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 Environmental Technology Site
F. E. Warren Air Force Base

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2007 Consolidated Report

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On the cover: Aphthona flava beetles attacking a leafy spurge plant en masse at the Buckley Air Force Base's Williams Lake infestation.

Introductory Notes

As of 2007, the biological control of noxious weeds project has been going on for eleven years at Ft. Carson Military Post (FTC), eight years at Air Force Academy (AFA), seven years at Rocky Flats Environmental Technology Site (RF), five years at Buckley Air Force Base (BAF), and four 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 mite 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

Each of the installations is at a different stage in the program. F. E. Warren Air Force Base, for example, is at a very early stage in the biological control process, concentrating primarily on the first objective of establishing healthy populations of bio-agents. In contrast, Fort Carson Military Post has seen dramatic reductions of weeds, including Canada thistle and spotted knapweed, over the eleven year history of the project. The focus of the noxious weed biocontrol program at this installation has evolved into activities related to objectives two (i.e. re-distribution of insects to newly discovered weed infestations) and three (i.e. detection and management of weed re-growth at historic sites). Additionally, we are monitoring weed infestations at each of the participating installations that are at various stages of biological control implementation:

1. New bio-agent release sites initiated in 2007, such as the Bike Trail diffuse knapweed and Ice Lake Road yellow toadflax sites at AFA and the Section 36 saltcedar infestation at FTC.
2. "Young" release sites that have just begun to show significant biocontrol agent impact in the past year (i.e. characteristic damage 'halos' from *Aphthona* beetles at the Runway and Williams Lake leafy spurge sites at BAF)
3. Weed infestations that have experienced consistent decline since bio-agents were released, including the Deadman's Creek leafy spurge and Kettle Creek St. Johnswort sites at AFA, the Fuel Site spotted knapweed patch at FTC and the Lindsay Ranch Canada thistle infestation at RF.
4. Weed infestations that have 'crashed', indicated by dissolution of dense weed patches into scattered fragments throughout a more naturalized landscape, such as Old Monument Creek's spotted knapweed patch at AFA, the ARA I Canada thistle infestation at FTC and the Original Dalmatian toadflax site at RF.

Navigating the 2007 Report

Figure 1 illustrates the locations of noxious weed biological control work over the past eleven years. With the exception of Monument Fire Center, we continue to actively tackle existing and new weed patches with highly host-specific insect agents at each of the listed installations. 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. Infestations we began monitoring in 2007 and sites discontinued in 2007 were not included in this quick summary table.

Beginning on page 12, we present the supplementary laboratory and field data collection from 2006 and 2007 that helps us to assess the establishment efficacy and damage potential of released bio-agents. Tables 3 and 4 present the results of knapweed seedhead collections in the 2006 and 2007 seasons, respectively, quantifying populations of the seed-feeders *Larinus minutus*, *Metzneria paucipunctella*, *Urophora affinis* and *U. quadrifasciata*. Traditionally, we have presented information from seedheads collected in the season prior to the reporting year, as seedhead dissection takes place in the winter following a given field season. This year, however, we are pleased to be able to offer data from both 2006 and 2007 knapweed seedhead-agent population densities. Table 5 represents a comparison of establishment levels of toadflax stem-borer, *Mecinus janthinus*, from the 2005 and 2006 field seasons. As toadflax stalks are generally collected in the spring following a field season, we will present data for the 2007 season in the 2008 report. Comparative population estimates of *Aphthona* spp. leafy spurge beetles from 2004-2007 are presented in Tables 6 and 7. These population estimates are taken from sweepnet samples, each covering 1m in area, obtained during peak beetle population densities. Table 6 presents *Aphthona* populations that occur at leafy spurge infestations we have mapped and monitored using our standard GPS-enabled data collection methods. The *Aphthona* abundance comparisons listed in Table 7 represent locations into which beetles were released in 2005 following the mass acquisition of 70,000 beetles for release. These 2005 *Aphthona* releases are monitored by randomly sampling ten locations near the bio-agent release point and are thus listed separately from sites that have been traditionally mapped and extensively monitored. Finally, Table 8 represents visual counts of bio-agent, *Chrysolina* sp., obtained during their population peaks on St. Johnswort at Air Force Academy.

In the remainder of the 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 Airbase. 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 $0.5m^2$ 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.

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 2007

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 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. The information we have obtained during the course of our monitoring activities from 1997-2007 has been consolidated, formatted, edited and archived into various geodatabases during the past two winters. The work, largely conducted by technician David Jurovich as part of the Department of Defense Legacy Resource Management Program, will be distributed at the 2008 Texas AgriLife Research Biological Control of Noxious Weeds Cooperative Agreement Meeting on March 18, 2008. 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. We will also be working in the winter of 2008 to incorporate site photographs into the geodatabases, linking these pictures to the actual locations from which they were taken.

General Trends in 2007

As discussed in the 2006 report, it is difficult to make broad, sweeping conclusions about the status of weeds at the participating installations, as monitoring sites are at various stages of biocontrol. During the planning phase of each season's work, we evaluate the progress of each weed infestation separately and make bio-agent release decisions on a case-by-case basis. These decisions are made by looking at the establishment success of released agents, visual and statistical impact estimates and any site management practices outside scope of our biocontrol work that may impact on insect efficacy. In 2007, however, we did see some general trends across installations, sites and weed types. The primary trend was that weeds growing in 2007 were larger and more robust than in 2006, causing significant increases in the heights of all monitored weed species (Table 1). Despite the robust nature of the weeds surveyed in 2007, we didn't observe a comparable increase in plant density within monitored patches. Many of the weeds surveyed declined, albeit not significantly, including Canada thistle, yellow toadflax, spotted knapweed, St. Johnswort and some leafy spurge and diffuse knapweed patches (Table 1). This suggests that, despite excellent growing conditions for weeds this season, infestations were still being suppressed by active biocontrol agents. Observed populations of bio-agents at sites such as Williams Lake (see cover picture) support the conclusion that it was not only a good year for plant growth but that biological control agent populations at many sites were booming.

It was thrilling this season to observe several relatively new populations of bio-agents (i.e. releases made in 2005), which established strong populations and caused heavy localized damage on target weed populations. This is highlighted within the summary for Buckley Air Force Base, in particular, in regards to the Runway and Williams Lake sites. We also observed spotted and diffuse knapweed seed and root feeders rebounding from a population suppression in 2006 that was likely caused by asynchrony in key weed and bio-agent activities (i.e. adult seed-feeding insects were late to emerge and were faced with already mature seedheads in which to lay eggs). In any given year, this phenomenon influences the efficacy of biological control agents, as moisture levels, temperature and other climatic factors can dramatically delay or encourage premature both plant and insect development. This year we observed that yellow toadflax emerged extremely late in the season at Air Force Academy. Shoots appeared in late July-August rather than the usual spring growth, well after *Mecinus janthinus* adults were ready to lay eggs into stems. We also observed this type of disconnect between host and biocontrol agent in field bindweed and the gall-forming mite *Aceria malherbae*, during the 2007 season. Throughout Colorado, field bindweed emerged from the ground early in the spring while mite populations lagged until summer, making them relatively ineffective in the control of large, mature bindweed foliage. Plans are underway for 2008 to further augment the 2006 and earlier *A. malherbae* releases in order to curb the growing field bindweed problem at several of our cooperating installations.

As always, please send us any comments you may have regarding the either our biocontrol efforts or the reporting format. We appreciate the continued opportunity to carry on this important work.

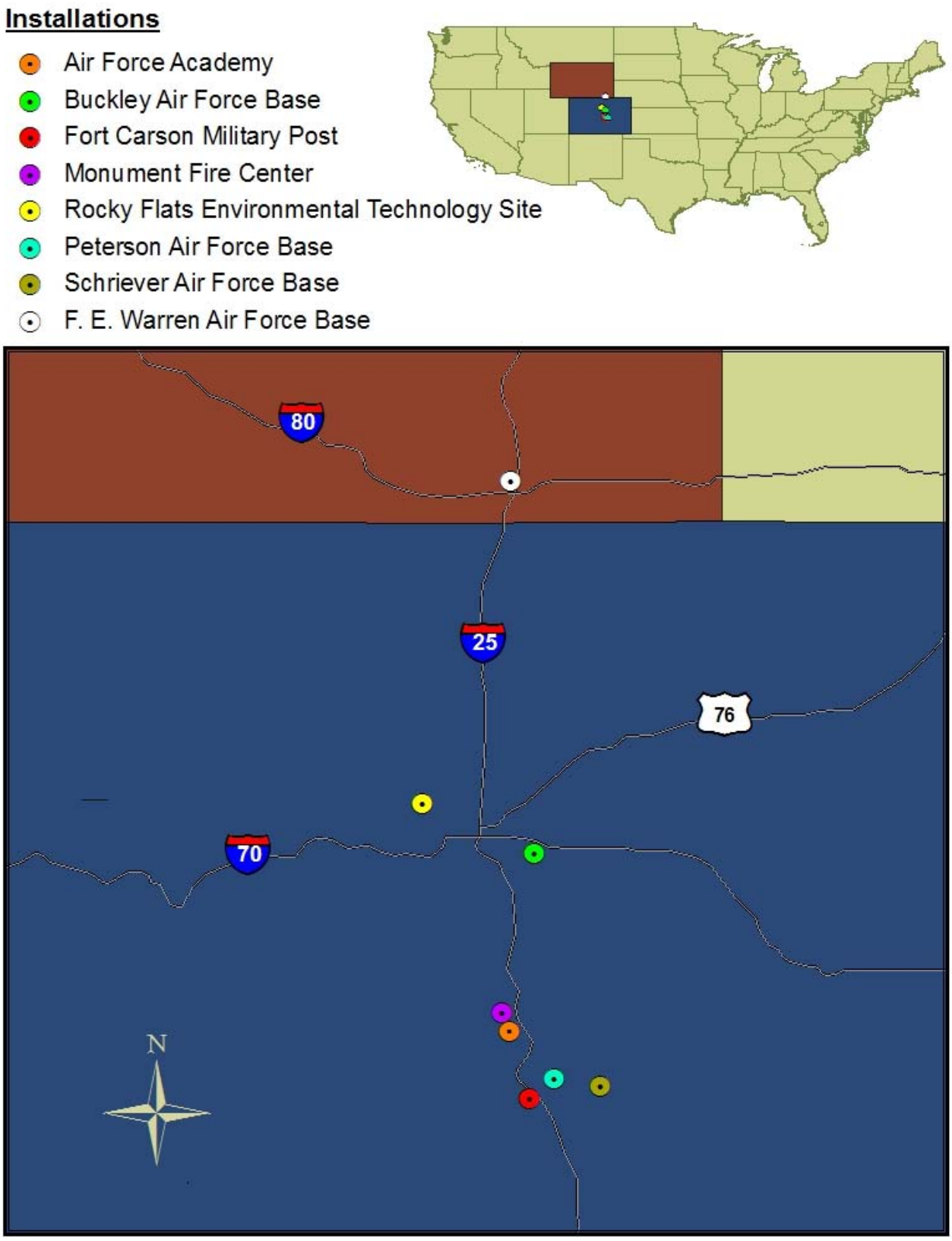


Figure 1. Map showing the federal installations in Colorado and Wyoming on which noxious weed biological control efforts are/have being made by Texas AgriLife Research.

Table 1. Overall summary of the trends in noxious weed parameter changes, 2006-2007, at the five participating installations in Colorado and Wyoming.

Noxious Weed	Parameter	Change in Parameter, 2006-2007				Total Compared Sites
		Significant decrease[1]	Decrease	Significant increase[1]	Increase	
Canada Thistle	Density	0	5	0	2	7
Canada Thistle	Height	0	0	6	1	7
Dalmatian Toadflax	Density	0	1	0	3	4
Dalmatian Toadflax	Height	0	0	3	1	4
Leafy Spurge	Density	0	3	2	3	8
Leafy Spurge	Height	0	2	6	0	8
Musk Thistle	Density	1	0	0	0	1
Musk Thistle	Height	1	0	0	0	1
Diffuse Knapweed	Density	0	2	1	1	4
Diffuse Knapweed	Height	0	0	3	1	4
Spotted Knapweed	Density	0	1	0	6	7
Spotted Knapweed	Height	0	0	6	1	7
St. John's Wort	Density	0	2	0	0	2
St. John's Wort	Height	0	0	2	0	2
Yellow Toadflax	Density	1	1	0	0	2
Yellow Toadflax	Height	0	0	2	0	2
Total		3	17	31	19	35

[1] Significance level, p=0.05

Table 2. Details of the changes in noxious weed parameters, 2006-2007, at Air Force Academy (AFA), Buckley Air Force Base (BAF), Fort Carson Military Post (FTC), Rocky Flats Environmental Technology Site (RF), and F. E. Warren Air Force Base (WAB). Sites that were monitored only one of these years are not included in the summary.

Installation	Site	Noxious Weed	Parameter	Annual Change	
AFA	Ice Lake Road I	Canada Thistle	Density	decrease	ns
AFA	Ice Lake Road I	Canada Thistle	Height	increase	*
AFA	Ice Lake Road II	Canada Thistle	Density	increase	ns
AFA	Ice Lake Road II	Canada Thistle	Height	increase	*
AFA	Kettle Lake	Canada Thistle	Density	decrease	ns
AFA	Kettle Lake	Canada Thistle	Height	increase	*
AFA	Parade Loop	Canada Thistle	Density	decrease	ns
AFA	Parade Loop	Canada Thistle	Height	increase	*
AFA	Deadman's Trail	Leafy Spurge	Density	decrease	ns
AFA	Deadman's Trail	Leafy Spurge	Height	increase	*
AFA	Douglass School	Leafy Spurge	Density	increase	*
AFA	Douglass School	Leafy Spurge	Height	increase	*
AFA	FERL	Leafy Spurge	Density	decrease	ns
AFA	FERL	Leafy Spurge	Height	increase	*
AFA	Highway 83	Diffuse Knapweed	Density	decrease	ns
AFA	Highway 83	Diffuse Knapweed	Height	increase	*
AFA	Water Treatment Plant	Mixed Knapweed	Density	increase	*
AFA	Water Treatment Plant	Mixed Knapweed	Height	increase	*
AFA	Monument Trail Road	Spotted Knapweed	Density	increase	ns
AFA	Monument Trail Road	Spotted Knapweed	Height	increase	*
AFA	New Monument Creek	Spotted Knapweed	Density	increase	ns
AFA	New Monument Creek	Spotted Knapweed	Height	increase	*
AFA	NPWR	Spotted Knapweed	Density	increase	ns
AFA	NPWR	Spotted Knapweed	Height	increase	*
AFA	Old Monument Creek	Spotted Knapweed	Density	increase	ns
AFA	Old Monument Creek	Spotted Knapweed	Height	increase	ns
AFA	Kettle Creek	St. Johnswort	Density	decrease	ns
AFA	Kettle Creek	St. Johnswort	Height	increase	*
AFA	Midway Kettle Creek	St. Johnswort	Density	decrease	ns
AFA	Midway Kettle Creek	St. Johnswort	Height	increase	*
AFA	Community Center Drive I	Yellow Toadflax	Density	increase	ns
AFA	Community Center Drive I	Yellow Toadflax	Height	increase	*
AFA	Community Center Drive II	Yellow Toadflax	Density	increase	*
AFA	Community Center Drive II	Yellow Toadflax	Height	increase	*
BAF	Aspen	Canada Thistle	Density	decrease	ns
BAF	Aspen	Canada Thistle	Height	increase	*

Table 2. Details of the changes in noxious weed parameters, 2006-2007, at Air Force Academy (AFA), Buckley Air Force Base (BAF), Fort Carson Military Post (FTC), Rocky Flats Environmental Technology Site (RF), and F. E. Warren Air Force Base (WAB). Sites that were monitored only one of these years are not included in the summary.

Installation	Site	Noxious Weed	Parameter	Annual Change	
BAF	Southwest Williams Lake	Leafy Spurge	Density	decrease	ns
BAF	Southwest Williams Lake	Leafy Spurge	Height	increase	*
BAF	Williams Lake	Leafy Spurge	Density	increase	ns
BAF	Williams Lake	Leafy Spurge	Height	increase	*
FTC	Highway 115	Canada Thistle	Density	increase	ns
FTC	Highway 115	Canada Thistle	Height	increase	*
FTC	Wildlife	Musk Thistle	Density	decrease	*
FTC	Wildlife	Musk Thistle	Height	increase	*
FTC	Gun Club	Diffuse Knapweed	Density	increase	ns
FTC	Gun Club	Diffuse Knapweed	Height	increase	*
FTC	Fuel Site	Spotted Knapweed	Density	decrease	ns
FTC	Fuel Site	Spotted Knapweed	Height	increase	*
FTC	HazMat	Spotted Knapweed	Density	increase	ns
FTC	HazMat	Spotted Knapweed	Height	increase	*
FTC	Turkey Creek	Spotted Knapweed	Density	increase	ns
FTC	Turkey Creek	Spotted Knapweed	Height	increase	*
RF	Lindsay Ranch	Canada Thistle	Density	decrease	ns
RF	Lindsay Ranch	Canada Thistle	Height	increase	ns
RF	Original Site	Dalmatian Toadflax	Density	increase	ns
RF	Original Site	Dalmatian Toadflax	Height	increase	*
RF	South Fence Transects	Dalmatian Toadflax	Density	increase	ns
RF	South Fence Transects	Dalmatian Toadflax	Height	increase	*
RF	North Buffer Transects	Diffuse Knapweed	Density	decrease	ns
RF	North Buffer Transects	Diffuse Knapweed	Height	increase	ns
WAB	Missile	Dalmatian Toadflax	Density	increase	ns
WAB	Missile	Dalmatian Toadflax	Height	increase	ns
WAB	Nature	Dalmatian Toadflax	Density	decrease	ns
WAB	Nature	Dalmatian Toadflax	Height	increase	*
WAB	Black Powder Road	Leafy Spurge	Height	increase	*
WAB	Black Powder Road	Leafy Spurge	Density	increase	ns
WAB	Nature Trail I	Leafy Spurge	Density	increase	*
WAB	Nature Trail I	Leafy Spurge	Height	decrease	ns
WAB	Nature Trail II	Leafy Spurge	Density	increase	ns
WAB	Nature Trail II	Leafy Spurge	Height	decrease	ns

at $p = 0.05$, * indicates parameters are significantly different, **ns** indicates no significant difference

Summary of 2006 and 2007 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 2006 and 2007 field seasons (Tables 3 and 4)
- *Mecinus janthinus* populations in toadflax stalks collected in 2006 and 2007 (Note: these collections represent *M. janthinus* populations present in the 2005 and 2006 field seasons) (Table 5)
- Comparative spring collections of *Aphthona* beetle populations found at mapped leafy spurge infestations during peak beetle emergence in 2004, 2005, 2006 and 2007 (Table 6).
- Comparative spring collections of *Aphthona* populations found at supplementary leafy spurge release sites in 2006 and 2007, from which 10 random sweeps were taken to collect the beetles in lieu of mapping the sites (Table 7).
- Comparative spring collections of *Chrysolina* beetle populations found at mapped St. Johnswort infestations during peak beetle emergence in 2004, 2005, 2006 and 2007 (Table 8).

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 2006 at Air Force Academy (AFA), Fort Carson Military Post (FTC) and Rocky Flats Environmental Technology Site (RF), identifying the proportion of knapweed seedheads attack (%) and the seed-feeding agents responsible.

Installation Abbreviation	Sample Site Name	n	Percent Heads Attacked	Seedheads with Biological Control Agents (%)			
				L. minutus	*U. affinis*	*U. quadrifasciata*	*M. paucipunctella*
AFA	Highway 83	214	24	0	2	22	1
AFA	New Monument Creek	354	15	0	1	15	0
AFA	Monument Trail Road	98	33	2	13	17	4
AFA	NPWR	319	56	2	26	31	1
AFA	Old Monument Creek	40	45	0	0	45	0
AFA	Parade Loop I	310	52	1	20	32	3
AFA	Parade Loop II	118	75	3	20	54	4
AFA	Parade Loop III	355	61	1	10	53	1
AFA	Water Treatment Plant	373	70	34	15	8	23
FTC	Fuel Site	406	56	0	2	52	2
FTC	Gun Club	137	31	5	0	26	1
FTC	Hazmat	378	36	0	0	35	1
FTC	Turkey Creek	238	16	0	0	16	0
RF	N Buffer Transects	650	27	1	8	18	2

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.

Table 4. Knapweed seedhead dissections from sampled plants in 2007 at Air Force Academy (AFA), Fort Carson Military Post (FTC) and Rocky Flats Environmental Technology Site (RF), identifying the proportion of knapweed seedheads attack (%) and the seed-feeding agents responsible.

Installation Abbreviation	Sample Site Name	n	Percent Heads Attacked	Seedheads with Biological Control Agents (%)			
				L. minutus	*U. affinis*	*U. quadrifasciata*	*M. paucipunctella*
AFA	Bike Trail [1]	380	41	7	19	9	7
AFA	Deadman's Creek [2]	119	31	8	10	4	8
AFA	Highway 83	383	41	7	19	9	7
AFA	New Monument Creek	516	61	25	7	4	25
AFA	Monument Trail Road	314	73	18	24	14	18
AFA	NPWR	541	56	14	25	3	14
AFA	Old Monument Creek	287	32	4	15	8	4
AFA	Parade Loop (combined)	699	42	8	13	12	8
AFA	Water Treatment Plant	579	91	33	22	2	33
FTC	Fuel Site	455	100	55	16	22	55
FTC	Gun Club	588	100	52	1	4	52
FTC	Hazmat	419	73	16	16	26	16
FTC	Turkey Creek	668	38	0	1	36	0
RF	N Buffer Transects	560	46	18	7	4	18

[1] *Site newly mapped in 2007.*

[2] *Seedhead collection commenced in 2007.*

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.

Table 5. Toadflax stem dissections taken from 30 stalks collected randomly at each site in the spring following a growing season. The installations included in this collection are: Air Force Academy (AFA), Buckley Air Force Base (BAF), Rocky Flats Environmental Technology Site (RF) and F. E. Warren Airbase (WAB). Comparative levels of stem attack (%) by biocontrol agent, *Mecinus janthinus*, and insect population abundance estimates are listed for the 2005 and 2006 growing seasons. Stems from the 2007 growing season will be dissected in spring 2008.

Installation	Sample	2006 *Mecinus janthinus* Population			2005 *Mecinus janthinus* Population		
Name	Site Name	% Attack	Oviposition	Total Insects	% Attack	Oviposition	Total Insects
AFA	Community Center Dr. I	--	--	--	0	0	0
AFA	Community Center Dr. II	--	--	--	3	3	0
BAF	South Aspen Way	53	46	32	40	28	1
BAF	South Fence [1]	3	3	2	--	--	--
RF	Original Site [2]	100	320	387	100	1,760	1,573
RF	South Fence transects [3]	21	100	66	38	451	85
WAB	Control	7	2	2	23	183	46
WAB	Missile	3	3	2	47	89	22
WAB	Nature	0	0	0	27	32	8
WAB	Nursery	53	72	46	63	157	121

[1] The data from this site do not represent a random stalk collection, as there is restricted access throughout this area.
[2] A total of 23 stems were collected from this site, as there is very little toadflax remaining.
[3] There were a total of 90 stalks collected from this site.
Note: the Nursery site at F. E. Warren Air Force Base is a release site only (i.e. the toadflax infestation has not been mapped there).

Table 6. Proportion of sampled leafy spurge 0.5m^2 quadrats populated by *Aphthona* species biological control agents, as identified through sweep net captures in 2004, 2005, 2006 and 2007 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.

Installation Abbreviation	Sample Site Name	2007 Sweeps n	2007 Sweeps % Inhabited	2006 Sweeps n	2006 Sweeps % Inhabited	2005 Sweeps n	2005 Sweeps % Inhabited	2004 Sweeps n	2004 Sweeps % Inhabited
AFA	Deadman's Trail	32	28	37	0	30	37	31	45
AFA	Douglass School	30	17	43	0	36	3	5	20
AFA	FERL	50	22	33	0	45	6	30	20
AFA	North FERL [2]	--	--	35	0	--	--	--	--
BAF	Interior [3]	--	--	10	20	28	36	--	--
BAF	Runway [3]	45	47	28	86	32	31	44	0
BAF	South Fence [1]	30	17	28	0	--	--	--	--
BAF	Southwest Williams Lake [3]	31	19	34	44	42	57	24	0
BAF	Williams Lake	56	43	45	2	31	32	77	9
WAB	Black Powder Road [2]	129	50	96	27	28	0	--	--
WAB	Control [3]	--	--	64	23	50	54	31	0
WAB	Nature I [3]	60	8	54	6	35	34	44	0
WAB	Nature II [3]	62	39	54	56	37	73	42	0

[1] Site initiated in 2006
[2] Site initiated in 2005
[3] Site initiated in 2004

Table 7. 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 $0.5m^2$ quadrats have been sampled at each release location in both 2006 and 2007.

Installation Abbreviation	Sample Site Name	2007 Sweep Samples		2006 Sweep Samples	
		% Quadrats Inhabited	# Insects/quadrat	% Quadrats Inhabited	# Insects/quadrat
BAF	North Runway 1	60	3	0	--
BAF	North Runway 2	50	1	0	--
BAF	North Runway 3 [1]	0	--	--	--
WAB	Black Powder 1 [2]	100	4	80	4
WAB	Black Powder 2 [2]	100	18	60	2
WAB	Black Powder 3 [2]	40	1	10	0.2
WAB	Black Powder 4 [2]	100	5	10	0.3
WAB	Black Powder 5 [2]	10	0.1	10	0.2
WAB	Black Powder 6 [2]	10	0.1	30	0.4
WAB	Bridge I [2]	60	1	60	5
WAB	Bridge II [2]	50	1	60	1
WAB	Nature III	0	--	70	3
WAB	Nature IIII [2]	0	--	30	0.6
WAB	Propane [2]	80	5	100	9

[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 8. Proportion of sampled St. Johnswort 0.5m^2 quadrats populated by *Chrysolina* species biological control agents at Air Force Academy, as identified through visual counts in 2004-2007. The number of quadrat samples taken at a site is indicated by n.

Sample	2007 Insect Counts		2006 Insect Counts		2005 Insect Counts		2004 Insect Counts	
Site Name	n	% Inhabited	n	% Inhabited	n	% Inhabited	n	% Inhabited
Kettle Creek	47	32	32	13	33	49	71	10
Midway Kettle Creek	32	44	30	7	40	48	19	32
Santa Fe	--	--	--	--	40	68	24	8

Note: The Santa Fe site was not sampled in 2006 or 2007, as there were not enough plants left at this site to sample.

Air Force Academy

Twenty-two noxious weed infestations were mapped at Air Force Academy this year over a total area of 8.6 ha (21.3 acres). Though the number of sites mapped in 2007 remained relatively consistent with monitoring activities in 2006, the infestation area surveyed quadrupled this season (from 1.78ha in 2006). As Table 9 indicates, this is largely due to the expansion of existing spotted and diffuse knapweed infestations. In 2007, eight knapweed patches accounted for 87% of the overall noxious weed area mapped at Air Force Academy (7.5 ha). Favorable weather conditions for optimum knapweed growth in 2007, combined with a dramatic decrease in the number of key bioagents present at infestations sites in 2006, appears to have allowed knapweeds to escape much of the control imposed by biocontrol agents in past years. For example, the size of the New Monument Creek spotted knapweed site increased between 2006 and 2007 by a full order of magnitude (Table 9). When looking at the insects inhabiting seedheads collected the 2006 field season (Table 3), we noticed an almost complete absence of *Larinus minutus* at this site, as compared to finding the weevil in 20% of seedheads the previous fall (p. 13 in the 2006 consolidated report). This trend, consistent across all of the Front Range knapweed sites, shows us that overwintering numbers of this otherwise very effective insect may not have been sufficient for the population to build enough to exert control on the knapweeds this season. Knapweed roots were collected in 2006-2007 in insufficient numbers to be analyzed statistically. However, our limited findings show that the highly-damaging weevil *Cyphocleonus achates* was only present within seven of the 60 roots dissected from Air Force Academy.

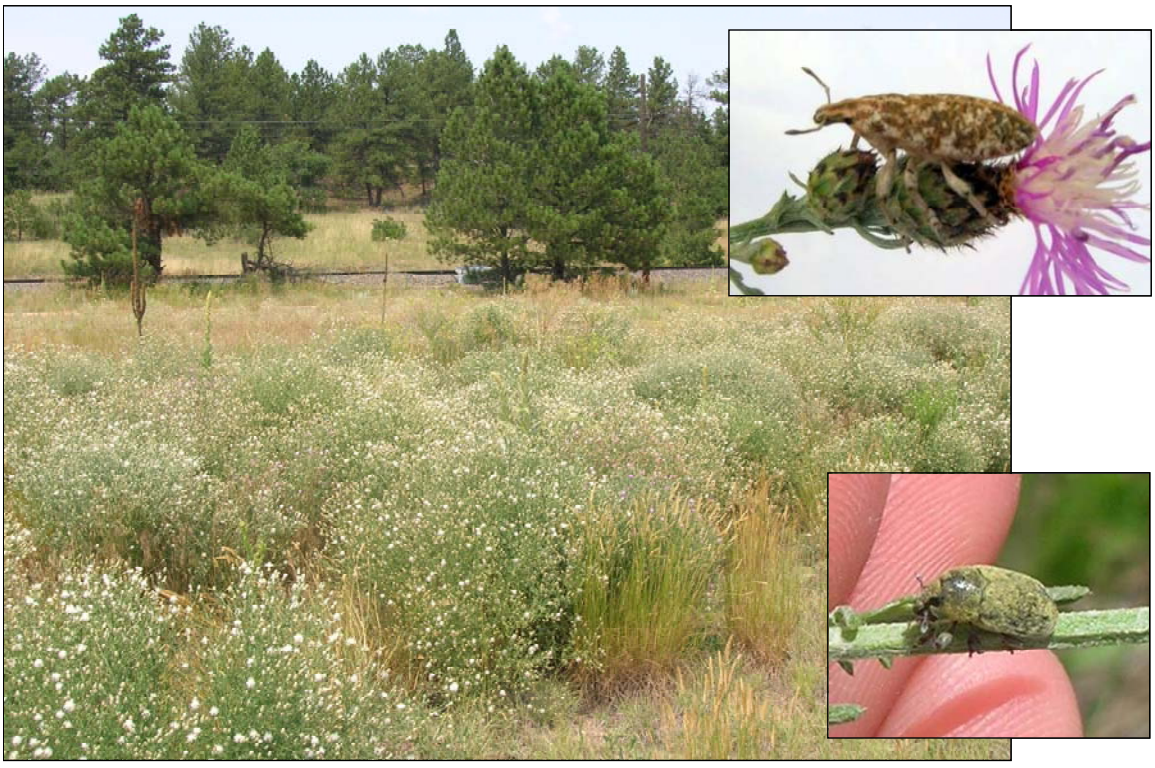
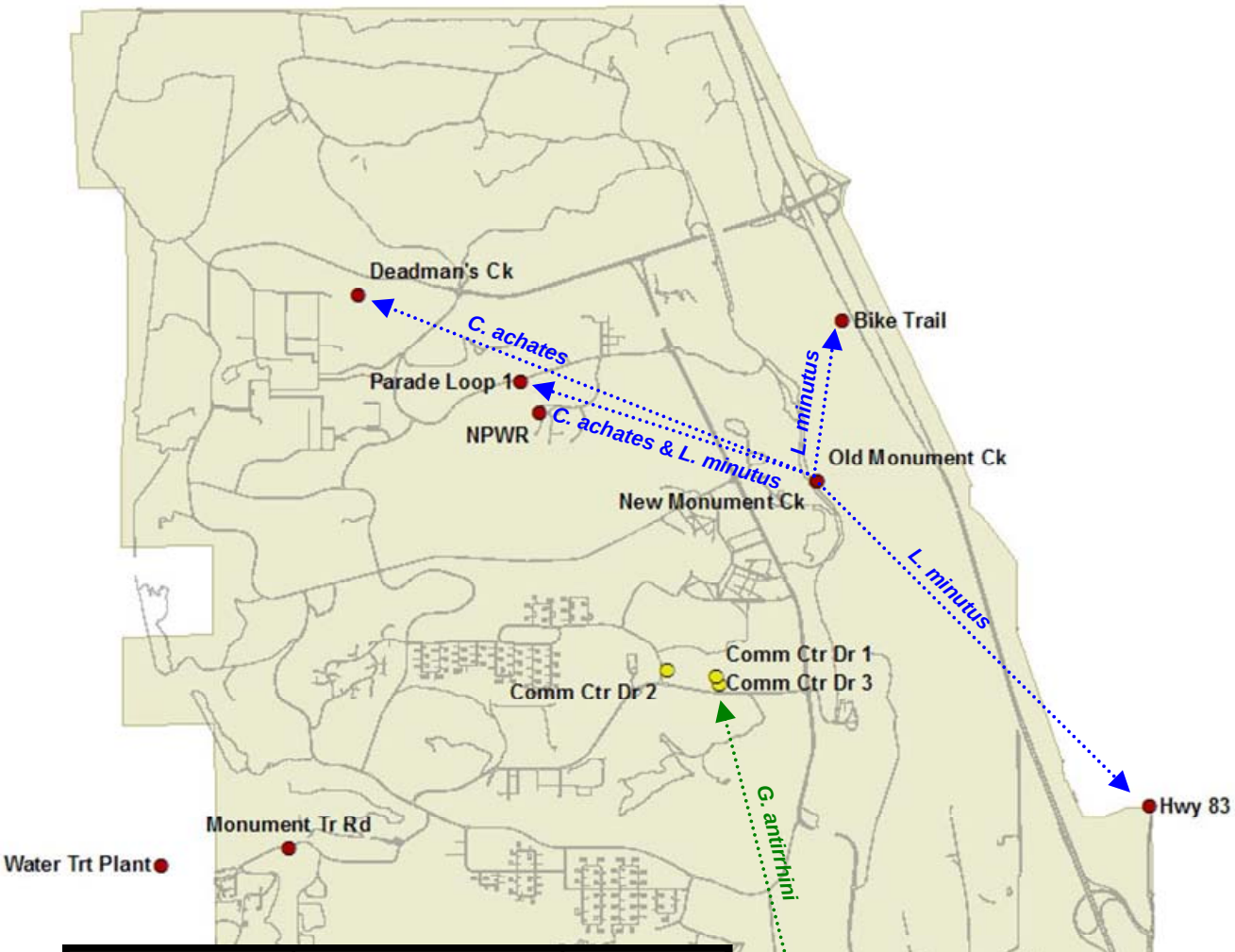


Figure 2. Spotted and diffuse knapweed at the New Monument Creek site in 2007. Biocontrol agents, *Cyphocleonus achates* (above) and *Larinus minutus* (below), have established at this site.



From	To	Distance
Old Monument Ck	Deadman's Ck	2.8 miles
Old Monument Ck	Bike Trail	0.9 miles
Old Monument Ck	Highway 83	2.6 miles
Old Monument Ck	Parade Loop	1.8 miles
Ice Lake Rd	Community Center Dr	1.9 miles

Figure 3. Schematic map of Air Force Academy and table showing dispersal distances traveled by biological control agents, *Cyphocleonus achates*, *Gymnetron antirrhini* and *Larinus minutus* during self-dispersal.

Despite their extensive population spread in 2007, individual knapweed plants still displayed signs of stress caused by attack by rebounding populations of key bio-agents. Heavily damaged plants displayed an abundance of weak, stunted shoots versus the few, strong primary shoots typically observed in healthy plants. Seedheads and roots collected at the end of the 2007 season confirmed that many of the biocontrol agent populations achieved a successful recovery from their depressed state in 2006 (Table 4), including the impressive attack rate of 61% at the New Monument Creek infestation (shown in Figure 2). Rates of seedhead damage in 2007 varied from 31% to 73% and bio-agents appear to be self-dispersing very well. Figure 3 highlights the distance traveled by some of the key knapweed agents, *L. minutus* and *C. achates*, across Air Force Academy. Random knapweed root collections also indicate that the strong fliers *Agapeta zoegana* and *Sphenoptera jugoslavica* self-spread to the Highway 83, Monument Trail Road, Non-potable Water Reservoir, and Parade Loop and new Bike Trail sitesfrom an unknown location outside the Academy. *Cyphocleonus achates*, a highly effective agent, has established well at release sites Monument Trail Road, Old Monument Creek, Parade Loop and Water Treatment Plant sites, inhabiting 20-40% of the same roots sampled. Interestingly, *C. achates* is generally thought to be limited in its dispersal capabilities as it is not known to fly. However, it was recovered this year in 33% of the roots sampled at the Deadman's Creek site, almost 3 miles from its nearest release site (Figure 3).

Figure 4. High populations of *Chrysolina* sp. beetles attacking St. Johnswort (left) typically cause complete defoliation of plants (right).

Additional monitoring was conducted at five Canada and musk thistle sites over 0.2 ha (0.5 acres), as well as four yellow toadflax patches within 0.08 ha (0.2 acres), three leafy spurge sites covering 0.5 ha (1.2 acres) and 0.2 ha of St. Johnswort near Kettle Lake (Table 9). Overall, there was a reduction in the density of the various weed species since 2006, with the exception of the knapweeds and yellow toadflax (see Table 2 for an overview). The FERL North leafy spurge infestation was not monitored in 2007 as the area had been herbicide treated prior to our crew's survey. Similar to 2006, the Santa Fe St. Johnswort site only contained scattered plants and could not be mapped. *Chrysolina* sp. beetles have established very well at all three Air Force Academy

sites and are beginning to heavily impact their target host (Figure 4). We will continue to check these areas, including Santa Fe, in future years to identify potential re-infestation.

As in previous years, we conducted some random sampling for both weed and bio-agent populations at two bio-agent release areas that do not traditionally get fully mapped. This included *L. minutus* on spotted knapweed at Deadman's Creek and field bindweed mite, *Aceria malherbae*, at the FERL and Stadium sites. Survey results indicate that the knapweed weevil has established well (Table 4), whereas bindweed mites exhibited only poor control over their host in 2006. As discussed in the general overview, field bindweed emerged early in spring of 2007 at all of our cooperating installations but its biocontrol agent appeared much later in the season. Preferring to inhabit younger tissues, the mites did not establish well in 2007 and, thus, allowed much of the bindweed to grow unchecked this season.

There is an alteration to the Parade Loop spotted knapweed sites listed in Table 9 (and corresponding site maps) that should be noted. In previous years, three discrete patches within a large, sprawling infestation had been chosen for survey purposes. As knapweed flourished this year, a more logical approach to surveying the area was to incorporate these previously separate patches into one knapweed patch, referred to in subsequent pages as Total Parade Loop.

Several biological control agent releases were made in 2007, including 1200 *Aphthona* spp. flea beetles onto leafy spurge at the Deadman's Trail site. Although we have had a successfully established colony of various species of *Aphthona* at this site for a number of years, we decided to augment the population with extra reinforcements to accelerate the decline of this infestation. Also, three hundred *Gymnetron antirrhini* were released into a new yellow toadflax site this year along Ice Lake Road. Although this seed-feeding weevil was discovered early in the 2007 season to have found its own way to the toadflax infestation at the Community Center Drive I site (Table 10), there did not appear to be not sufficient numbers to visibly impact the plants. As a result, we initiated the Ice Lake Road site in order to create a nursery site for *G. antirrhini*.

In addition to the release activities listed above, a "rescue" and "relocation" effort was made in 2007 to move key knapweed bio-agents from spotted to diffuse knapweed on base. This was in response to a planned herbicide treatment of all spotted knapweed that was to have taken place on Air Force Academy in October 2007. As populations of both *L. minutus* and *C. achates* had begun thriving at traditional spotted knapweed biocontrol sites this year, we attempted to remove as many insects as possible from sites slated for sprays and establish a nursery site with the surplus beetles on a diffuse knapweed patch now known as Bike Trail. During our monitoring this year, several new insect recoveries were made at the knapweed sites including *A. zoegana*, *C. achates*, *L. minutus* and *S. jugoslavica* (as discussed above). A summary of the bio-agent recoveries discovered in 2007 can be found in Table 10.

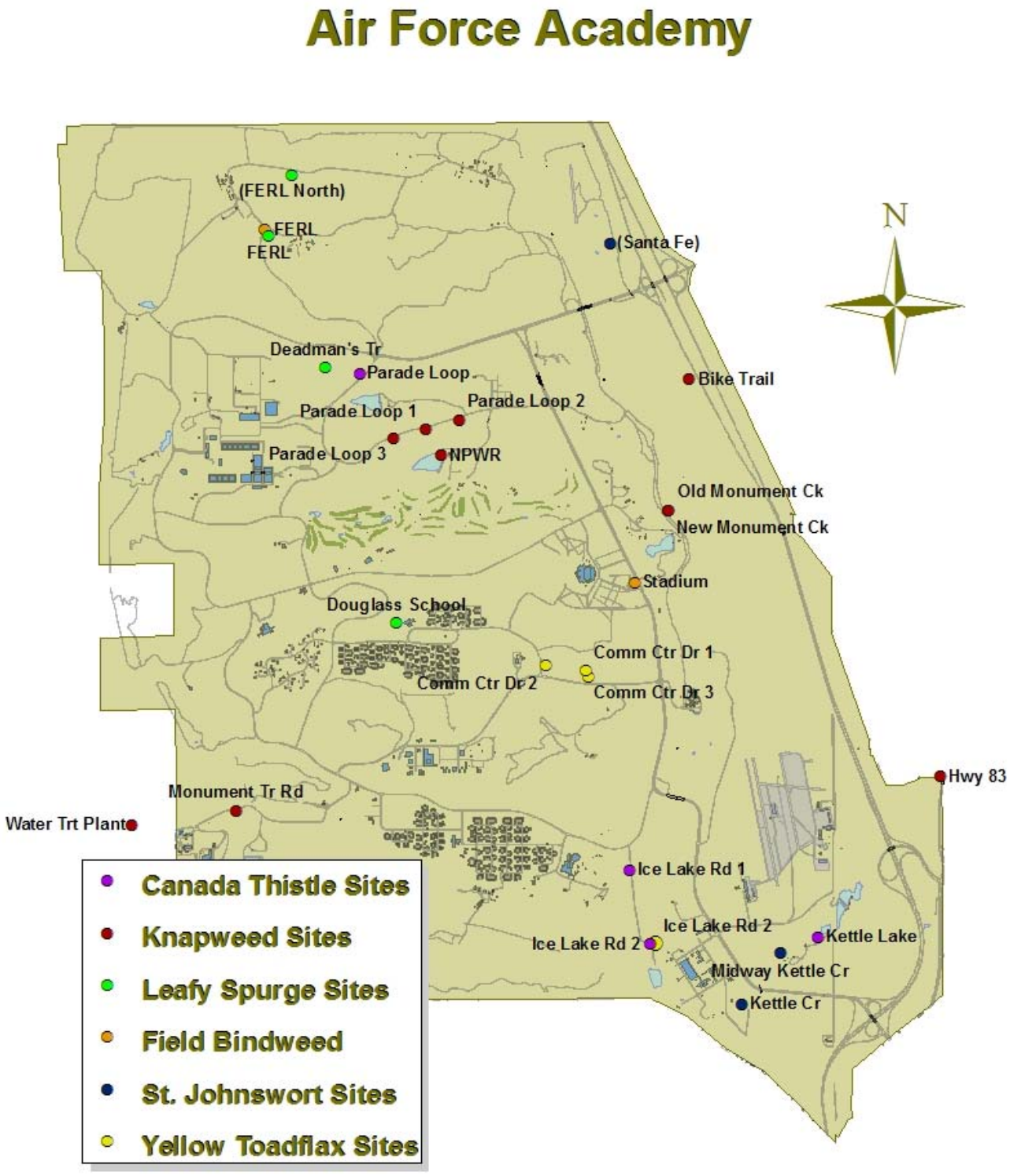


Figure 5. Schematic diagram of Air Force Academy with current weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2007.

Table 9. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Canada thistle – Ice Lake Road I												
2000			9.00		66.83							
2001	976	39	7.48	40	91.80	143	47.38	0.52		-16.89	37.36	
2002	449	33	2.26	21	14.56	97	0.46	0.90	-54.00	-69.79	-84.14	
2003	80	49	2.61	14	33.02	107	6.78	0.25	-82.22	15.49	126.79	
2004	244	45	1.27	16	45.62	74	3.23	0.54	205.84	-51.34	38.16	
2005	244	30	3.67	17	49.04	82	7.30	0.39	0	188.97	7.50	
2006	272	27	4.52	13	33.76	62	1.71	0.23	11.48	23.16	-31.16	
2007	406	31	4.32	12	72.19	129	12.85	0.50	49.26	-4.42	113.83	-58.40
Canada thistle – Ice Lake Road II												
2000	341	65	7.21	36	64.53	115						
2001	434	32	4.70	46		79			27.45	-34.81		
2002	214	27	1.74	18	16.12	124	3.85	0.21	-50.78	-62.97		
2003	46	18	2.28	16	39.72	100	10.33	0.27	-78.45	31.03	146.40	
2004	145	31	1.09	11	44.85	145	5.76	3.50	214.94	-52.19	12.92	
2005	114	24	5.21	17	79.69	110	25.91	2.05	-21.38	377.98	77.68	
2006	206	27	3.19	9	31.21	52	4.89	0.39	80.70	-38.77	-60.84	
2007	288	56	3.71	16	71.52	123	11.90	5.06	39.81	16.30	129.16	-15.54
Canada thistle – Kettle Lake												
2003	1,153	72	6.03	110	62.35	132	9.32	0.38				
2004	1,165	52	6.90	23	50.53	87	9.06	0.94	1.07	14.43	-18.96	
2005	917	31	5.34	13	75.25	121	12.86	0.61	-21.27	-22.61	48.92	
2006	943	33	4.67	26	30.83	59	0.93	0.12	2.84	-12.55	-59.03	
2007	959	22	3.00	12	63.78	129	9.17	0.47	1.70	-35.76	106.87	-16.83

Table 9. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Canada thistle – Parade Loop												
2003	6	1	0.82	10	24.09	70						
2004	36	10	4.30	13	62.29	87	6.00	2.40	483.36	424.39	158.57	
2005	61	26	3.32	14	71.92	105	18.2	0.62	69.44	-22.79	15.46	
2006	92	30	5.07	19	32.09	62	9.73	0.47	50.82	52.71	-55.38	
2007	153	20	3.50	14	126.09	167	19.45	0.79	66.30	-30.97	292.93	2450.00
Musk thistle – Ice Lake Road I												
2000	1,016	129	7.76	82	58.87	171						
2001	976	39	1.13	6	23.82	158	2.57	0.90	-3.95	-85.44	-59.54	
2002	449	7	2.00	6	63.66	111	9.00	2.18	-54.00	76.99	167.25	
2003												
2004	98	30	1.26	8	31.93	131	1.11	10.40	-78.17**	-37.00**	-49.84**	
2005	*(see Note a)*											
2006	*(see Note a)*											
2007	567	20	1.15	4	122.08	189	7.17	32.67	478.57	-8.73**	282.33**	-44.19
Leafy spurge – Deadman's Trail												
2000	406	28	63.50	195	44.33	76						
2001	1,148	66	59.78	214	50.25	97			182.75	-5.86	13.35	
2002	1,145	117	40.51	196	33.66	89			-0.27	-32.23	-33.01	
2003	249	21	9.00	22	49.25	85			-78.24	-77.78	46.32	
2004	494	31	31.03	93	42.10	80			98.21	244.78	-14.52	
2005	780	30	42.10	169	45.96	70			57.89	35.68	9.17	
2006	840	37	24.38	117	24.08	44			7.69	-42.09	-47.61	
2007	1,263	32	17.28	85	45.89	79			50.36	-29.12	90.57	211.08

Table 9. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Leafy spurge – Douglass School												
2000	187	30	16.62	56	36.96	62						
2001	290	93	29.11	103	53.32	82			55.43	75.15	44.26	
2002	380	72	3.33	60	12.24	66			31.03	-88.56	-77.04	
2003	67	5	2.40	3	65.00	80			-82.35	-27.93	431.05	
2004	52	10	11.60	23	50.25	62			-23.20	383.33	-22.69	
2005	81	36	11.05	39	46.62	65			55.77	-4.74	-7.22	
2006	261	43	9.95	59	26.42	52			222.22	-9.95	-43.33	
2007	323	30	24.13	62	56.20	77			23.75	142.51	112.72	11.38
Leafy spurge - FERL												
2000	1,139		5.21		19.54							
2001	1,528	24	4.26	194	24.59	67			34.15	-18.23	25.84	
2002	796	66	11.29	66	19.85	49			-47.89	165.92	-19.28	
2003	329	28	11.54	51	40.54	85			-58.71	2.21	104.23	
2004	2,145	103	7.31	88	31.85	54			551.95	-36.66	-21.44	
2005	196*	45	16.64	141	39.00	61			-90.86*	127.63	22.45	
2006	470	33	21.36	116	21.22	37			139.80	28.37	-45.59	
2007	3,865	50	16.10	91	45.04	68			722.34	-24.63	112.25	239.33
Leafy spurge – FERL North												
2006	696	35	10.69	32	27.69	46						
2007	*(see Note b)*											
Diffuse knapweed – Bike Trail												
2007	628	33	1.21	5	79.70	115	389.14	3.95	n/a	n/a	n/a	n/a

Table 9. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Diffuse knapweed – Highway 83												
2003	606	61	1.58	3	49.17	97	46.31	0.07				
2004	2,601	41	2.02	12	47.93	108	88.28	2.60	329.06	27.85	-2.52	
2005	3,001	35	2.58	8	53.23	82	65.36	0.38	15.38	27.72	11.06	
2006	2,278	27	5.74	37	13.03	29			-24.09	122.48	-75.52	
2007	5,750	38	2.87	20	56.48	85			152.41	-50.00	333.46	848.84
Diffuse/Spotted knapweed – Water Treatment Plant												
2003	1,162	97	2.16	23	54.75	107	36.13	0.13				
2004	1,539	42	9.81	38	47.28	91	9.00	2.60	32.47	354.17	-13.64	
2005	2,118	32	5.22	22	56.89	100	49.43	0.42	37.62	-46.79	20.33	
2006	3,525	30	5.53	19	34.88	54	29.53	3.04	66.43	5.94	-38.69	
2007	6,291	37	2.92	9	54.77	81	111.57	5.03	78.47	-47.20	57.02	441.39
Spotted knapweed – Monument Trail Road												
2003	484	20	1.50	7	27.09	115	23.02					
2004	1,937	32	3.00	17	69.57	112	48.24	4.00	300.26	100.00	153.12	
2005	2,074	39	7.94	25	93.65	148	49.17	0.60	7.07	164.67	34.61	
2006	1,948	30	1.33	11	34.30	58	7.00	0.30	-6.08	-83.25	-63.37	
2007	519	26	2.04	15	56.79	77	35.47	5.62	-73.36	53.38	65.57	7.23
Spotted knapweed – New Monument Creek												
2004	700	44	3.36	23	28.96	90	35.07	1.70				
2005	629	35	2.94	16	74.22	111	51.19	0.42	-10.14	-12.50	156.28	
2006	522	30	1.60	9	20.75	35	29.42	0.29	-17.01	-45.58	-72.04	
2007	5,385	31	1.94	10	73.63	127	224.39	4.74	931.61	21.25	254.84	669.29

Table 9. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Spotted knapweed – Non-potable Water Reservoir (NPWR)												
2003	124	29	0.97	5	24.43	100	9.62	0.61				
2004	491	31	1.35	13	44.25	78	26.33	2.70	295.03	39.18	81.13	
2005	234	30	4.37	29	49.48	89	18.39	0.61	-52.34	223.70	11.82	
2006	98	31	1.55	5	32.15	69	29.95	0.53	-58.12	-64.53	-35.02	
2007	1,937	40	1.55	7	59.72	122	84.26	5.52	1876.53	0	85.75	1462.10
Spotted knapweed – Old Monument Creek												
2000	622	35	9.00	25	37.30	80						
2001	948	45	9.52	68	39.70	98	133.15		52.36	5.78	6.43	
2002	746	41	2.19	26	8.40	73	2.62	0.26	-21.32	-77.00	-78.84	
2003	236	44	1.50	9	27.09	93	23.02	0.28	-68.37	-31.51	222.50	
2004	*(see Note a)*											
2005		49	0.30	14	33.00	39	0.50	2.00				
2006	389	38	0.32	11	25.25	35	13.00	0.60		6.67	-23.49	
2007	1,834	33	0.76	5	72.04	127	226.93	5.54	371.47	137.50	185.30	194.86
Spotted knapweed – Parade Loop I***												
2003	1,437	65	0.81	4	34.18	130	7.10	0.39				
2004	921	43	3.58	13	45.07	97	7.51	3.00	-35.91	341.98	31.86	
2005	941	30	3.93	25	59.44	89	13.87	0.51	2.17	9.78	31.88	
2006	1,108	36	2.00	14	40.50	75	27.00	0.50	17.75	-49.11	-31.86	
Spotted knapweed – Parade Loop II***												
2004	578	33	0.79	3	34.15	118	118.11	2.90				
2005	282	28	3.24	13	57.71	88	9.59	0.31	-51.21	310.13	68.99	
2006	953	36	0.89	9	40.25	69	31.08	0.53	237.94	-72.53	-30.25	

Table 9. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Spotted knapweed – Parade Loop III***												
2004	1,412	41	1.53	11	21.37	73	11.68	2.60				
2005	106*	22	2.68	14	76.17	117	18.00	0.59	-92.49*	75.16	256.43	
2006	2,235	30	1.60	9	33.05	51	13.18	0.53	2008.49	-40.30	-56.61	
Spotted knapweed – Total Parade Loop***												
2007	53,820	64	1.95	22	71.38	118	108.81	5.47	n/a	n/a	n/a	n/a
St. Johnswort – Kettle Creek												
2004	1,254	90	30.94	85	53.92	85						
2005	224	33	20.00	53	68.18	94			-82.14	-35.36	26.45	
2006	619	32	13.43	60	33.09	68			176.34	-32.85	-51.47	
2007	1,599	47	8.21	47	69.61	95			158.32	-38.87	110.37	27.51
St. Johnswort – Midway Kettle Creek												
2004	196	19	28.63	60	54.95	70						
2005	678	40	23.88	73	69.72	93			245.92	-16.59	26.88	
2006	134	30	21.53	59	42.24	62			-80.24	-9.84	-39.41	
2007	776	32	19.03	85	74.61	101			479.10	-11.61	76.63	295.92
St. Johnswort – Santa Fe												
2004	266	24	33.96	96	46.75	73						
2005	420	40	35.35	130	71.41	85			57.89	4.09	52.75	
2006	*(see Note a)*											
2007	*(see Note a)*											
Yellow toadflax – Community Center Drive I												
2003	52	4	9.25	15	26.25	40						

Table 9. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
2004	30	18	19.61	57	21.00	44			-42.21	112.00	-20.00	
2005	100	32	19.11	65	27.45	46			233.33	-2.55	30.71	
2006	93	25	13.64	72	15.50	29			-7.00	-28.62	-43.53	
2007	134	37	34.92	239	39.71	63			44.09	156.01	156.19	157.69
Yellow toadflax – Community Center Drive II												
2003	96	8	8.63	34	29.88	95						
2004	112	34	6.44	47	9.18	44			16.82	-25.38	-6 9.28	
2005	59	23	11.00	40	23.25	60		1.31	-47.32	70.81	153.27	
2006	110	27	1.74	16	12.38	29			86.44	-84.18	-46.75	
2007	129	23	13.96	44	25.97	38			17.27	702.30	109.77	34.38
Yellow toadflax – Community Center Drive III												
2005	21	10	12.90	28	44.77	57						
2006	*(see Note a)*											
2007	30	10	32.90	63	34.70	47			42.86**	155.04**	-22.49**	42.86**
Yellow toadflax – Ice Lake Road												
2007	538	21	20.90	68	33.93	65			n/a	n/a	n/a	n/a

n – number of samples or observations
n/a – not applicable, data represent first year of sampling
* - 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

Table 10. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2007.

Release Location	Target Weed	Release Site	Species released	Species recovered	New releases	New site
Air Force Academy	Canada & musk thistle	Ice Lake Road I	*Trichosirocalus horridus*	X		
Air Force Academy	Canada thistle	Ice Lake Road I	*Urophora cardui*			
Air Force Academy	Canada thistle	Ice Lake Road II	*Cassida rubiginosa*	X		
Air Force Academy	Canada thistle	Ice Lake Road II	*Larinus planus*	X		
Air Force Academy	Canada thistle	Ice Lake Road II	*Urophora cardui*			
Air Force Academy	Canada thistle	Kettle Lake	*Cassida rubiginosa*			
Air Force Academy	Canada thistle	Kettle Lake	*Ceutorhynchus litura*			
Air Force Academy	Canada thistle	Parade Loop	*Urophora cardui*			
Air Force Academy	Leafy spurge	Deadman's Trail	*Aphthona czwalinae*	X	X	
Air Force Academy	Leafy spurge	Deadman's Trail	*Aphthona lacertosa*	X	X	
Air Force Academy	Leafy spurge	Deadman's Trail	*Aphthona nigriscutis*	X	X	
Air Force Academy	Leafy spurge	Douglas School	*Aphthona czwalinae*	X		
Air Force Academy	Leafy spurge	Douglas School	*Aphthona lacertosa*	X		
Air Force Academy	Leafy spurge	Douglas School	*Aphthona nigriscutis*	X		
Air Force Academy	Leafy spurge	FERL	*Aphthona cyparissiae*	X		
Air Force Academy	Leafy spurge	FERL	*Aphthona czwalinae*			
Air Force Academy	Leafy spurge	FERL	*Aphthona lacertosa*	X		
Air Force Academy	Leafy spurge	FERL	*Aphthona nigriscutis*	X		
Air Force Academy	Leafy spurge	FERL North	*Aphthona cyparissiae*			
Air Force Academy	Leafy spurge	FERL North	*Aphthona czwalinae*			
Air Force Academy	Leafy spurge	FERL North	*Aphthona lacertosa*			
Air Force Academy	Leafy spurge	FERL North	*Aphthona nigriscutis*			
Air Force Academy	Diffuse knapweed	Bike Trail	*Agapeta zoegana*	X [1,2]		
Air Force Academy	Diffuse knapweed	Bike Trail	*Cyphocleonus achates*		X	X
Air Force Academy	Diffuse knapweed	Bike Trail	*Larinus minutus*		X	X

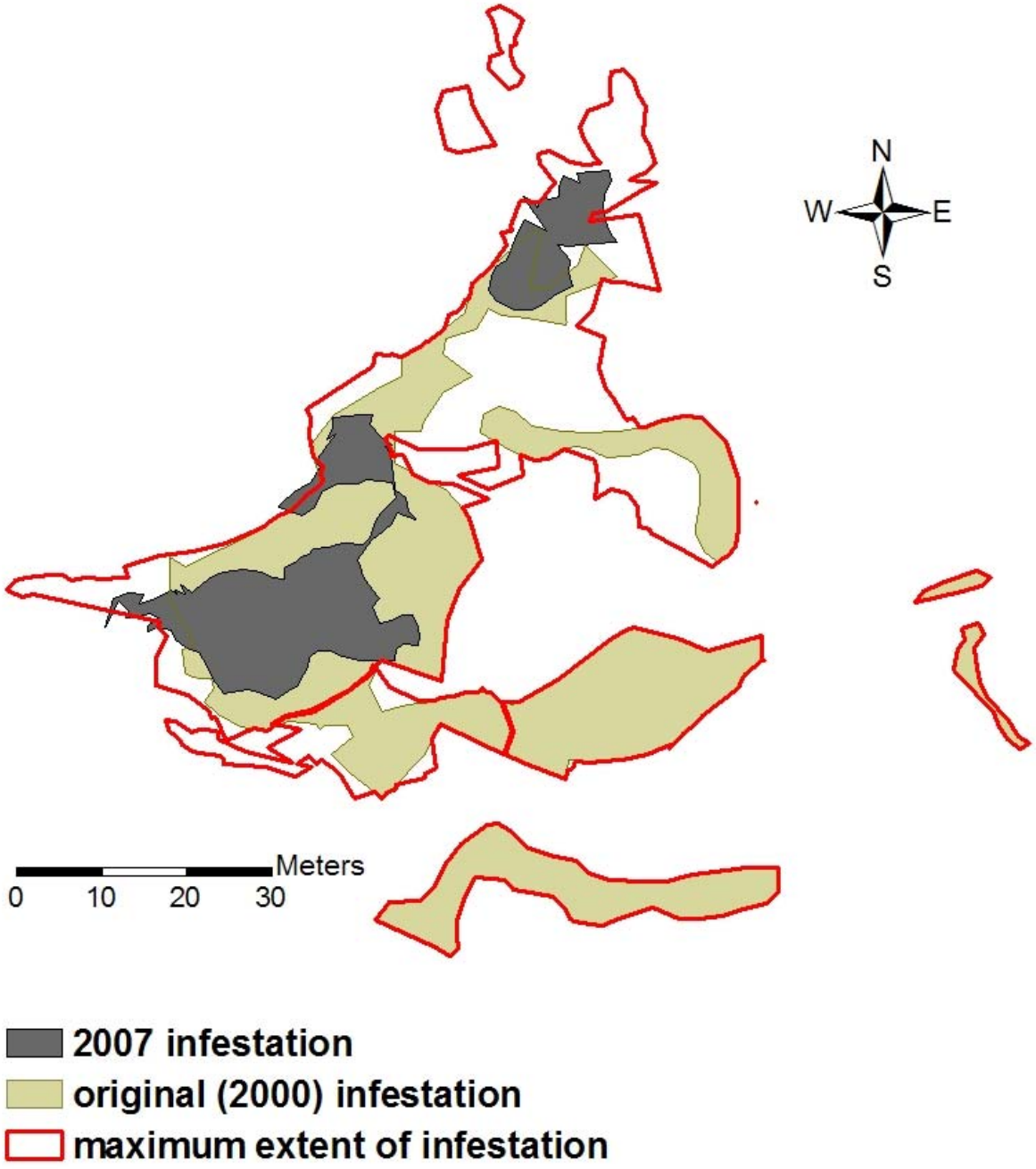
Table 10. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2007.

Release Location	Target Weed	Release Site	Species released	Species recovered	New releases	New site
Air Force Academy	Diffuse knapweed	Highway 83	*Agapeta zoegana*	X [1,2]		
Air Force Academy	Diffuse knapweed	Highway 83	*Cyphocleonus achates*	X [1]		
Air Force Academy	Diffuse knapweed	Highway 83	*Larinus minutus*	X [2]		
Air Force Academy	Diffuse knapweed	Highway 83	*Metzneria paucipunctella*	X [2]		
Air Force Academy	Diffuse knapweed	Highway 83	*Urophora affinis*	X [2]		
Air Force Academy	Spotted knapweed	Deadman's Creek	*Cyphocleonus achates*	X [1,2]		
Air Force Academy	Spotted knapweed	Deadman's Creek	*Larinus minutus*	X [1]		
Air Force Academy	Spotted knapweed	Monument Trail Road	*Cyphocleonus achates*	X [1]		
Air Force Academy	Spotted knapweed	Monument Trail Road	*Larinus minutus*	X		
Air Force Academy	Spotted knapweed	Monument Trail Road	*Metzneria paucipunctella*	X [2]		
Air Force Academy	Spotted knapweed	Monument Trail Road	*Sphenoptera jugoslavica*	X [1,2]		
Air Force Academy	Spotted knapweed	Monument Trail Road	*Urophora affinis*	X [2]		
Air Force Academy	Spotted knapweed	New Monument Creek	*Cyphocleonus achates*	X [1]		
Air Force Academy	Spotted knapweed	New Monument Creek	*Larinus minutus*	X		
Air Force Academy	Spotted knapweed	New Monument Creek	*Metzneria paucipunctella*	X [2]		
Air Force Academy	Spotted knapweed	New Monument Creek	*Urophora affinis*	X [2]		
Air Force Academy	Spotted knapweed	NPWR	*Larinus minutus*	X		
Air Force Academy	Spotted knapweed	NPWR	*Metzneria paucipunctella*	X [2]		
Air Force Academy	Spotted knapweed	NPWR	*Sphenoptera jugoslavica*	X [1,2]		
Air Force Academy	Spotted knapweed	NPWR	*Urophora affinis*	X [2]		
Air Force Academy	Spotted knapweed	Old Monument Creek	*Cyphocleonus achates*	X		
Air Force Academy	Spotted knapweed	Old Monument Creek	*Larinus minutus*	X		
Air Force Academy	Spotted knapweed	Old Monument Creek	*Metzneria paucipunctella*	X		
Air Force Academy	Spotted knapweed	Old Monument Creek	*Urophora affinis*	X [2]		
Air Force Academy	Spotted knapweed	Parade Loop I		X [3]		
Air Force Academy	Spotted knapweed	Parade Loop II		X [3]		

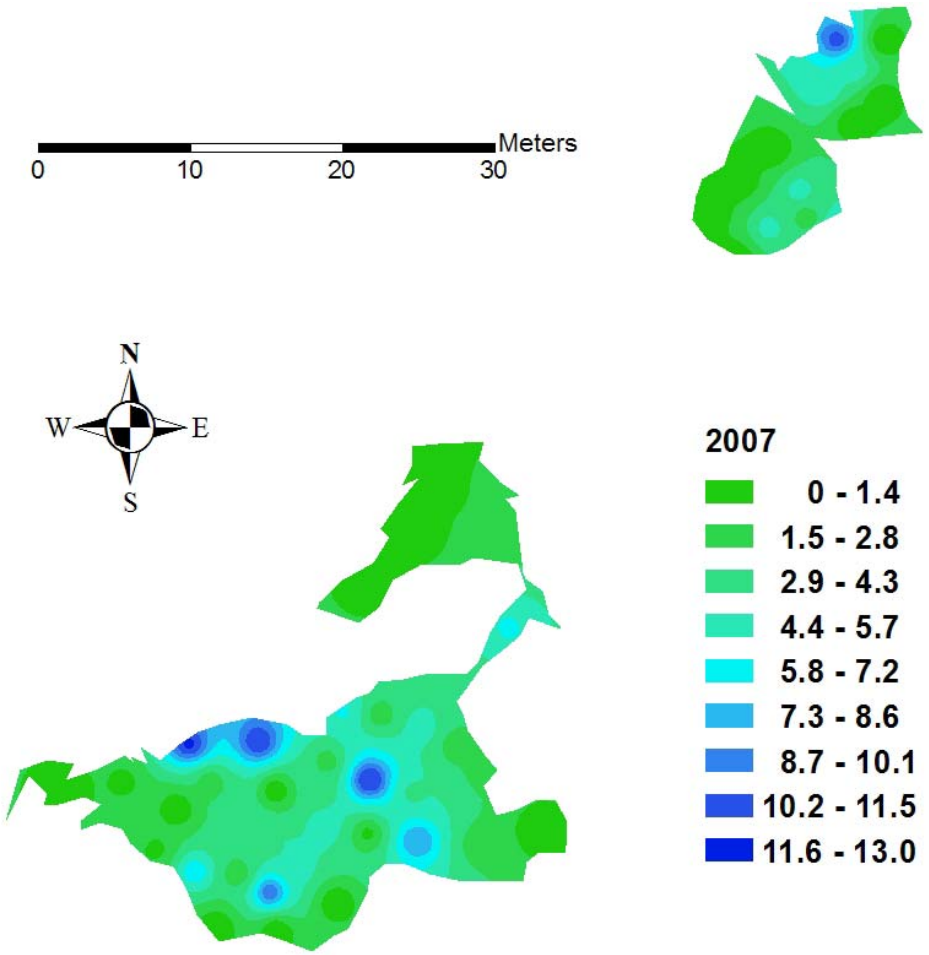
Table 10. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2007.

Release Location	Target Weed	Release Site	Species released	Species recovered	New releases	New site
Air Force Academy	Spotted knapweed	Parade Loop III		X [3]		
Air Force Academy	Diffuse & spotted knapweed	Water Treatment Plant	*Cyphocleonus achates*	X		
Air Force Academy	Diffuse & spotted knapweed	Water Treatment Plant	*Larinus minutus*	X		
Air Force Academy	Diffuse & spotted knapweed	Water Treatment Plant	*Metzneria paucipunctella*	X [2]		
Air Force Academy	Diffuse & spotted knapweed	Water Treatment Plant	*Urophora affinis*	X [2]		
Air Force Academy	St. Johnswort	Kettle Creek	*Chrysolina sp.*	X		
Air Force Academy	St. Johnswort	Midway Kettle Creek	*Chrysolina sp.*	X		
Air Force Academy	St. Johnswort	Santa Fe	*Chrysolina sp*.	X		
Air Force Academy	Yellow toadflax	Comm Center Drive I	*Mecinus janthinus*	X		
Air Force Academy	Yellow toadflax	Comm Center Drive II	*Gymnetron antirrhini*	X [1,2]		
Air Force Academy	Yellow toadflax	Comm Center Drive II	*Mecinus janthinus*	X		
Air Force Academy	Yellow toadflax	Comm Center Drive III	*Gymnetron antirrhini*	X [1,2]		
Air Force Academy	Yellow toadflax	Ice Lake Road	*Gymnetron antirrhini*		X	X

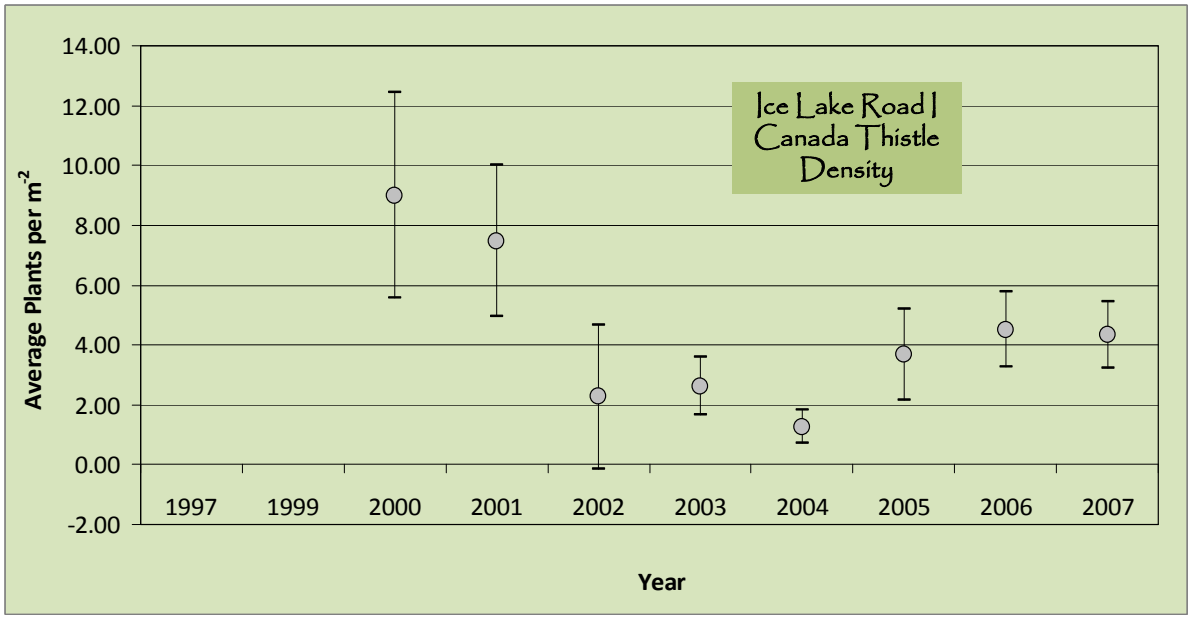
[1] New insect recovery in 2007
[2] Adventitious recovery, no release made at this site
[3] No insect releases were made at this site, however, the following biological control agents have been recovered from seedheads and roots collected within the mapped weed perimeter since 2005: *L. minutus, U. affinis, C. achates, M. paucipunctella, S. jugoslavica*

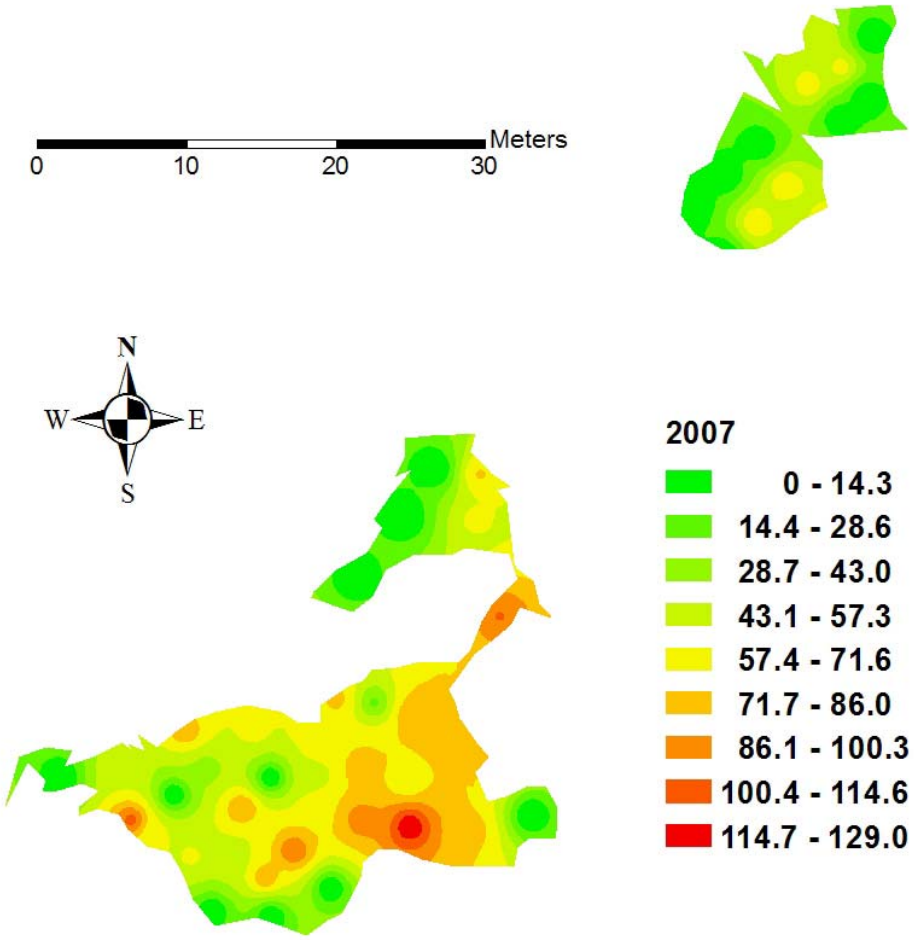


Ice Lake Road I Canada thistle perimeter in 2007.

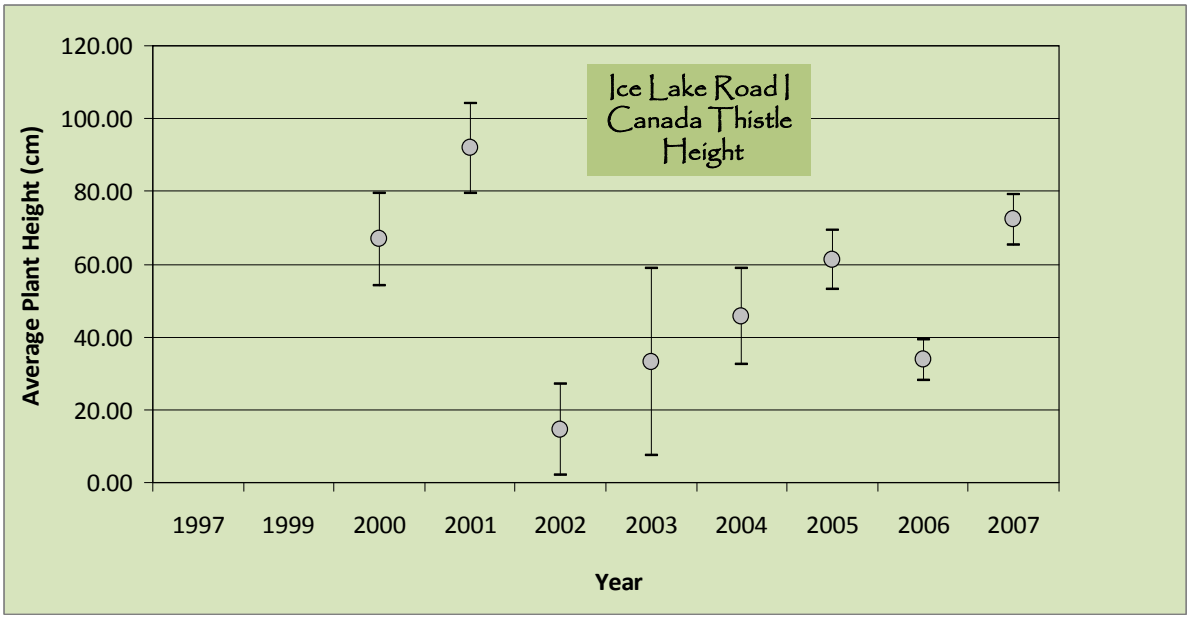


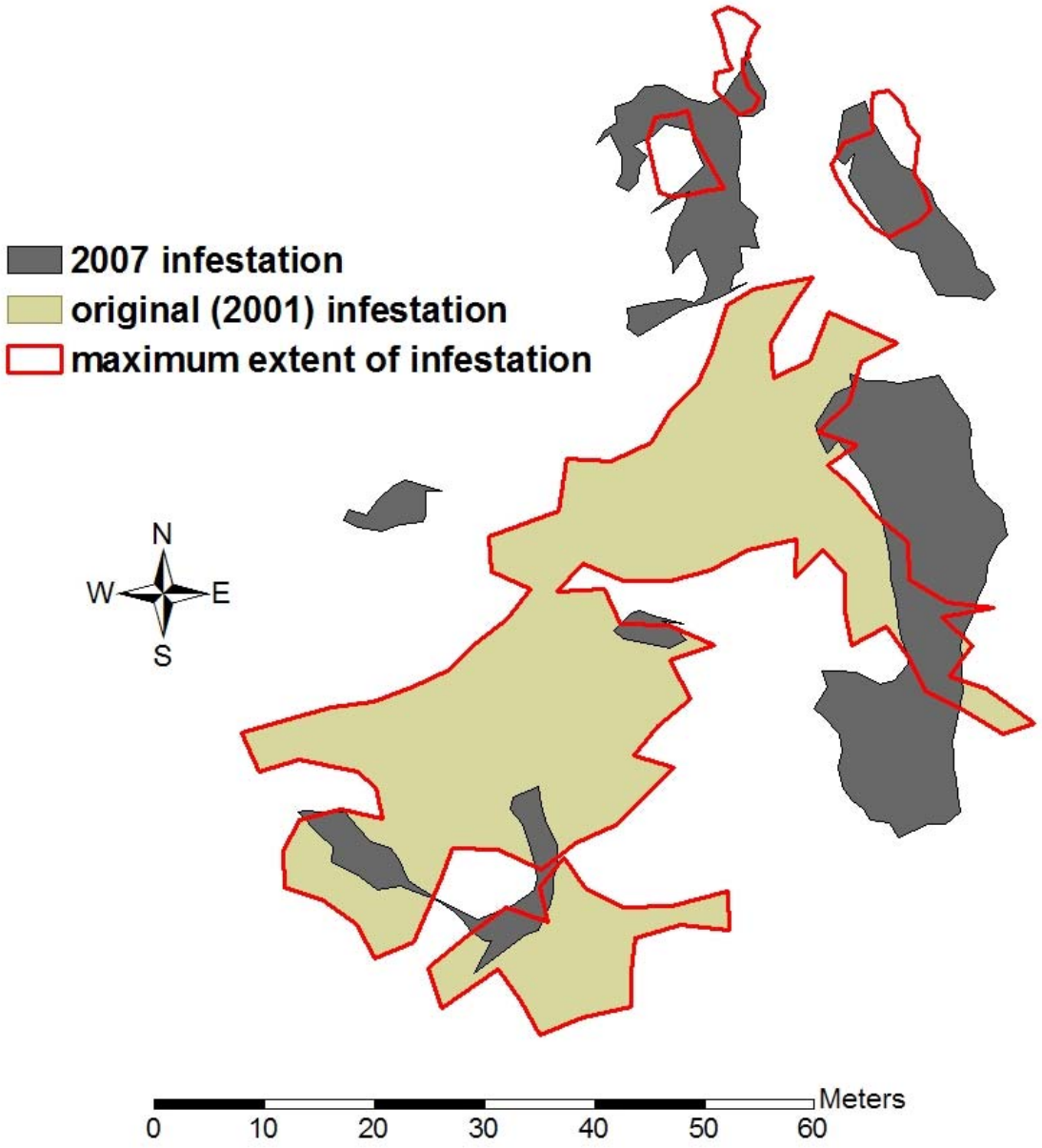
Ice Lake Road I Canada thistle density in 2007.



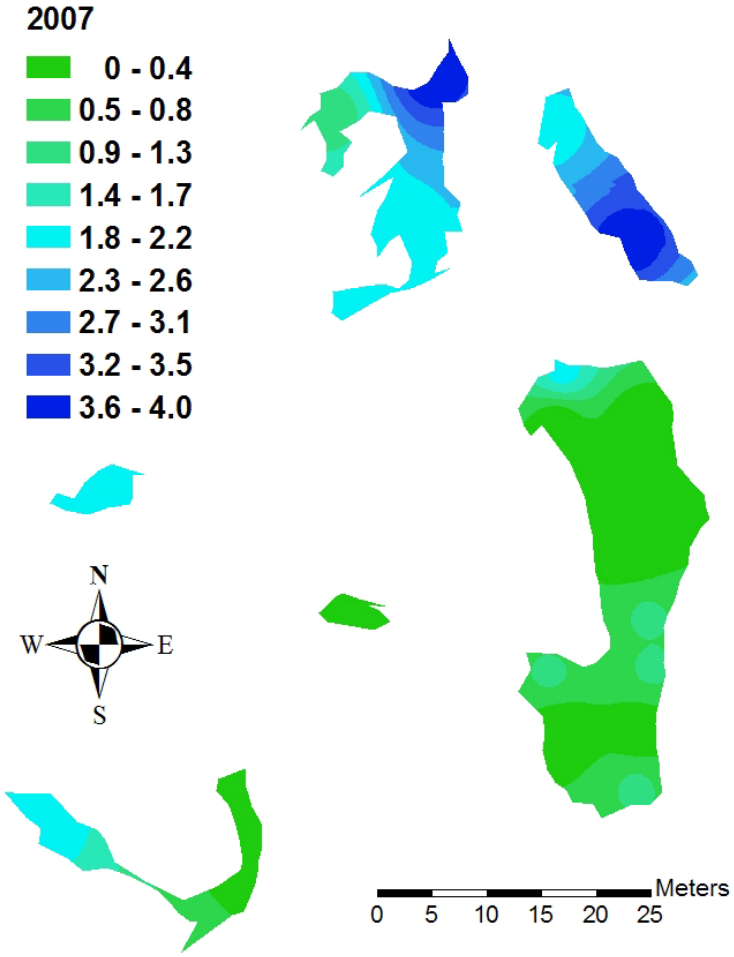


Ice Lake Road I Canada thistle height in 2007.

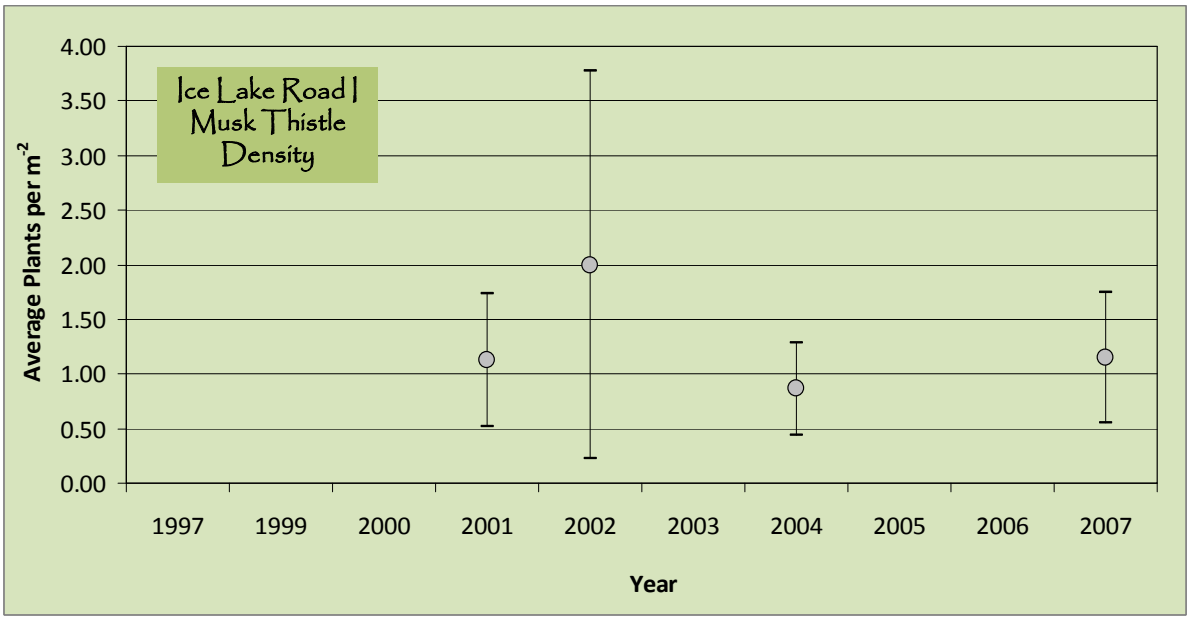


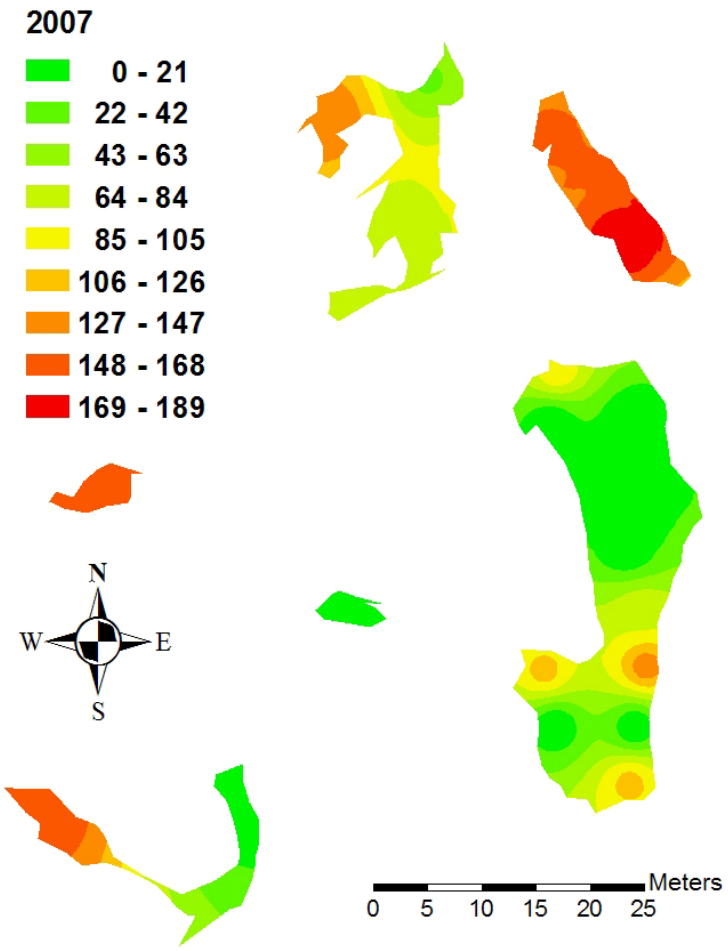


Ice Lake Road I musk thistle perimeter in 2007.



Ice Lake Road I musk thistle density in 2007.





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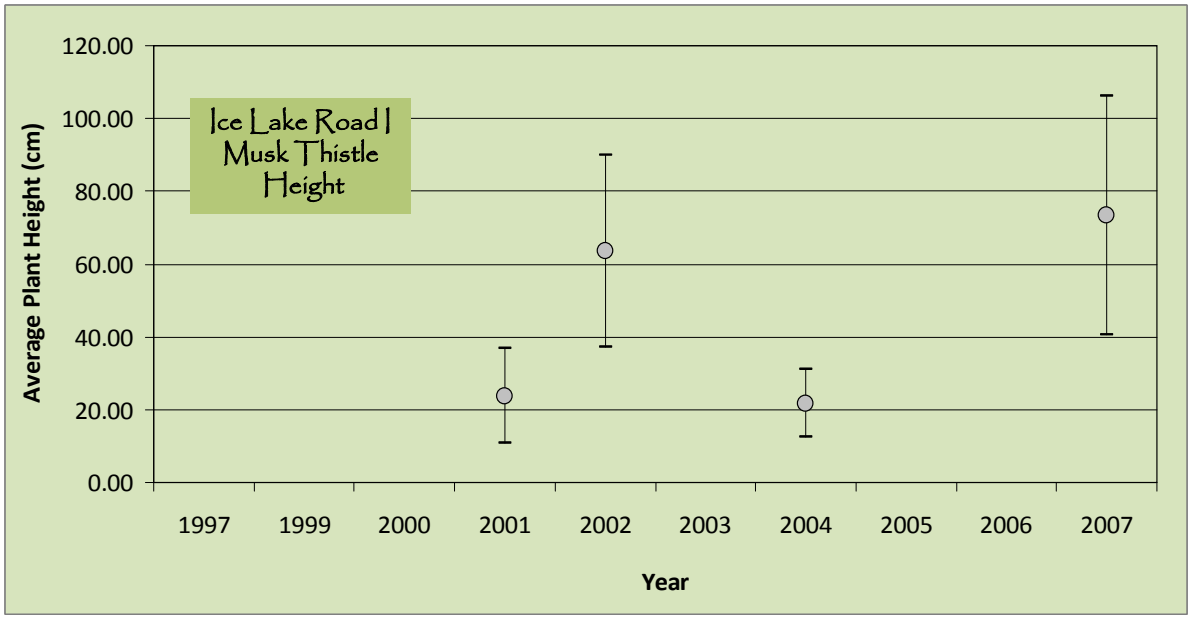
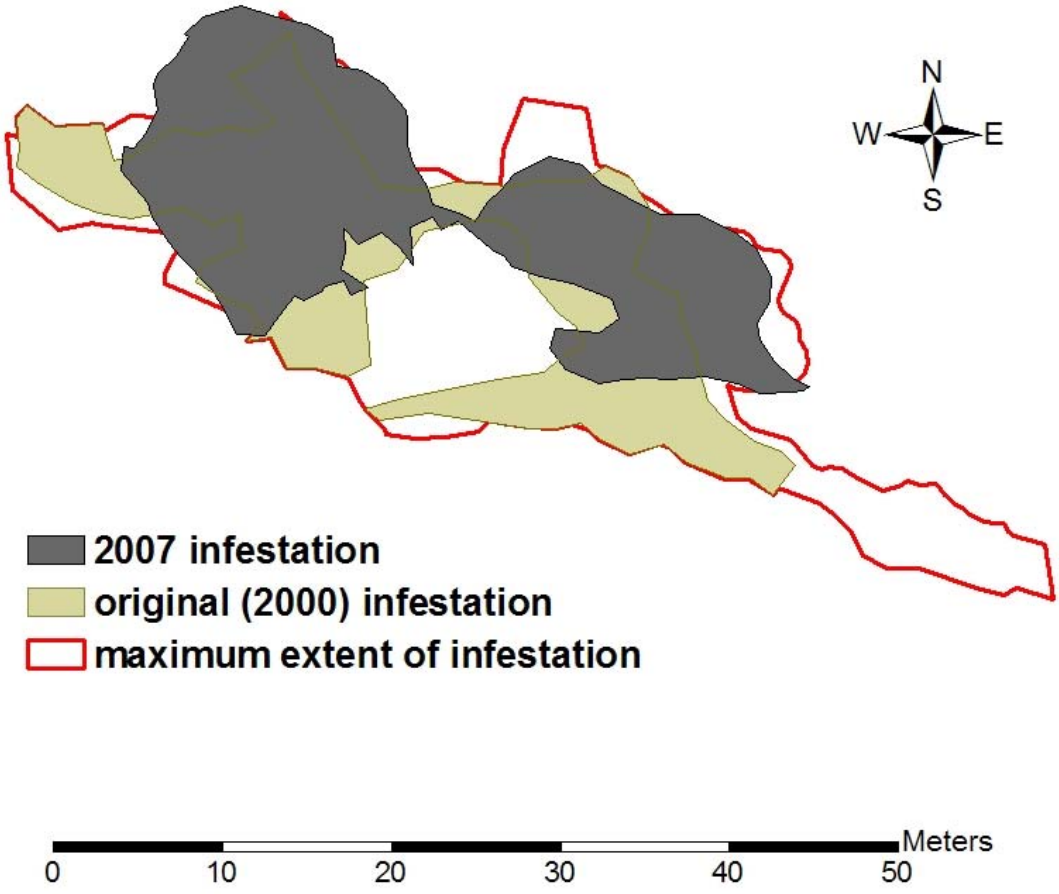
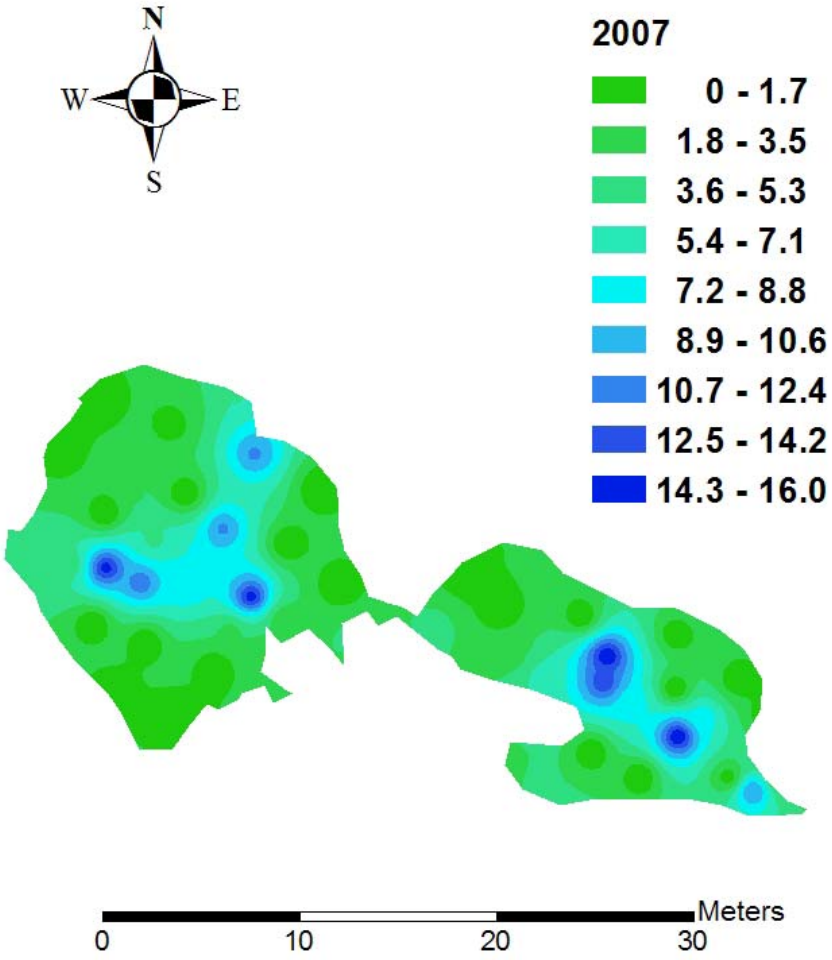
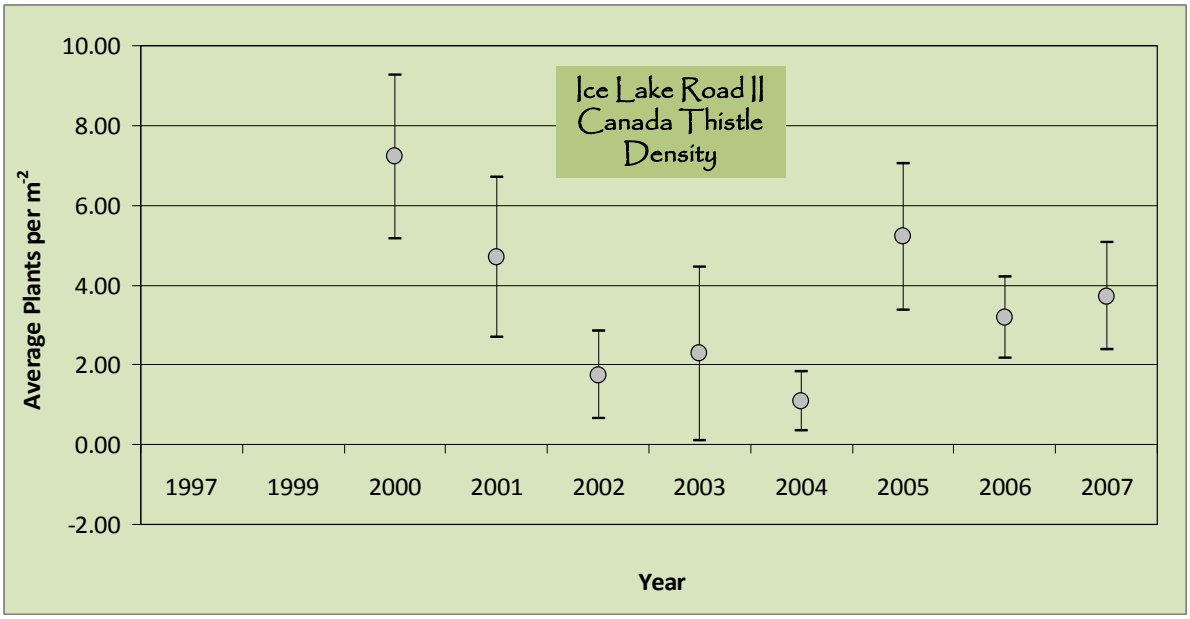


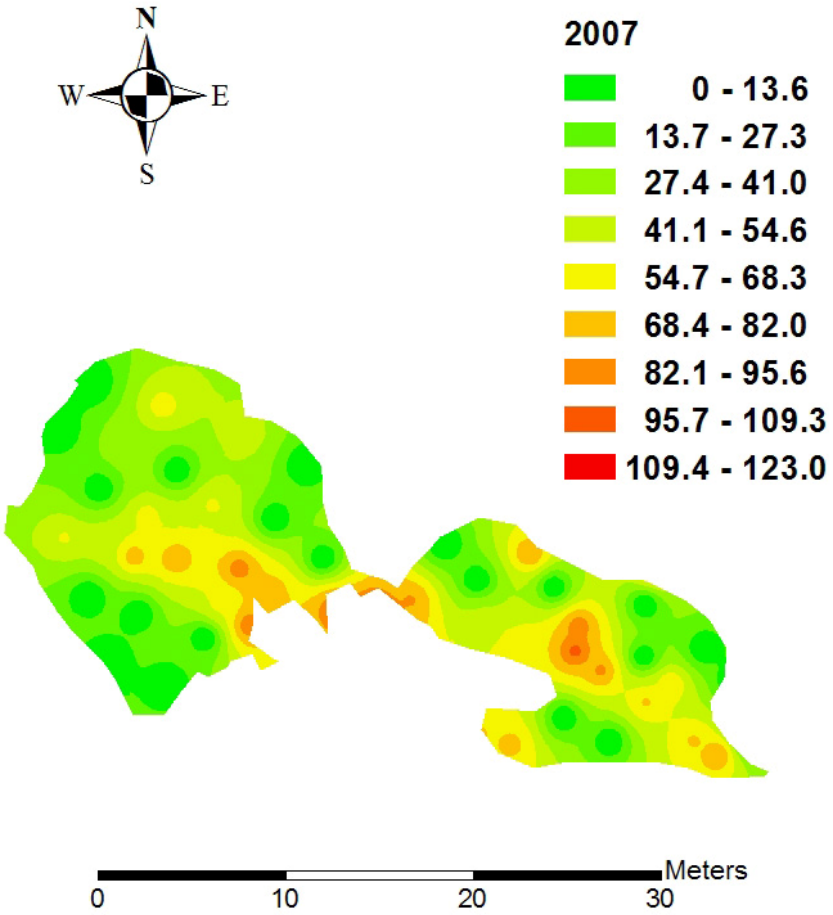


Ice Lake Road II Canada thistle perimeter in 2007.

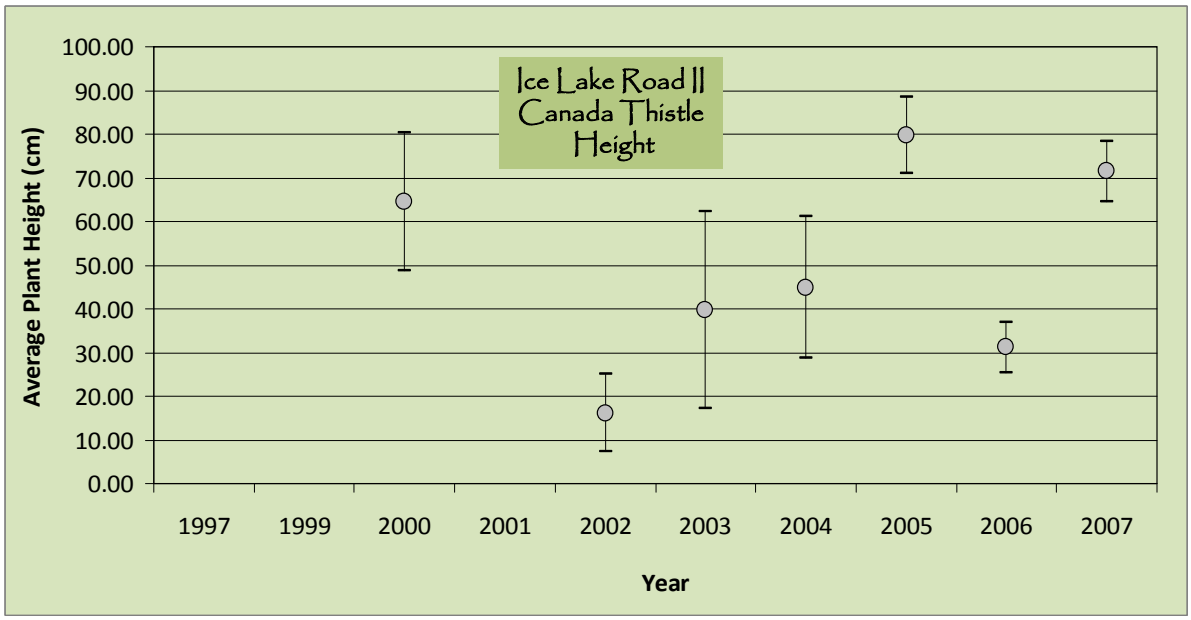


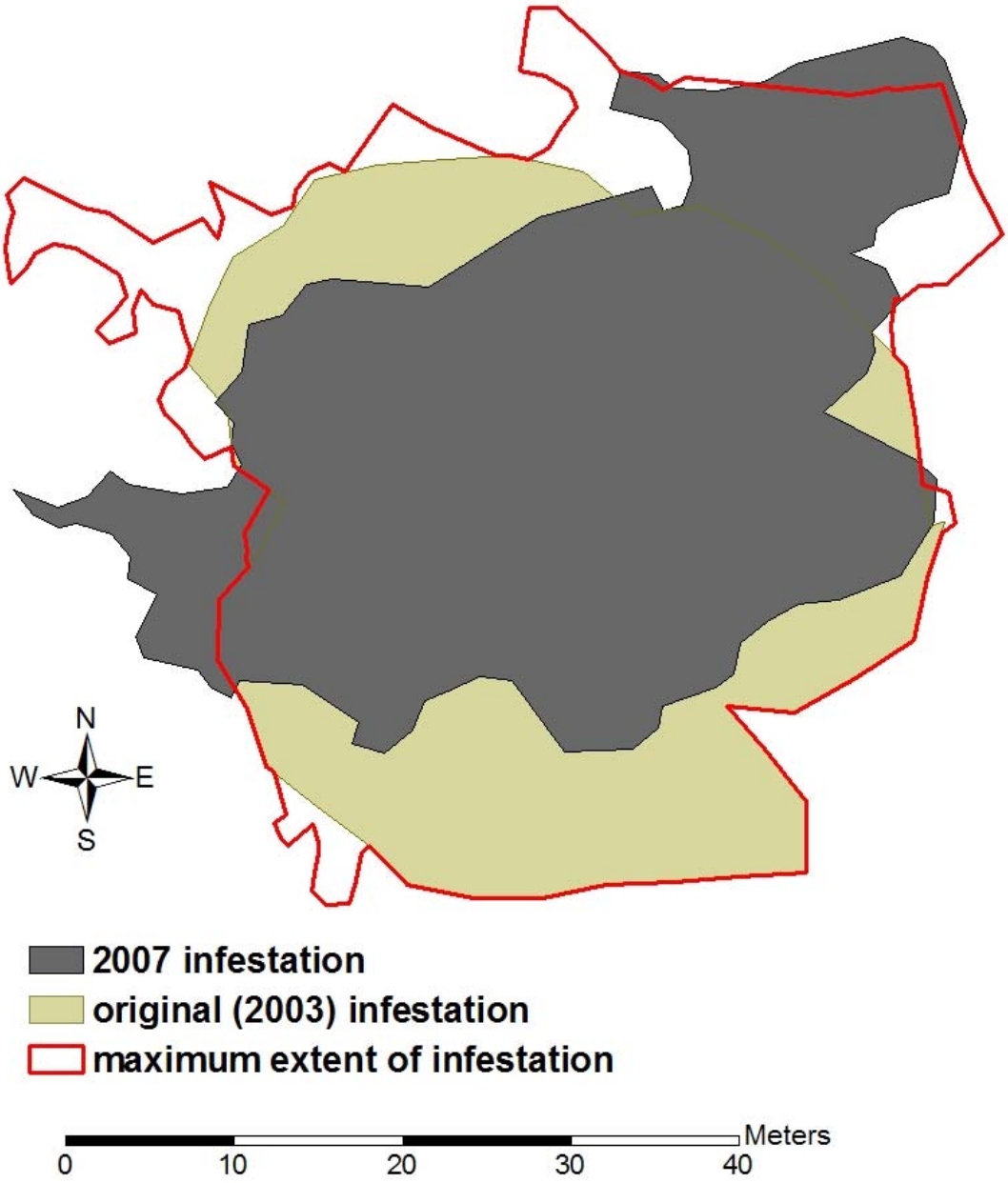
Ice Lake Road II Canada thistle density in 2007.



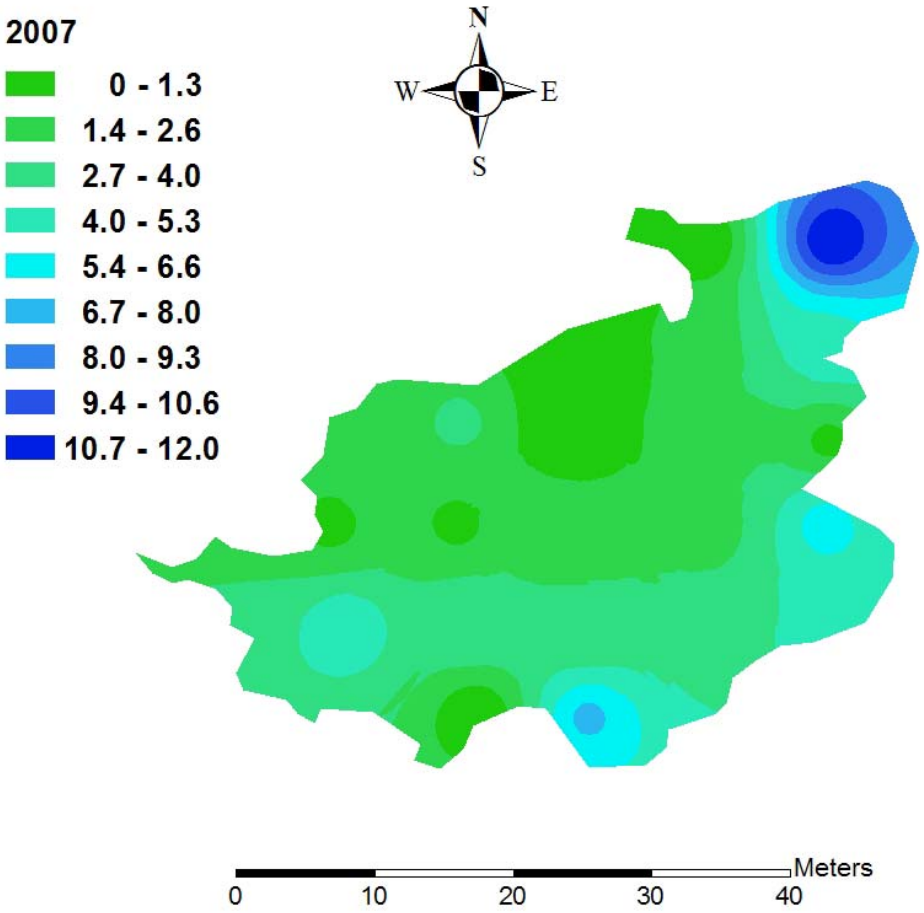


Ice Lake Road II Canada thistle height in 2007.

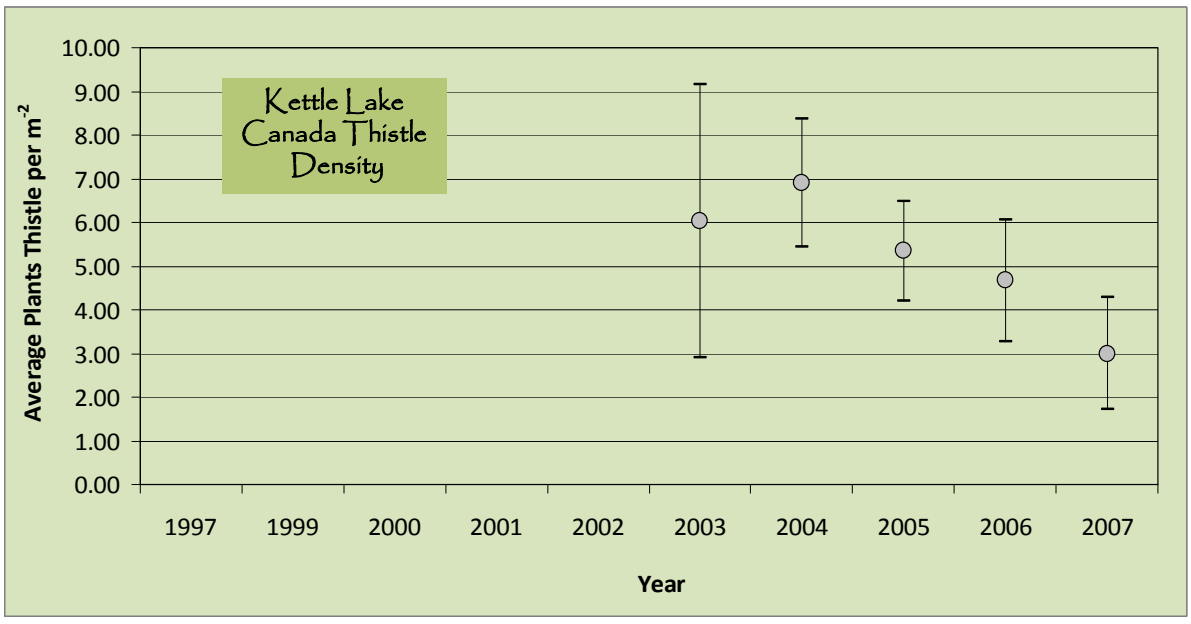


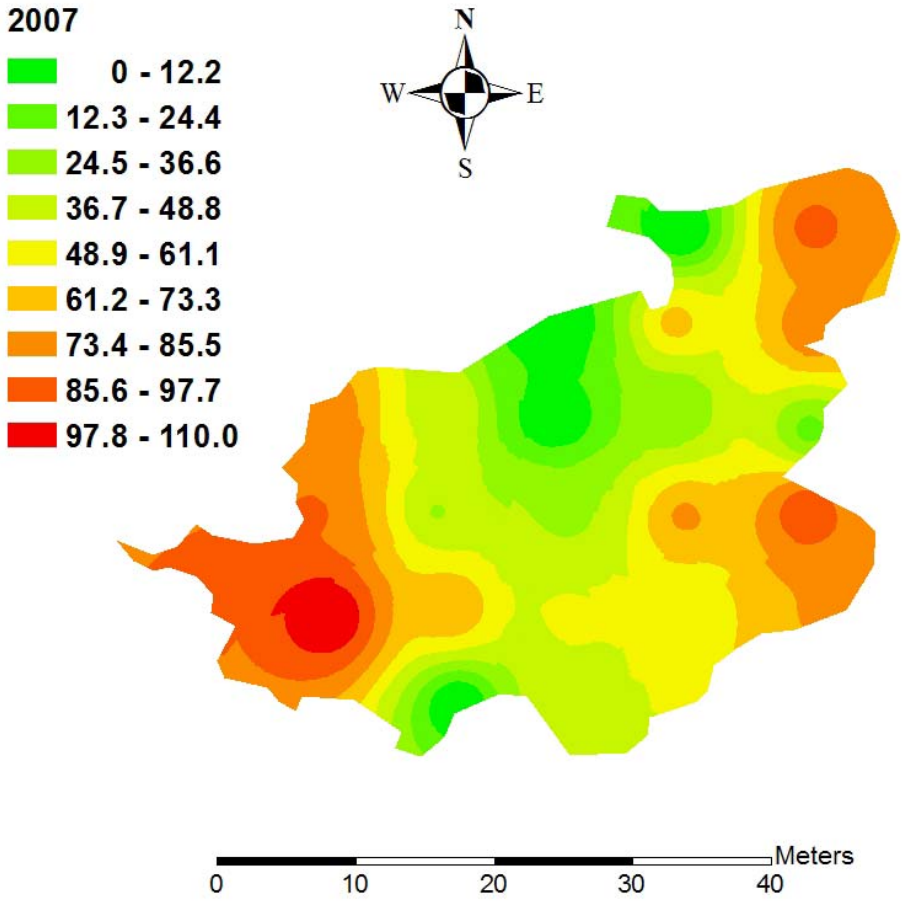


Kettle Lake Canada thistle perimeter in 2007.

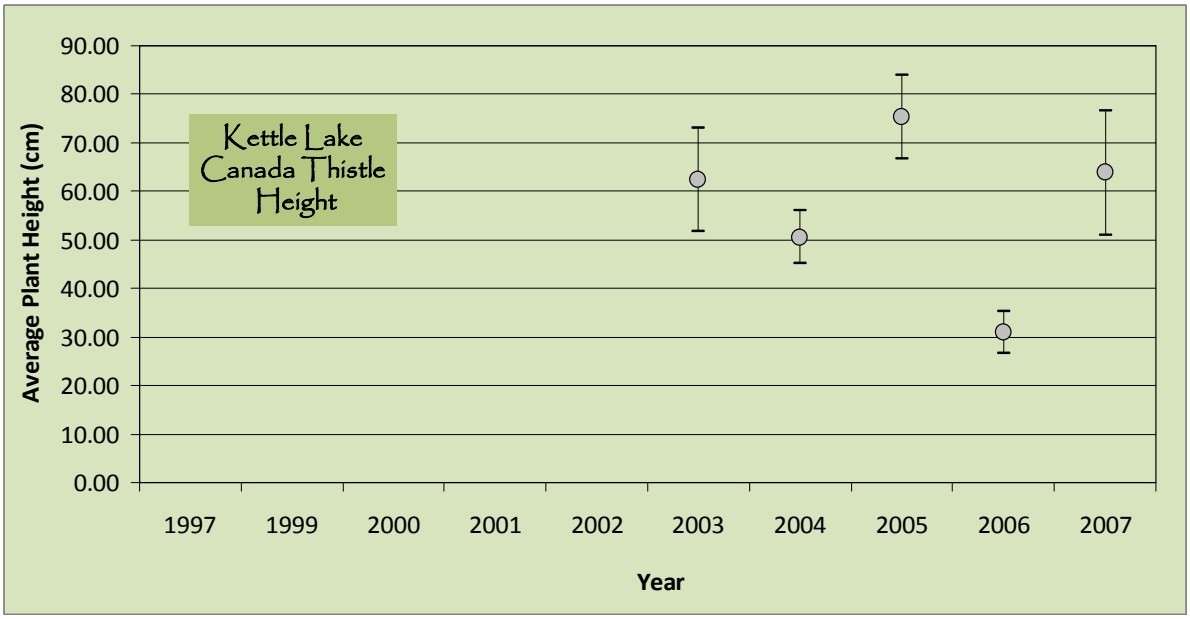


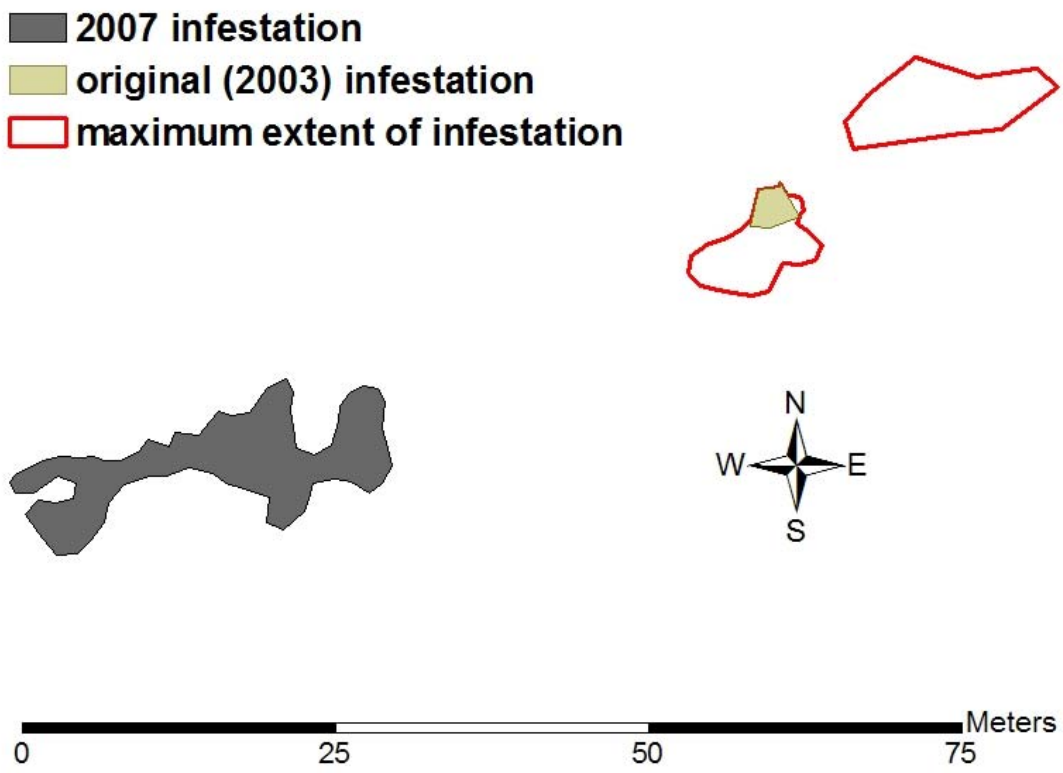
Kettle Lake Canada thistle density in 2007.



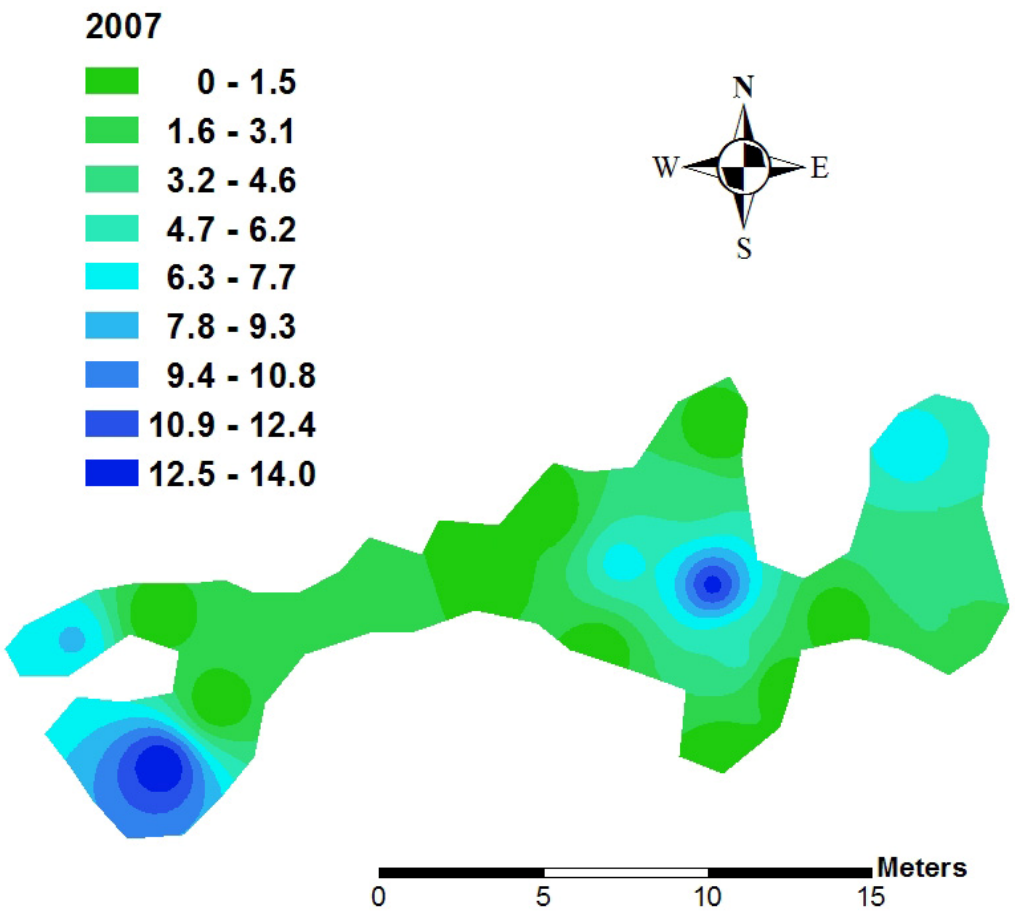


Kettle Lake Canada thistle height in 2007.

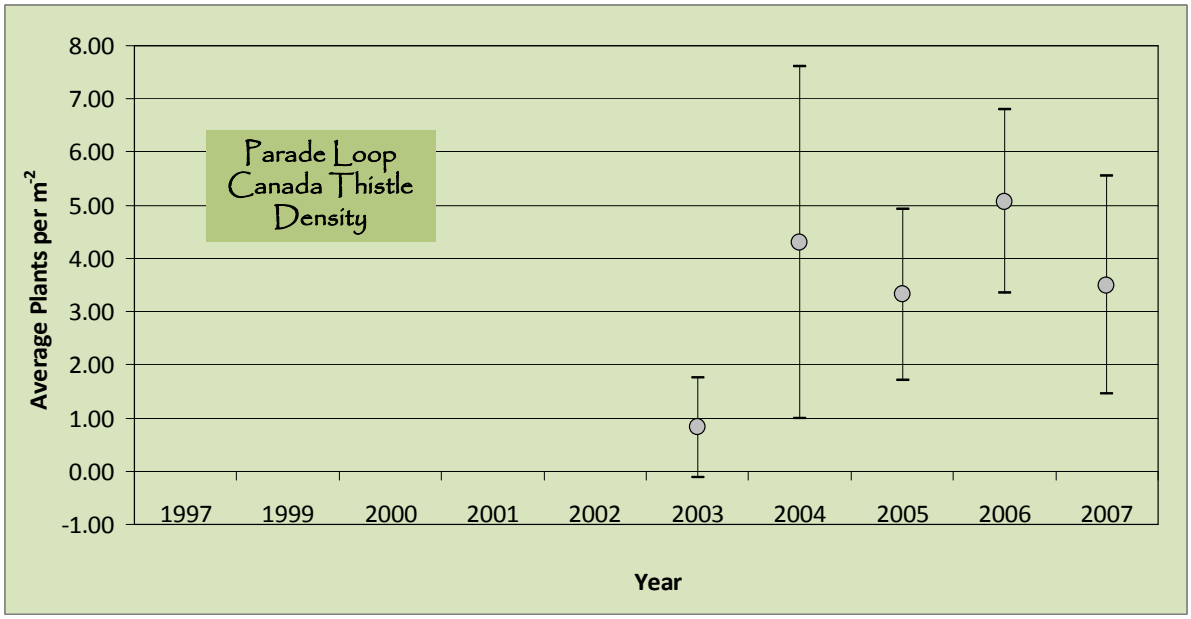


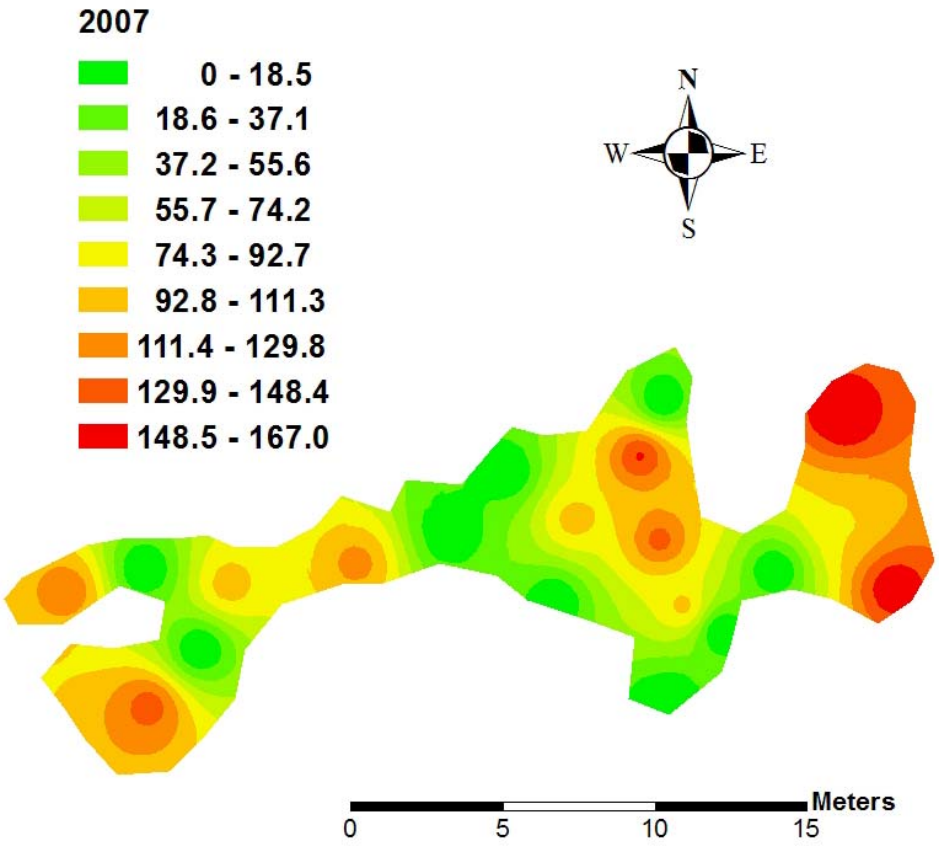


Parade Loop Canada thistle perimeter in 2007.

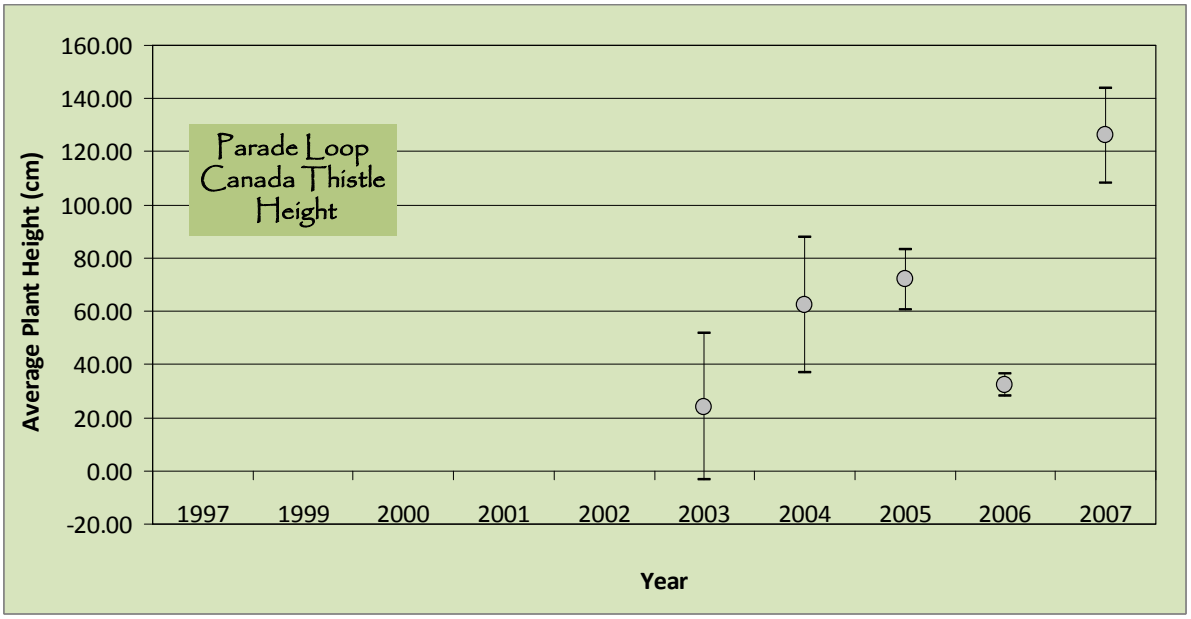


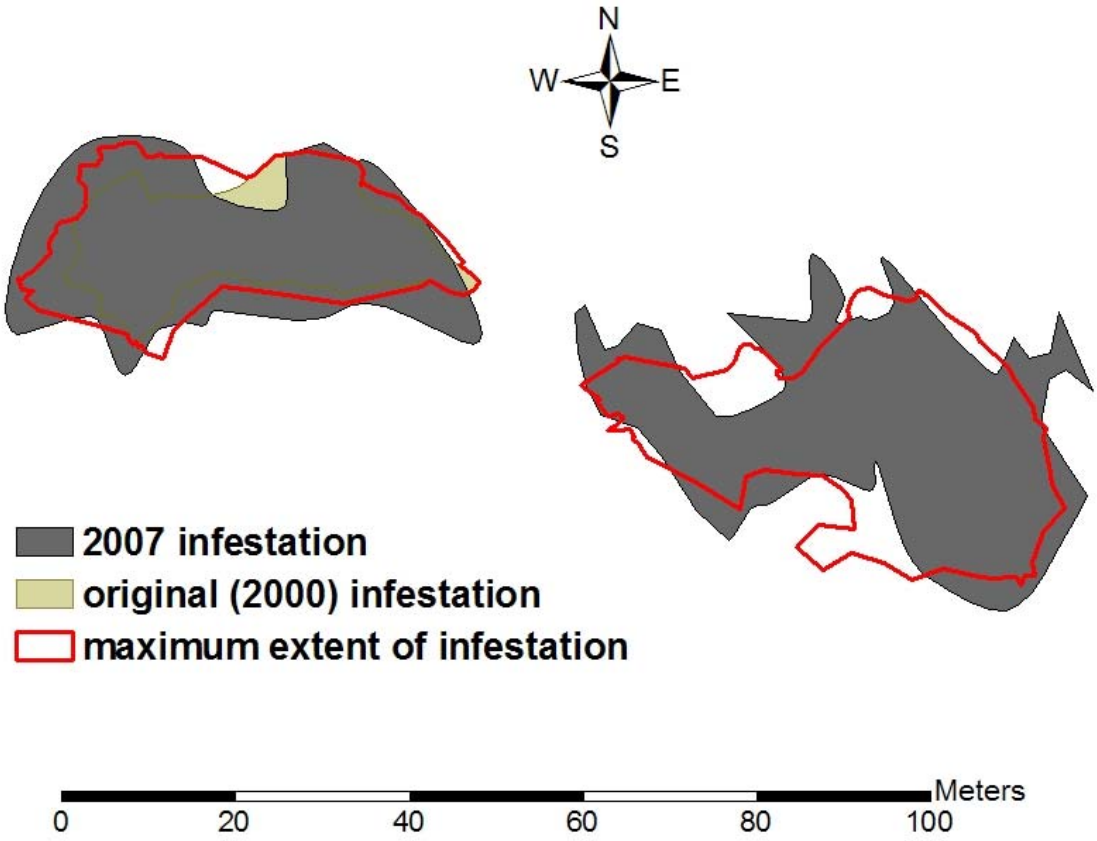
Parade Loop Canada thistle density in 2007.



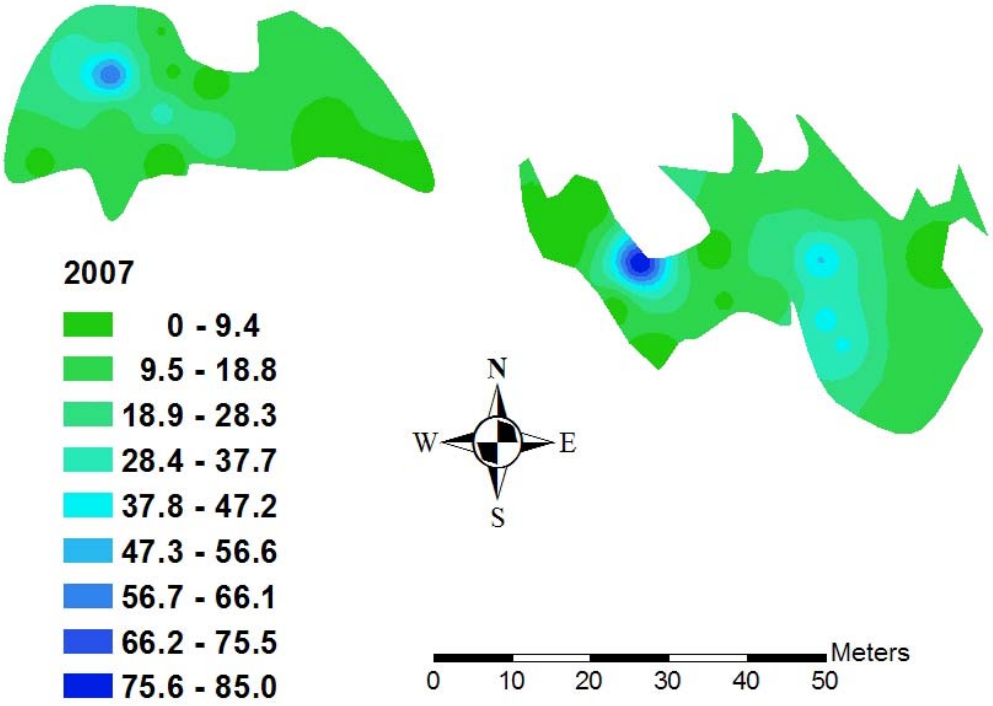


Parade Loop Canada thistle height in 2007.

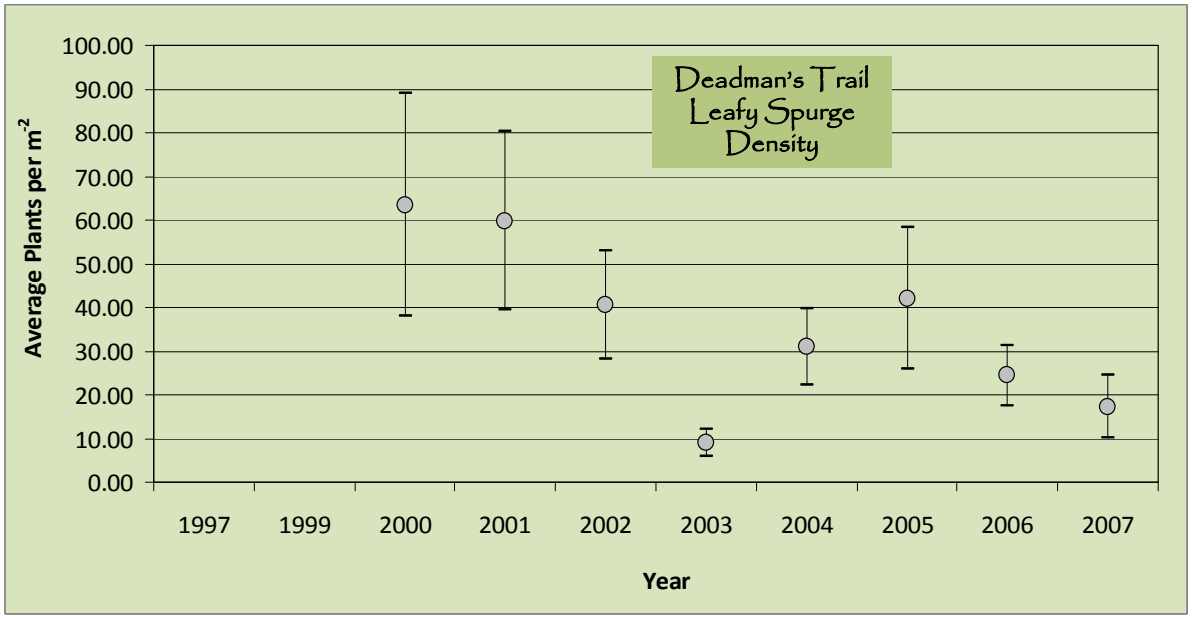


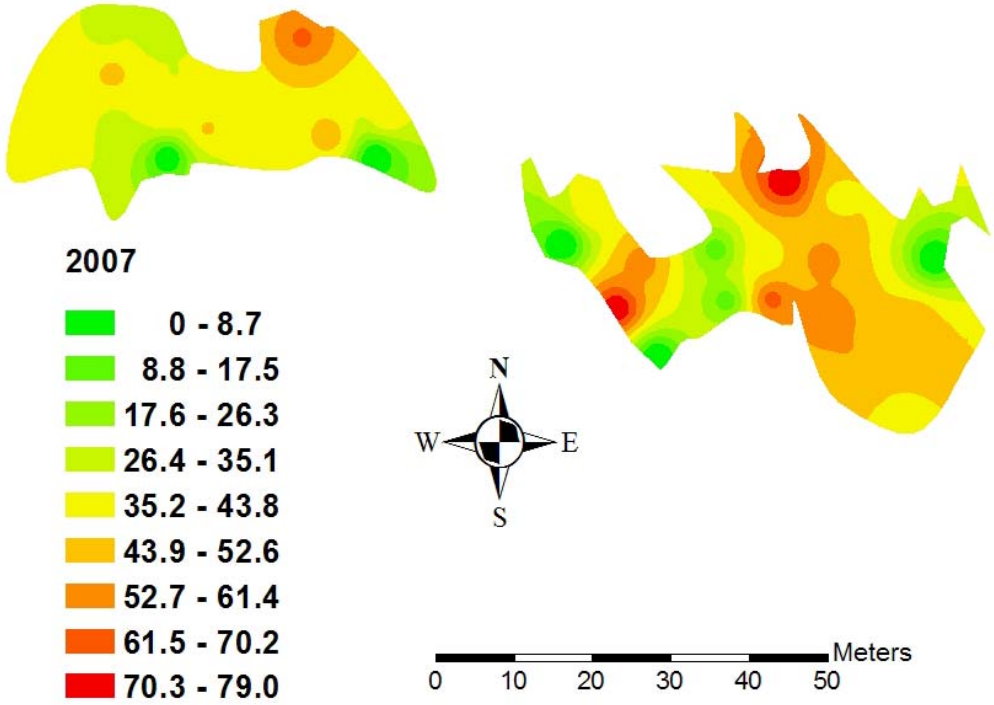


Deadman's Trail leafy spurge perimeter in 2007.

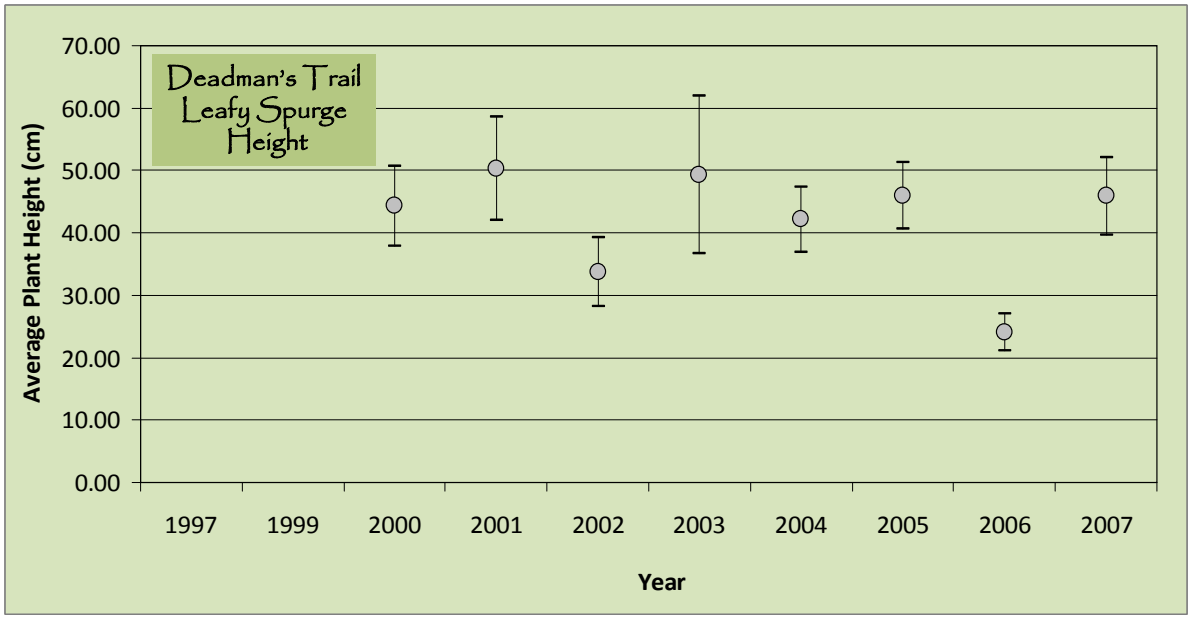


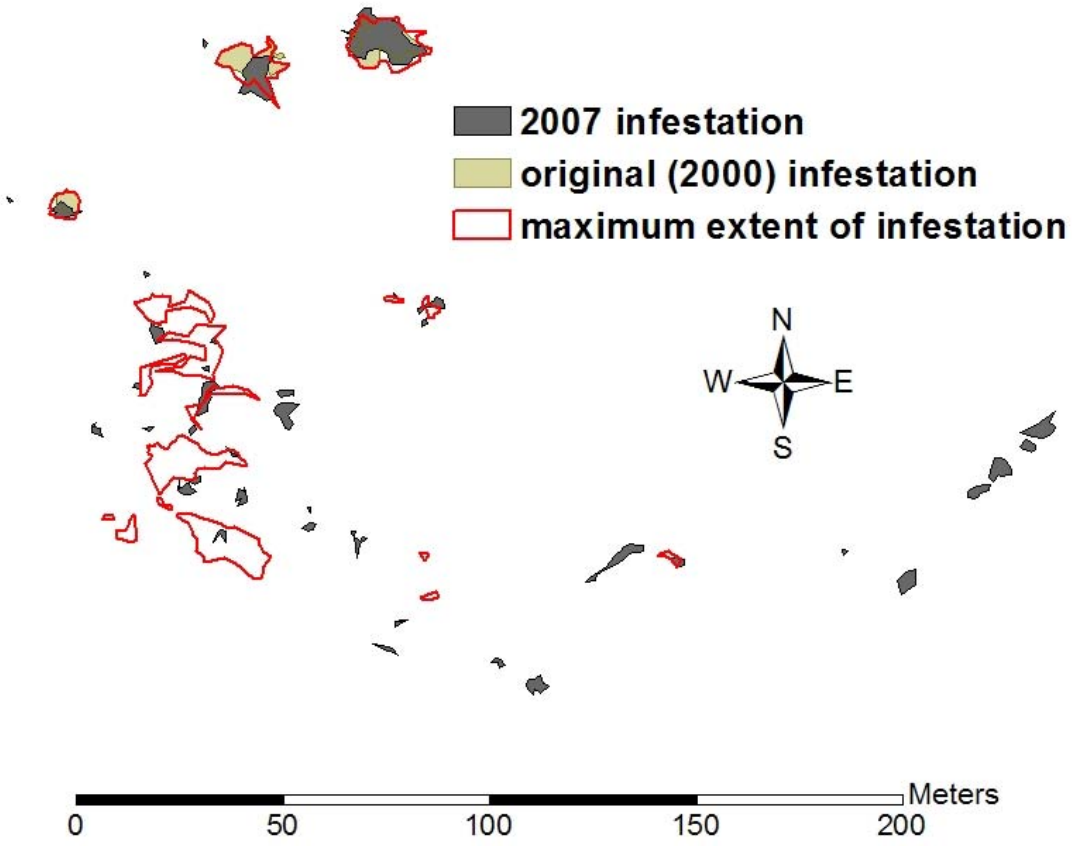
Deadman's Trail leafy spurge density in 2007.



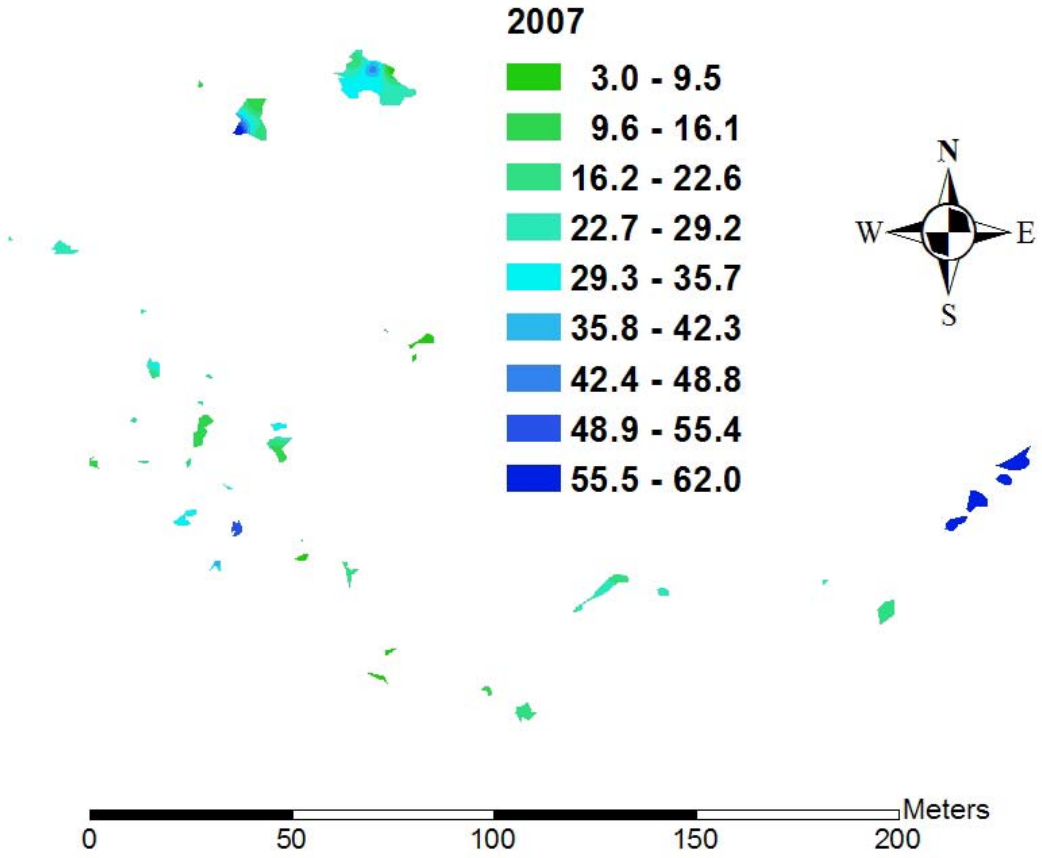


Deadman's Trail leafy spurge height in 2007.

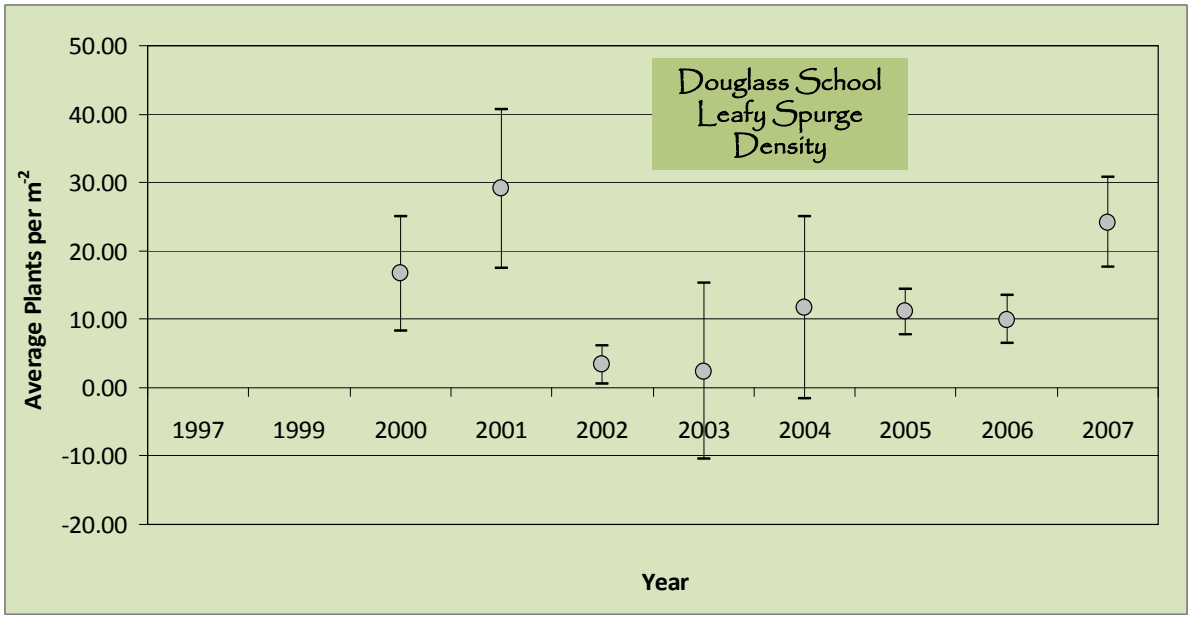


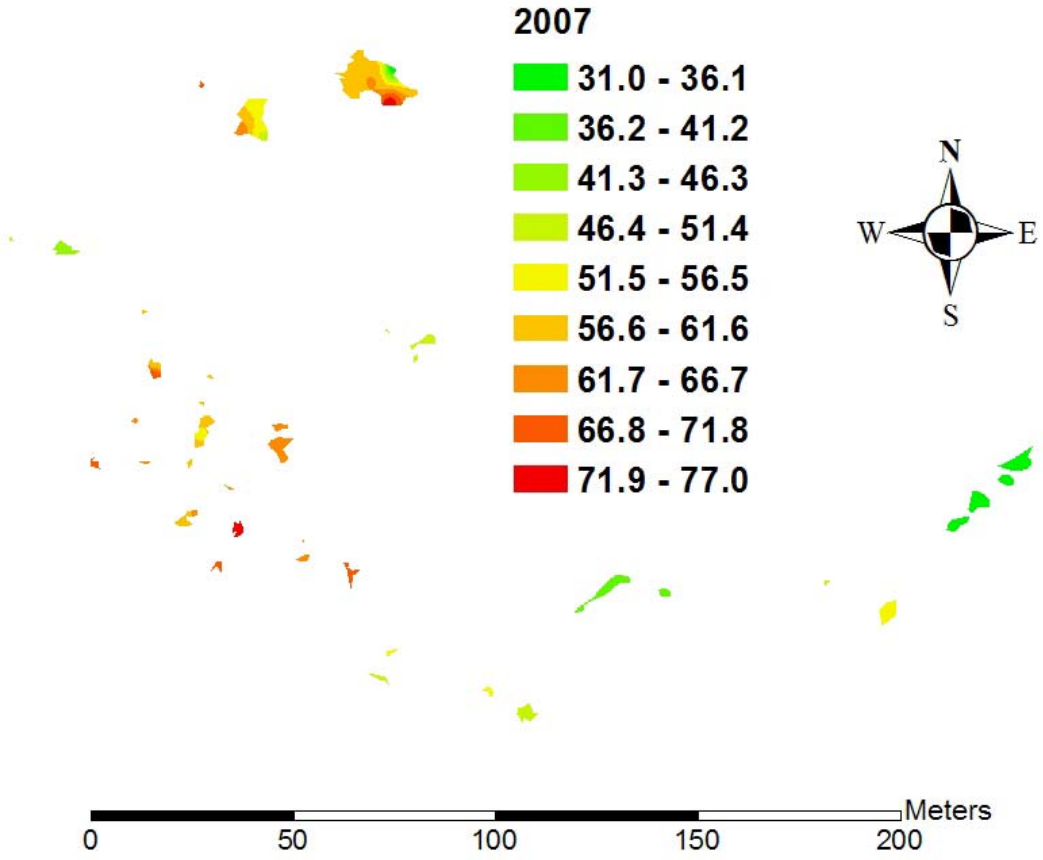


Douglass School leafy spurge perimeter in 2007.

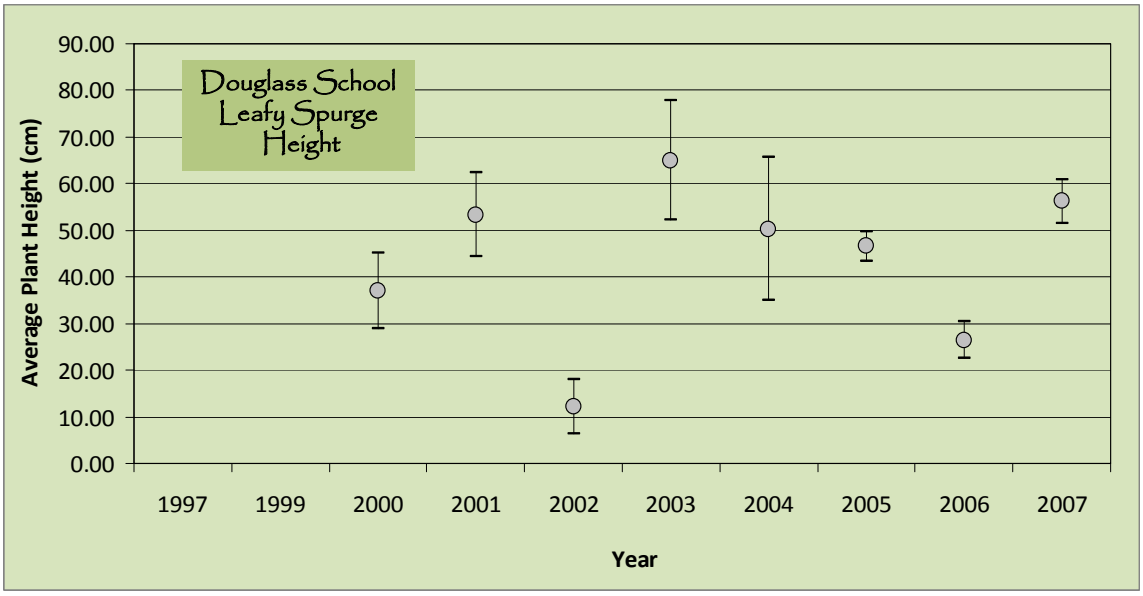


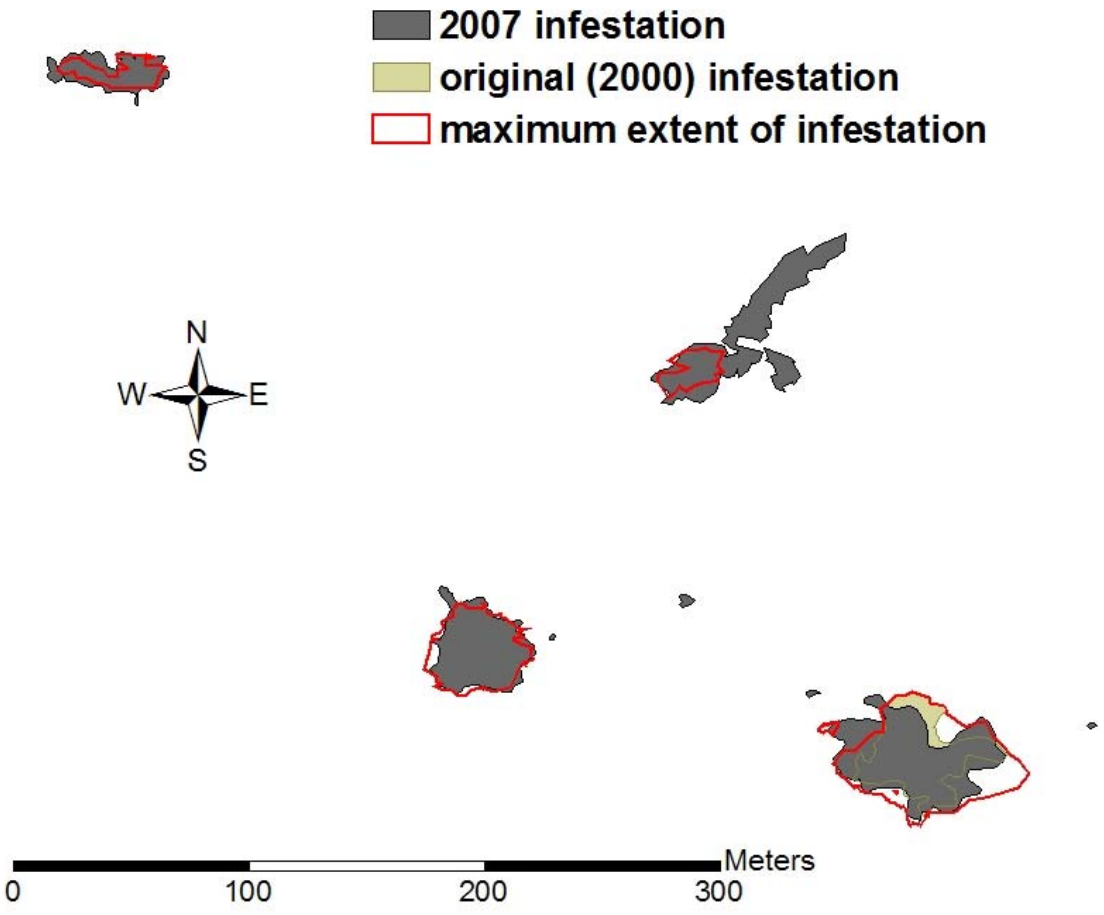
Douglass School leafy spurge density in 2007.



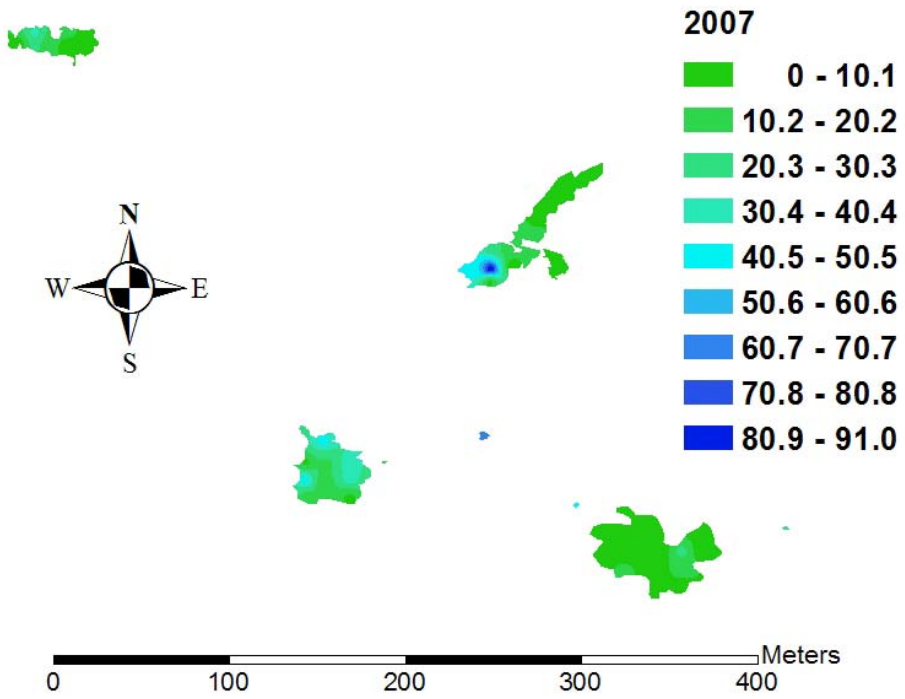


Douglass School leafy spurge height in 2007.

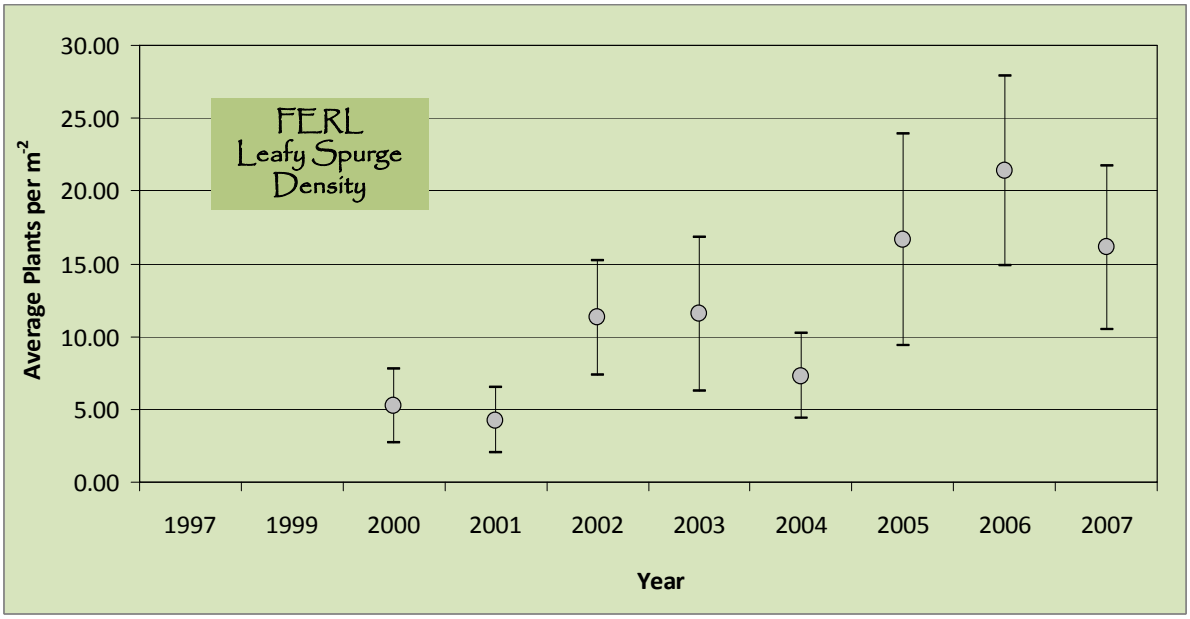


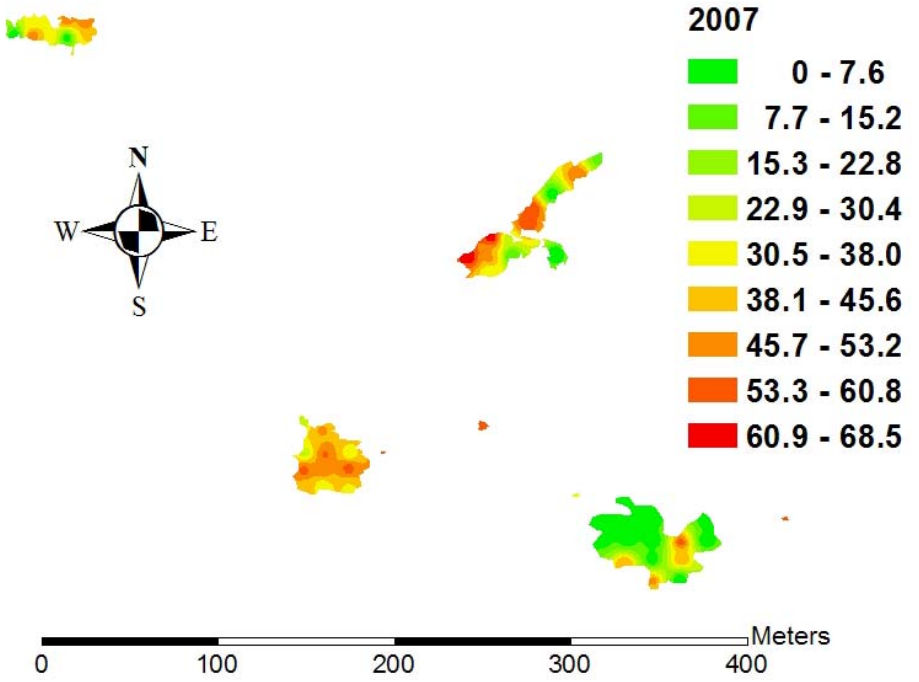


FERL leafy spurge perimeter in 2007.

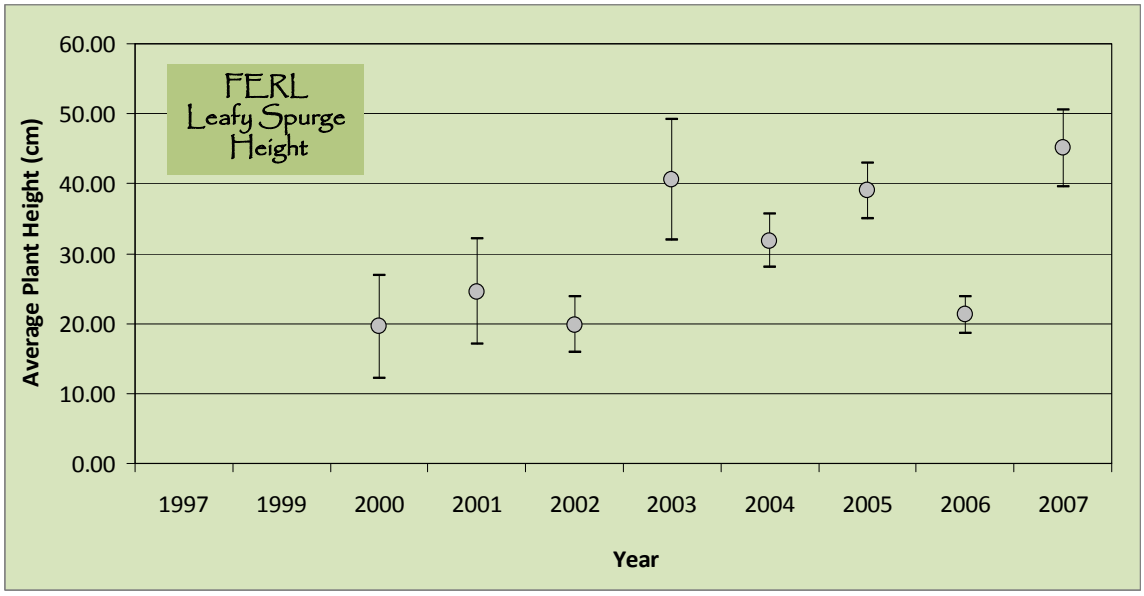


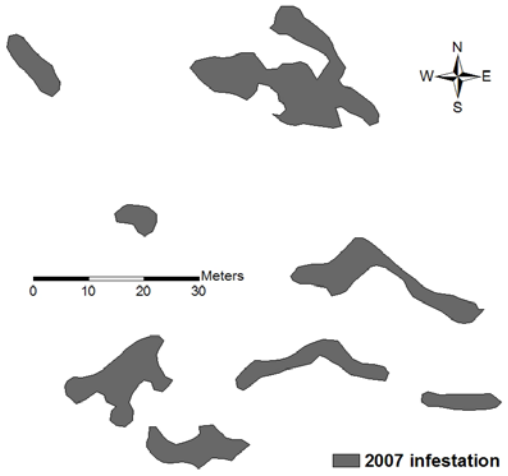
FERL leafy spurge density in 2007.



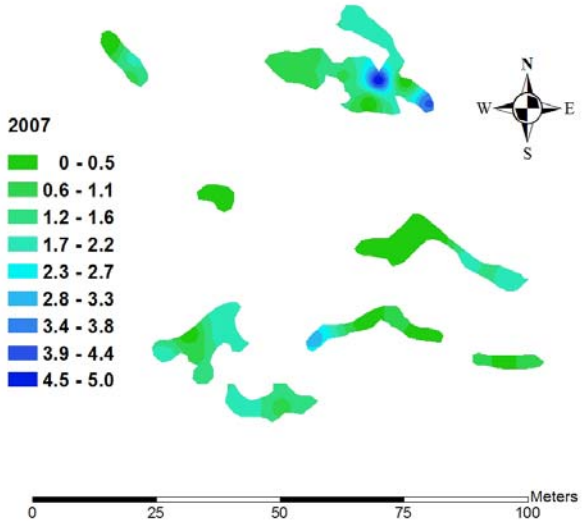


FERL leafy spurge height in 2007.

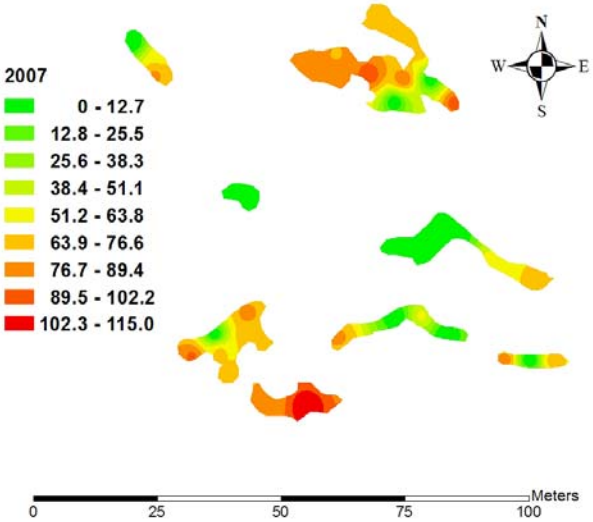




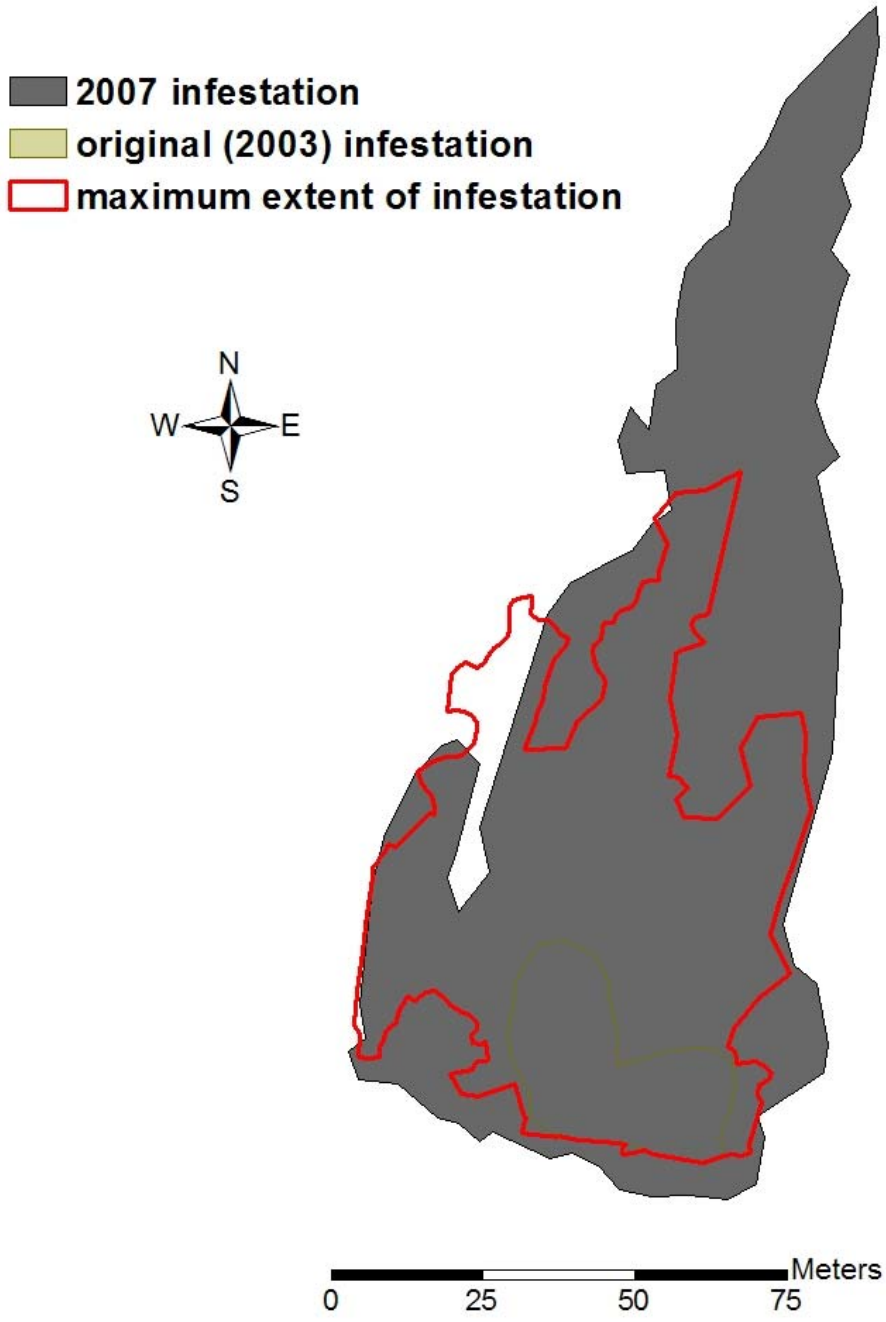
Bike Trail diffuse knapweed perimeter in 2007.



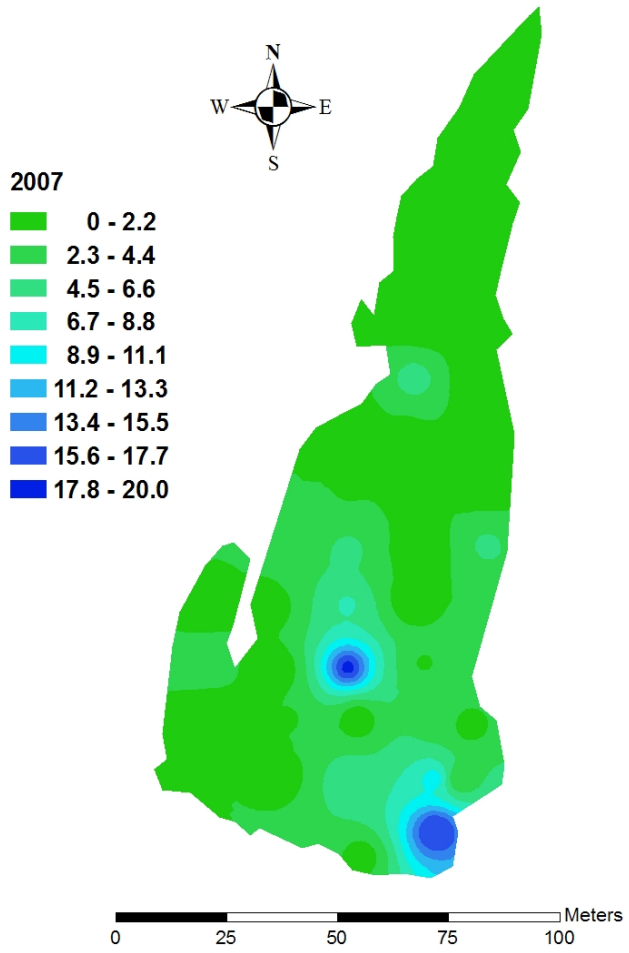
Bike Trail diffuse knapweed density in 2007.



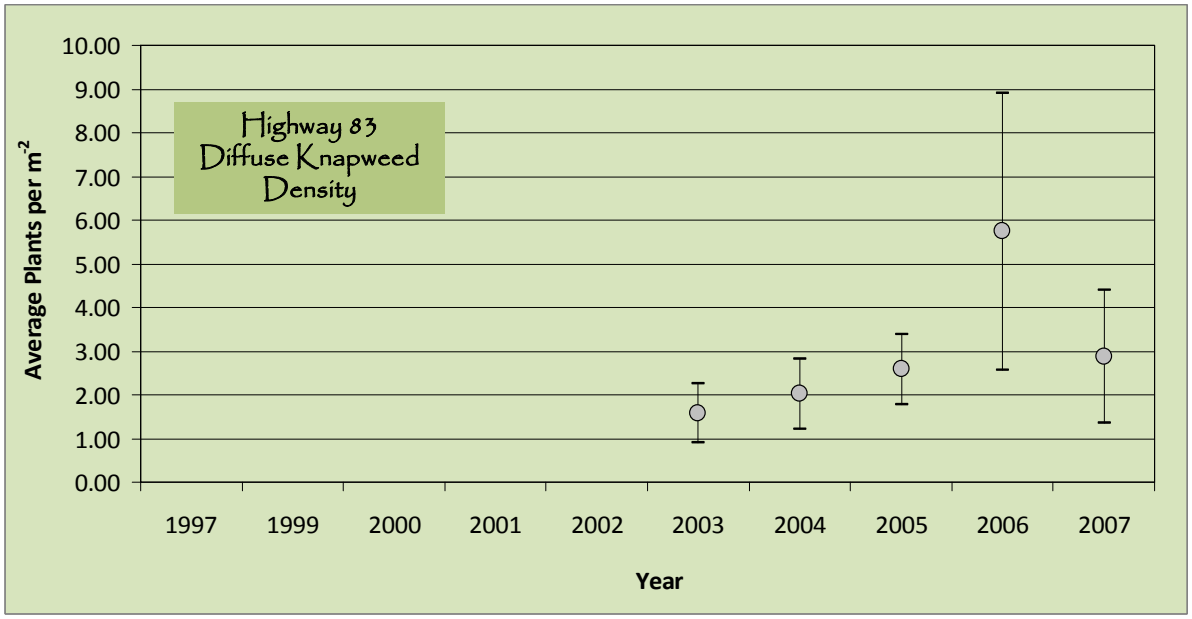
Bike Trail diffuse knapweed height in 2007.

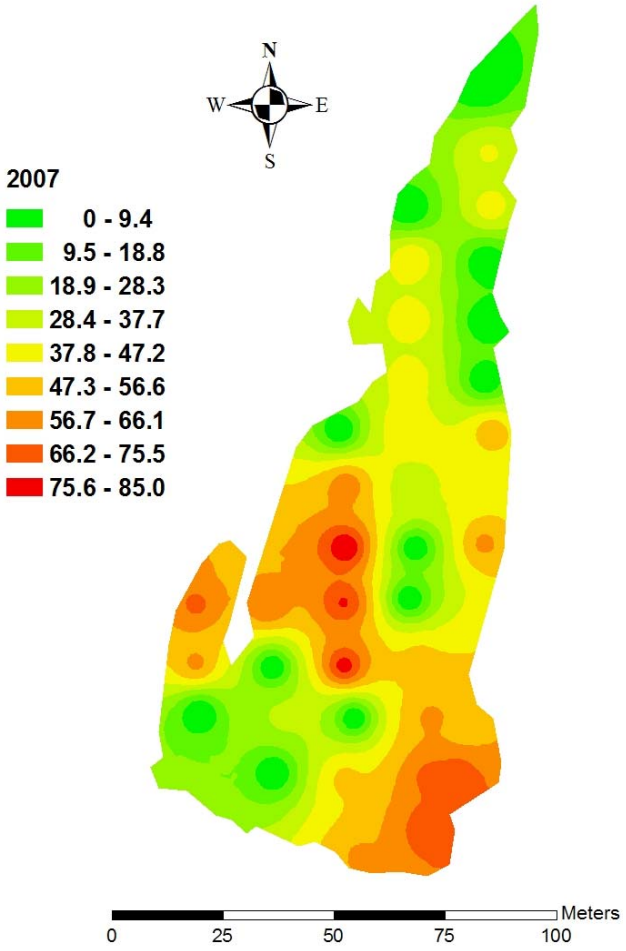


Highway 83 diffuse knapweed perimeter in 2007.

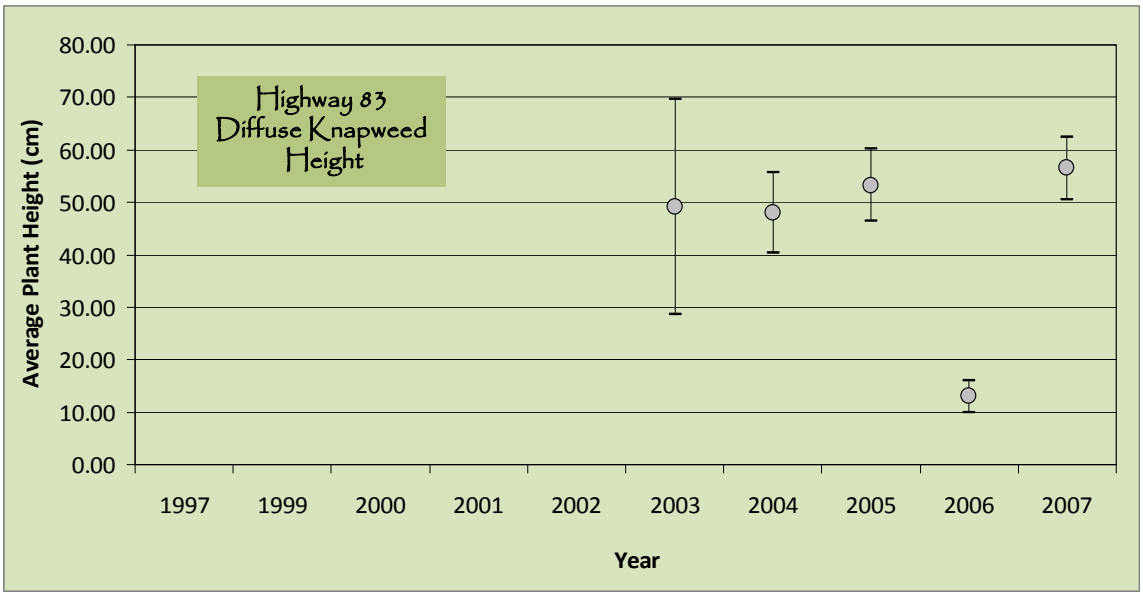


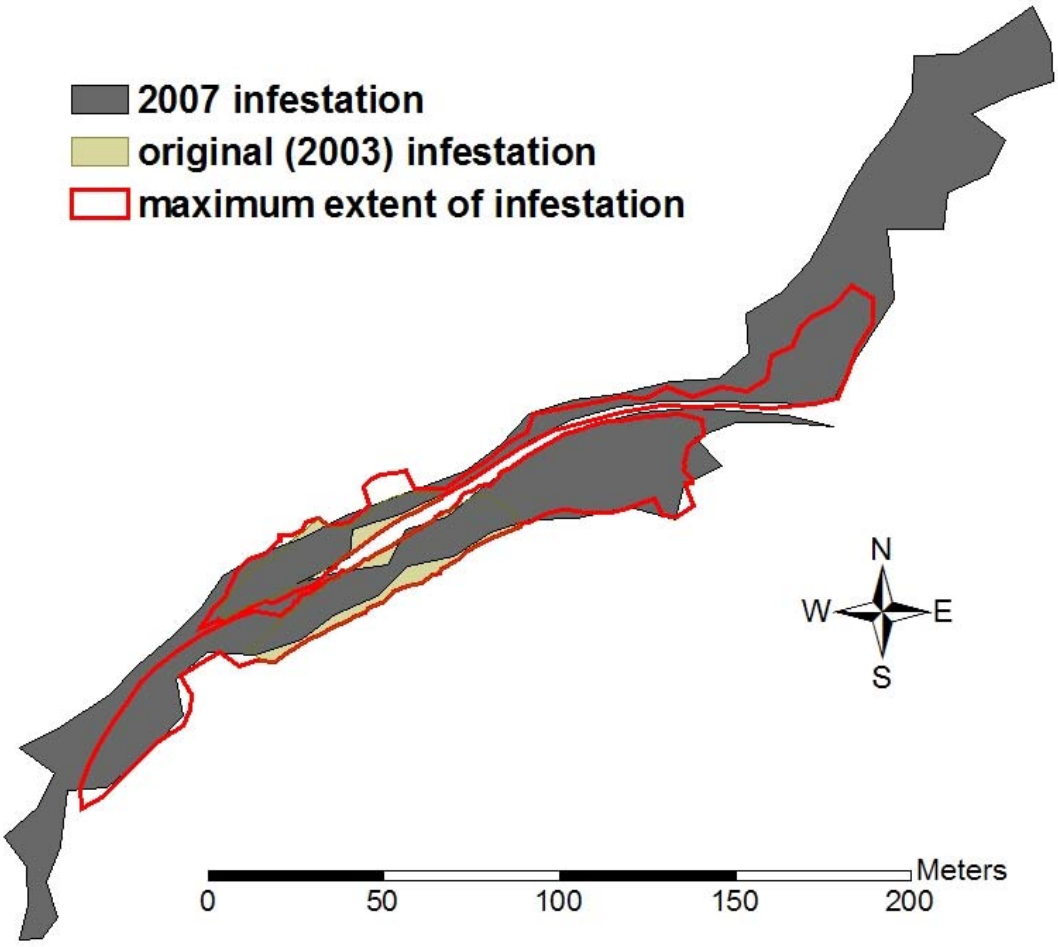
Highway 83 diffuse knapweed density in 2007.



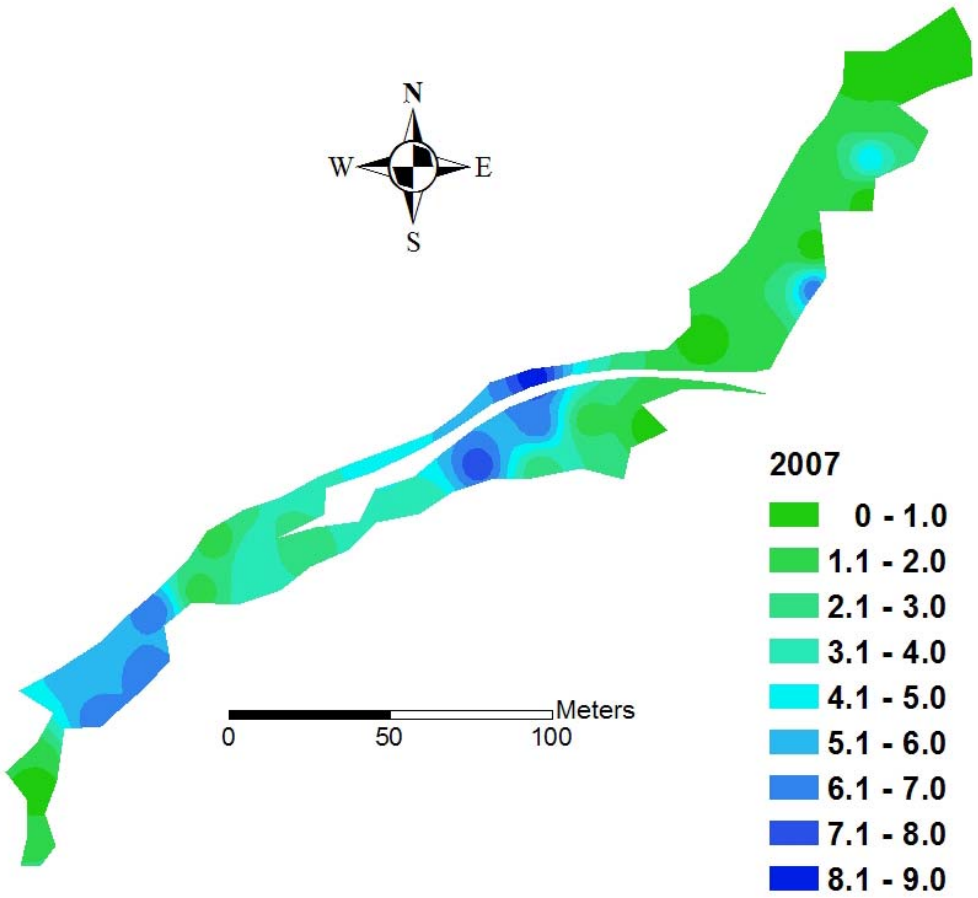


Highway 83 diffuse knapweed height in 2007.

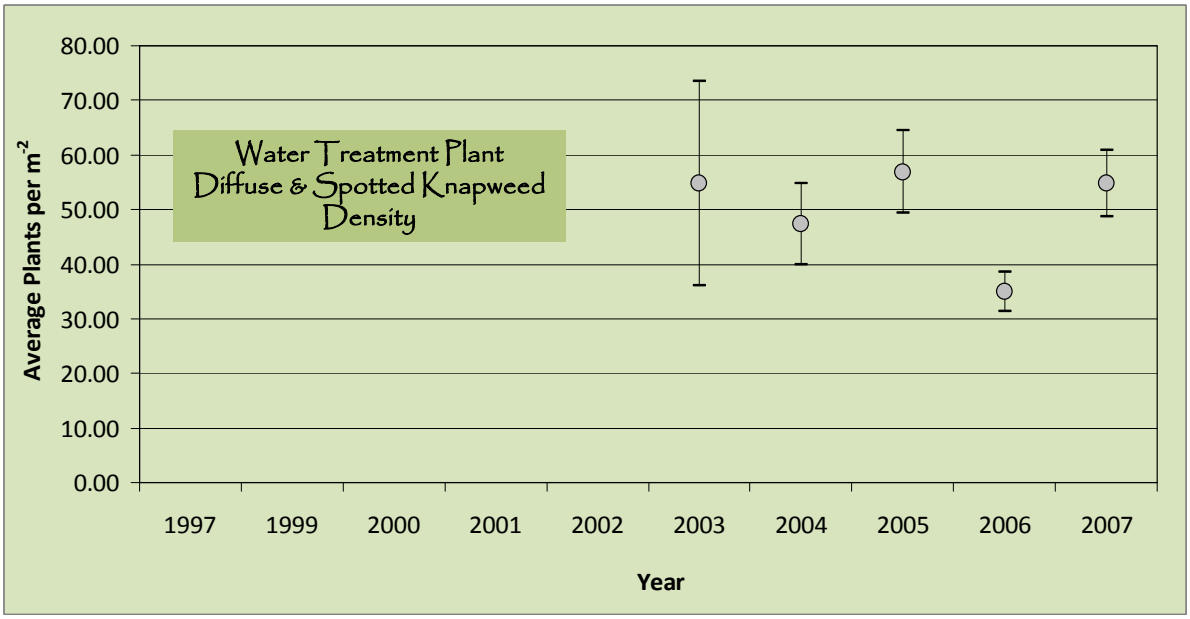


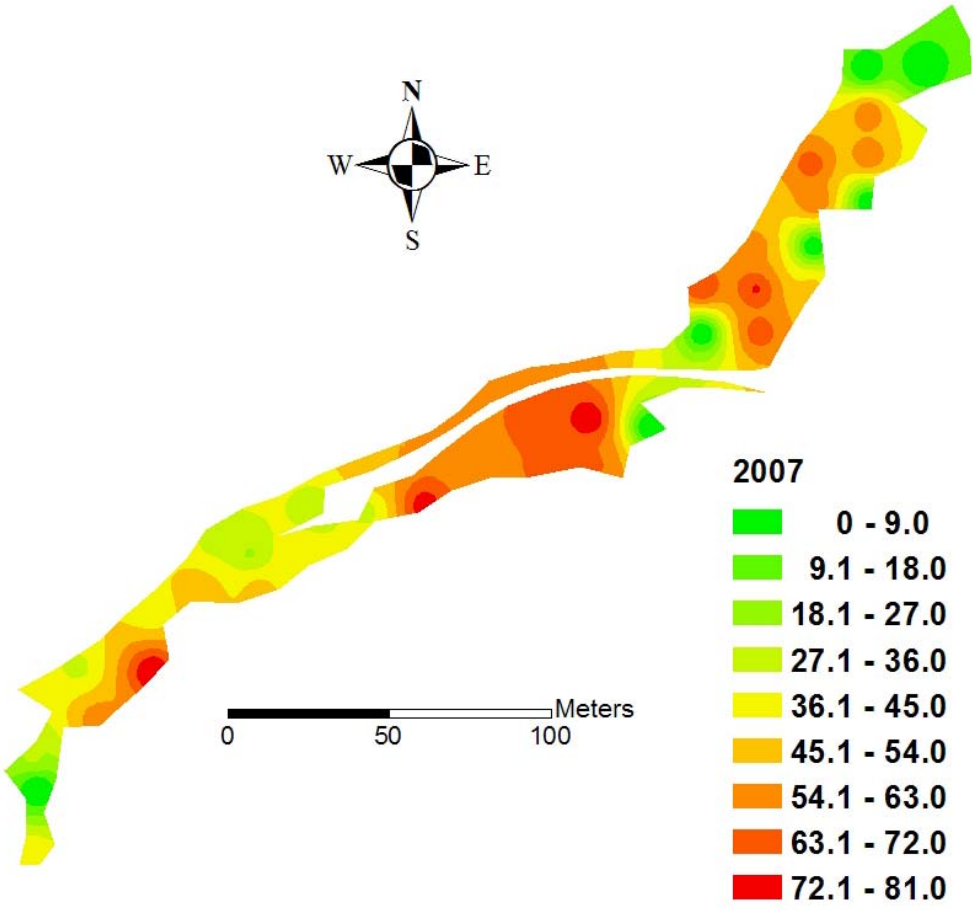


Water Treatment Plant diffuse and spotted knapweed perimeter in 2007.

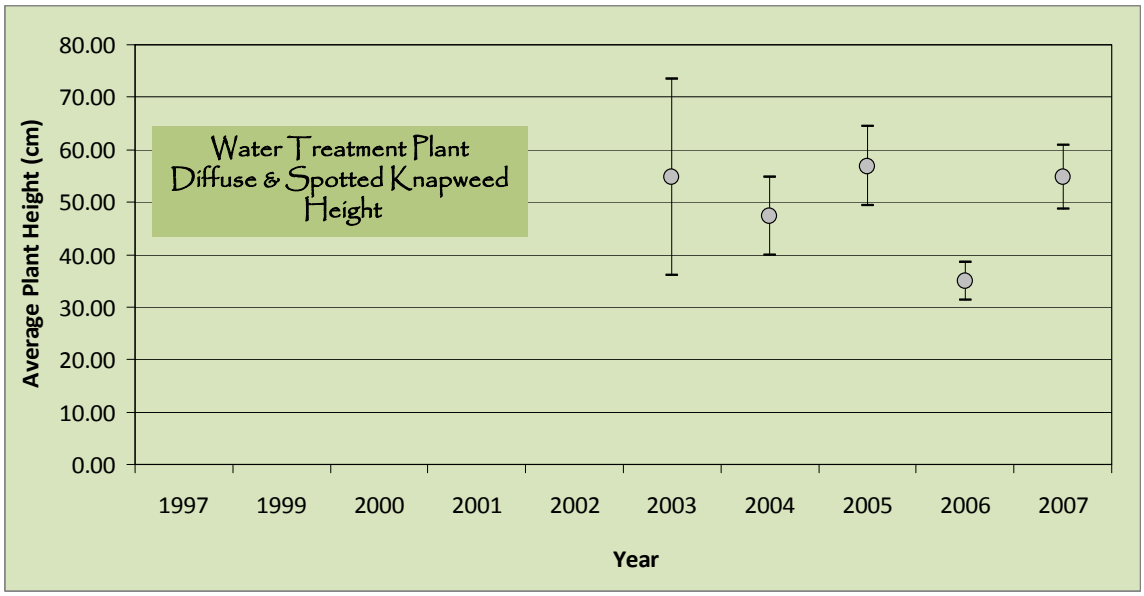


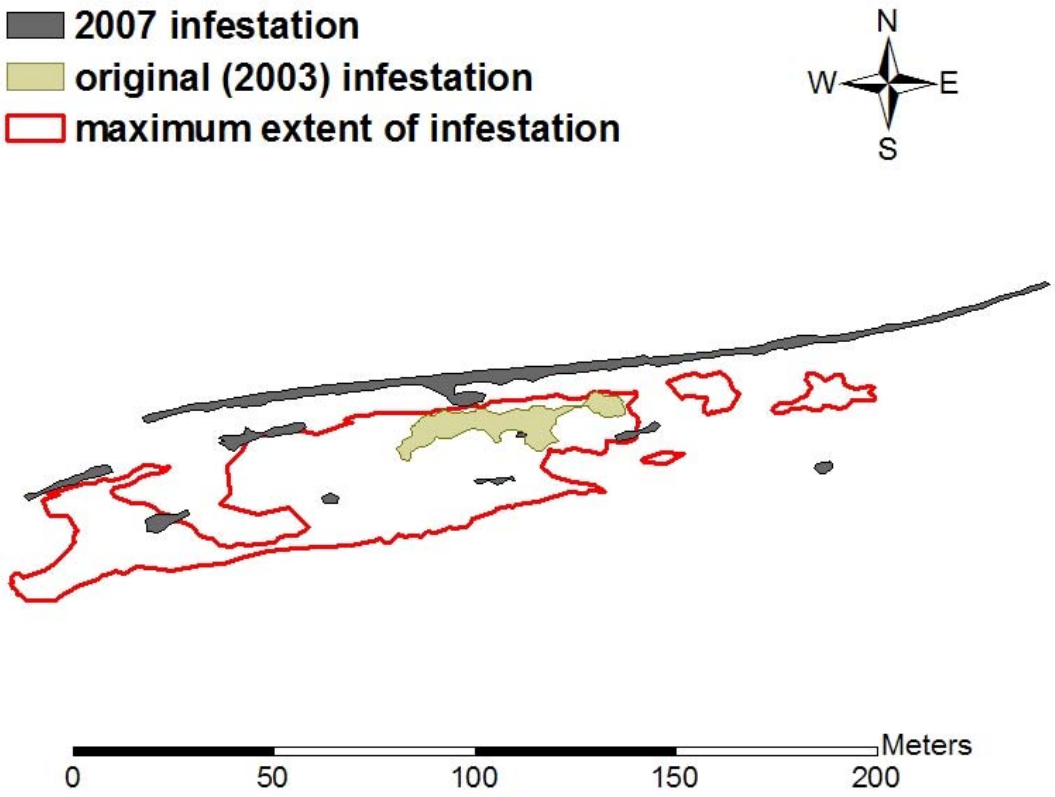
Water Treatment Plant diffuse and spotted knapweed density in 2007.



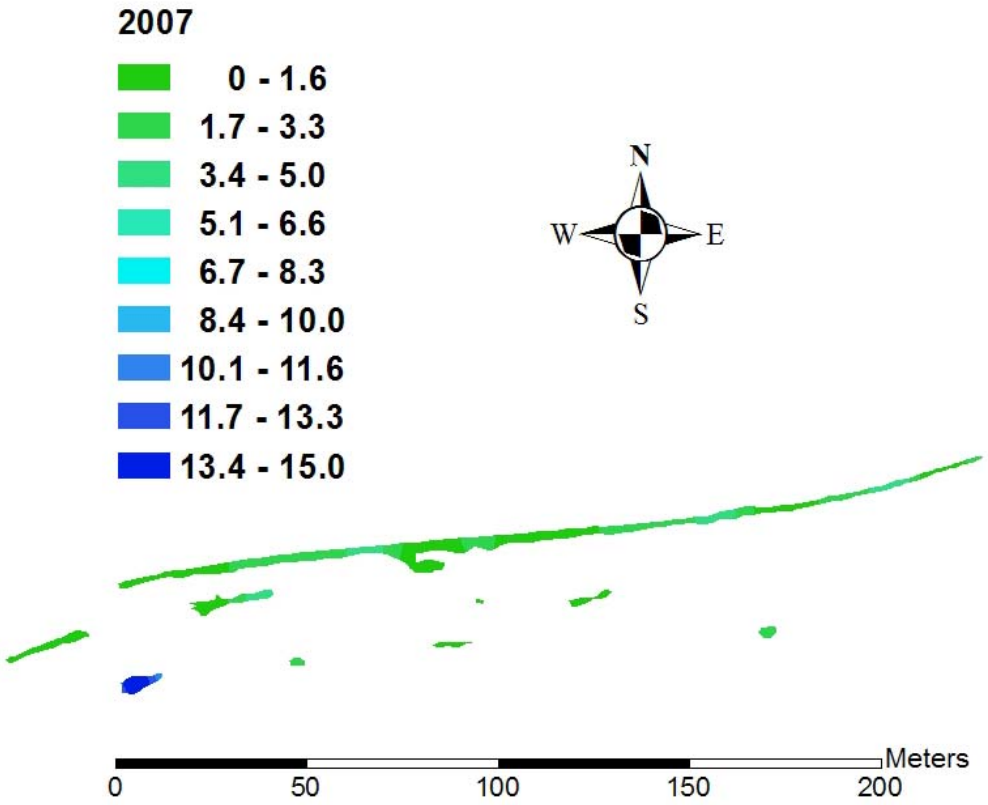


Water Treatment Plant diffuse and spotted knapweed height in 2007.

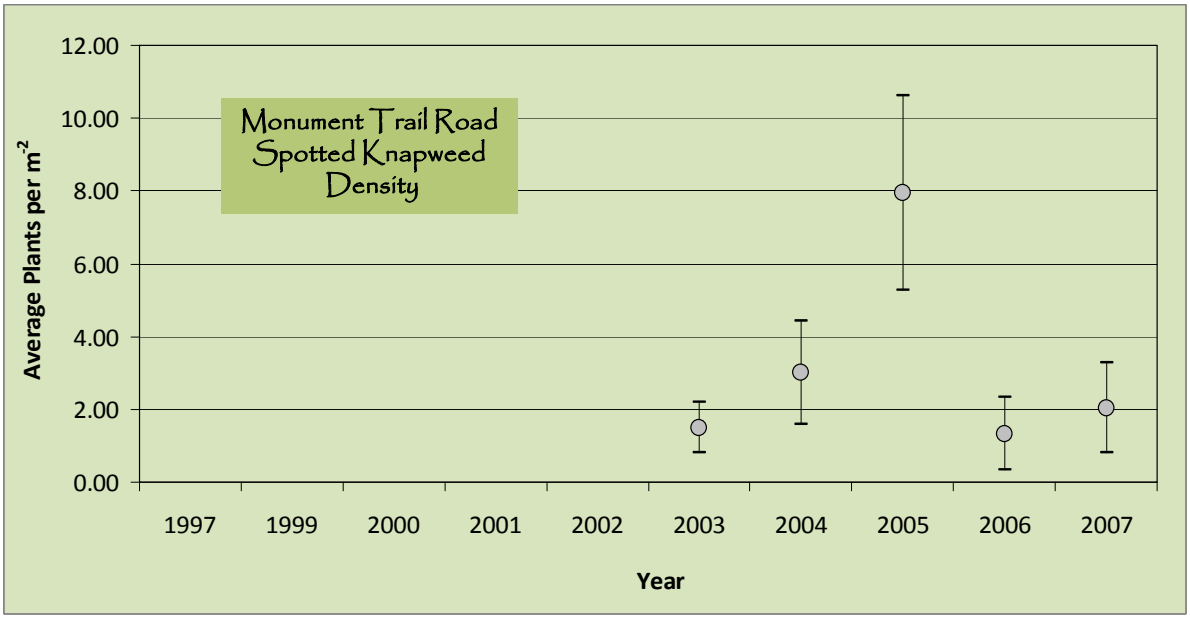


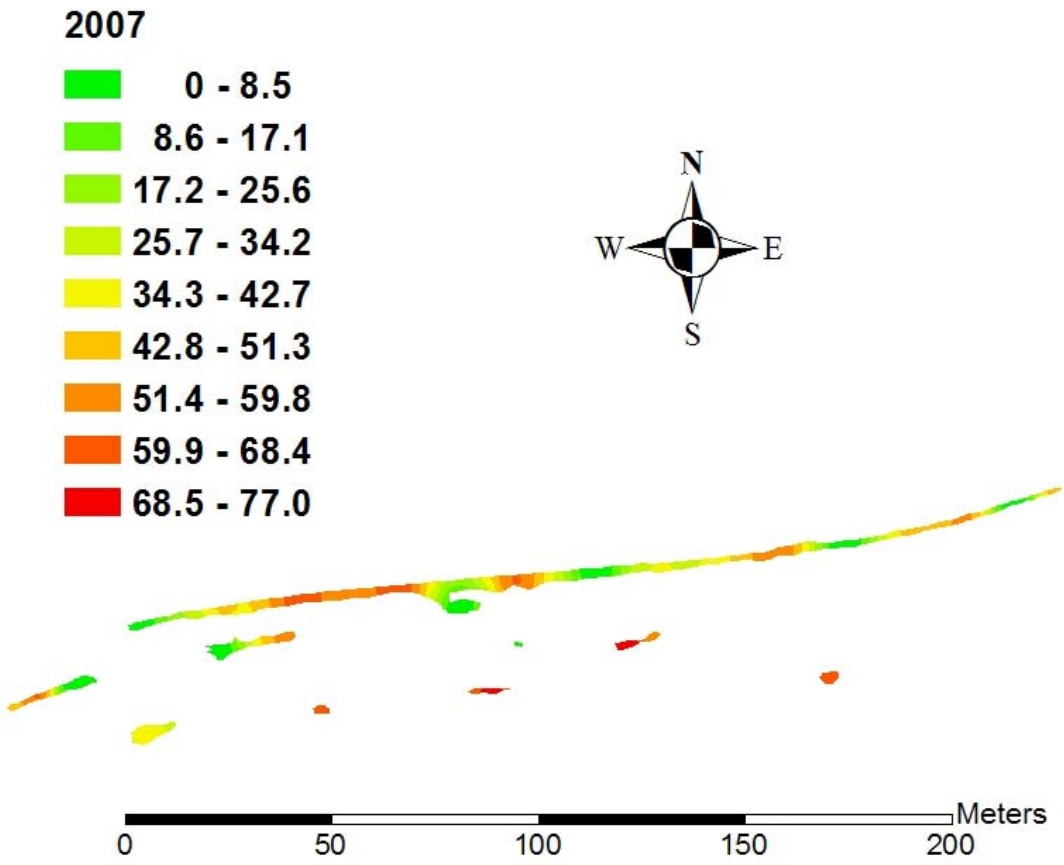


Monument Trail Road spotted knapweed perimeter in 2007.

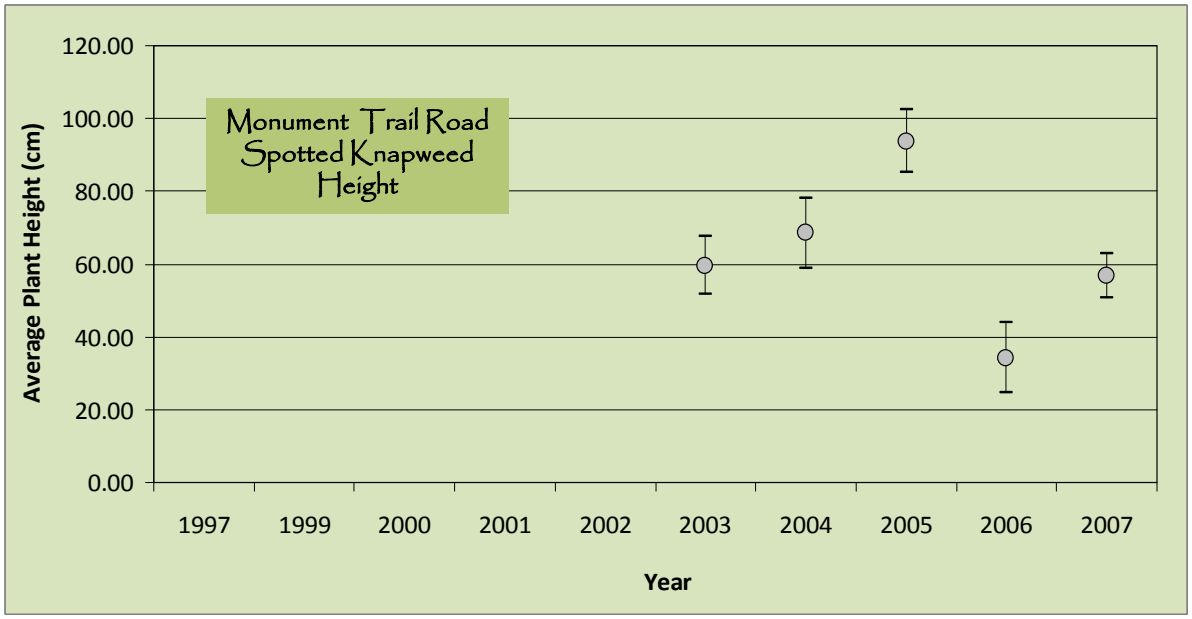


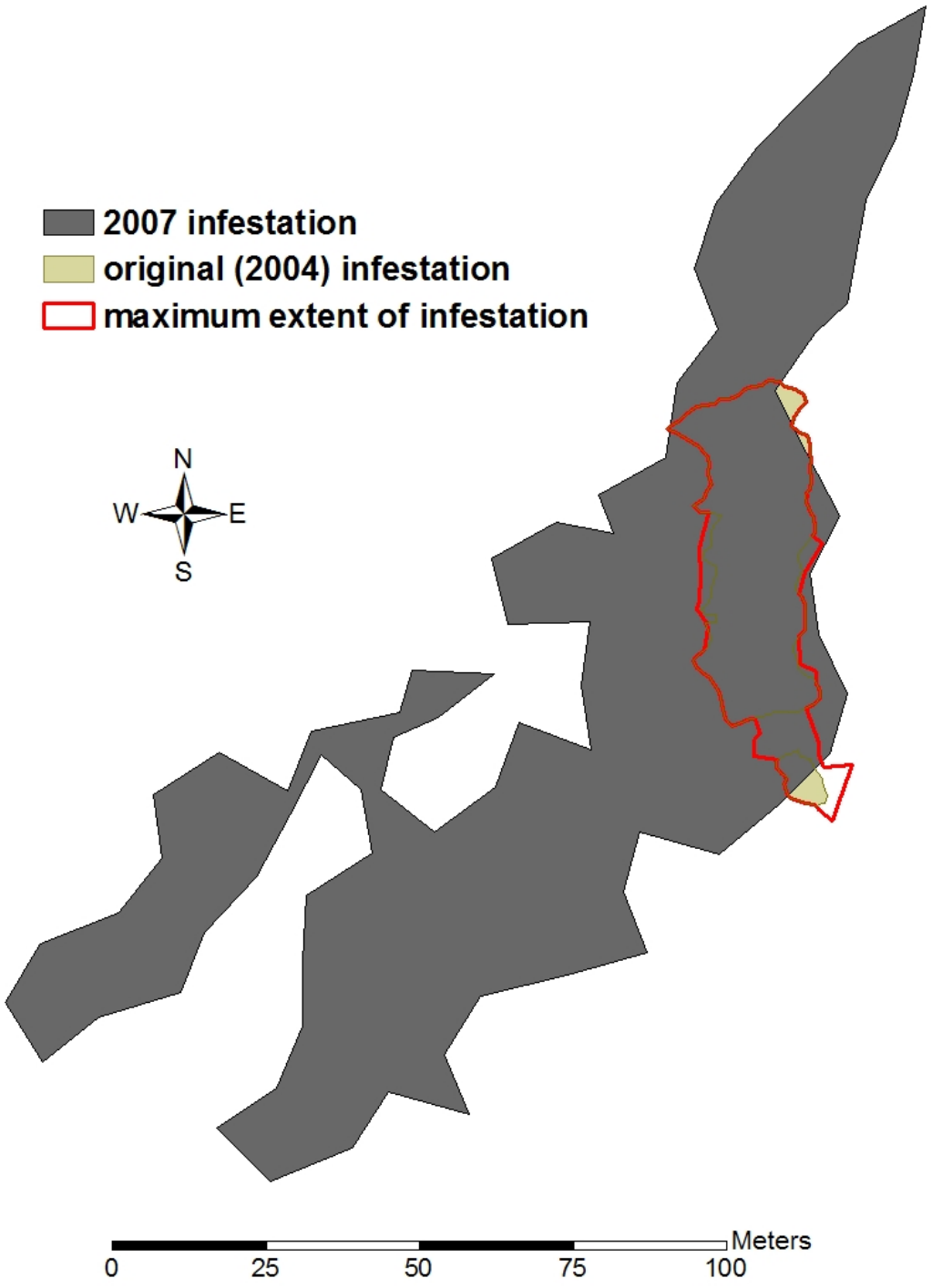
Monument Trail Road spotted knapweed density in 2007.



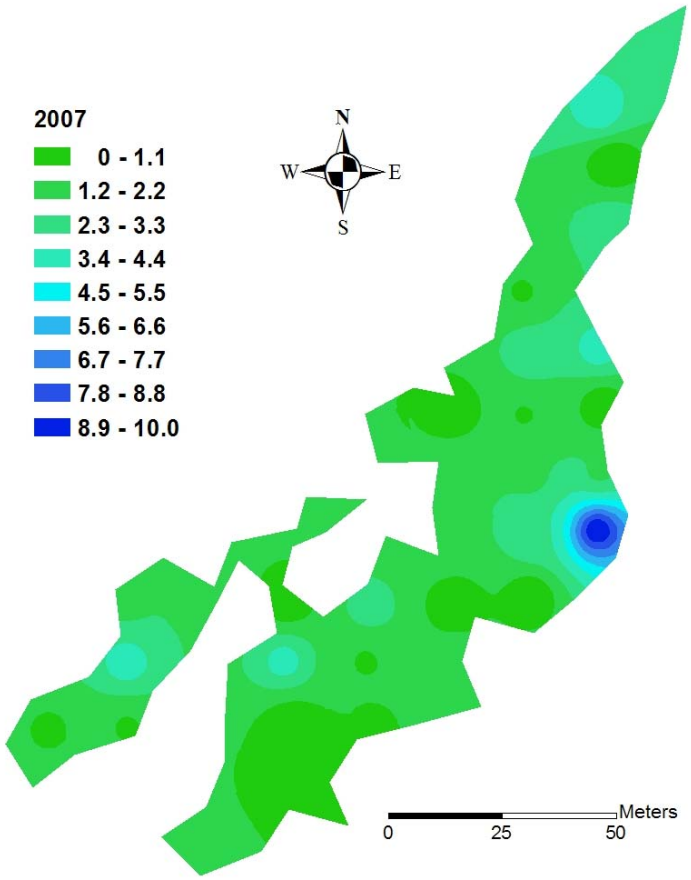


Monument Trail Road spotted knapweed height in 2007.

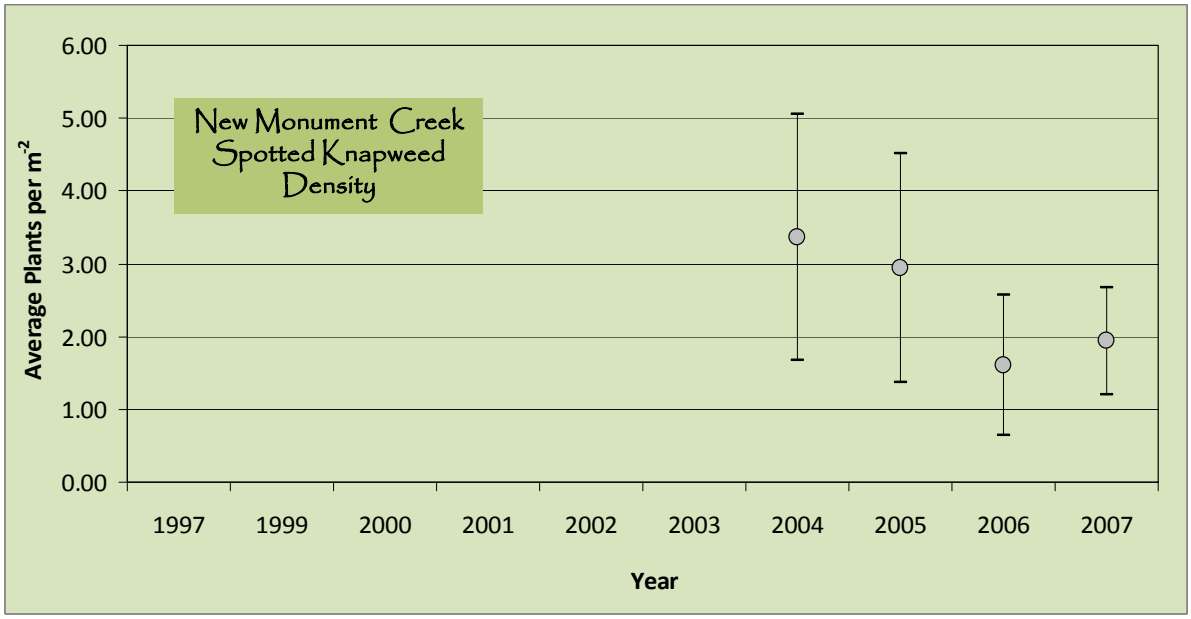


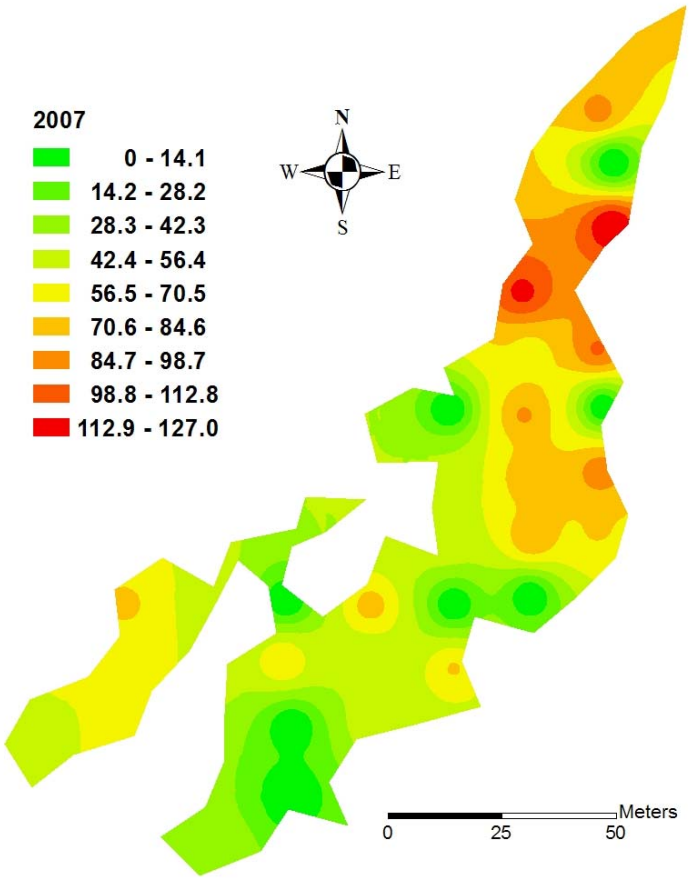


New Monument Creek spotted knapweed perimeter in 2007.

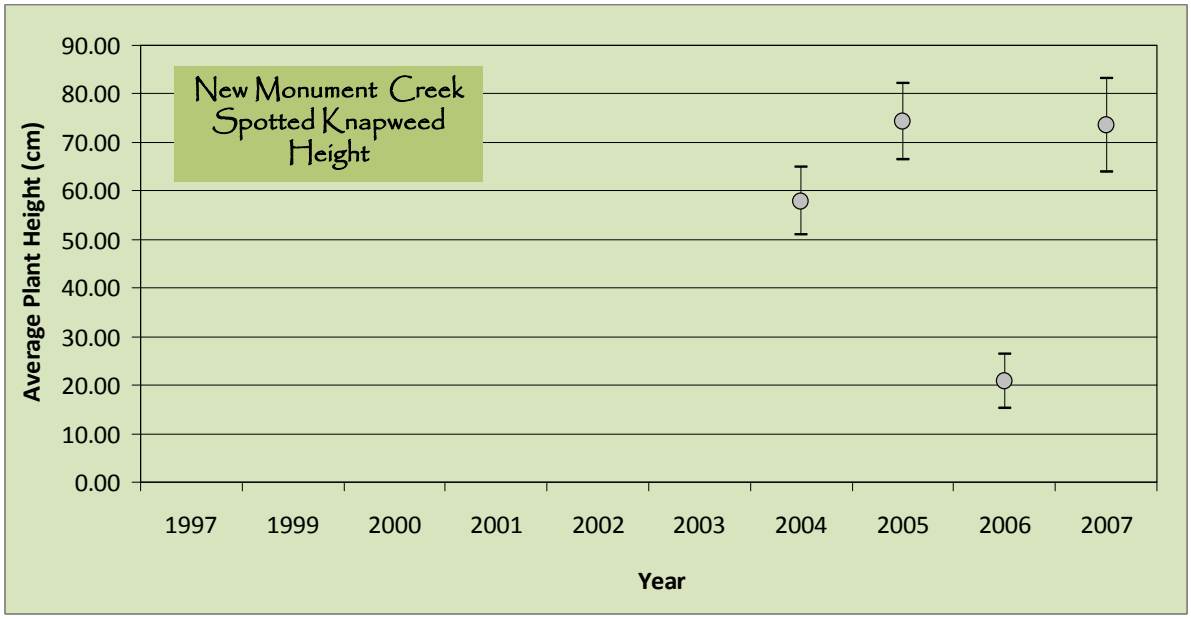


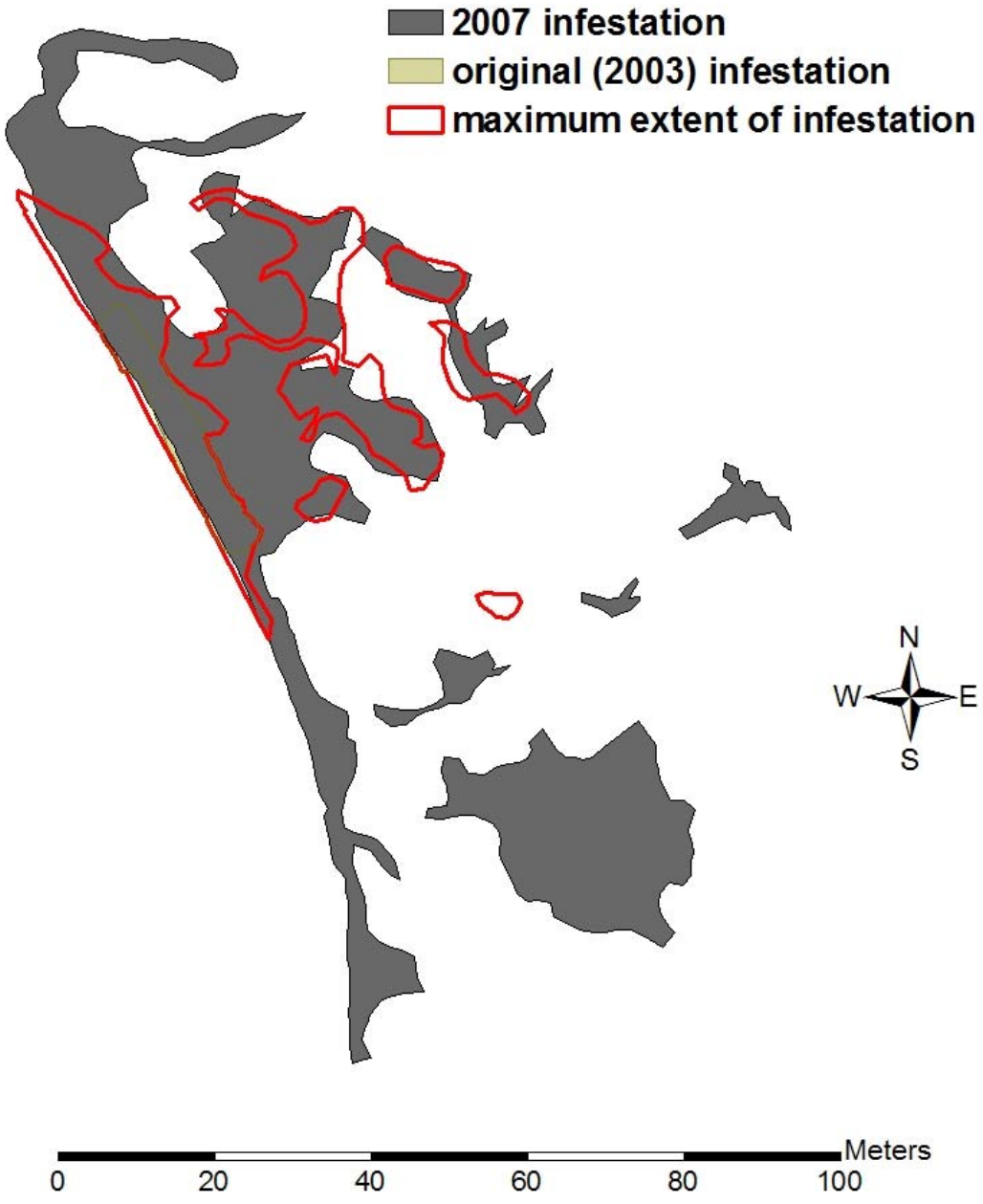
New Monument Creek spotted knapweed density in 2007.



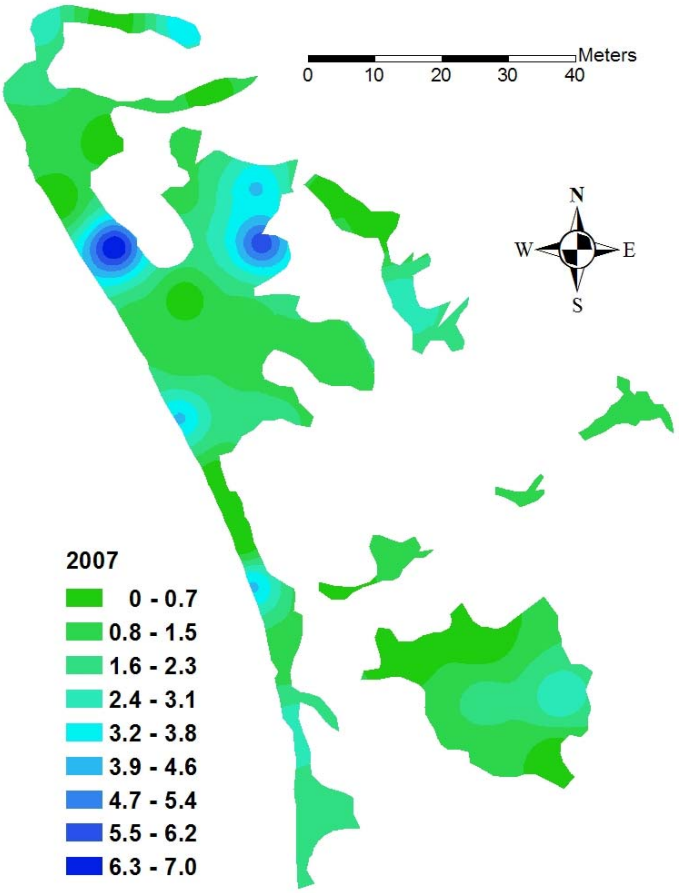


New Monument Creek spotted knapweed height in 2007.

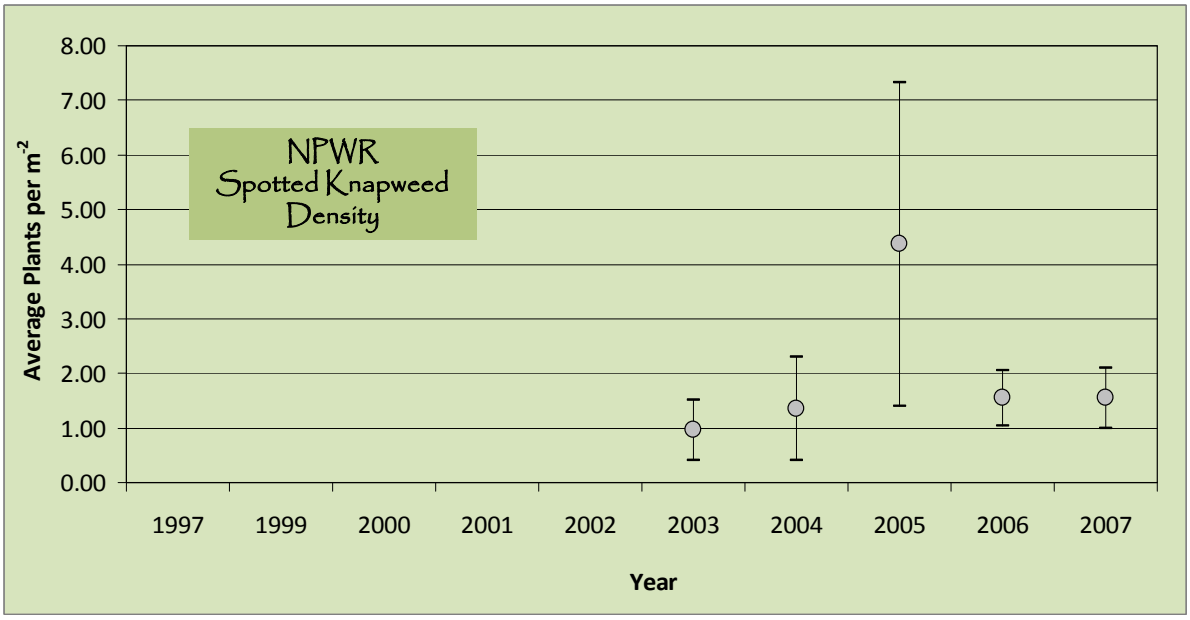


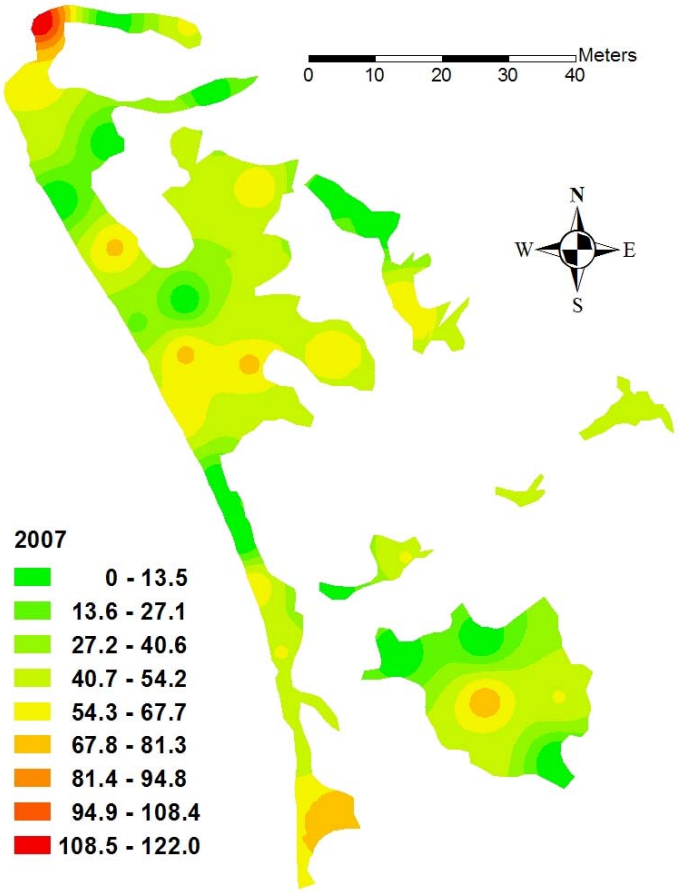


Non-potable Water Reservoir (NPWR) spotted knapweed perimeter in 2007.

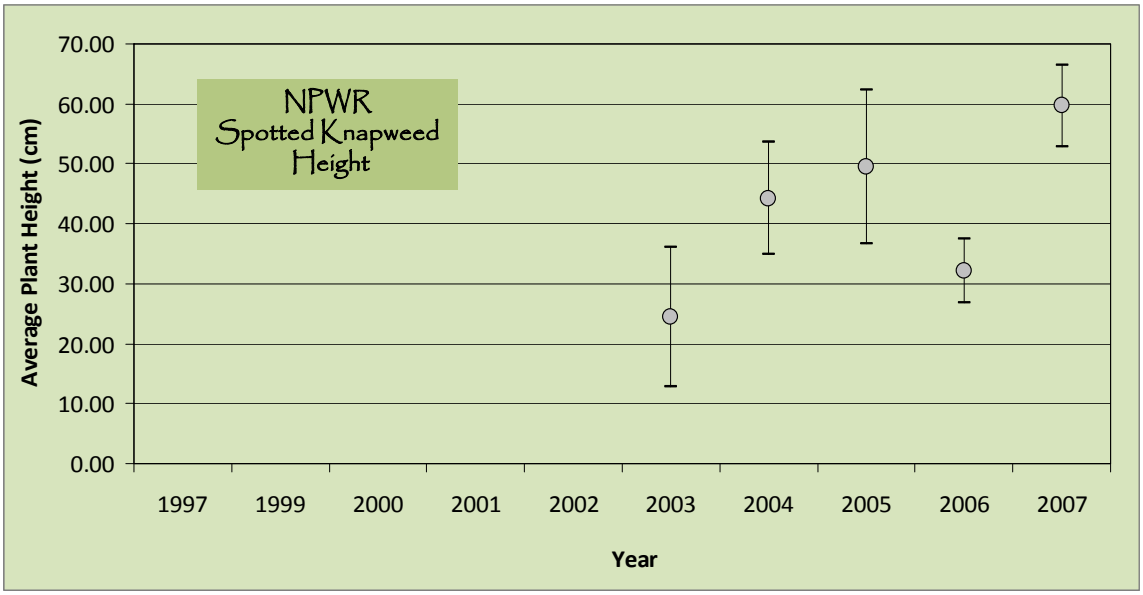


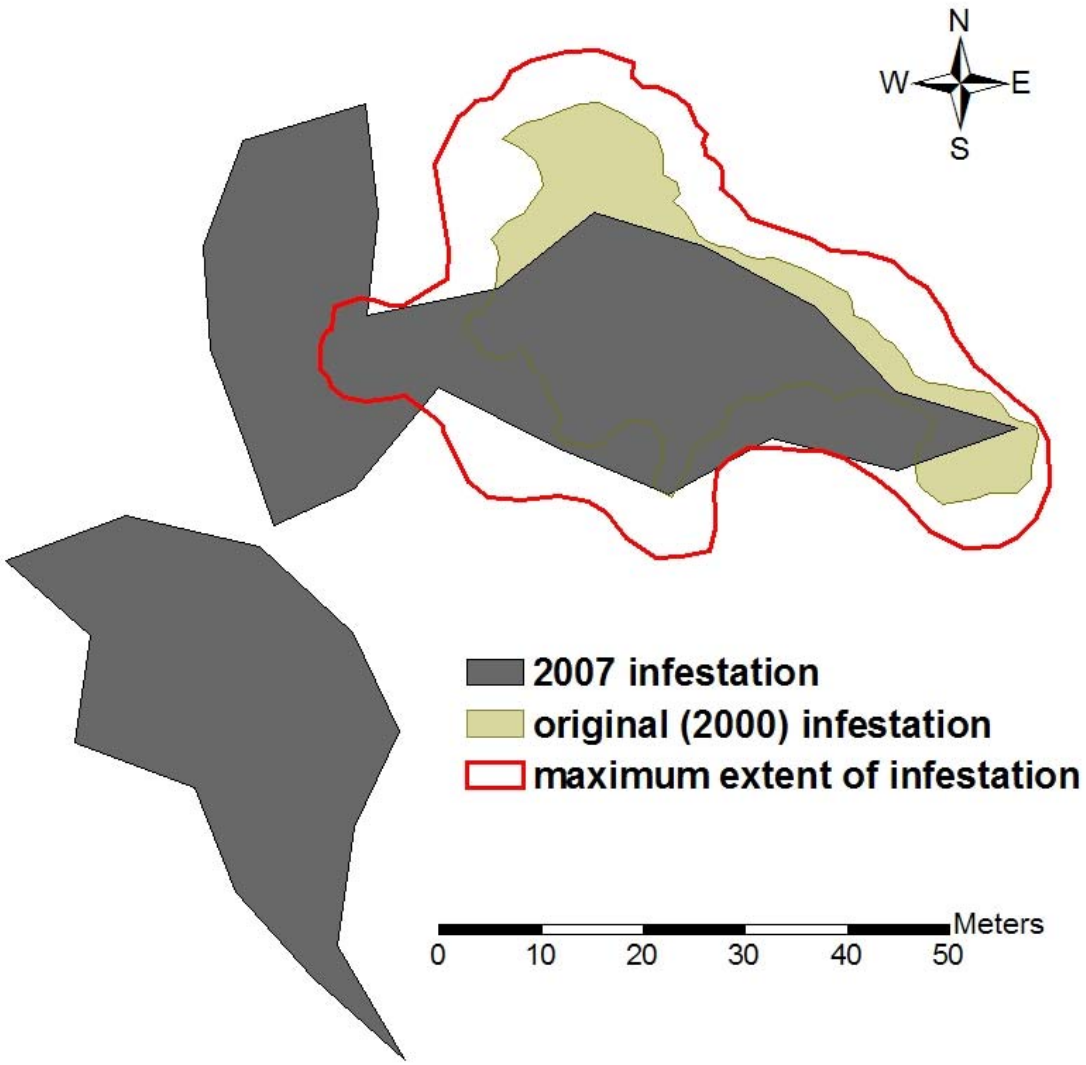
Non-potable Water Reservoir (NPWR) spotted knapweed density in 2007.



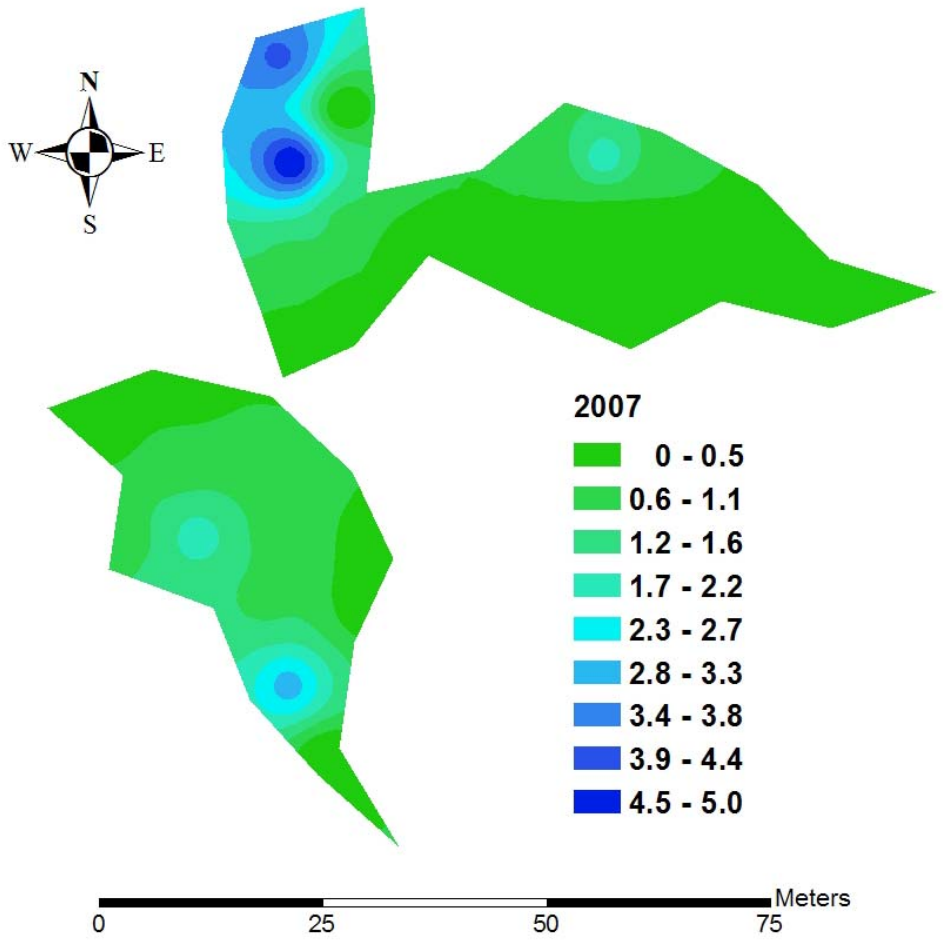


Non-potable Water Reservoir (NPWR) spotted knapweed height in 2007.

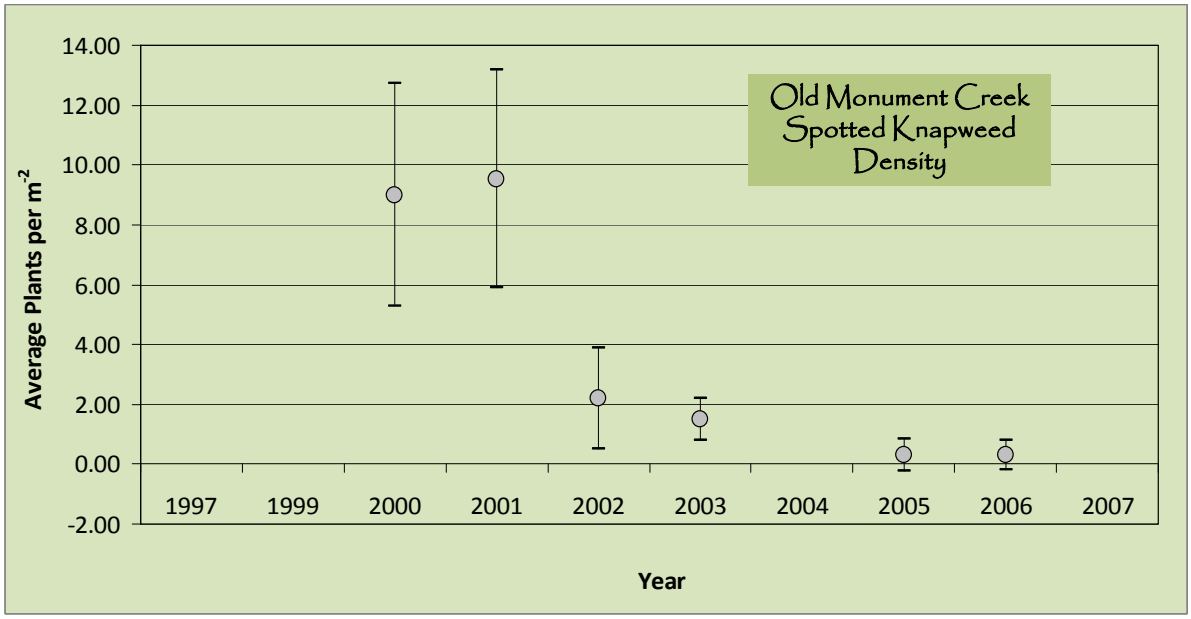


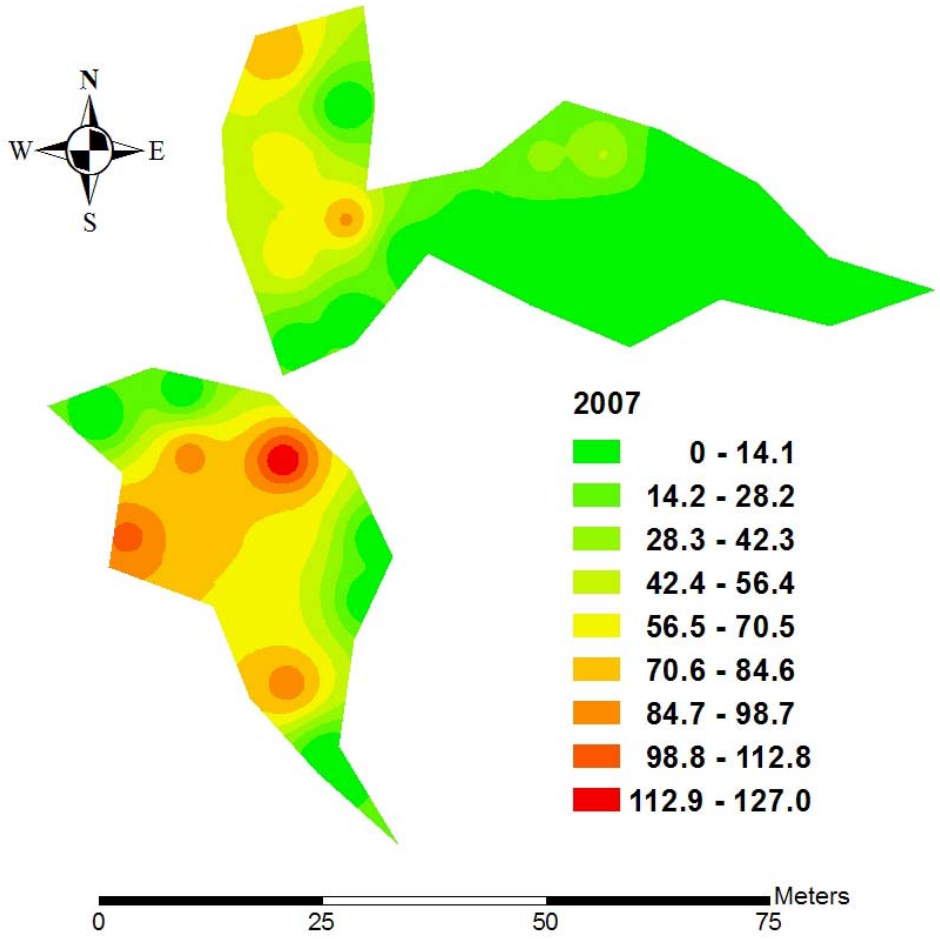


Old Monument Creek spotted knapweed perimeter in 2007.

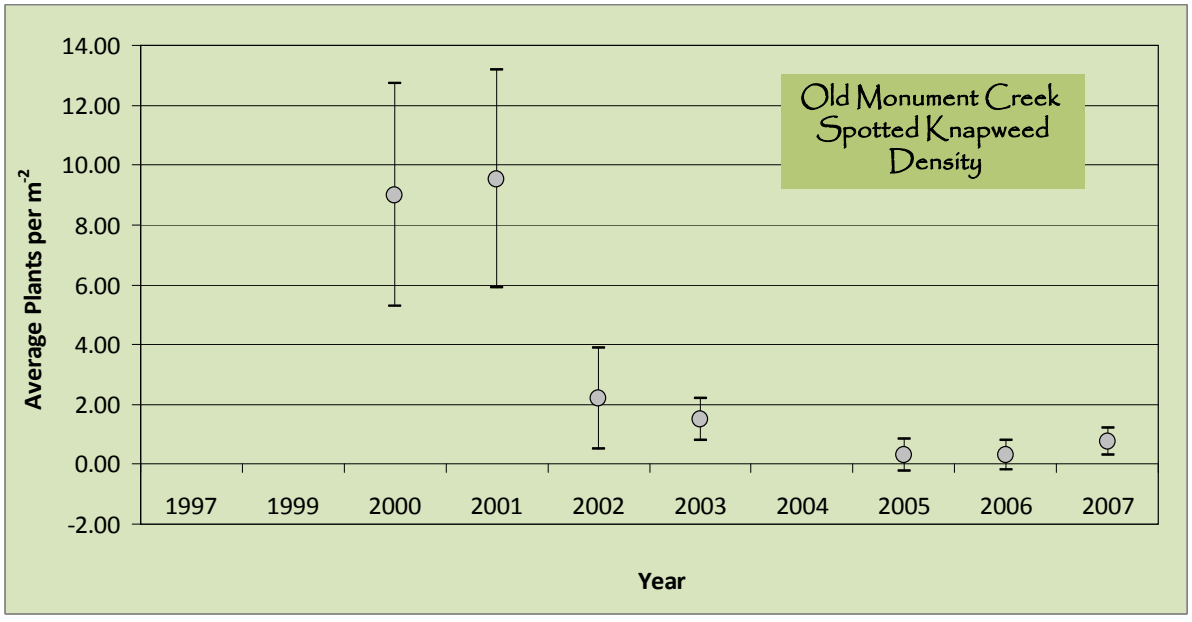


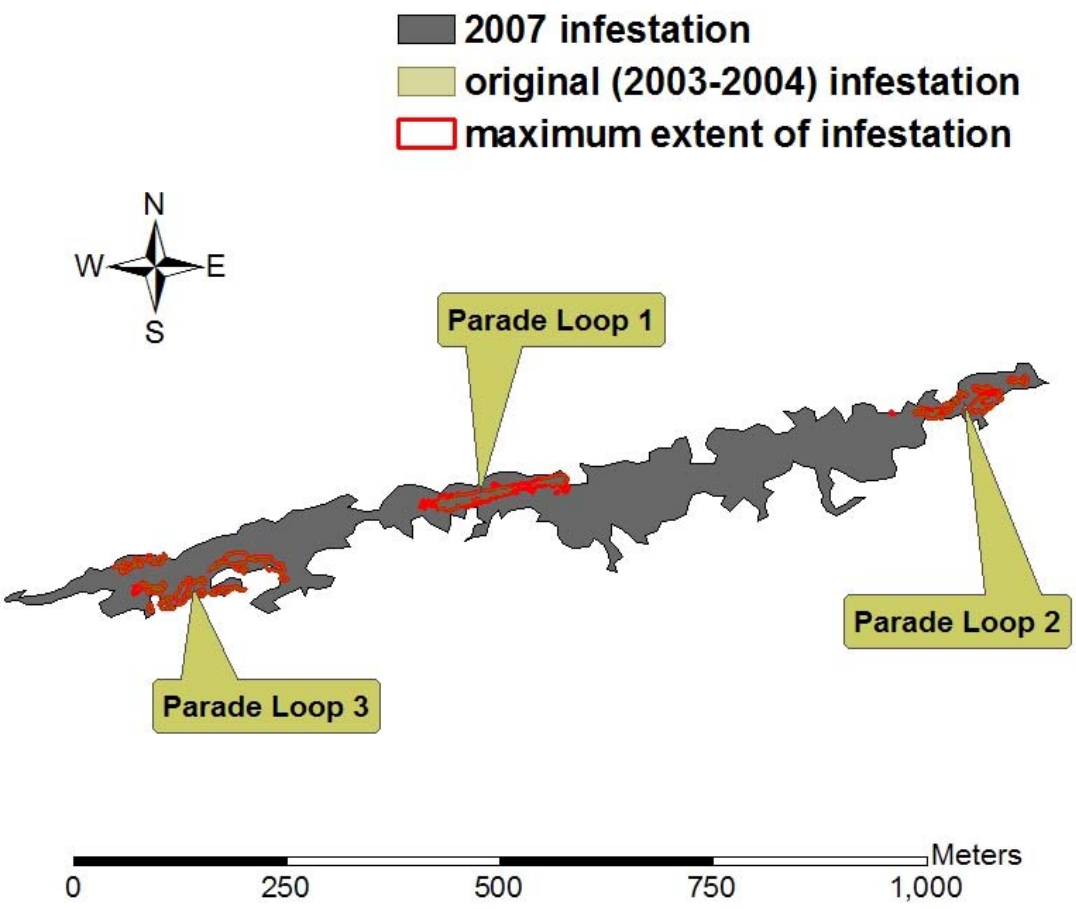
Old Monument Creek spotted knapweed density in 2007.



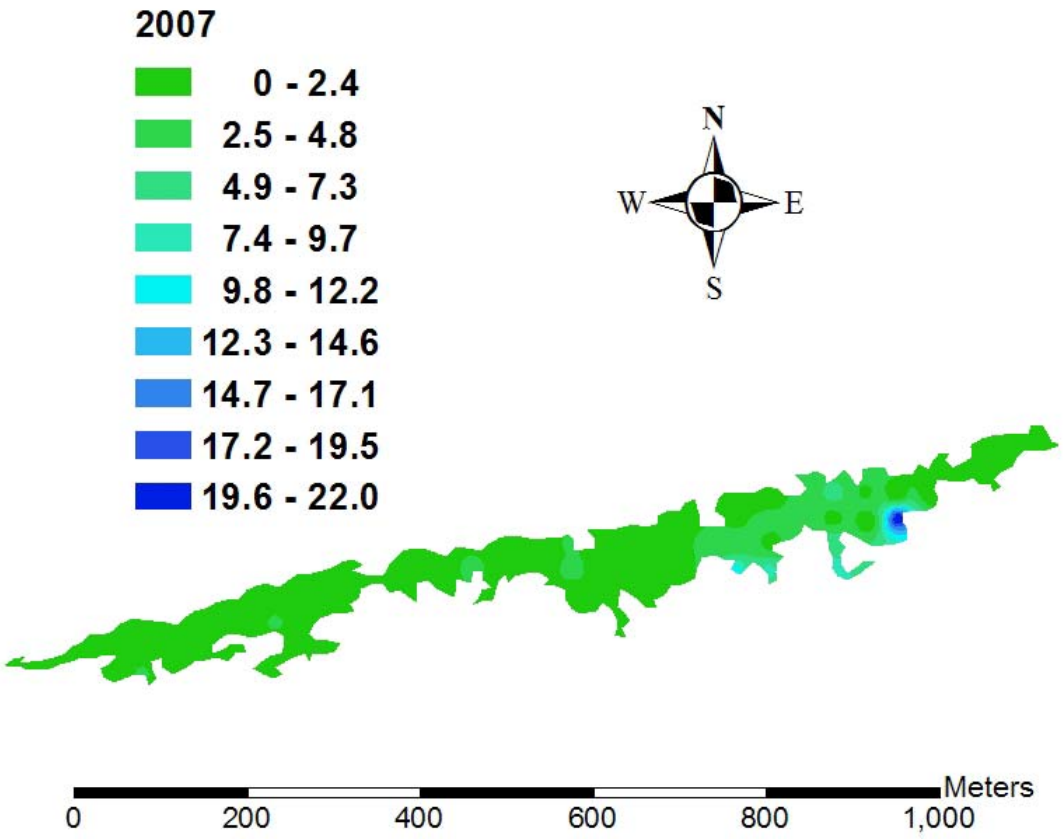


Old Monument Creek spotted knapweed height in 2007.

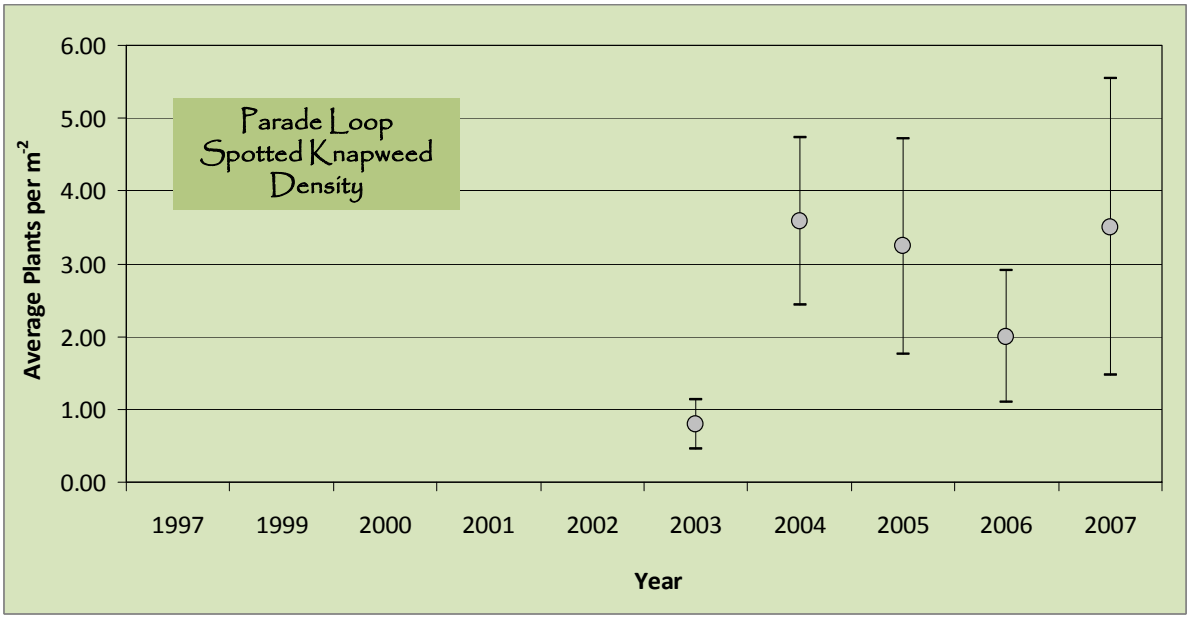


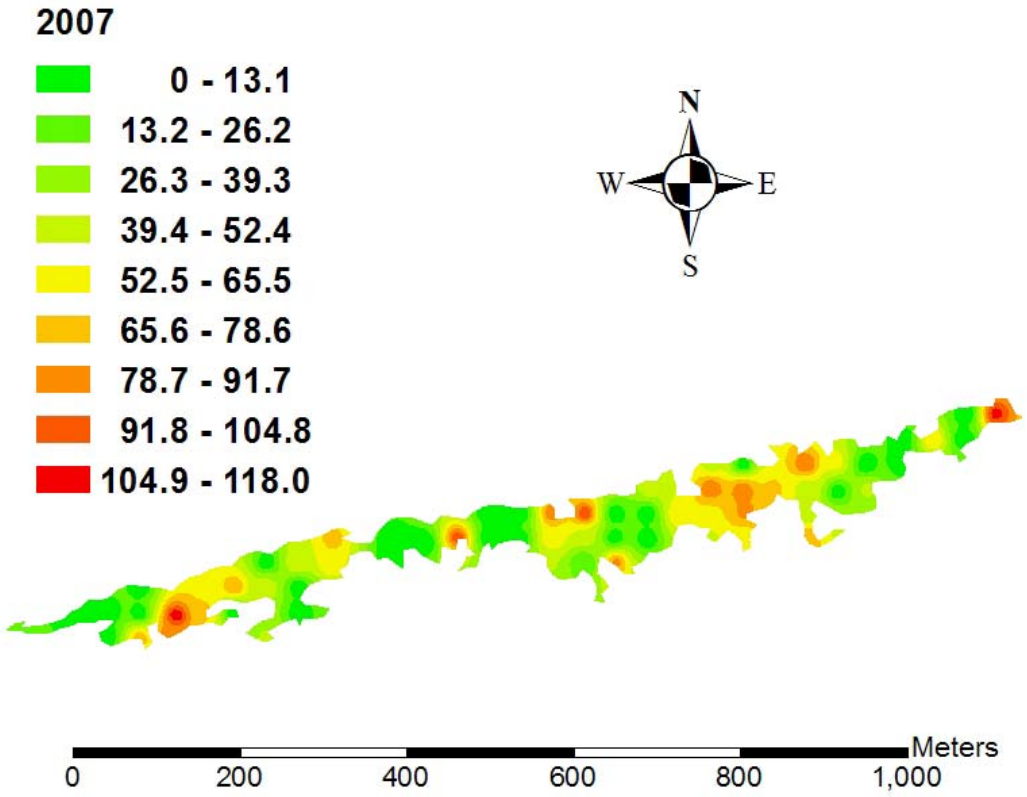


Total Parade Loop spotted knapweed perimeter in 2007.

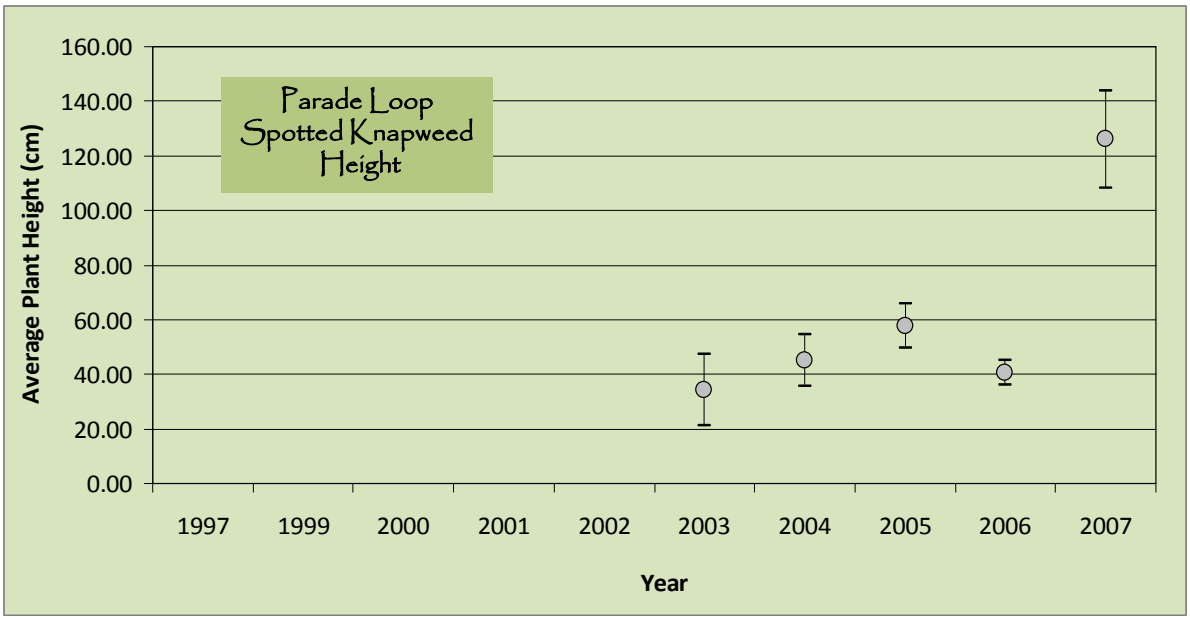


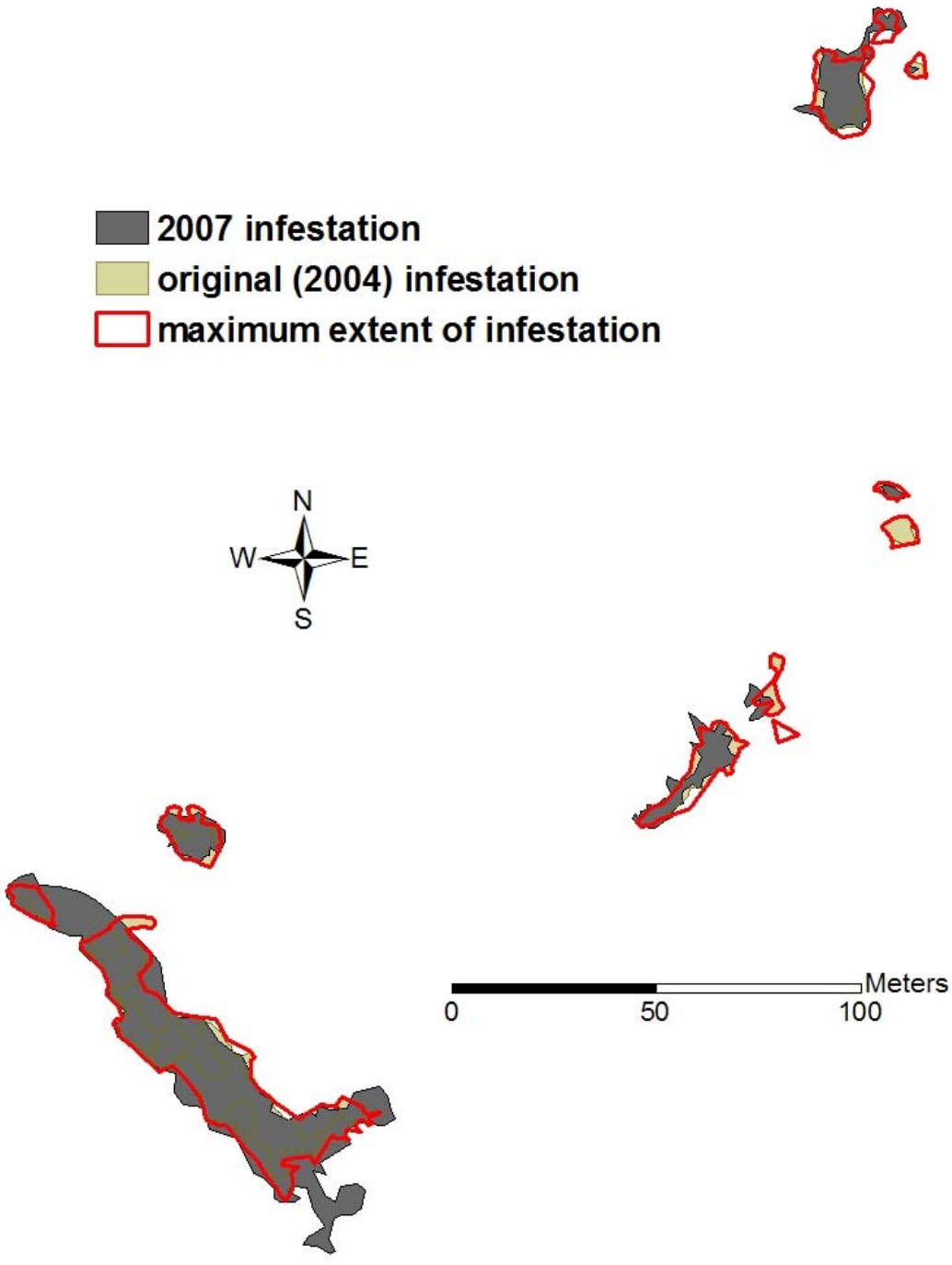
Total Parade Loop spotted knapweed density in 2007.



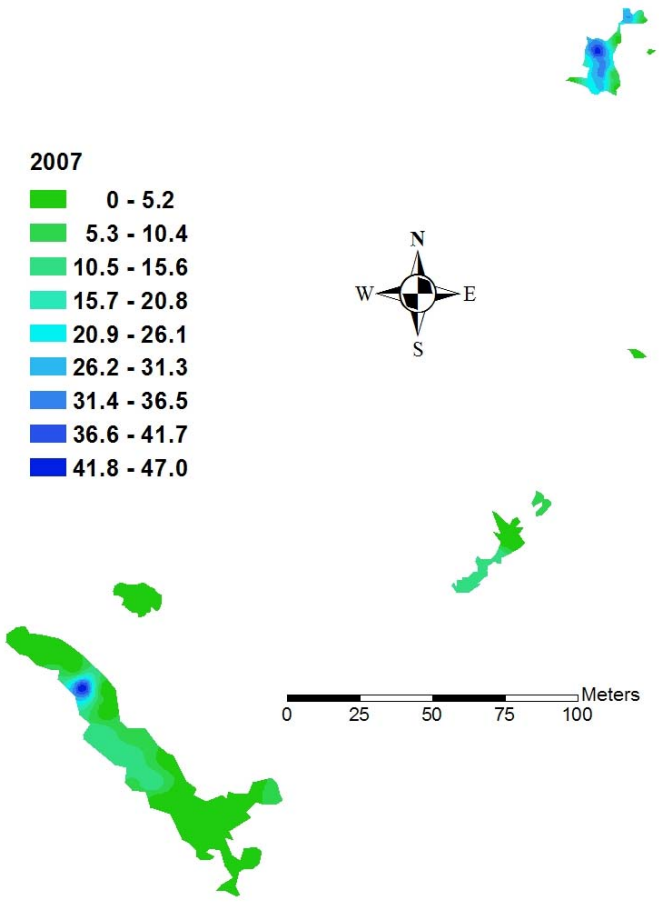


Total Parade Loop spotted knapweed height in 2007.

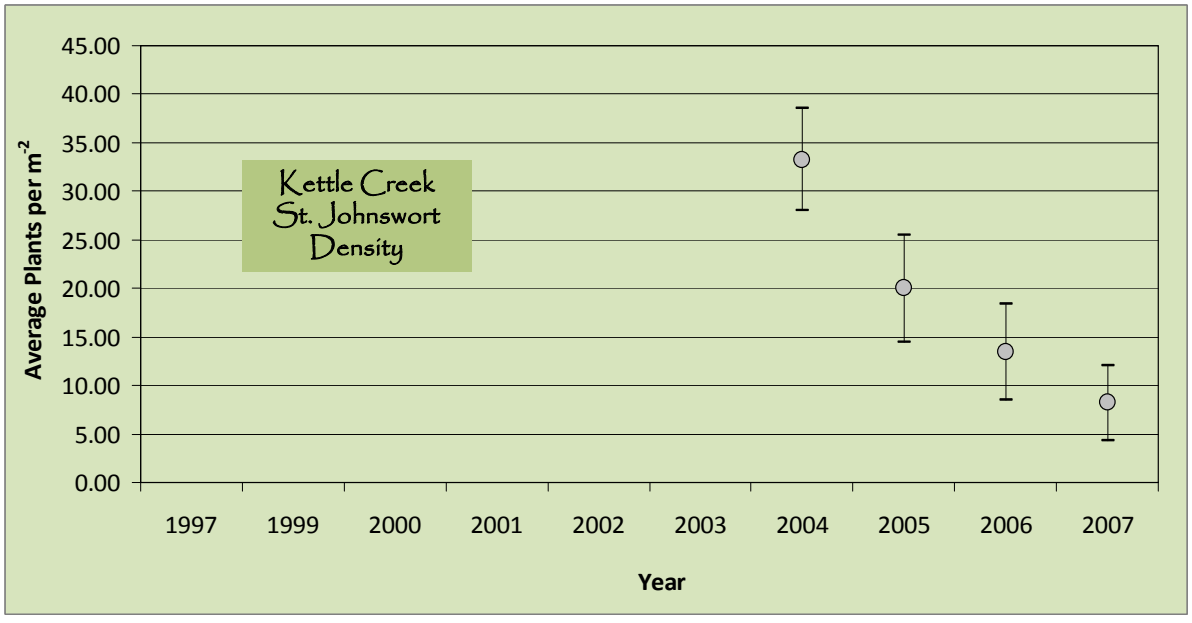


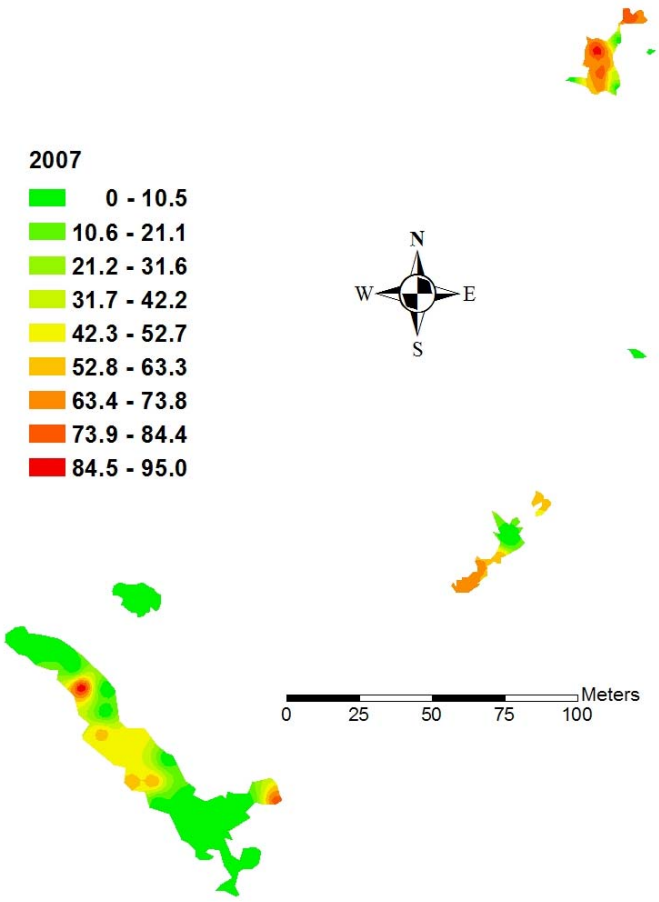


Kettle Creek St. Johnswort perimeter in 2007.

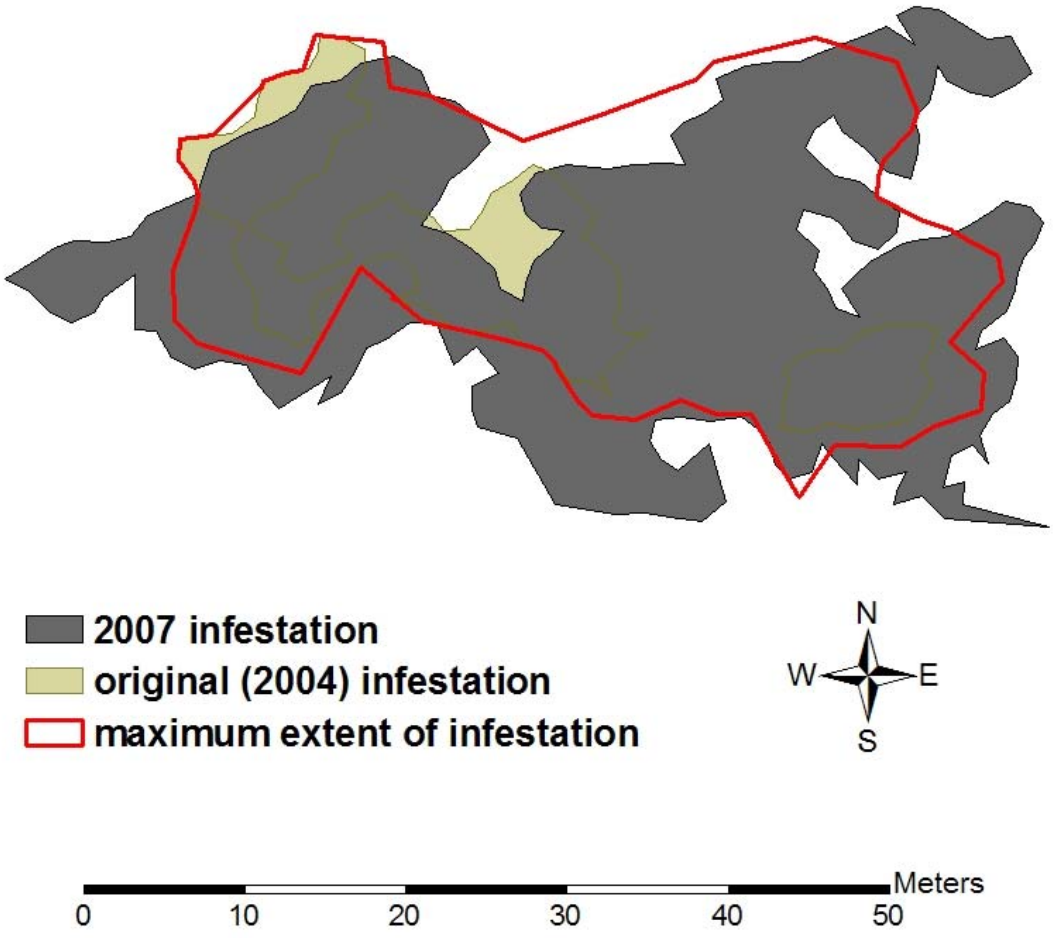


Kettle Creek St. Johnswort density in 2007.

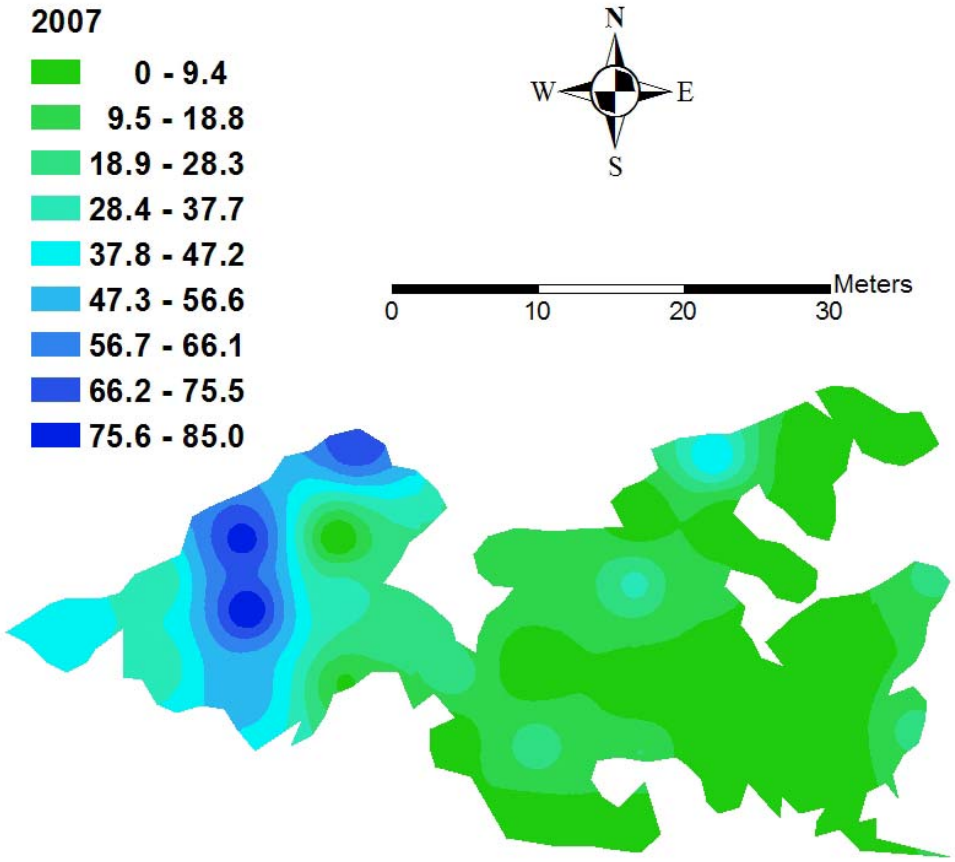




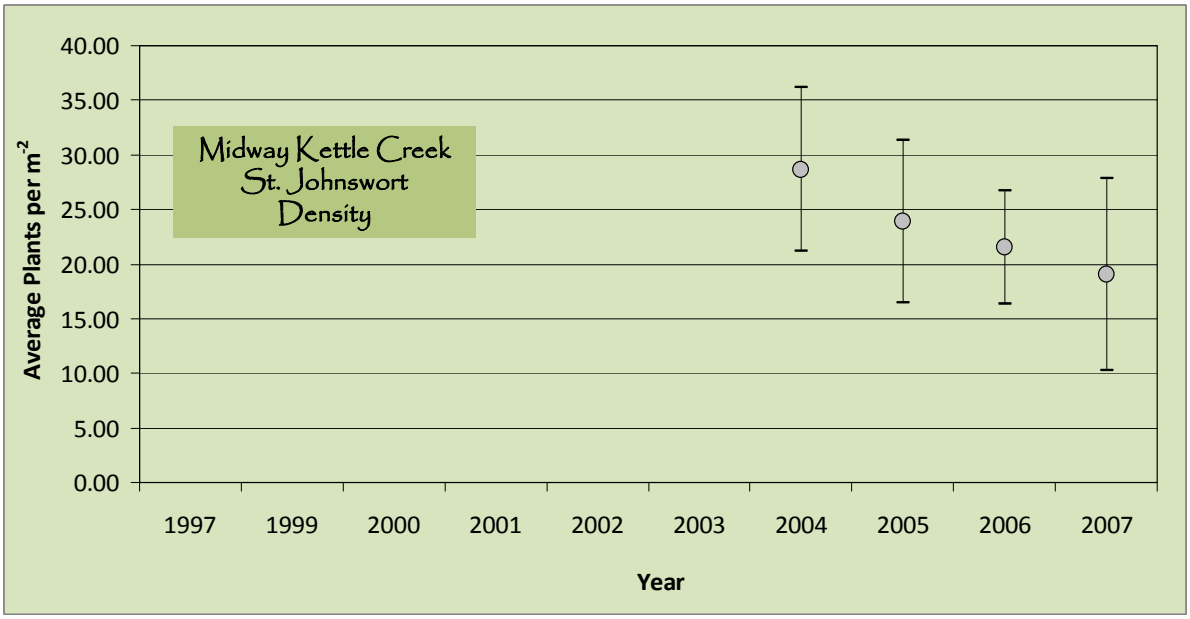
Kettle Creek St. Johnswort height in 2007.

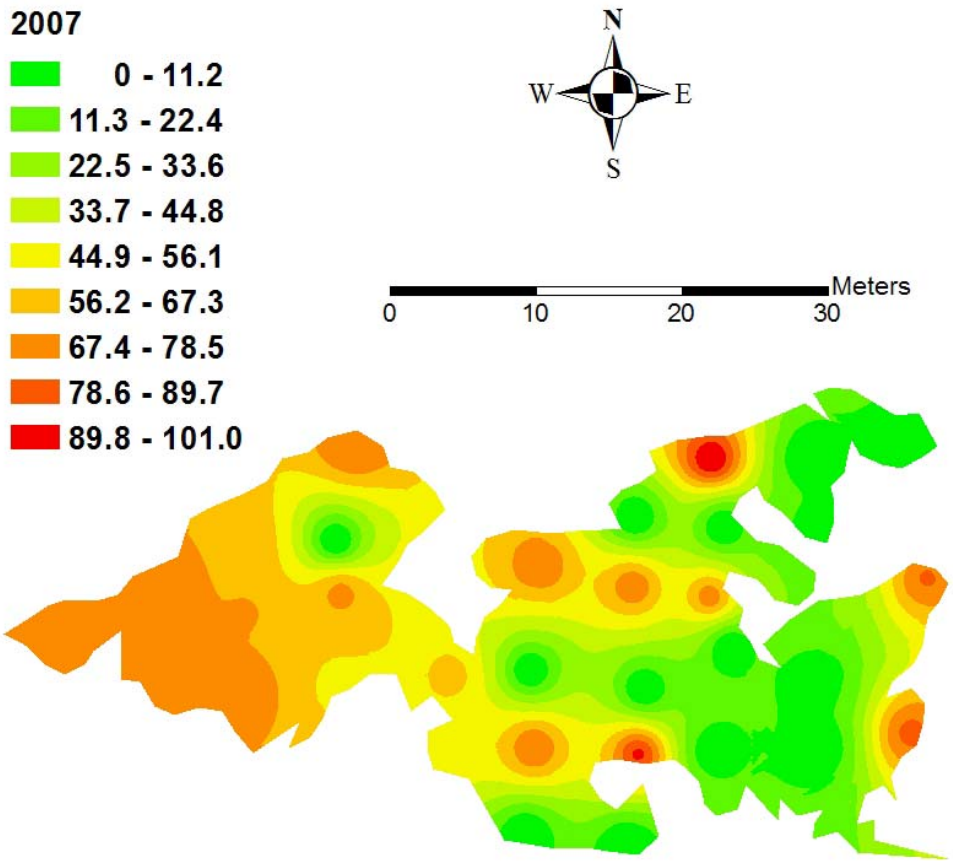


Midway Kettle Creek St. Johnswort perimeter in 2007.

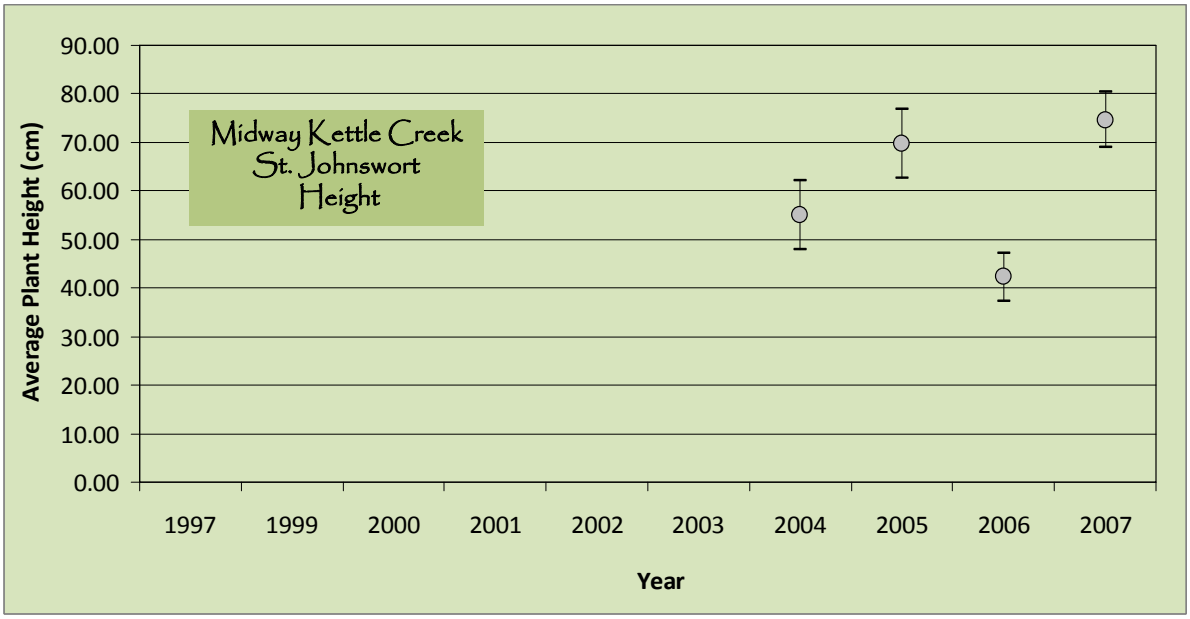


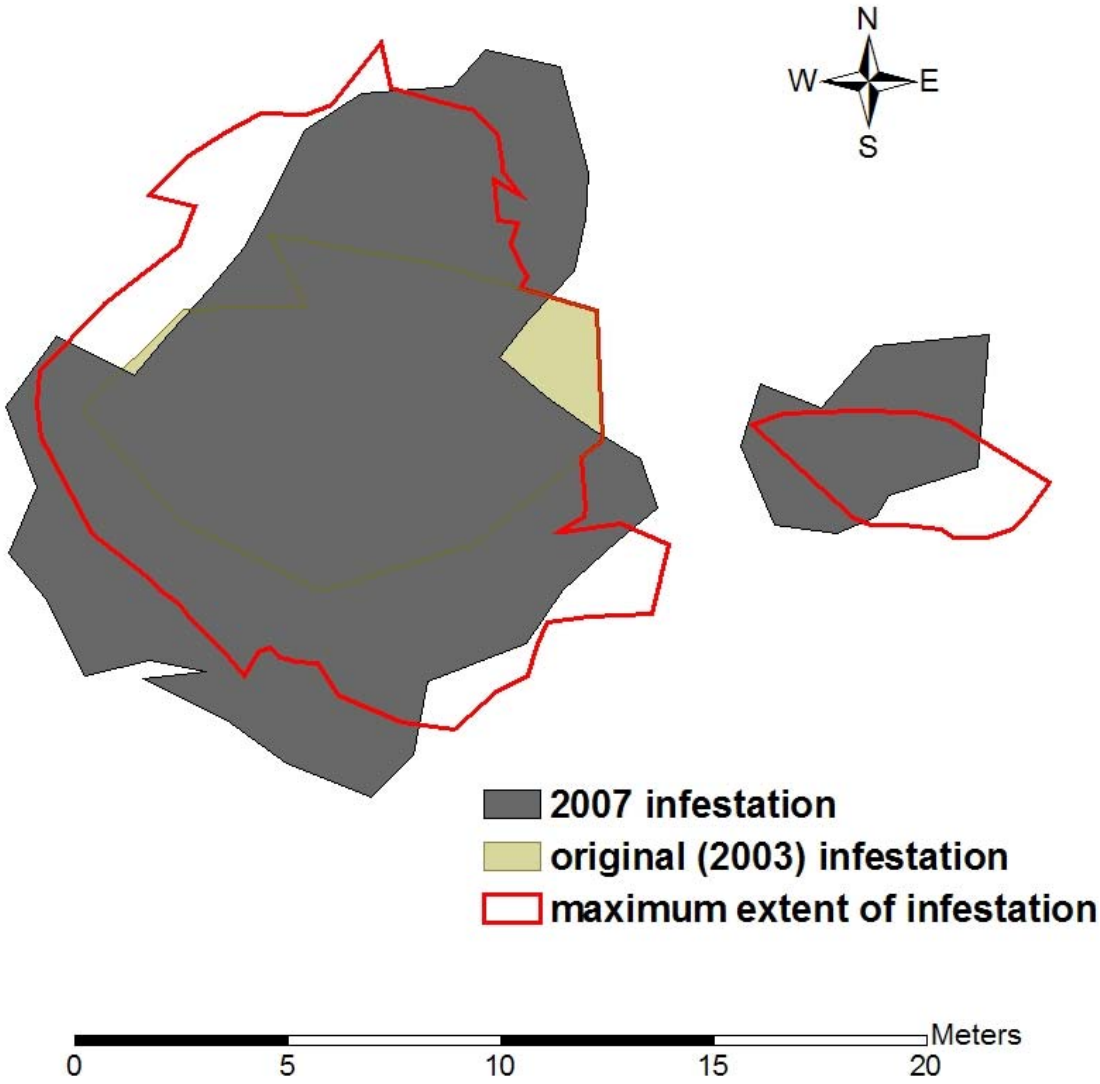
Midway Kettle Creek St. Johnswort density in 2007.



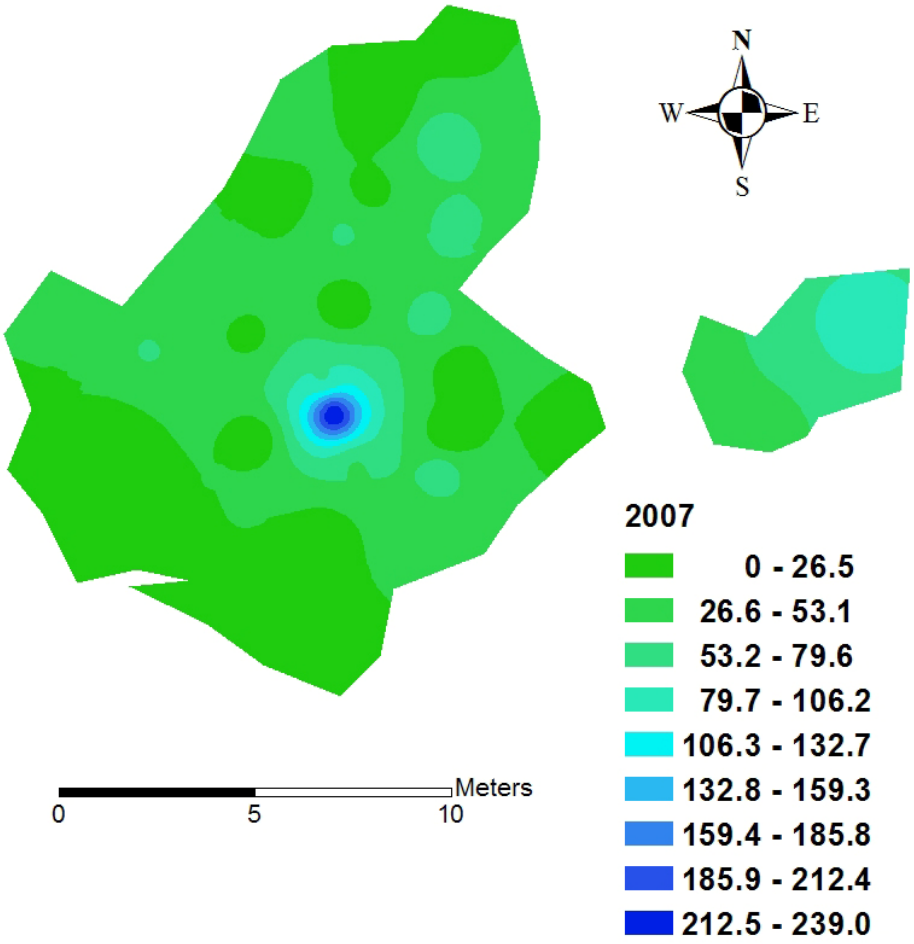


Midway Kettle Creek St. Johnswort height in 2007.

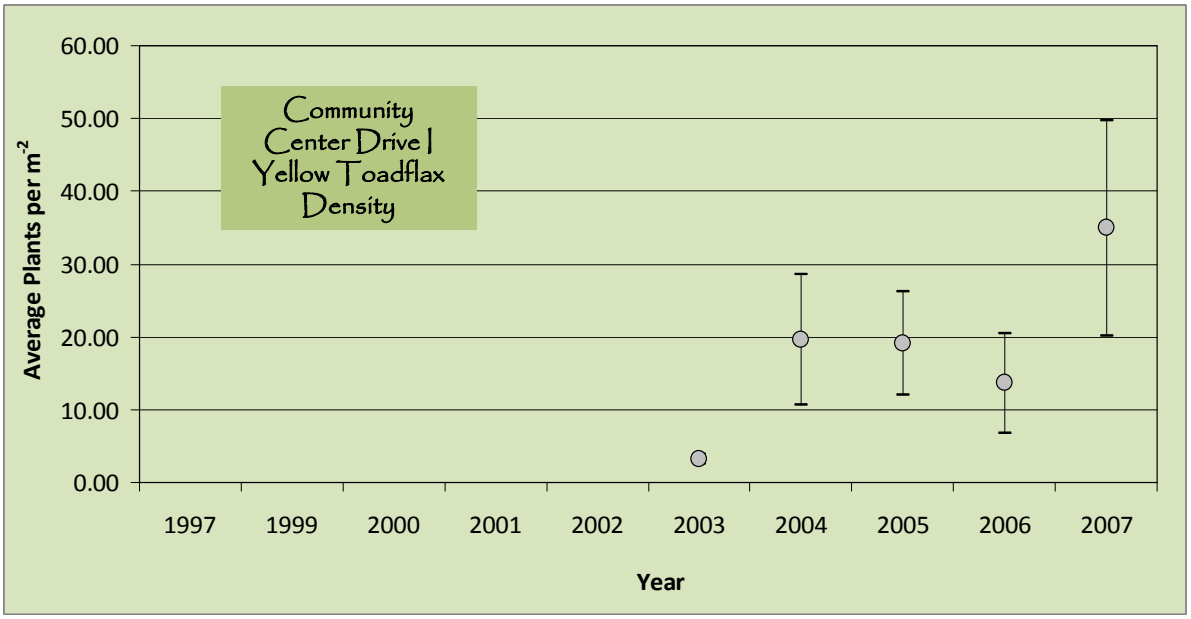


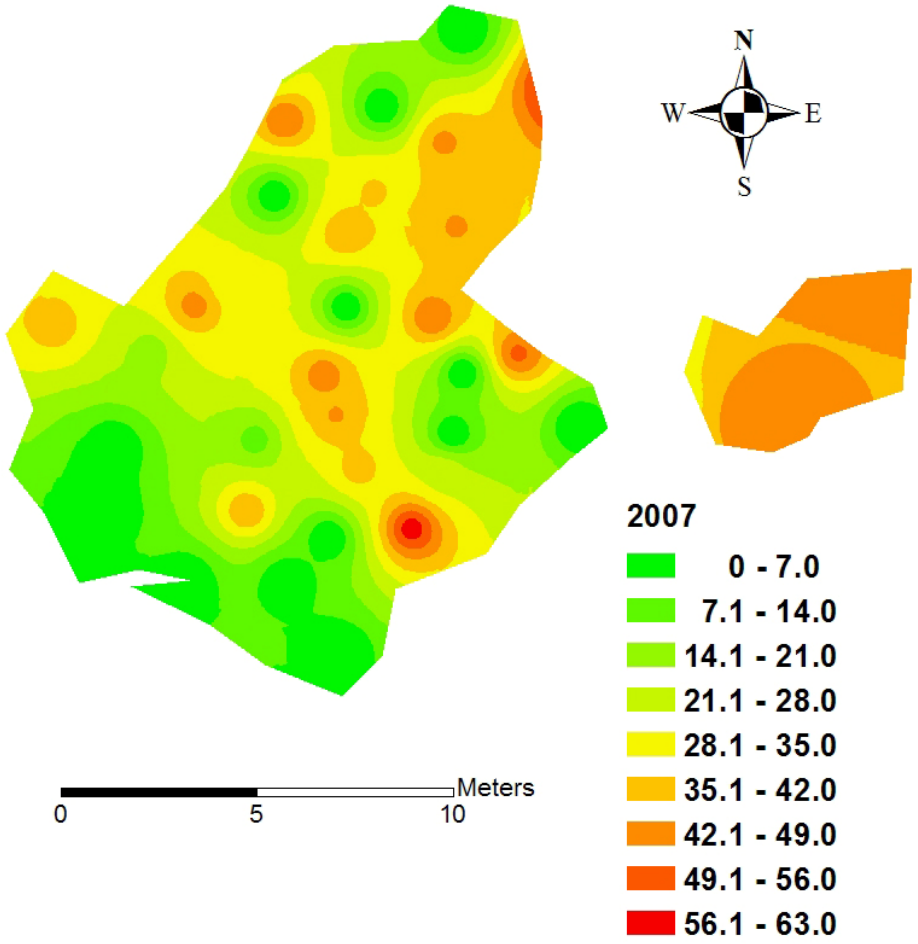


Community Center Drive I yellow toadflax perimeter in 2007.

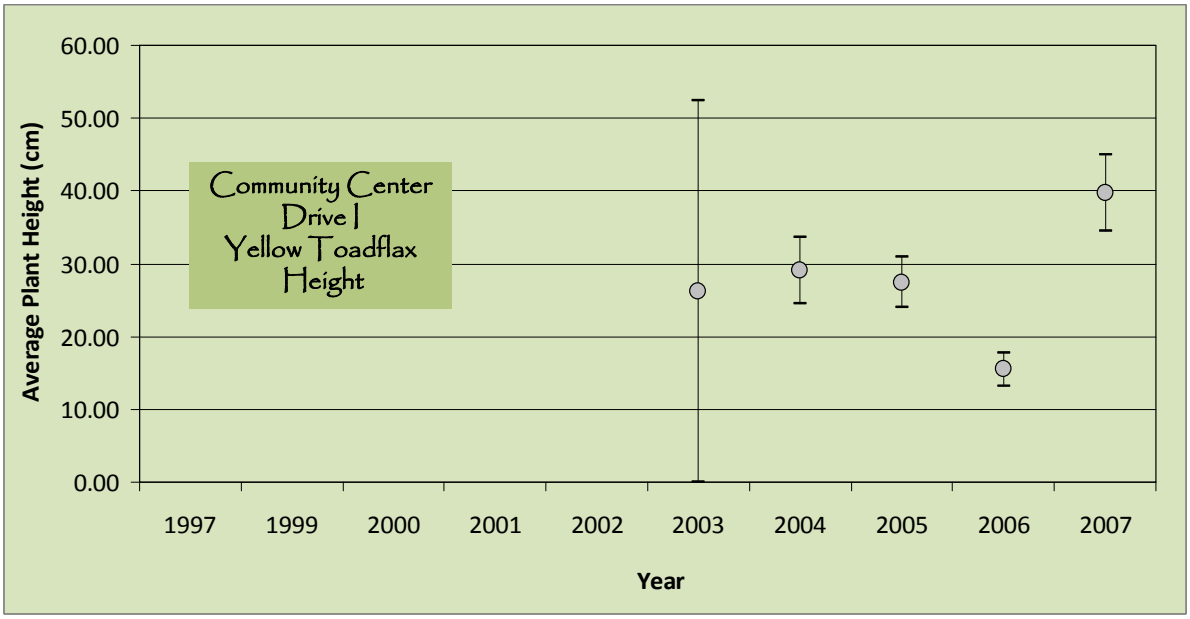


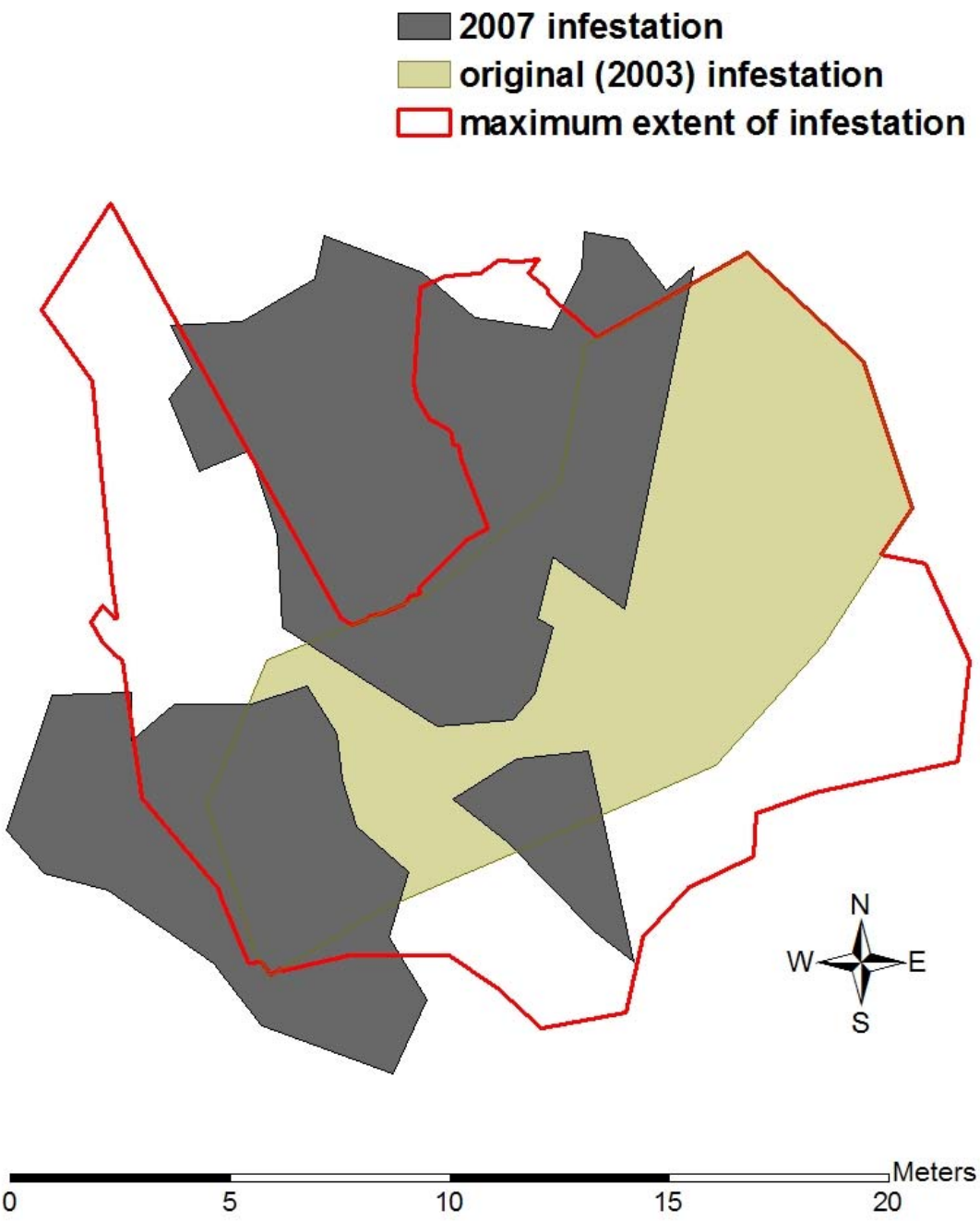
Community Center Drive I yellow toadflax density in 2007.



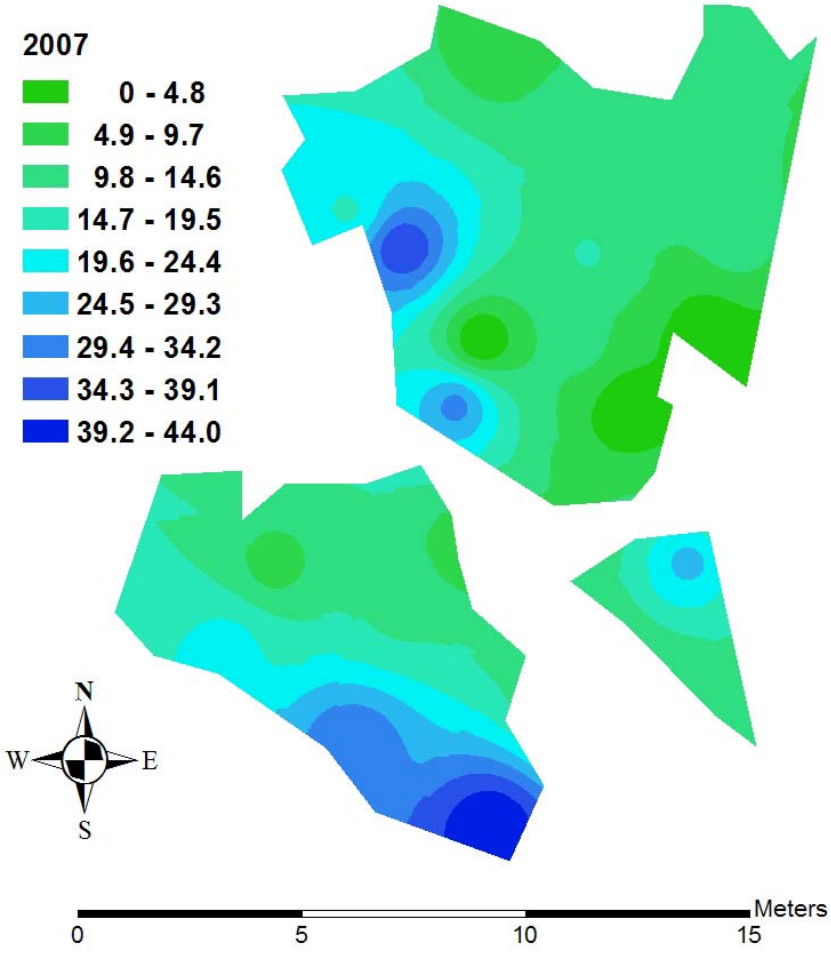


Community Center Drive I yellow toadflax height in 2007.

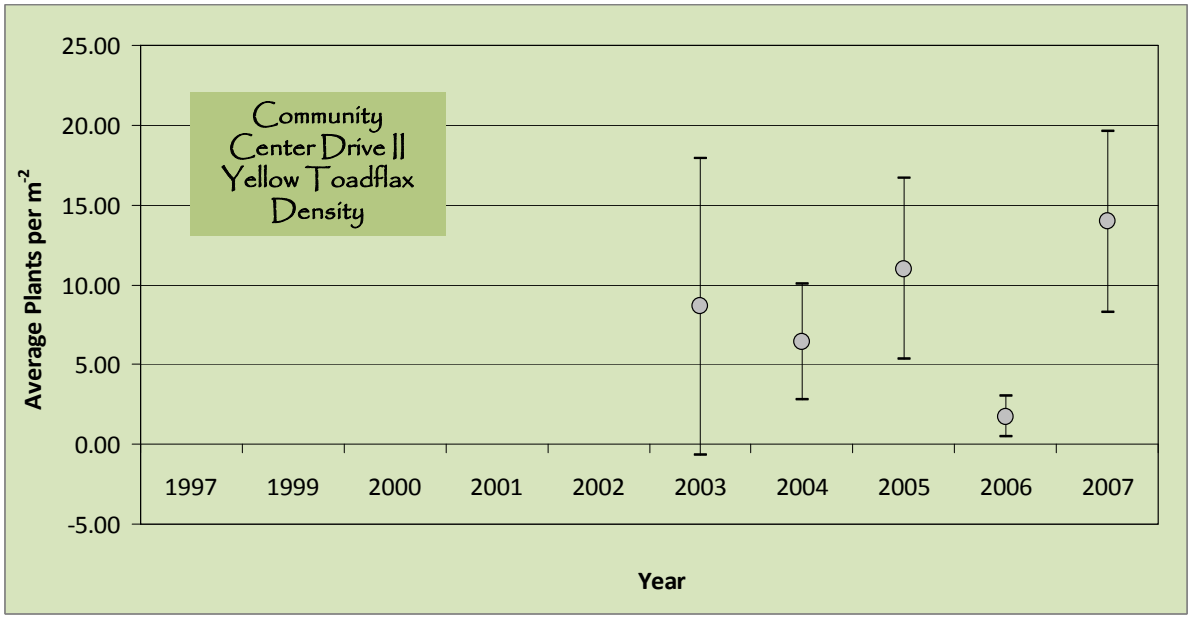


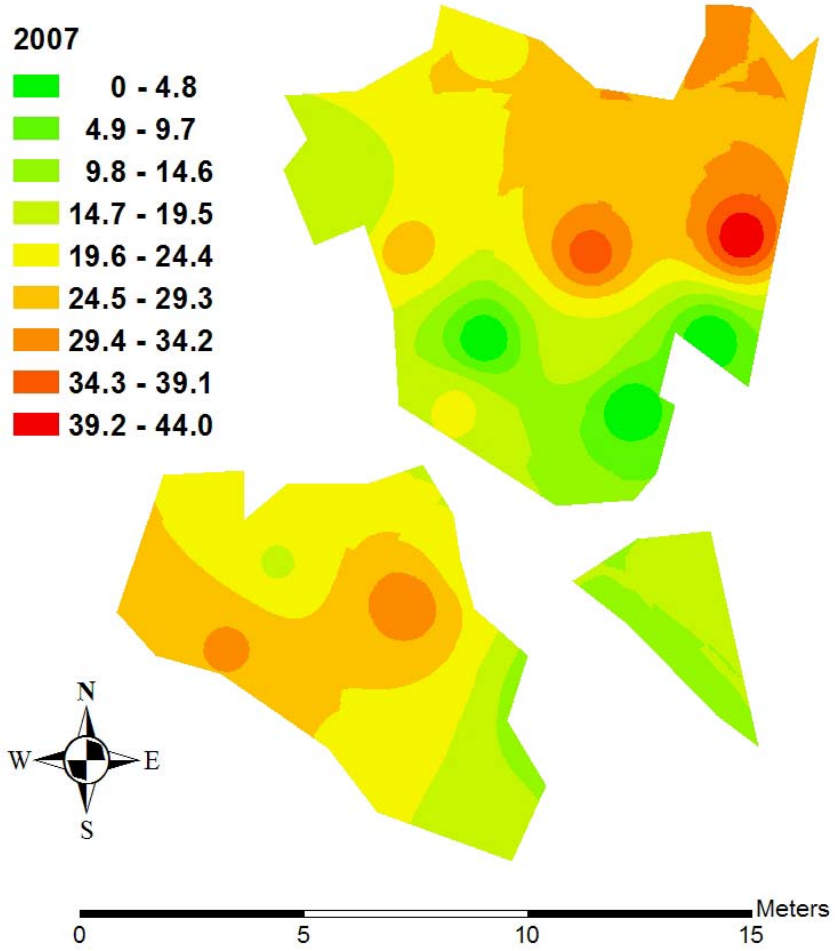


Community Center Drive II yellow toadflax perimeter in 2007.

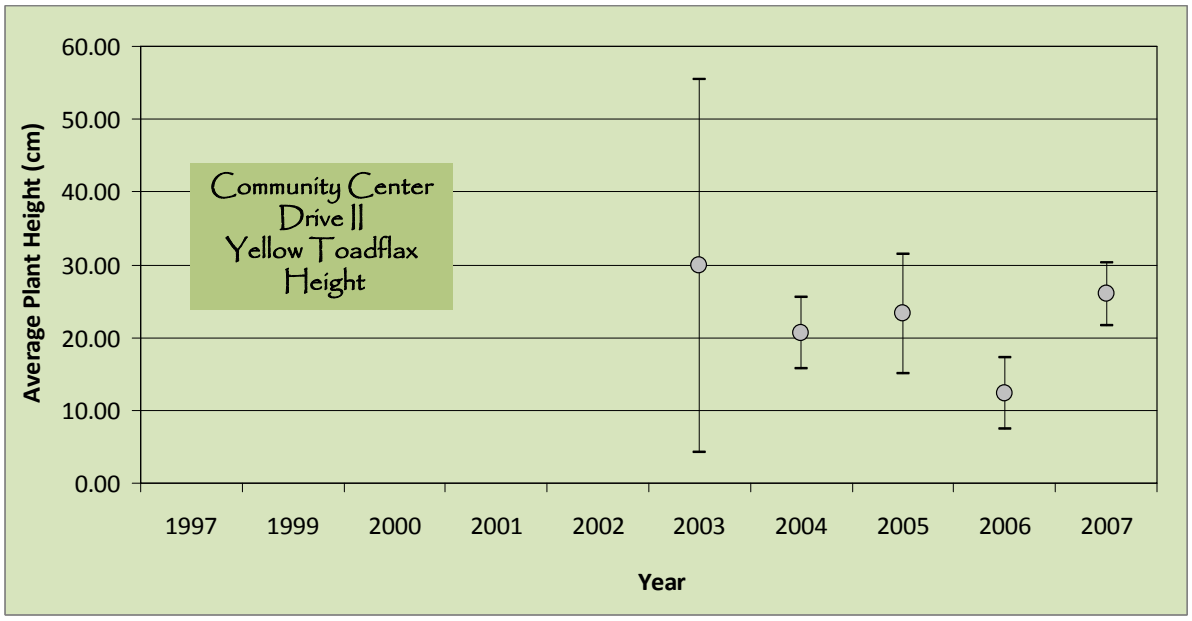


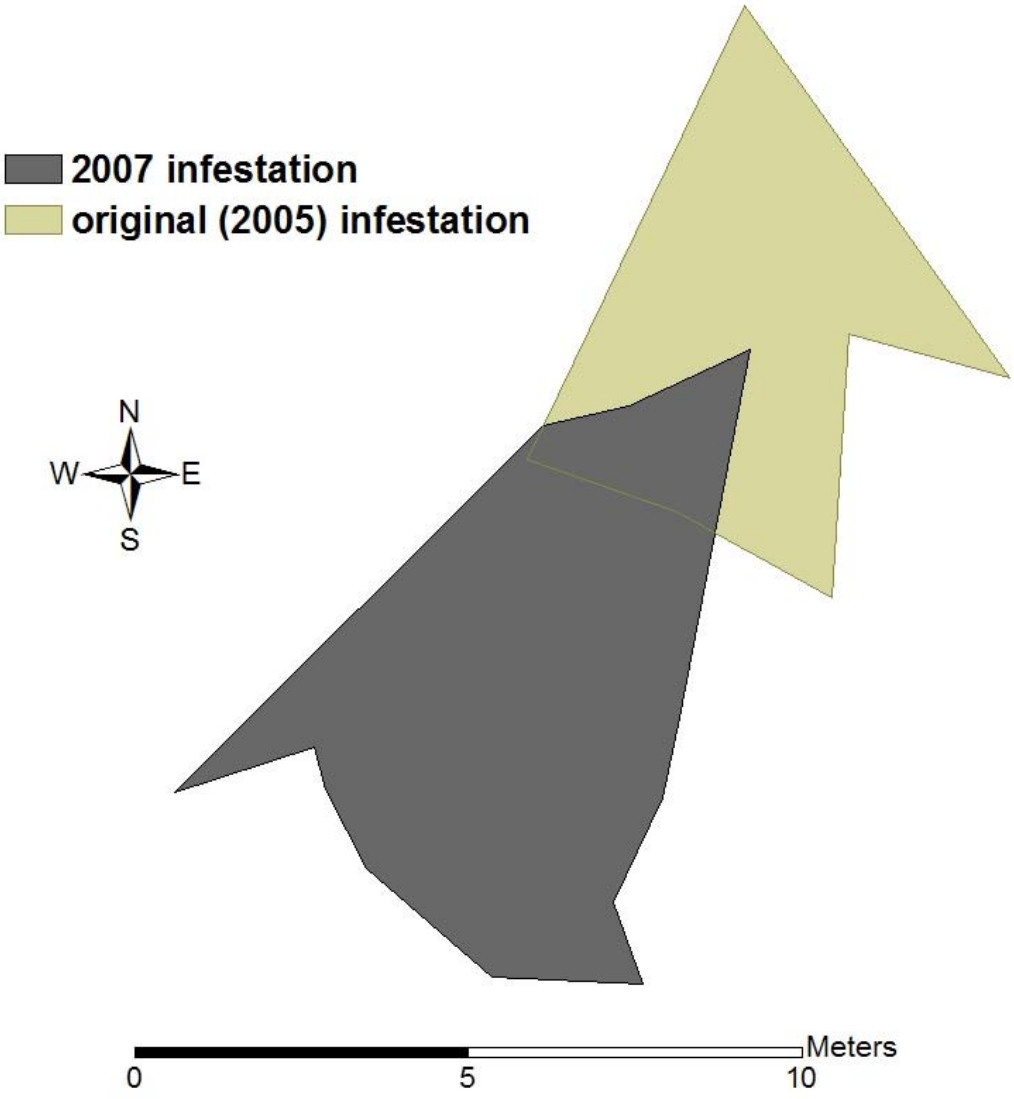
Community Center Drive II yellow toadflax density in 2007.



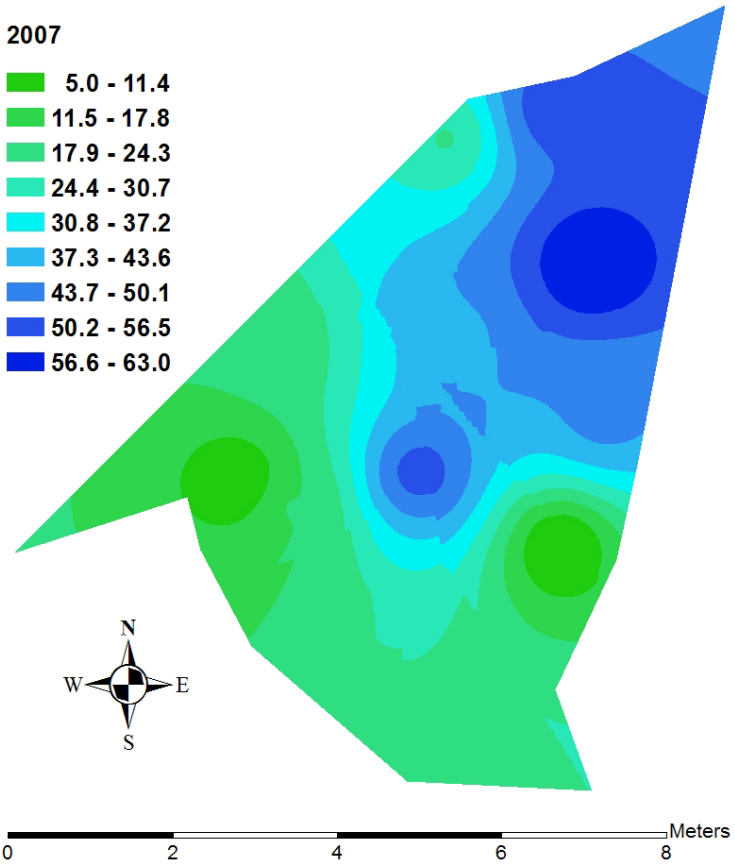


Community Center Drive II yellow toadflax height in 2007.

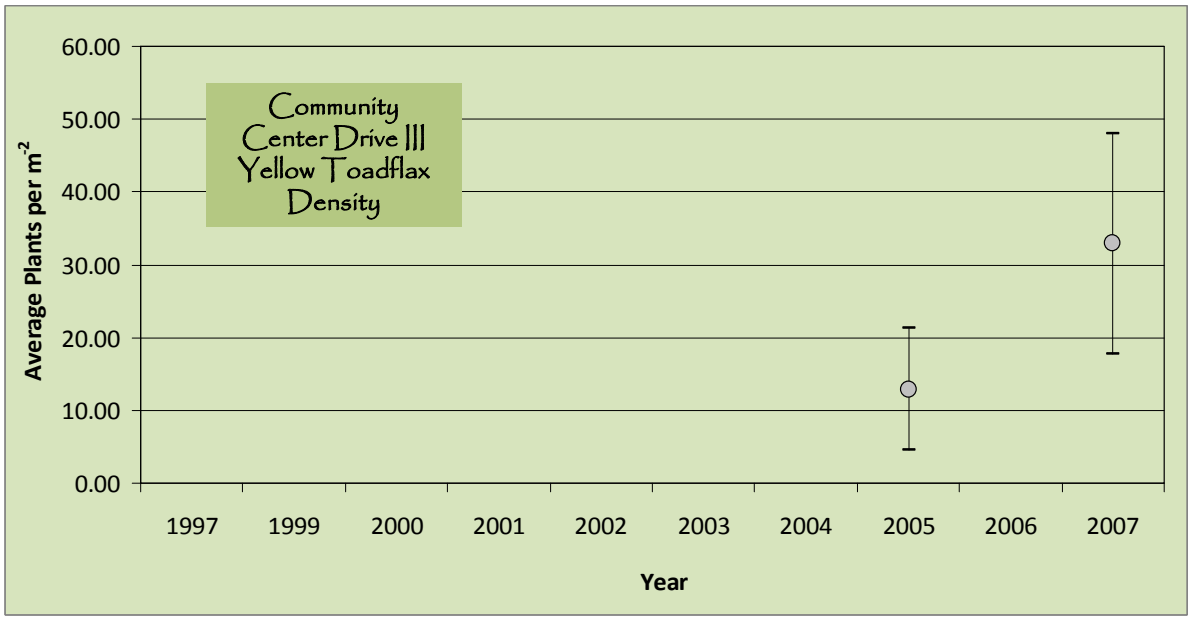


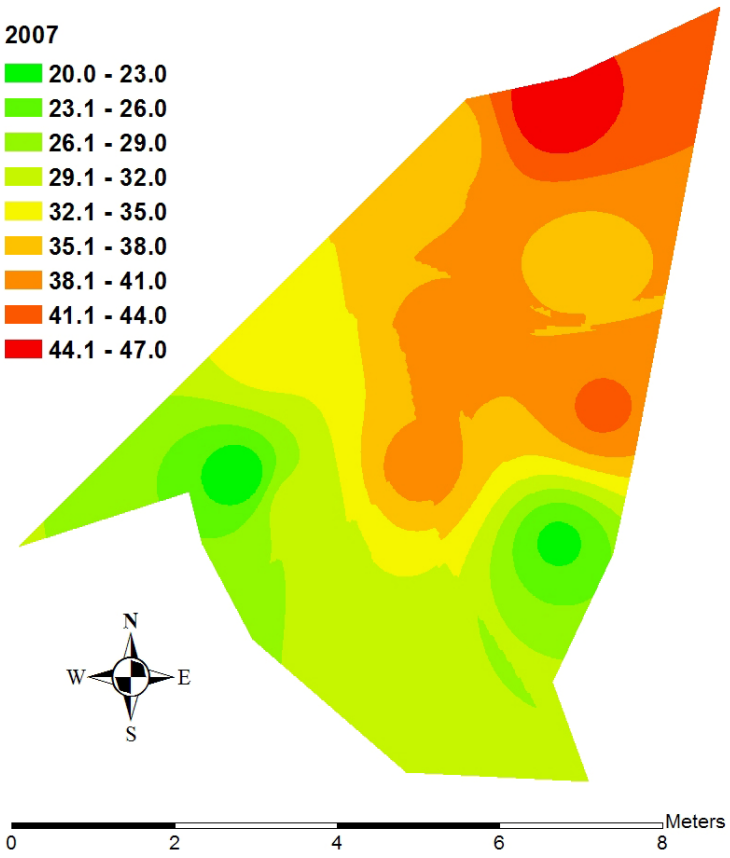


Community Center Drive III yellow toadflax perimeter in 2007.

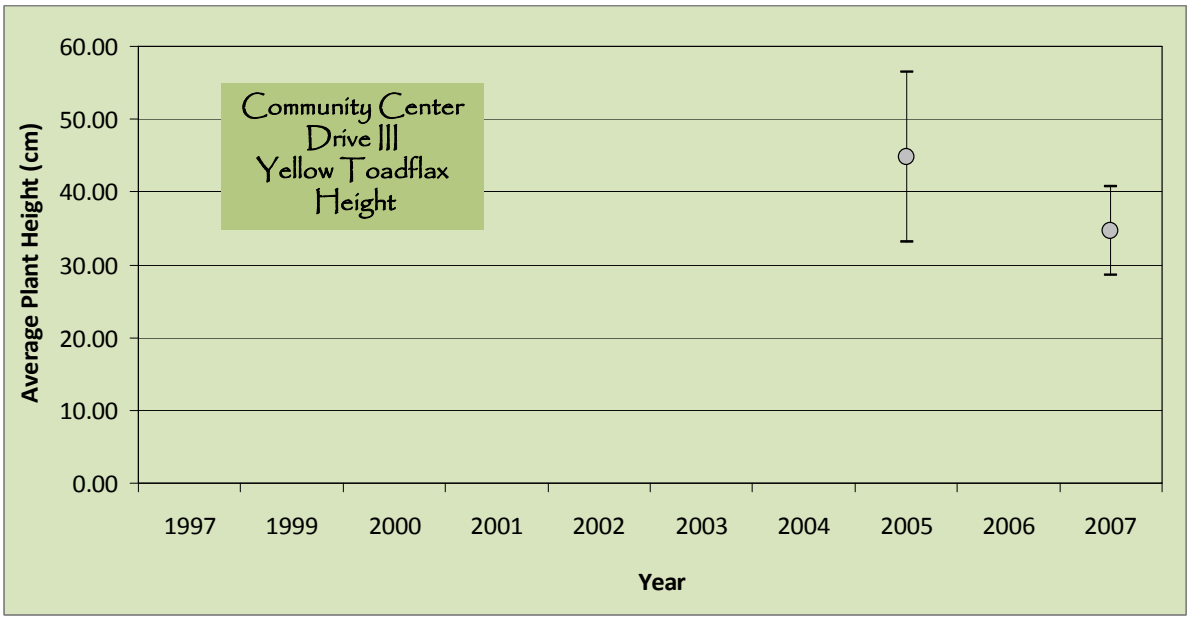


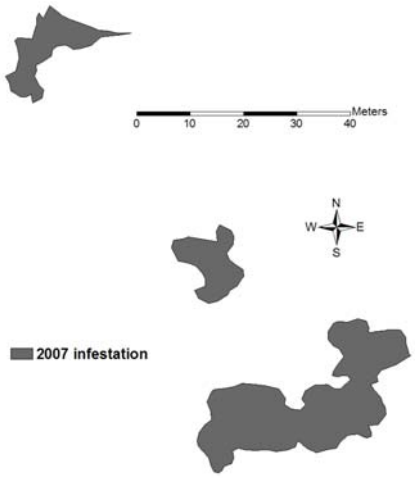
Community Center Drive III yellow toadflax density in 2007.



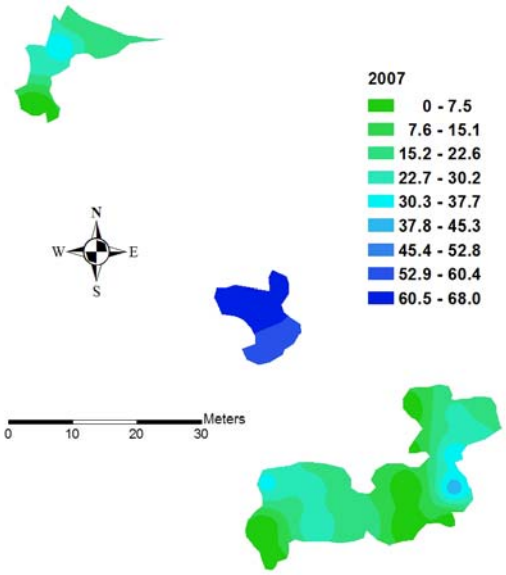


Community Center Drive III yellow toadflax height in 2007.

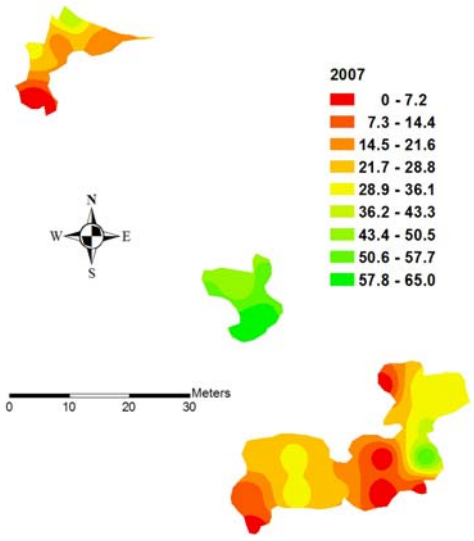




Ice Lake Road yellow toadflax perimeter in 2007.



Ice Lake Road yellow toadflax density in 2007.



Ice Lake Road yellow toadflax height in 2007.

Buckley Air Force Base

A total of 13.5 ha (33.4 acres) of weeds were mapped and eight patches intensively monitored including three Canada/musk thistle sites (12.0 ha), one Dalmatian toadflax site (0.5 ha) and four leafy spurge sites (0.9 ha) (Table 11). Two weed infestations that had traditionally been monitored, the Interior leafy spurge and South Fence Dalmatian toadflax sites, were not mapped this year as the former was mowed and access to the latter was restricted. At an additional 22 sites, weed infestations were monitored using a random sampling technique to determine changes to plant density and vigor as a follow up to biocontrol agent release in previous years. These sites included 19 *Aceria malherbae* releases on field bindweed and *Aphthona* leafy spurge beetles at three locations.

While the overall trend at Buckley Air Force Base in 2007 was moderate to large increase in both weed density and height (as observed in leafy spurge and Dalmatian toadflax base-wide), Canada thistle declined 40-60% at the Aspen and Williams Lake sites (Table 11). Although a low number of beetles have been recovered at the Aspen site to date, *Trichosirocalus horridus* has successfully established itself one year after its release (Table 12). Primarily a musk thistle agent, this weevil will feed within Canada thistle and, if its population expands, should provide some control for both thistle species intermixed at this site. We did not monitor the Canada thistle sites in 2007 for the presence of *Aceria anthocoptes*, a tissue galling mite also released in 2006, but plan to evaluate its establishment in 2008 in order to determine if these agents are also contributing to the suppression of the thistles.

Figure 6. First observation of *Trichosirocalus horridus* (right) damaging musk thistle (left) one year after release at the Aspen site.

Figure 7. *Aphthona lacertosa* attacking leafy spurge at Williams Lake on June 5, 2007 (left); *A. flava* and *A. nigriscutis* finish up the meal on June 26, 2007 (right).

Overall, leafy spurge had a favorable growing season in Colorado and Wyoming in 2007, causing the plants to rebound after an initial spring attack by bio-agents. The Runway and Williams Lake sites saw excellent defoliation in early June (Figure 7), showing characteristic damage 'halos' inflicted on leafy spurge patches near the point of release. These damage 'halos' typically occur 3-5 years post-establishment as the various species of *Aphthona* bio-agents virtually strip plants of leaves and flowers. As Figure 8 illustrates, we are beginning to achieve population hotspots of the beetles, resulting in heavily impacted plants. We are also observing self-dispersal to new areas like the North Runway sites (Table 7). With established and expanding *Aphthona* populations, along with supplementary releases, such as the 1200 beetles added to the North Runway sites in 2007, we anticipate a widening of damage 'halos' in coming years and a dramatic reduction in both population density and vigor of remaining weeds across the installation.

Figure 8. Leafy spurge was completely absent within the *Aphthona* spp. release zone at the Runway site on June 19, 2007. The damage 'halo' effect occurs when beetle populations become well established and typically just prior to massive plant damage events.

Field bindweed managed to escape serious damage from *Aceria malherbae* mites this year at all of the 19 locations monitored. Throughout Front Range installations in 2007, the bio-agents emerged from overwintering in the soil much later than its host, allowing bindweed a significant head-start past the mite's preferred stage of attack. As Figure 9 shows, mites were abundant in a few locations on base, but bindweed achieved substantial growth by the time the mites were present, mitigating any damage the mites could cause this season. There are plans to augment the existing *A. malherbae* populations in 2008 with additional mites from Texas and to coordinate releases with on-base mowing schedules for optimal bio-agent dispersal.

Figure 9. A field bindweed runner displaying healthy, mature growth in 2007 (left). Bindweed shown on the right is weak and galled indicating a heavy mite infestation.

We are observing a promising rate of establishment for *Mecinus janthinus* at the South Aspen Way site. Even prior to releases made in 2006, individual weevils had been found at there, presumably migrants from the South Fence site. In 2006, we augmented this adventitious population with 400 beetles and found that, in the following spring, 40% of the toadflax stems we collected had evidence of *M. janthinus* attack (Table 5). Stem dissections in the spring of 2007 indicate that over 50% of stems had been used for egg laying and/or beetle development, suggesting that these bio-agents are establishing well and beginning to build up in number. Stem collection and dissection will be conducted in the spring of 2008 in order to compare this season's *M. janthinus* numbers to the 2006 field populations listed in Table 5.

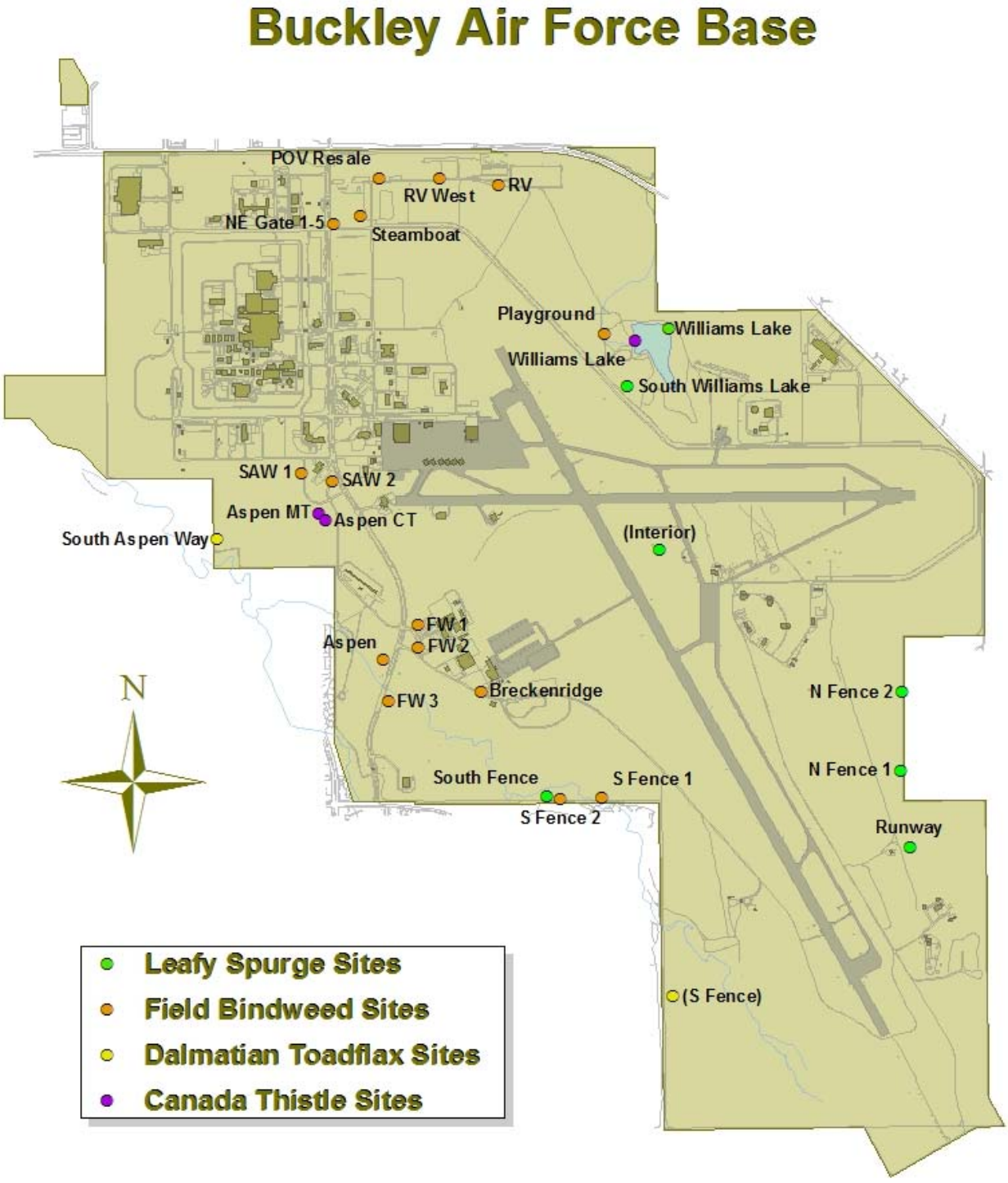


Figure 10. Schematic diagram of Buckley Air Force Base with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2007.

Table 11. Historic noxious weed infestation parameters, Buckley Air Force Base, Colorado, 2003-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
						Canada thistle – Aspen						
2006	30,861	48	11.17	74	55.56	92	19.21	0.69				
2007	36,229	44	6.52	22	84.05	127	14.03	7.76	17.39	-41.63	51.28	17.39
						Canada thistle – Williams Lake						
2003	1,070	129	6.45	26	65.92	145	17.83	0.71				
2004	1,419	66	9.52	47	51.92	98	1.40	1.80	32.63	47.60	-21.24	
2005	2,004	40	5.26	18	74.31	105	18.97	0.88	41.23	-44.75	43.12	
2006	1,117	33	6.48	32	35.61	76	4.11	0.33	-44.26	23.19	-52.08	
2007	1,074	56	2.71	14	76.68	111	9.44	6.06	-3.85	-58.18	115.33	0.37
						Musk thistle - Aspen						
2007	83,162	47	2.17	20	124.28	197			n/a	n/a	n/a	n/a
						Leafy spurge - Interior						
2005	102	28	8.07	99	39.59	57						
2006	111	10	1.00	4	22.00	34			8.82	-87.61	-44.43	
2007	*(see Note a)*											
						Leafy spurge - Runway						
2004	597	44	22.61	42	35.09	54						
2005	751	34	29.50	95	43.92	66			25.80	30.47	25.16	
2006	656	28	10.57	39	8.42	25			-12.65	-64.17	-80.83	
2007	1,037	45	28.24	169	45.94	71			58.08	167.17	445.61	73.70
						Leafy spurge – South Fence						
2006	705	28	13.07	48	42.46	76						
2007	794	30	23.80	55	67.83	103			12.62	82.10	59.75	12.62

Table 11. Historic noxious weed infestation parameters, Buckley Air Force Base, Colorado, 2003-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Leafy spurge – Southwest Williams Lake												
2004	530	24	8.92	26	25.13	52						
2005	646	40	16.62	77	29.64	54			21.89	86.32	17.95	
2006	1,039	34	7.91	32	12.02	23			60.84	-52.41	-59.45	
2007	1,066	31	24.03	167	25.77	63			2.60	203.79	114.39	101.13
Leafy spurge – Williams Lake												
2003	4,615	112	36.53	123	51.06	98						
2004	3,617	77	15.01	52	39.61	73			-21.63	-58.91	-22.42	
2005	2,890	33	27.52	97	39.69	63			-20.10	83.34	0.20	
2006	3,572	45	19.62	97	30.80	89			23.60	-28.71	-22.40	
2007	6,386	56	28.82	182	48.92	77			78.78	46.89	58.83	38.37
Dalmatian toadflax – South Aspen Way												
2003	3,185											
2004	300	20	0.95	7	11.40	38			-99.08			
2005	275	28	12.00	61	39.47	59	10.61		-8.33	1163.16	246.23	
2006	1,328	29	2.76	18	14.43	28			382.91	-77.00	-63.44	
2007	5,044	47	4.19	35	64.97	98			279.82	51.81	350.24	58.37
Dalmatian toadflax – South Fence												
2003	32,556	374	3.50	78	36.10	128						
2004	20,657	101	3.31	18	29.28	82			-36.55	-5.43	-18.89	
2005	20,443	68	18.70	56	56.76	78	20.71		-1.04	464.95	93.85	
2006	35,786	35	3.03	15	33.03	57	10.55		75.05	-83.80	-41.81	
2007	*(see Note b)*											

n – number of samples or observations
n/a – not applicable, data represent first year of sampling
Note - Could not map this site, as: a) weeds were mowed prior to our survey, or b) site was inaccessible

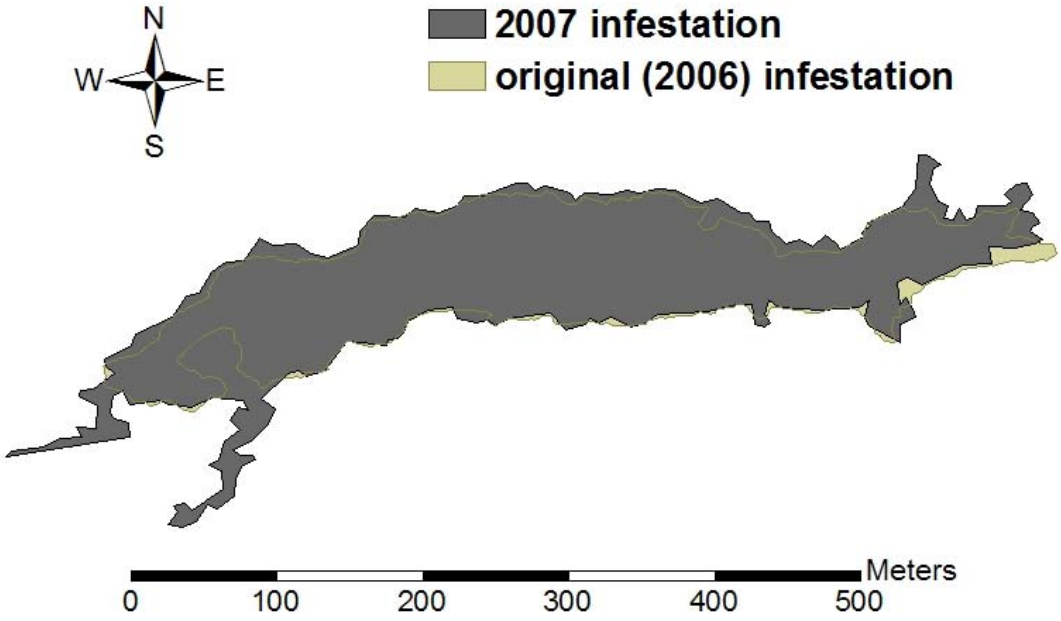
Table 12. Noxious weed biological control sites, target weeds, species released and recoveries at Buckley Air Force Base, Colorado, 2007.

Release Location	Target Weed	Release Site	Species released	Species recovered	New releases	New site
Buckley Airbase	Canada thistle	Aspen	*Aceria anthocoptes*			
Buckley Airbase	Canada thistle	Aspen	*Trichosirocalus horridus*	X [2]		
Buckley Airbase	Canada thistle	Williams Lake	*Cassida rubiginosa*			
Buckley Airbase	Canada thistle	Williams Lake	*Trichosirocalus horridus*	X [1]		
Buckley Airbase	Canada thistle	Williams Lake	*Urophora cardui*			
Buckley Airbase	Musk thistle	Aspen	*Trichosirocalus horridus*	X [2]		X
Buckley Airbase	Leafy spurge	Interior	*Aphthona flava*			
Buckley Airbase	Leafy spurge	Interior	*Aphthona nigriscutis*	X		
Buckley Airbase	Leafy spurge	Runway North	*Aphthona czwalinae*	X [2]	X	
Buckley Airbase	Leafy spurge	Runway North	*Aphthona flava*	X	X	
Buckley Airbase	Leafy spurge	Runway North	*Aphthona nigriscutis*	X	X	
Buckley Airbase	Leafy spurge	Runway	*Aphthona flava*	X		
Buckley Airbase	Leafy spurge	Runway	*Aphthona nigriscutis*	X		

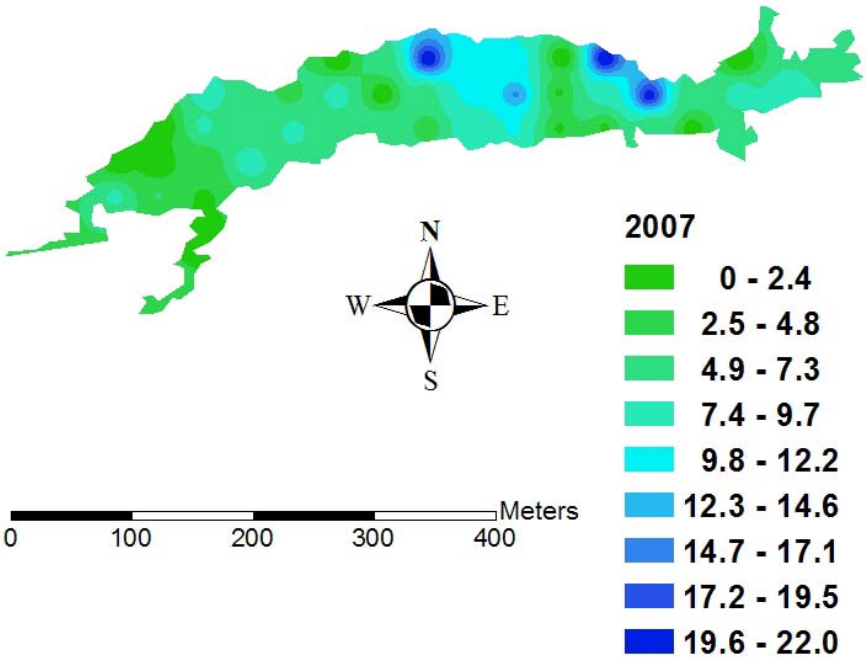
Table 12. Noxious weed biological control sites, target weeds, species released and recoveries at Buckley Air Force Base, Colorado, 2007.

Release Location	Target Weed	Release Site	Species released	Species recovered	New releases	New site
Buckley Airbase	Leafy spurge	South Fence	*Aphthona cyparissiae*	X		
Buckley Airbase	Leafy spurge	South Fence	*Aphthona czwalinae*	X		
Buckley Airbase	Leafy spurge	South Fence	*Aphthona lacertosa*	X		
Buckley Airbase	Leafy spurge	South Fence	*Aphthona nigriscutis*	X		
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona cyparissiae*	X		
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona czwalinae*	X [2]		
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona flava*	X		
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona lacertosa*			
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona nigriscutis*	X		
Buckley Airbase	Leafy spurge	Williams Lake	*Spurgia esula*			
Buckley Airbase	Leafy spurge	Southwest Williams Lake	*Aphthona cyparissiae*			
Buckley Airbase	Leafy spurge	Southwest Williams Lake	*Aphthona czwalinae*			
Buckley Airbase	Leafy spurge	Southwest Williams Lake	*Aphthona flava*	X		
Buckley Airbase	Leafy spurge	Southwest Williams Lake	*Aphthona lacertosa*			
Buckley Airbase	Leafy spurge	Southwest Williams Lake	*Aphthona nigriscutis*	X		
Buckley Airbase	Dalmatian toadflax	South Aspen Way	*Mecinus janthinus*	X [1]	X	
Buckley Airbase	Dalmatian toadflax	South Fence	*Mecinus janthinus*	X		

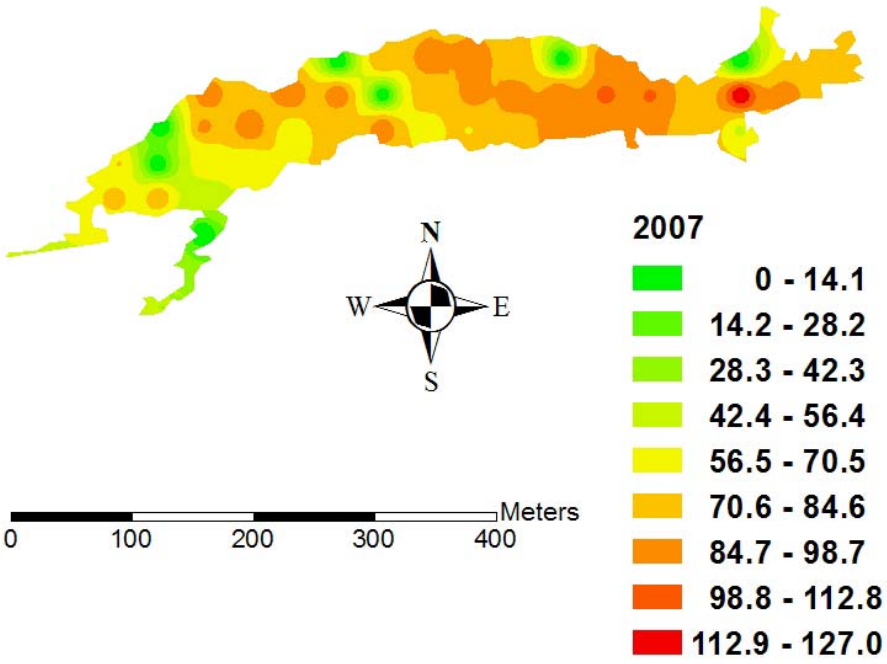
[1] Adventitious recovery, insects were not released at this location
[2] New insect recovery in 2007



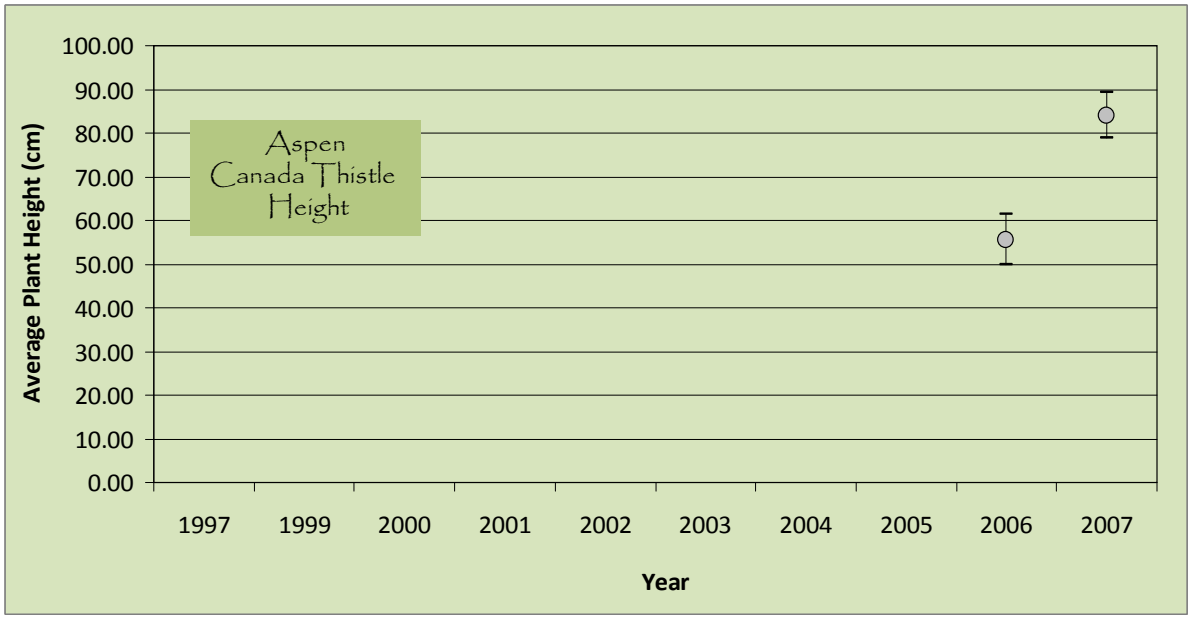
Aspen Canada thistle perimeter in 2007.

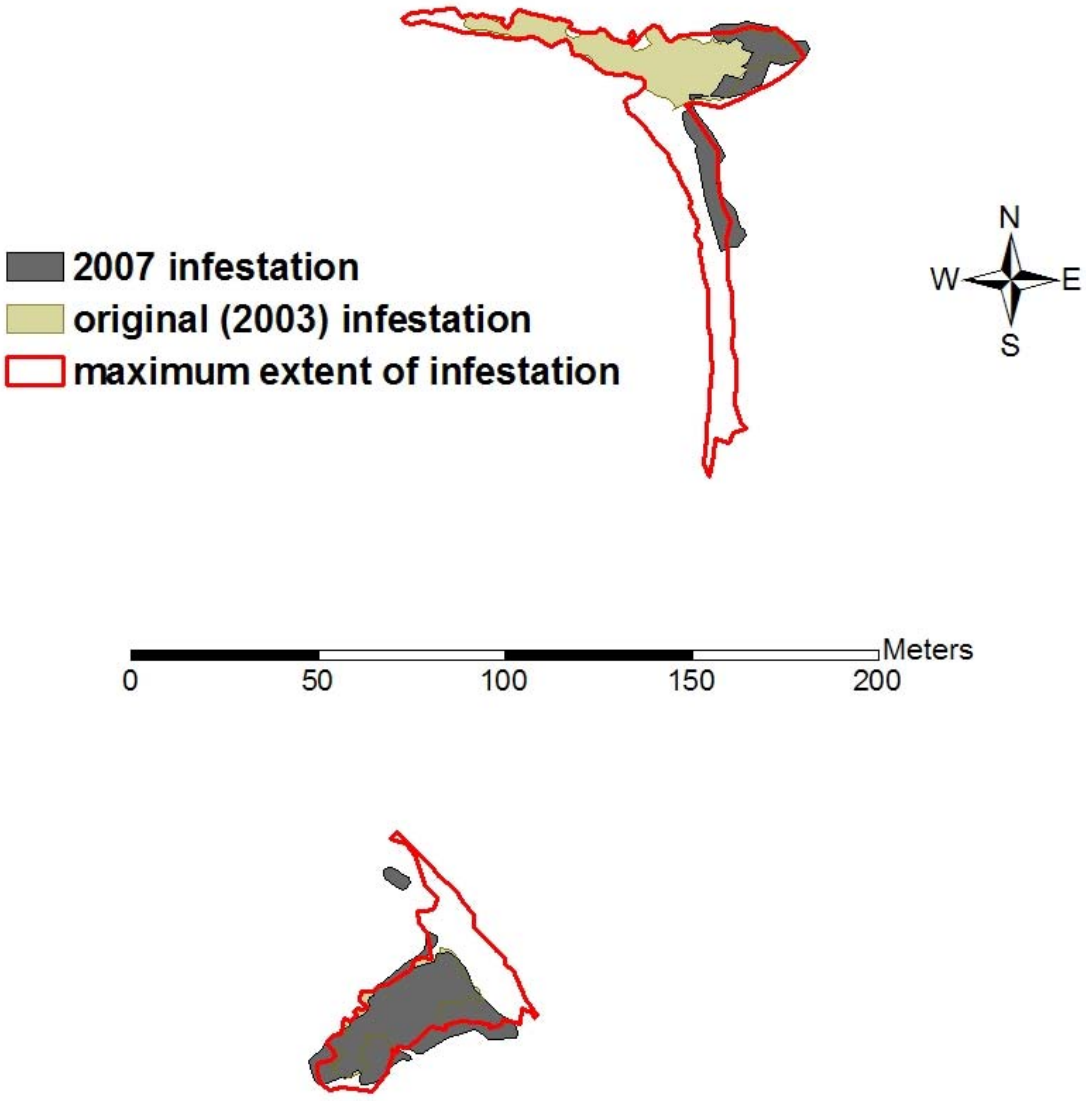


Aspen Canada thistle density in 2007.

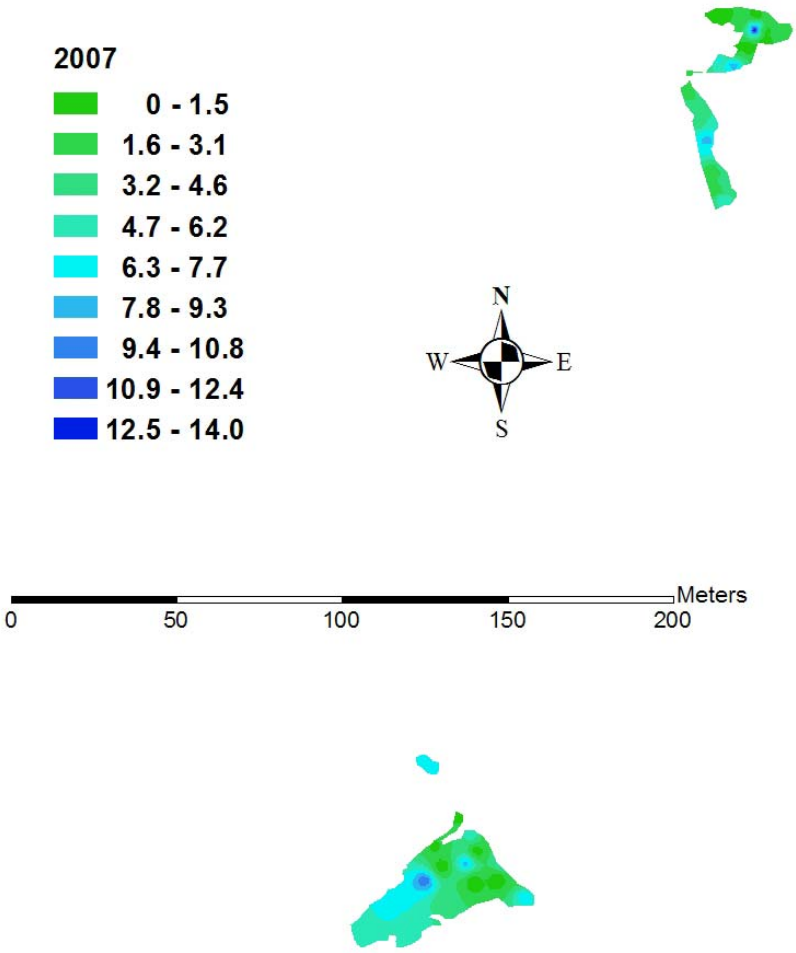


Aspen Canada thistle height in 2007.

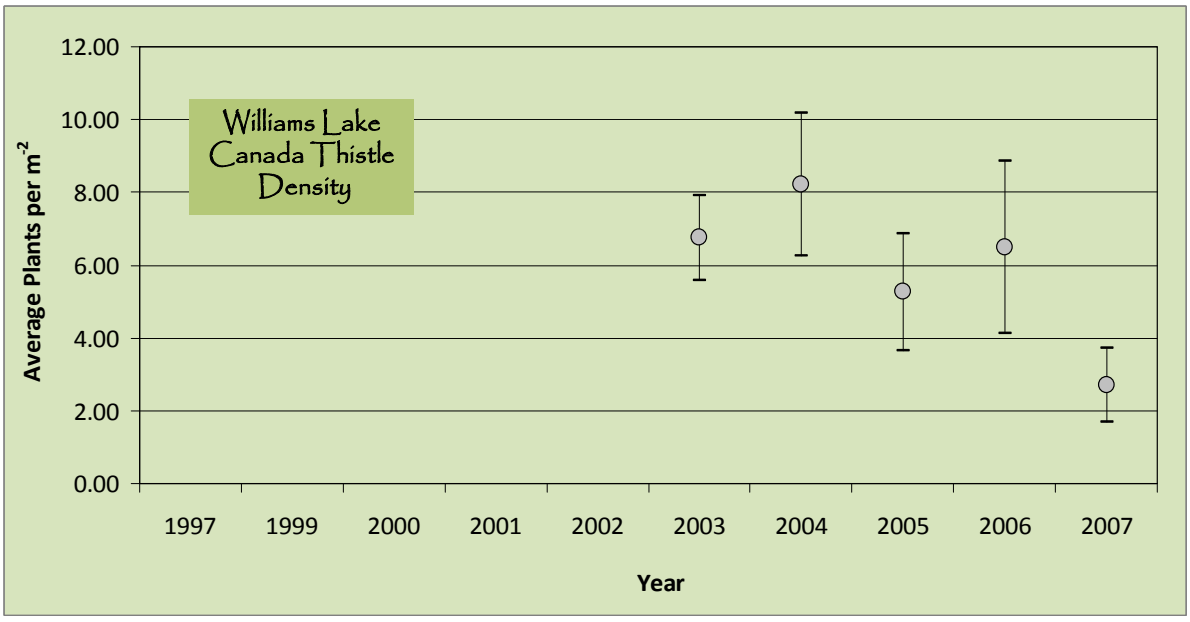


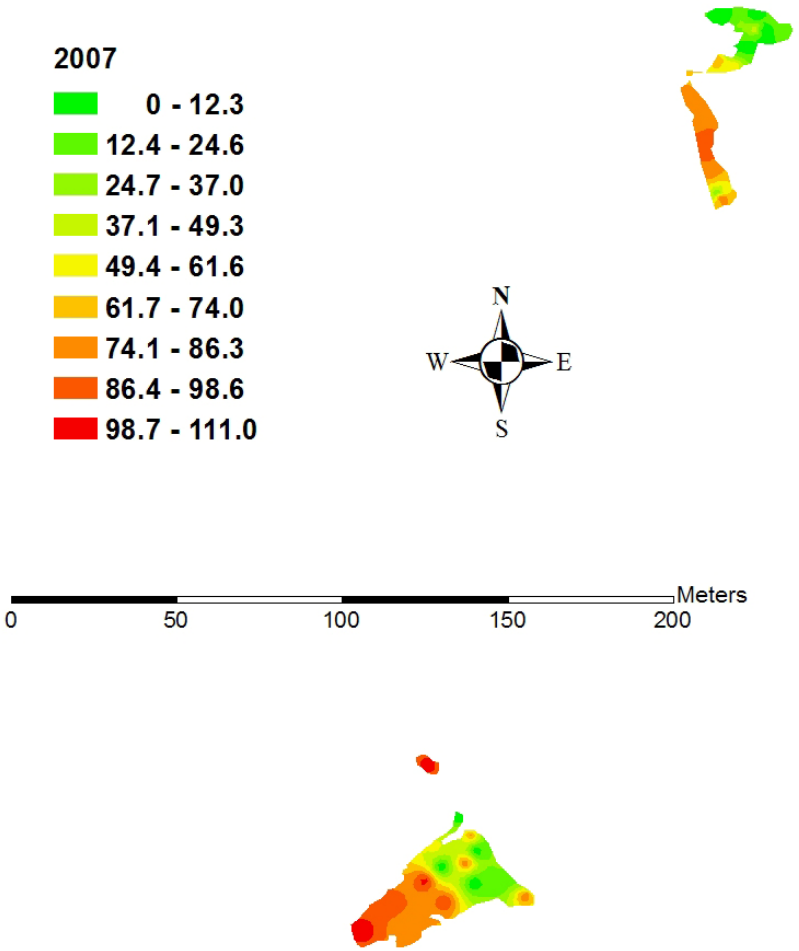


Williams Lake Canada thistle perimeter in 2007.

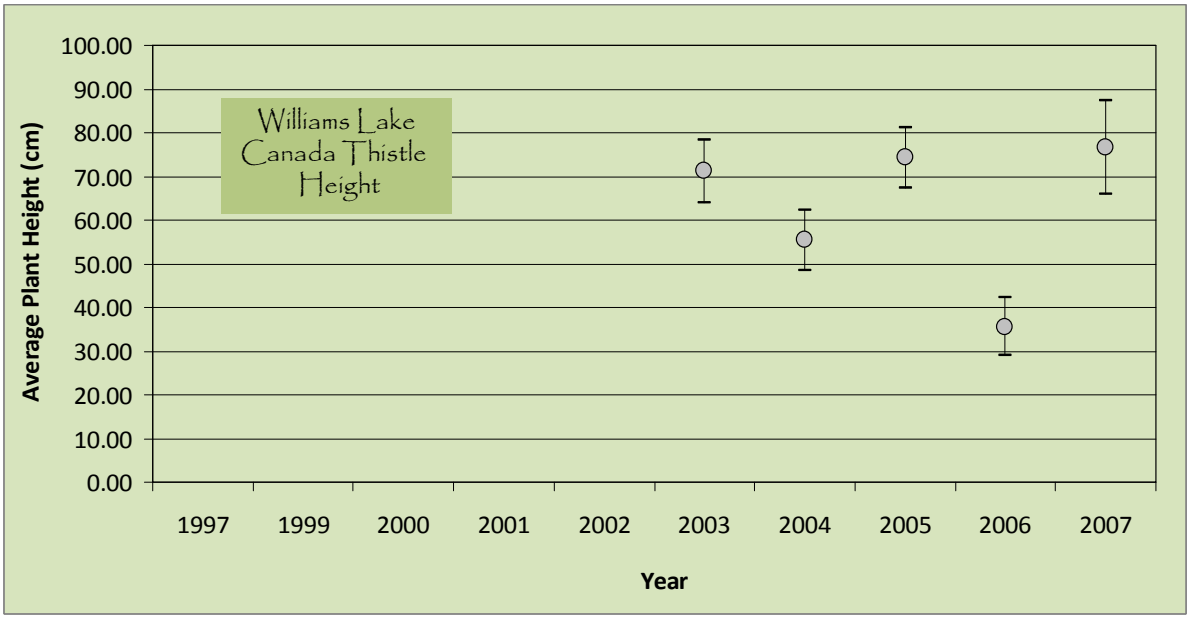


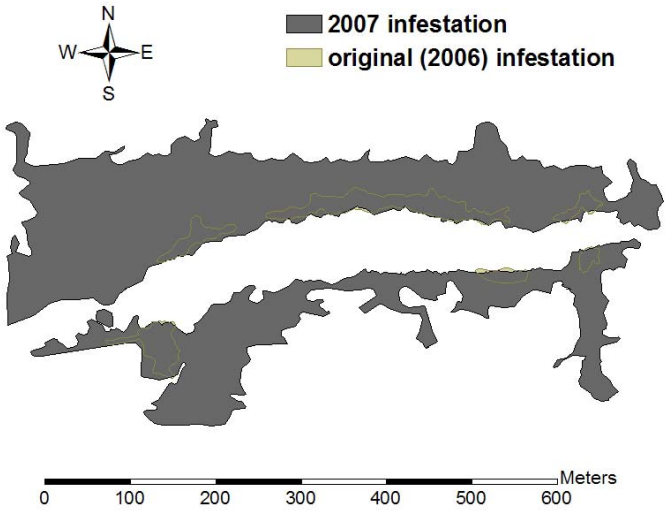
Williams Lake Canada thistle density in 2007.



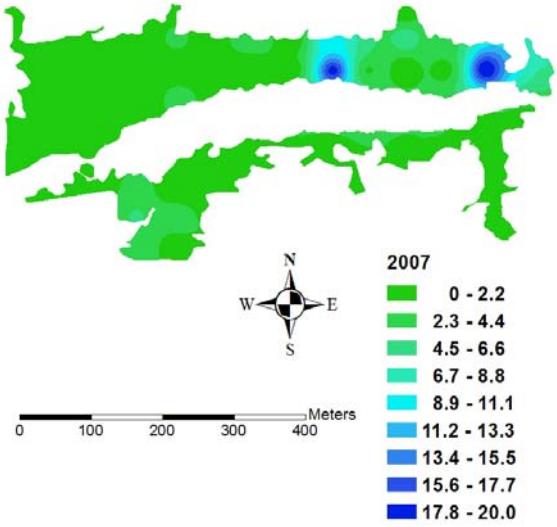


Williams Lake Canada thistle height in 2007.

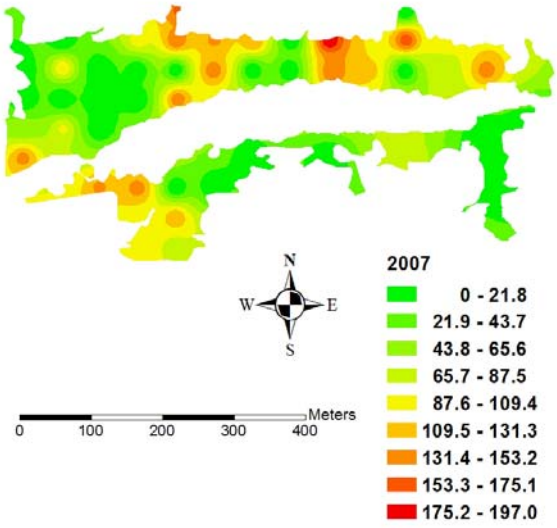




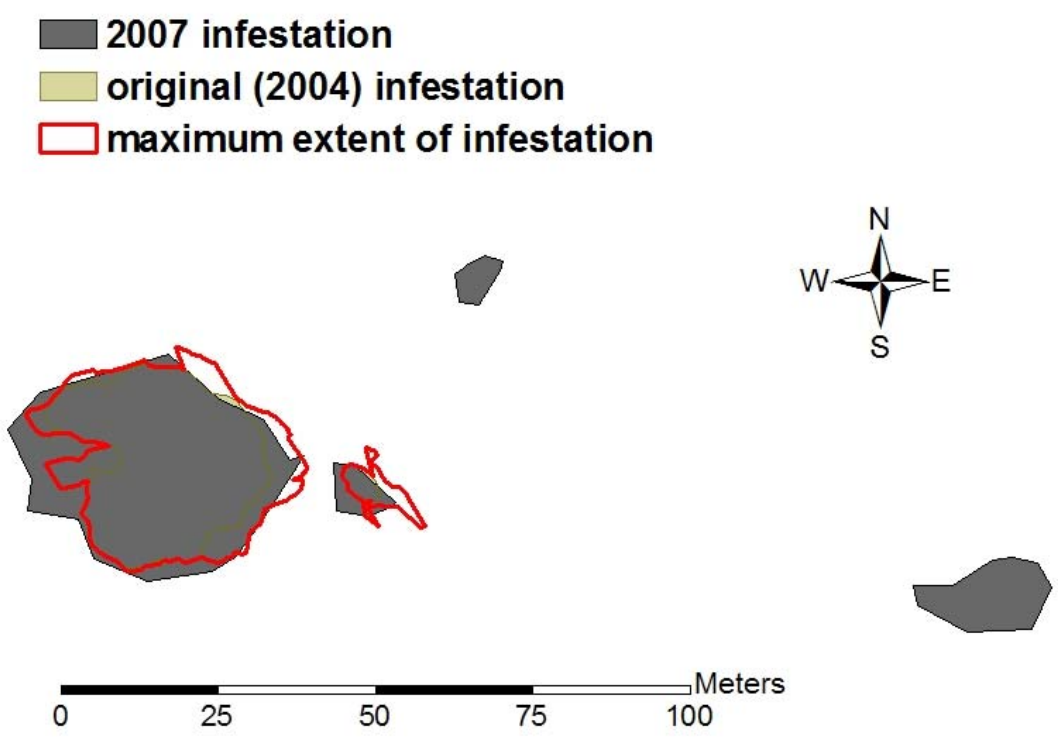
Aspen musk thistle perimeter in 2007.



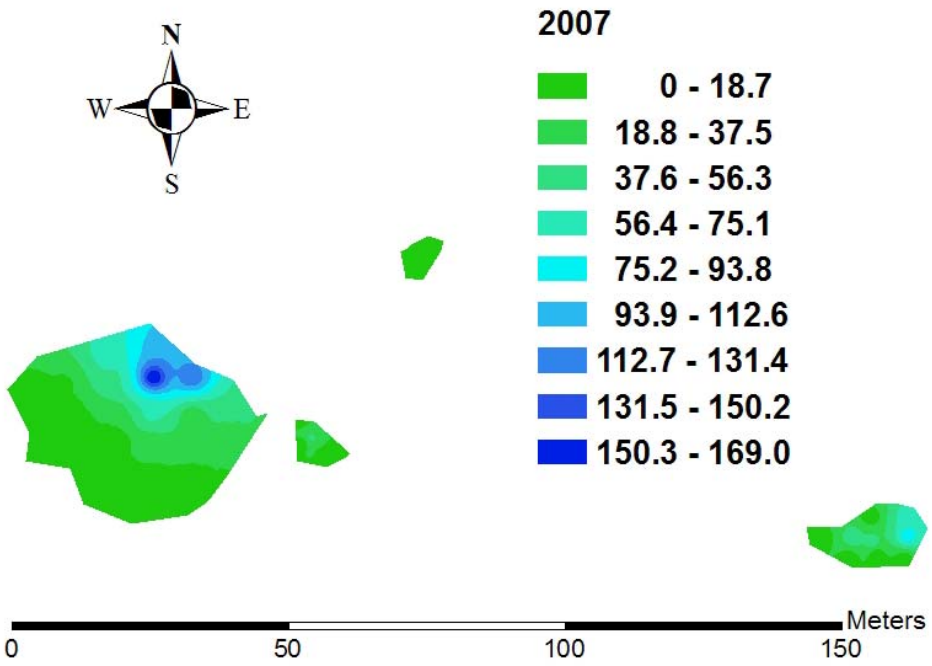
Aspen musk thistle density in 2007.



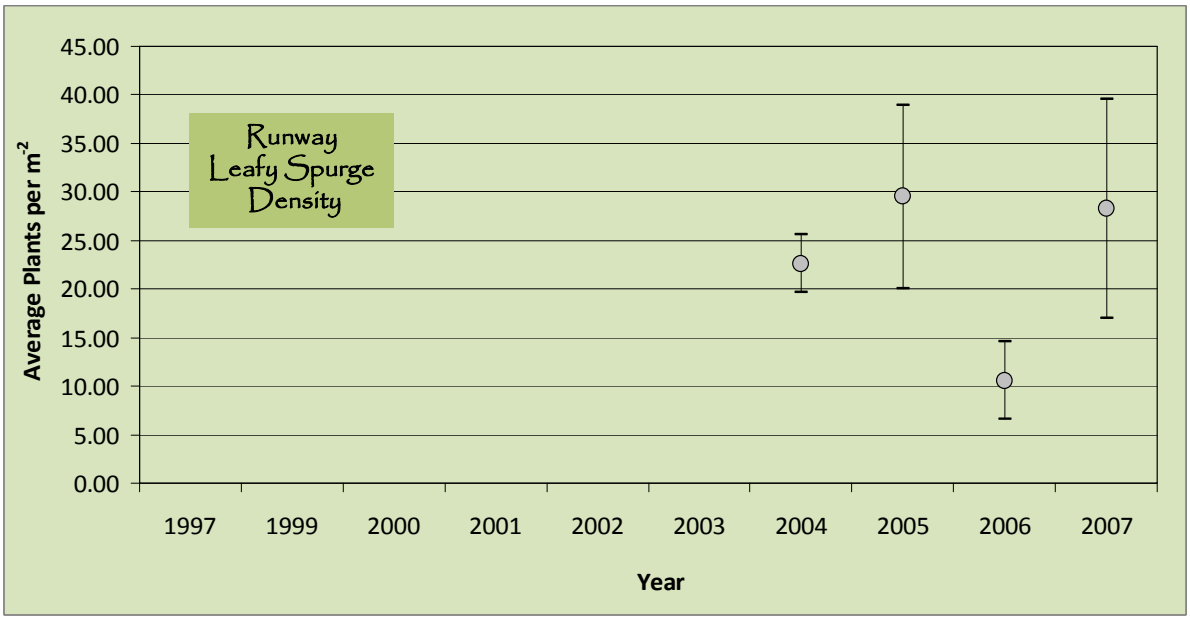
Aspen musk thistle height in 2007.

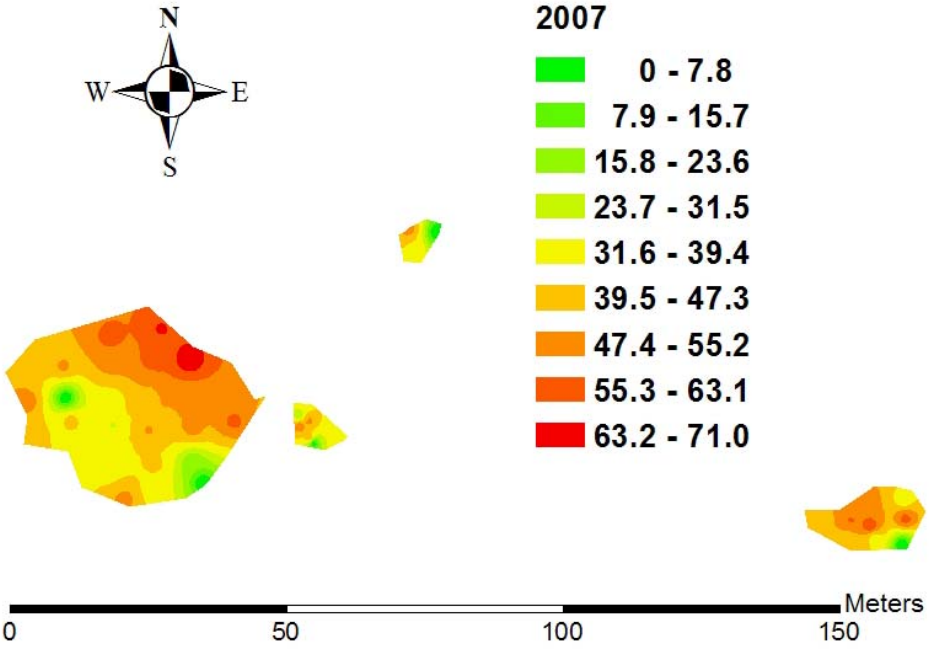


Runway leafy spurge perimeter in 2007.

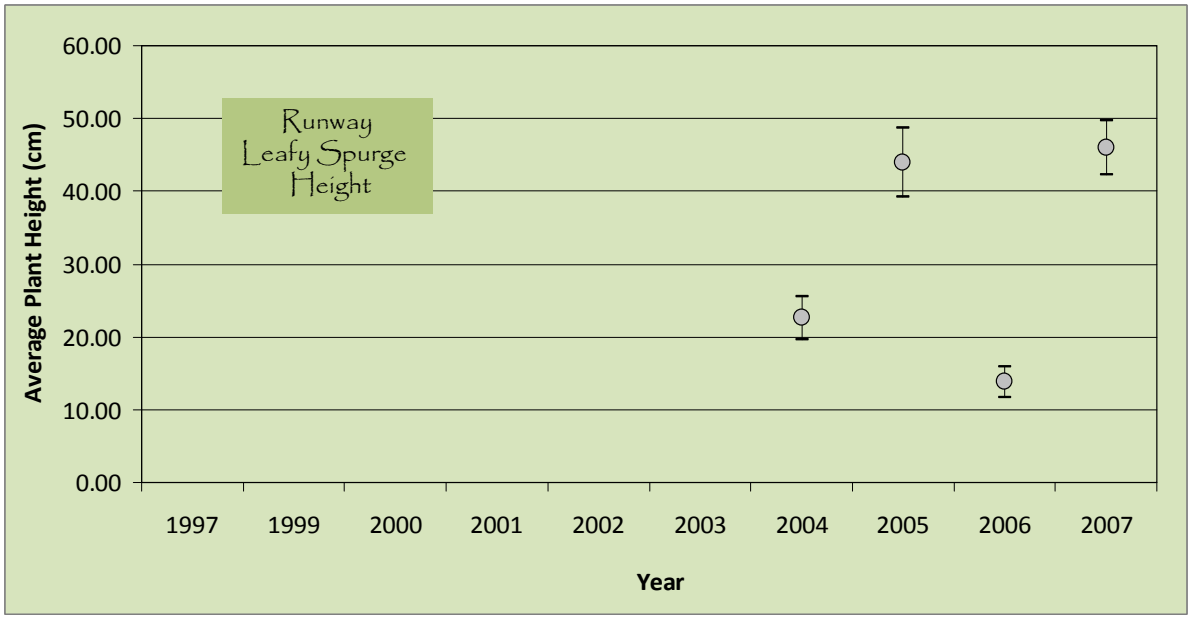


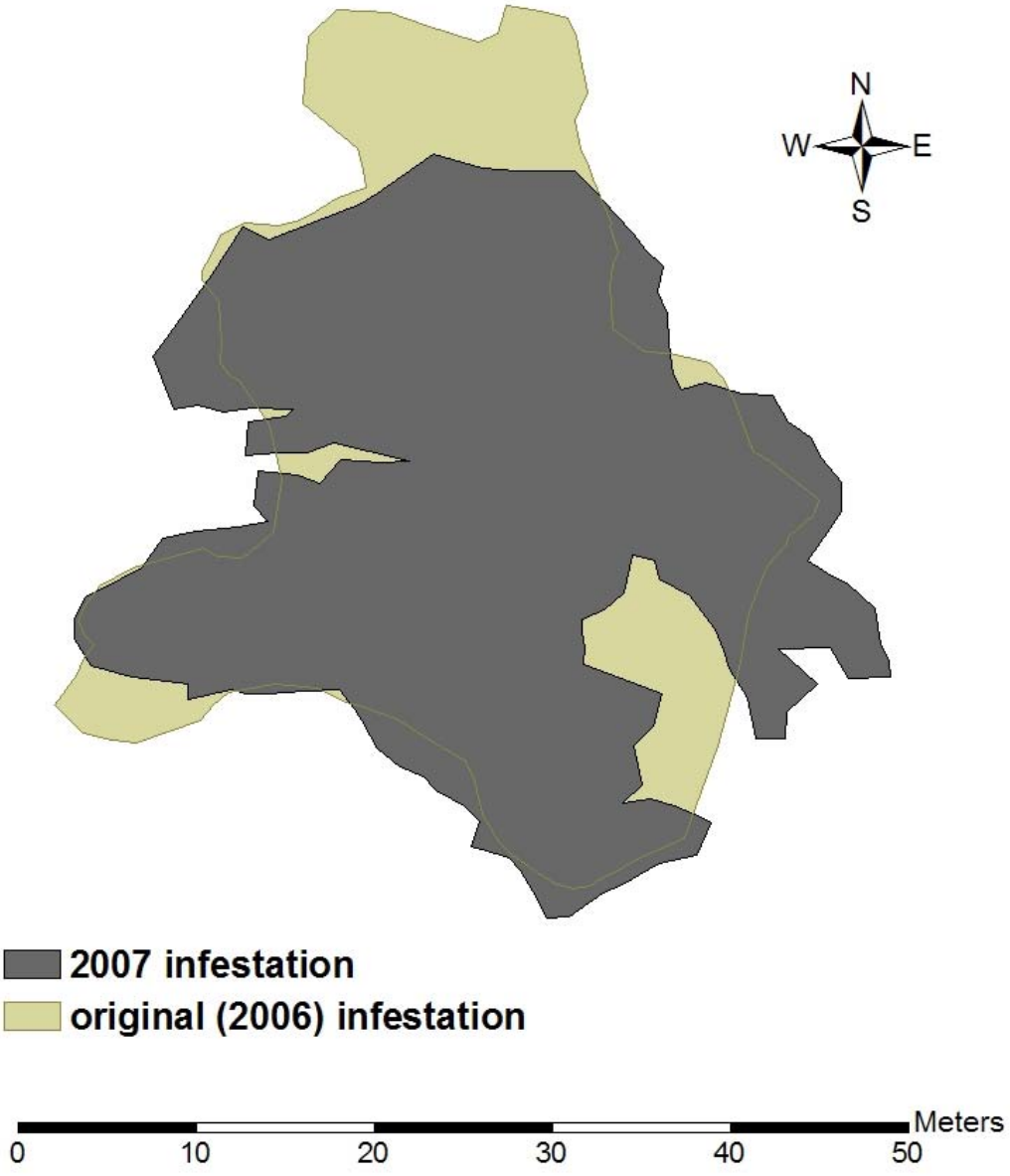
Runway leafy spurge density in 2007.



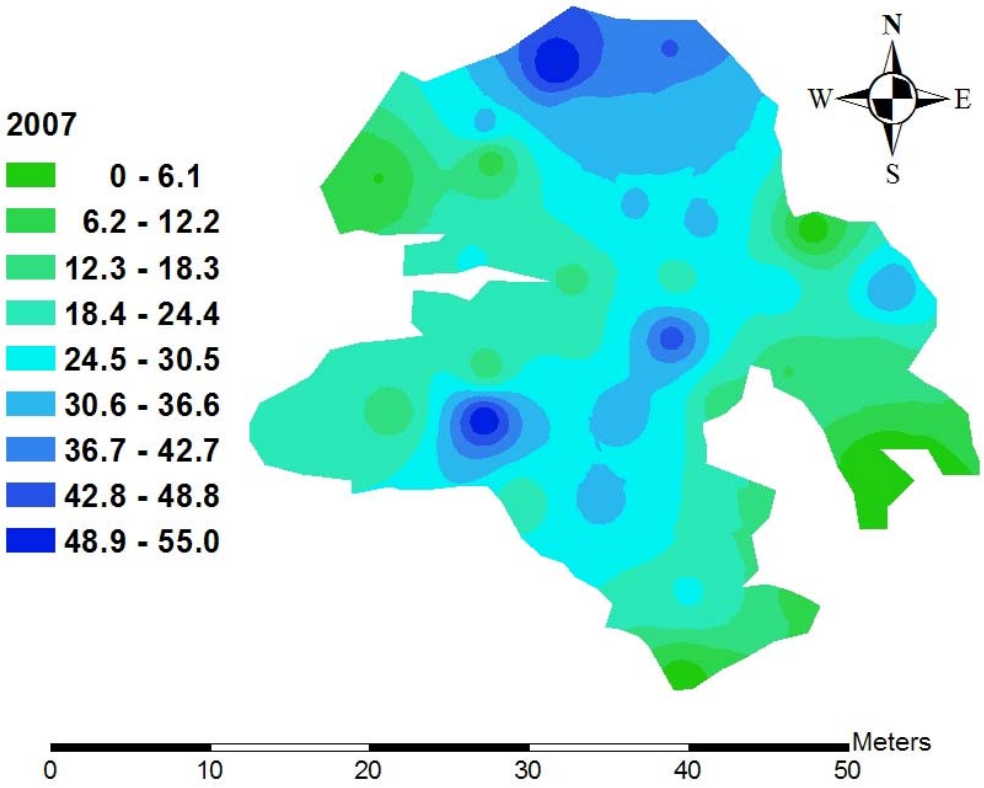


Runway leafy spurge height in 2007.

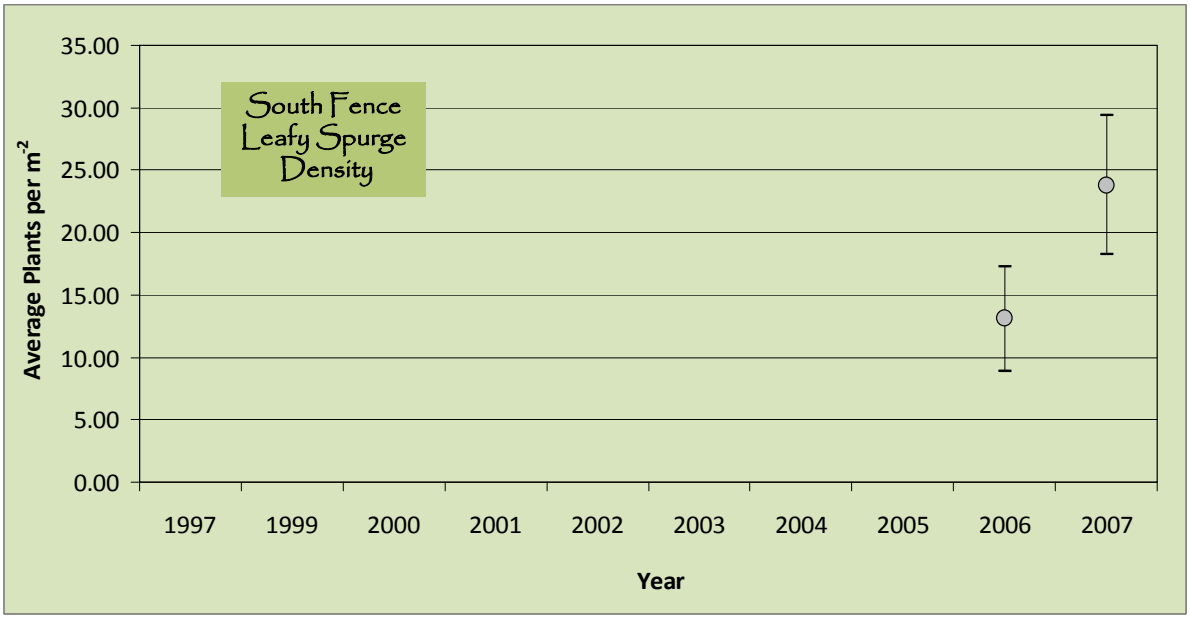


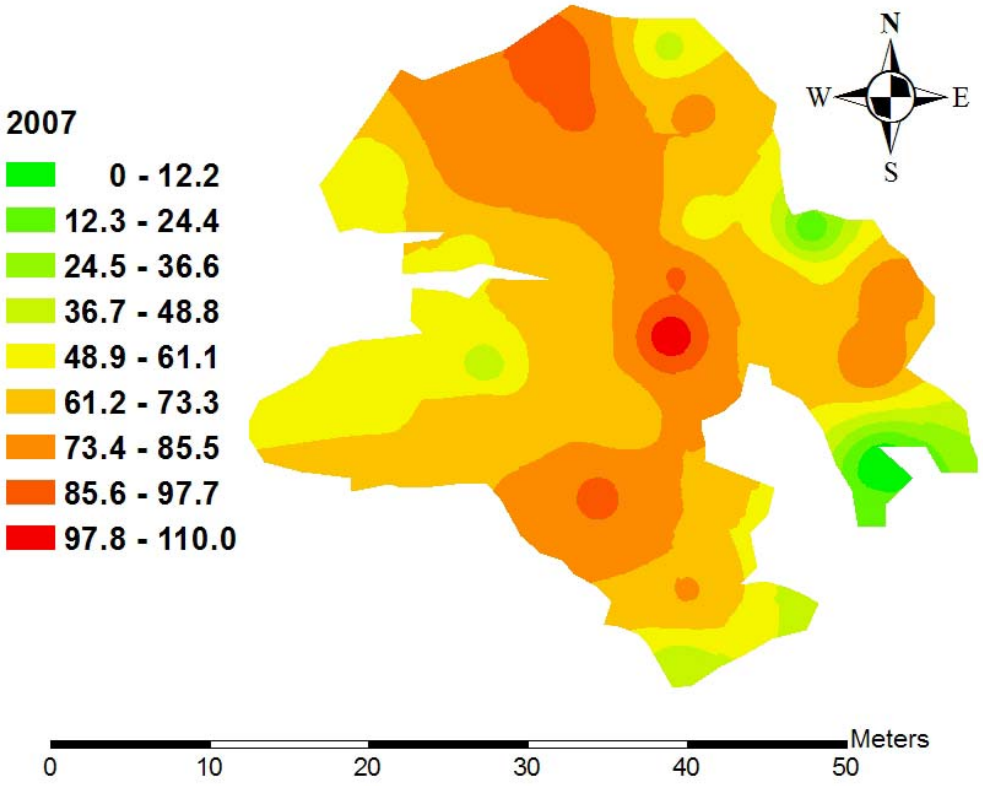


South Fence leafy spurge perimeter in 2007.

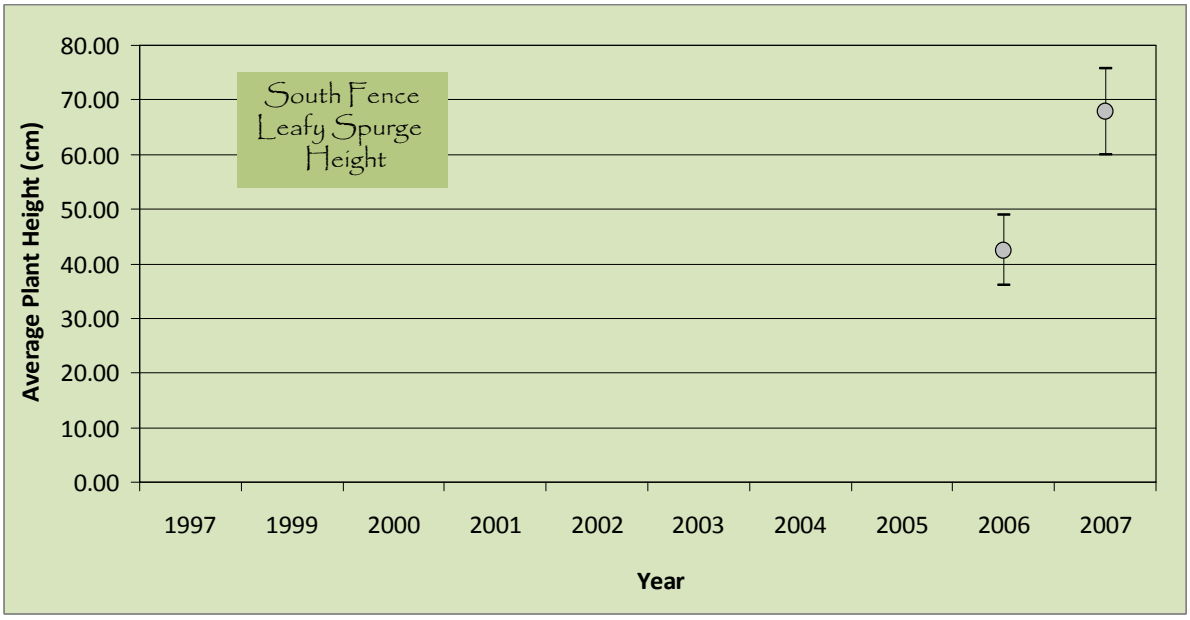


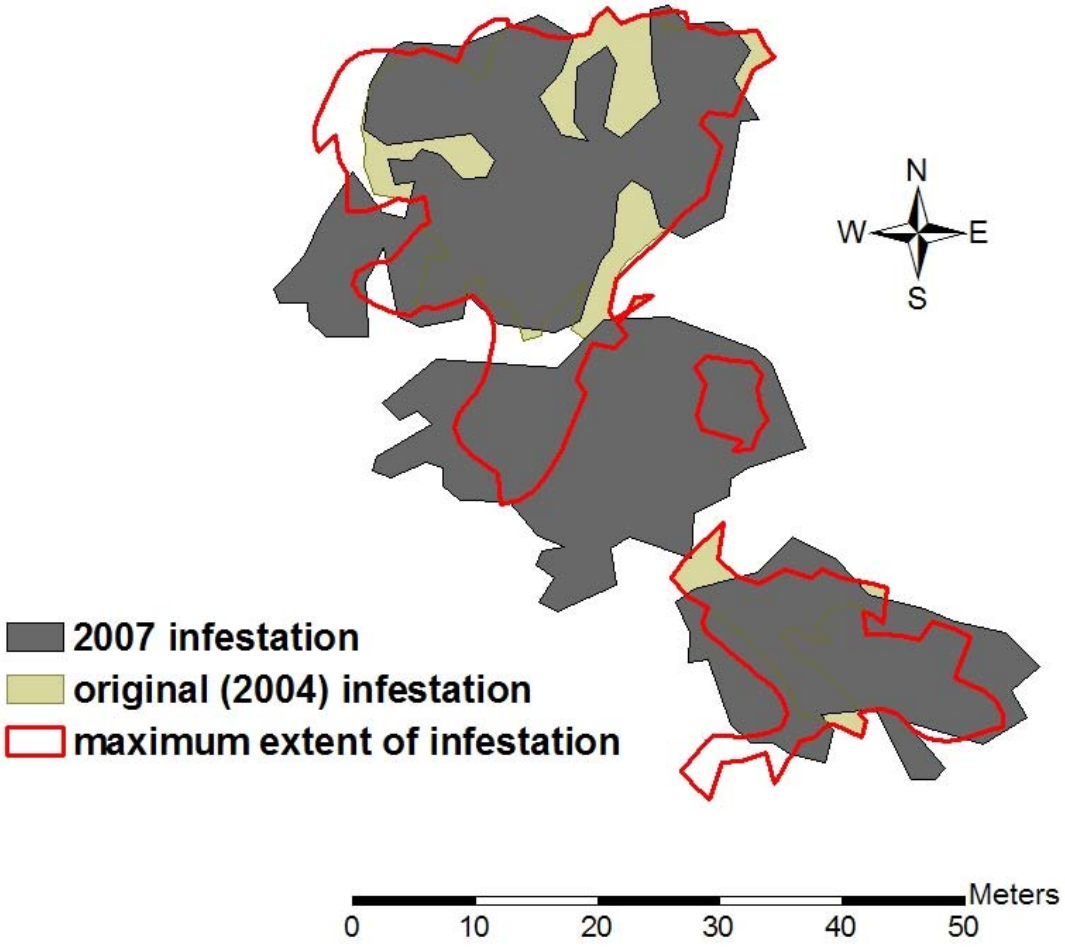
South Fence leafy spurge density in 2007.



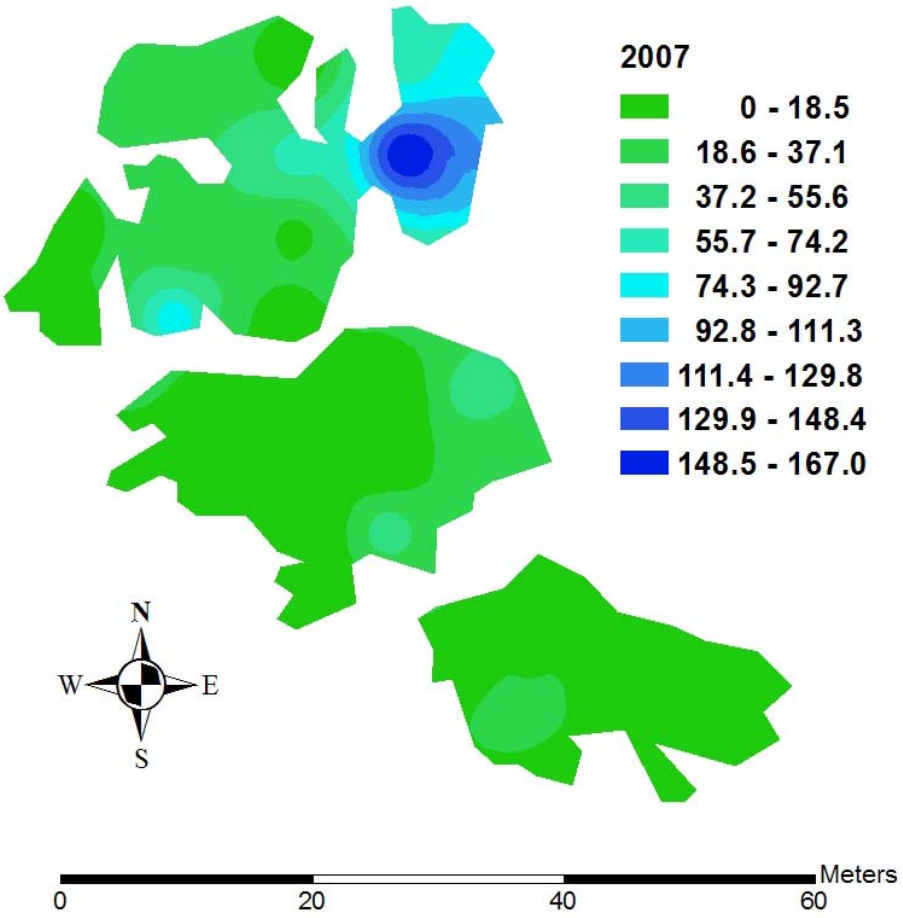


South Fence leafy spurge height in 2007.

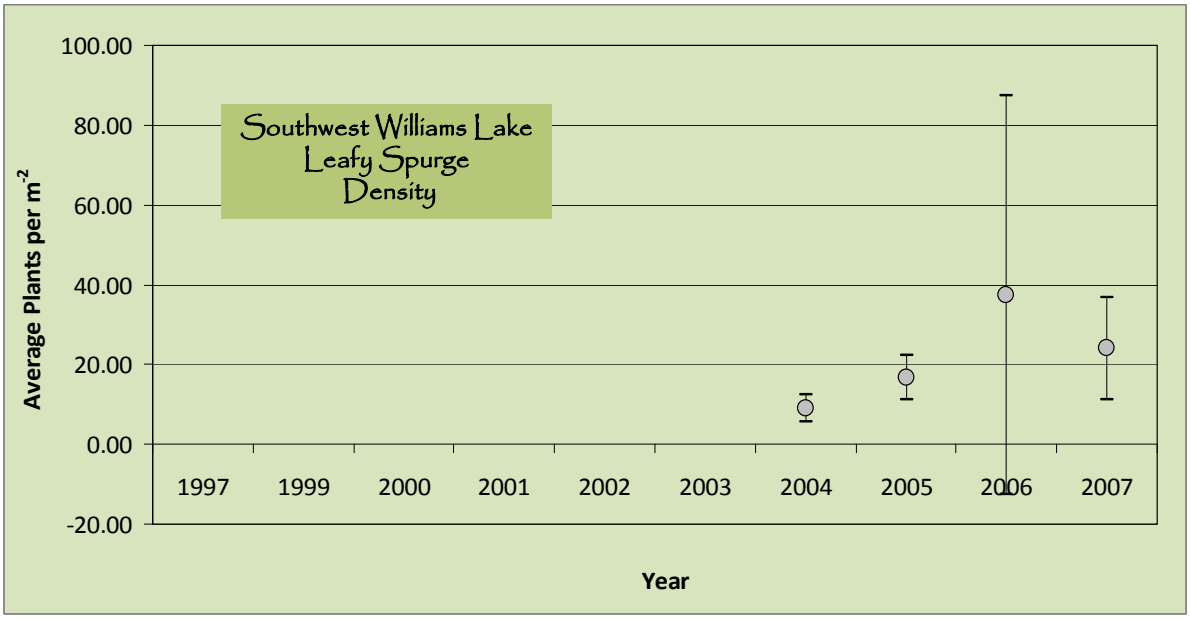


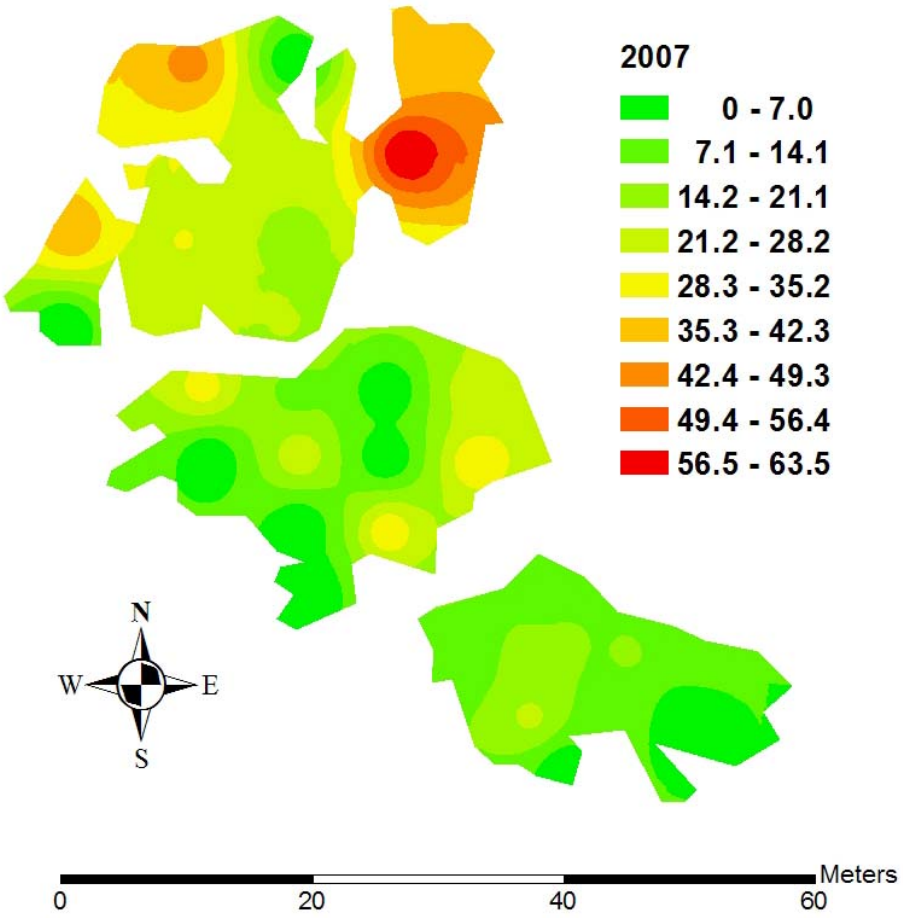


Southwest Williams Lake leafy spurge perimeter in 2007.

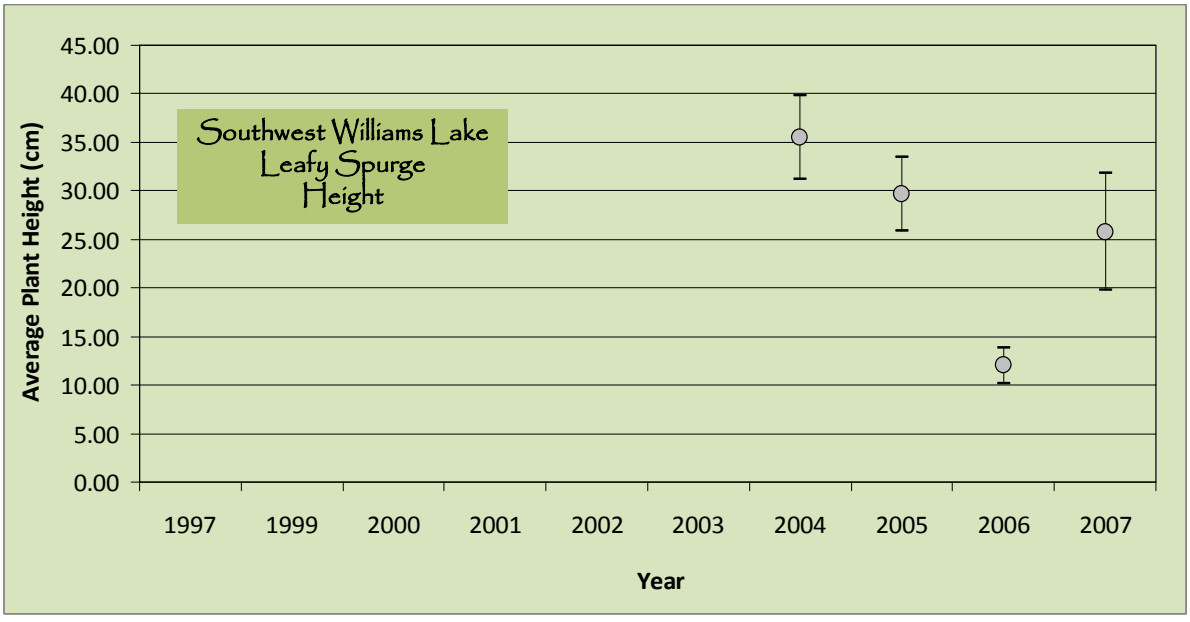


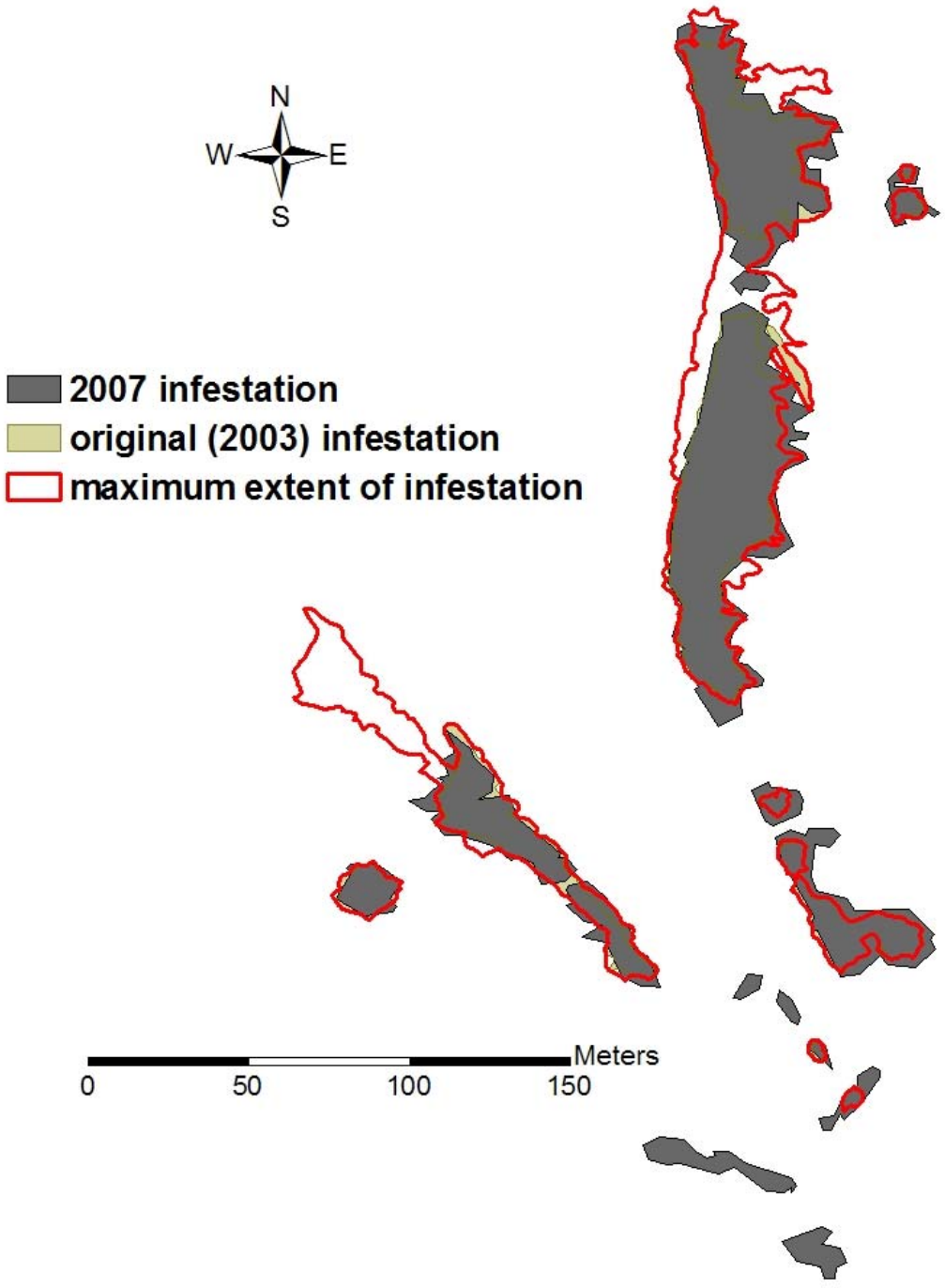
Southwest Williams Lake leafy spurge density in 2007.



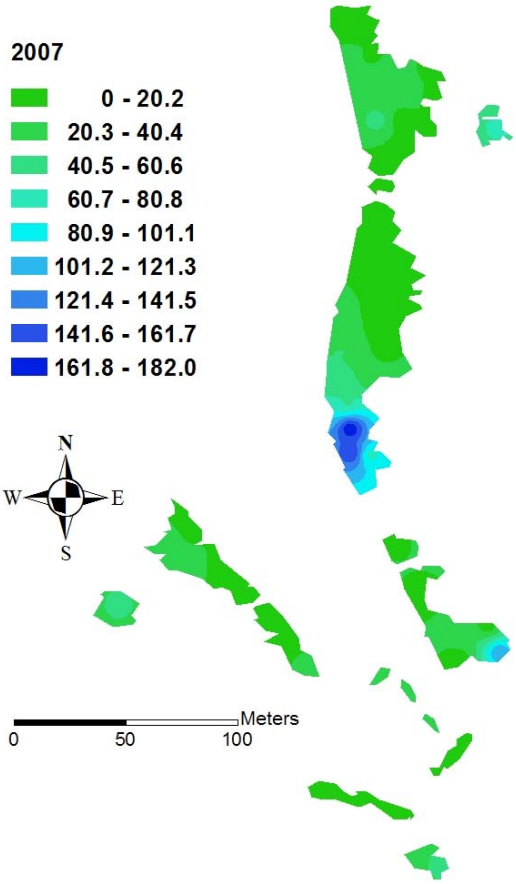


Southwest Williams Lake leafy spurge height in 2007.

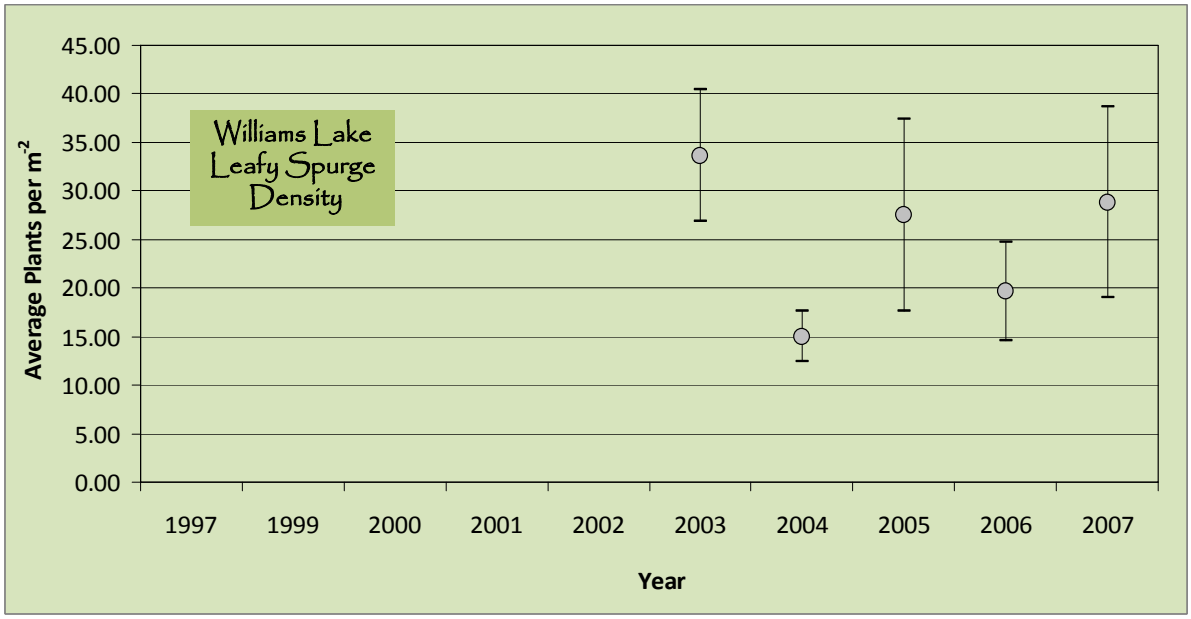


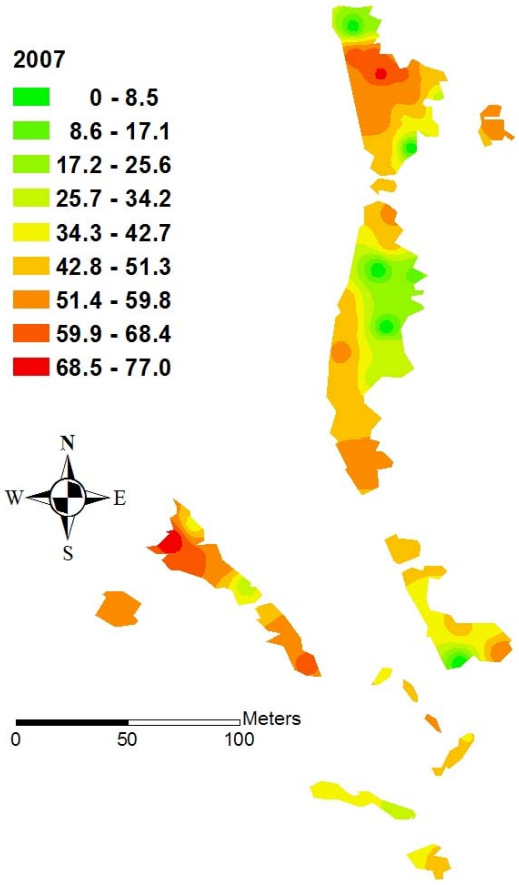


Williams Lake leafy spurge perimeter in 2007.

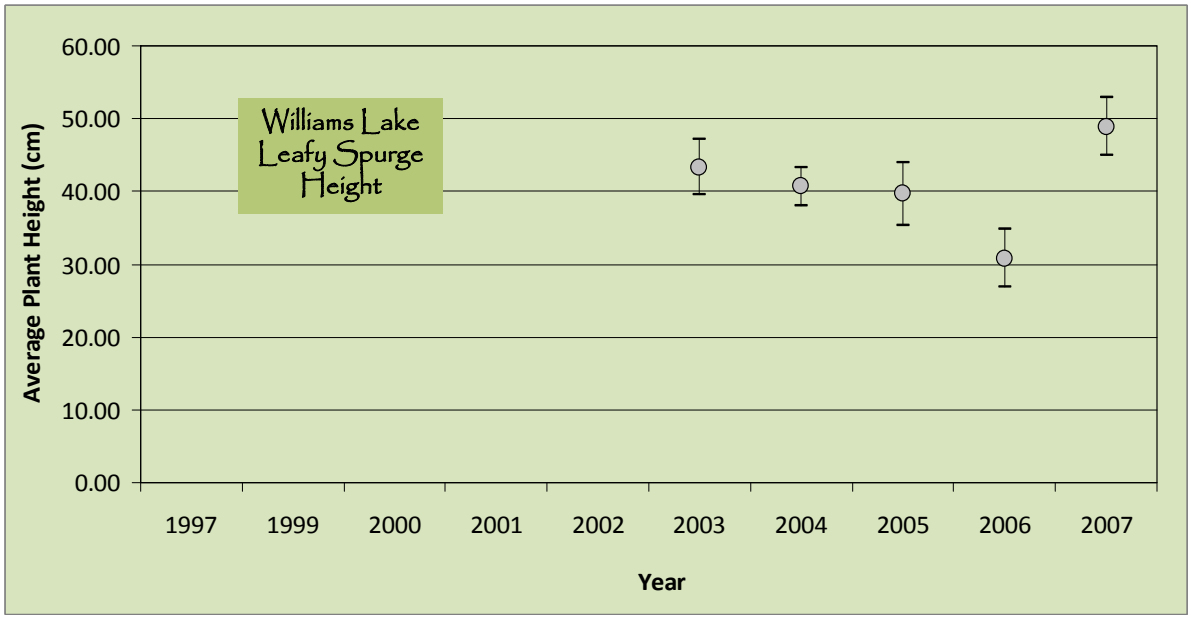


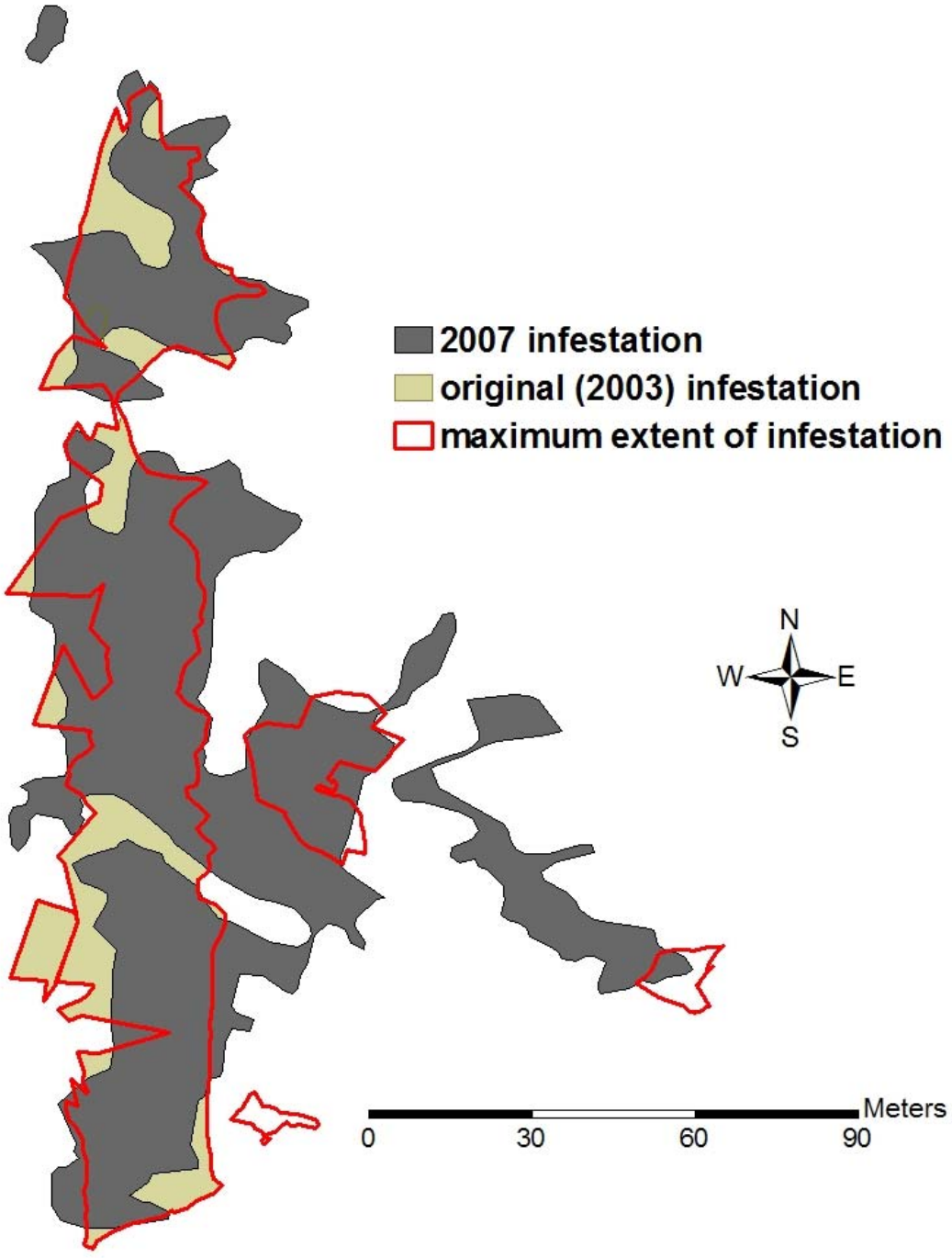
Williams Lake leafy spurge density in 2007.



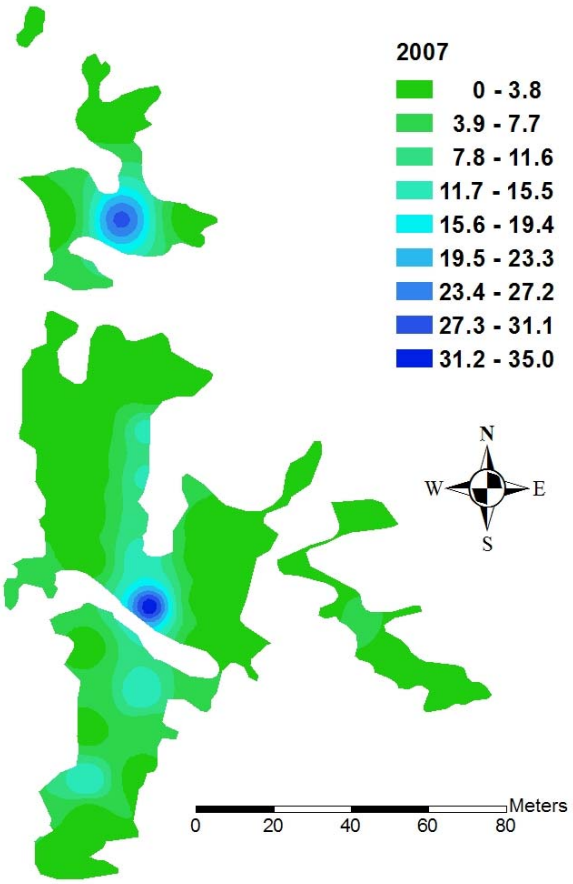


Williams Lake leafy spurge height in 2007.

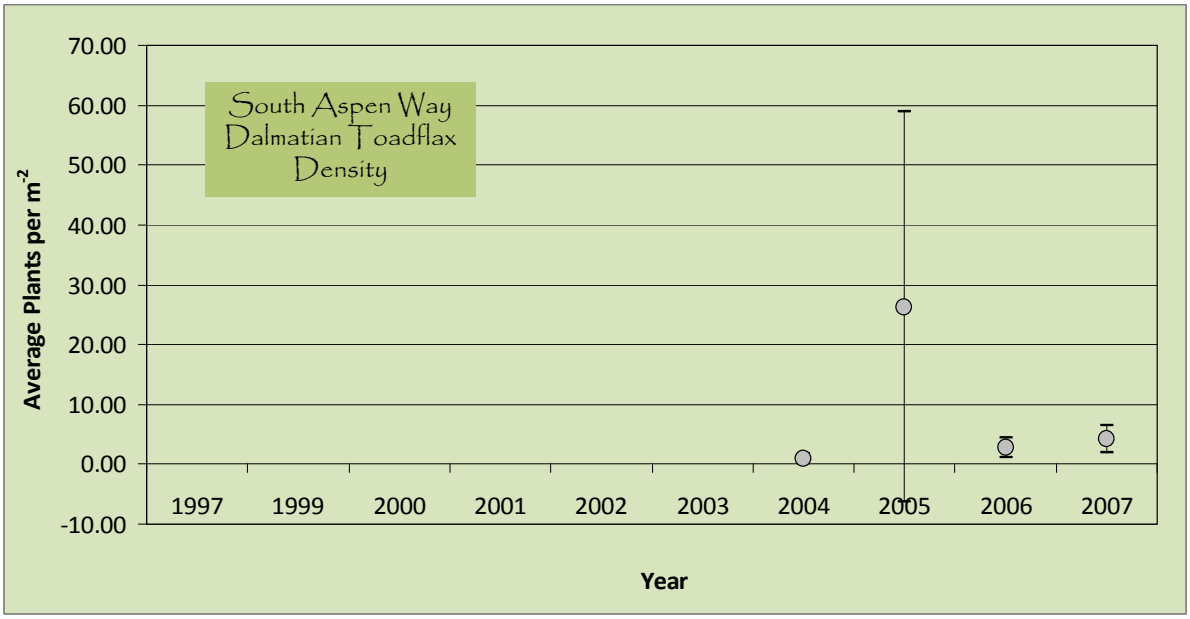


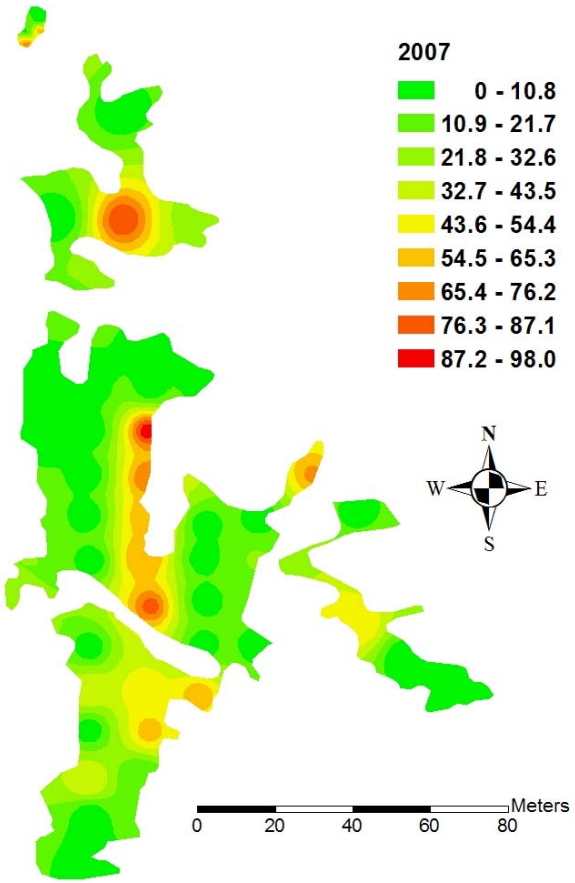


South Aspen Way Dalmatian toadflax perimeter in 2007.

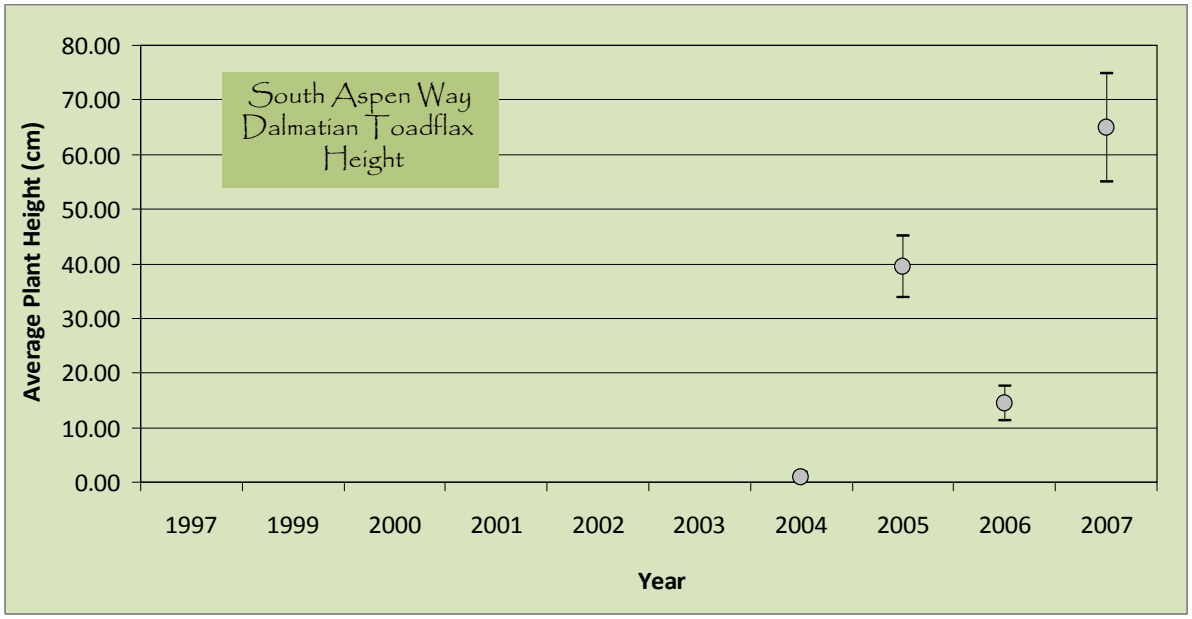


South Aspen Way Dalmatian toadflax density in 2007.





South Aspen Way Dalmatian toadflax height in 2007.



Fort Carson Military Post

Over the course of the 2007 growing season, ten weed infestations were mapped and monitored over a total of 36.0 ha (88.9 acres), as indicated in Table 13. The majority of the area mapped was comprised of Canada and musk thistle sites, located throughout six infestations covering 27.6 ha (68.2 acres). The additional monitoring occurred at four knapweed sites over 8.4 ha (20.8 acres), where three sites were infested with spotted knapweed and one was infested with diffuse knapweed. Additionally, we revisited the 35 field bindweed patches where *Aceria malherbae* had been released in past years to take random vegetation samples and check for the presence of mites. As mentioned in the summaries for Air Force Academy and Buckley Air Force Base, we saw a very low level of impact by *A. malherbae* this year on field bindweed as the weed sprouted earlier than the mites emerged, thereby avoiding the damage in its most susceptible stage of young tender leaves. Mites will be monitored for establishment on field bindweed at all Fort Carson Military Post release sites in 2008. We are also planning to coordinate the release of additional mites with base mowing operations wherever possible in order to maximize the spread of these agents to bindweed infestations throughout the Cantonment.

Changes to our monitoring plans in 2007 involved two historic thistle infestations, monitored since 1997 and 2000, respectively. One of the earliest Canada thistle sites to be treated with biological control agents in 1997, ARA I, was not monitored this season as the target weed has been virtually eliminated from the area. Figure 14 from the 2006 Consolidated Report (p. 125) shows the reclamation of this site from dense stands of Canada thistle even into 2002 to a more diverse plant community in 2006, as few Canada thistles persisted. We will continue to monitor this site to detect re-infestation and determine the persistence of biocontrol agents should re-infestation occur. We were unable to access another of the original 1997 Canada thistle infestations, Reservoir, due to construction blocking access to the site. We will revisit this site in 2008, if possible. And finally, a musk thistle infestation at Highway 115 that has been monitored since 2000 was re-initiated in 2007 after a one-year hiatus, as a resurgence of musk thistle allowed us to map and monitor 0.2 ha (0.5 acres) this season.

Although some weed populations have rebounded on Fort Carson Military Post since 2006 (Table 2), many of the infestations that have been monitored over the course of a decade are showing a steady, long-term decline in area, density or both parameters (Table 13). This includes ARA I, Duckpond, Highway 115, Fuel Site, Hazmat and Turkey Creek. Newer sites, such as Gun Club, are beginning to show very promising establishment of biological control agents. For example, attack on seedheads at Gun Club rose from 31% in 2006 to 100% in 2007 (Tables 3 and 4, respectively) and the highly damaging seed weevil, *Larinus minutus*, was found in over half of the seedheads collected and dissected this year (Table 4). Additionally, root-feeder *Cyphocleonus achates* was recovered from 33% of the roots randomly collected throughout that site. Both agents cause great damage to knapweed plants and are currently considered to be highly effective when applied in combination to knapweed infestations. We anticipate that the Gun Club diffuse knapweed infestation will begin to show a similar pattern of weed decline and heavy insect damage to the spotted knapweed sites Fuel Site, Hazmat (Figure 11) and Turkey Creek over the next few years. We're also making efforts to maximize this success with additional bio-agent releases (i.e. 4000 *L. minutus* in 2007).

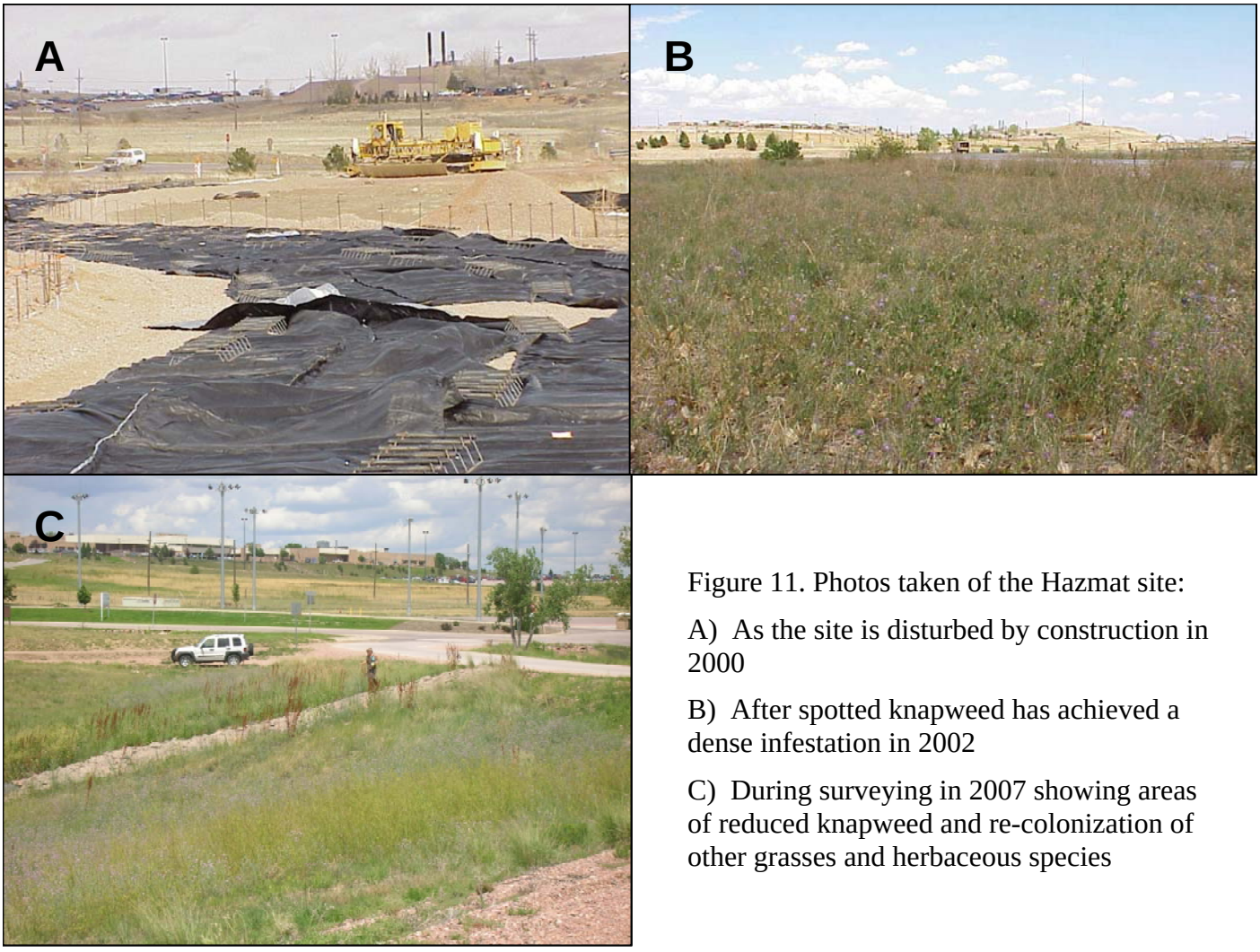


Figure 11. Photos taken of the Hazmat site:

A) As the site is disturbed by construction in 2000

B) After spotted knapweed has achieved a dense infestation in 2002

C) During surveying in 2007 showing areas of reduced knapweed and re-colonization of other grasses and herbaceous species

Although we have not concentrated in past years on checking for bio-agents on weeds outside our listed survey sites, we did observe some self-dispersal of agents to areas other than the original release sites this season. In 2007, for example, we found *Trichosirocalus horridus*, on musk thistle near Turkey Creek, which presumably migrated almost 2 km from the Highway 115 release (Figure 12). We also confirmed the establishment of *T. horridus* at the Highway 115 site this season, along with finding self-spreading knapweed agents, *Agapeta zoegana* and *Sphenoptera jugoslavica*, at the Gun Club and Turkey Creek sites (Table 14). We plan to modify our monitoring efforts in 2008 to include more insect dispersal survey work in order to better quantify the movement and establishment of released bio-agents.

Figure 12. Biological control agent, *Trichosirocalus horridus*, found near the Turkey Creek spotted knapweed site on musk thistle, presumably self-dispersed from the Highway 115 release site.

We were finally able to initiate saltcedar biocontrol in 2007 with a small release of *Diorhabda elongata* beetles in Section 36, south of the Artillery Impact Area (Figure 13). This year's release, consisting of 241 beetles, is not likely to build up to a large population or cause serious defoliation to saltcedar trees in the near future but serves to establish an initial nursery site for the agent. As lack of bio-agent availability has inhibited our initiation of a saltcedar biocontrol program in Colorado until this year, we were fortunate to obtain the small number of beetles to make this release, albeit in sub-optimal number. It has been desirable for a number of years to initiate a saltcedar biological control at Fort Carson Military Post and this effort was a listed objective in our Statement of Work submitted to the Department of Defense Legacy Resource Management Program in 2005-2006. However, availability of beetles and regulatory issues prevented us from releasing beetles until this season. We are now making plans to release a large number of additional beetles at various locations across Fort Carson in 2008, as some of the issues regarding bio-agent availability have greatly improved.

Figure 13. New saltcedar biological control site, Section 36, where *Diorhabda elongata* beetles (inset) were released.

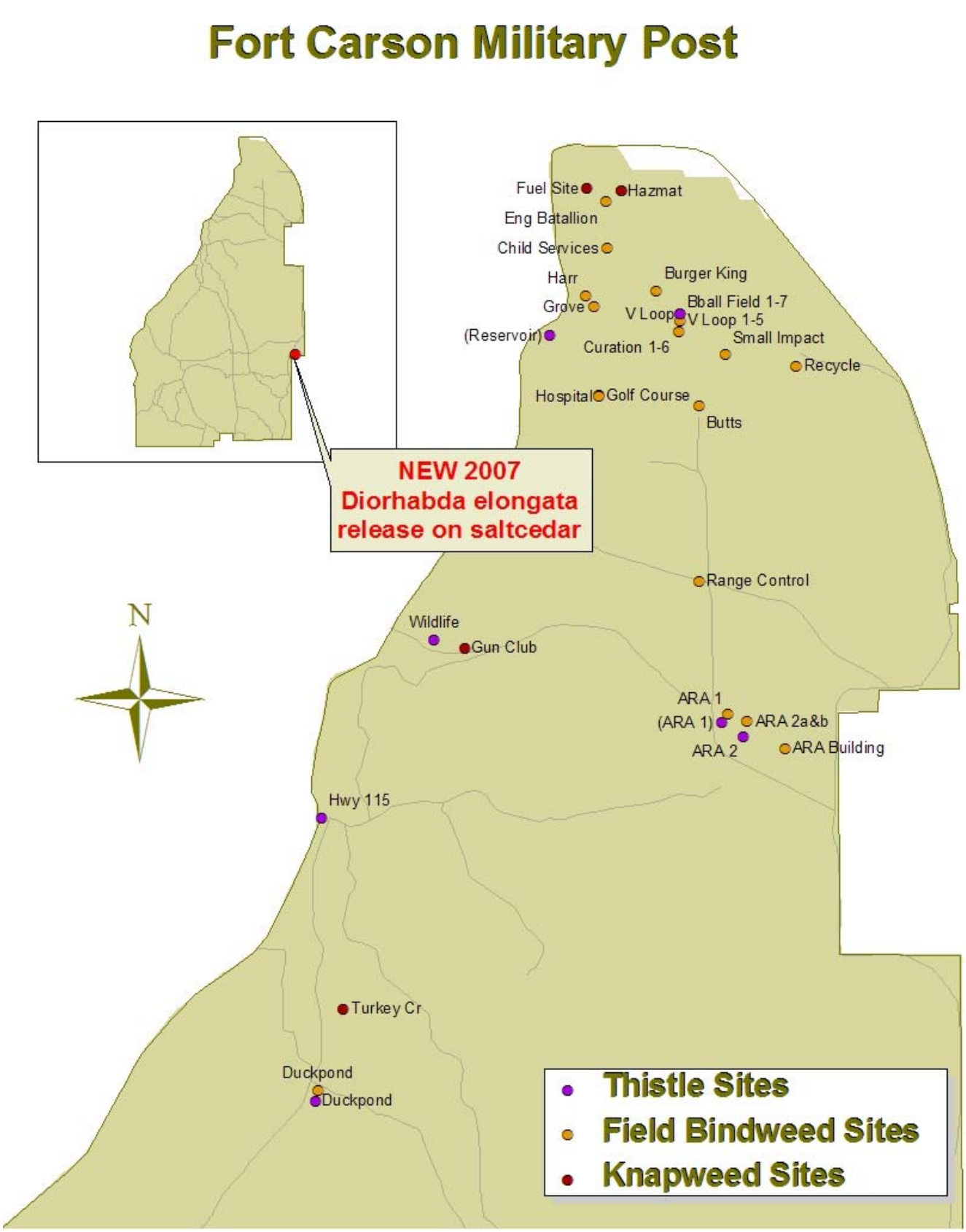


Figure 14. Schematic diagram of Fort Carson Military Post with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2007.

Table 13. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads per plant	Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Canada thistle – ARA I												
1997		23	25.55	42								
1998												
1999		40			62.33	95						
2000	37,062	166	13.96	58	45.87	91					-26.41	
2001	37,061	299	12.94	64	52.98	122	18.95	0.57	0	-7.31	15.50	
2002	38,002	386	4.95	40	12.89	84	8.54	0.12	2.54	-61.75	-75.67	
2003	14,708	161	0.78	9	12.19	74	1.13	0.15	-61.30	-84.24	-5.43	
2004	4,919	75	2.53	19	10.83	37	0.24	0.26	-66.56	224.36	-11.16	
2005	10,528	34	3.59	14	42.79	62	10.58	0.74	114.03	41.90	295.11	
2006	22,882	32	1.91	11	29.68	64	6.42	0.71	117.34	-46.80	-30.64	
2007	*(see Note a)*											
Canada thistle – ARA II												
2003	6,284	63	6.48	24	61.21	125	1.28	0.07				
2004	13,845	64	13.20	38	50.14	98	1.48	2.50	120.33	103.70	-18.09	
2005	270,294	31	9.23	24	69.41	105	20.17	0.66	1852.29	-30.08	38.43	
2006	371,111	34	10.09	36	59.86	111	11.86	0.60	37.30	9.32	-13.76	
2007	241,585	54	9.06	24	59.50	105	9.69	5.75	-34.90	-10.21	-0.60	3744.45
Canada thistle – Duckpond												
1997		19	35.00	82								
1998	27,769											
1999		33			70.82	114	34.88					
2000	28,788	267	9.33	58	76.76	193					8.38	

Table 13. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. seedheads per plant	Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
2001	39,409	26	16.23	70	66.73	136	18.12		36.90	73.95	-13.07	
2002	38,916	196	7.74	56	21.30	124	11.33	0.23	-1.25	-52.31	-68.08	
2003	29,486	147	5.25	29	38.90	143	3.08	0.22	-24.23	-32.17	82.63	
2004	20,724	65	14.17	116	26.03	90	1.18	0.62	-29.72	169.90	-33.08	
2005	21,130	35	9.43	28	61.46	115	25.61	0.74	1.96	-33.45	136.11	
2006	17,902	30	8.03	32	47.52	80	20.67	0.72	245.33	-4.97	3.19	
2007	6,411	54	11.26	112	92.00	184	21.02	6.39	-64.19	40.22	93.60	-76.91
							Canada thistle – HWY 115					
2000	1,445	82	12.47	40	53.49	80						
2001	4,239	54	10.22	48	57.87	147	14.51	0.64	193.36	-18.04	8.88	
2002	1,114	70	1.58	14	7.24	24	2.25	0.06	-73.72	-84.54	-87.49	
2003												
2004	1,287	69	6.29	23	38.33	96	7.95	0.47	15.53**	298.10**	429.62**	
2005	*(see Note a)*											
2006	91	10	3.70	8	30.25	71	2.75	0.21	-92.93**	-41.18**	-21.08**	
2007	965	21	4.43	16	81.47	114	15.37	4.84	960.44	19.73	169.32	-33.22
							Musk thistle – HWY 115					
2000	1,445	8	7.13	22								
2001	5,082	30	4.00	14	64.30	121	6.53	2.18	251.70	-43.90		
2002	827	53	2.13	13	6.26	35	0.63	0.43	-83.73	-46.75	-90.26	
2003	1,263	61	0.62	5	17.64	127	0.68		52.72	-70.89	181.79	
2004	9,918	55	1.85	25	24.88	100	3.47	0.97	685.27	198.39	41.04	
2005	735	44	1.05	7	42.31	90	1.56	1.51	-92.59	-43.24	70.06	
2006	*(see Note a)*											

Table 13. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
2007	2,101	29	0.69	3	110.65	188	7.23	3.08	185.85**	-34.29**	161.52**	45.40
						Canada thistle - Reservoir						
1997		22	20.82	30								
1998												
1999		26			73.12	109	19.12					
2000												
2001	9,517	143	7.25	31	39.53	84	13.55					
2002	5,268	101	8.16	32	24.26	65	6.36	0.30	-44.64	12.55	-38.63	
2003	3,635	165	6.09	38	41.48	123	6.02	0.38	-31.00	-25.37	70.98	
2004	4,549	68	6.13	28	23.22	57	0.52	0.74	25.13	0.66	-44.02	
2005	5,184	40	8.45	27	46.05	86	15.06	0.61	13.96	37.85	98.32	
2006	2,251	35	6.71	24	20.20	39	2.34	0.33	-56.58	-20.59	-56.13	-76.35
2007	*(see Note b)*											
						Musk thistle – Wildlife						
1999		59			110.92	175	7.53					
2000	5,035	114	1.76	14	43.14	138						
2001	2,844	68	3.84	21	72.22	174	6.07		-43.52	118.18	67.41	
2002	1,838	61	2.82	36	8.65	57	8.18	0.22	-35.39	-26.56	-88.02	
2003	10,219	77	0.27	3	14.39	124	1.17		456.14	-90.43	66.36	
2004	6,777	46	1.23	7	27.46	173	3.50	7.13	-33.68	355.56	90.83	
2005	3,453	36	1.37	9	98.31	187	8.69	2.75	-49.05	11.38	258.01	
2006	390	30	2.73	9	58.77	105	3.42	1.98	-88.71	99.27	-40.22	
2007	23,861	44	0.80	6	93.58	147	4.25	3.51	6018.21	-70.70	59.23	373.90

Table 13. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2007.

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			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Diffuse knapweed – Gun Club												
2004	14,941	46	1.59	8	21.87	65	36.04	1.43				
2005	9,685	35	3.40	22	41.36	57	42.48	0.45	-35.18	113.84	89.12	
2006	20,781	30	2.60	12	24.47	40	39.87	0.41	114.57	-23.53	-40.84	
2007	24,806	41	3.51	6	57.37	88	108.17	4.37	19.37	35.00	134.45	66.03
Spotted knapweed – Fuel Site (Cantonment I)												
1997		22	55.27	82								
1998												
1999		50			71.68	104						
2000	2,072	154	16.71	50	46.69	91					-34.86	
2001	2,869	113	55.19	564	55.88	104	134.48	1.88	38.46	230.28	19.68	
2002	2,375	155	6.04	36	20.56	72	45.60	0.34	-17.22	-89.06	-63.21	
2003	2,093	92	5.98	35	64.35	150	52.26	1.92	-11.87	-0.99	212.99	
2004	6,830	42	4.64	21	46.64	100	9.39	5.00	226.41	-22.41	-27.52	
2005	2,567	41	5.16	26	42.52	74	13.25	0.52	-62.42	11.21	-8.83	
2006	9,913	37	4.70	21	31.50	91	12.72	0.42	286.17	-8.91	-25.92	
2007	1,984	33	3.27	9	70.37	126	42.15	2.23	-79.99	-30.43	123.40	-4.25
Spotted knapweed – Hazmat (Cantonment II)												
1997		21	49.05	62								
1998												
1999		100			79.66	42						
2000	8,462	361	10.54	52	42.56	43	127.00				-46.57	
2001	9,094	143	20.66	140	60.48	100	72.35		7.47	96.02	41.11	
2002	3,429	92	12.24	58	22.69	81	31.16	0.35	-62.30	-40.46	-62.48	

Table 13. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
2003	5,254	160	5.26	70	57.42	140	64.85	0.67	53.23	-57.03	153.06	
2004	5,779	57	5.37	18	43.07	97	9.41	4.62	10.00	2.09	-24.99	
2005	990	50	12.48	53	52.12	90	20.32	0.58	-82.87	132.40	21.01	
2006	15,458	33	6.24	29	27.68	65	8.57	0.32	1461.41	-50.00	46.89	
2007	27,783	41	7.46	76	63.52	113	39.20	5.07	79.73	19.55	129.48	228.33
Spotted knapweed – Turkey Creek												
1997		22	16.00	18								
1998												
1999	11,818	25	12.72	20	109.67	132	19.36			-20.50		
2000	16,848	285	17.05	68	59.57	101			42.56	34.04	-45.68	
2001	30,681	375	8.83	65	54.66	125	44.30		82.10	48.21	-8.24	
2002	1,314	79	2.24	27	10.99	73	13.51	0.27	-95.72	-74.63	-79.89	
2003	328	48	5.33	43	46.83	118		0.34	-75.01	137.95	326.11	
2004	13,218	73	1.42	10	42.76	101	42.94		3929.79	-73.36	-8.69	
2005	5,937	40	1.70	15	52.47	89	17.67	0.43	-55.08	19.72	22.71	
2006	2,711	34	1.26	10	30.67	46	15.93	0.60	-54.34	-25.88	-41.55	
2007	29,455	45	2.64	14	87.40	148	58.83	1.21	986.50	109.52	184.97	149.24

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

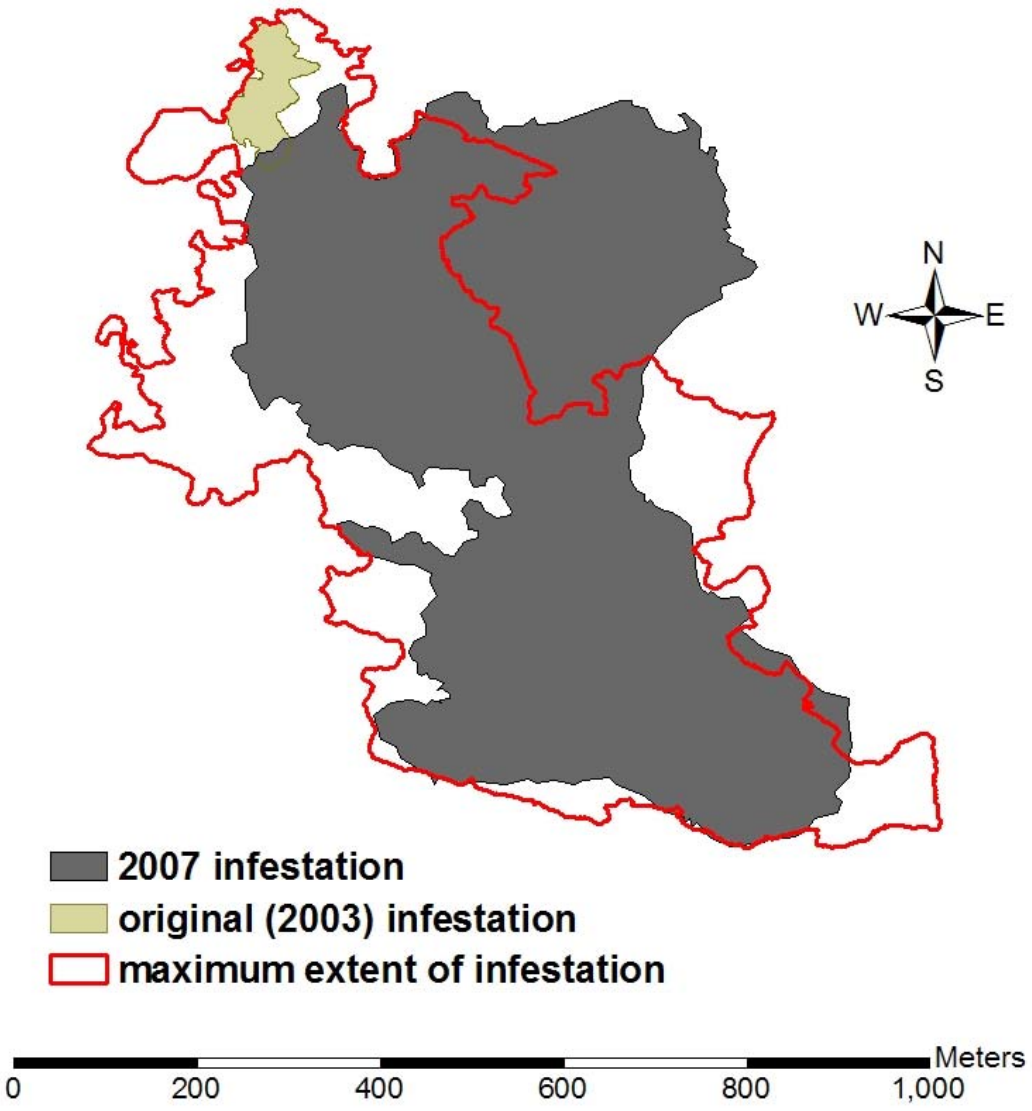
Table 14. Noxious weed biological control sites, target weeds, species released and recoveries at Fort Carson Military Post, 2007.

Location	Target weed	Site	Species released	Species recovered	New releases	New site
Ft. Carson	Canada thistle	ARA I	*Cassida rubiginosa*	X		
Ft. Carson	Canada thistle	ARA I	*Ceutorhynchus litura*			
Ft. Carson	Canada thistle	ARA I	*Larinus planus*	X		
Ft. Carson	Canada thistle	ARA I	*Trichosirocalus horridus*	X		
Ft. Carson	Canada thistle	ARA I	*Urophora cardui*	X		
Ft. Carson	Canada thistle	ARA II	*Cassida rubiginosa*			
Ft. Carson	Canada thistle	ARA II	*Ceutorhynchus litura*			
Ft. Carson	Canada thistle	Duckpond	*Cassida rubiginosa*	X		
Ft. Carson	Canada thistle	Duckpond	*Ceutorhynchus litura*			
Ft. Carson	Canada thistle	Duckpond	*Larinus planus*			
Ft. Carson	Canada thistle	Duckpond	*Urophora cardui*	X		
Ft. Carson	Musk thistle	Highway 115	*Trichosirocalus horridus*	X [2]		
Ft. Carson	Musk thistle	Highway 115	*Urophora cardui*	X		
Ft. Carson	Canada thistle	Reservoir	*Cassida rubiginosa*	X		
Ft. Carson	Canada thistle	Reservoir	*Ceutorhynchus litura*			
Ft. Carson	Canada thistle	Reservoir	*Larinus planus*			
Ft. Carson	Canada thistle	Reservoir	*Urophora cardui*	X		
Ft. Carson	Musk thistle	Wildlife Refuge	*Trichosirocalus horridus*	X		
Ft. Carson	Diffuse knapweed	Gun Club	*Agapeta zoegana*	X [1,2]		
Ft. Carson	Diffuse knapweed	Gun Club	*Cyphocleonus achates*	X		
Ft. Carson	Diffuse knapweed	Gun Club	*Larinus minutus*	X		
Ft. Carson	Diffuse knapweed	Gun Club	*Metzneria paucipunctella*	X [1]		
Ft. Carson	Diffuse knapweed	Gun Club	*Sphenoptera jugoslavica*	X [1,2]		
Ft. Carson	Diffuse knapweed	Gun Club	*Urophora affinis*	X [1]		
Ft. Carson	Spotted knapweed	Fuel Site	*Agapeta zoegana*	X [2]		
Ft. Carson	Spotted knapweed	Fuel Site	*Bangasternus fausti*			
Ft. Carson	Spotted knapweed	Fuel Site	*Cyphocleonus achates*	X		

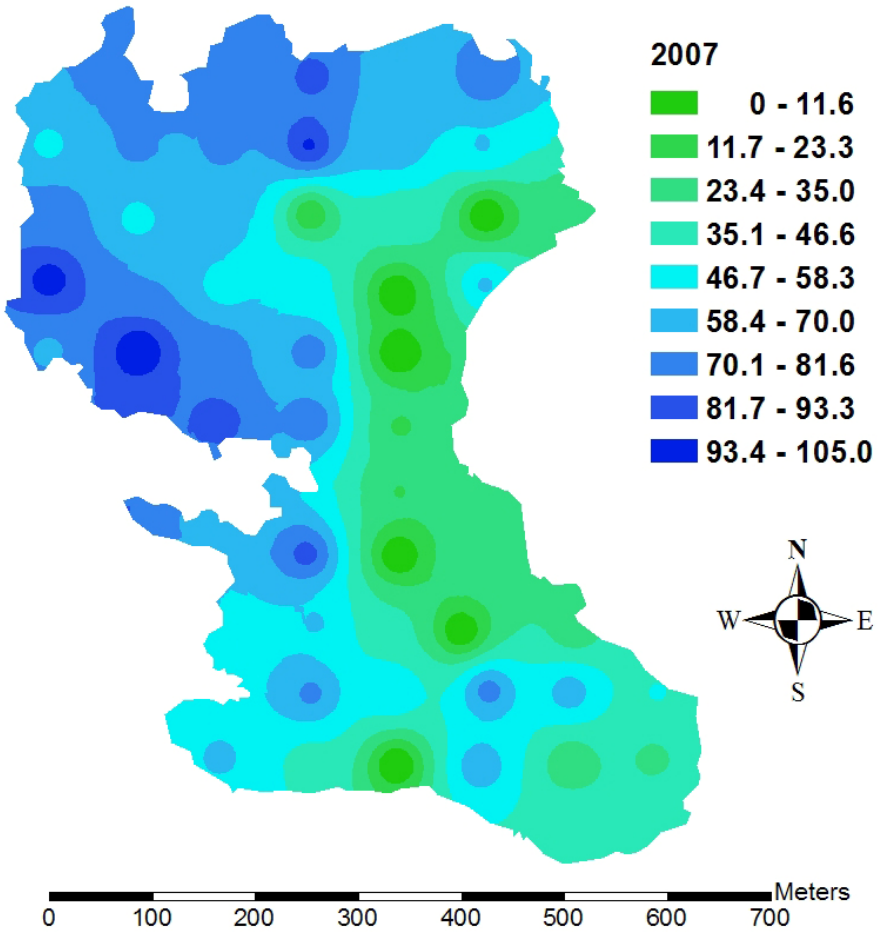
Table 14. Noxious weed biological control sites, target weeds, species released and recoveries at Fort Carson Military Post, 2007.

Location	Target weed	Site	Species released	Species recovered	New releases	New site
Ft. Carson	Spotted knapweed	Fuel Site	*Larinus minutus*	X		
Ft. Carson	Spotted knapweed	Fuel Site	*Larinus obtusus*			
Ft. Carson	Spotted knapweed	Fuel Site	*Metzneria paucipunctella*	X		
Ft. Carson	Spotted knapweed	Fuel Site	*Sphenoptera jugoslavica*	X		
Ft. Carson	Spotted knapweed	Fuel Site	*Urophora affinis*	X		
Ft. Carson	Spotted knapweed	HazMat	*Agapeta zoegana*	X [1,2]		
Ft. Carson	Spotted knapweed	HazMat	*Bangasternus fausti*			
Ft. Carson	Spotted knapweed	HazMat	*Cyphocleonus achates*	X		
Ft. Carson	Spotted knapweed	HazMat	*Larinus minutus*	X		
Ft. Carson	Spotted knapweed	HazMat	*Larinus obtusus*			
Ft. Carson	Spotted knapweed	HazMat	*Metzneria paucipunctella*	X		
Ft. Carson	Spotted knapweed	HazMat	*Sphenoptera jugoslavica*	X		
Ft. Carson	Spotted knapweed	HazMat	*Urophora affinis*	X		
Ft. Carson	Spotted knapweed	Turkey Creek	*Agapeta zoegana*			
Ft. Carson	Spotted knapweed	Turkey Creek	*Cyphocleonus achates*	X		
Ft. Carson	Spotted knapweed	Turkey Creek	*Larinus minutus*	X		
Ft. Carson	Spotted knapweed	Turkey Creek	*Metzneria paucipunctella*	X		
Ft. Carson	Spotted knapweed	Turkey Creek	*Sphenoptera jugoslavica*			
Ft. Carson	Spotted knapweed	Turkey Creek	*Urophora affinis*	X		
Ft. Carson	Saltcedar	Section 36	*Diorhabda elongata*		X	X

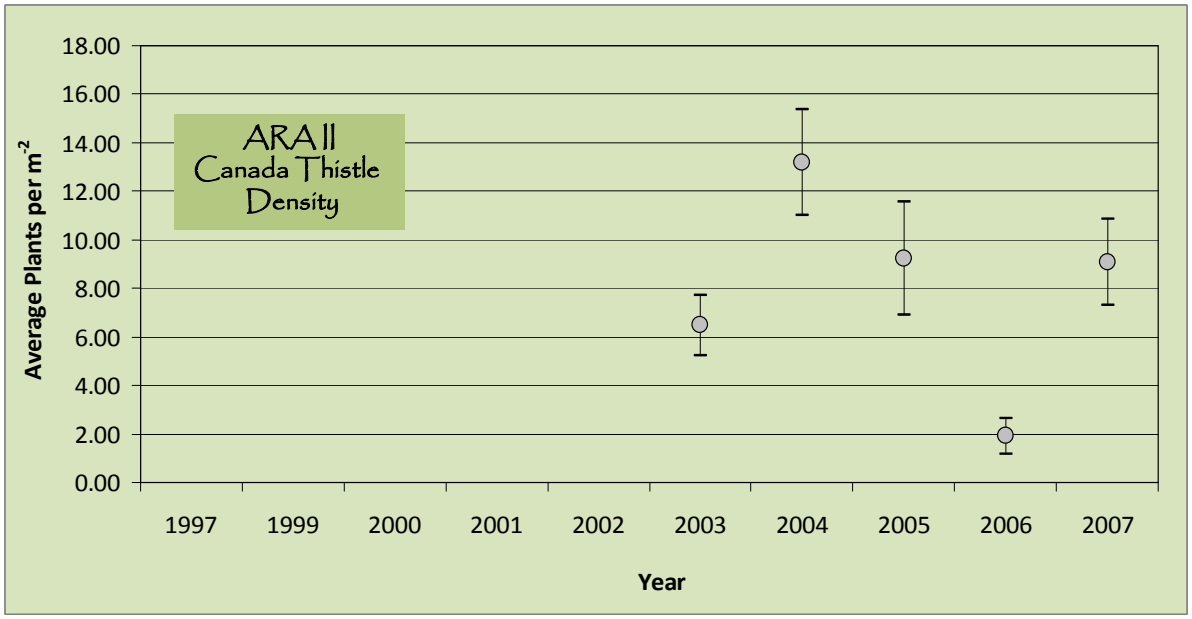
[1] Adventitious recovery, insects were not released at this location
[2] New recovery in 2007

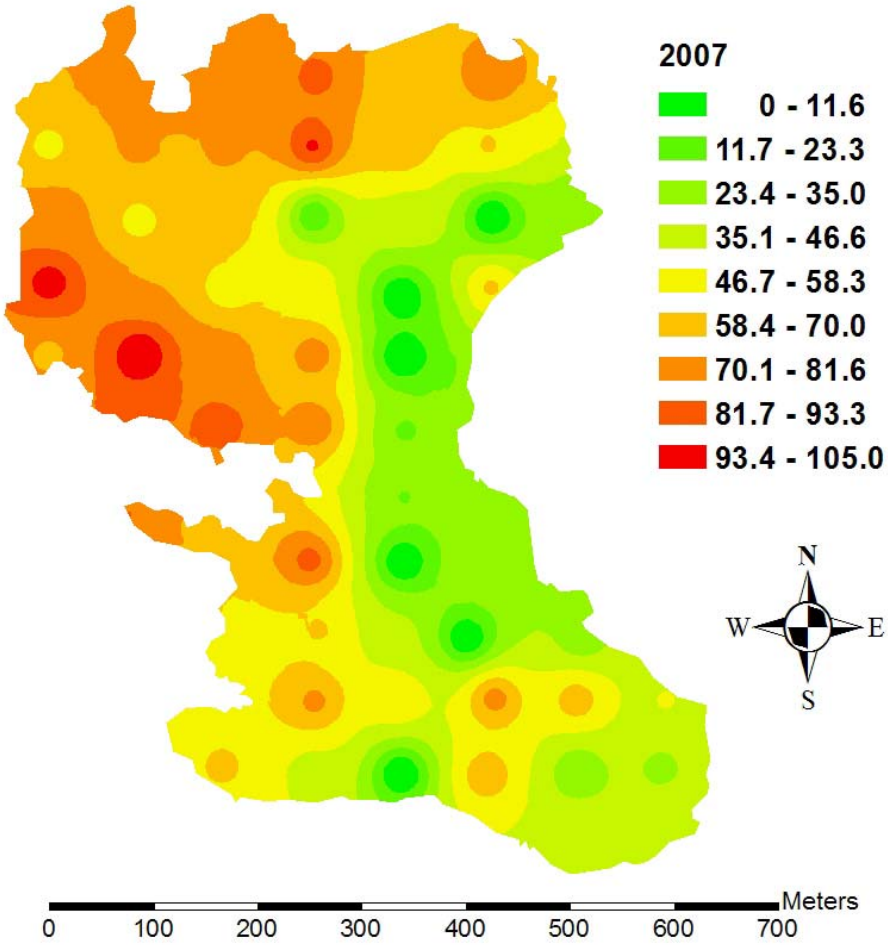


ARA II Canada thistle perimeter in 2007.

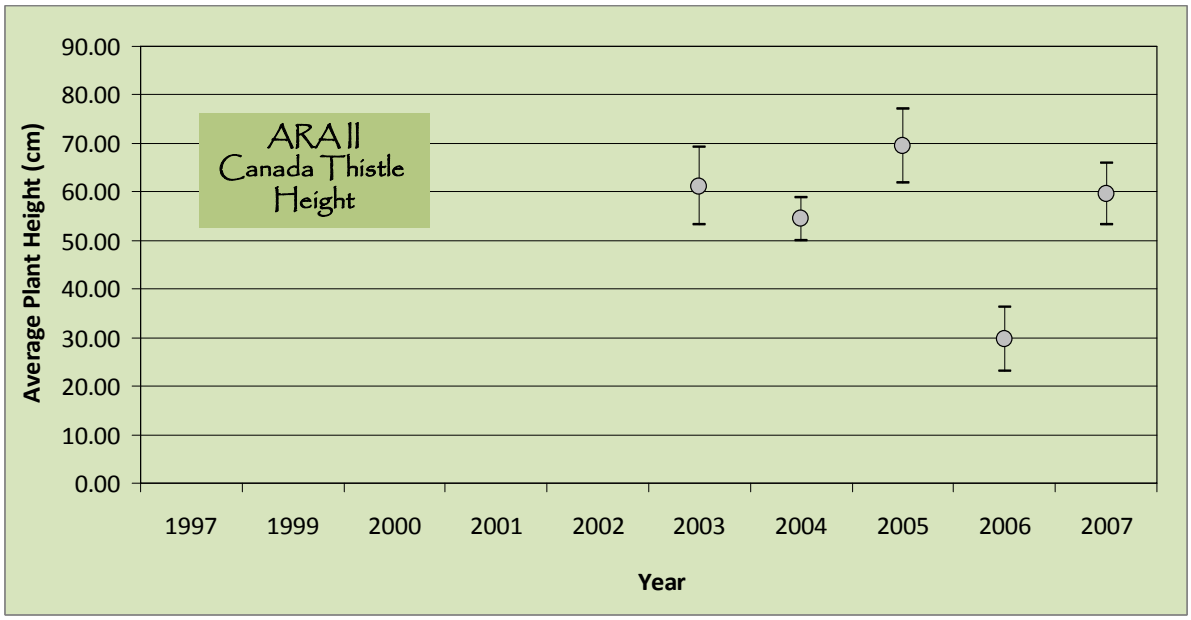


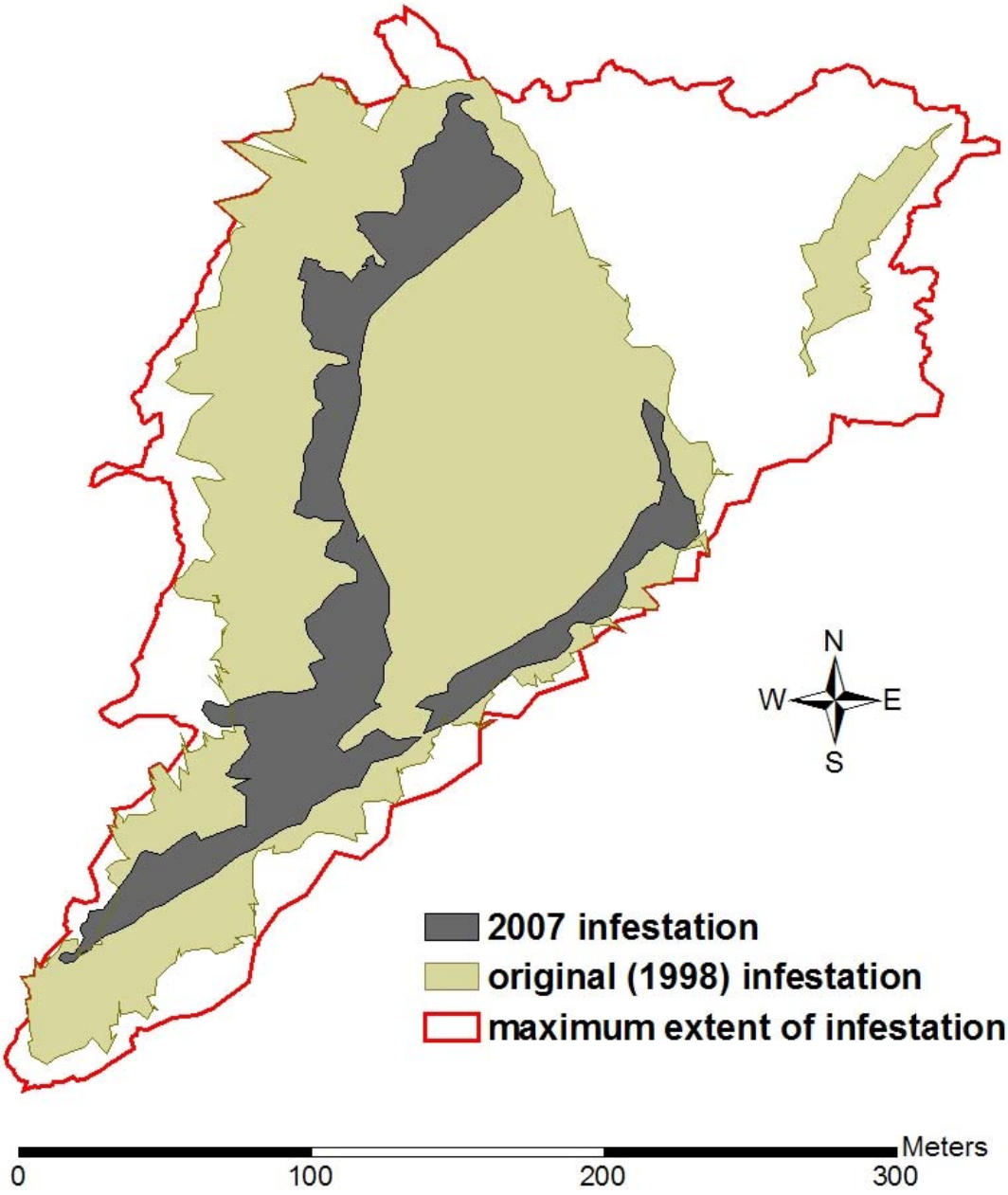
ARA II Canada thistle density in 2007.



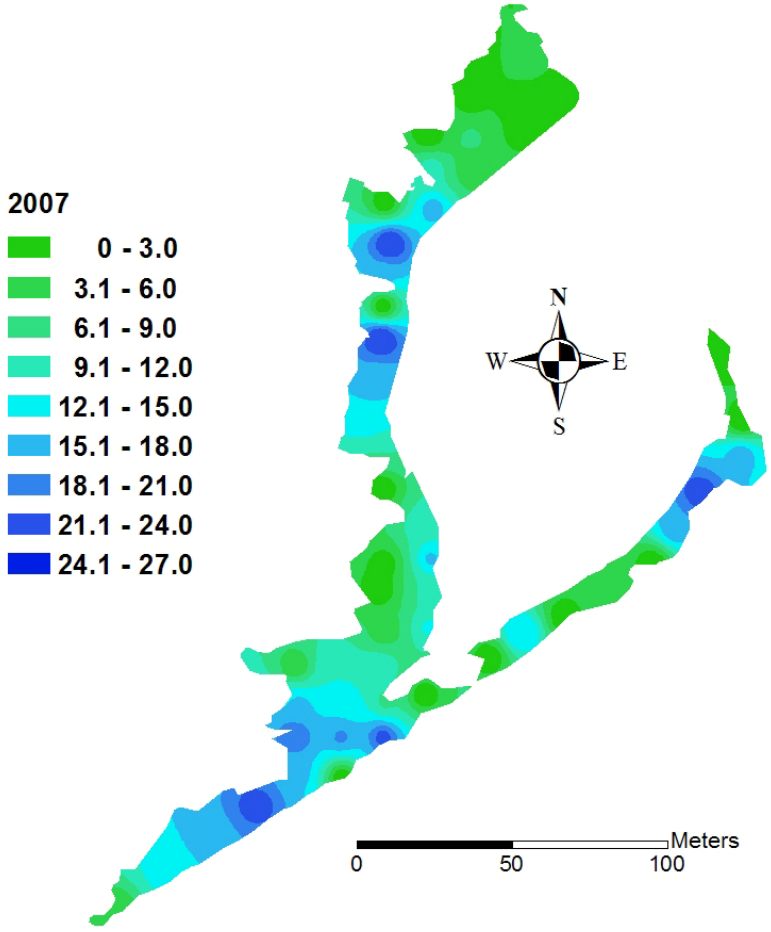


ARA II Canada thistle height in 2007.

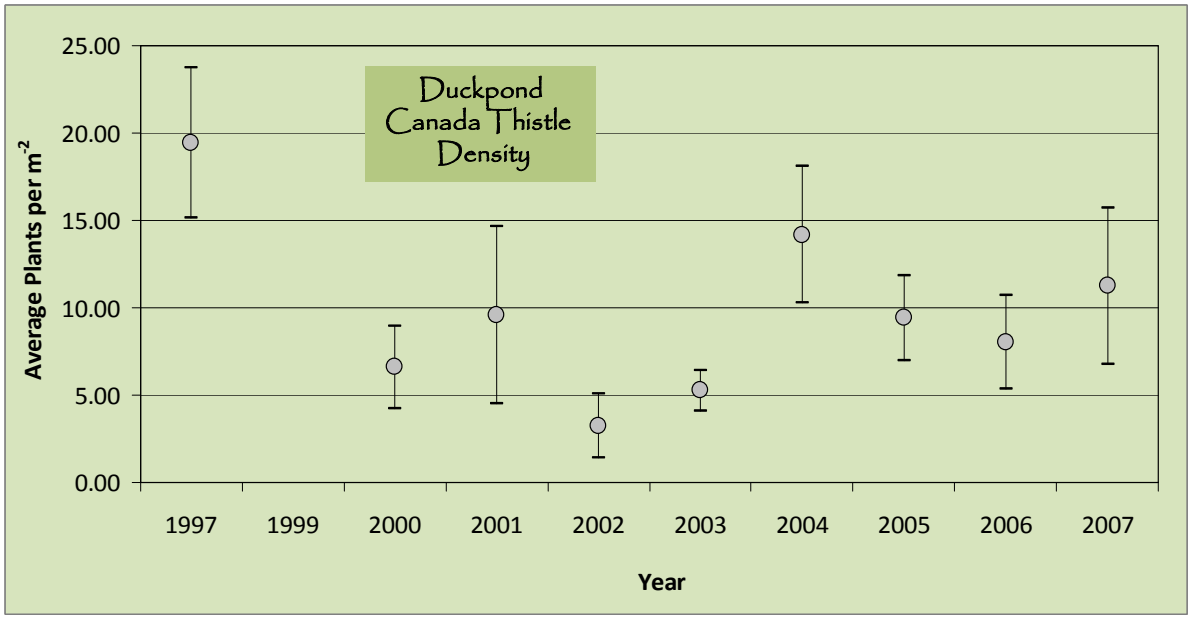


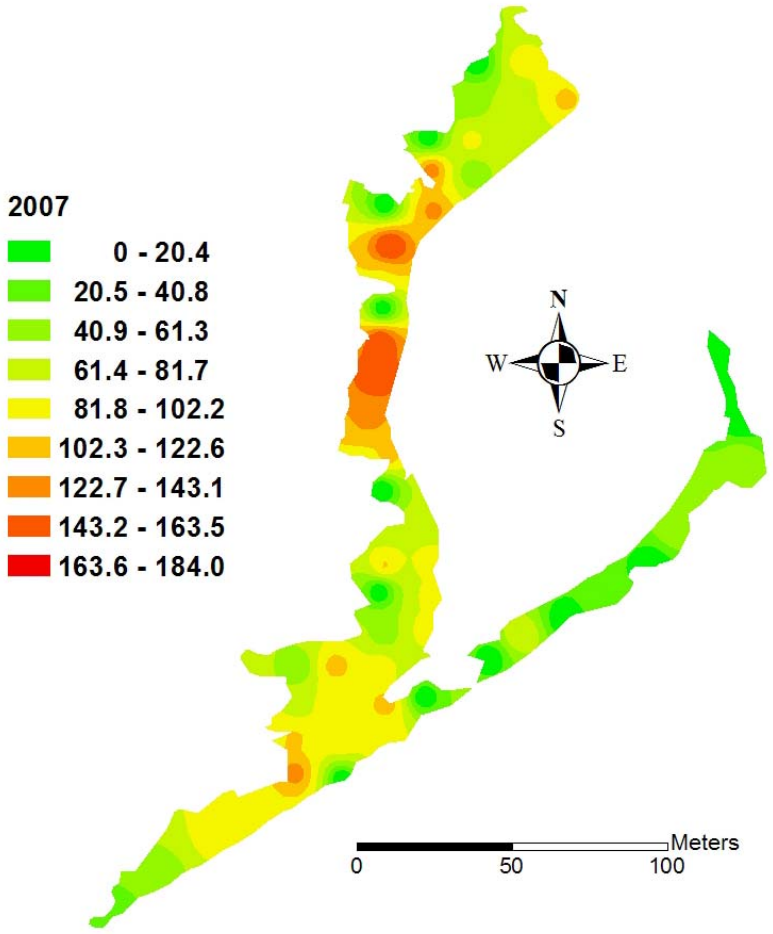


Duckpond Canada thistle perimeter in 2007.

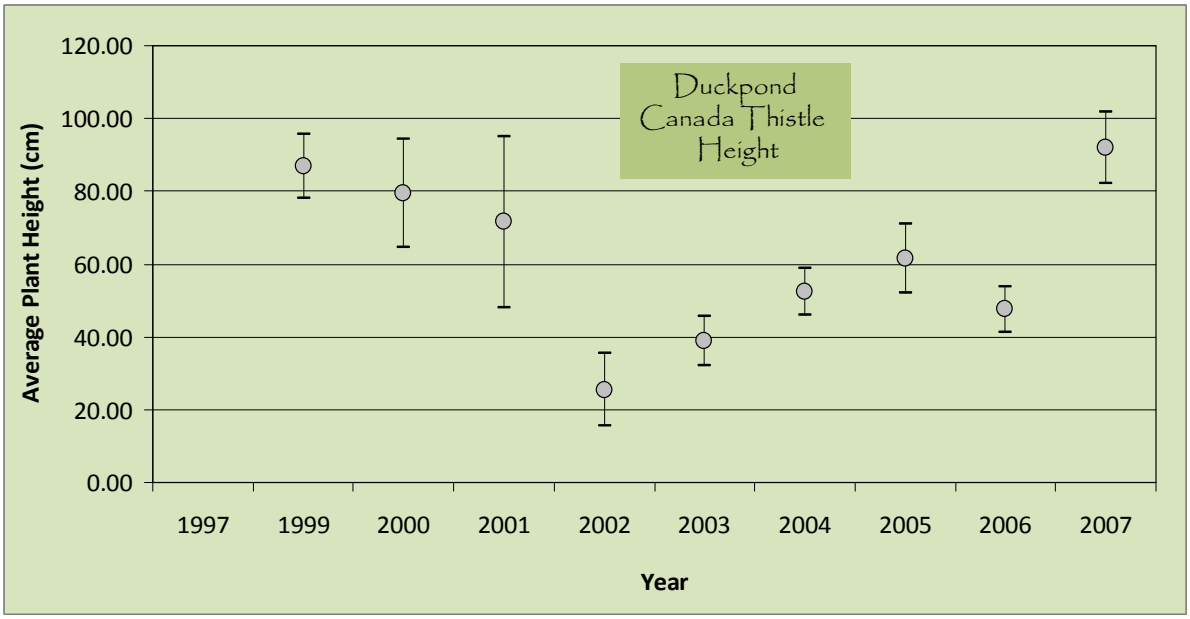


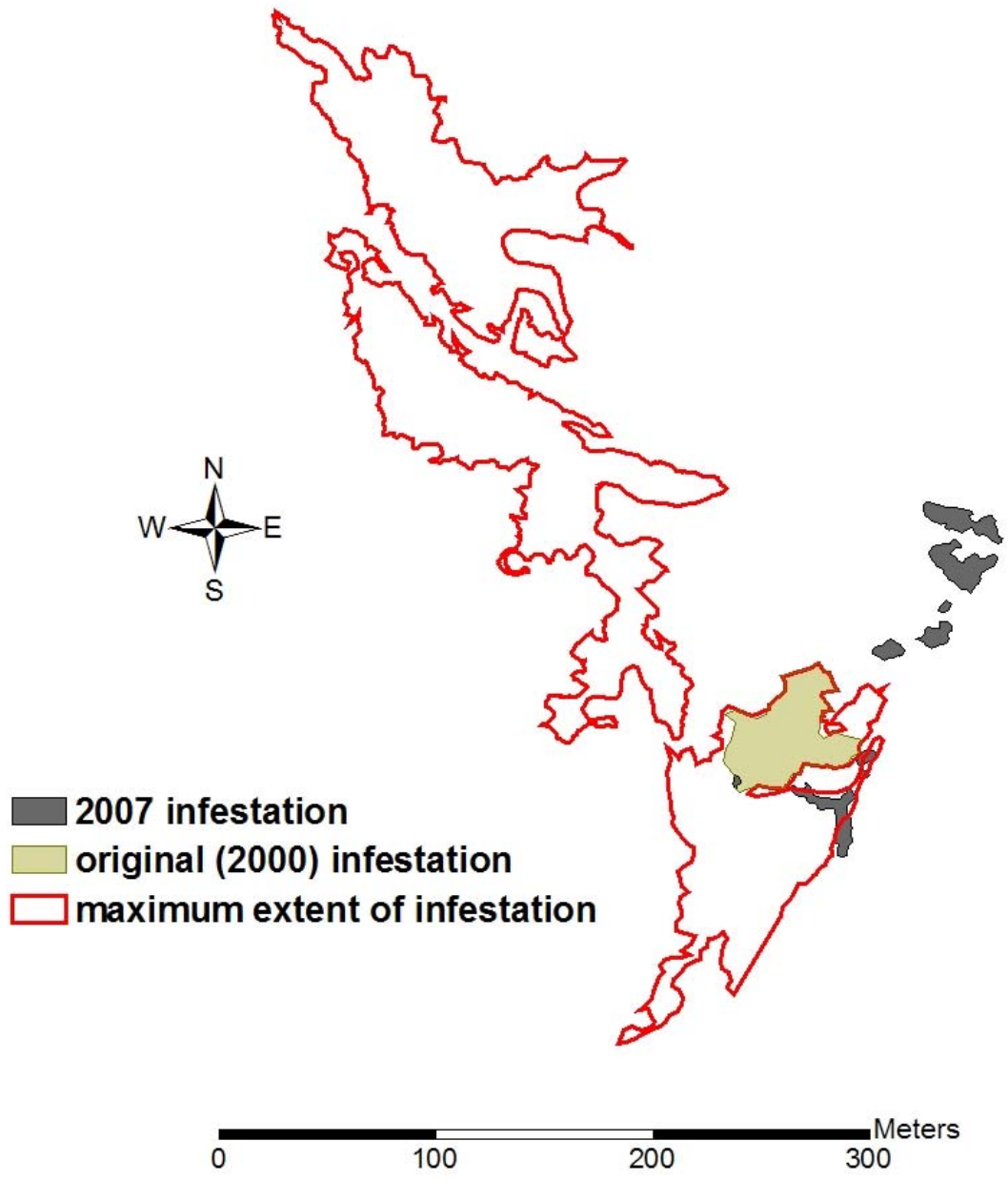
Duckpond Canada thistle density in 2007.



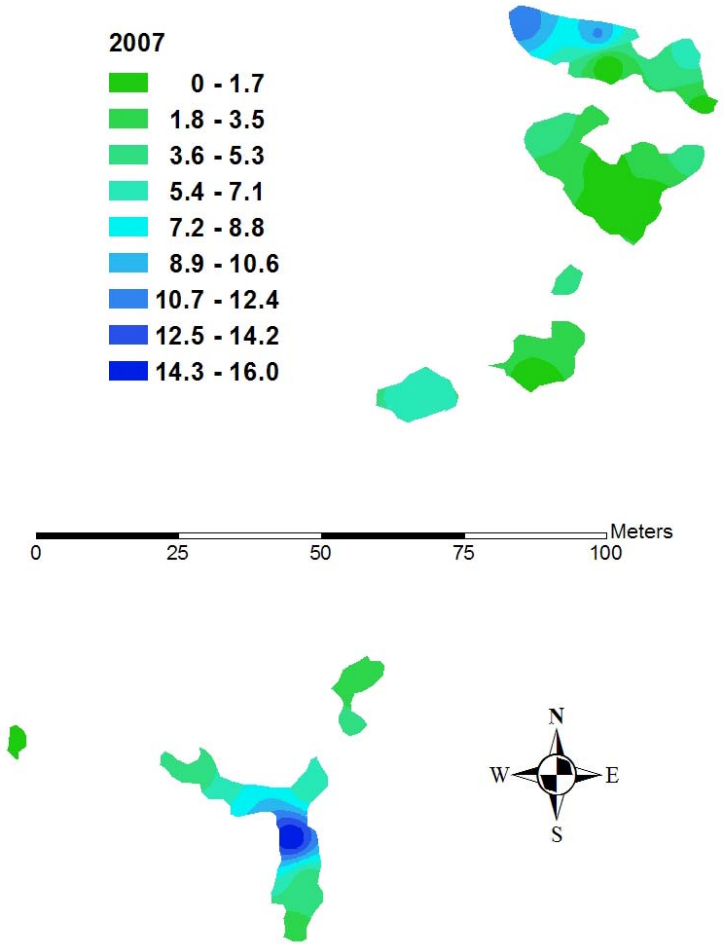


Duckpond Canada thistle height in 2007.

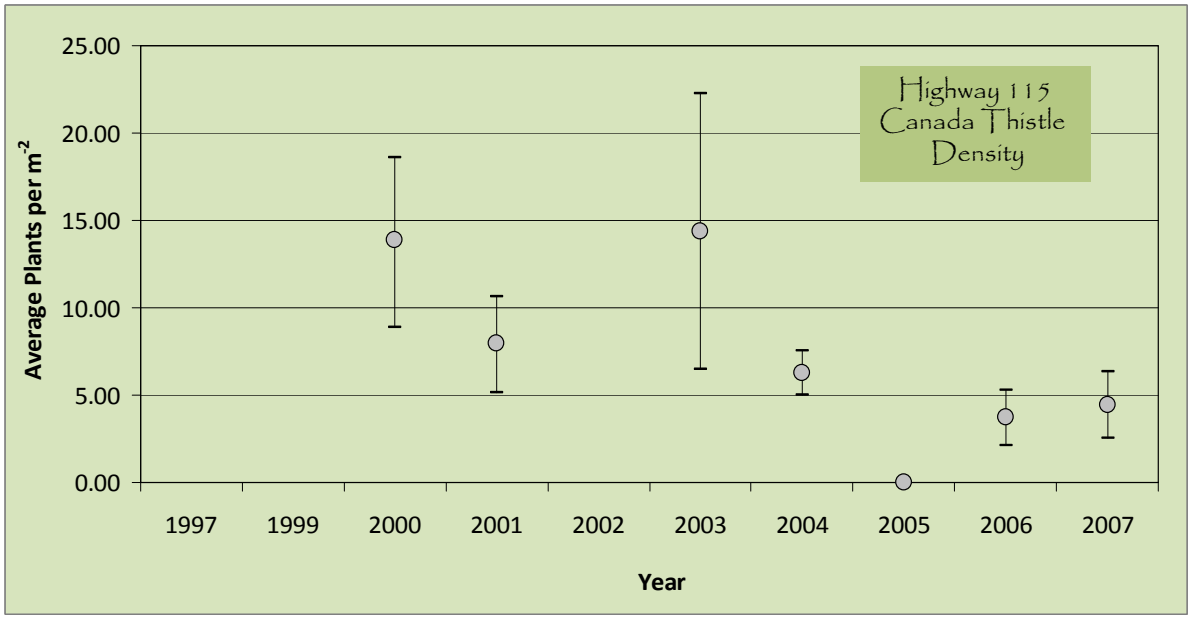


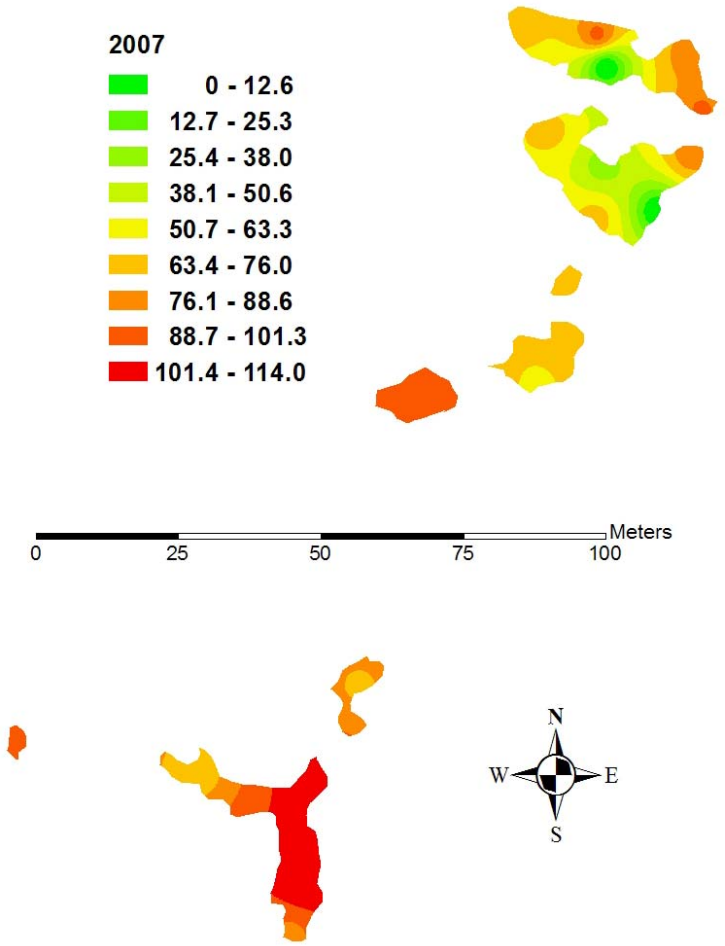


Highway 115 Canada thistle perimeter in 2007.

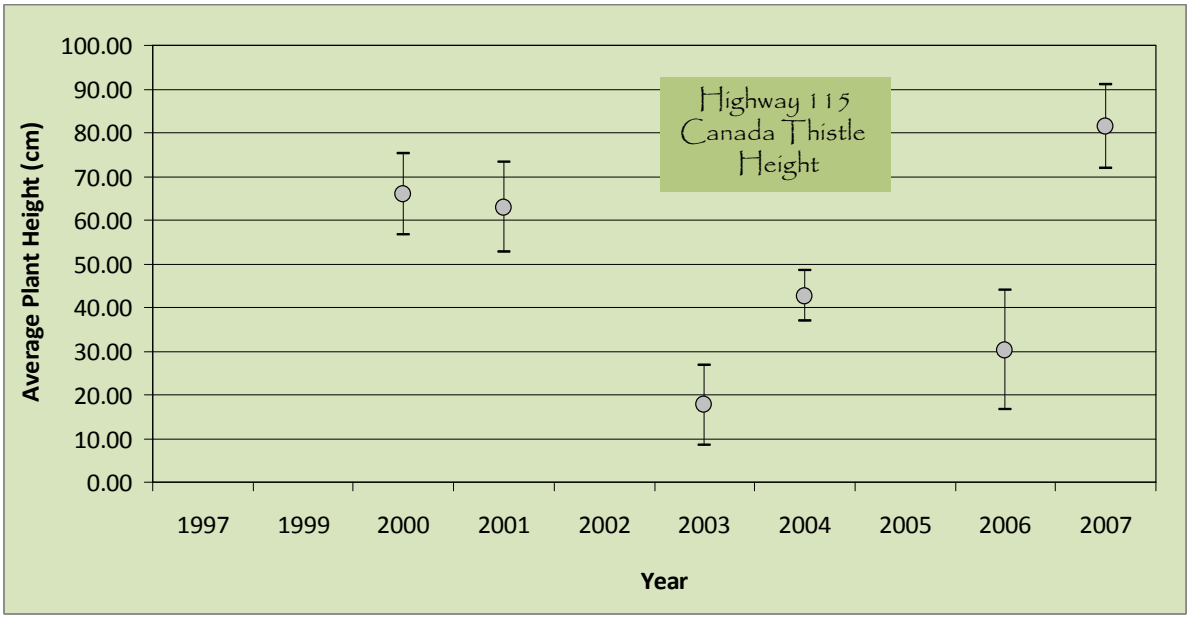


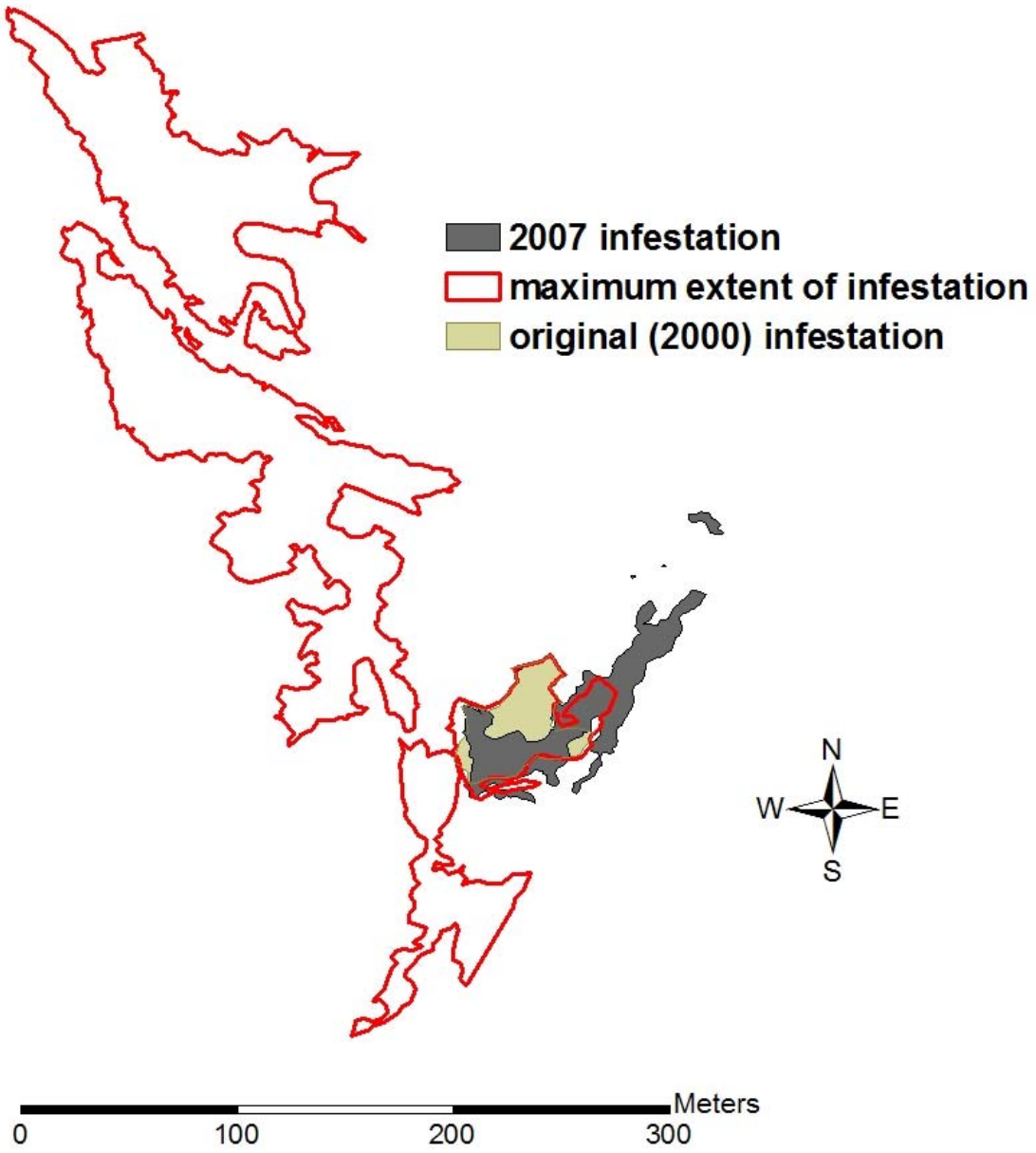
Highway 115 Canada thistle density in 2007.



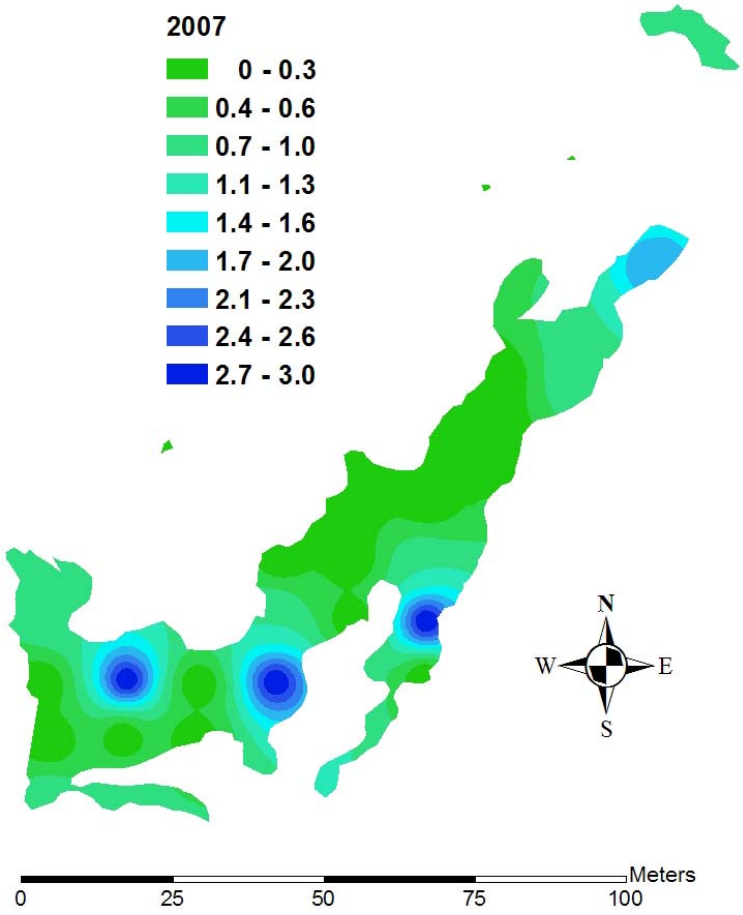


Highway 115 Canada thistle height in 2007.

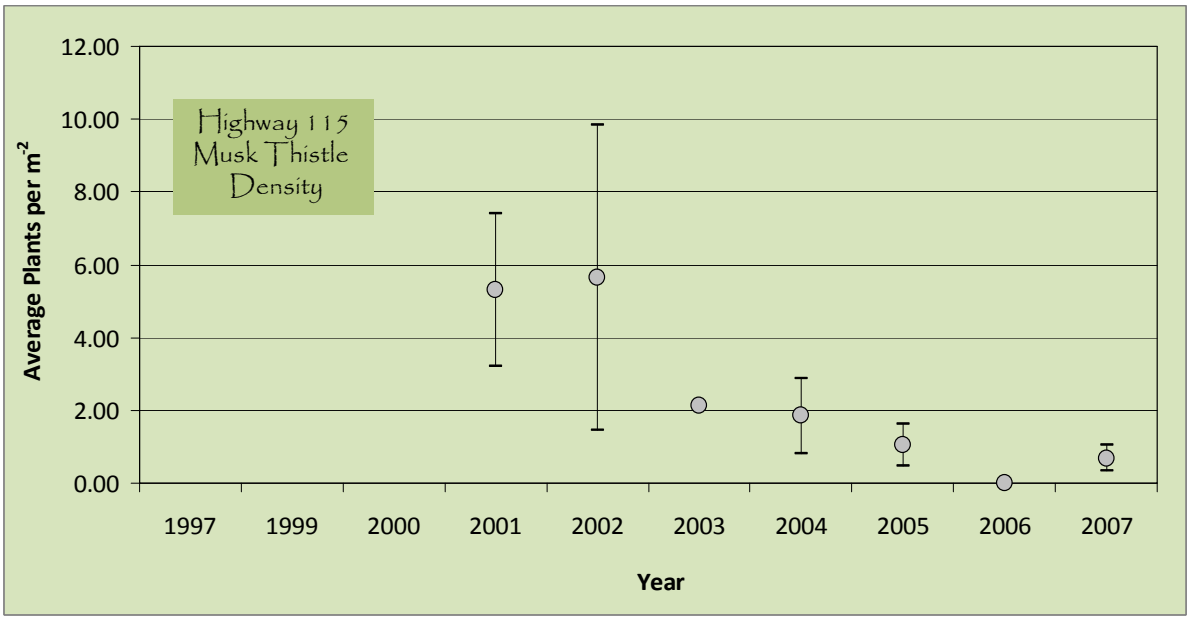


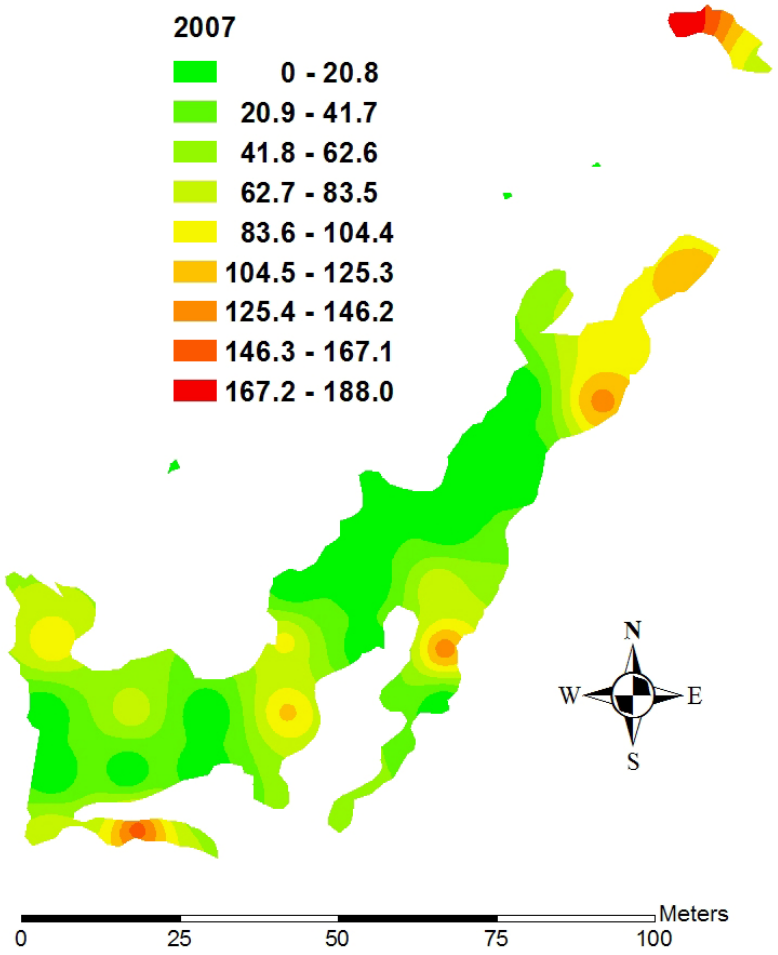


Highway 115 musk thistle perimeter in 2007.

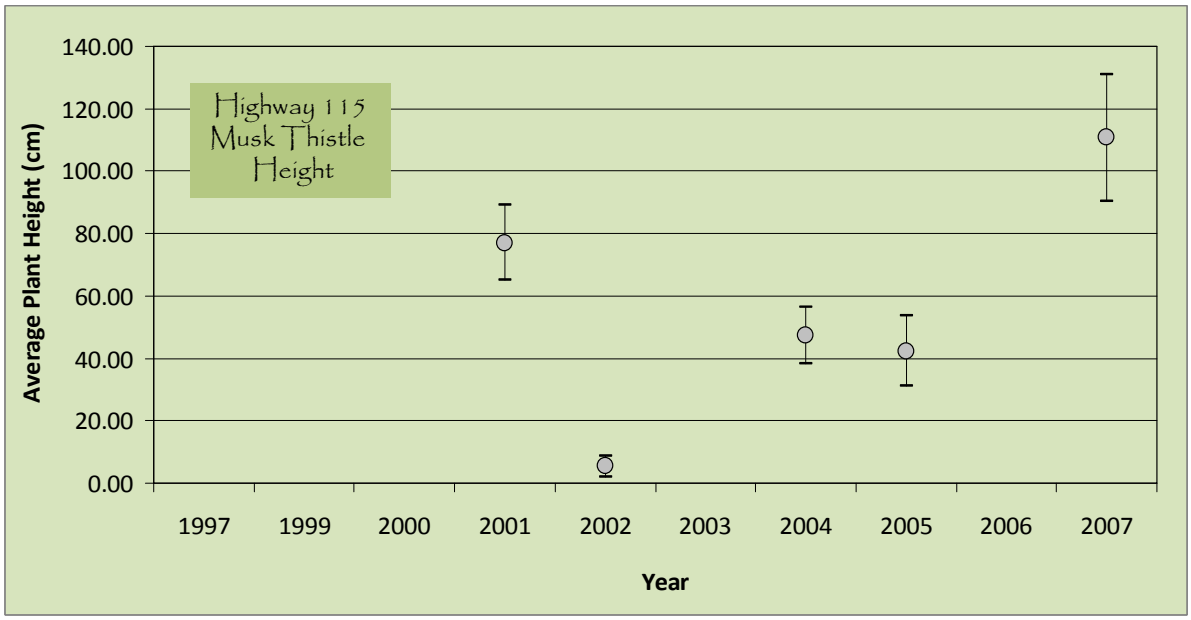


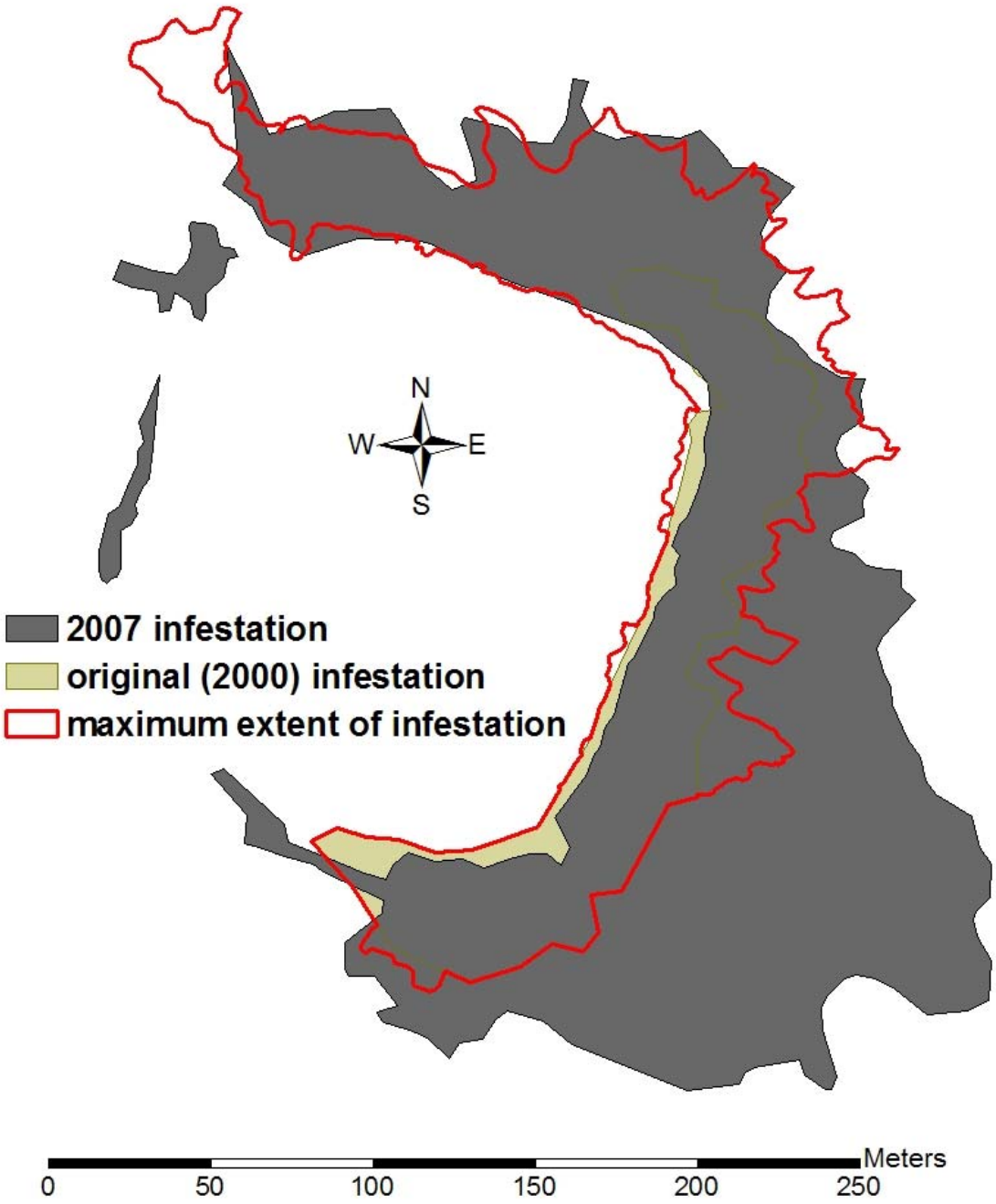
Highway 115 musk thistle density in 2007.



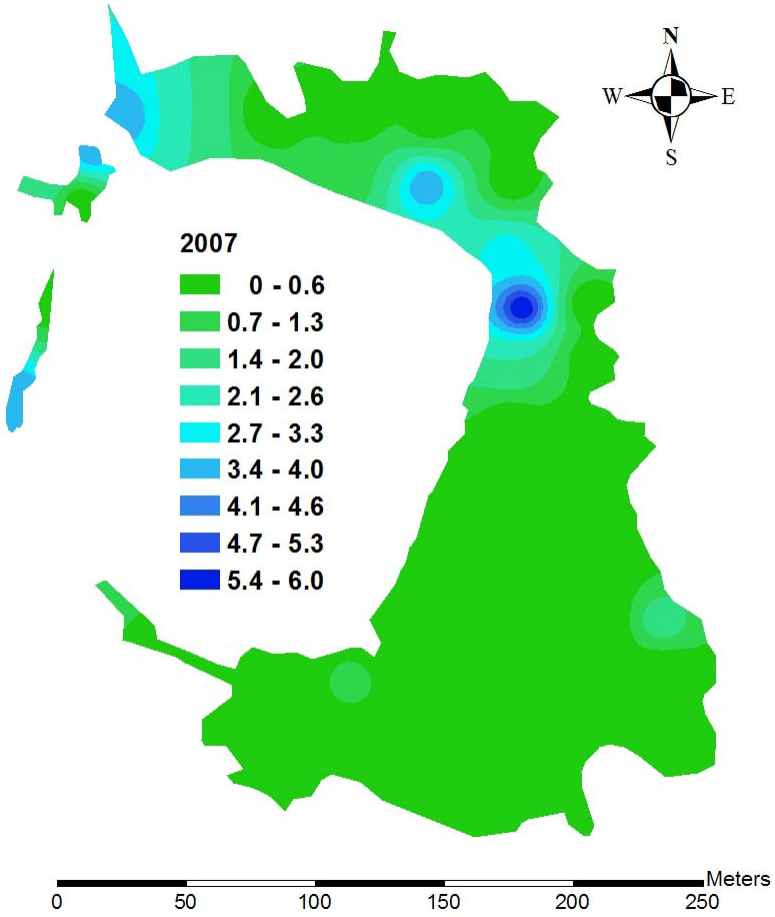


Highway 115 musk thistle height in 2007.

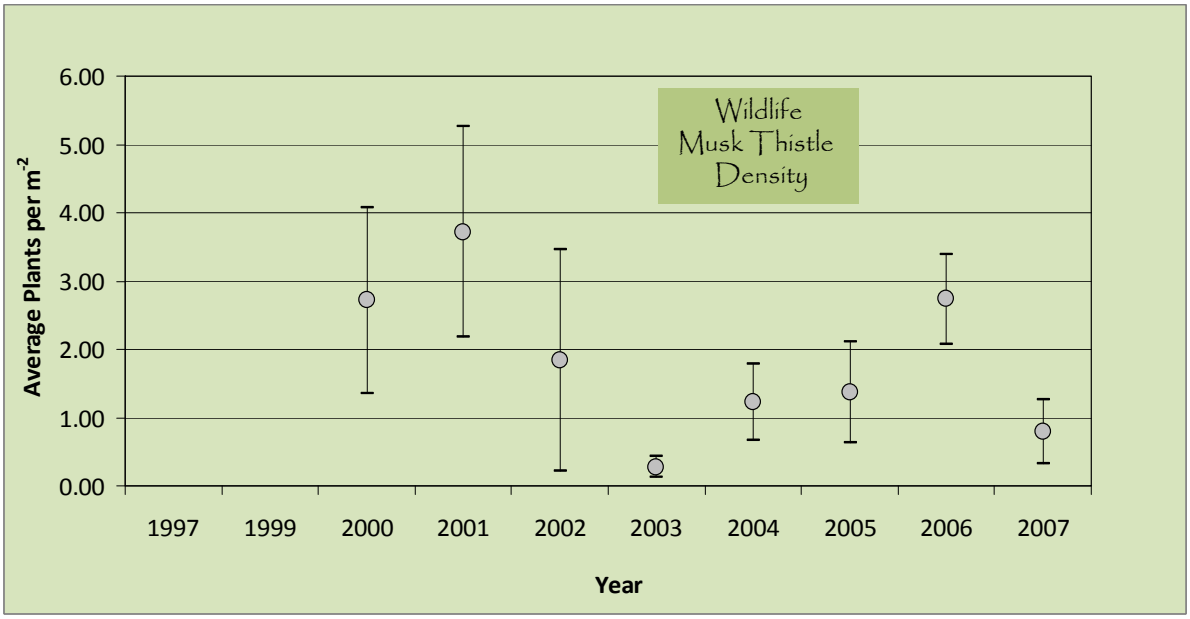


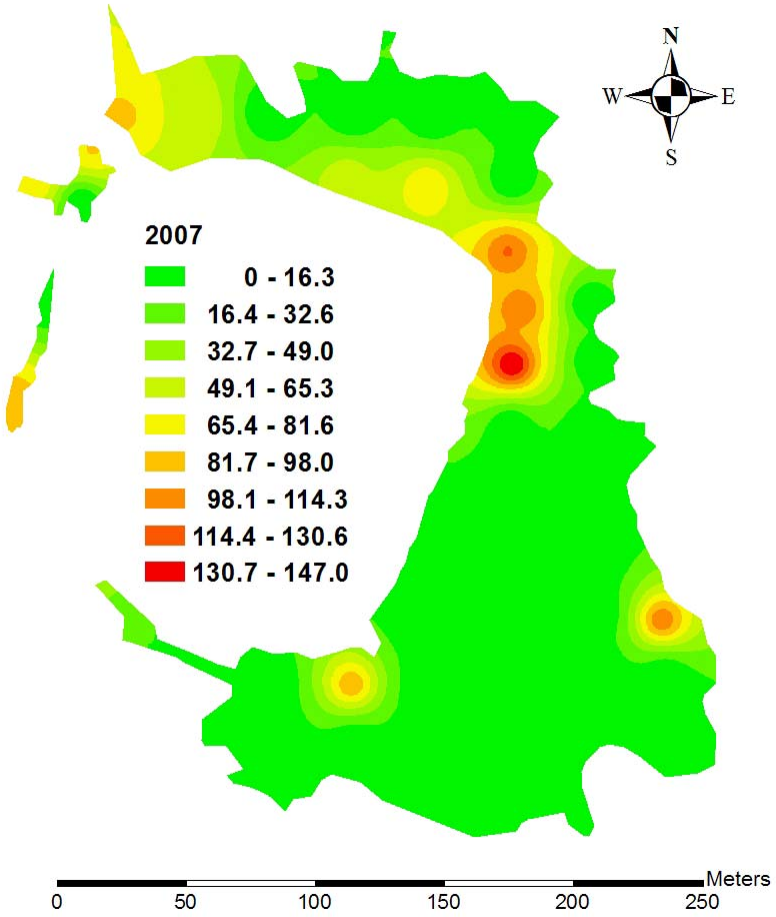


Wildlife musk thistle perimeter in 2007.

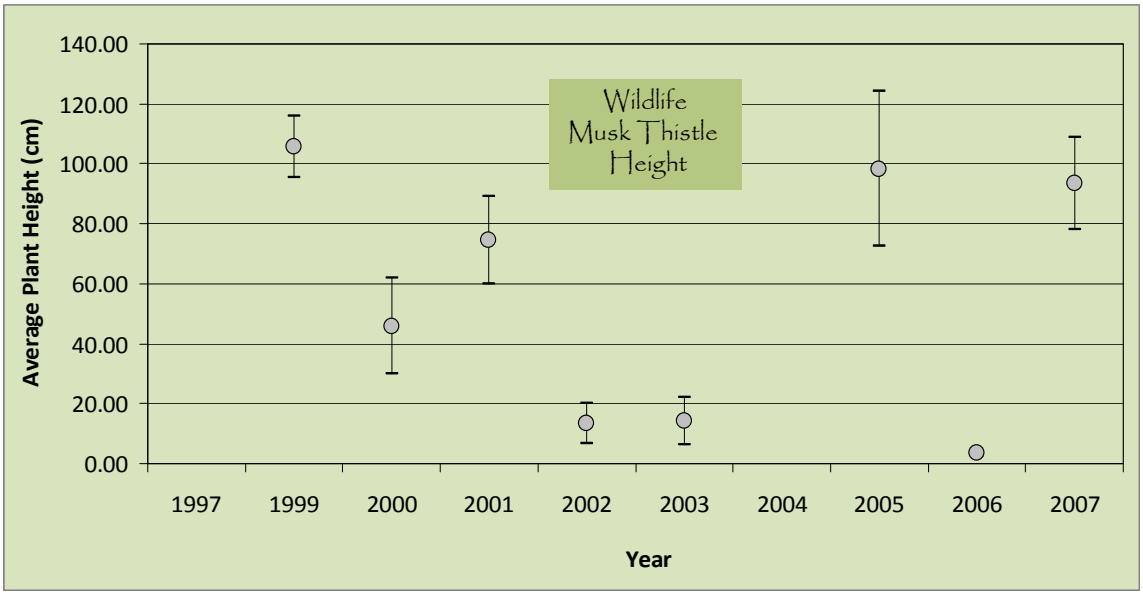


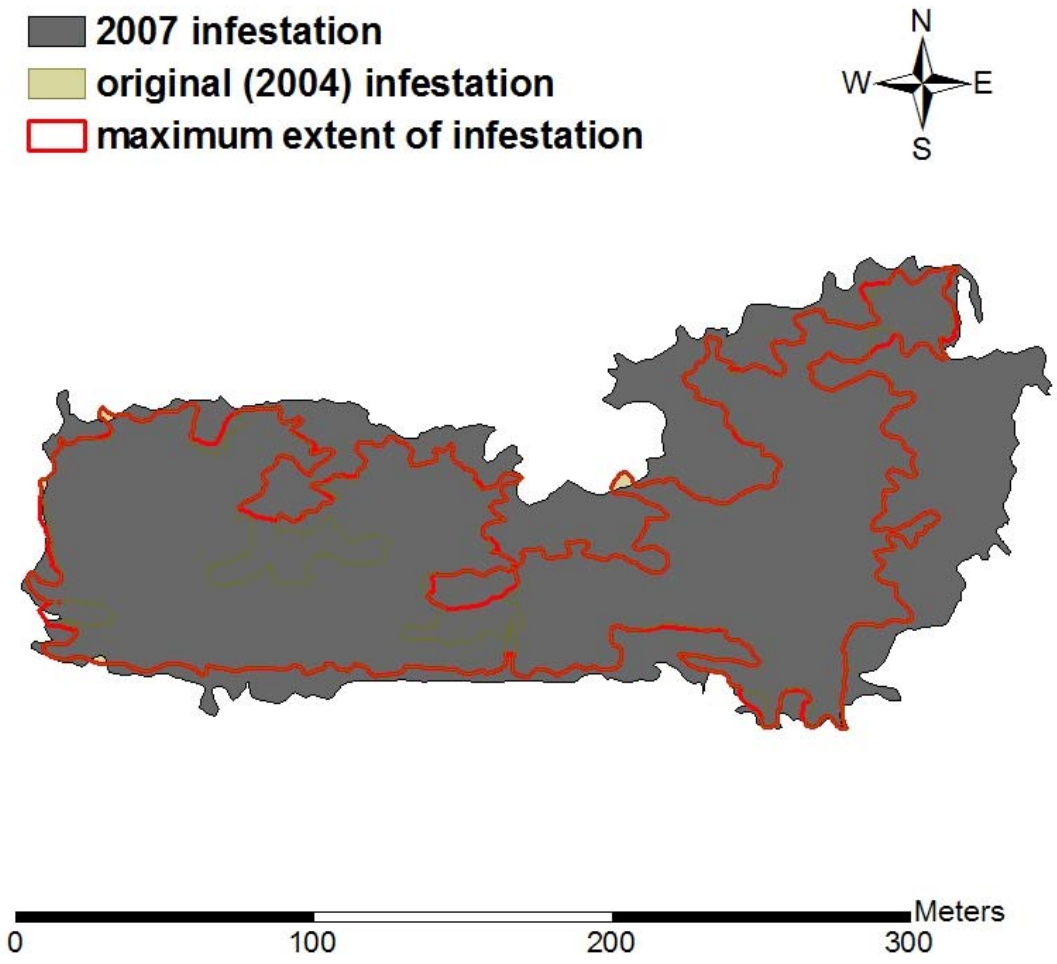
Wildlife musk thistle density in 2007.



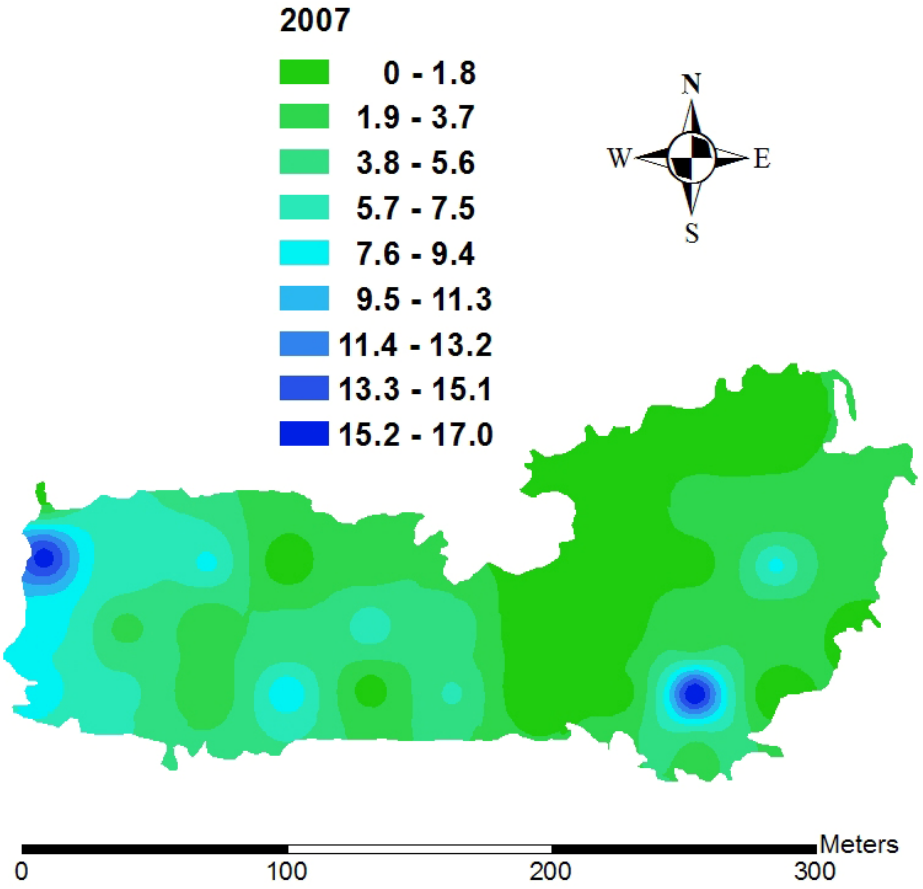


Wildlife musk thistle height in 2007.

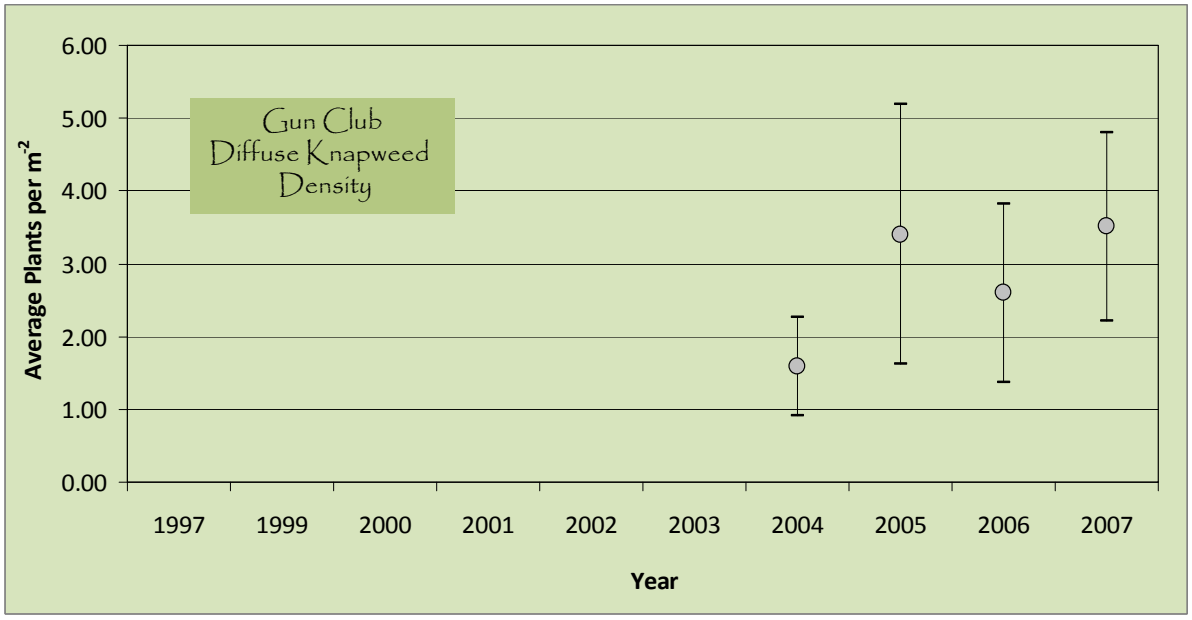


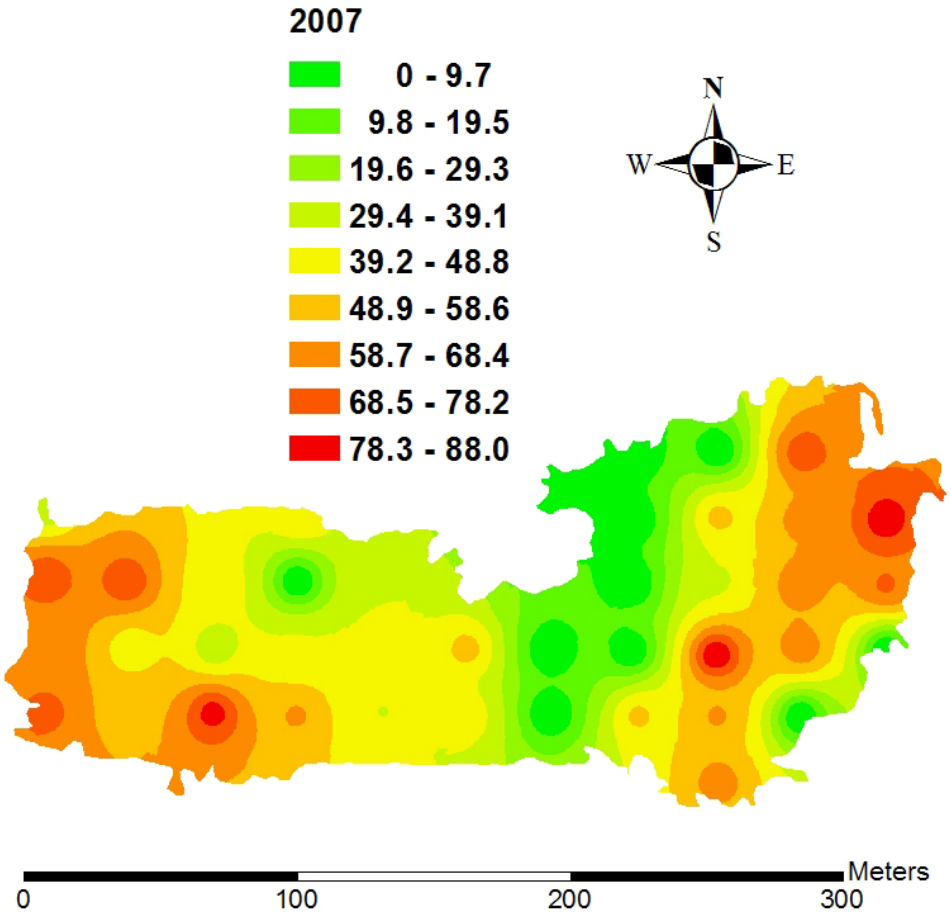


Gun Club diffuse knapweed perimeter in 2007.

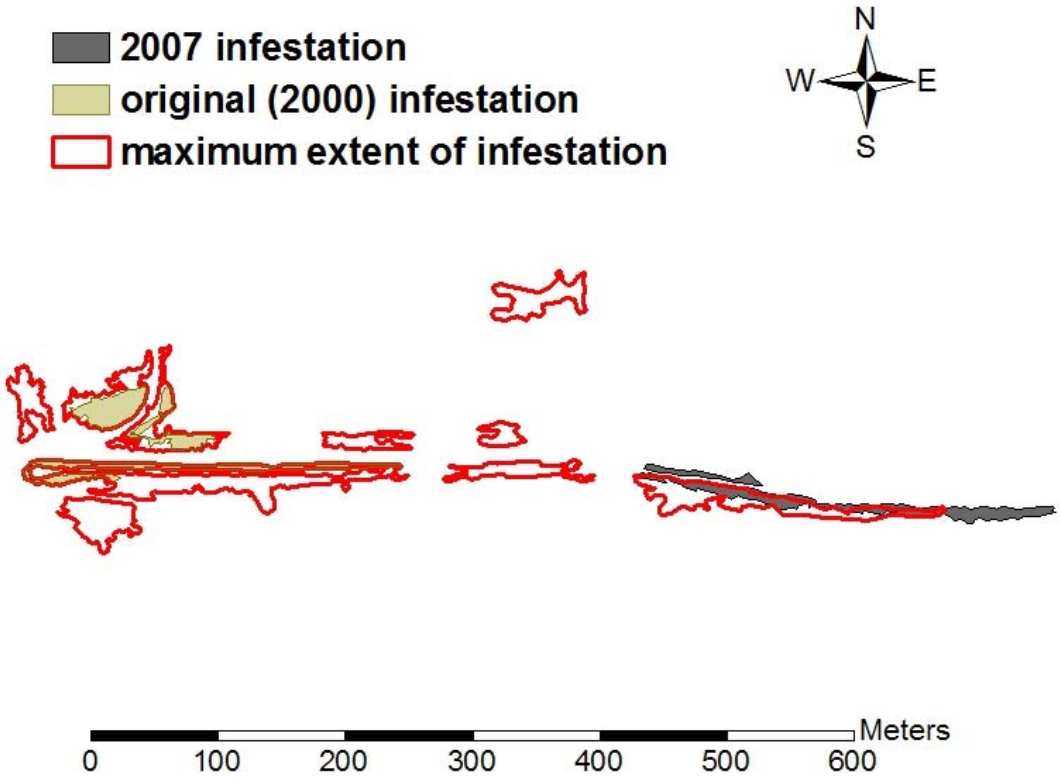


Gun Club diffuse knapweed density in 2007.

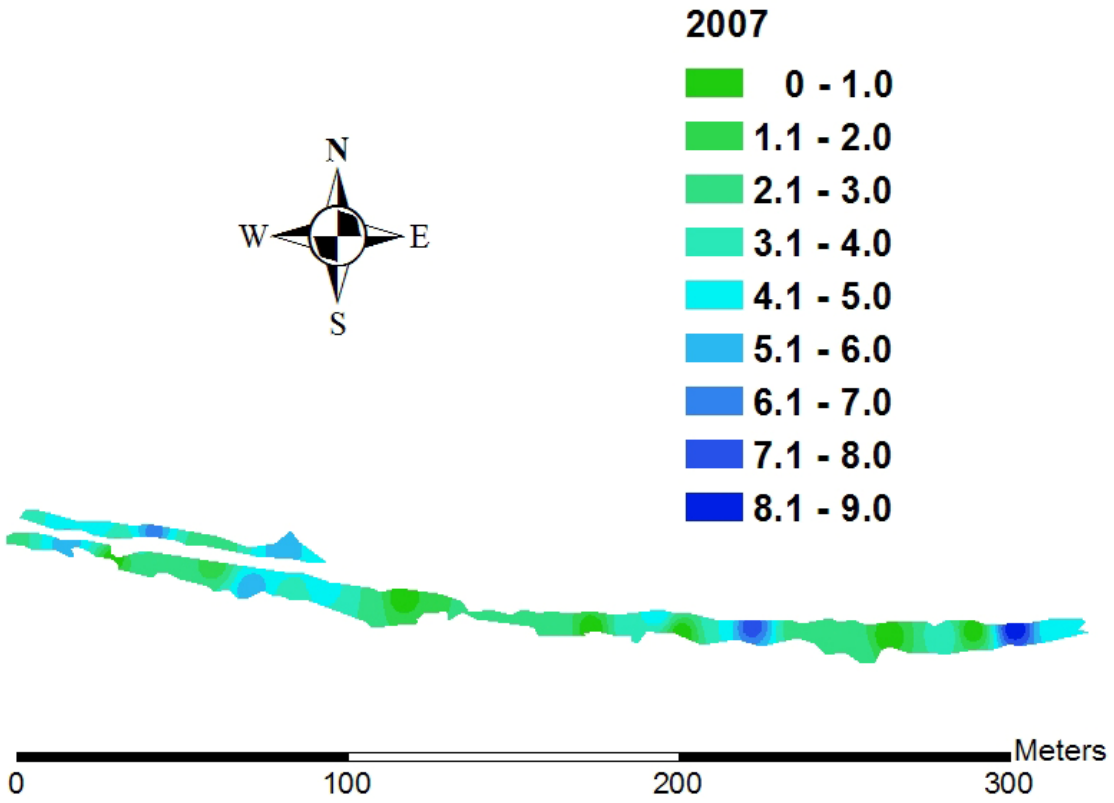




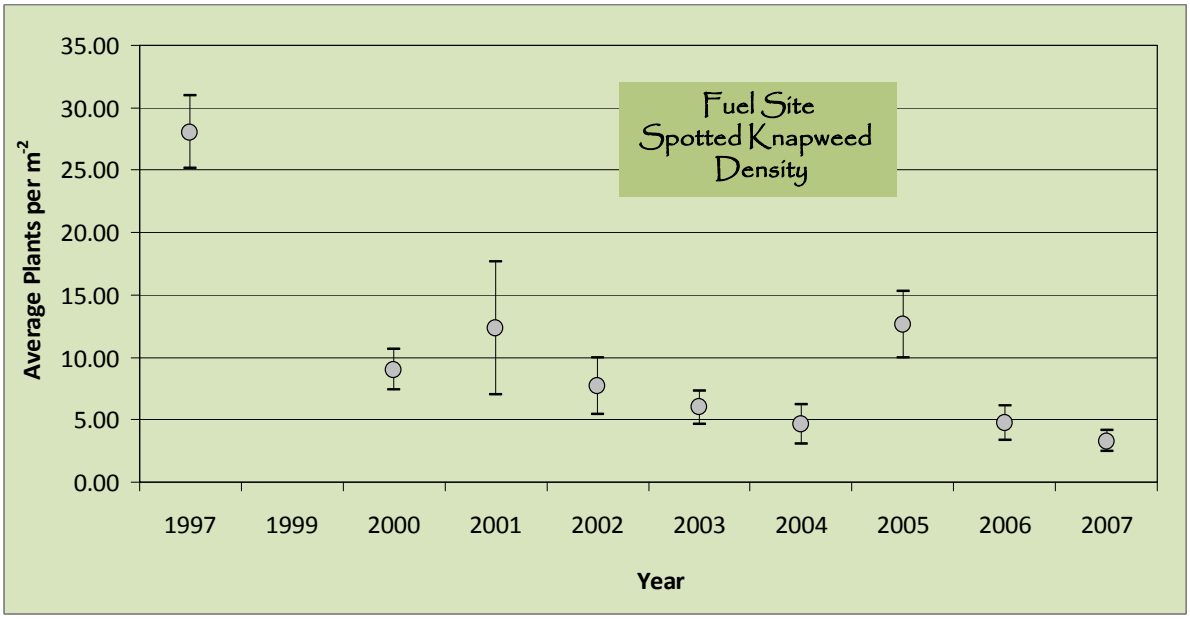
Gun Club diffuse knapweed height in 2007.

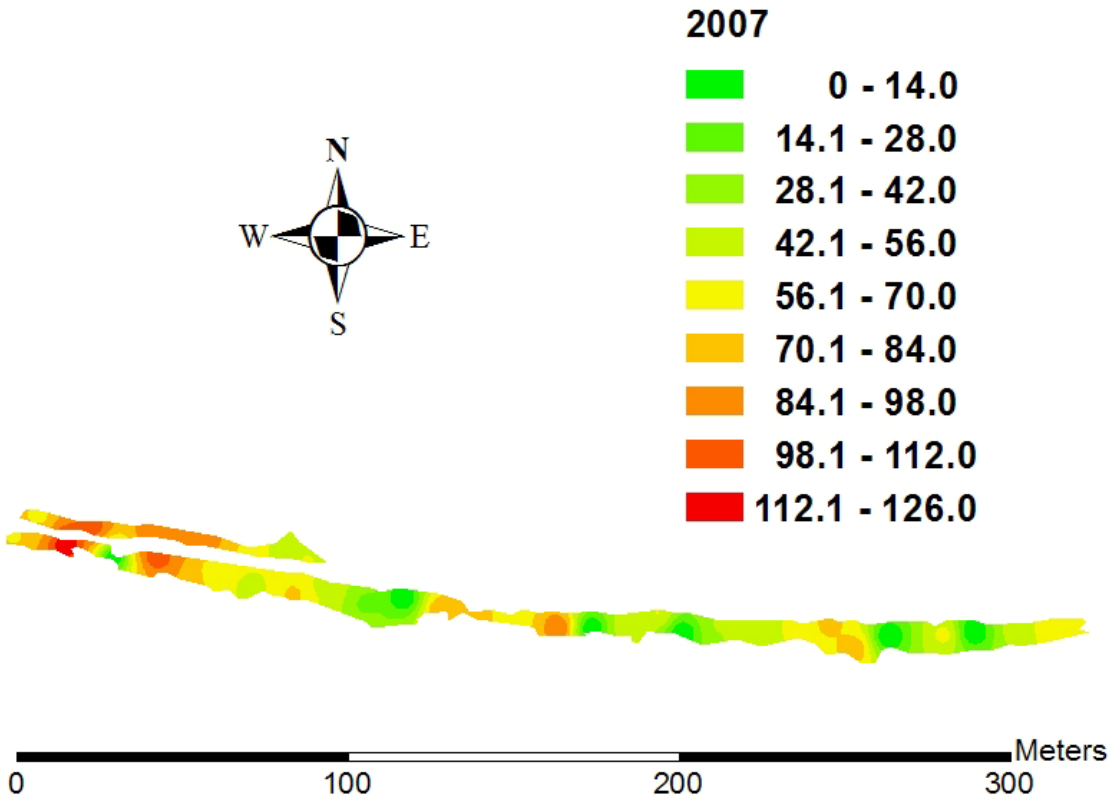


Fuel Site (Cantonment I) spotted knapweed perimeter in 2007.

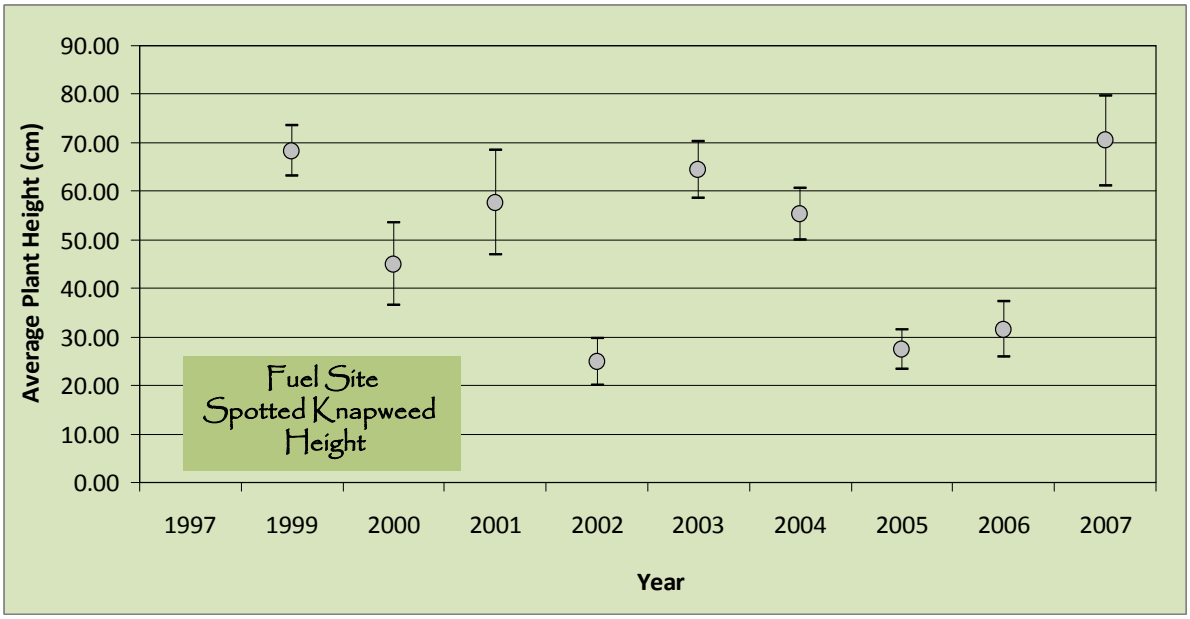


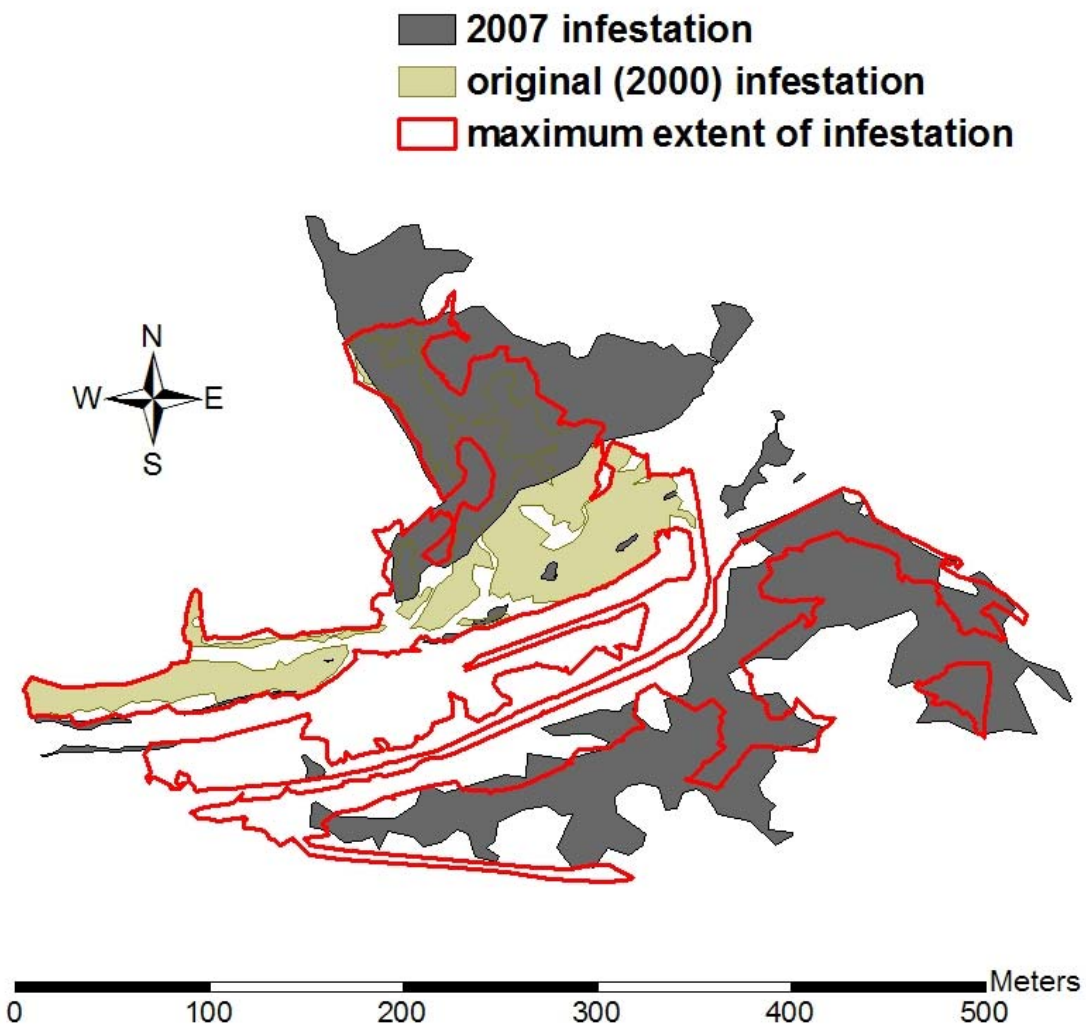
Fuel Site (Cantonment I) spotted knapweed density in 2007.



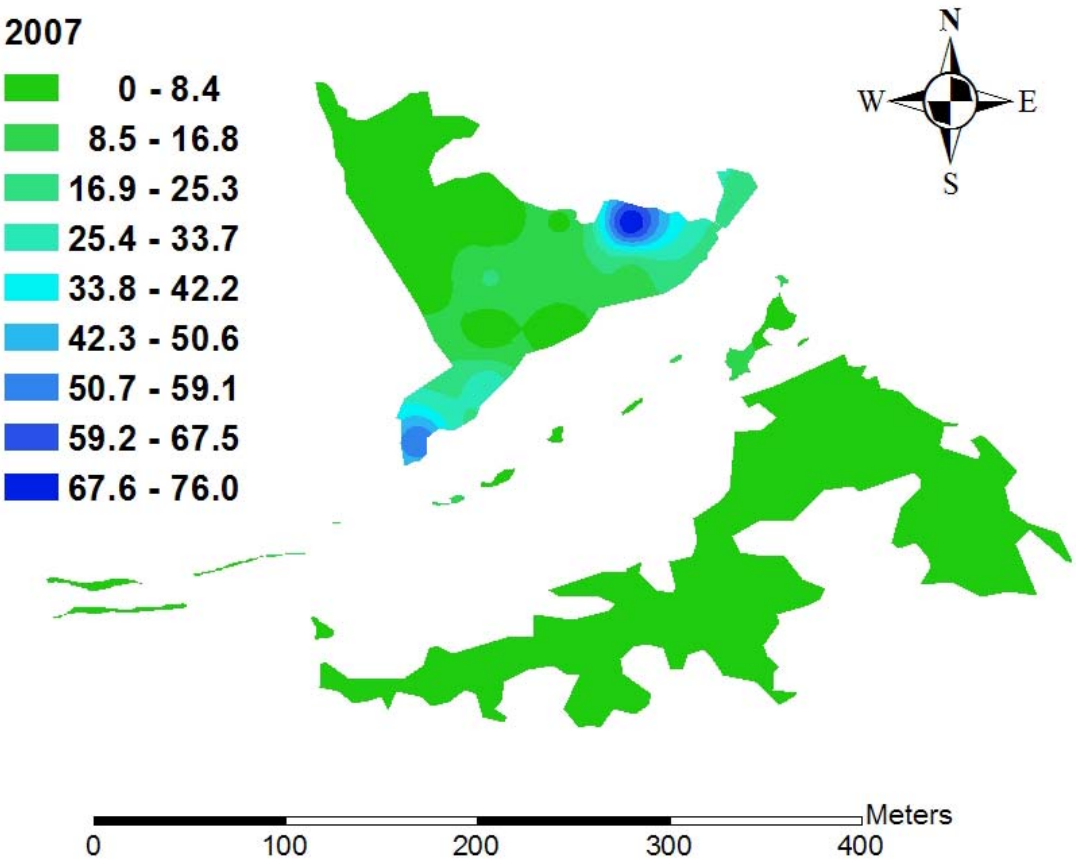


Fuel Site (Cantonment I) spotted knapweed height in 2007.

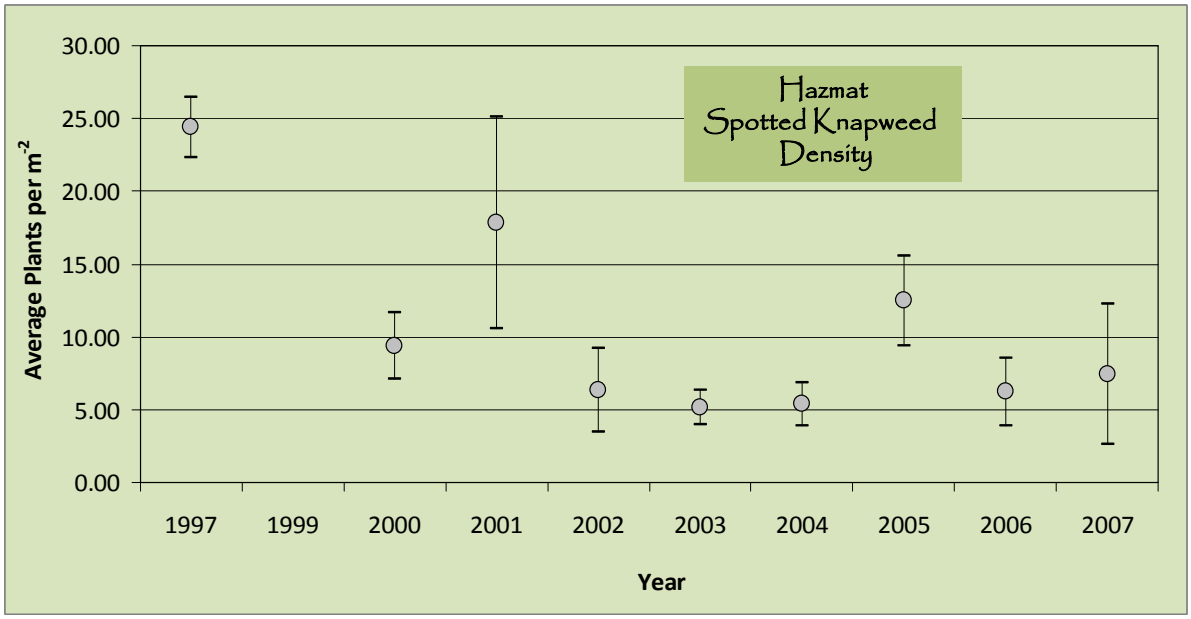


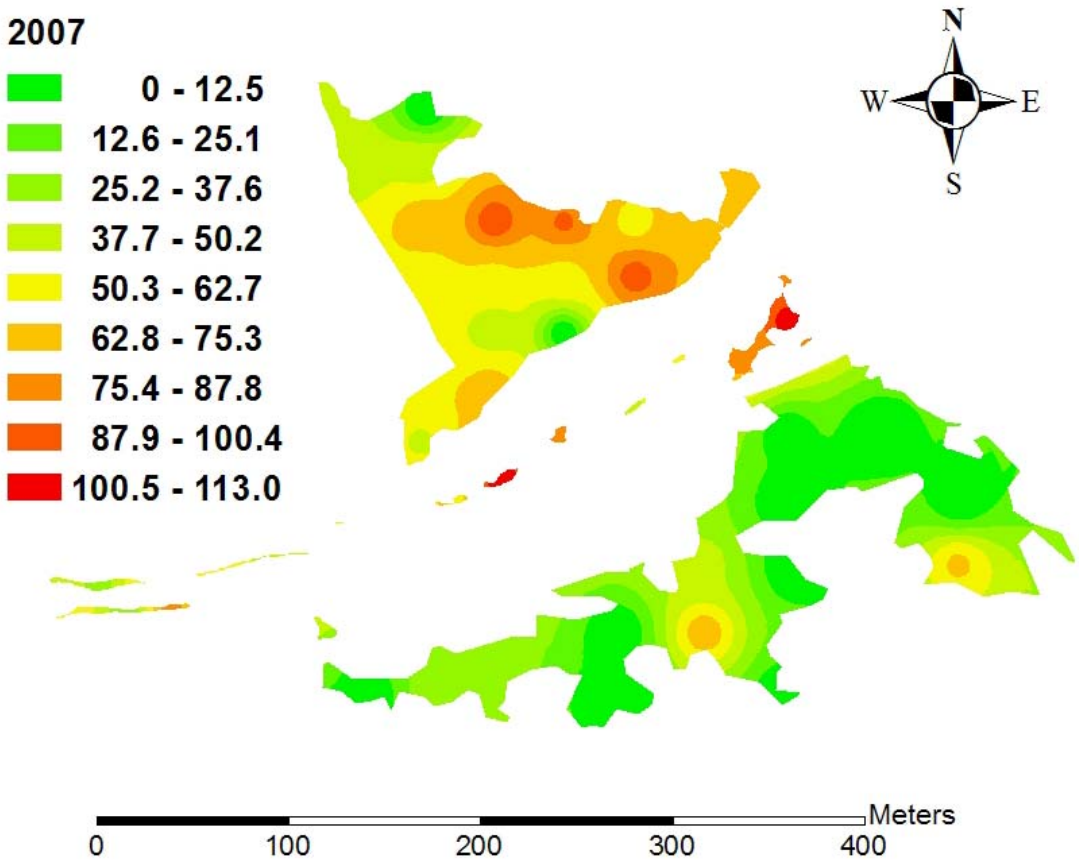


HazMat (Cantonment II) spotted knapweed perimeter in 2007.

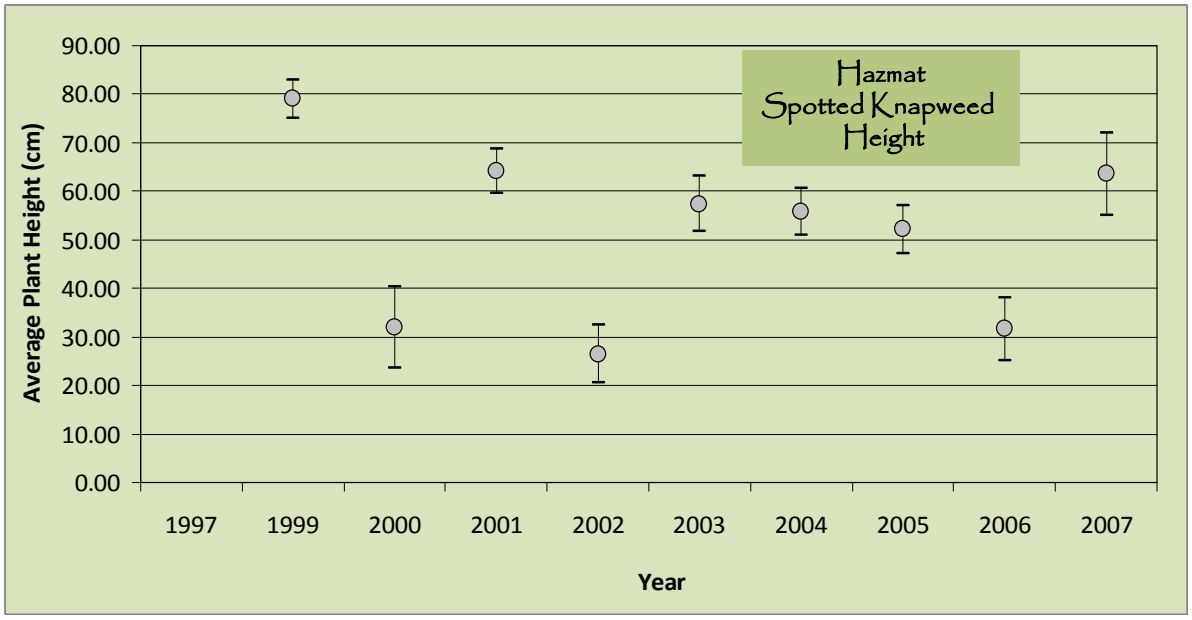


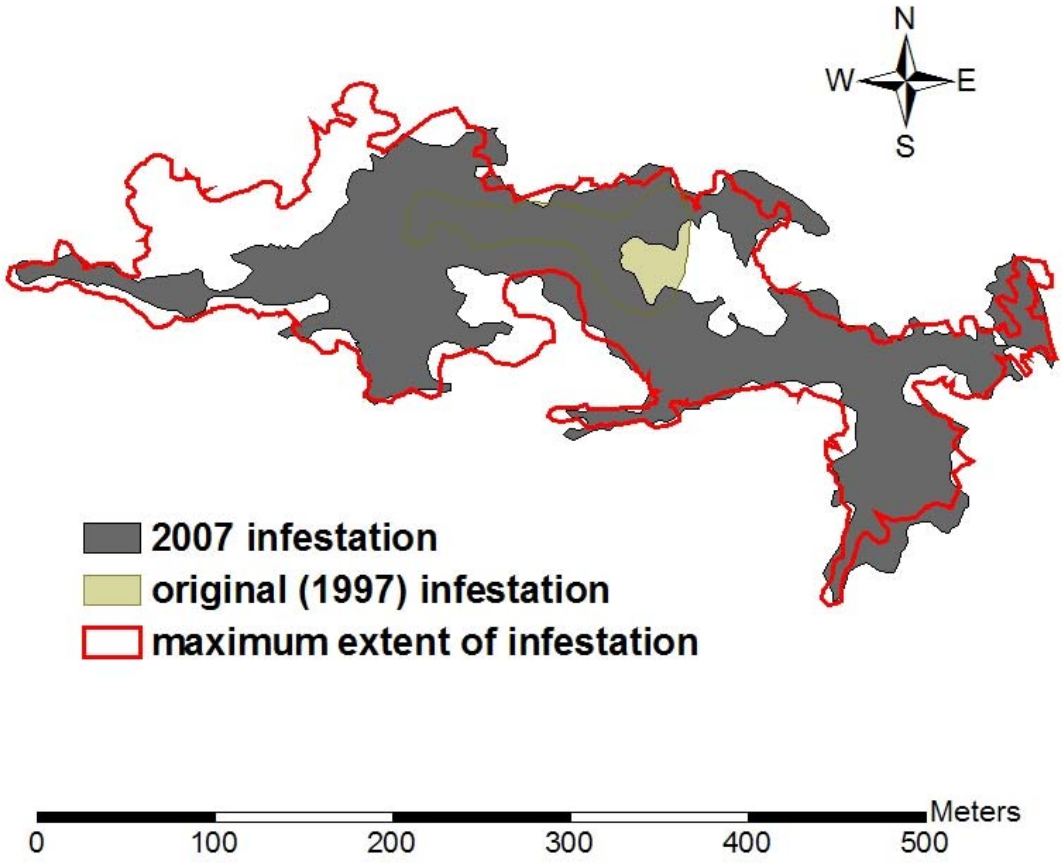
HazMat (Cantonment II) spotted knapweed density in 2007.



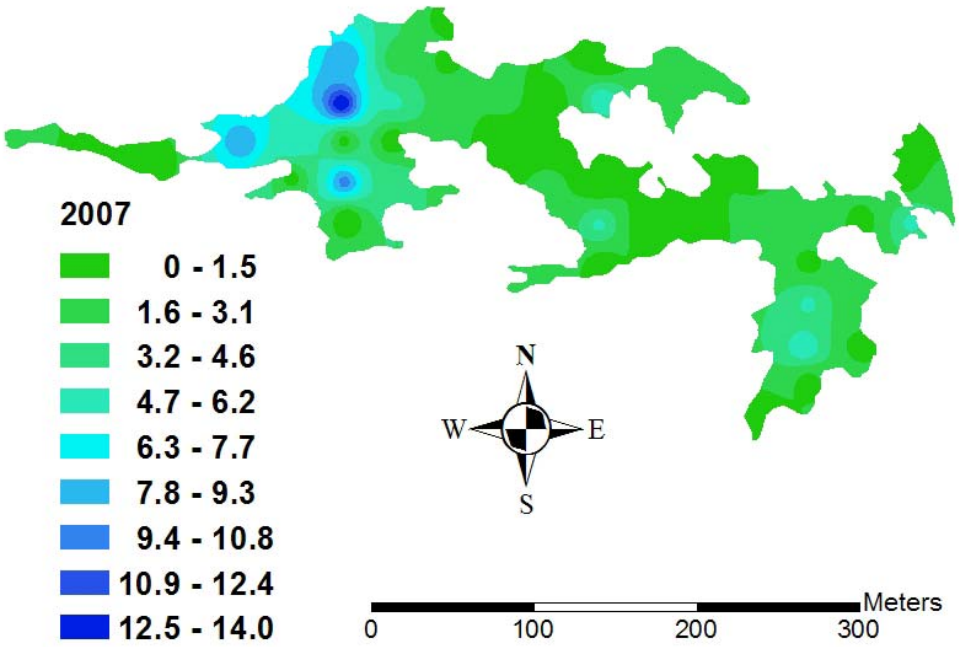


HazMat (Cantonment II) spotted knapweed height in 2007.

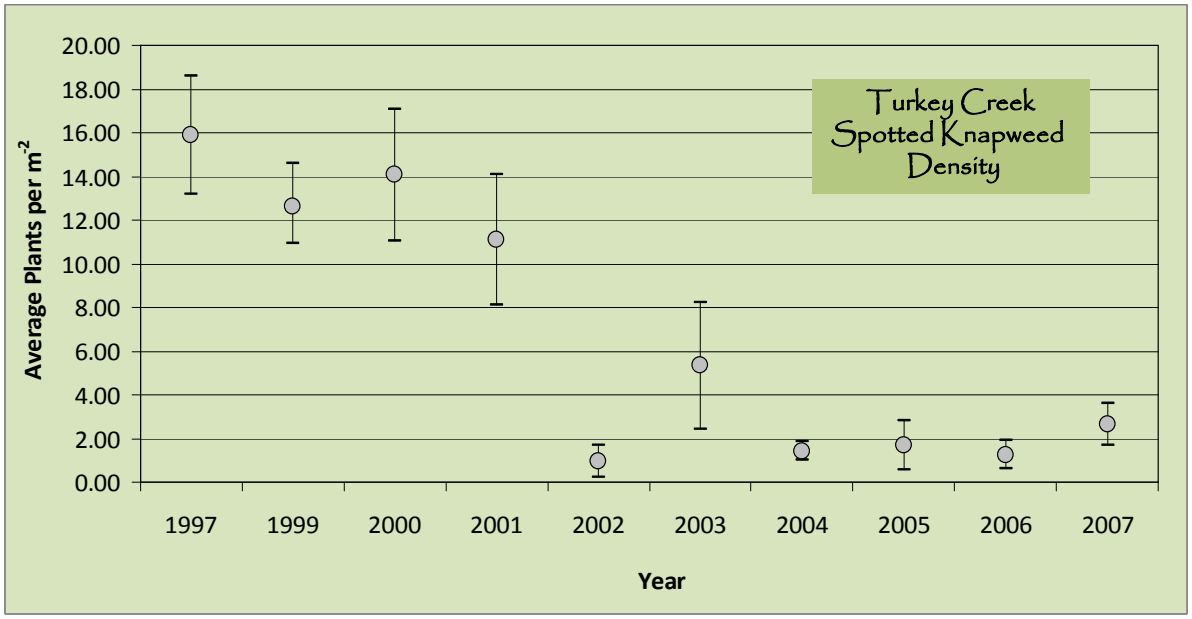


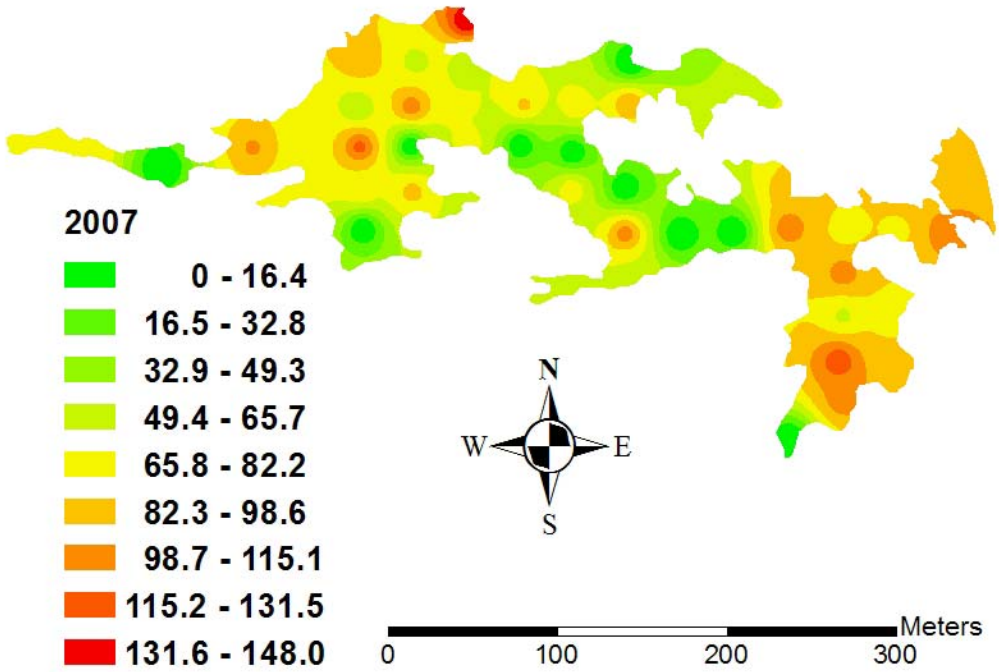


Turkey Creek spotted knapweed perimeter in 2007.

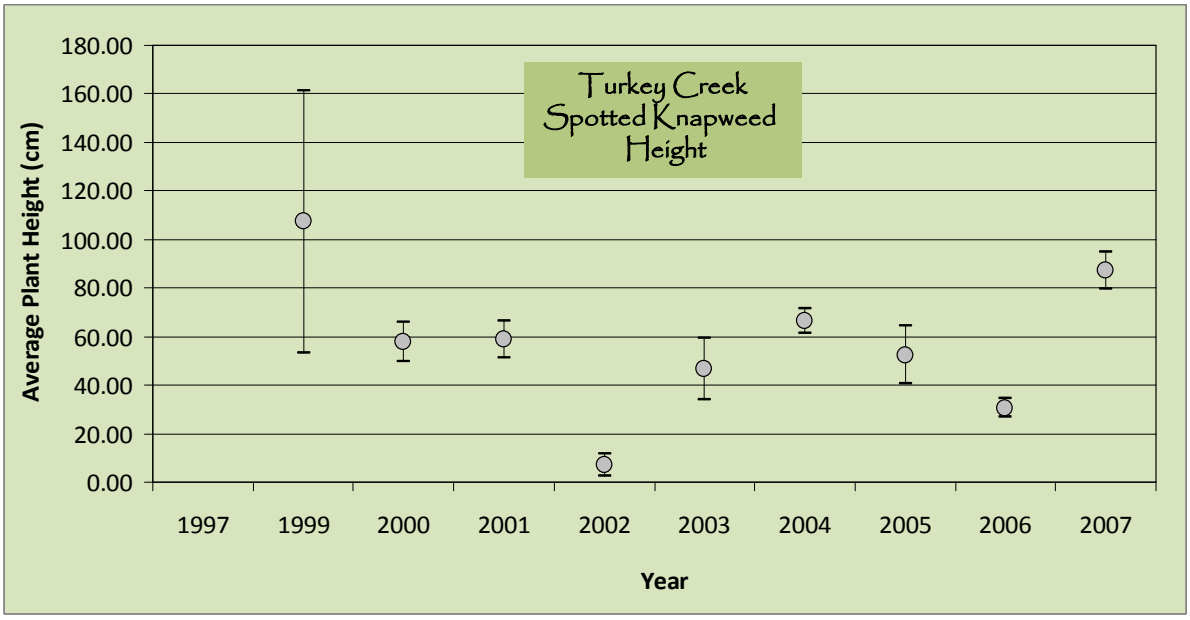


Turkey Creek spotted knapweed density in 2007.





Turkey Creek spotted knapweed height in 2007.



Rocky Flats Environmental Technology Site

Four weed infestations were intensively sampled at Rocky Flats Environmental Technology Site in 2007. Transect surveys were performed over 4.2 km of diffuse knapweed in the North Buffer area and along 1.4 km of Dalmatian toadflax running along the South Fence (Table 15). Of the biocontrol release sites previously mapped at Rocky Flats Environmental Technology Site, only the Lindsay Ranch Canada thistle infestation and Original Dalmatian toadflax were mapped in 2007, comprising 0.3 ha (0.7 acres) and 2.6 ha (6.4 acres) respectively (Table 15). Many of the previous release sites had been destroyed during decommissioning of the installation.

As a result of the disturbance to much of the central part of the base and surrounding areas, weed populations such as Dalmatian toadflax, diffuse knapweed and musk thistle have established throughout the installation. Consequently, our crews had difficulty determining a distinct perimeter for the Original toadflax site, resulting in a large area being mapped to include widely spread clumps of toadflax. Within the 2.6 ha mapped at the Original site, less than 35% of samples taken actually contained a toadflax plant. Much of the newly mapped area is outside the traditional extent of the 2001-2006 Original infestation, so care should be taken when viewing and interpreting the area of "infestation" in Table 15. We've previously addressed this issue by shifting our weed sampling techniques from intensively mapping weed patches at the North Buffer diffuse knapweed and South Fence Dalmatian toadflax sites to linear transects. We are again looking at modifying our sampling methods to accommodate the widely distributed, though sparsely populated, Original toadflax infestation and surrounding toadflax.

Figure 15. Dalmatian toadflax from the South Fence site (left), on which a female *M. janthinus* weevil was observed drilling into a shoot in order to lay an egg (right).

Both Canada thistle and diffuse knapweed sites declined in density since 2006 (Table 2), and over the entire course of our monitoring (Table 15). Both released biocontrol agents, *Cassida rubiginosa* and *Urophora cardui*, are established at the Lindsay Ranch site and can be easily observed damaging plant leaf and stem tissues (Figure 16). In addition to the released agents on diffuse knapweed, *Larinus minutus* and *Cyphocleonus achates*, which were present in 46 and 55% of sampled seedheads (Table 4) and roots, respectively, we observed several other knapweed bio-agents in roots and seedheads from Rocky Flats Environmental Technology Site. These include strong fliers *Agapeta zoegana*, *Metzneria paucipunctella*, *Sphenoptera jugoslavica* and *Urophora affinis* (Table 16).

Figure 16. Canada thistle from the Lindsay Ranch site The entire plant, pictured on the left, shows moderate attack by defoliator *Cassida* rubiginosa (top right). Also commonly seen at this site is stem-galler *Urophora cardui* (bottom right).

In contrast, both of the monitored Dalmatian toadflax infestations, Original and South Fence, experienced minor population expansion in 2007. Biocontrol insect pressure was lower in 2007 than 2006 on Dalmatian toadflax as reduced numbers of *M. janthinus* emerging from 2006 field season coincided with an increased abundance of toadflax shoots in 2007 (Table 15). Attack rates and *M. janthinus* population density estimates declined in 2006 to approximately 20-30% of those reported from 2005 toadflax stem dissections (Table 5). In response to the growing toadflax issue occurring throughout the base, we obtained and released an additional 300 *M. janthinus* along the South Fence site, as the insects have already proven to readily establish in this area. Spring samples of Dalmatian toadflax stems for dissection will reveal if weevil populations successfully rebounded in 2007. Otherwise, additional reinforcements may be necessary to boost this bio-agent's ability to overcome the expansion of its target host, particularly along the south perimeter of the installation.

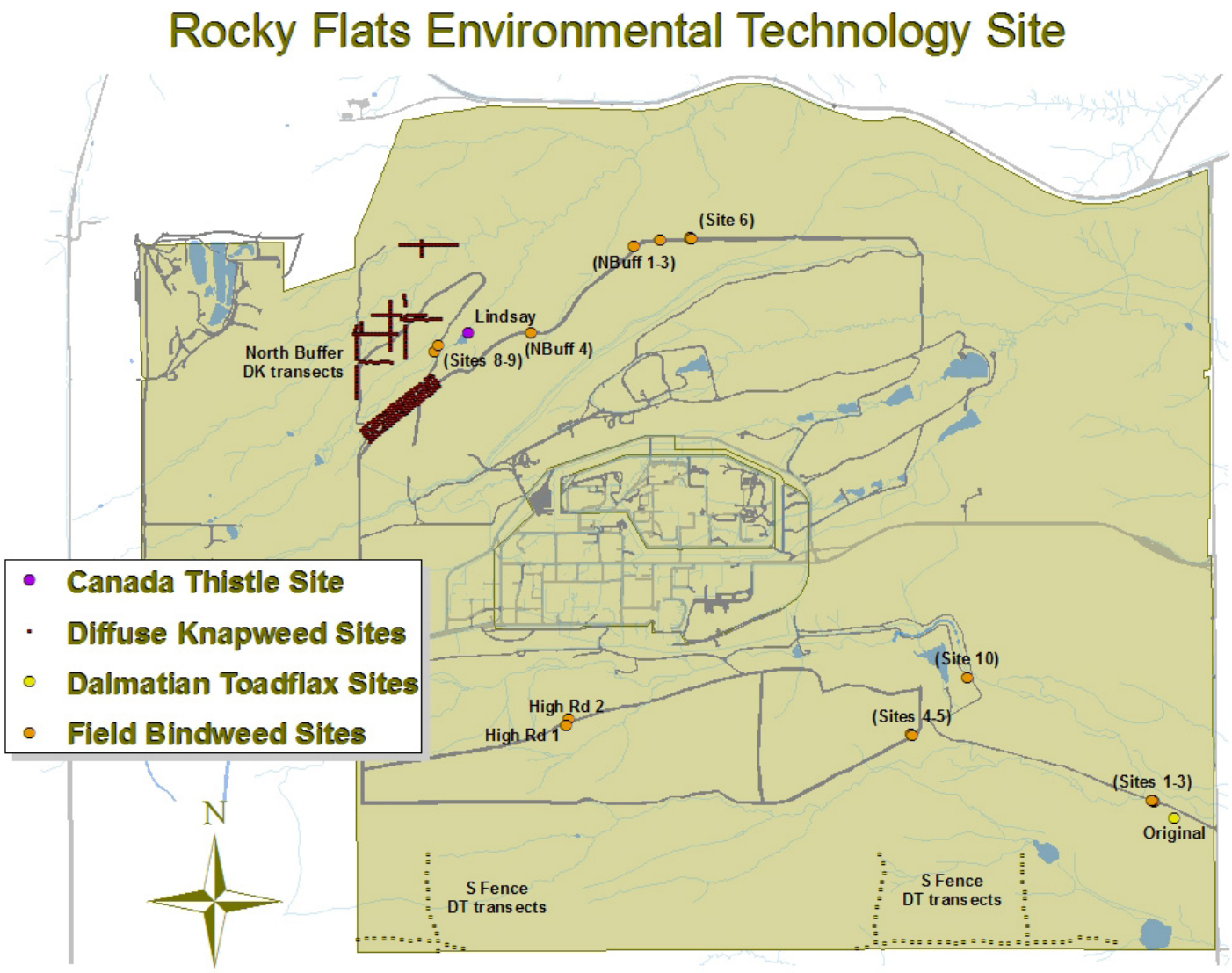


Figure 17. Schematic diagram of Rocky Flats Environmental Technology Site with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2007.

Table 15. Historic noxious weed infestation parameters, Rocky Flats Environmental Technology Site, Colorado, 2001-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads per plant	Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Canada thistle – Lindsay Ranch												
2004	692	43	7.84	34	56.05	104	1.64	0.30				
2005	2,205	30	5.93	16	94.23	165	18.14	0.72	218.64	-24.36	68.12	
2006	5,617	47	5.89	19	46.07	100	9.28	0.51	154.74	-0.67	-51.11	
2007	2,560	36	4.53	45	58.45	98	8.09	5.68	-54.42	-23.09	26.87	269.94
Dalmatian toadflax – Original Site												
2001	1,688	48	22.43	64	52.94	84						
2002	7,913	93	3.81	23	12.90	55			368.78	-83.01	-75.63	
2003	*(see Note)*											
2004	*(see Note)*											
2005	2,216	69	8.21	26	43.40	66	16.81					
2006	1,686	90	1.16	19	12.15	20			-23.91	-85.87	-72.00	
2007	26,077	44	1.45	17	46.23	62			1446.68	25.00	280.49	1444.85
Dalmatian toadflax – South Fence *												
2005		71	3.04	29	47.94	74	9.76	1.12				
2006		74	1.31	12	26.50	57	1.40			-56.91	-44.72	
2007		74	2.05	21	49.25	79				56.48	85.84	
Diffuse knapweed – North Buffer *												
2004		249	0.85	12	17.72	72	21.37	0.18				
2005		250	1.13	21	52.95	120	49.72	0.53		32.94	198.81	
2006		249	0.59	22	34.43	188	53.00	0.42		-47.79	-34.98	
2007		123	0.44	11	46.17	73	117.21	3.75		-25.42	34.10	

n – number of samples or observations

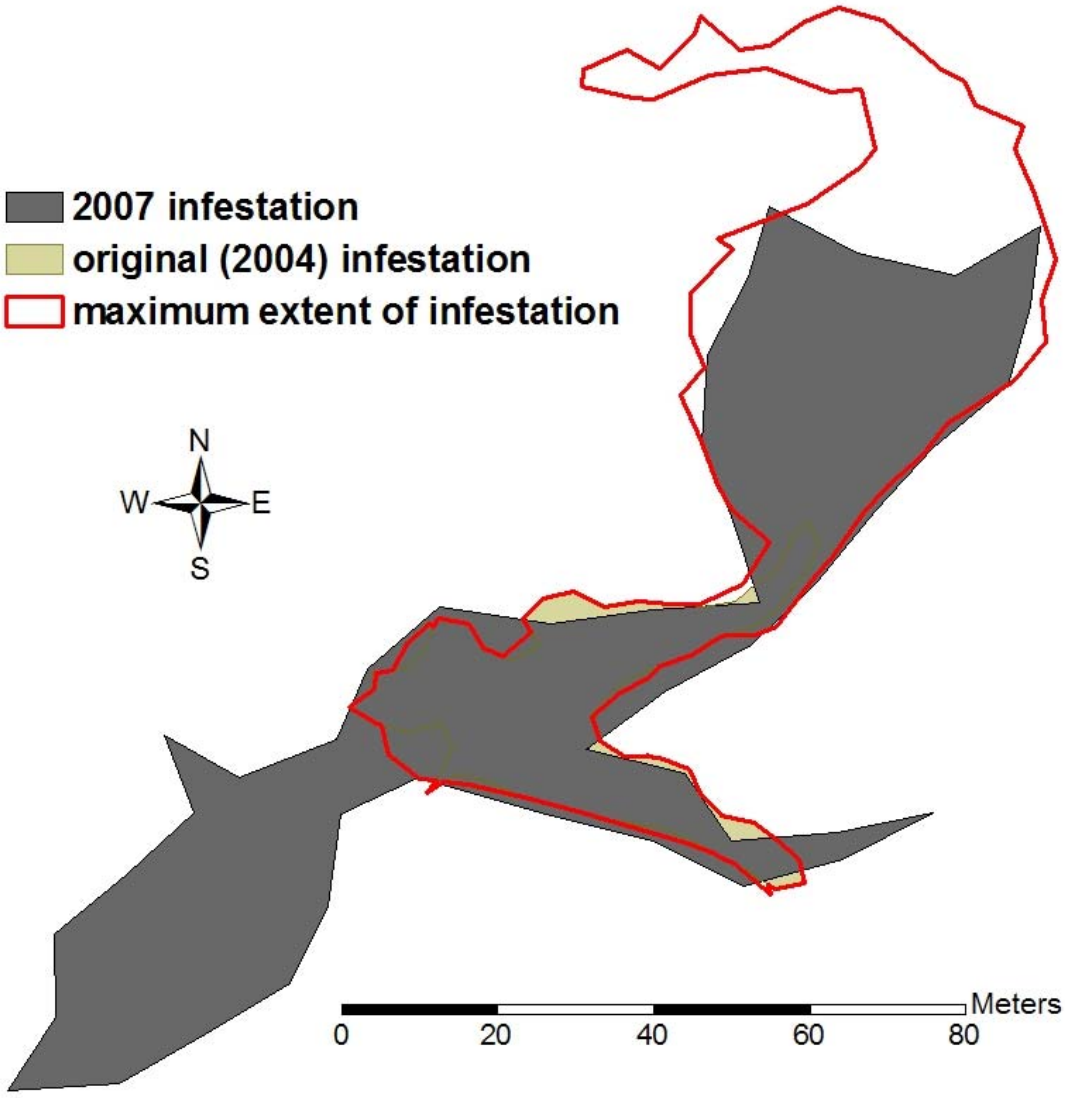
* - infestation was not mapped (a linear transect method was utilized to survey the weed population)

Note - site was not mapped, as toadflax infestation had been reduced to a few scattered plants.

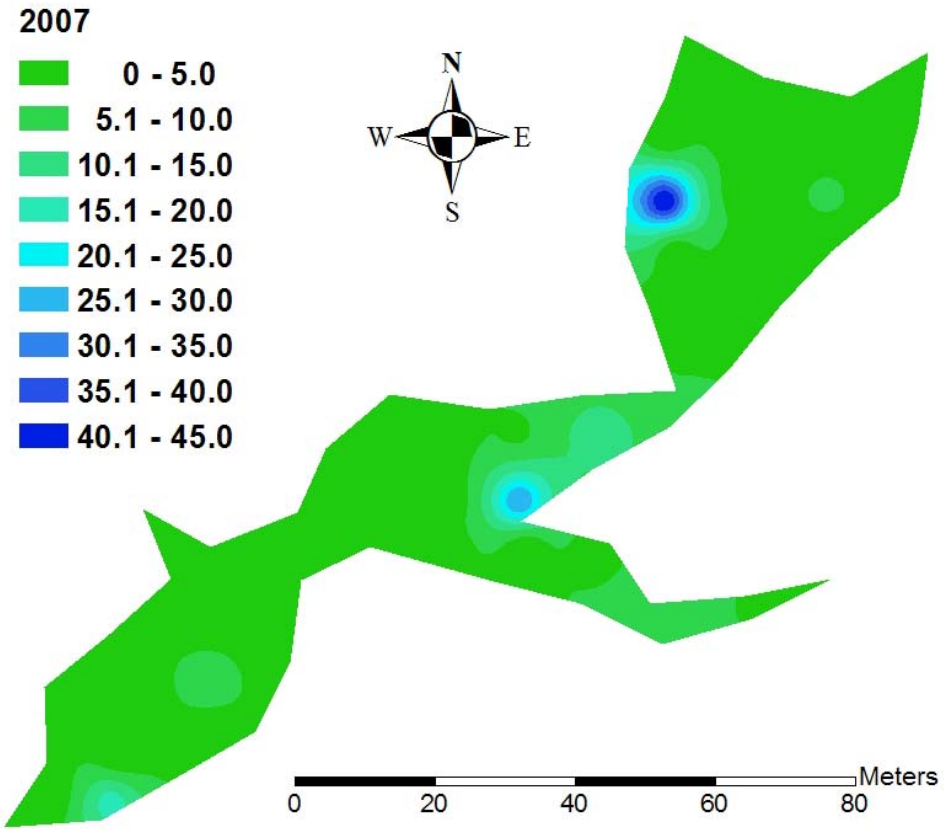
Table 16. Noxious weed biological control sites, target weeds, species released and recoveries at Rocky Flats, 2007.

Location	Target weed	Site	Species released	Species recovered	New release	New site
Rocky Flats	Canada thistle	Lindsay Ranch	*Cassida rubiginosa*	X		
Rocky Flats	Canada thistle	Lindsay Ranch	*Urophora cardui*	X		
Rocky Flats	Musk thistle	North Buffer	*Trichosirocalus horridus*	X		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Agapeta zoegana*	X [1,2]		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Cyphocleonus achates*	X		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Larinus minutus*	X		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Metzneria paucipunctella*	X [1]		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Sphenoptera jugoslavica*	X		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Urophora affinis*	X [1]		
Rocky Flats	Dalmatian toadflax	Original Site	*Mecinus janthinus*	X		
Rocky Flats	Dalmatian toadflax	Southeast Buffer Zone	*Mecinus janthinus*	X		
Rocky Flats	Dalmatian toadflax	Sites III & IV	*Mecinus janthinus*	X		
Rocky Flats	Dalmatian toadflax	South Fence	*Mecinus janthinus*	X	X	

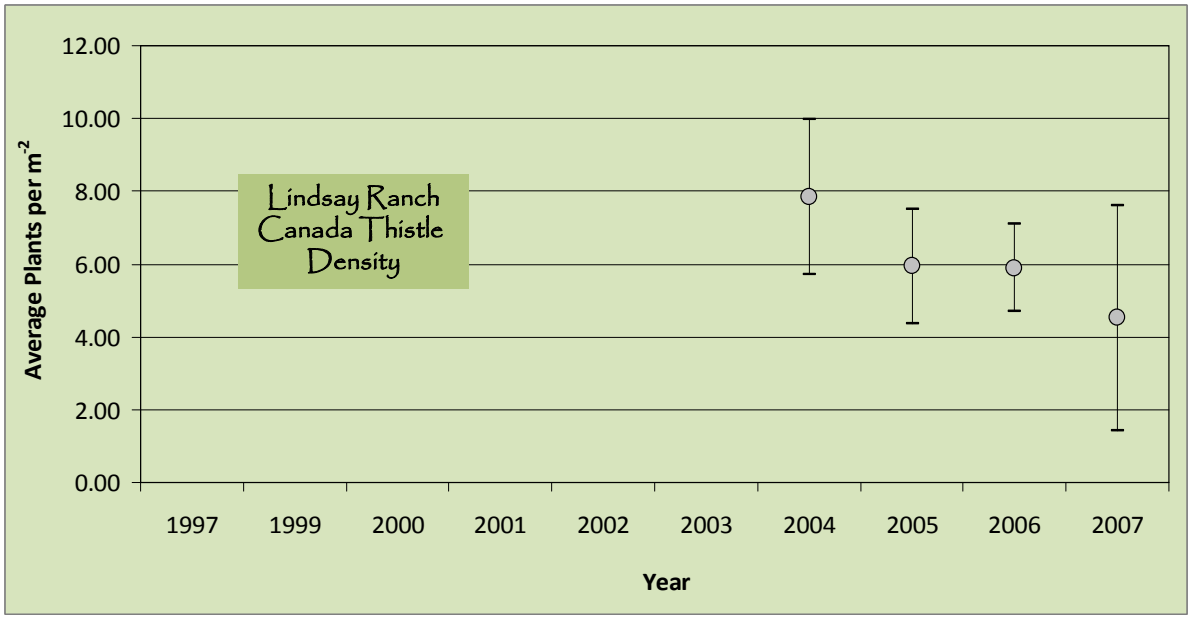
[1] Adventitious recovery, insects were not released at this location
[2] New recovery in 2007

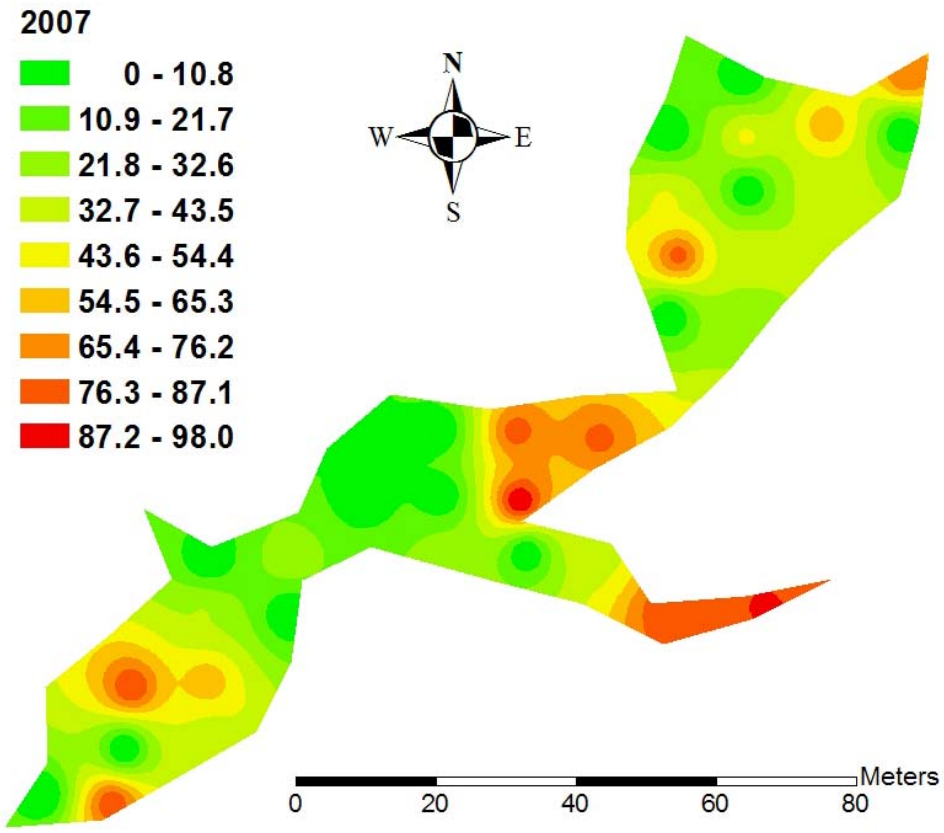


Lindsay Ranch Canada thistle perimeter in 2007.

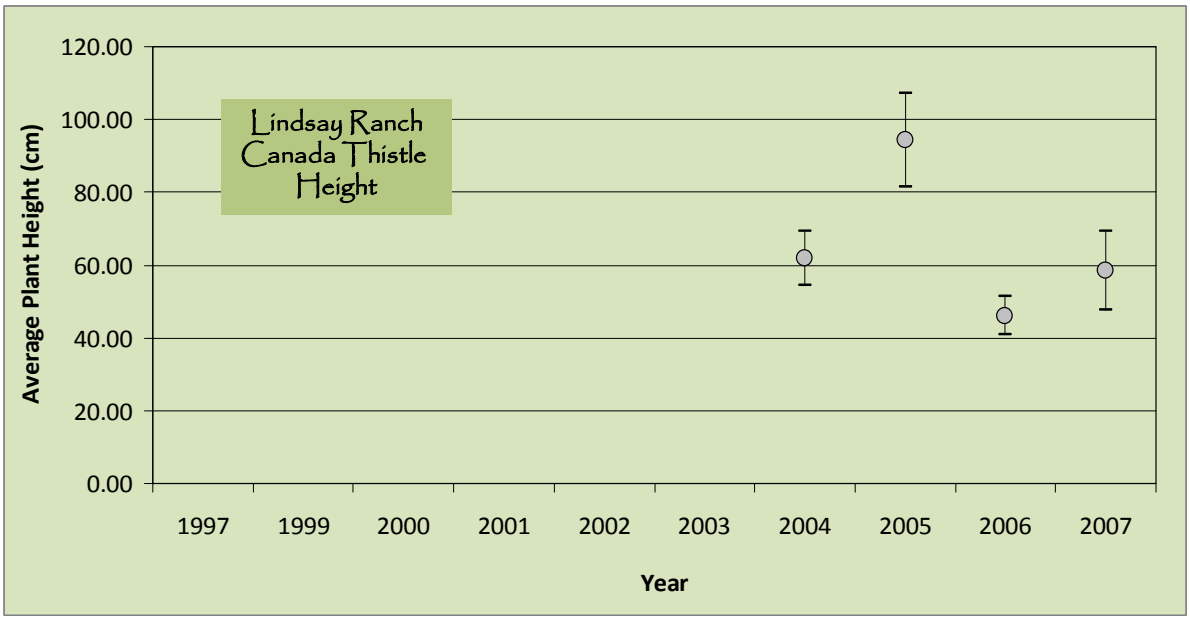


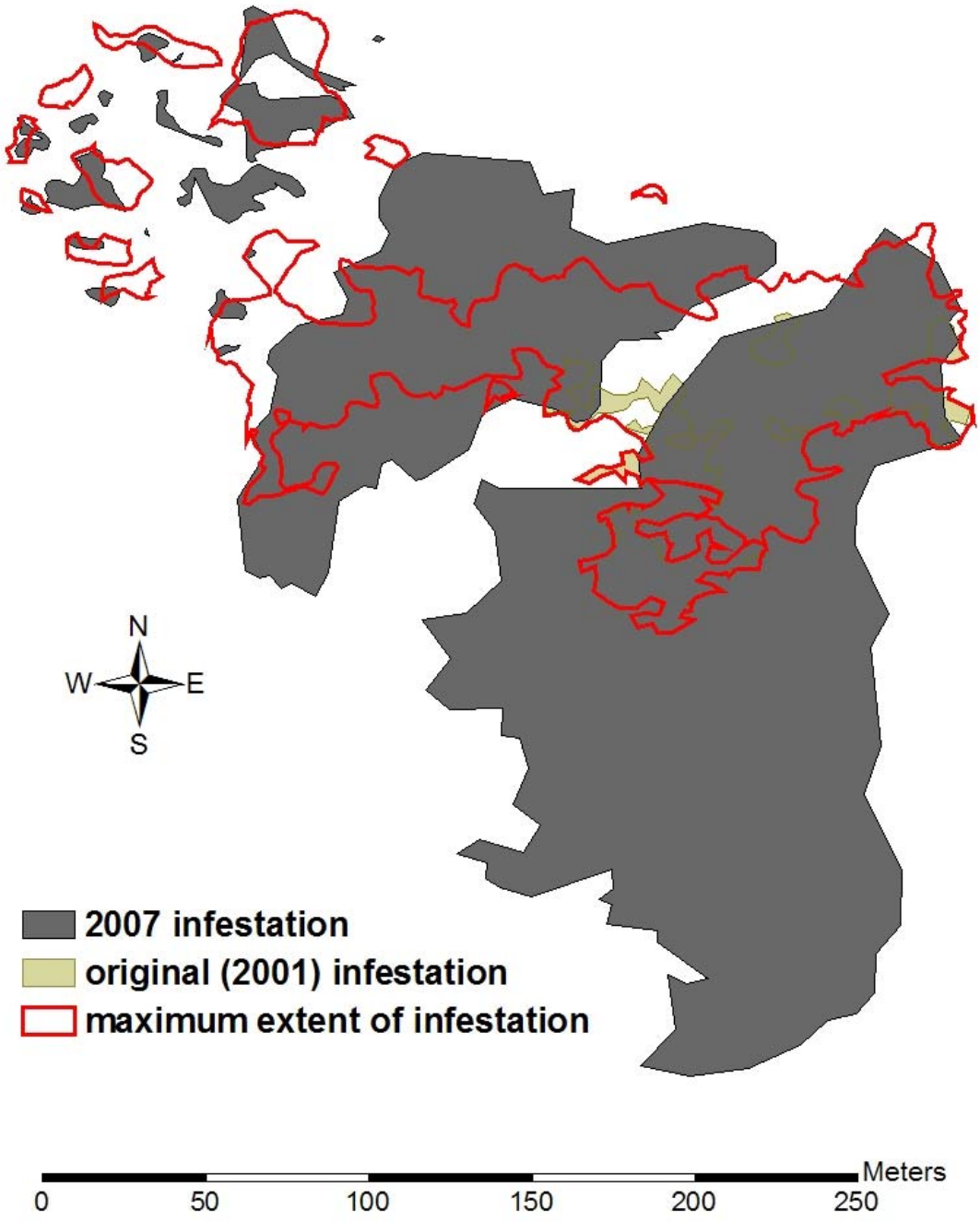
Lindsay Ranch Canada thistle density in 2007.



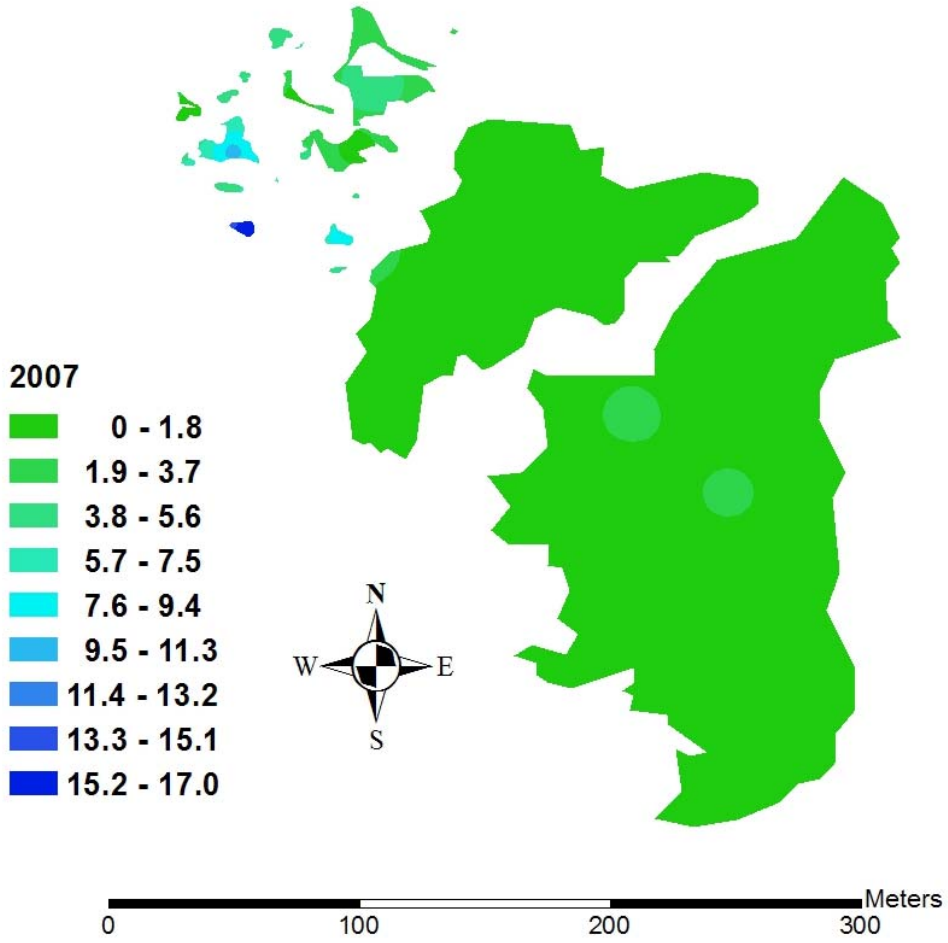


Lindsay Ranch Canada thistle height in 2007.

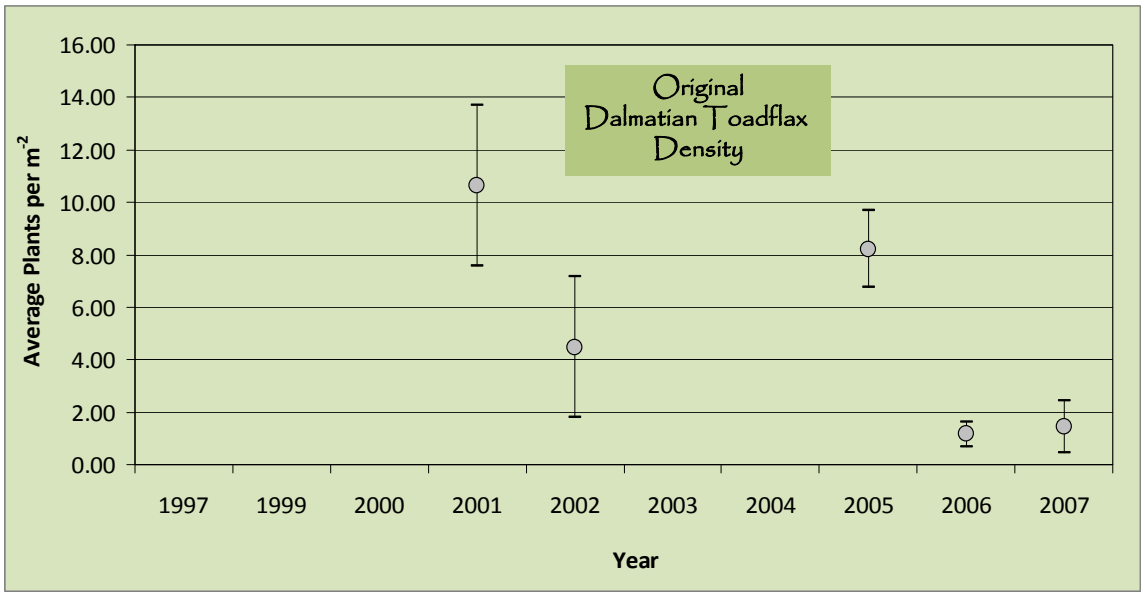


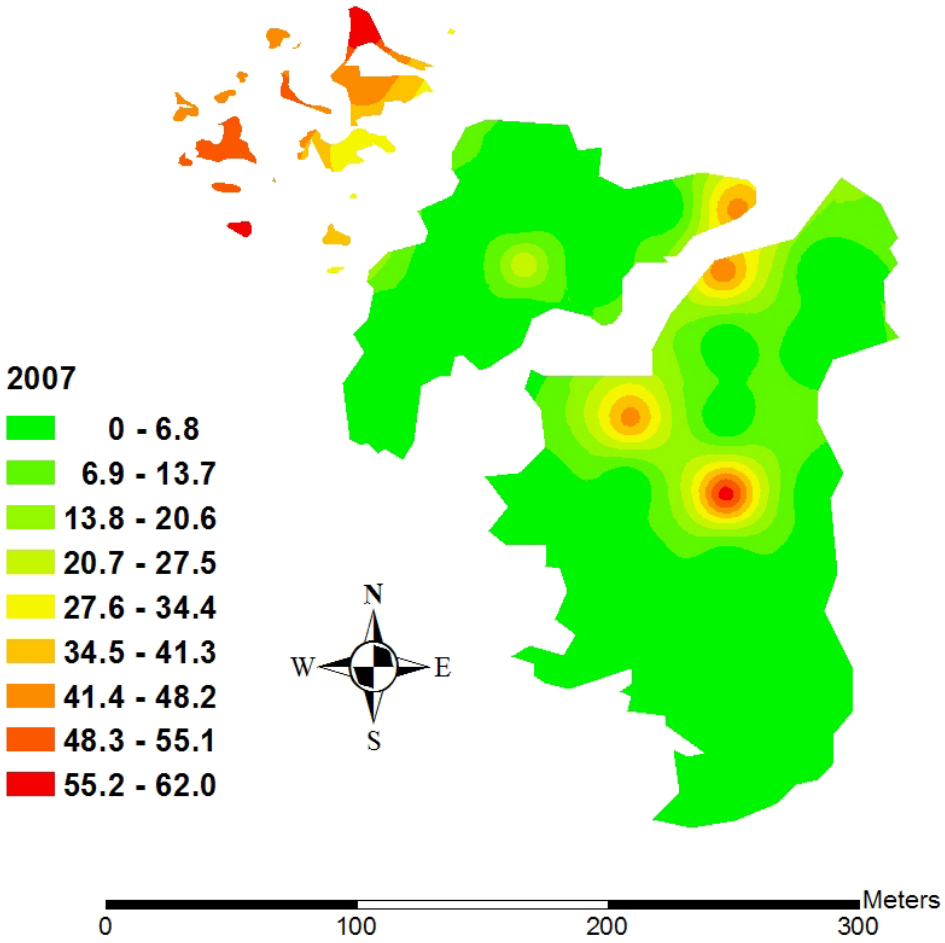


Original Dalmatian toadflax perimeter in 2007.

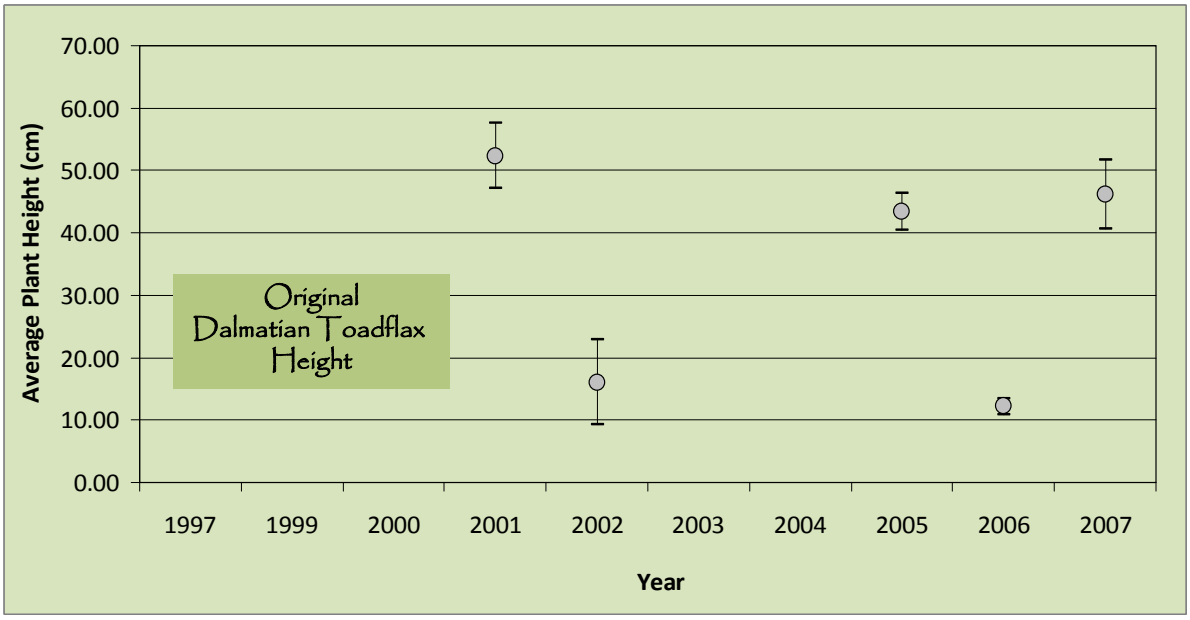


Original Dalmatian toadflax density in 2007.





Original Dalmatian toadflax height in 2007.



Diffuse Knapweed & Dalmatian Toadflax Transect Surveys

We are presenting the results of data collected by vegetation transect method in a more concise format this year as compared to previous reports. Instead of breaking down the changes observed in weed density and height across each of the individual bio-agent release points, we provide a summary for the impacted regions, namely the entire South Fence Dalmatian toadflax infestation and the North Buffer diffuse knapweed patch in its entirety.

Presented in Figure 18 are the historical survey data for Dalmatian toadflax parameters, density and height, along the South Fence transects. Density measurements are used to determine the relative quantity of weeds within an infestation, whereas height measurements represent the vigor or quality of plants in a given growing season. Consistent with the Original Dalmatian toadflax infestation, weeds along the south fence line at Rocky Flats Environmental Technology Site increased slightly in density since 2006, but have decreased since monitoring started in 2005, albeit neither changed significantly. From the lower graph, we observe that individual plants grew well in 2007, achieving significantly greater height in 2007, as did most weeds surveyed this season.

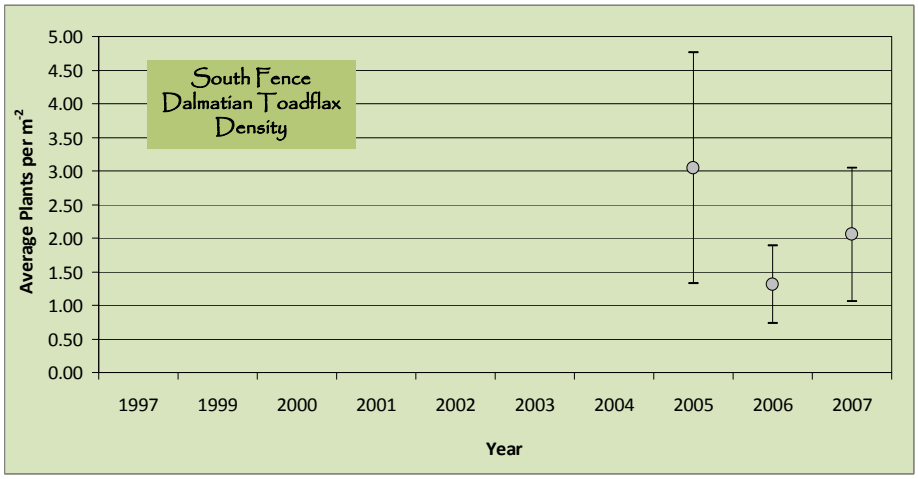
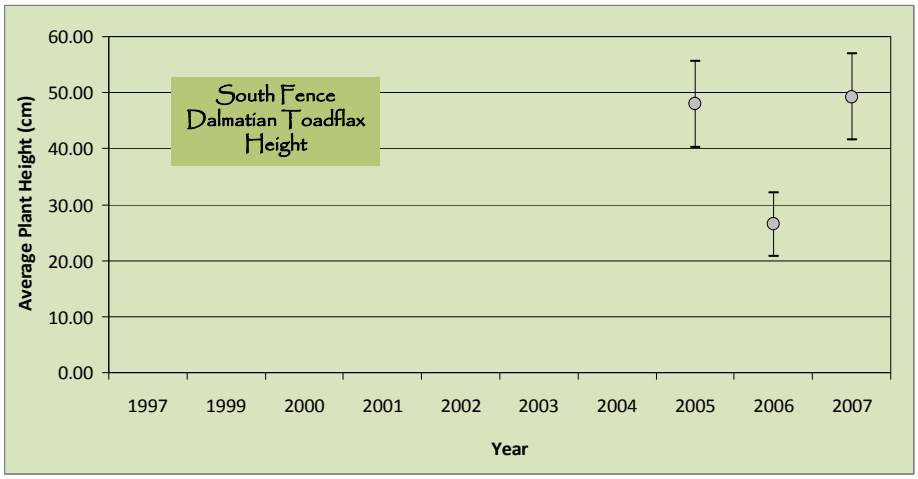


Figure 18. History of the South Fence Dalmatian toadflax densities (above) and height (below), sampled between 2005 and 2007.



Diffuse knapweed populations continued to decrease in 2007 at Rocky Flats Environmental Technology Site, showing slightly, but not significantly, lower density than in 2006. A promising trend of overall decline in knapweed populations since the release of bio-agents, *Cyphocleonus achates* and *Larinus minutus*, can be observed in Figure 19 (upper graph). Heavy damage by seed-feeding insects in 2007, as described above and in Table 4, achieved a small suppression the growth of diffuse knapweed plants at this site despite the ideal knapweed growing conditions throughout the 2007 season. As expected, diffuse knapweed plants were taller in 2007 than the previous season, but remained smaller than weeds measured in 2004 and 2005 (Figure 19, lower graph).

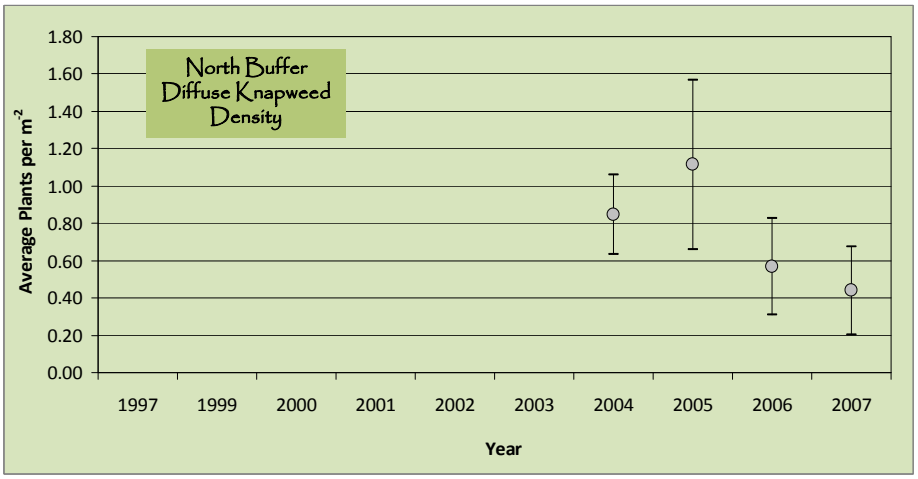
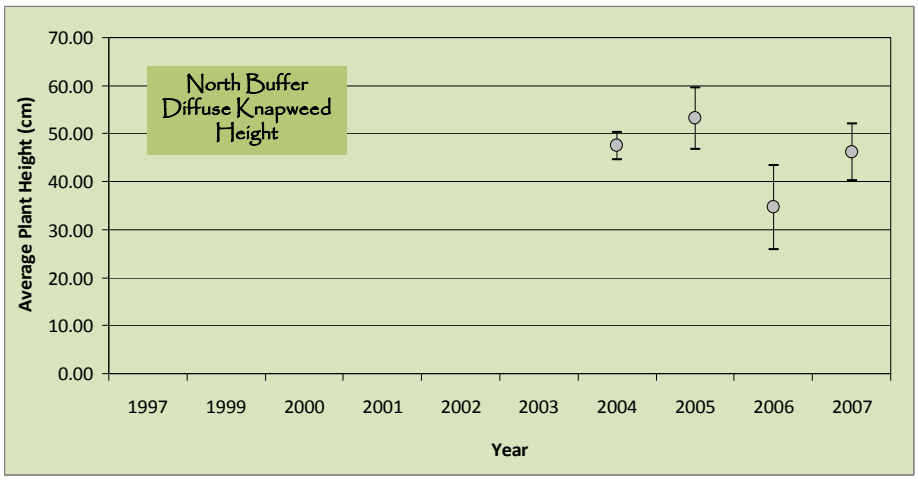


Figure 19. History of the North Buffer diffuse knapweed densities (above) and height (below), sampled between 2005 and 2007.



F. E. Warren Air Force Base

The number of sites mapped at F. E. Warren Air Force Base declined in 2007 to five from the original seven, comprising 7.1 ha (17.5 acres) of Dalmatian toadflax at two sites and 4.1 ha (10.1 acres) of leafy spurge at three sites (Table 17). Two of the original monitoring sites from 2004 that had not yet received biocontrol agent releases (i.e. the Control sites) were grazed by goats in 2007. We observed weeds growing vigorously at F. E. Warren Air Force Base this season and, as a result, infestations remained generally the same size as they had been in previous monitoring years, while plant density increased in most cases. This should be interpreted cautiously in terms of the assessing the efficacy of released insect agents, however. The focus of any biological control program during the first 3-5 years is primarily to establish and increase insect populations. Wide-scale damage is not apparent yet at this installation, but we are observing promising trends in terms of bio-agent increase and dispersal (Tables 5 and 6). We also continue to augment initial populations of biocontrol agents, releasing 200 *Mecinus janthinus* at the Nature Dalmatian toadflax site, along with 600 *Aphthona* spp. beetles at the Black Powder 1-6, Bridge 1-2, Nature 4 and Propane leafy spurge sites (Figure 20).

Figure 20. *Aphthona* beetle release at the Black Powder 5 site. Notice the mixture of beetle species in the release container (inset), with *A. nigriscutis* (brown beetles) and *A. lacertosa* (black beetles) dominating.

In addition to the mapped weed infestations, 11 patches of leafy spurge that had received large quantities of *Aphthona* sp. beetles in 2005 were also re-checked and evaluated for changes in plant density and height and assessed for bio-agent establishment. The results of samples randomly taken at these sites in 2006 and 2007 indicate that *Aphthona* beetles have established themselves very well throughout the

release areas, often infesting 100% of the randomly-acquired sweepnet samples (Table 7). Four species of *Aphthona* have been observed across the F. E. Warren Air Force Base, including *A. cyparissiae*, *A. czwalinae*, *A. lacertosa* and *A. nigriscutis* (Table 18). The diversity of species recovered from the release areas is encouraging, as the various beetle species have been found to exhibit different preferences for site conditions and, as a result, vary in establishment and damage levels to host plants.

Establishment of stem-borer, *Mecinus janthinus*, since its initial release in 2004, has been poor at F. E. Warren Air Force Base with the exception of the Nursery site. As Figure 21 indicates, we had concentrated the majority of releases at the extensive Nature and Missile sites in order to distribute agents throughout the largest Dalmatian toadflax infestations on base. However, establishment at these sites has been minimal. Looking at Table 5, more than half of the stems randomly collected at the small Nursery release site contained *M. janthinus* in 2006, whereas establishment at the Nature and Missile sites was less than 4%. The Nursery site differs from the other two release areas in terms of both density of host plant, Dalmatian toadflax, and growing conditions. It is set in a sheltered, moist area with a small but densely-populated patch of toadflax, compared to the drier, wind-exposed expanses of low density toadflax at both Missile and Nature sites. In the future, we plan to re-distribute insects from the thriving Nursery population to other failed release areas in hopes that they have acclimated enough to the climatic conditions at F. E. Warren Air Force Base that they may overcome the establishment difficulties faced by naïve insects originating from outside Wyoming.

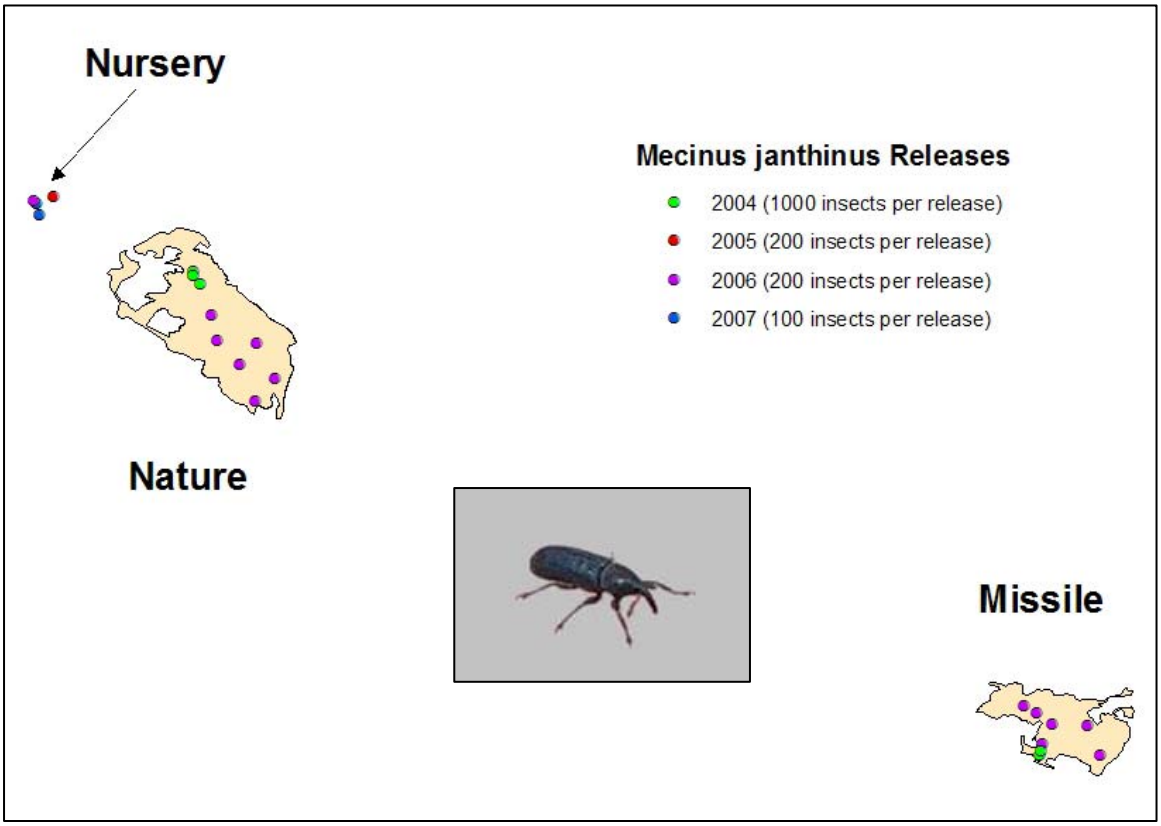


Figure 21. Schematic map of the three toadflax biocontrol release areas, Missile, Nature and Nursery. Releases have been largely unsuccessful to date at the Missile and Nature sites, however the Nursery site is producing healthy populations of *M.* janthinus (inset) and will serve as a feeder population for Dalmatian toadflax base-wide in future years.

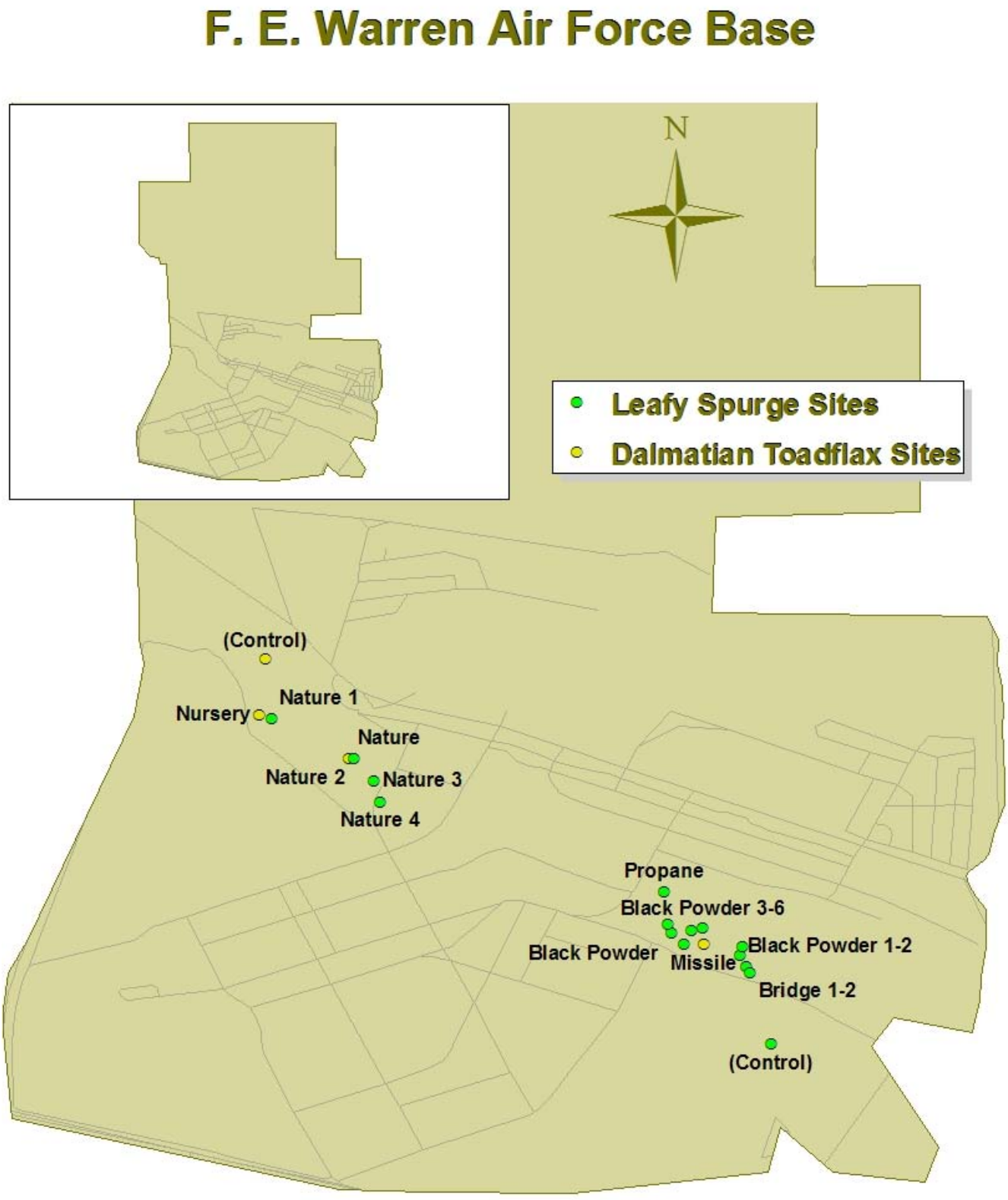


Figure 22. Schematic diagram of F. E. Warren Air Force Base with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2007.

Table 17. Historic noxious weed infestation parameters, F. E. Warren Air Force Base, Wyoming, 2004-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads per plant	Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Dalmatian toadflax - Control												
2004	18,424	45	2.67	21	32.73	91						
2005	23,234	44	3.66	25	49.36	74	13.57		26.11	37.08	50.81	
2006	10,540	37	0.35	6	43.13	60	4.25		-54.64	-90.44	-12.62	
2007	*(see Note)*											
Dalmatian toadflax - Missile												
2004	20,356	49	0.63	3	24.14	80						
2005	27,247	54	4.35	54	53.52	91	10.22		33.85	590.48	121.71	
2006	9,601	41	0.30	9	53.50	58	16.00		-64.76	-93.10	-0.04	
2007	19,406	110	0.68	16	57.96	84			102.12	126.67	8.34	-4.67
Dalmatian toadflax – Nature												
2004	45,471	80	1.16	8	25.01	84						
2005	49,471	63	4.61	29	55.15	98	14.26		8.80	297.41	120.51	
2006	49,727	84	2.28	49	33.26	76	3.66		0.52	-50.54	-39.69	
2007	51,205	130	1.48	43	42.78	76			2.97	-35.09	28.62	12.61
Leafy spurge – Black Powder Road												
2005	2,797	28	48.82	127	64.93	91						
2006	32,077	96	35.80	178	45.80	91			1046.84	-26.67	-29.46	
2007	36,874	129	69.35	534	47.79	110			14.95	93.71	4.34	1218.34
Leafy spurge - Control												
2004	5,526	31	41.70	98	48.71	69						
2005	60,606	50	59.80	362	63.03	94			996.74	43.41	29.40	
2006	55,476	64	35.97	118	48.86	81			-8.46	-39.85	-22.48	
2007	*(see Note)*											

Table 17. Historic noxious weed infestation parameters, F. E. Warren Air Force Base, Wyoming, 2004-2007.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads per plant	Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Leafy spurge – Nature I												
2004	1,849	44	36.95	88	67.14	95						
2005	1,547	35	45.77	250	68.35	97			-16.33	23.87	1.80	
2006	2,120	54	23.41	59	66.98	105				-48.85	-2.00	
2007	2,382	60	63.68	217	57.55	93			12.36	172.02	-14.08	28.83
Leafy spurge – Nature II												
2004	1,703	42	66.19	129	55.98	81						
2005	1,463	38	85.30	184	62.35	80			-14.09	28.87	11.38	
2006	2,071	54	48.30	125	53.87	90			41.56	-43.38	-13.60	
2007	1,940	62	68.55	211	52.68	92			-6.33	41.93	-2.21	13.92

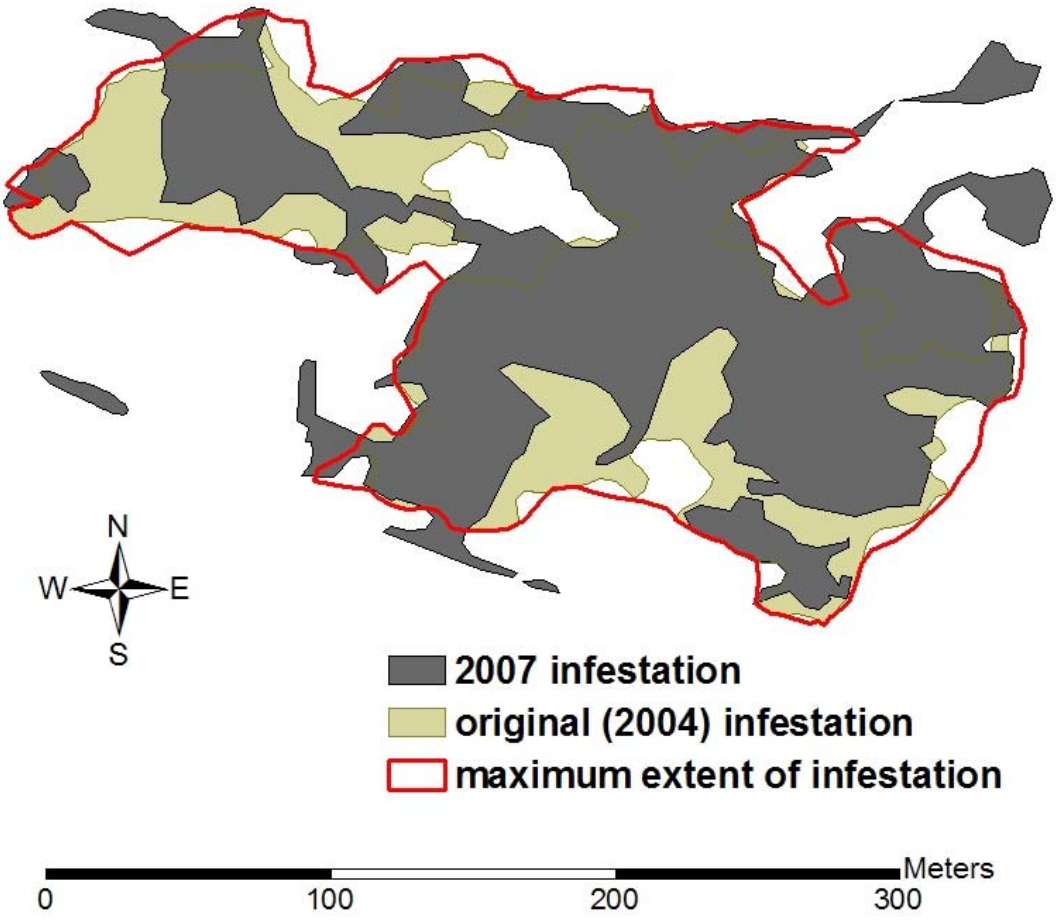
n – number of samples or observations

Note: site was not mapped, as goat grazing prevented an accurate survey

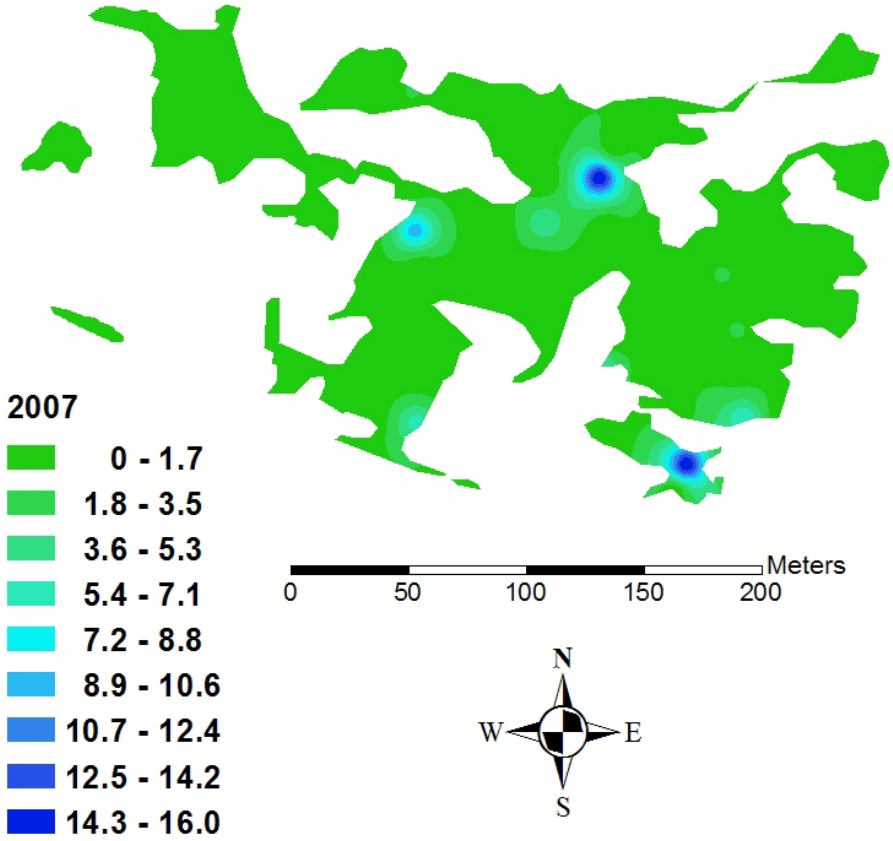
Table 18. Noxious weed biological control sites, target weeds, species released and recoveries at F. E. Warren Air Force Base, 2007.

Release Location	Target Weed	Release Site	Species released	Species recovered	New release	New site
F. E. Warren AFB	Leafy spurge	Black Powder	*Aphthona* sp. complex [2]	X		
F. E. Warren AFB	Leafy spurge	Black Powder I [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Black Powder II [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Black Powder III [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Black Powder IV [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Black Powder V [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Black Powder VI [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Bridge I [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Bridge II [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Control	*Aphthona czwalinae*	X [3]		
F. E. Warren AFB	Leafy spurge	Control	*Aphthona lacertosa*	X [3]		
F. E. Warren AFB	Leafy spurge	Control	*Aphthona nigriscutis*	X [3]		
F. E. Warren AFB	Leafy spurge	Nature I	*Aphthona* sp. complex [2]	X		
F. E. Warren AFB	Leafy spurge	Nature Ib [1]	*Aphthona* sp. complex [2]	X		
F. E. Warren AFB	Leafy spurge	Nature II	*Aphthona* sp. complex [2]	X		
F. E. Warren AFB	Leafy spurge	Nature IIa [1]	*Aphthona* sp. complex [2]	X		
F. E. Warren AFB	Leafy spurge	Nature III [1]	*Aphthona* sp. complex [2]	X		
F. E. Warren AFB	Leafy spurge	Nature IV [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Leafy spurge	Propane [1]	*Aphthona* sp. complex [2]	X	X	
F. E. Warren AFB	Dalmatian toadflax	Control	*Mecinus janthinus* [3]	X		
F. E. Warren AFB	Dalmatian toadflax	Nature	*Mecinus janthinus*	X	X	
F. E. Warren AFB	Dalmatian toadflax	Nursery [1]	*Mecinus janthinus*	X		
F. E. Warren AFB	Dalmatian toadflax	Missile	*Mecinus janthinus*	X		

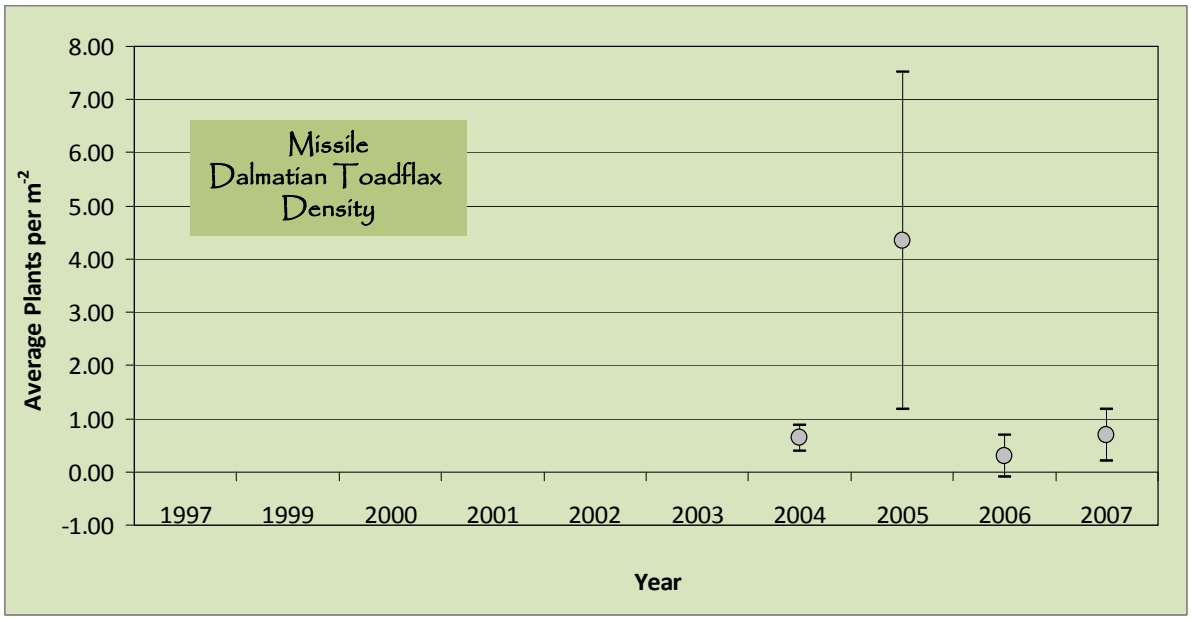
[1] Area not mapped, release only
[2] *Aphthona sp*. complex is composed of varying proportions of *A. cyparissiae*, *A. czwalinae*, *A. lacertosa* and *A. nigriscutis*
[3] Adventitious recovery, no release made at this site

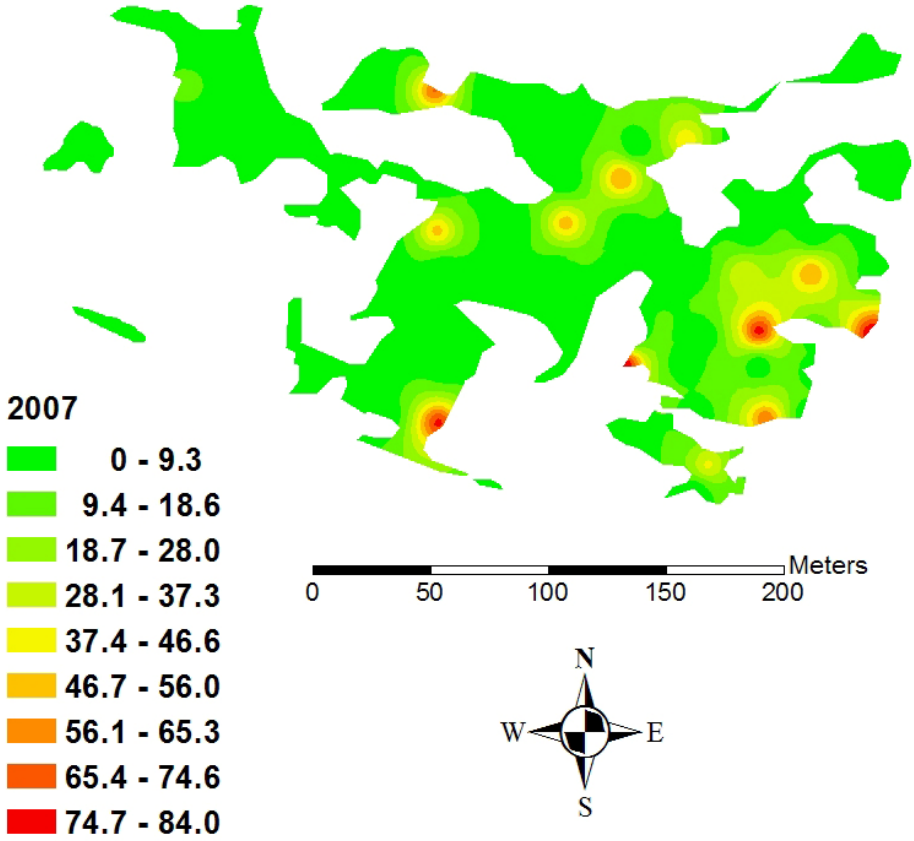


Missile Dalmatian toadflax perimeter in 2007.

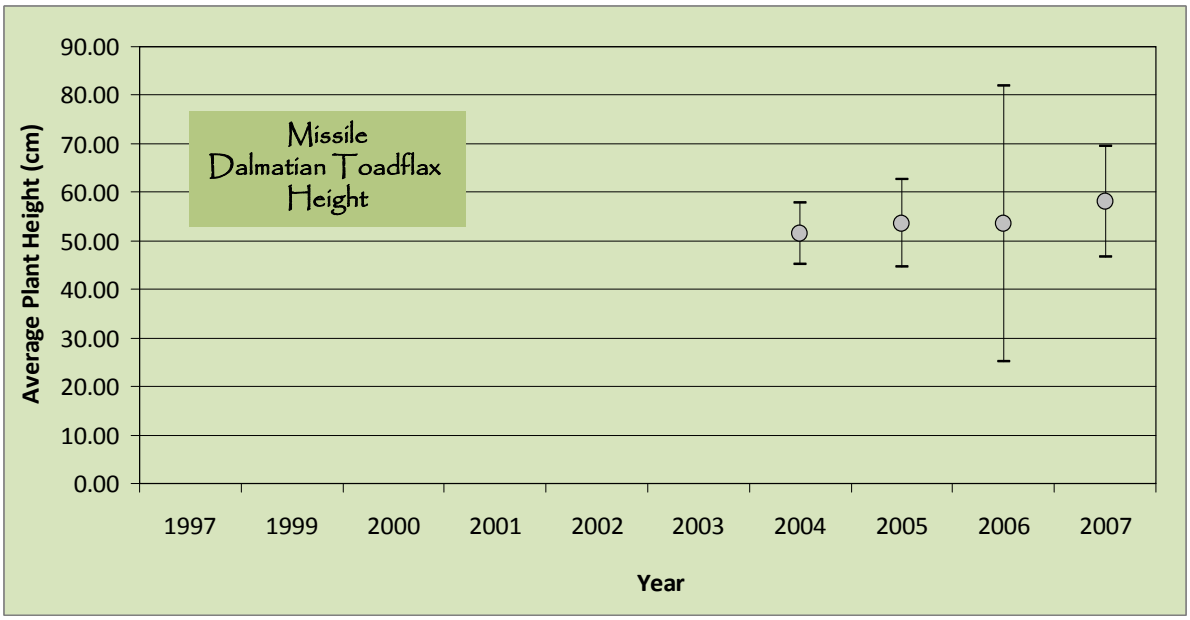


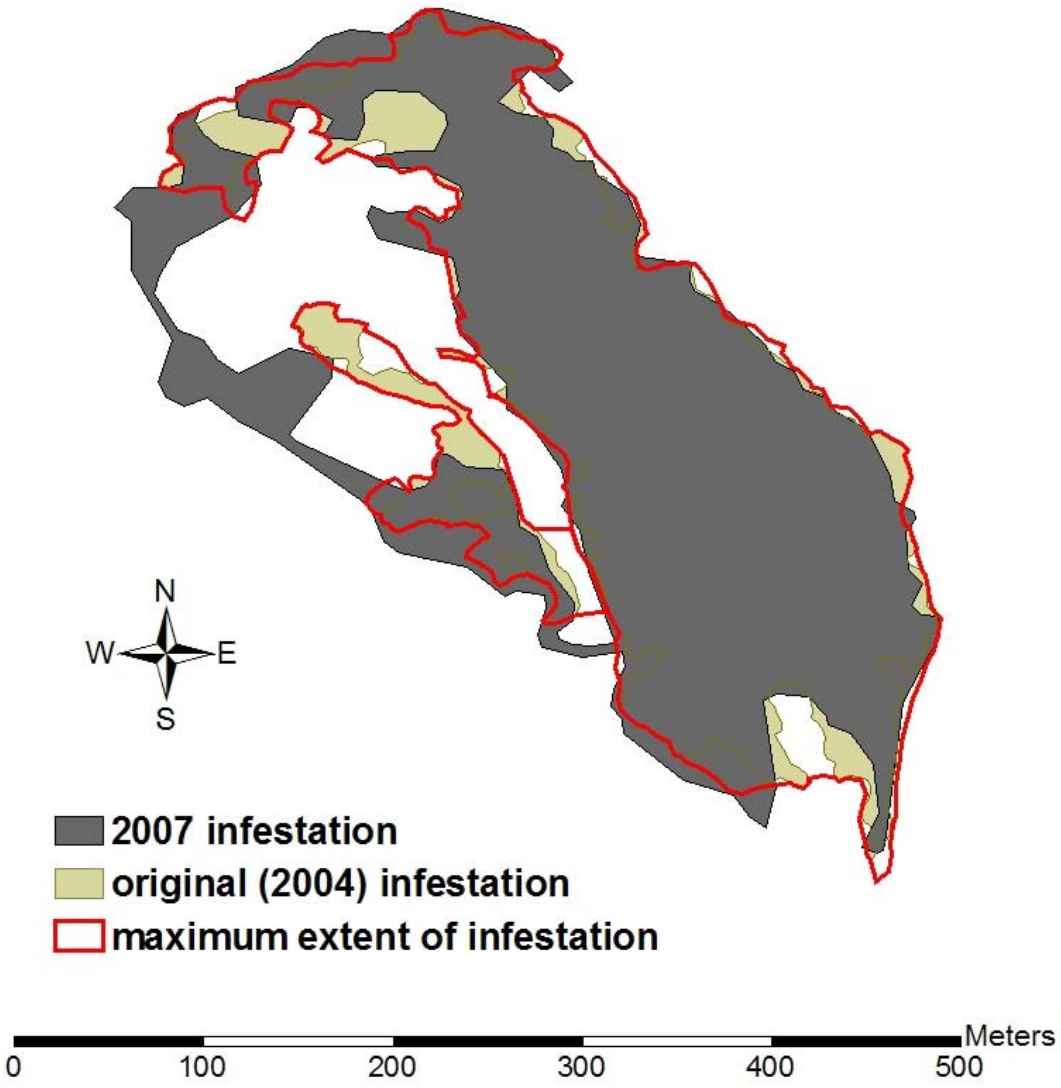
Missile Dalmatian toadflax density in 2007.



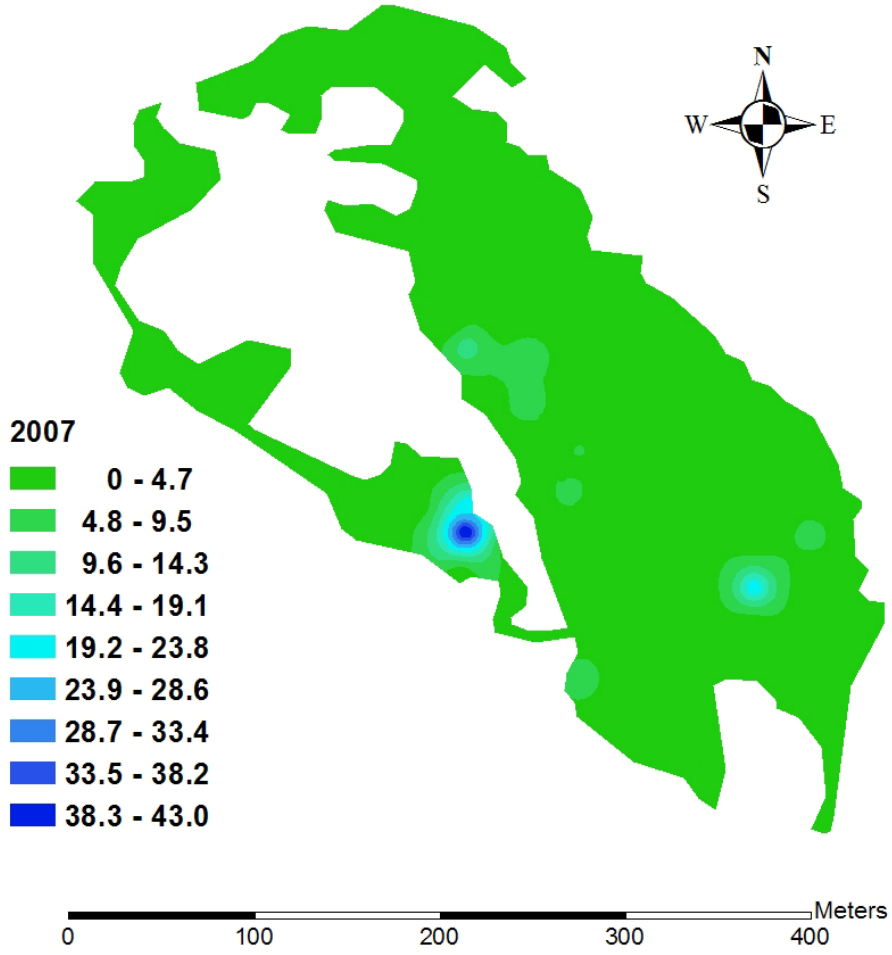


Missile Dalmatian toadflax height in 2007.

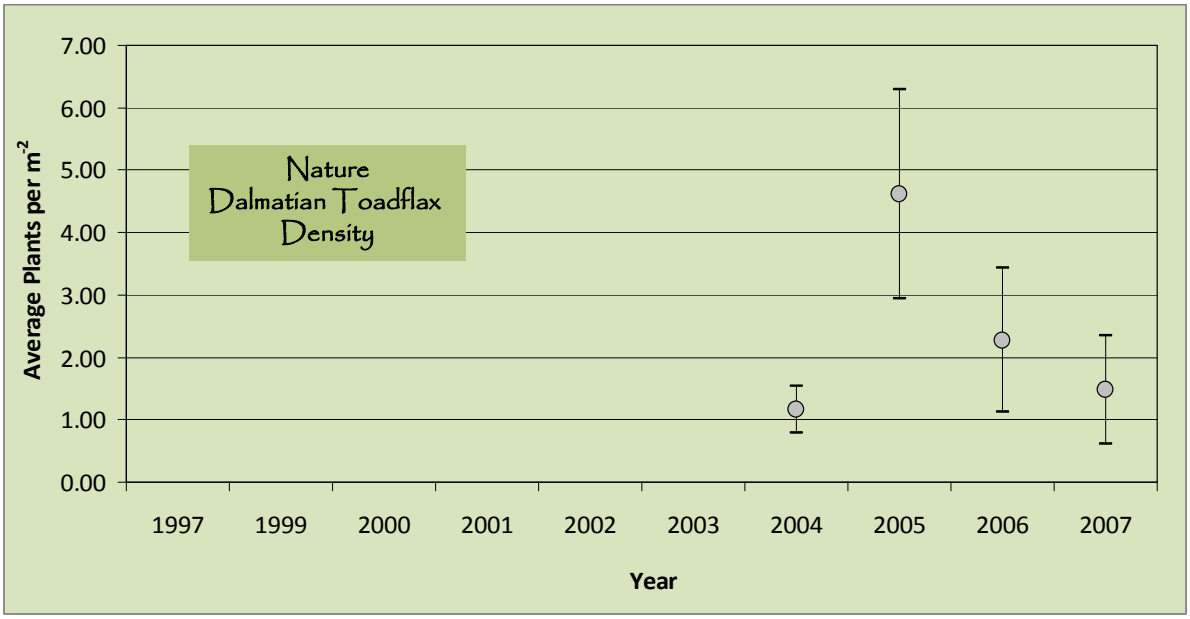


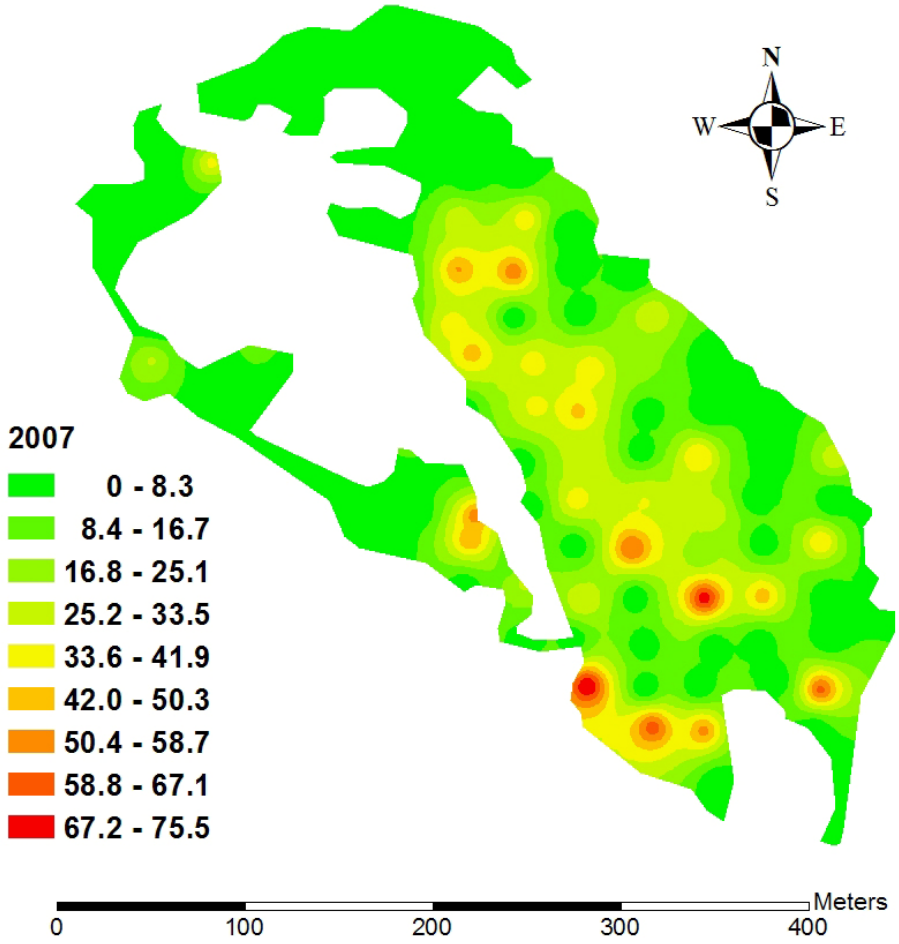


Nature Dalmatian toadflax perimeter in 2007.

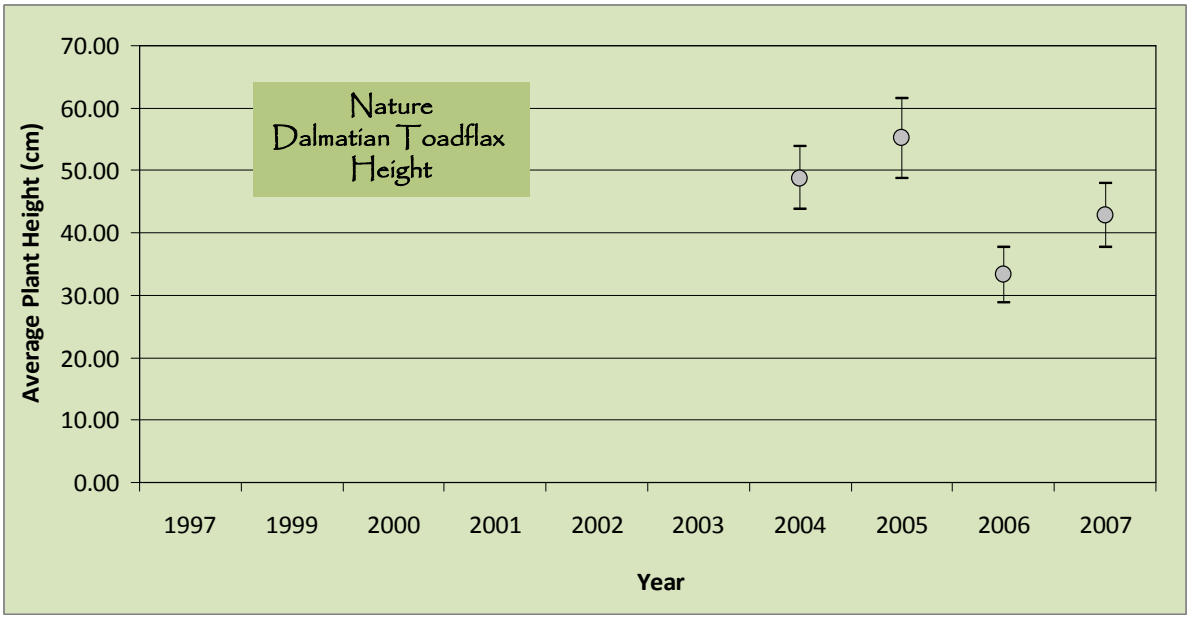


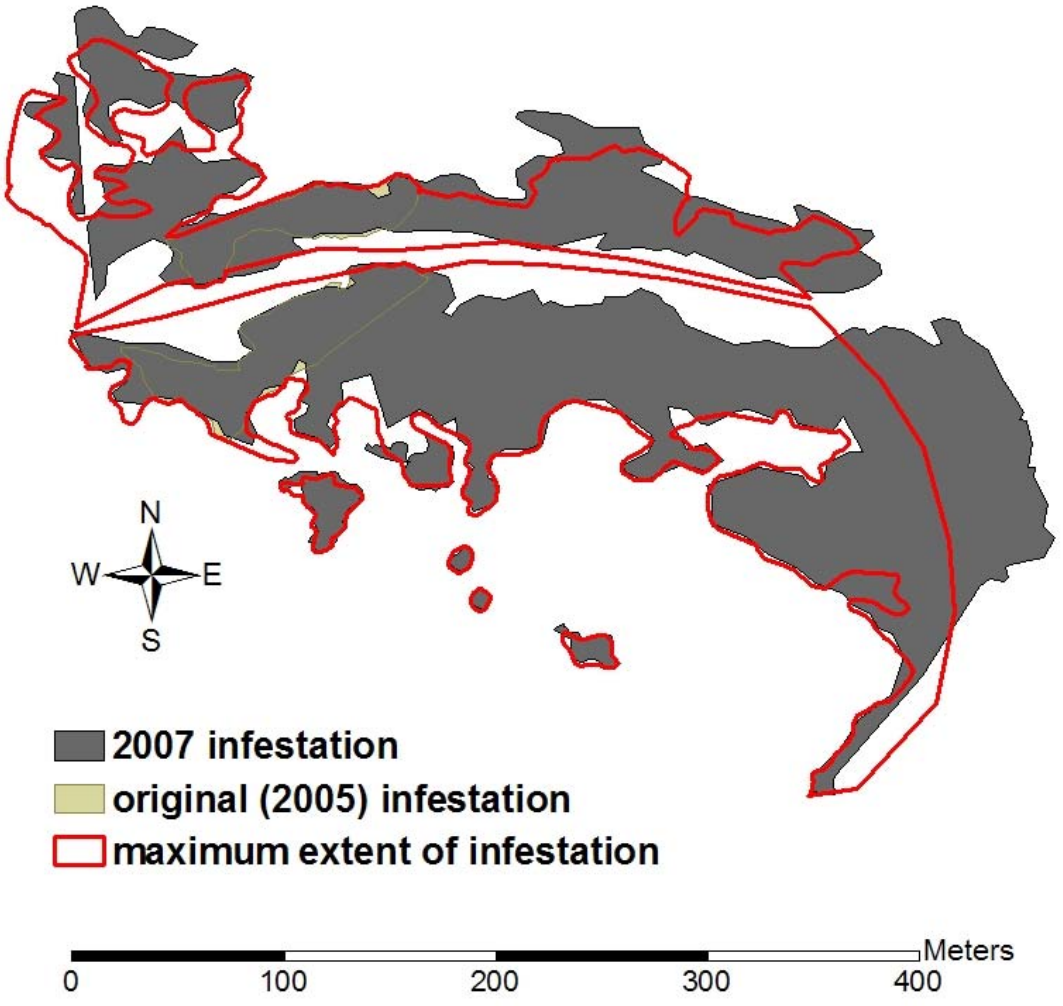
Nature Dalmatian toadflax density in 2007.



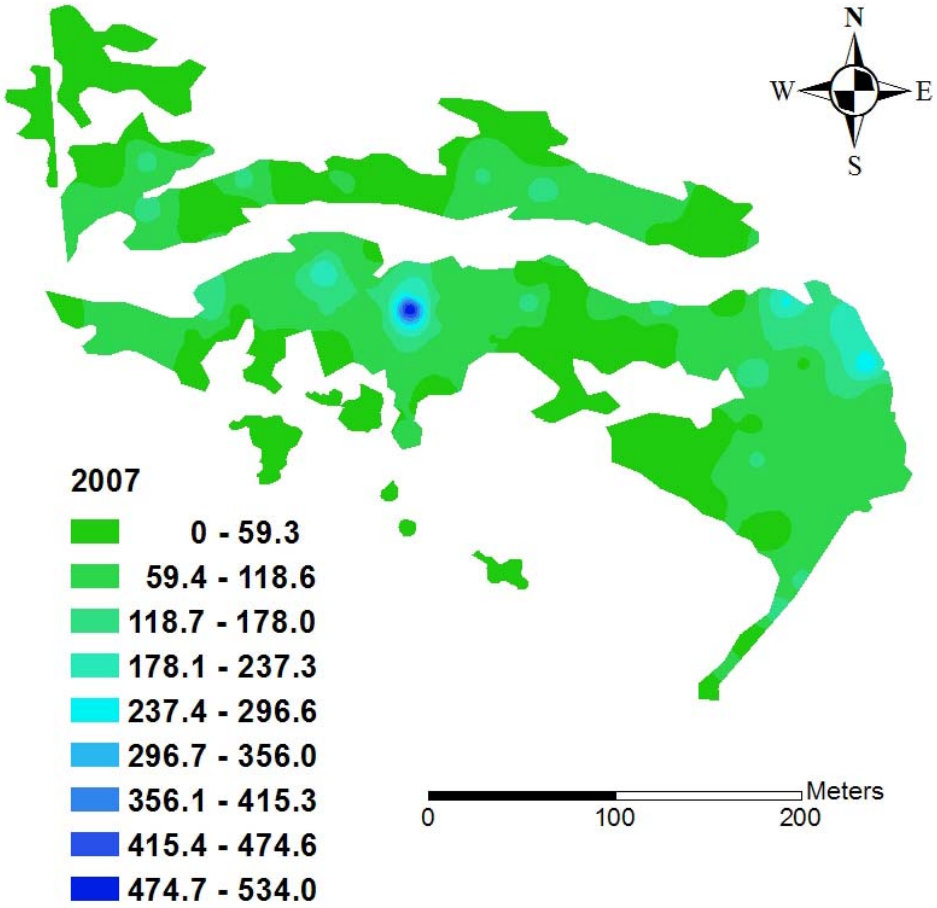


Nature Dalmatian toadflax height in 2007.

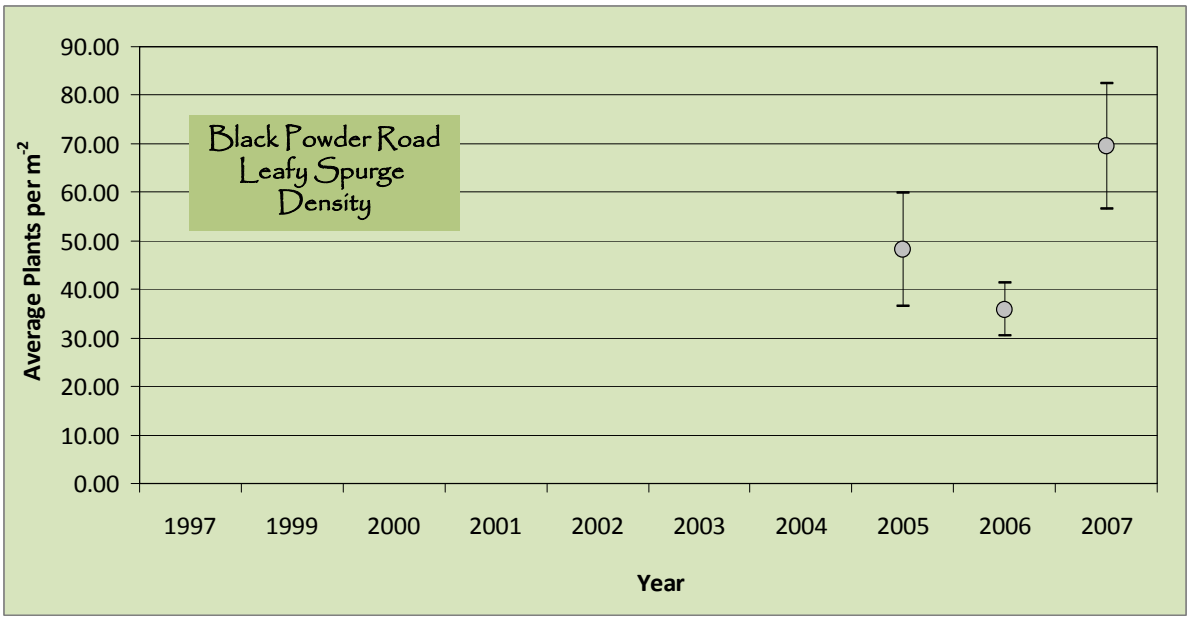


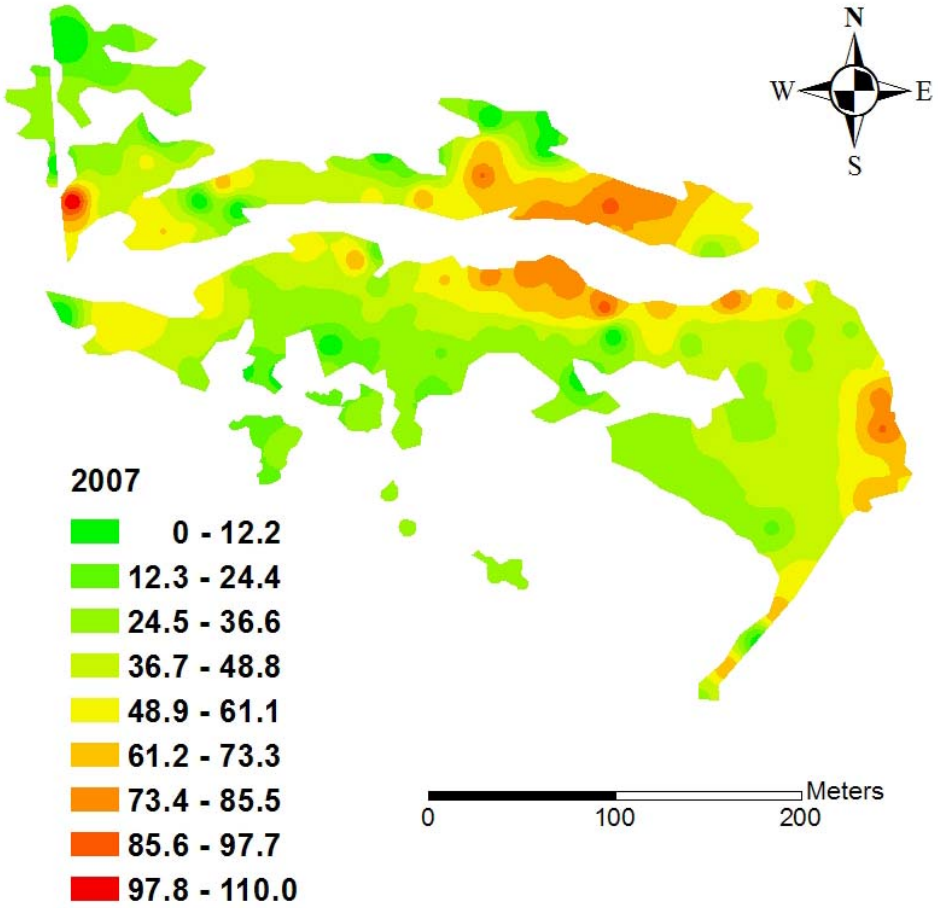


Black Powder Road leafy spurge perimeter in 2007.

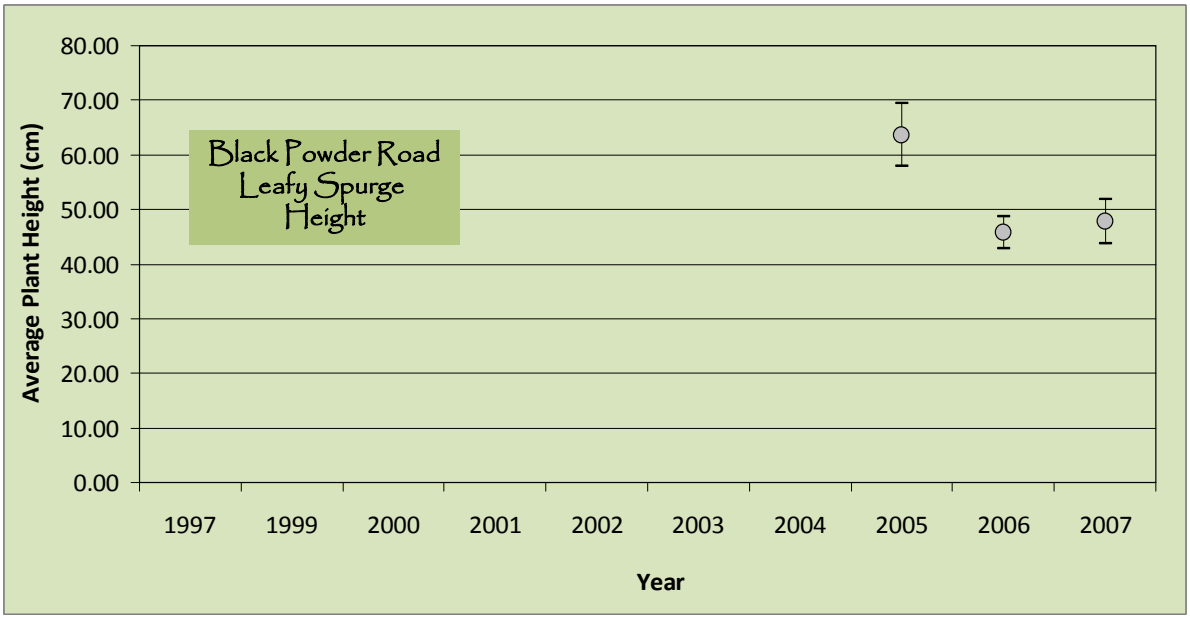


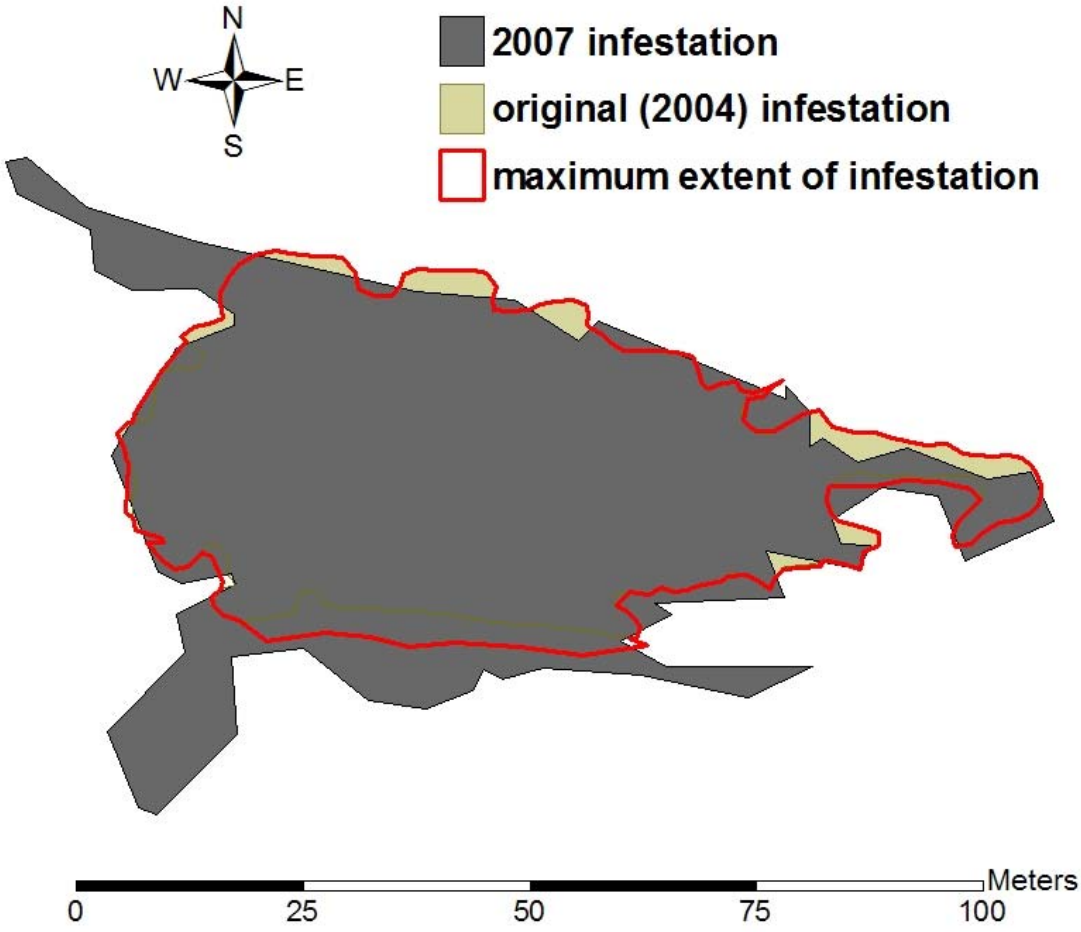
Black Powder Road leafy spurge density in 2007.



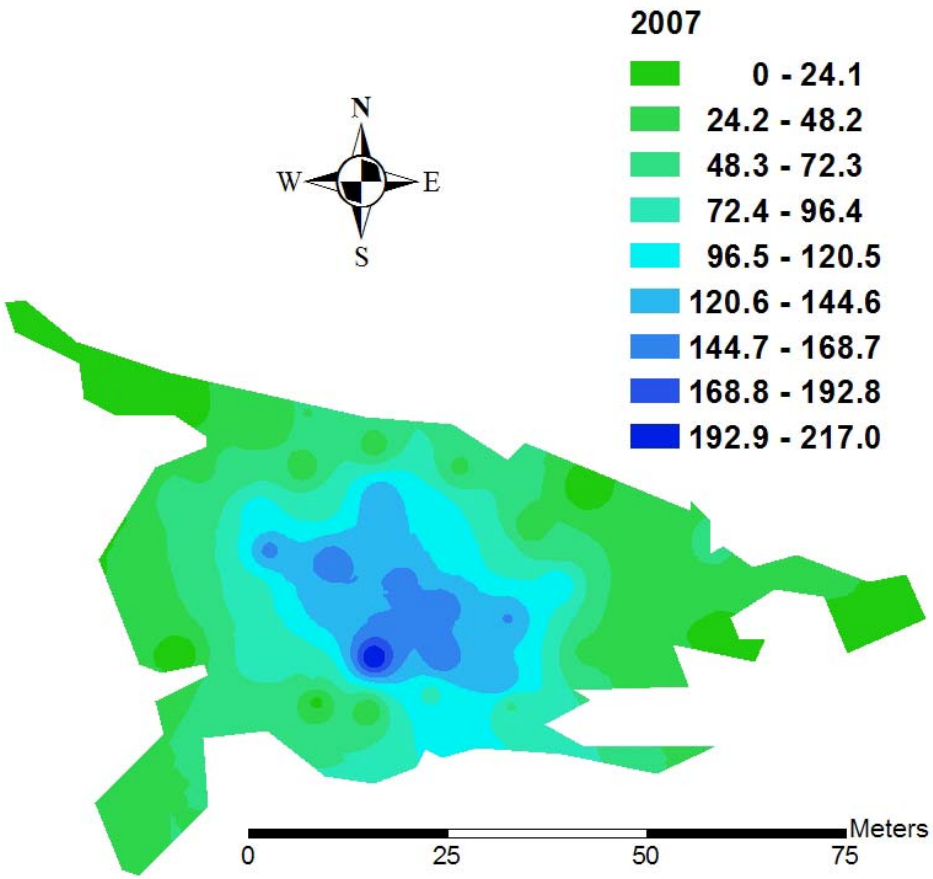


Black Powder Road leafy spurge height in 2007.

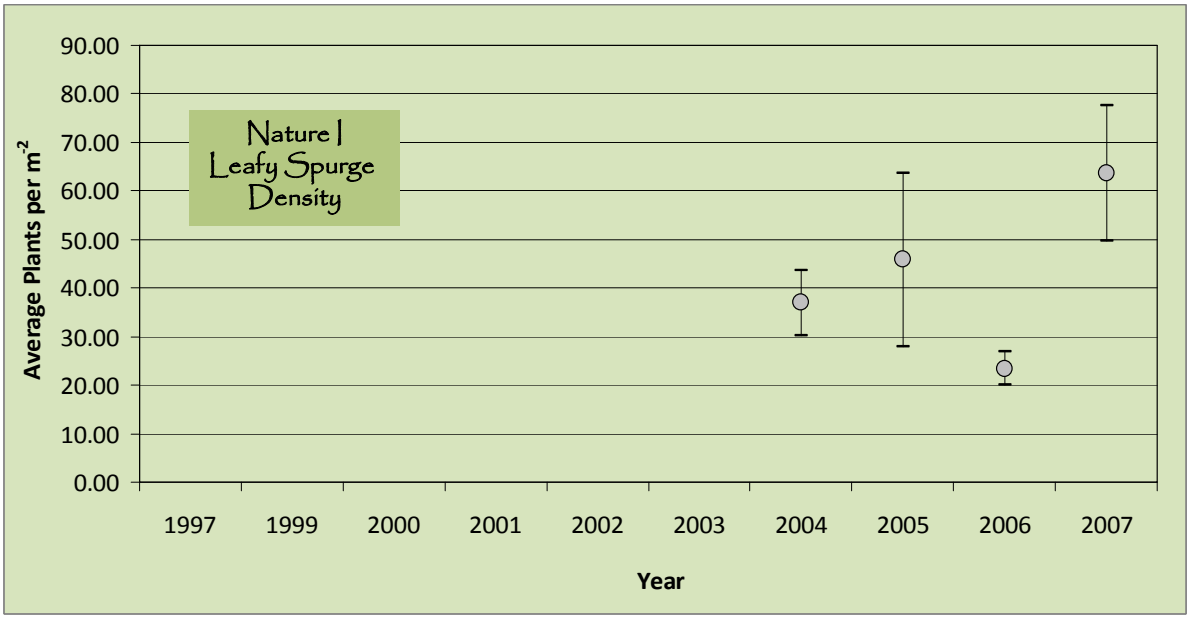


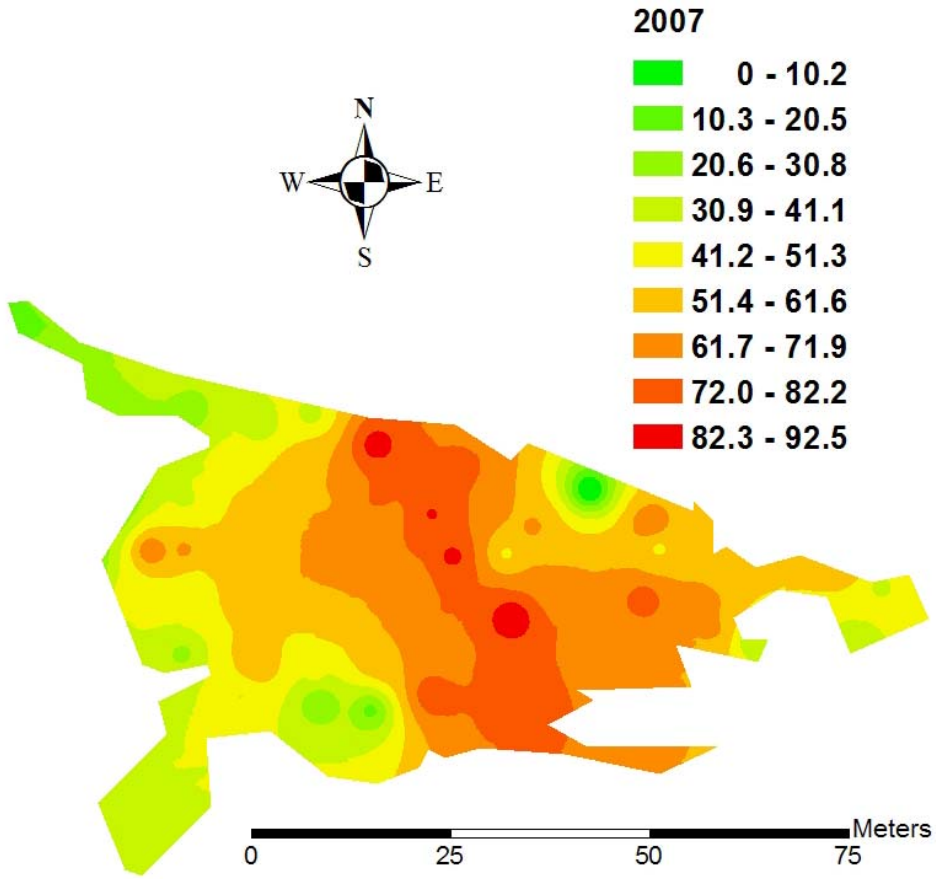


Nature I leafy spurge perimeter in 2007.

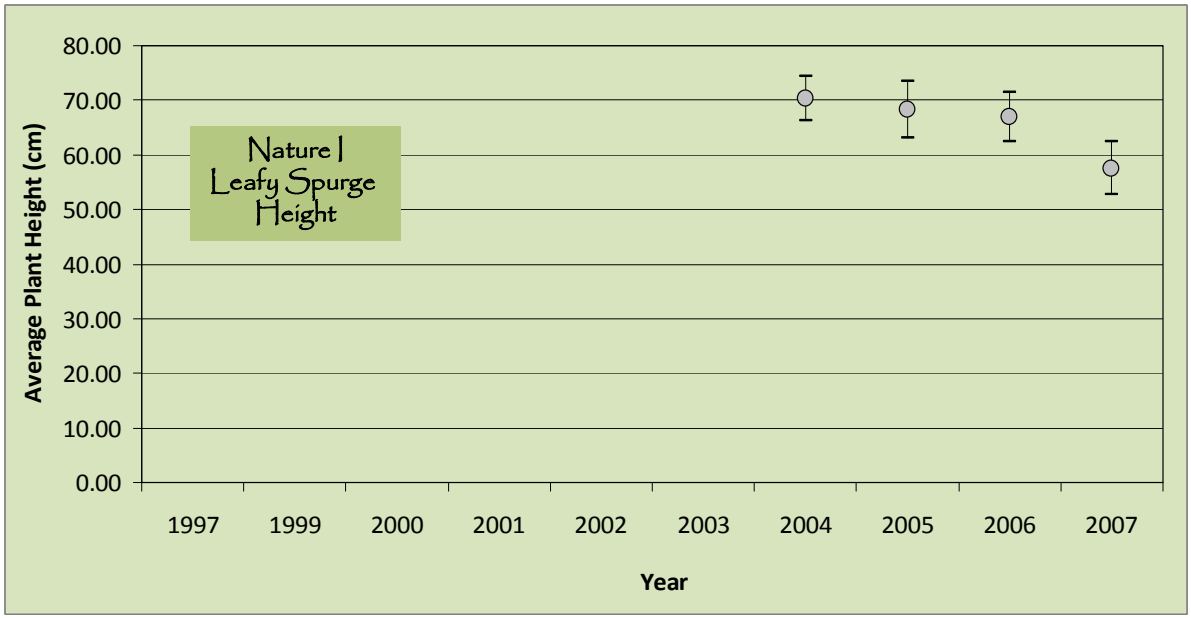


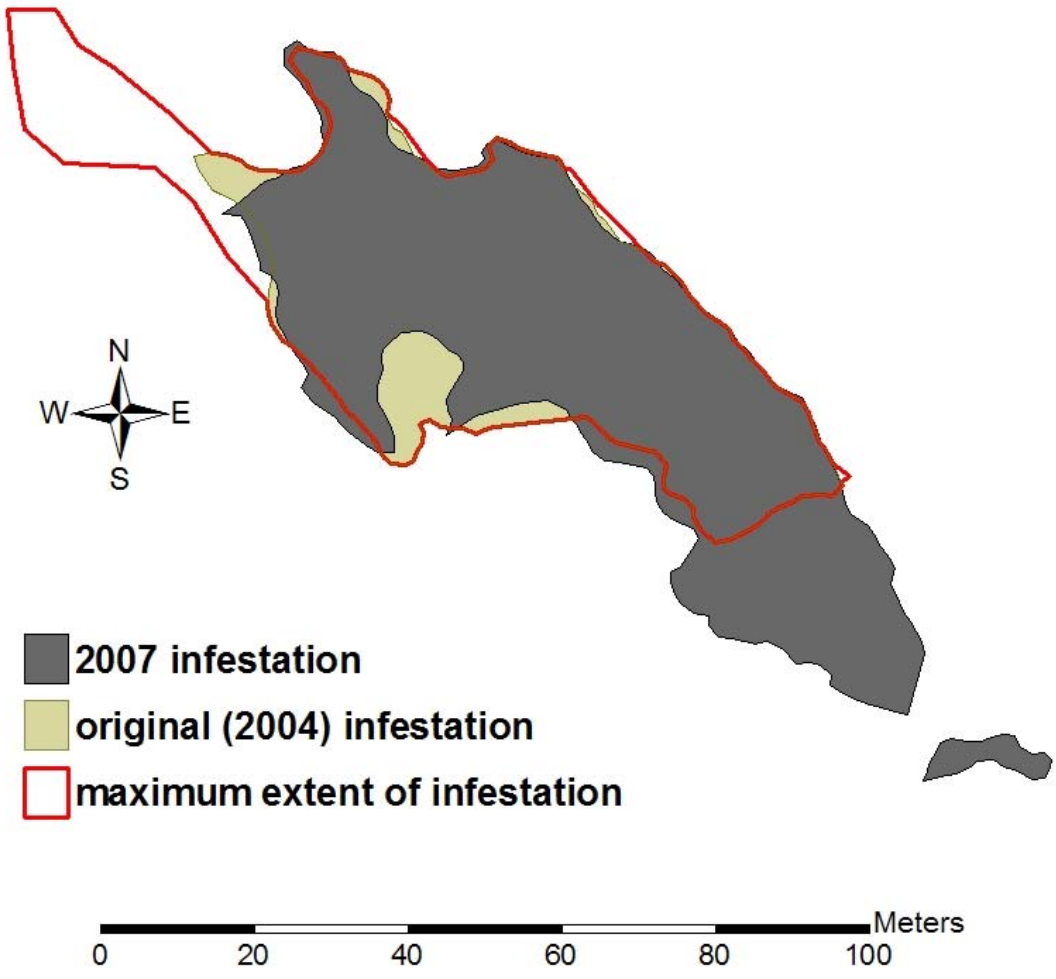
Nature I leafy spurge density in 2007.



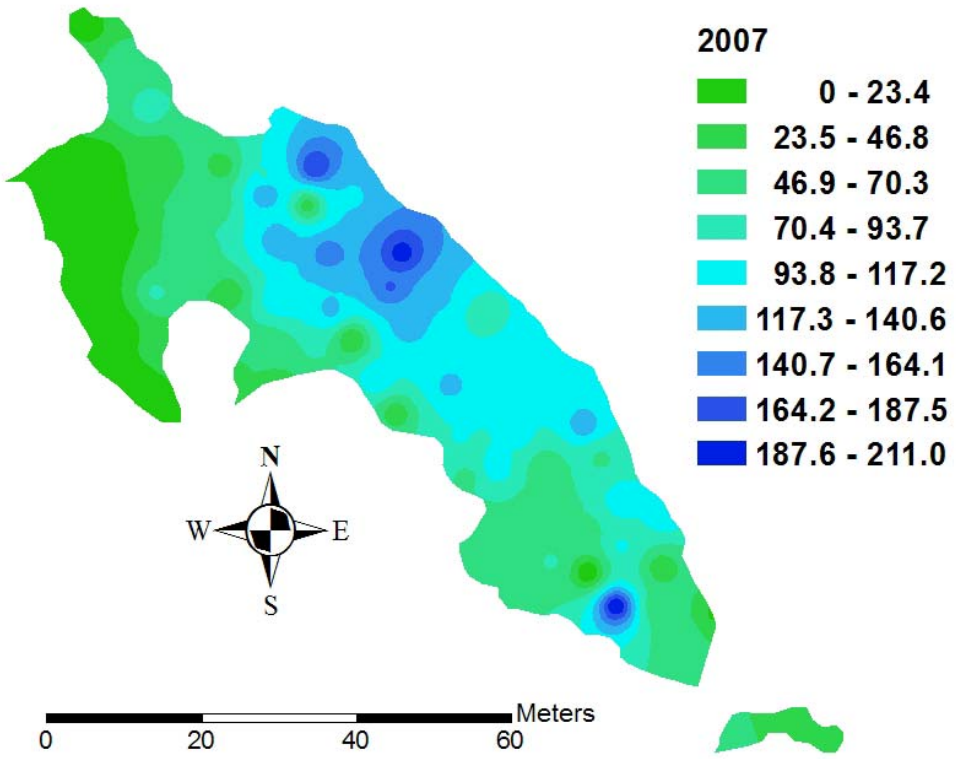


Nature I leafy spurge height in 2007.

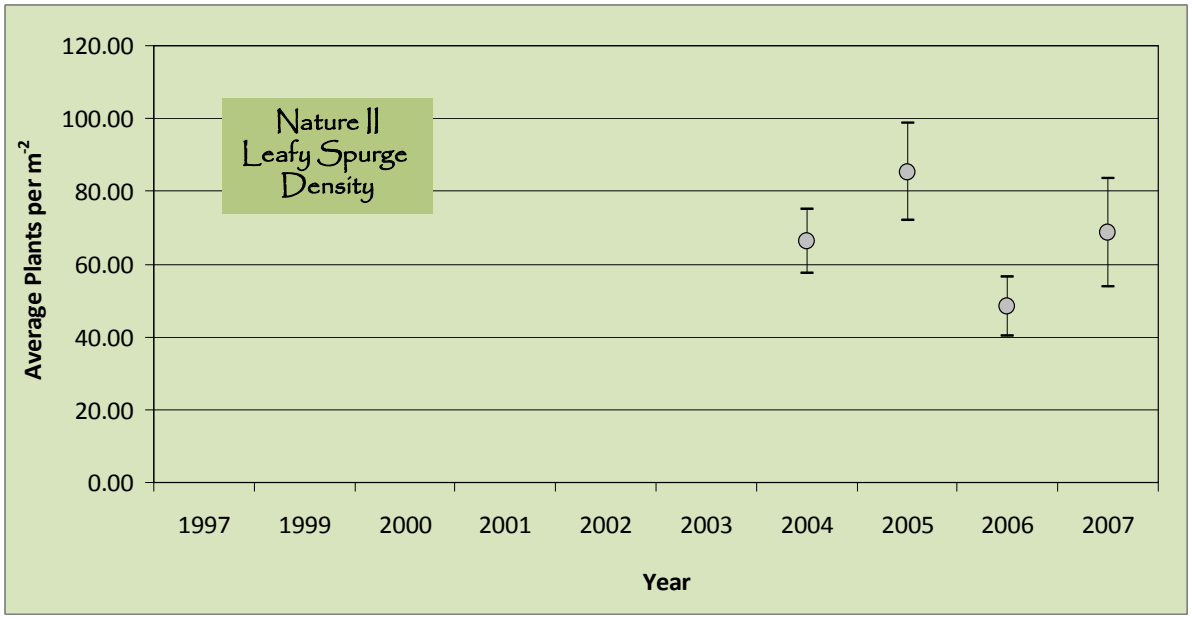


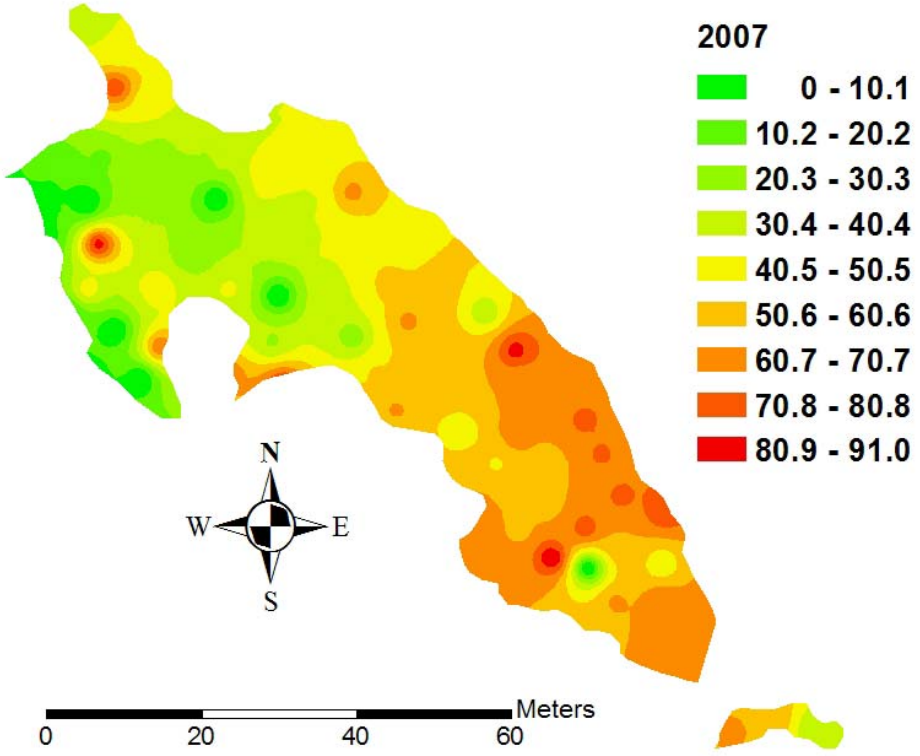


Nature II leafy spurge perimeter in 2007.



Nature II leafy spurge density in 2007.





Nature II leafy spurge height in 2007.