Lake Canada thistle and Old Monument Creek spotted knapweed) had infestations of yellow toadflax in addition to the original weed infestation. Unfortunately, as stated in the 2006 report we do not yet have highly successful agents for yellow toadflax, though some *G. antirrhini* were recovered this year from Ice Lake Road I where releases were made last year. Next year we will focus on searching for self-dispersed agents at these new toadflax sites and/or redistributing agents from established sites to these areas. We will also consider supplementing *G. antirrhini* at the Academy if commercial or other sources can be found.
Figure 5: Schematic diagram of Air Force Academy with current weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2008.

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Leafy spurge - FERL

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Diffuse knapweed – Highway 83

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Spotted knapweed – Non-potable Water Reservoir (NPWR)

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<th>Avg. Head size (mm)</th>
<th>Year to year % change</th>
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Spotted knapweed – Old Monument Creek

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St. John’s wort – Kettle Creek

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St. John’s wort – Midway Kettle Creek

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<th>Avg. Head size (mm)</th>
<th>Year to year % change</th>
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St. John’s wort – Santa Fe

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<td>Max</td>
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(see Note a)

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<td>-74.23</td>
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**Note a** - a complete perimeter could not be mapped at this site, area recorded reflects the weed patch available at the time of sampling

**Note b** - values given in the year-to-year change column reflect 2- or 3-year changes, as sampling was not done at all sites all years

*** - Parade Loop spotted knapweed sites 1, 2 and 3 became part of a large, continuous weed infestation in 2007 and, as such, were mapped and monitored as the larger mega-site, Total Parade Loop

*Note - Could not map this site, as: a) few scattered plants remained to survey, b) weeds were chemically treated prior to our survey or c) site was destroyed*
Figure 6. Percent change in area and density of all sites monitored this year at the Air Force Academy. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year’s data by the area or density from this year. The number of years represented vary and depend on when the sites were established.

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<th>Target Weed</th>
<th>Release Site</th>
<th>Species</th>
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<th>New releases</th>
<th>New site</th>
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<td>Ice Lake Road I</td>
<td><em>Rhinocyllus conicus</em></td>
<td>X²</td>
<td>X</td>
<td></td>
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<tr>
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<td>AFA</td>
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<td>Old Monument Creek</td>
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<tr>
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<td>Metzneria paucipunctella</td>
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<td>Water Treatment Plant</td>
<td>Agapeta zoegana</td>
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<tr>
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<td>Yellow toadflax</td>
<td>Comm Center Drive II&lt;sup&gt;3&lt;/sup&gt;</td>
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<tr>
<td>AFA</td>
<td>Yellow toadflax</td>
<td>Comm Center Drive II&lt;sup&gt;3&lt;/sup&gt;</td>
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<td>Comm Center Drive III</td>
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<td>AFA</td>
<td>Yellow toadflax</td>
<td>Ice Lake Road</td>
<td>Gymnetron antirrhini</td>
<td>X&lt;sup&gt;1&lt;/sup&gt;</td>
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<sup>1</sup> New insect recovery in 2008  <sup>2</sup> Adventitious recovery, no release made at this site  <sup>3</sup> Site not monitored for insects this year

No insect releases were made at this site, however, the following biological control agents have been recovered from seedheads and roots collected within the mapped weed perimeter since 2005: \textit{L. minutus}, \textit{U. affinis}, \textit{U. quadrifasciata}, \textit{M. paucipunctella}, \textit{C. achates}, \textit{S. jugoslavica}, \textit{A. zoegana}. 
Ice Lake Road | Canada thistle perimeter in 2008.
Ice Lake Road I Canada thistle density in 2008.
Ice Lake Road I Canada thistle height in 2008.
Ice Lake Road II Canada thistle perimeter in 2008.
Ice Lake Road II Canada thistle density in 2008.
Ice Lake Road II Canada thistle height in 2008.
Kettle Lake Canada thistle perimeter in 2008.
Parade Loop Canada thistle perimeter in 2008.
Parade Loop Canada thistle density in 2008.
Parade Loop Canada thistle height in 2008.
Water Treatment Plant diffuse and spotted knapweed perimeter in 2008.
2008

- 0.0 - 1.2
- 1.3 - 2.4
- 2.5 - 3.6
- 3.7 - 4.8
- 4.9 - 6.1
- 6.2 - 7.3
- 7.4 - 8.5
- 8.6 - 9.7
- 9.8 - 11.0

Water Treatment Plant diffuse and spotted knapweed density in 2008.
Water Treatment Plant diffuse and spotted knapweed height in 2008.

![Map showing the distribution of spotted knapweed height in 2008.](image)

![Graph showing the average plant height over years.](image)
Deadman’s Trail leafy spurge perimeter in 2008.
2008

- 0.0 - 9.2
- 9.3 - 18.4
- 18.5 - 27.6
- 27.7 - 36.8
- 36.9 - 46.1
- 46.2 - 55.3
- 55.4 - 64.5
- 64.6 - 73.7
- 73.8 - 83.0

Deadman's Trail leafy spurge height in 2008
2008

0.0 - 3.3
3.4 - 6.6
6.7 - 10.0
10.1 - 13.3
13.4 - 16.6
16.7 - 20.0
20.1 - 23.3
23.4 - 26.6
26.7 - 30.0

FERL North leafy spurge perimeter in 2008
2008

- 0.0 - 4.5
- 4.6 - 9.1
- 9.2 - 13.6
- 13.7 - 18.2
- 18.3 - 22.7
- 22.8 - 27.3
- 27.4 - 31.8
- 31.9 - 36.4
- 36.5 - 41.0

FERL North leafy spurge density in 2008
FERL North leafy spurge height in 2008
Midway Kettle Creek St. Johnswort perimeter in 2008.
Midway Kettle Creek St. Johnswort density in 2008.
Midway Kettle Creek St. Johnswort height in 2008.
New Monument Creek spotted knapweed perimeter in 2008.
New Monument Creek spotted knapweed density in 2008.
New Monument Creek spotted knapweed height in 2008.
Monument Trail Road spotted knapweed perimeter in 2008.
Monument Trail Road spotted knapweed density in 2008.
Monument Trail Road spotted knapweed height in 2008.
Old Monument Creek spotted knapweed perimeter in 2008.
Old Monument Creek spotted knapweed density in 2008.
Old Monument Creek spotted knapweed height in 2008.
Total Parade Loop spotted knapweed perimeter in 2008.
Community Center Drive | yellow toadflax perimeter in 2008.
Community Center Drive III yellow toadflax perimeter in 2008.
Community Center Drive III yellow toadflax height in 2008.
Ice Lake Road II yellow toadflax perimeter in 2008.
Ice Lake Road II yellow toadflax density in 2008.
Buckley Air Force Base

A total of eight sites were fully mapped this year, covering 3.24 hectares (8.01 acres). Two Canada thistle sites comprised the largest area (2.57 ha; 6.35 acres), a single Dalmatian toadflax site covered 0.47 ha (1.16 acres) and five leafy spurge sites comprised 0.20 ha (0.49 acres). Sixteen field bindweed sites were randomly sampled for the mite Aceria malherbae. An additional three leafy spurge sites (North Runway I, II, and III, also called North Fence) were randomly sampled for the Aphthona sp. beetles released in 2005. Mapping was not conducted at the South Fence Dalmatian toadflax site as access to the site was once again restricted this year. Only a few scattered plants remained at the musk thistle Aspen site so it was not mapped this year (Figure 7). The leafy spurge Interior site, however, had rebounded somewhat from last year and was fully mapped this summer (Figure 7).

![Image](image1)

![Image](image2)

![Image](image3)

![Image](image4)

Figure 7. Only a few scattered plants remain in the Aspen musk thistle site in 2008 (top left); a dramatic decrease from just last year (top right). In contrast the leafy spurge Interior site (bottom left) doubled in size from 2006 after being considered eliminated in 2007 (bottom right).

The loss of the Aspen musk thistle site is perhaps responsible for the bulk of the decrease in total area covered by thistles from 12.0 ha in 2007 to a scant 2.57 ha in 2008. However, the remaining two thistle sites (Aspen and Williams Lake Canada thistle) also showed a decrease in area both from last year and since site monitoring began. This year seemed to be a good one for
Figure 8. Schematic map of Buckley Air Force Base and table showing dispersal distances traveled by biological control agents, *Cassida rubiginosa*, *Aphthona cyparissiae*, *A. flava* and *A. lacertosa* during self-dispersal.

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Williams Lake</td>
<td>Aspen</td>
<td>1.9 km</td>
</tr>
<tr>
<td>Williams Lake</td>
<td>South Fence</td>
<td>2.4 km</td>
</tr>
<tr>
<td>Williams Lake</td>
<td>North Run 1</td>
<td>2.5 km</td>
</tr>
<tr>
<td>Williams Lake</td>
<td>Runway</td>
<td>2.8 km</td>
</tr>
<tr>
<td>South Fence</td>
<td>Runway</td>
<td>1.8 km</td>
</tr>
</tbody>
</table>
thistle agents, several were recovered from the Aspen musk thistle site, and three bio-agents were recovered at the Williams Lake site where no agents had been recovered previously (Table 12). *Cassida rubiginosa* was recovered from the musk thistle Aspen site and may have self-dispersed from the Williams Lake Canada thistle site 1.9 km away (Figure 8). *Rhinocyllus conicus* had not previously been released on Buckley Air Force Base and appears to have self-dispersed from an unknown location to both the Aspen musk thistle and Williams Lake Canada thistle sites.

Though no plants were tested for the mite *Aceria anthocoptes*, several plants at the Williams Lake Canada thistle site exhibited the characteristic chlorosis, hypertrophy and overall unhealthy look associated with the mite (Figure 9). Plans are underway to collect samples next year to determine if this condition is indeed due to mite damage and not simply dry conditions.

The Canada thistle Aspen site, at least a portion of it, is slated for construction this fall. While the construction will probably reduce the size of the site, the disturbance is likely to provide ideal habitat for the establishment of new invasive species. Two additional thistle sites were marked this year, and monitoring of these sites along with insects releases are planned for next summer.

![Figure 9](image-url). Canada thistle plants exhibiting possible symptoms of *A. anthocoptes* mite infestations (left and bottom right). The Williams Lake thistle site also showed a thriving population of *C. rubiginosa* not previously recorded at this site (left, top right).

Buckley Air Force Base has had dense monocultures of field bindweed for several years despite efforts to establish the gall forming mite *A. malherbae*. This year several releases of infected runners collected from a site in Amarillo, Texas were made at FW1, FW2, Steamboat, NE Gate, POV Resale, Playground, and South Fence sites. Sixteen field bindweed sites were randomly sampled for mites, with eleven out of the sixteen containing infected runners (Table 8).
Efforts to establish nursery sites both in Texas and Colorado should allow us to continue to make releases in future seasons until populations are established on the base.

Overall, the total area of the leafy spurge sites were reduced by 22% (from 0.9 ha to 0.2 ha). No “halos” of spurge free areas were observed this summer, though sites that had releases in 2007 (Runway North) are not be expected to exhibit halos until 2011-2013. The self dispersal of bio-agents continued this year from sites of releases in 2005, with various agents dispersing 2-3 km away to the Runway North, Runway, and South Fence sites (Figure 8).

Figure 10. Student workers Sundhya Solanki and Nathanial (JJ) Engel use sweep-nets to sample for *Aphthona sp.* beetles at the Runway site. Two species of beetles self-dispersed to and one dispersed from this site to another site this year (Figure 7).

This year was not a good one for Dalmatian toadflax as the remaining accessible site saw a significant decline in plant height, though plant density seemed unaffected and area decreased by a mere 6% (Table 11). It was also a bad year for the stem-feeding weevil *Mecinus janthinus*. Only a handful of insects were observed from early June to early July, and only during sentinel site sweeps. Dissection of this year’s stems to determine the size of weevil populations are planned for next spring.
Figure 11. Schematic diagram of Buckley Air Force Base with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (m²)</th>
<th>n</th>
<th>Density (1/2m²)</th>
<th>Height (cm)</th>
<th>Avg Head size (mm)</th>
<th>Year to year % change</th>
<th>% Change to date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Avg.</td>
<td>Max</td>
<td>Avg.</td>
<td>Max</td>
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<tr>
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**Canada thistle – Aspen**

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<th>Avg Head size (mm)</th>
<th>Year to year % change</th>
<th>% Change to date</th>
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**Canada thistle – Williams Lake**

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<th>Height (cm)</th>
<th>Avg Head size (mm)</th>
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**Leafy spurge - Interior**

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**Leafy spurge - Runway**

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<th>Density (1/2m²)</th>
<th>Height (cm)</th>
<th>Avg Head size (mm)</th>
<th>Year to year % change</th>
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**Leafy spurge – South Fence**

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<th>Height (cm)</th>
<th>Avg. Seedheads per plant</th>
<th>Avg. Head size (mm)</th>
<th>Year to year % change</th>
<th>% Change to date</th>
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<td>Avg.</td>
<td>Max</td>
<td>Avg.</td>
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Leafy spurge – Southwest Williams Lake

Year to year % change

<table>
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<th>Area (m²)</th>
<th>n</th>
<th>Density (1/2m²)</th>
<th>Height (cm)</th>
<th>Avg. Seedheads per plant</th>
<th>Avg. Head size (mm)</th>
<th>Year to year % change</th>
<th>% Change to date</th>
</tr>
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<td></td>
<td>Avg.</td>
<td>Max</td>
<td>Avg.</td>
<td>Max</td>
<td>Avg.</td>
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<td>Avg. density</td>
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Leafy spurge – Williams Lake

Dalmatian toadflax – South Aspen Way

Year to year % change

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<th>Height (cm)</th>
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<th>Avg. Head size (mm)</th>
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Dalmatian toadflax – South Fence

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(see Note b) | (see Note c)

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* - a complete perimeter could not be mapped at this site, area recorded reflects the weed patch available at the time of sampling

** - values given in the year-to-year change column reflect 2- or 3-year changes, as sampling was not done at all sites all years

*** - Parade Loop spotted knapweed sites 1, 2 and 3 became part of a large, continuous weed infestation in 2007 and, as such, were mapped and monitored as the larger mega-site, Total Parade Loop

Note - Could not map this site, as: a) few scattered plants remained to survey, or b) weeds were chemically treated prior to our survey c) access to the site restricted.
Figure 12. Percent change in area and density of all sites monitored this year at Buckley Air Force Base. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year’s data by the area or density from this year. The number of years represented vary and depend on when the sites were established.

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<th>Release Location</th>
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<th>Target Weed</th>
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<th>Species</th>
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1 Adventitious recovery, none released at this site
2 New insect recovery in 2008
3 Site not mapped this year
2008

- 0.0 - 4.1
- 4.2 - 8.2
- 8.3 - 12.3
- 12.4 - 16.4
- 16.5 - 20.5
- 20.6 - 24.6
- 24.7 - 28.7
- 28.8 - 32.8
- 32.9 - 37.0


![Graph showing average plants per m² over years from 1997 to 2008.](image)
2008

0.0 - 5.9
6.0 - 11.9
12.0 - 17.9
18.0 - 23.9
24.0 - 29.9
30.0 - 35.9
36.0 - 41.9
42.0 - 47.9
48.0 - 54.0

South Fence leafy spurge perimeter in 2008.
South Fence leafy spurge height in 2008.
Southwest Williams Lake leafy spurge perimeter in 2008.
Southwest Williams Lake leafy spurge height in 2008.
Williams Lake leafy spurge perimeter in 2008
Williams Lake leafy spurge density 2008.
Williams Lake leafy spurge height 2008.
Fort Carson Military Post

Seven sites were fully mapped at Fort Carson this summer, covering a total of 24.7 ha (61.1 acres). Four Canada and musk thistle sites covered 23.7 ha (58.6 acres) and three sites consisted of diffuse and spotted knapweed (1.02 ha, 2.52 acres). Two thistle sites (ARA I and Highway 115) were not monitored this year because the remaining plants were too few and/or scattered to map (Table 14). The HazMat spotted knapweed site was mowed at the beginning of the summer and there were no plants left to monitor this summer. Sixteen of the 34 field bindweed sites were randomly sampled for the presence of the mite Aceria malherbae and additional releases of infested runners were made on four sites.

The thistle sites took up the largest percentage of the total area covered by weeds. The ARA II sites was the largest of the thistle sites, with a total area of 22.8 ha and a perimeter of 4 km. In addition to Canada thistle, the site has a large infestation of teasel (Dipsacus sylvestris) and Russian olive (Elaeagnus angustifolia) indicating that other invasive plants rather than native plants are moving into the site. No evidence was seen this year of establishment of A. anthocoptes mites that were released last year, but we will continue to monitor the six established release plots next summer. Two hundred fifty-three Cassida rubiginosa beetles were collected from a site at the Rocky Flats National Wildlife Refuge in Golden, Colorado and released at the ARA II site in early July (Table 14). The agent Rhinocyllus conicus appears to have self-dispersed from the now defunct ARA I site to both the nearby ARA II and the Wildlife Refuge site (5.8 km away).

Figure 13. ARA I (left) and ARA II (right) Canada thistle sites. The ARA I site is been re-colonized mainly by grasses. Though the picture is a little blurry, there is evidence of a dense Canada thistle population (white specks in foreground) and a dense teasel population (brown lines in background).

All of the knapweed sites mapped this year declined in area and had significant decreases in plant height, though not in plant density. Despite what appeared to be a poor growing season for the plants, this year was particularly good for the knapweed seedhead feeders Larinus minutus and the root feeder Cyphocleonus achates across many installations and Fort Carson was no exception. L. minutus was detected on plants at the Fuel site and both species were detected in visual counts of the Gun Club and Turkey Creek sites (Table 14). Though a forest fire on the Turkey Creek site (Figure 14) gave the plants a later start than at other knapweed sites, bio-
agents seemed to be re-colonizing rapidly from the surrounding areas (Table 14). No seedheads or roots were collected for dissection in the fall, but collections are planned for spring of 2009.

Figure 14. The Turkey Creek spotted knapweed site recovering after a spring fire.

Field bindweed flourished this year across the base despite efforts to establish the gall forming mite *A. malherbae* (Figure 15). This year several releases of infected runners collected from a site in Amarillo, Texas, were made at the ARA I, Range Control, Vet, and Wildlife sites. Seventeen field bindweed sites were randomly sampled for mites, with nine out of the seventeen sites having quadrats containing infected runners (Table 8). Efforts to establish nursery sites both in Texas and Colorado should allow us to continue to make releases in future seasons until populations are established on the base.

Figure 15. The ARA 1 field bindweed site showing a healthy crop of flowers (right). Very few runners showed signs of mite damage, most had healthy leaves and buds (above)
In 2007, 241 *Diorhabda elongata* (salt cedar (*Tamarix*) leaf beetles) were released at a site in Section (Training Area) 36. Unfortunately, the large area of the infestation combined with *D. elongata’s* ability to fly long distances made it difficult for such a small number of insects to establish a self-sustaining population. Fortunately this year we were able to release approximately 2000 beetles supplied by the Colorado Department of Agriculture’s Palisade, Colorado, laboratory. Some beetles were recovered during three 15 minute visual sweeps one week later. We will continue to monitor the site for beetles next summer and hope to see some indications that a population has established itself. We also anticipate being able to release more beetles in the next few years if necessary.

Figure 16. Student worker Nathanial (JJ) Engel searches for *D. elongata* beetles at the Section 36 release site (top left). Top right; salt cedar plants in flower, bottom; salt cedar growing near some cottonwood trees.
Figure 17. Schematic diagram of Fort Carson Military Post with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2008.
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**Canada thistle – ARA I**

**Canada thistle – ARA II**

**Canada thistle – Duckpond**

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Canada thistle – HWY 115

Musk thistle – HWY 115

Canada thistle - Reservoir

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<th>Height (cm)</th>
<th>Avg. Seedheads per plant</th>
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<th>Height (cm)</th>
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**Spotted knapweed – Fuel Site (Cantonment I)**

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**Spotted knapweed – Hazmat (Cantonment II)**

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n – number of samples or observations
**values given in year-to-year change column actually reflect 2-year changes, as sampling was not done at all sites in all years

*Note: Could not map a perimeter, as: a) the few remaining plants at this site were scattered, or b) the site was inaccessible*
Figure 18. Percent change in area and density of all sites monitored this year at Fort Carson. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year’s data by the area or density from this year. The number of years represented vary and depend on when the sites were established.

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¹ Adventitious recovery, insects were not released at this location
² New recovery in 2008
³ Site not monitored, or only sentinel site data
ARA II Canada thistle density in 2008.
Duckpond Canada thistle perimeter in 2008.
Reservoir Canada thistle density in 2008.

![Map showing thistle density in Reservoir Canada in 2008]
Reservoir Canada thistle height in 2008.
Fuel Site (Cantonement I) spotted knapweed perimeter in 2008.
Fuel Site (Cantonment I) spotted knapweed density in 2008.
2008

0.0 - 3.7
3.8 - 7.5
7.6 - 11.3
11.4 - 15.1
15.2 - 18.8
18.9 - 22.6
22.7 - 26.4
26.5 - 30.2
30.3 - 34.0

Fuel Site (Cantonement I) spotted knapweed height in 2008.

Average Plant Height (cm)

Year
Turkey Creek spotted knapweed perimeter in 2008.
Turkey Creek spotted knapweed density in 2008.
Turkey Creek spotted knapweed height in 2008.
Rocky Flats National Wildlife Refuge

Four invasive plant sites were mapped at Rocky Flats National Wildlife Refuge this year. The Dalmatian toadflax Original (Figure 19) and North Buffer musk thistle sites did not have enough plants to map, however, the Weather site, which had not been mapped since 2004, came back strong with 0.15 ha (0.37 acres) of weeds. Additionally, four field bindweed sites were randomly sampled to assess the establishment of the mite Aceria malherbae. The two sites that were fully mapped (Lindsay Ranch Canada thistle and Weather Dalmatian toadflax) covered a total area of 0.79 ha (1.95 acres) (Table 15). Just as last year, the Dalmatian toadflax South Fence and diffuse knapweed North Buffer sites were surveyed as transects. No significant changes occurred in either height or density at any of the four sites sampled.

Figure 19. The Original Dalmatian toadflax site, showing only a few scattered populations of toadflax in the background.

This year was conducive to several species of bio-agents at the Lindsey Ranch Canada thistle site (Figure 20). Eleven of the 75 quadrats surveyed when the site was mapped had at least one gall caused by Urophora cardui, and 15 galls were counted in all. Cassida rubiginosa also flourished at this site, on one insect survey alone 216 C. rubiginosa were detected in 10 quadrats. No other site at any of the other participating installations had counts of the insect above five, and most recoveries of C. rubiginosa recovery were incidental observations. Similar to Buckley Air Force Base and Fort Carson Military Post, the Canada thistle biocontrol agent Rhinocyllus conicus was found to have self-dispersed to the Lindsey Ranch site at Rocky Flats, despite never having been released there. Larinus planus, another thistle feeder, was also detected on the site this year, though it was not released on this installation.
The scenic and pastoral Lindsey Ranch Canada thistle site. High levels of *Cassida rubiginosa* (cause of the window-paneing, upper inset) and *Urophora cardui* (bottom inset) were detected at this site this summer.

The toadflax and knapweed sites did not show any trends this year with regards to plant parameters or insect recoveries compared to last year’s numbers. Dissections were carried out on seedheads and roots of plants sampled from the Cardinal transect knapweed site (Table 16). All seedhead and root feeding insects were recovered except for *Agapeta zoegana*. Information regarding the stem feeding insect *Mecinus janthinus* will be obtained from stem dissections conducted in the spring of 2009.

Figure 21. Root tunneling larvae munching on knapweeds at the field bindweed sites 8 and 9, near Lindsay Ranch.
Field bindweed sites Highroad 1, Highroad 2, Site 8 and Site 9 were randomly sampled for the mite *A. malherbae*. Only the Highroad1 site appeared to have a well established mite colony with 60% of quadrats having infested runners. Releases of mites on infested runners collected in Amarillo, Texas, were made at the Highroad site, Site 6, Site 7 and Site 8. More releases are planned for next year if necessary; we also plan to incorporate mowing with our releases as has been done in previous years. Experience has shown that mowing bindweed sites approximately two weeks after the release of *A. malherbae* can increase the distribution and infection rates.

Figure 22. Student worker Brian Mulhern shows a field bindweed runner heavily infested by the leaf gall mite *Aceria malherbae*. The runner was collected at the field bindweed Site 8.
Figure 23: Schematic diagram of Rocky Flats National Wildlife Refuge with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2008.

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<th>Year</th>
<th>Area (m²)</th>
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<th>Density (1/m²)</th>
<th>Height (cm)</th>
<th>Avg. Seedheads per plant</th>
<th>Avg. Head size (mm)</th>
<th>Year to year % change</th>
<th>% Change to date</th>
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<td></td>
<td></td>
<td>Avg.</td>
<td>Max</td>
<td>Avg.</td>
<td>Max</td>
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Canada thistle – Lindsay Ranch

Dalmatian toadflax – Original Site

(see Note)

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<th>Height (cm)</th>
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<td>Avg.</td>
<td>Max</td>
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<td>Max</td>
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Dalmatian toadflax – South Fence *

Dalmatian toadflax - Weather

(see Note)

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n – number of samples or observations  
* - infestation was not mapped (a linear transect method was utilized to survey the weed population)  
** - values given in the year-to-year change column reflect 2- or 3-year changes, as sampling was not done at all sites all years  
Note - site was not mapped, as toadflax infestation had been reduced to a few scattered plants
Figure 24. Percent change in area and density of all sites at Rocky Flats. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year’s data by the area or density from this year. The number of years represented vary and depend on when the sites were established. The South Fence and North Buffer sites have no area data; the Weather site has area data only for this year.

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<th>Target Weed</th>
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<th>New site</th>
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<td>Diffuse knapweed</td>
<td>Northwest Buffer Zone</td>
<td><em>Agapeta zoegana</em></td>
<td></td>
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</tr>
<tr>
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<td><em>Cyphocleonus achates</em></td>
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<tr>
<td>RF</td>
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<td><em>Larinus minutus</em></td>
<td>X</td>
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</tr>
<tr>
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<td><em>Metzneria paucipunctella</em></td>
<td>X</td>
<td></td>
<td></td>
</tr>
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<td>RF</td>
<td>Diffuse knapweed</td>
<td>Northwest Buffer Zone</td>
<td><em>Sphenoptera jugoslavica</em></td>
<td>X</td>
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<tr>
<td>RF</td>
<td>Diffuse knapweed</td>
<td>Northwest Buffer Zone</td>
<td><em>Urophora affinis</em></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>RF</td>
<td>Diffuse knapweed</td>
<td>Northwest Buffer Zone</td>
<td><em>Urophora quadrifasciata</em></td>
<td>X&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF</td>
<td>Dalmatian toadflax</td>
<td>Original Site</td>
<td><em>Mecinus janthinus</em></td>
<td>X</td>
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<td></td>
</tr>
<tr>
<td>RF</td>
<td>Dalmatian toadflax</td>
<td>Southeast Buffer Zone</td>
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<tr>
<td>RF</td>
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<td>Sites III &amp; IV</td>
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<tr>
<td>RF</td>
<td>Dalmatian toadflax</td>
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<tr>
<td>RF</td>
<td>Dalmatian toadflax</td>
<td>Weather</td>
<td><em>Mecinus janthinus</em></td>
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<tr>
<td>RF</td>
<td>Field bindweed</td>
<td>Multiple sites</td>
<td><em>Aceria malherbae</em></td>
<td>X</td>
<td>X</td>
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</tbody>
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<sup>1</sup> Adventitious recovery, this species not released at this site

<sup>2</sup> New recovery in 2008
Lindsay Ranch Canada thistle perimeter in 2008.
Figure 25. History of the South Fence Dalmatian toadflax densities (above) and height (below), sampled between 2005 and 2008.
Figure 26. History of the North Buffer diffuse knapweed densities (above) and height (below), sampled between 2005 and 2008.
Warren Air Force Base

Only one site at Warren Air Force Base, Black Powder Road leafy spurge (0.73 ha; 1.8 acres), was mapped this year. The plants at the remaining sites that have been mapped in the past were too few and scattered to adequately survey. Eleven leafy spurge sites were randomly sampled for establishment of species in the *Aphthona* sp. complex (see Table 18) from a release made in 2005.

Figure 27. This year’s Dalmatian toadflax Control site. There were not enough toadflax plants to map this year, only a small patch is visible in this photos (red circle).

This year seemed to be particularly bad for Dalmatian toadflax (Figure 21); toadflax plants at all four toadflax sites (Control, Nature Trail, Missile Drive, and Nursery) were short and did not form the dense yellow stands seen in earlier photopoints. The Dalmatian toadflax infestation at the Nursery site is virtually eliminated and instead has been replaced by an infestation of leafy spurge. The Nursery site is a good candidate for release of the *Aphthona* sp. complex next summer (if enough insects are available) as this mix of beetles has been successful at controlling leafy spurge at other sites around the base.

Leafy spurge did not appear to have a favorable growing season either. The Black Powder leafy spurge site had an 80% decline in area and a significant decrease in density despite the presence of a single quadrat with over 144 plants. Plant height was also lower, but not significantly so. All *Aphthona* beetles except *A. czwalinae* were recovered at the Black Powder site during the sentinel site surveys, though none were recorded during the site mapping (Figure 22). The leafy spurge sites randomly surveyed for *Aphthona* sp. beetles also appeared to have a lower plant density, though height and density data was not recorded for these sites this year. The only *Aphthona* species that was found during these random sweeps was *A. nigriscutis*. 

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Figure 28. Top left, leafy spurge at Black Powder 3 in 2007 is much denser and taller than the same site in 2008 (top right). Below, student worker Sundhya Solanki peers into a sweepnet searching for *Aphthona* sp. at the Black Powder 4 site.
Figure 29. Schematic diagram of F. E. Warren Air Force Base with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2008.

<table>
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<tr>
<th>Year</th>
<th>Area (m²)</th>
<th>n</th>
<th>Density (1/2m²)</th>
<th>Height (cm)</th>
<th>Avg. Seedheads per plant</th>
<th>Year to year % change</th>
<th>% Change to date</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Avg.</td>
<td>Max</td>
<td>Avg.</td>
<td>Max</td>
<td>Area (m²)</td>
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<th>Area (m²)</th>
<th>n</th>
<th>Density (1/2m²)</th>
<th>Height (cm)</th>
<th>Avg. Seedheads per plant</th>
<th>Year to year % change</th>
<th>% Change to date</th>
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<td>Max</td>
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<td>Avg. height</td>
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Leafy spurge – Nature I

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<th>Density (1/2m²)</th>
<th>Height (cm)</th>
<th>Avg. Seedheads per plant</th>
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<td>(see Note b)</td>
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Leafy spurge – Nature II

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<th>Year to year % change</th>
<th>% Change to date</th>
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n – number of samples or observations

Note: site was not mapped, as a) goat grazing prevented an accurate survey b) infestation had been reduced to a few scattered plants c) site was destroyed
Figure 30. Percent change in area and density of all sites at Rocky Flats. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year’s data by the area or density from this year. The number of years represented vary and depend on when the sites were established. The South Fence and North Buffer sites have no area data; the Weather site has area data only for this year.

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<th>Release Location</th>
<th>Target Weed</th>
<th>Release Site</th>
<th>Species</th>
<th>Species recovered</th>
<th>New releases</th>
<th>New site</th>
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<td>Leafy spurge</td>
<td>Black Powder</td>
<td><em>Aphthona</em> sp. complex &lt;sup&gt;2&lt;/sup&gt;</td>
<td>X</td>
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<tr>
<td>WAB</td>
<td>Leafy spurge</td>
<td>Black Powder I&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAB</td>
<td>Leafy spurge</td>
<td>Black Powder II&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
<td>X&lt;sup&gt;4&lt;/sup&gt;</td>
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</tr>
<tr>
<td>WAB</td>
<td>Leafy spurge</td>
<td>Black Powder III&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
<td>X&lt;sup&gt;4&lt;/sup&gt;</td>
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</tr>
<tr>
<td>WAB</td>
<td>Leafy spurge</td>
<td>Black Powder IV&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
<td>X&lt;sup&gt;4&lt;/sup&gt;</td>
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<tr>
<td>WAB</td>
<td>Leafy spurge</td>
<td>Black Powder V&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
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<tr>
<td>WAB</td>
<td>Leafy spurge</td>
<td>Black Powder VI&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
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</tr>
<tr>
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<td>Leafy spurge</td>
<td>Bridge I&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
<td>X&lt;sup&gt;4&lt;/sup&gt;</td>
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<tr>
<td>WAB</td>
<td>Leafy spurge</td>
<td>Bridge II&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
<td>X&lt;sup&gt;4&lt;/sup&gt;</td>
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<td>Control</td>
<td><em>Aphthona czwalinae</em></td>
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<td>Leafy spurge</td>
<td>Control</td>
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<tr>
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<td>Leafy spurge</td>
<td>Nature I</td>
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<td>Nature Ib&lt;sup&gt;1&lt;/sup&gt;</td>
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<td>Leafy spurge</td>
<td>Nature II</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
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<td>Nature IIa&lt;sup&gt;1&lt;/sup&gt;</td>
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<td>Nature IV&lt;sup&gt;1&lt;/sup&gt;</td>
<td><em>Aphthona</em> sp. complex&lt;sup&gt;2&lt;/sup&gt;</td>
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<tr>
<td>WAB</td>
<td>Dalmatian toadflax</td>
<td>Control</td>
<td><em>Mecinus janthinus</em></td>
<td></td>
<td></td>
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<tr>
<td>WAB</td>
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<td>Nature</td>
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<tr>
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<td>Dalmatian toadflax</td>
<td>Nursery&lt;sup&gt;1&lt;/sup&gt;</td>
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<td>Missile</td>
<td><em>Mecinus janthinus</em></td>
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<sup>1</sup> Area not mapped, release only

<sup>2</sup> *Aphthona* sp. complex is composed of varying proportions of *A. cyparissiae*, *A. czwalinae*, *A. lacertosa*, and *A. nigriscutis*, though no *A. czwalinae* were recovered this year.

<sup>3</sup> Adventitious recovery, no release made at this site

<sup>4</sup> Only *Aphthona nigriscutis* recovered out of all the *Aphthona* species released.

![Map showing Black Powder leafy spurge height in 2008]
Apéndice 1. Tabla mostrando el tamaño de las áreas de estudio por especie y por instalación.

<table>
<thead>
<tr>
<th>Especie</th>
<th>Academia del Cuerpo Aéreo</th>
<th>Base Aérea de Buckley</th>
<th>Fort Carson&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Rocky Flats</th>
<th>Base Aérea de Warren&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Acéres</th>
<th>Hectáreas</th>
<th>Acéres</th>
<th>Hectáreas</th>
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<td>58.6</td>
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<td>Total acéres (ha)</td>
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<td>61.1</td>
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<sup>1</sup> Total no incluye área de alce en Sección 36 (4.61 acéres; 1.87 ha).
<sup>2</sup> Total no incluye área de sitios monitoreados por transectos.