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

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

Gerald J. Michels, Jr., Heather Lynn Lindon, Donnie Lunsford, Tracy Perfors, Chelsea Chen, Rachel A. Lange

Texas AgriLife Research
2301 Experiment Station Road
Bushland, Texas 79012

2009 Consolidated Report

AgriLIFE RESEARCH
Texas A&M System
Improving Life Through Science and Technology

Table of Contents

Introductory Notes……..4

Figure 1. Schematic map of installations participating in weed biocontrol…..…..8

Table 1. Size of area under biocontrol by species and installation ……....9

Table 2.. Summary of the changes seen across weed species, 2007-2009…...10

Table 3. Detailed summary of weed changes at all sites, 2007-2009….....…11

Table 4. Biological control agents in knapweed seedheads, 2009……..…15

Table 5. Biological control agents in knapweed roots, 2009……..……16

Table 6. *Aphthona* spp. sweeps from mapped leafy spurge sites, 2004-2009...17

Table 7. *Aphthona* spp. sweeps from other leafy spurge sites, 2007-2009……. 18

Table 8. *Chrysolina* sp. counts on St. John's wort, 2004-2009……..……...19

Table 9. Field Bindweed counts of *Aceria malherbae* 2006-2009……..……20

Air Force Academy……...21

Figure 4. Schematic map of biocontrol sites at Air Force Academy...……..23

Table 10. Historic noxious weed infestation parameters, 2000-2009……24

Table 11. List of biological control agents released as of 2009……35

Buckley Air Force Base……..……39

Figure 9. Schematic map of biocontrol sites at Buckley AFB…….....41

Table 12. Historic noxious weed infestation parameters, 2003-2009…….....42

Table 13. List of biological control agents released as of 2009……...46

Fort Carson Military Post……48

Figure 17. Schematic map of biocontrol sites at Fort Carson……...135

Table 14. Historic noxious weed infestation parameters, 1997-2009……...136

Table 15. List of biological control agents released as of 2009……..……142

Rocky Flats National Wildlife Refuge……..…….165

Figure 16. Schematic map of biocontrol sites at Rocky Flats……...…….....66

Table 16. Historic noxious weed infestation parameters, 2001-2009……....67

Table 17. List of biological control agents released as of 2009……..……70

F. E. Warren Air Force Base……..181

Figure 24. Schematic map of biocontrol sites at F. E. Warren AFB..……....73

Table 18. Historic noxious weed infestation parameters, 2004-2009……....74

Table 19. List of biological control agents released as of 2009……..…78

Appendix ***Area, perimeter and density figures with density and height graphs .……79***

On the cover: Chelsea Chen and Tracy Perfors hard at work checking leafy spurge for* Aphthona spp. *flea beetles at Warren Air Base in Cheyenne, WY.
Photo credit: Donnie Lunsford.

Introductory Notes

As of 2009, the biological control of noxious weeds project completes the thirteenth year at Ft. Carson Military Post (FTC), tenth year at Air Force Academy (AFA), ninth year at Rocky Flats National Wildlife Refuge (RF), seventh year at Buckley Air Force Base (BAF), and sixth year at F. E. Warren Air Force Base (WAB). As stated in previous years, the program's focus is threefold:

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

In 2009 we were fortunate to have a full time technician, Donnie Lunsford, working out of Colorado Springs. The focus of the biocontrol project this year was on redistributing agents, releasing new agents at existing sites and establishing new sites with agent releases. We were able to release a new leafy spurge agent, the cerambycid stem tunneling beetle *Oberea erythrocephala* at Buckley Air Force Base on 16 July 2009. As with last year, we continued our efforts to release and establish the bindweed mite *Aceria malherbae* at four of the five installations. Biocontrol efforts on this weed began in 2006 and additional releases of the biocontrol mite were made in 2009 with mites harvested from the Pinon Canyon Maneuver Site in Model, CO.

Navigating the 2009 Report

Figure 1 illustrates the locations of noxious weed biological control work over the past eleven years. This year, as in 2008, we have focused on five installations, Air Force Academy, Buckley Air Force Base, Fort Carson Military Post, Rocky Flats National Wildlife Refuge, and F. E. Warren Air Force Base. Table 1. is new this year and lists the total area under biocontrol for each weed type at each base. Table 2 presents an overview of the general trends in noxious weed intensity and growth over the past year. Table 3 provides a quick reference to the changes in weed population parameters, density and height, on a site-by-site basis for each of the participating installations. Sites discontinued in 2009 were not included in this quick summary table.

Beginning on page 14, we present the supplementary laboratory and field data collection from 2009 that help us assess the establishment efficacy and damage potential of released bio-agents. Tables 4 and 5 represent the results of knapweed seedhead and root collections in 2009. Tables 6 and 7 contain information about *Aphthona* sp. establishment and Table 9 describes the success of the control of St. John's wort at the Air Force Academy. Table 8 contains data on field bindweed infestations across four installations. In previous years a comparison of establishment levels of toadflax stem-borer, *Mecinus janthinus*, from the previous field season were included in this section. However, the summer of 2008 was not favorable for toadflax stem growth and the stems were too small to contain stem-borer larvae. Another attempt to collect stems will be made early in spring 2010.

In the remainder of this consolidated report we discuss the details of activities at the various locations in alphabetical order, beginning with the Air Force Academy and ending with F. E. Warren Air Force Base. As in previous reports, this format provides a written narrative of the key observations and activities at each location, followed by tabular material with historic site data, plant parameter changes, and biocontrol agent release and recovery records.

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. Sentinel sites are monitored several times in the season and therefore bio-agents have a better chance of being detected than in previous years when only one survey was conducted per season. The species recovery tables reflect data from both sentinel site visits and data from species counted during site mapping.

As an appendix to this report, this year's weed density and height estimates are 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 2009

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

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

All maps and graphs presented in our annual consolidated reports are generated from georeferenced data, obtained in the field using GPS-enabled data collectors. All of the data collected on weed infestation perimeters, plant density and height, bio-agent release and detection up to the 2009 field season are contained within a geodatabase. Using this information, we are able to analyze data both statistically and spatially, along with converting data to visual maps, using GIS. Just as with the geodatabase from 2008 we will again make the geodatabase available on a CD to allow each installation to utilize the data we have collected to meet their own planning and analysis needs. Photopoint photos for all years available will again be incorporated into the database this year. 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. Where available, these data will also be supplemented by the raw plant dissection and insect observation information that was used to produce Tables 3-8.

General Trends in 2009

Of the sites monitored in both 2008 and 2009, the overall trend across all species and all installations was an increase, though not always significant, in both plant density and plant height (Table 2) with 22 and 19 sites showing increases respectively. Fifteen of the 41 sites sampled showed a significant increase in average plant height, though only 4 showed a significant increase in density. This seeming increase in plant robustness and abundance may be a result of this summer being wetter than last year. As noted in the 2008 report the average precipitation in the Colorado Springs area over the period from June 3rd to the end of August was from 0 up to 4.5 inches lower than normal (NOAA). This year the total precipitation for June-August was 8.57 inches, and was only .10 of an inch below average for those months. This relatively dry year followed by a wetter year can account for an increase in plant parameters and may not be attributable to a failure of bioagents to control the weeds.

Despite the increase in plant parameters this year each installation had some sites where the area and density of weeds were reduced to such low levels that accurate mapping was not possible. There were four sites at the Air Force Academy, one at Buckley Air Force Base, two at Fort Carson Military Post, one at Rocky Flats National Wildlife Refuge and three at F.E. Warren Air Force Base that could not be mapped due to low density.

Larinus minutus was particularly a successful agent again this year and we were able to redistribute agents from the Air Force Academy to existing and new sites as well as provide some to researchers from the University of Arkansas. We also were informed of a site near Pueblo, CO where the saltcedar beetle *Diorhabda elongata* had been successfully established and collections of beetles from that site were distributed to the site at Fort Carson. A large number of field bindweed runners infested with the mite *Aceria malherbae* were collected from a site at Pinon Canyon Maneuver Site in Model, CO and distributed to sites at the Air Force Academy, Buckley Air Force Base and Rocky Flats.

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

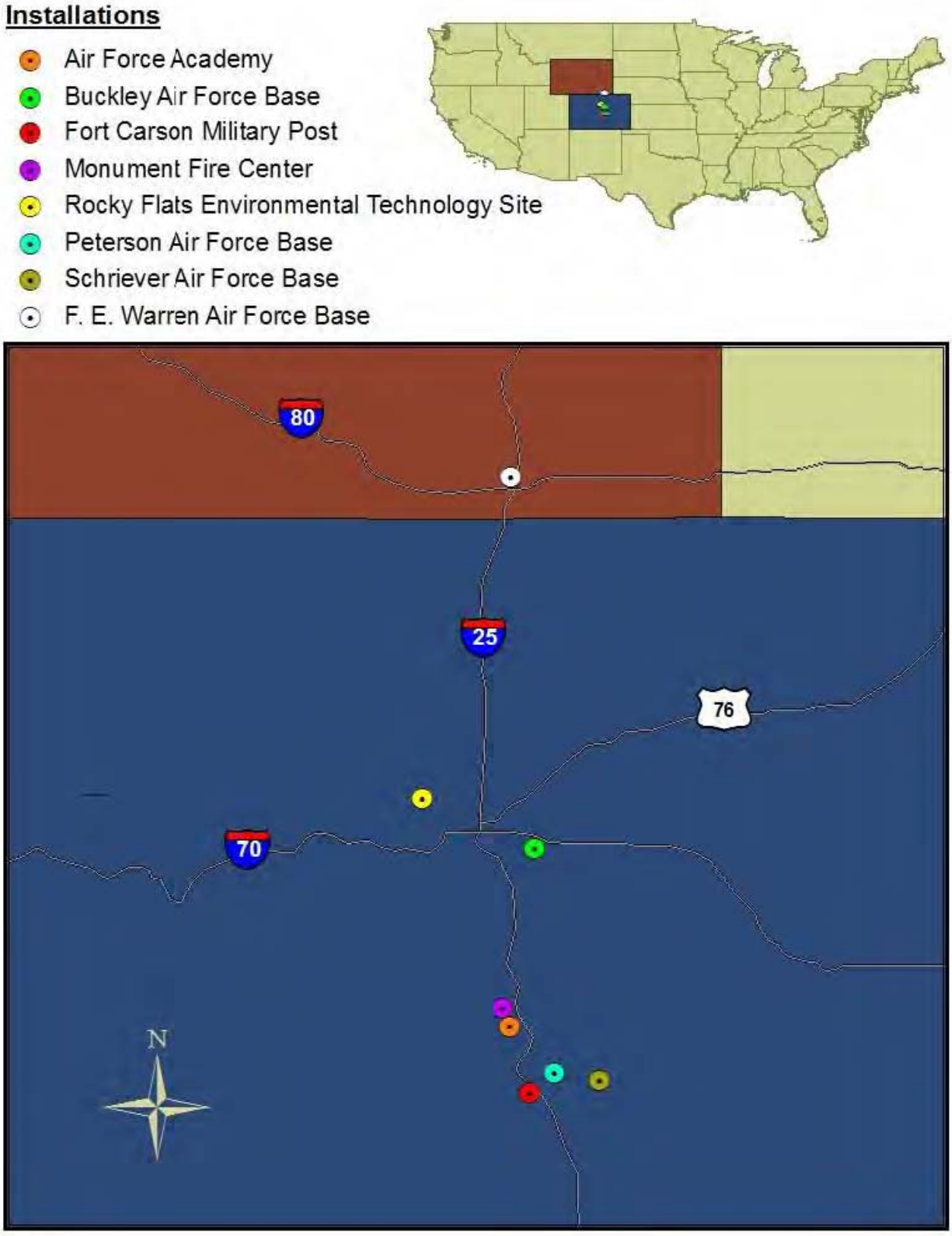


Figure 1. Map showing the federal installations in Colorado and Wyoming on which noxious weed biological control efforts are being/have been made by Texas AgriLife Research.

Table 1. Size of area under biocontrol for 2009 and for the maximum extent over all years by weed species and installation.

Species	Air Force Academy		Buckley Air Force Base		Fort Carson[1]		Rocky Flats		Warren Air Base[2]	
For 2009	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares
Thistle	0.49	0.20	8.57	3.47	107.89	43.66	1.45	0.59	-	-
Knapweeds	5.51	2.23	-	-	6.23	2.52	-	-	-	-
Leafy Spurge	0.77	0.31	0.78	0.32	-	-	-	-	30.99	12.54
Toadflax	0.20	0.08	0.94	0.38	-	-	8.28	3.35	0.17	0.07
St. John's Wort	0.44	0.18	-	-	-	-	-	-	-	-
Total	7.41	3.00	10.29	4.17	114.11	46.18	9.73	3.94	31.16	12.61
Max. for All Years	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares
Thistle	1.73	0.70	31.01	12.55	173.30	70.14	2.09	0.84	-	-
Knapweeds	22.97	9.30	-	-	33.98	13.75	-	-	-	-
Leafy Spurge	2.62	1.03	2.71	1.10	-	-	-	-	26.51	23.54
Toadflax	0.44	0.18	16	6.47	-	-	14.41	5.83	35.52	22.22
St. John's Wort	0.91	0.37	-	-	-	-	-	-	-	-
Total	28.67	11.57	49.72	20.12	207.28	83.88	16.50	6.68	62.03	45.75

[1] Total does not include area of salt cedar in Section 36
[2] Total does not include area of sites monitored by transects

Table 2. Overall summary of the trends in noxious weed parameter changes, 2008-2009, at the five participating installations in Colorado and Wyoming.

Noxious Weed	Parameter	Change in Parameter, 2008-2009				Total Compared Sites
		Significant decrease[1]	Decrease	Significant increase[1]	Increase	
Canada Thistle	Density		2		8	10
Canada Thistle	Height		1	7	2	10
Dalmatian Toadflax	Density		2	1	1	4
Dalmatian Toadflax	Height			1	3	4
Leafy Spurge	Density			1	7	8
Leafy Spurge	Height	1		1	6	8
Musk Thistle	Density				1	1
Musk Thistle	Height				1	1
Diffuse Knapweed	Density		1	1	1	3
Diffuse Knapweed	Height		1	1	1	3
Spotted Knapweed	Density	3	1	1	1	6
Spotted Knapweed	Height		1		5	6
Mixed Knapweed	Density				1	1
Mixed Knapweed	Height				1	1
St. John's wort	Density		2			2
St. John's wort	Height			2		2
Yellow Toadflax	Density		1		2	3
Yellow Toadflax	Height			3		3
Total		**4**	**12**	**19**	**41**	**38**

[1]Significance level, p=0.05

Table 3.. Details of the changes in noxious weed parameters, 2008-2009, 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	increase	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	increase	ns
AFA	Kettle Lake	Canada Thistle	Height	increase	*
AFA	Parade Loop	Canada Thistle	Density	increase	ns
AFA	Parade Loop	Canada Thistle	Height	increase	*
AFA	Deadman's Trail	Leafy Spurge	Density	increase	ns
AFA	Deadman's Trail	Leafy Spurge	Height	increase	ns
AFA	Douglass School	Leafy Spurge	Density	increase	ns
AFA	Douglass School	Leafy Spurge	Height	increase	ns
AFA	FERL North	Leafy Spurge	Density	increase	ns
AFA	FERL North	Leafy Spurge	Height	increase	ns
AFA	FERL	Leafy Spurge	Density	increase	ns
AFA	FERL	Leafy Spurge	Height	increase	ns
AFA	Highway 83	Diffuse Knapweed	Density	increase	ns
AFA	Highway 83	Diffuse Knapweed	Height	increase	*
AFA	Water Treatment Plant	Mixed Knapweed	Density	increase	ns
AFA	Water Treatment Plant	Mixed Knapweed	Height	increase	ns
AFA	Monument Trail Road	Spotted Knapweed	Density	decrease	ns
AFA	Monument Trail Road	Spotted Knapweed	Height	decrease	ns
AFA	New Monument Creek	Spotted Knapweed	Density	increase	*
AFA	New Monument Creek	Spotted Knapweed	Height	increase	ns
AFA	Old Monument Creek	Spotted Knapweed	Density	decrease	*
AFA	Old Monument Creek	Spotted Knapweed	Height	increase	ns
AFA	Parade Loop	Spotted Knapweed	Density	decrease	*
AFA	Parade Loop	Spotted Knapweed	Height	increase	ns
AFA	Kettle Creek	St. John’s wort	Density	decrease	ns
AFA	Kettle Creek	St. John’s wort	Height	increase	*
AFA	Midway Kettle Creek	St. John’s wort	Density	decrease	ns
AFA	Midway Kettle Creek	St. John’s wort	Height	increase	*

Table 3.. cont.

Installation	Site	Noxious Weed	Parameter	Annual Change	
AFA	Community Center Drive I	Yellow Toadflax	Density	increase	ns
AFA	Community Center Drive I	Yellow Toadflax	Height	increase	*
AFA	Community Center Drive III	Yellow Toadflax	Density	decrease	ns
AFA	Community Center Drive III	Yellow Toadflax	Height	increase	*
AFA	Ice Lake Road II	Yellow Toadflax	Density	increase	ns
AFA	Ice Lake Road II	Yellow Toadflax	Height	increase	*
BAF	Aspen	Canada Thistle	Density	increase	ns
BAF	Aspen	Canada Thistle	Height	increase	*
BAF	Williams Lake	Canada Thistle	Density	increase	ns
BAF	Williams Lake	Canada Thistle	Height	decrease	ns
BAF	Williams Lake	Leafy Spurge	Density	increase	ns
BAF	Williams Lake	Leafy Spurge	Height	increase	ns
BAF	Interior	Leafy Spurge	Density	increase	*
BAF	Interior	Leafy Spurge	Height	decrease	*
BAF	Runway	Leafy Spurge	Density	increase	ns
BAF	Runway	Leafy Spurge	Height	increase	*
BAF	South Fence	Spotted Knapweed	Density	increase	ns
BAF	South Fence	Spotted Knapweed	Height	increase	ns
BAF	South Aspen Way	Dalmatian Toadflax	Density	increase	ns
BAF	South Aspen Way	Dalmatian Toadflax	Height	increase	ns
BAF	South Fence	Dalmatian Toadflax	Density	decrease	ns
BAF	South Fence	Dalmatian Toadflax	Height	increase	ns
FTC	ARA II	Canada Thistle	Density	increase	ns
FTC	ARA II	Canada Thistle	Height	increase	ns
FTC	Duckpond	Canada Thistle	Density	decrease	ns
FTC	Duckpond	Canada Thistle	Height	increase	ns
FTC	Reservoir	Canada Thistle	Density	decrease	ns
FTC	Reservoir	Canada Thistle	Height	increase	*
FTC	Wildlife	Musk Thistle	Density	increase	ns
FTC	Wildlife	Musk Thistle	Height	increase	ns
FTC	Gun Club	Diffuse Knapweed	Density	increase	*
FTC	Gun Club	Diffuse Knapweed	Height	increase	ns
FTC	Turkey Creek	Spotted Knapweed	Density	decrease	*
FTC	Turkey Creek	Spotted Knapweed	Height	increase	ns
RF	Lindsay Ranch	Canada Thistle	Density	increase	ns
RF	Lindsay Ranch	Canada Thistle	Height	increase	*
RF	South Fence Transects	Dalmatian Toadflax	Density	decrease	ns

Table 3.. cont.

Installation	Site	Noxious Weed	Parameter	Annual Change	
RF	South Fence Transects	Dalmatian Toadflax	Height	increase	ns
RF	Weather	Dalmatian Toadflax	Density	increase	*
RF	Weather	Dalmatian Toadflax	Height	increase	*
RF	North Buffer Transects	Diffuse Knapweed	Density	decrease	ns
RF	North Buffer Transects	Diffuse Knapweed	Height	decrease	ns
WAB	Black Powder Road	Leafy Spurge	Height	increase	ns
WAB	Black Powder Road	Leafy Spurge	Density	increase	ns

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

Summary of 2009 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 during the summer and dissection of plant materials from bio-agent release areas 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 in September- October 2009 (Table 1.)
- Comparative spring collections of *Aphthona sp.* beetle populations found at mapped leafy spurge infestations during peak beetle emergence in 2004, 2005, 2006, and 2007 (data from 2008 were not collected because stems were too small) (Table 5).
- Comparative spring collections of *Aphthona sp.* populations found at supplementary leafy spurge release sites in 2006, 2007, 2008, and 2009 from which 10 random sweeps were taken to collect the beetles in lieu of mapping the sites (Table 6).
- Comparative spring collections of *Chrysolina sp.* beetle populations found at mapped St. John's wort infestations during peak beetle emergence in 2004, 2005, 2006, 2007, 2008 and 2009 (Table 7).

Discussions of the bio-agent establishment and damage reported in these tables will take place within the subsequent sections for individual installations.

Table 4. Knapweed seedhead dissections from sampled plants in 2009 at Air Force Academy (AFA), Fort Carson Military Post (FTC) and Rocky Flats National Wildlife Refuge (RF), identifying the proportion of knapweed seedheads attack (%) and the seed-feeding agents responsible.

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	199	46	9	30	8.5	2.5
AFA	Deadman's Creek	140	29	1	19	8	0.7
AFA	Highway 83	198	68	38	24	5	4
AFA	New Monument Creek	200	50	37	7	3	5
AFA	Monument Trail Road	199	62	7	46	11	6
AFA	NPWR[1]						
AFA	Old Monument Creek	195	41	2	33	11	0
AFA	Parade Loop (combined)	200	39	12	15	16	2.5
AFA	Railroad	40	23	13	5	0	5
AFA	Water Treatment Plant	199	70	40	28	2.5	4
FTC	Fuel Site	199	16	5	7	7	1.5
FTC	Gun Club	200	32	18	8	4	5
FTC	Hazmat	200	23	1.5	19	10	2
FTC	Turkey Creek[1]						
RF	N Buffer Transects	200	37	24	8	1.5	4

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

[1] Not sampled this year

Table 5. Knapweed root dissections from sampled plants in 2009 at Air Force Academy (AFA), Fort Carson Military Post (FTC) and Rocky Flats National Wildlife Refuge (RF), identifying the proportion of knapweed roots attack (%) and the root-feeding agents responsible.

Installation Abbreviation	Site Name	n	Percent Roots Attacked	Roots with Biological Control Agents (%)		
				C. achates	*A. zoegana*	*S. jugoslavica*
AFA	Bike Trail	29	17	3	7	7
AFA	Deadman's Creek	13	77	8	69	0
AFA	Highway 83	32	63	9	53	0
AFA	New Monument Creek	50	46	8	34	12
AFA	Monument Trail Road	50	36	14	18	4
AFA	NPWR[1]					
AFA	Old Monument Creek	50	26	8	2	0
AFA	Parade Loop (combined)	29	45	0	34	10
AFA	Railroad[2]	10	0	0	0	0
AFA	Water Treatment Plant	50	30	16	10	0
FTC	Fuel Site[2]	3	67	0	67	0
FTC	Gun Club	50	28	0	18	10
FTC	Hazmat[2]	11	55	0	55	0
FTC	Turkey Creek[1]					
RF	N Buffer Transects	33	42	33	3	6

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

[1] Not sampled this year
[2] Extremely low knapweed density

Table 6. Proportion of sampled leafy spurge 0.5m^2 quadrats populated by *Aphthona* species biological control agents, as identified through sweep net captures in 2004-2009 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.

		2004 Sweeps		2005 Sweeps		2006 Sweeps		2007 Sweeps		2008 Sweeps		2009 Sweeps	
Installation Abbreviation	Site Name	n	% Infested	n	% Infested	n	% Infested	n	% Infested	n	% Infested	n	% Infested
AFA	Deadman's Trail	31	45	30	37	37	0	32	28	33	27	14	71
AFA	Douglass School	5	20	36	3	43	0	30	17	12	0	11	64
AFA	FERL	30	20	45	6	33	0	50	22	10	0	18	78
AFA	North FERL [2]	--	--	--	--	35	0	--	--	71	21	10	50
BAF	Interior [3]	--	--	28	36	10	20	--	--	11	0	10	0
BAF	Runway [3]	44	0	32	31	28	86	45	47	31	19	10	70
BAF	South Fence [1]	--	--	--	--	28	0	30	17	10	40	10	70
BAF	Southwest Williams Lake [3]	24	0	42	57	34	44	31	19	10	0	10	0
BAF	Williams Lake	77	9	31	32	45	2	56	43	19	16	11	55
WAB	Black Powder Road [2]	--	--	28	0	96	27	129	50	27	0	10	0
WAB	Control [3]	31	0	50	54	64	23	--	--	--	--	31	0
WAB	Nature I [3]	44	0	35	34	54	6	60	8	--	--	16	38
WAB	Nature II [3]	42	0	37	73	54	56	62	39	--	--	10	30

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

Table 7. Comparison of establishment rates at additional *Aphthona sp.* 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 2006-2009.

		2006 Sweep Samples		2007 Sweep Samples		2008 Sweep Samples		2009 Sweep Samples	
Installation Abbreviation	Sample Site Name	% Quadrats Infested	# Insects/ quadrat	% Quadrats Infested	# Insects/ quadrat	% Quadrats Infested	#Insects/ quadrat	% Quadrats Infested	#Insects/ quadrat
BAF	North Runway 1	0	--	60	3	10	1	80	1.5
BAF	North Runway 2	0	--	50	1	0	--	70	1.7
BAF	North Runway 3 [1]	--	--	0	--	0	--	10	0.1
WAB	Black Powder 1 [2]	80	4	100	4	0	--	50	1.1
WAB	Black Powder 2 [2]	60	2	100	18	50	2	40	0.5
WAB	Black Powder 3 [2]	10	0.2	40	1	90	5	50	0.8
WAB	Black Powder 4 [2]	10	0.3	100	5	20	1.5	40	1
WAB	Black Powder 5 [2]	10	0.2	10	0.1	0	--	10	0.4
WAB	Black Powder 6 [2]	30	0.4	10	0.1	0	--	0	--
WAB	Bridge I [2]	60	5	60	1	20	1	0	--
WAB	Bridge II [2]	60	1	50	1	20	2	30	1.1
WAB	Nature III	70	3	0	--	0	--	0	--
WAB	Nature IV [2]	30	0.6	0	--	0	--	0	--
WAB	Propane [2]	100	9	80	5	67	2	30	0.6

[1] Initial release of *Aphthona* species beetles made in 2007.
[2] Supplementary release of *Aphthona sp.* beetles made in 2007 (following the insect establishment survey).

Table 8. Proportion of sampled St. John's wort $0.5m^2$ quadrats populated by *Chrysolina sp.* biological control agents at Air Force Academy, as identified through visual counts in 2004-2009. The number of quadrat samples taken at a site is indicated by n.

	2004 Insect Counts		2005 Insect Counts		2006 Insect Counts		2007 Insect Counts		2008 Insect Counts		2009 Insect Counts	
Site Name	n	% Infested	n	% Infested	n	% Infested	n	% Infested	n	% Infested	n	% Infested
Kettle Creek	71	10	33	49	32	13	47	32	39	31	30	0
Midway Kettle Creek	19	32	40	48	30	7	32	44	34	3	15	0
Santa Fe	24	8	40	68	--	--	--	--	--	--	--	--

Note: The Santa Fe site was not sampled in 2006-2009, as there were not enough plants left at this site to sample.

Table 9. Proportion of sampled Field Bindweed 0.5m^2 quadrats populated by biological control agent *Aceria malherbae* at Air Force Academy (AFA), Buckley Air Force Base (BAF), and Fort Carson Military Post (FTC) as identified through random sampling in 2006-2009. The number of quadrat samples taken at a site is indicated by n.

Installation Abbreviation	Sample Site Name	2006 Sample		2007 Sample		2008 Sample		2009 Sample	
		n	% Infested	n	% Infested	n	% Infested	n	% Infested
AFA	Stadium[5]	--	--	30	0	30	0	10	0
AFA	FERL[1]	--	--	10	0	10	0	10	0
BAF	Aspen	10	0	10	0	--	--	10	40
BAF	Breckenridge	10	0	10	0	10	30	10	10
BAF	FW1[4,6]	10	10	10	0	10	40	10	30
BAF	FW2[4,6]	10	30	20	0	10	70	10	0
BAF	FW3[5]	10	0	10	0	10	50	10	10
BAF	NE Gate 1[5,6]	--	--	10	0	10	10	10	0
BAF	NE Gate 2[5]	--	--	10	0	10	0	10	0
BAF	NE Gate 3[5]	--	--	10	0	10	20	10	0
BAF	NE Gate 4[5]	--	--	10	0	10	0	10	0
BAF	NE Gate 5[5]	--	--	10	0	10	10	10	30
BAF	Playground[5,6,7]	10	0	10	30	10	30	10	30
BAF	POV Resale[5,6,7]	10	30	10	0	10	0	30	27
BAF	RV [5]	10	10	10	0	10	0	10	10
BAF	RV West[5]	10	0	10	0	10	0	10	0
BAF	Fence 1[5]	10	0	10	0	10	20	10	10
BAF	Fence 2[5]	10	0	10	0	10	10	10	10
BAF	Steamboat[6]	10	0	10	0	10	40	10	20
FTC	ARA 1[1,6]	10	40	10	0	10	10	--	--
FTC	ARA 2a	10	0	10	0	10	20	--	--
FTC	ARA 2b	10	20	10	0	10	0	--	--
FTC	ARA Building[3]	10	0	10	0	10	10	--	--
FTC	Basketball Field 1	10	0	10	0	10	0	--	--

Table 9. Continued

Installation Abbreviation	Sample Site Name	2006 Sample n	2006 Sample % Infested	2007 Sample n	2007 Sample % Infested	2008 Sample n	2008 Sample % Infested	2009 Sample n	2009 Sample % Infested
FTC	Basketball Field 2	--	--	10	0	10	10	--	--
FTC	Basketball Field 3	--	--	10	0	10	20	--	--
FTC	Basketball Field 4	--	--	10	0	10	10	--	--
FTC	Basketball Field 5	--	--	10	0	10	0	--	--
FTC	Basketball Field 7	--	--	10	0	10	0	--	--
FTC	Curation 2	10	0	10	0	10	30	10	10
FTC	Curation 3	10	0	10	0	10	0	10	0
FTC	Curation 5	10	0	10	0	10	40	10	0
FTC	Curation 6	--	--	10	0	10	10	10	0
FTC	Golf Course[5]	10	0	10	0	10	0	--	--
FTC	Hospital[5]	10	0	10	0	10	0	--	--
FTC	Range Control[2,6]	10	0	20	0	10	0	--	--
RF	Highroad 1[6]	--	--	--	--	10	60	--	--
RF	Highroad 2[6]	--	--	--	--	10	20	--	--
RF	Site 8[6]	10	30	--	--	10	30	10	70
RF	Site 9	10	20	--	--	10	30	10	60

[1] Denotes sites where mites were released in 2000
[2] Denotes sites where mites were released in 2001
[3] Denotes sites where mites were released in 2004
[4] Denotes sites where mites were released in 2005
[5] Denotes sites where mites were released in 2006
[6] Denotes sites where mites were released in 2008
[7] Denotes sites where mites were released in 2009

Air Force Academy

Twenty-four noxious weed infestations were mapped at Air Force Academy this year over a total area of 3.00 ha (7.41 acres), an increase of 0.30 ha (0.75 acres) from last year. However, a new site was included this year (DK Railroad) which added 0.57 ha (1.41 acres) to the total area monitored (Table 10). Two additional sites, Stadium and FERL field bindweed, were not mapped. Instead, random sampling was conducted to detect the presence of bio-agents on these two sites. Seven of the twenty-two mapped sites showed a decrease since the beginning of biocontrol efforts in all three parameters measured i.e. % density, % height, and total estimated number of plants (Figure 6). Seven sites had mixed changes with some parameters increasing and some decreasing and seven sites had an increase in all three parameters. Mapped and monitored sites this year included five thistle sites over 0.20 ha (0.49 acres), four leafy spurge sites over 0.31 ha (0.77 acres), eight knapweed sites over 2.23 ha (5.51 acres) two St. John's wort sites over 0.18 ha (0.44 acres) and three yellow toadflax sites over 0.08 ha (0.20 acres). Of the 19 sites that were surveyed in both 2008 and 2009, 13 saw an increase in density (one site with a significant change) while six sites had a decrease in density (with only two sites significantly less dense). See Table 10 for a year by year summary of each site including area, density, height, and where applicable, seedhead number and size.

Figure 2. Photos showing newly established diffuse knapweed Railroad site at the Air Force Academy. 1000 *L. minutus* agents were released at the site on July 7, 2009.

As they have for several years running, the knapweed sites (eight total) mapped in 2009 comprised the largest percentage (74%) of the total area mapped at the Air Force Academy this year. Knapweed seedheads and roots were collected in September/October to analyze the percent heads and roots attacked by plant-boring insects (Tables 4 and 5). With two exceptions (Old Monument Creek and Railroad) all seedhead feeders were found at all sites. As was the case last year, the root samples were dominated by *A. zoegana* with fewer roots affected by *C. achates* and *S. jugoslavica*.

One site, spotted knapweed Monument Creek, was sprayed with herbicide before it was mapped this year. However, due to an access road running through the site only half of the site was sprayed while the other half was left untouched. This will be an interesting site to take note

of in the future to see if and how the bioagents are affected by herbicide treatment and any interactions between herbicide and biocontrol. Of particular interest will be to see if the combination of control methods provides greater suppression of knapweed growth than either treatment alone. Photos of the herbicide damage were taken and the sprayed area was mapped so that comparisons can be made across years.

Figure 3. Left, the spotted knapweed monument creek site sprayed with herbicide; on the right is the unsprayed portion of the site. This unintentional experiment will hopefully provide some information as to the possible efficacy of using a combination of herbicide and biocontrol to eliminate weeds.

Leafy spurge covered the next largest area on the base with 10% of the area under biocontrol devoted to it. Canada and musk thistles comprised 6% of the area monitored, as did St. John's wort. Yellow toadflax covered the least amount, just 3% of the area under biocontrol. The Ice Lake I musk thistle site was not monitored for the past two summers because too few plants were left to monitor. However, this year there were just enough plants to warrant mapping the site again, though we expect as small as this population is it will likely waver on the threshold of being too small to map for a few years to come.

Several insects were noted at sites where they had not been deliberately introduced. For example a single *Urophora carduii* gall was observed at the Canada thistle Kettle Lake site even though no releases had been made there; a single *U. carduii* gall was also observed at this site last year. Similarly, *Cassida rubiginosa* were observed at the Ice Lake I thistle site despite not being released there. The release of *L. minutus* at the newly created diffuse knapweed Railroad site was the only release made at Air Force Academy this summer but *L. minutus*, *U. affinis* and *M. paucipunctella* were recovered from seedhead dissections. Efforts were made to establish new field bindweed sites as the FERL and Stadium sites have only a few scattered plants remaining but no new sites were established. The establishment of new field bindweed sites will be a continuing goal for us in the 2010 field season as will the establishment of biocontrol agents at sites of other species.

Five sites that had been monitored in previous years at the Air Force Academy were not monitored this year. They include the spotted knapweed Dead Man's Creek, Bike Trail, and Non Potable Water Reserve (NPWR) none of which had any plants to map. The St. John's wort Santa Fe site and yellow toadflax Community Center Dr. 2 sites also were not monitored this

year because of insufficient plant densities. All except the toadflax Community Center Dr. 2 sites were also not mapped in 2008 and will hopefully continue their weed free status indefinitely.

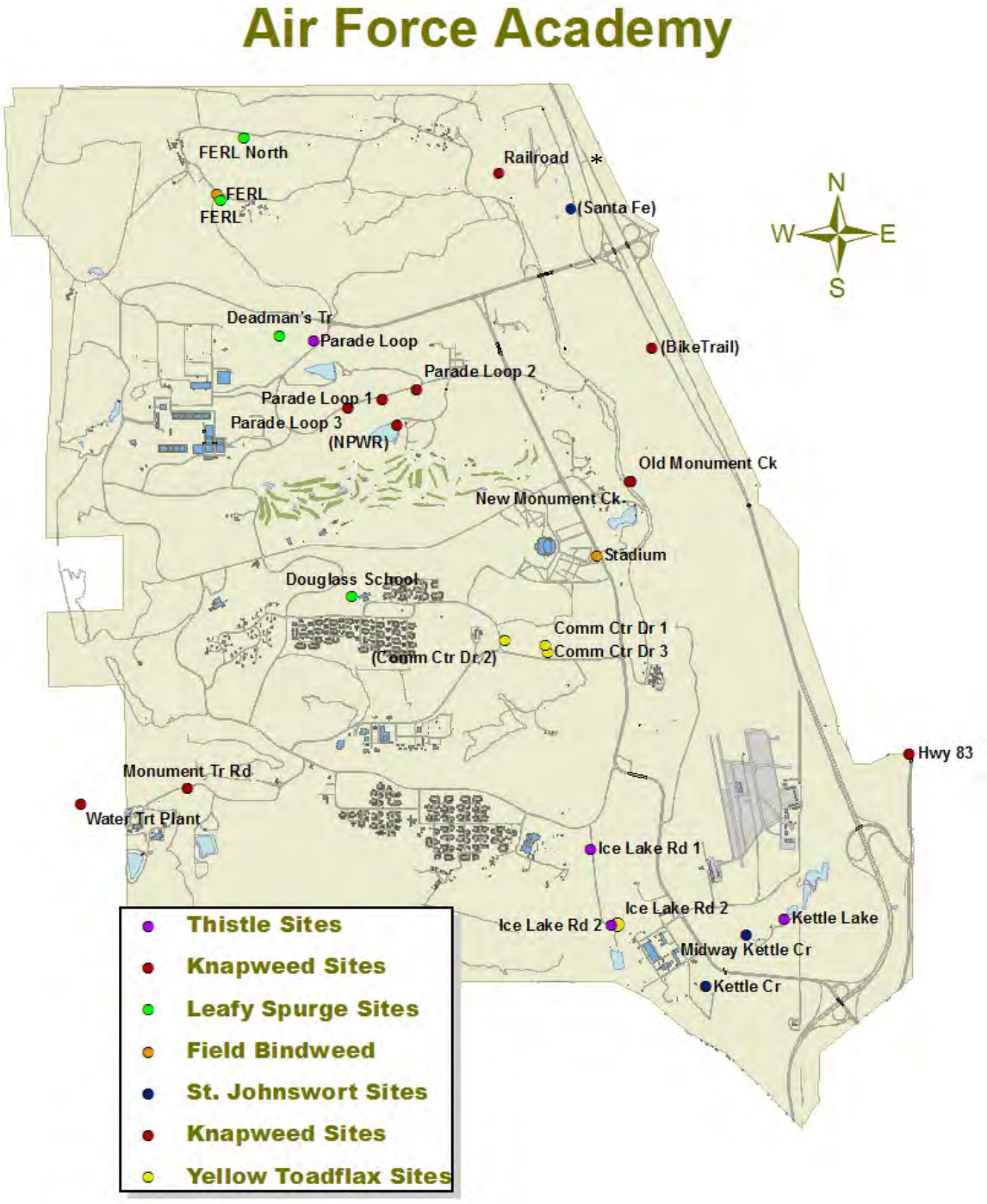


Figure 4: Schematic diagram of Air Force Academy with current weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2009.
*new site in 2009

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
Canada thistle – Ice Lake Road I																
2000			9		66.83											
2001	976	39	7.48	40	91.8	143	47.38	0.52	7300.48		-16.89	37.36				
2002	449	33	2.26	21	14.56	97	0.46	0.9	1014.74	-54	-69.79	-84.14	-86.10			
2003	80	49	2.61	14	33.02	107	6.78	0.25	208.8	-82.22	15.49	126.79	-79.42			
2004	244	45	1.27	16	45.62	74	3.23	0.54	309.88	205.84	-51.34	38.16	48.41			
2005	244	30	3.67	17	49.04	82	7.3	0.39	895.48	0	188.97	7.5	188.98			
2006	272	27	4.52	13	33.76	62	1.71	0.23	1229.44	11.48	23.16	-31.16	37.29			
2007	406	31	4.32	12	72.19	129	12.85	0.5	1753.92	49.26	-4.42	113.83	42.66			
2008	278	10	3.4	16	40.31	74	6.38	3.63	945.2	-31.53	-21.3	-44.16	-46.11			
2009	248	10	6.8	11	108.6	151	42.5	0.98	1686.4	-10.71	100	169.41	78.42	-74.59	-24.44	-76.90
Canada thistle – Ice Lake Road II																
2000	341	65	7.21	36	64.53	115			2458.61							
2001	434	32	4.7	46		79			2039.8	27.45	-34.81		-17.03			
2002	214	27	1.74	18	16.12	124	3.85	0.21	372.36	-50.78	-62.97		-81.75			
2003	46	18	2.28	16	39.72	100	10.33	0.27	104.88	-78.45	31.03	146.4	-71.83			
2004	145	31	1.09	11	44.85	145	5.76	3.5	158.05	214.94	-52.19	12.92	50.70			
2005	114	24	5.21	17	79.69	110	25.91	2.05	593.94	-21.38	377.98	77.68	275.79			
2006	206	27	3.19	9	31.21	52	4.89	0.39	657.14	80.7	-38.77	-60.84	10.64			
2007	288	56	3.71	16	71.52	123	11.9	5.06	1068.48	39.81	16.3	129.16	62.60			
2008	674	11	4.55	14	38.58	50	16.83	4.83	3066.7	134.03	22.64	-32.94	187.02			
2009	523	10	10.3	27	81.2	120	20.3	1.31	5386.9	-22.4	126.37	110.47	75.66	53.37	42.86	119.16

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
Canada thistle – Kettle Lake																
2003	1,153	72	6.03	110	62.35	132	9.32	0.38	6952.59							
2004	1,165	52	6.9	23	50.53	87	9.06	0.94	8038.5	1.07	14.43	-18.96	15.62			
2005	917	31	5.34	13	75.25	121	12.86	0.61	4896.78	-21.27	-22.61	48.92	-39.08			
2006	943	33	4.67	26	30.83	59	0.93	0.12	4403.81	2.84	-12.55	-59.03	-10.07			
2007	959	22	3	12	63.78	129	9.17	0.47	2877	1.7	-35.76	106.87	-34.67			
2008	541	31	2.32	8	29.78	82	4.35	2.3	1255.12	-43.59	-22.67	-53.31	-56.37			
2009	1120	17	3	7	58.15	103	3.54	0.49	3360	107.02	29.31	95.27	167.70	-2.86	-76.39	-51.67
Canada thistle – Parade Loop																
2003	6	1	0.82	10	24.09	70			4.92							
2004	36	10	4.3	13	62.29	87	6	2.4	154.8	483.36	424.39	3046.34	158.57			
2005	61	26	3.32	14	71.92	105	18.2	0.62	202.52	69.44	-22.79	30.82	15.46			
2006	92	30	5.07	19	32.09	62	9.73	0.47	466.44	50.82	52.71	130.31	-55.38			
2007	153	20	3.5	14	126.09	167	19.45	0.79	535.5	66.3	-30.97	14.81	292.93			
2008	388	10	5.4	9	62.78	103	8.33	4.22	2095.2	153.59	54.29	291.26	50.21			
2009	60	10	9.5	17	102.5	113.31	39.3	1.06	570	-89.05	75.93	63.27	-72.79	900	1058.54	11485.34

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
Musk Thistle – Ice Lake Road I																
2000	1,016	129	7.76	82	58.87	171			7884.16							
2001	976	39	1.13	6	23.82	158	2.57	0.9	1102.88	-3.95	-85.44	-59.54	-86.01			
2002	449	7	2	6	63.66	111	9	2.18	898	-54	76.99	167.25	-18.57			
2003																
2004	98	30	1.26	8	31.93	131	1.11	10.4	123.48	-78.17**	-37.00**	-49.84**	-86.24**			
2005	*(see Note a)*															
2006	*(see Note a)*															
2007	567	20	1.15	4	122.08	189	7.17	32.67	652.05	478.57	-8.73**	282.33**	428.06**			
2008	*(see Note a)*															
2009	33	10	1.2	3	150.83	212	19.5	4.17	39.6	-94.18**	4.35**	23.55**	-93.93**	-96.75	-84.54	-99.5
Leafy Spurge – Deadman's Trail																
2000	406	28	63.5	195	44.33	76			25781							
2001	1,148	66	59.78	214	50.25	97			68627.44	182.75	-5.86	13.35	166.19			
2002	1,145	117	40.51	196	33.66	89			46383.95	-0.27	-32.23	-33.01	-32.41			
2003	249	21	9	22	49.25	85			2241	-78.24	-77.78	46.32	-95.17			
2004	494	31	31.03	93	42.1	80			15328.82	98.21	244.78	-14.52	584.02			
2005	780	30	42.1	169	45.96	70			32838	57.89	35.68	9.17	114.22			
2006	840	37	24.38	117	24.08	44			20479.2	7.69	-42.09	-47.61	-37.64			
2007	1,263	32	17.28	85	45.89	79			21824.64	50.36	-29.12	90.57	6.57			
2008	429	33	11.97	40	52.62	83			5135.13	-66.03	-30.73	-14.67	-76.47			
2009	529	14	14	44	66.15	107			7406	23.31	-57.58	25.71	44.22	-87.24	-50.00	-71.27

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
									Leafy spurge - Douglass School							
2000	187	30	16.62	56	36.96	62			3107.94							
2001	290	93	29.11	103	53.32	82			8441.9	55.43	75.15	44.26	171.62			
2002	380	72	3.33	60	12.24	66			1265.4	31.03	-88.56	-77.04	-85.01			
2003	67	5	2.4	3	65	80			160.8	-82.35	-27.93	431.05	-87.29			
2004	52	10	11.6	23	50.25	62			603.2	-23.2	383.33	-22.69	275.12			
2005	81	36	11.05	39	46.62	65			895.05	55.77	-4.74	-7.22	48.38			
2006	261	43	9.95	59	26.42	52			2596.95	222.22	-9.95	-43.33	190.15			
2007	323	30	24.13	62	56.2	77			7793.99	23.75	142.51	112.72	200.12			
2008	335	12	11.75	30	45	75			3936.25	3.72	-51.31	-19.93	-49.50			
2009	75	11	14	32	47.45	66			1050	-77.61	19.49	5.44	-73.32	-59.89	-15.76	-66.22
									Leafy spurge - FERL							
2000	1,139		5.21		19.54				5934.19							
2001	1,528	24	4.26	194	24.59	67			6509.28	34.15	-18.23	25.84	9.69			
2002	796	66	11.29	66	19.85	49			8986.84	-47.89	165.92	-19.28	38.06			
2003	329	28	11.54	51	40.54	85			3796.66	-58.71	2.21	104.23	-57.75			
2004	2,145	103	7.31	88	31.85	54			15679.95	551.95	-36.66	-21.44	312.99			
2005	196*	45	16.64	141	39	61			3261.44	-90.86*	127.63	22.45	-79.20			
2006	470	33	21.36	116	21.22	37			10039.2	139.8	28.37	-45.59	207.81			
2007	3,865	50	16.1	91	45.04	68			62226.5	722.34	-24.63	112.25	519.84			
2008	882	10	16.3	36	28.88	63			14376.6	-77.18	1.24	-35.88	-76.90			
2009	2400	18	19.06	84	52.38	90			45744	172.11	16.93	81.37	218.18	110.71	265.83	670.85

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
Leafy spurge – FERL North																
2006	696	35	10.69	32	27.69	46			7440.24							
2007	*(see Note b)*															
2008	2042	71	5.04	41	36.67	60			10291.68							
2009	122	10	7.6	23	47	55			928.49	-94.03	50.79	28.17	-90.98	-82.47	-28.91	-87.52
Diffuse knapweed – Bike Trail																
2007	628	33	1.21	5	79.7	115	389.14	3.95	759.88							
2008	(*see Note a)*															
2009	19	4	3.5	11	54	77	144.67	0.37	68.01	-96.97	189.26	-32.25	91.05	-96.97	189.26	91.05
Diffuse knapweed – Highway 83																
2003	606	61	1.58	3	49.17	97	46.31	0.07	957.48							
2004	2,601	41	2.02	12	47.93	108	88.28	2.6	5254.02	329.06	27.85	-2.52	448.73			
2005	3,001	35	2.58	8	53.23	82	65.36	0.38	7742.58	15.38	27.72	11.06	47.36			
2006	2,278	27	5.74	37	13.03	29			13075.72	-24.09	122.48	-75.52	68.88			
2007	5,750	38	2.87	20	56.48	85			16502.5	152.41	-50	333.46	26.21			
2008	6,029	44	2.27	12	34.4	62	43.8	3.76	13685.83	4.85	-20.91	-39.09	-17.07			
2009	487	31	2.45	12	52.84	92	311.37	0.71	1193.15	-91.92	7.93	53.6	-91.28	-19.64	55.06	24.61
Diffuse knapweed – Railroad																
2009	5,723	25	6.08	22	44.91	84	133.26	0.37	34795.84	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
Diffuse/Spotted knapweed – Water Treatment Plant																
2003	1,162	97	2.16	23	54.75	107	36.13	0.13	2509.92							
2004	1,539	42	9.81	38	47.28	91	9	2.6	15097.59	32.47	354.17	-13.64	501.52			
2005	2,118	32	5.22	22	56.89	100	49.43	0.42	11055.96	37.62	-46.79	20.33	-26.77			
2006	3,525	30	5.53	19	34.88	54	29.53	3.04	19493.25	66.43	5.94	-38.69	76.31			
2007	6,291	37	2.92	9	54.77	81	111.57	5.03	18369.72	78.47	-47.2	57.02	-5.76			
2008	6,388	11	2	11	40.8	75	87	1.73	12776	1.54	-31.5	-25.51	-30.45			
2009	4,267	16	4	18	55.58	98	280.58	0.55	17068	-33.2	100	36.23	33.59	267.21	85.19	580.02
Spotted knapweed – Monument Trail Road																
2003	484	20	1.5	7	27.09	115	23.02		726							
2004	1,937	32	3	17	69.57	112	48.24	4	5811	300.26	100	153.12	700.41			
2005	2,074	39	7.94	25	93.65	148	49.17	0.6	16467.56	7.07	164.67	34.61	183.39			
2006	1,948	30	1.33	11	34.3	58	7	0.3	2590.84	-6.08	-83.25	-63.37	-84.27			
2007	519	26	2.04	15	56.79	77	35.47	5.62	1058.76	-73.36	53.38	65.57	-59.13			
2008	444	10	4.4	18	61.4	75	47.4	5	1953.6	-14.45	115.69	8.12	84.52			
2009	357	13	2.08	11	60.67	124	149.89	0.68	742.56	-19.59	-52.73	-1.19	-61.99	-26.24	38.67	2.28
Spotted knapweed – New Monument Creek																
2004	700	44	3.36	23	28.96	90	35.07	1.7	2352							
2005	629	35	2.94	16	74.22	111	51.19	0.42	1849.26	-10.14	-12.5	156.28	-21.38			
2006	522	30	1.6	9	20.75	35	29.42	0.29	835.2	-17.01	-45.58	-72.04	-54.84			
2007	5,385	31	1.94	10	73.63	127	224.39	4.74	10446.9	931.61	21.25	254.84	1150.83			
2008	2,444	11	2.09	8	40.57	54	63.71	4.29	5107.96	-54.61	7.73	-44.9	-51.11			
2009	2,473	30	10.07	33	60.39	117	558.64	0.42	24903.11	1.19	381.82	48.85	387.54	253.59	199.7	958.80

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
Spotted knapweed – Non-potable Water Reservoir (NPWR)																
2003	124	29	0.97	5	24.43	100	9.62	0.61	120.28							
2004	491	31	1.35	13	44.25	78	26.33	2.7	662.85	295.03	39.18	81.13	451.09			
2005	234	30	4.37	29	49.48	89	18.39	0.61	1022.58	-52.34	223.7	11.82	54.27			
2006	98	31	1.55	5	32.15	69	29.95	0.53	151.9	-58.12	-64.53	-35.02	-85.15			
2007	1,937	40	1.55	7	59.72	122	84.26	5.52	3002.35	1876.53	0	85.75	1876.53	1462.10	59.79	26.29
2008	*(see Note a)*															
2009	*(see Note a)*															
Spotted knapweed – Old Monument Creek																
2000	622	35	9	25	37.3	80			5598							
2001	948	45	9.52	68	39.7	98	133.15		9024.96	52.36	5.78	6.43	61.22			
2002	746	41	2.19	26	8.4	73	2.62	0.26	1633.74	-21.32	-77	-78.84	-81.90			
2003	236	44	1.5	9	27.09	93	23.02	0.28	354	-68.37	-31.51	222.5	-78.33			
2004	*(see Note a)*															
2005		49	0.3	14	33	39	0.5	2								
2006	389	38	0.32	11	25.25	35	13	0.6	124.48		6.67	-23.49	-64.84			
2007	1,834	33	0.76	5	72.04	127	226.93	5.54	1393.84	371.47	137.5	185.3	1019.73			
2008	456	30	7.3	35	50.5	68	27.75	5	3328.8	-75.14	860.53	-29.9	138.82			
2009	725	18	1.17	3	69.73	117	228.73	0.58	845.35	58.99	-83.97	38.08	-74.60	16.56	-87.00	-84.90
Spotted knapweed – Parade Loop I***																
2003	1,437	65	0.81	4	34.18	130	7.1	0.39	1163.97							
2004	921	43	3.58	13	45.07	97	7.51	3	3297.18	-35.91	341.98	31.86	183.27			
2005	941	30	3.93	25	59.44	89	13.87	0.51	3698.13	2.17	9.78	31.88	12.16			
2006	1,108	36	2	14	40.5	75	27	0.5	2216	17.75	-49.11	-31.86	-40.08	-22.89	146.91	90.38

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
							Spotted knapweed – Parade Loop II***									
2004	578	33	0.79	3	34.15	118	118.11	2.9	456.62							
2005	282	28	3.24	13	57.71	88	9.59	0.31	913.68	-51.21	310.13	68.99	100.10			
2006	953	36	0.89	9	40.25	69	31.08	0.53	848.17	237.94	-72.53	-30.25	-7.17	64.88	12.66	85.75
							Spotted knapweed – Parade Loop III***									
2004	1,412	41	1.53	11	21.37	73	11.68	2.6	2160.36							
2005	106*	22	2.68	14	76.17	117	18	0.59	284.08	-92.49*	75.16	256.43	-86.85			
2006	2,235	30	1.6	9	33.05	51	13.18	0.53	3576	2008.49	-40.3	-56.61	1158.80	58.29	4.58	65.53
							Spotted knapweed – Total Parade Loop***									
2007	53,820	64	1.95	22	71.38	118	108.81	5.47	104949	n/a	n/a	n/a				
2008	3,124	30	10.27	30	51.32	101	29.64	4.55	32083.48	-94.2	427.67	-28.1	-69.43			
2009	8,223	63	2.59	22	58.00	107	69.28	0.59	21274.18	163.22	-74.78	13.1	-33.69	-84.72	32.82	-79.73
							St. John's wort – Kettle Creek									
2004	1,254	90	30.94	85	53.92	85			38798.76							
2005	224	33	20	53	68.18	94			4480	-82.14	-35.36	26.45	-88.45			
2006	619	32	13.43	60	33.09	68			8313.17	176.34	-32.85	-51.47	85.56			
2007	1,599	47	8.21	47	69.61	95			13127.79	158.32	-38.87	110.37	57.92			
2008	1,011	39	16.62	54	48.16	72			16802.82	-36.77	102.44	-30.81	27.99			
2009	991	30	14.09	84	66.91	91			13963.19	-1.98	-15.22	38.93	-16.90	-20.97	-54.46	-64.01

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
St. John's wort – Midway Kettle Creek																
2004	196	19	28.63	60	54.95	70			5611.48							
2005	678	40	23.88	73	69.72	93			16190.64	245.92	-16.59	26.88	188.53			
2006	134	30	21.53	59	42.24	62			2885.02	-80.24	-9.84	-39.41	-82.18			
2007	776	32	19.03	85	74.61	101			14767.28	479.1	-11.61	76.63	411.86			
2008	322	56	17.32	56	49.19	87			5577.04	-58.51	-8.99	-34.07	-62.23			
2009	769	15	16.00	89	71.77	97			12304	138.82	-7.62	45.29	120.62	292.35	-44.11	119.28
St. John's wort – Santa Fe																
2004	266	24	33.96	96	46.75	73			9033.36							
2005	420	40	35.35	130	71.41	85			14847	57.89	4.09	52.75	-64.36	57.89	4.09	-64.36
2006	*(see Note a)*															
2007	*(see Note a)*															
2008	*(see Note a)*															
2009	*(see Note a)*															
Yellow toadflax – Community Center Drive I																
2003	52	4	9.25	15	26.25	40			481							
2004	30	18	19.61	57	21	44			588.3	-42.21	112	-20	22.31			
2005	100	32	19.11	65	27.45	46			1911	233.33	-2.55	30.71	224.83			
2006	93	25	13.64	72	15.5	29			1268.52	-7	-28.62	-43.53	-33.62			
2007	134	37	34.92	239	39.71	63			4679.28	44.09	156.01	156.19	268.88			
2008	130	10	9	40	14.36	21			1170	-2.99	-74.23	-63.84	-75.00			
2009	100	10	24	45	68.6	114			2400	-23.08	166.67	377.71	105.13	92.31	159.46	398.96

Table 10. Historic noxious weed infestation parameters, Air Force Academy, Colorado Springs, Colorado, 2000-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. Height	# of Plants	Area	Avg. Density	# of plants
Yellow toadflax – Community Center Drive II																
2003	96	8	8.63	34	29.88	95			828.48							
2004	112	34	6.44	47	9.18	44			721.28	16.82	-25.38	-6 9.28	-12.94			
2005	59	23	11	40	23.25	60		1.31	649	-47.32	70.81	153.27	-10.02			
2006	110	27	1.74	16	12.38	29			191.4	86.44	-84.18	-46.75	-70.51			
2007	129	23	13.96	44	25.97	38			1800.84	17.27	702.3	109.77	840.88	34.38	61.76	117.37
2008	*(see Note a)*															
2009	*(see Note a)*															
Yellow toadflax – Community Center Drive III																
2005	21	10	12.9	28	44.77	57			270.9							
2006	*(see Note a)*															
2007	30	10	32.9	63	34.7	47			987	42.86**	155.04**	-22.49**	264.34**			
2008	138	10	16.3	29	20.78	30			2249.4	360	-50.46	-40.12	127.90			
2009	166	10	15.9	31	87.2	118			2651	20.29	-2.45	319.63	17.87	690.48	-100.2	878.59
Yellow toadflax – Ice Lake Road																
2007	538	21	20.9	68	33.93	65			11244.2	n/a	n/a	n/a				
2008	909	35	13.49	61	17.12	32			12262.41	68.96	-35.45	-49.54	9.06			
2009	544	31	28.45	118	46.56	72			15478.68	-40.15	110.9	171.96	26.23	1.11	36.12	37.66

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, b) weeds were chemically treated prior to our survey or c) site was destroyed

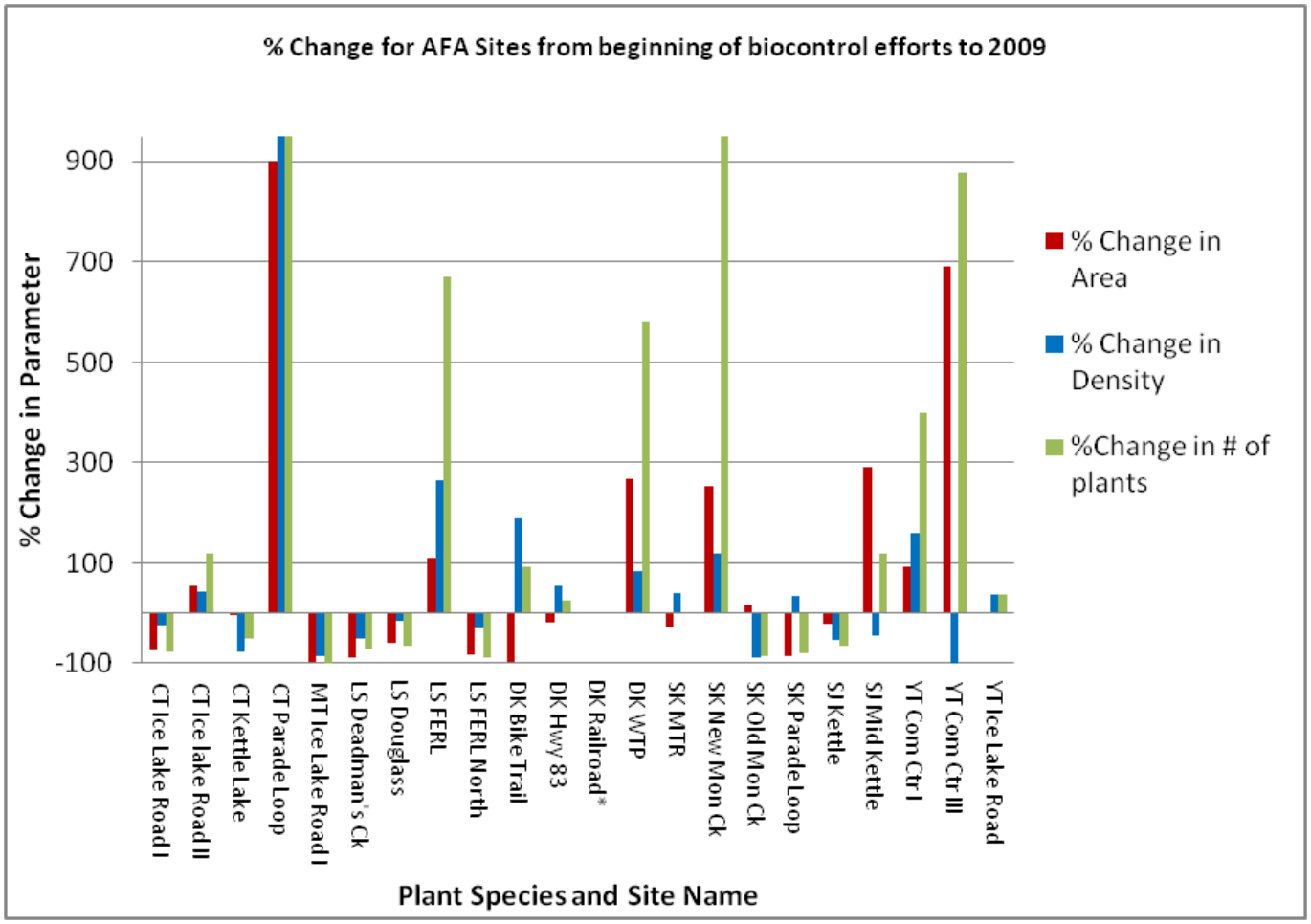


Figure 5. Percent change in area, density, and number of plants of all sites monitored this year at the Air Force Academy. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year's data by the area, density or number of plants from this year. The number of years represented vary and depend on when the sites were established.

* The DK Railroad site was new this year and therefore no changes could be calculated.

Table 11. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2009.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
AFA	Canada thistle & Musk thistle	Ice Lake Road I	*Rhinocyllus conicus*	X		
AFA	Canada thistle & Musk thistle	Ice Lake Road I	*Trichosirocalus horridus*	X		
AFA	Canada thistle & Musk thistle	Ice Lake Road I	*Cassida rubiginosa*	X[1,2]		
AFA	Canada thistle	Ice Lake Road I	*Urophora carduii*			
AFA	Canada thistle	Ice Lake Road I	*Larinus planus*			
AFA	Canada thistle	Ice Lake Road II	*Cassida rubiginosa*			
AFA	Canada thistle	Ice Lake Road II	*Larinus planus*			
AFA	Canada thistle	Ice Lake Road II	*Urophora carduii*			
AFA	Canada thistle	Kettle Lake	*Cassida rubiginosa*	X		
AFA	Canada thistle	Kettle Lake	*Ceutorynchus litura*			
AFA	Canada thistle	Kettle Lake	*Larinus planus*	X		
AFA	Canada thistle	Kettle Lake	*Rhinocyllus conicus*	X		
AFA	Canada thistle	Kettle Lake	*Urophora carduii*	X[2]		
AFA	Canada thistle	Parade Loop	*Urophora carduii*			
AFA	Field bindweed	FERL	*Aceria malherbae*			
AFA	Field bindweed	Stadium	*Aceria malherbae*	X		
AFA	Leafy spurge	Deadman's Trail	*Aphthona cyparissiae*			
AFA	Leafy spurge	Deadman's Trail	*Aphthona czwalinae*			
AFA	Leafy spurge	Deadman's Trail	*Aphthona lacertosa*			
AFA	Leafy spurge	Deadman's Trail	*Aphthona flava*	X[1,2]		
AFA	Leafy spurge	Deadman's Trail	*Aphthona nigriscutis*	X		
AFA	Leafy spurge	Douglas School	*Aphthona czwalinae*			
AFA	Leafy spurge	Douglas School	*Aphthona lacertosa*			
AFA	Leafy spurge	Douglas School	*Aphthona nigriscutis*			
AFA	Leafy spurge	FERL	*Aphthona cyparissiae*			
AFA	Leafy spurge	FERL	*Aphthona czwalinae*			
AFA	Leafy spurge	FERL	*Aphthona lacertosa*			

Table 11. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2009.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
AFA	Leafy spurge	FERL North	*Aphthona cyparissiae*			
AFA	Leafy spurge	FERL North	*Aphthona czwalinae*			
AFA	Leafy spurge	FERL North	*Aphthona lacertosa*			
AFA	Leafy spurge	FERL North	*Aphthona nigriscutis*			
AFA	Diffuse knapweed	Bike Trail	*Agapeta zoegana*	X[2]		
AFA	Diffuse knapweed	Bike Trail	*Cyphocleonus achates*	X		
AFA	Diffuse knapweed	Bike Trail	*Larinus minutus*	X		
AFA	Diffuse knapweed	Bike Trail	*Metzneria paucipunctella*	X[2]		
AFA	Diffuse knapweed	Bike Trail	*Sphenoptera jugoslavica*	X[2]		
AFA	Diffuse knapweed	Bike Trail	*Urophora affinis*	X[2]		
AFA	Diffuse knapweed	Bike Trail	*Urophora quadrifasciata*	X[2]		
AFA	Diffuse knapweed	Highway 83	*Agapeta zoegana*	X[2]		
AFA	Diffuse knapweed	Highway 83	*Cyphocleonus achates*	X		
AFA	Diffuse knapweed	Highway 83	*Larinus minutus*	X		
AFA	Diffuse knapweed	Highway 83	*Metzneria paucipunctella*	X[2]		
AFA	Diffuse knapweed	Highway 83	*Urophora affinis*	X		
AFA	Diffuse knapweed	Highway 83	*Urophora quadrifasciata*	X[2]		
AFA	Diffuse knapweed	Railroad	*Larinus minutus*	X[1]	X	X
AFA	Diffuse knapweed	Railroad	*Metzneria paucipunctella*	X[1,2]		X
AFA	Diffuse knapweed	Railroad	*Urophora affinis*	X[1,2]		X
AFA	Diffuse knapweed	Railroad	*Urophora quadrifasciata*	X[1,2]		X
AFA	Spotted knapweed	Deadman's Creek	*Agapeta zoegana*	X[2]		
AFA	Spotted knapweed	Deadman's Creek	*Cyphocleonus achates*	X[2]		
AFA	Spotted knapweed	Deadman's Creek	*Larinus minutus*	X		
AFA	Spotted knapweed	Deadman's Creek	*Metzneria paucipunctella*	X[2]		
AFA	Spotted knapweed	Deadman's Creek	*Urophora affinis*	X[2]		
AFA	Spotted knapweed	Deadman's Creek	*Urophora quadrifasciata*	X[2]		
AFA	Spotted knapweed	Monument Trail Road	*Agapeta zoegana*	X[2]		
AFA	Spotted knapweed	Monument Trail Road	*Cyphocleonus achates*	X		

Table 11. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2009.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
AFA	Spotted knapweed	Monument Trail Road	*Larinus minutus*	X		
AFA	Spotted knapweed	Monument Trail Road	*Metzneria paucipunctella*	X[2]		
AFA	Spotted knapweed	Monument Trail Road	*Sphenoptera jugoslavica*	X[2]		
AFA	Spotted knapweed	Monument Trail Road	*Urophora affinis*	X[2]		
AFA	Spotted knapweed	Monument Trail Road	*Urophora quadrifasciata*	X[2]		
AFA	Spotted knapweed	New Monument Creek	*Agapeta zoegana*	X[1,2]		
AFA	Spotted knapweed	New Monument Creek	*Cyphocleonus achates*	X[2]		
AFA	Spotted knapweed	New Monument Creek	*Larinus minutus*	X		
AFA	Spotted knapweed	New Monument Creek	*Metzneria paucipunctella*	X		
AFA	Spotted knapweed	New Monument Creek	*Sphenoptera jugoslavica*	X[2]		
AFA	Spotted knapweed	New Monument Creek	*Urophora affinis*	X[2]		
AFA	Spotted knapweed	New Monument Creek	*Urophora quadrifasciata*	X[2]		
AFA	Spotted knapweed	NPWR[3]	*Larinus minutus*			
AFA	Spotted knapweed	NPWR[3]	*Metzneria paucipunctella*			
AFA	Spotted knapweed	NPWR[3]	*Sphenoptera jugoslavica*			
AFA	Spotted knapweed	NPWR[3]	*Urophora affinis*			
AFA	Spotted knapweed	Old Monument Creek	*Agapeta zoegana*	X[2]		
AFA	Spotted knapweed	Old Monument Creek	*Cyphocleonus achates*	X		
AFA	Spotted knapweed	Old Monument Creek	*Larinus minutus*	X		
AFA	Spotted knapweed	Old Monument Creek	*Metzneria paucipunctella*			
AFA	Spotted knapweed	Old Monument Creek	*Urophora affinis*	X[2]		
AFA	Spotted knapweed	Old Monument Creek	*Urophora quadrifasciata*	X[2]		
AFA	Spotted knapweed	Parade Loop [4]	*Urophora carduii*			
AFA	Diffuse & Spotted knapweed	Water Treatment Plant	*Agapeta zoegana*	X[2]		
AFA	Diffuse & Spotted knapweed	Water Treatment Plant	*Cyphocleonus achates*	X		
AFA	Diffuse & Spotted knapweed	Water Treatment Plant	*Larinus minutus*	X		
AFA	Diffuse & Spotted knapweed	Water Treatment Plant	*Metzneria paucipunctella*	X[2]		
AFA	Diffuse & Spotted knapweed	Water Treatment Plant	*Urophora affinis*	X[2]		
AFA	Diffuse & Spotted knapweed	Water Treatment Plant	*Urophora quadrifasciata*	X[2]		

Table 11. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2009.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
AFA	St. John's wort	Kettle Creek	*Chrysolina* sp.	X		
AFA	St. John's wort	Midway Kettle Creek	*Chrysolina* sp.			
AFA	St. John's wort	Santa Fe[3]	*Chrysolina* sp.			
AFA	Yellow toadflax	Comm Center Drive I	*Mecinus janthinus*			
AFA	Yellow toadflax	Comm Center Drive II[3]	*Gymnetron antirrhini*			
AFA	Yellow toadflax	Comm Center Drive II[3]	*Mecinus janthinus*			
AFA	Yellow toadflax	Comm Center Drive III	*Gymnetron antirrhini*			
AFA	Yellow toadflax	Ice Lake Road	*Gymnetron antirrhini*			

[1] New insect recovered in 2009
[2] Adventitious recoveries, no release made at this site
[3] Site not monitored for insects this year
[4] No insect releases were made at this site, however, some or all of the following biological control agents have been recovered from seedheads and roots collected within the mapped weed perimeter since 2005: *L. minutus, U. affinis, U. quadrifasciata, M. paucipunctella, C. achates, S. jugoslavica, A. zoegana.*

Buckley Air Force Base

A total of nine sites were fully mapped in 2009, covering 4.16 hectares (10.28 acres). Three Canada thistle sites comprised the largest area (3.47 ha; 8.57 acres), a single Dalmatian toadflax site (South Aspen Way) covered 0.38 ha (0.94 acres) and five leafy spurge sites comprised 0.32 ha (0.79 acres) (Table 12). Seventeen field bindweed sites were randomly sampled for the mite *Aceria malherbae*. An additional three leafy spurge sites (North Runway I, II, and III) were randomly sampled for the *Aphthona* sp. beetles released in 2005. As usual, mapping was not conducted at the South Fence Dalmatian toadflax site as access to the site is restricted. The musk thistle Aspen site was not mapped last year because too few plants remained; however, this year the population had rebounded sufficiently to require mapping. A new leafy spurge site was established just north of the Williams Lake site and named North Fence. This site was fully mapped and sampled with one *Aphthona flava* and three *Aphthona nigriscutis* recovered this year though only releases of *Oberea erythrocephala* were made. If populations permit next summer we plan to make another release at this site with flea beetles collected from one of the other leafy spurge sites on base.

Figure 6. The new North Fence leafy spurge site located just north of Williams Lake along the eastern fence line.

Contrary to expectations, the construction at the thistle Aspen site that began last summer did not appear to negatively impact the invasive plant population. Though the population was too reduced last year to map, this year the plants rebounded and musk thistle in particular was once again abundant at the site (Figure 7). Despite the population rebound from last year, all three parameters measured over time (area, density and number of plants) have decreased since the beginning of biocontrol efforts at the site. A Canada thistle site that was partially mapped last year and given the name Mississippi Gate was not mapped this year because of construction on the site. We will continue to monitor this site over the next few years to see if the population persists after construction is completed.

In a continuing effort to control the bindweed mite infestations this year several infected runners of the gall forming mite *A. malherbae* were collected from a site at Pinon Canyon Maneuver Site in Model, CO and distributed at the playground and POV resale sites. Seventeen field bindweed sites were randomly sampled for mites, with eleven out of seventeen containing

infected runners (Table 9). Two of the sites, SAW 1 and SAW 2 were not sampled because they were destroyed. Efforts to redistribute the mite will continue in 2010 and hopefully mite populations will reach sufficient levels at the base to use the sites there as a source for infesting bindweed populations instead of collecting from other parts of Colorado and Texas.

Figure 7. The musk thistle Aspen site, recovered from last year when there were just a scattered handful of plants.

Total area of leafy spurge sites under biocontrol was about the same this year as last year (0.3 ha in 2009; 0.2 ha in 2008). No "halos" of spurge free areas were observed this summer, though sites that had releases in 2007 (Runway North) are not be expected to exhibit halos until 2011-2013. About 300 new leafy spurge biocontrol agents of the cerambycid *Oberea erythrocephala* were released at the new North Fence site on 16 July. These agents feed on the leaves and flowers of leafy spurge as adults and the larvae will tunnel into the stem and root crown where they will feed during the winter. The beetles are active fliers and are expected to disperse to other leafy spurge sites around the base. However, some populations introduced in the U. S. seem to require two years to complete their life cycle, so adult agents may not be apparent on the plants again until the summer of 2011.

Figure 8.
The leafy spurge agent,
a cerambycid called
Oberea erythrocephala

The total area of Dalmatian toadflax under biocontrol at Buckley covered 0.38 ha, almost the same area as the leafy spurge. Unfortunately for the toadflax, the stems this spring were too small to be collected to look for evidence of *Mecinus janthinus* infestations from 2008. The reduced stem size may be a result of the drier than usual summer in 2008. Hopefully the scarcity of rain accounts for the small size of the plants and this year's stems should be large enough to dissect. We plan to collect stems in the spring of 2010 to sample for the agent. No agents were recorded on the plants during the sentinel site surveys and no agents were recorded at the other two installations that have Dalmatian toadflax sites either.

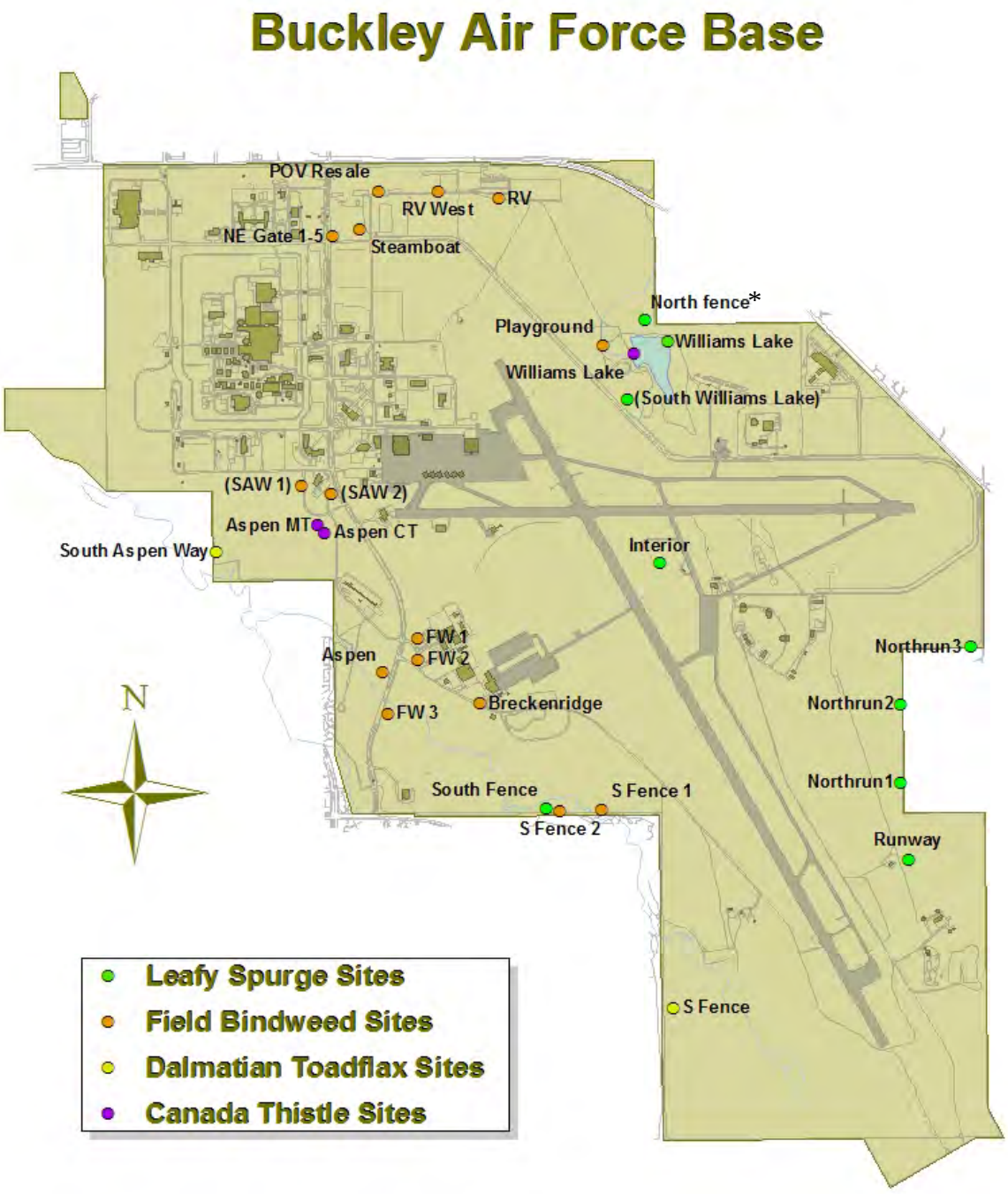


Figure 9. Schematic diagram of Buckley Air Force Base with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2009.
*new site in 2009

Table 12. Historic Noxious weed infestation parameters, Buckley Air Force Base, Colorado, 2003-2009.

Year	Area (m^2)	n	Density ($1/2m^2$) Avg.	Density ($1/2m^2$) Max	Height (cm) Avg.	Height (cm) Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Year to year % change: Area (m^2)	Year to year % change: Avg. density	Year to year % change: Avg. height	Year to year % change: # of Plants	% Change to date: Area	% Change to date: Avg. Density	% Change to date: # of plants
Canada thistle – Aspen																
2006	30,861	48	11.17	74	55.56	92	19.21	0.69	344717							
2007	36,229	44	6.52	22	84.05	127	14.03	7.76	236213	17.39	-41.63	51.28	-31.48			
2008	25,151	30	4.87	16	54.9	108	10.34	4.86	122485	-30.58	-25.31	-34.68	-48.15			
2009	21,950	20	9.30	28	80.82	120	22.35	1.65	204133	-12.73	90.97	47.21	66.66	-28.87	-16.74	-40.78
Canada thistle – Williams Lake																
2003	1,070	129	6.45	26	65.92	145	17.83	0.71	6902							
2004	1,419	66	9.52	47	51.92	98	1.4	1.8	13509	32.63	47.6	95.74	-21.24			
2005	2,004	40	5.26	18	74.31	105	18.97	0.88	10541	41.23	-44.75	-21.97	43.12			
2006	1,117	33	6.48	32	35.61	76	4.11	0.33	7238	-44.26	23.19	-31.33	-52.08			
2007	1,074	56	2.71	14	76.68	111	9.44	6.06	2911	-3.85	-58.18	-59.79	115.33			
2008	510	36	4.19	15	70.82	104	5.07	4.64	2137	-52.51	54.61	-26.58	-7.64			
2009	883	11	8.45	16	69.64	108	19	1.85	7461	73.13	101.67	1.67	249.17	-17.48	31.01	8.11
Musk thistle - Aspen																
2007	83,162	47	2.17	20	124.28	197			180462	n/a		n/a		n/a		
2008	*(see Note b)*															
2009	11834.01	30	5.30	20	108.93	197			62720	-97.79	144.24	-12.35	-65.24	-97.79	144.24	-65.24
Leafy spurge - Interior																
2005	102	28	8.07	99	39.59	57			823							
2006	111	10	1.00	4	22	34			111	8.82	-87.61	-44.43	-86.52			
2007	*(see Note a)*															
2008	218	11	1.45	10	25	30			316	96.40**	45.00**	13.64**	184.77**			
2009	167	10	9.00	18	34.89	40			1503	-23.39	521	39.56	375.48	63.73	11.52	82.59
Leafy spurge - North Fence																
2009	886	17	22.47	46	70.76	116			19900	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table 12. Historic Noxious weed infestation parameters, Buckley Air Force Base, Colorado, 2003-2009.

			Density (1/2m^2)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max				Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
									Leafy spurge - Runway							
2004	597	44	22.61	42	35.09	54			13498							
2005	751	34	29.50	95	43.92	66			22155	25.8	30.47	25.16	64.13			
2006	656	28	10.57	39	8.42	25			6934	-12.65	-64.17	-80.83	-68.70			
2007	1,037	45	28.24	169	45.94	71			29285	58.08	167.17	445.61	322.34			
2008	329	31	21.23	37	37.67	54			6985	-68.27	-24.82	-18.00	-76.15			
2009	256	10	35.40	74	58.2	70			9062	-22.19	66.75	54.50	29.75	-57.12	56.57	-32.83
									Leafy spurge – South Fence							
2006	705	28	13.07	48	42.46	76			9214							
2007	794	30	23.80	55	67.83	103			18897	12.62	82.1	59.75	105.08			
2008	708	10	15.50	30	70.6	108			10974	-10.83	18.59	66.27	-41.93			
2009	873	10	28.90	111	76.38	93			25230	23.3	86.45	8.19	129.90	23.83	121.11	173.81
									Leafy spurge – Southwest Williams Lake							
2004	530	24	8.92	26	25.13	52			4728							
2005	646	40	16.62	77	29.64	54			10737	21.89	86.32	17.95	127.10			
2006	1,039	34	7.91	32	12.02	23			8218	60.84	-52.41	-59.45	-23.45			
2007	1,066	31	24.03	167	25.77	63			25616	2.6	203.79	114.39	211.69			
2008	120	10	6.60	28	12	20			792	-88.74	-72.53	-53.43	-96.91			
2009	*(see Note)*															

Table 12. Historic Noxious weed infestation parameters, Buckley Air Force Base, Colorado, 2003-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
								Leafy spurge – Williams Lake								
2003	4,615	112	36.53	123	51.06	98			168586							
2004	3,617	77	15.01	52	39.61	73			54291	-21.63	-58.91	-22.42	-67.80			
2005	2,890	33	27.52	97	39.69	63			79533	-20.1	83.34	0.20	46.49			
2006	3,572	45	19.62	97	30.8	89			70083	23.6	-28.71	-22.40	-11.88			
2007	6,386	56	28.82	182	48.92	77			184045	78.78	46.89	58.83	162.61			
2008	627	19	4.68	26	43.08	68			2934	-86.41	-83.76	-11.94	-98.41			
2009	989	11	10.64	20	51.45	66			10523	57.73	127.35	19.43	258.61	-78.57	-70.87	-93.76
								Dalmatian toadflax – South Aspen Way								
2003	3,185															
2004	300	20	0.95	7	11.4	38			285	-99.08						
2005	275	28	12.00	61	39.47	59	10.61		3300	-8.33	1163.16	246.23	1057.89			
2006	1,328	29	2.76	18	14.43	28			3665	382.91	-77	-63.44	11.07			
2007	5,044	47	4.19	35	64.97	98			21134	279.82	51.81	350.24	476.61			
2008	4,735	40	3.89	14	37.68	60			18419	-6.13	-7.16	-42.00	-12.85			
2009	3,808	23	2.78	14	47.91	104			10586	-19.58	-28.53	27.15	-42.53	19.56	192.63	3614.47
								Dalmatian toadflax – South Fence								
2003	32,556	374	3.50	78	36.1	128			113946							
2004	20,657	101	3.31	18	29.28	82			68375	-36.55	-5.43	-18.89	-39.99			
2005	20,443	68	18.70	56	56.76	78	20.71		382284	-1.04	464.95	93.85	459.10			
2006	35,786	35	3.03	15	33.03	57	10.55		108432	75.05	-83.8	-41.81	-71.64	9.92	-13.43	-4.84
2007	*(see Note b)*															
2008	*(see Note b)*															
2009	*(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

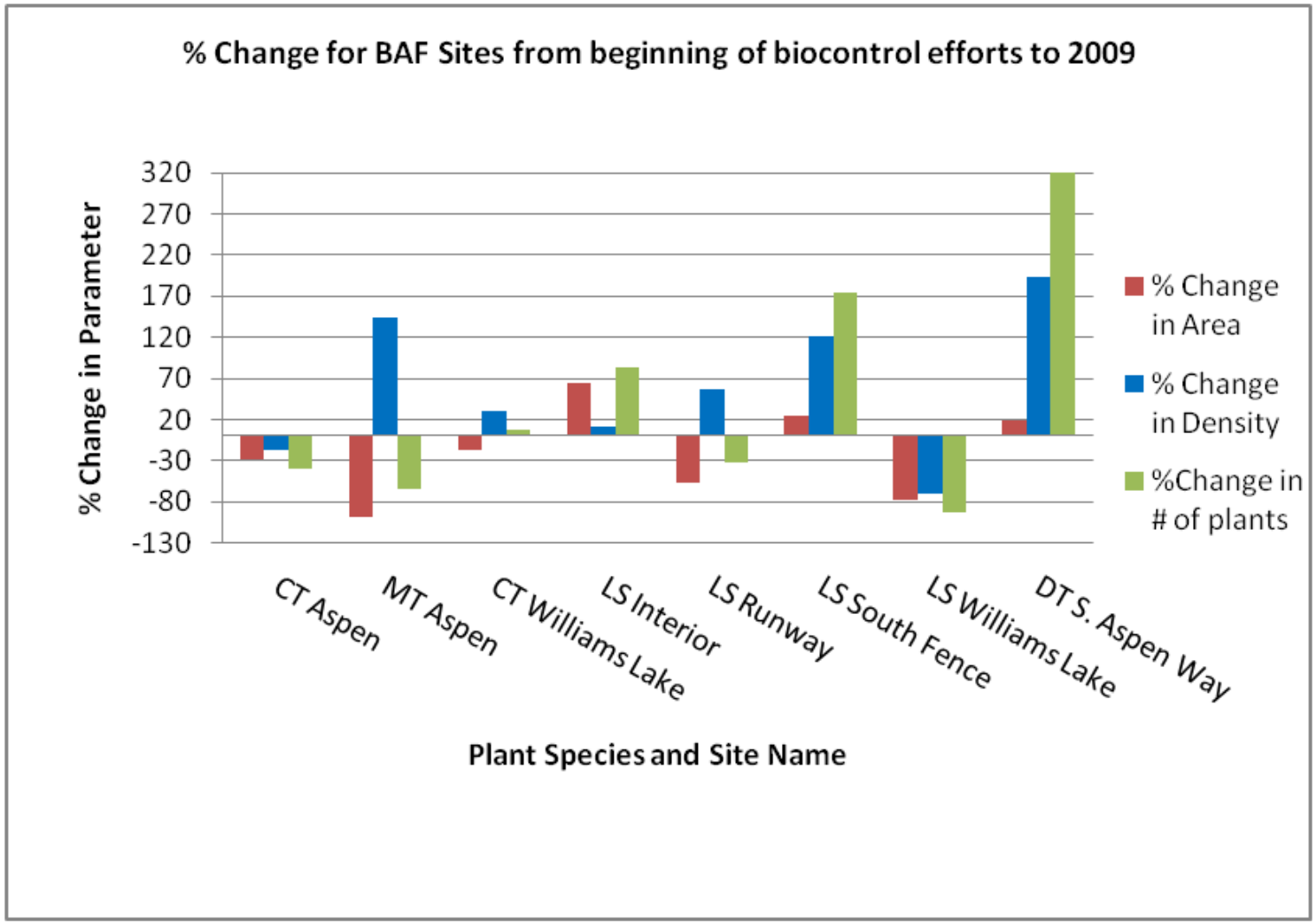


Figure 10. Percent change in area and density of all sites monitored this year at Buckley Air Force Base. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year's data by the area or density from this year. The number of years represented vary and depend on when the sites were established.

Table 13. Noxious weed biological control sites, target weeds, species released and recoveries at Buckley Air Force Base, Colorado, 2009.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
BAF	Canada thistle	Aspen	*Aceria anthocoptes*			
BAF	Canada thistle	Aspen	*Trichosirocalus horridus*	X		
BAF	Canada thistle	Williams Lake	*Cassida rubiginosa*	X		
BAF	Canada thistle	Williams Lake	*Rhinocyllus conicus*			
BAF	Canada thistle	Williams Lake	*Trichosirocalus horridus*			
BAF	Canada thistle	Williams Lake	*Urophora carduii*			
BAF	Musk thistle	Aspen[3]	*Cassida rubiginosa*			
BAF	Musk thistle	Aspen[3]	*Rhinocyllus conicus*			
BAF	Musk thistle	Aspen[3]	*Trichosirocalus horridus*			
BAF	Field bindweed	Multiple Sites	*Aceria malherbae*	X		
BAF	Leafy spurge	Interior	*Aphthona flava*			
BAF	Leafy spurge	Interior	*Aphthona nigriscutis*			
BAF	Leafy spurge	Runway North	*Aphthona cyparissiae*			
BAF	Leafy spurge	Runway North	*Aphthona czwalinae*			
BAF	Leafy spurge	Runway North	*Aphthona flava*			
BAF	Leafy spurge	Runway North	*Aphthona nigriscutis*			
BAF	Leafy spurge	Runway	*Aphthona cyparissiae*			
BAF	Leafy spurge	Runway	*Aphthona flava*	X		
BAF	Leafy spurge	Runway	*Aphthona lacertosa*			
BAF	Leafy spurge	Runway	*Aphthona nigriscutis*	X		
BAF	Leafy spurge	North Fence	*Oberea erythrocephala*		X	X
BAF	Leafy spurge	South Fence	*Aphthona cyparissiae*			
BAF	Leafy spurge	South Fence	*Aphthona czwalinae*			
BAF	Leafy spurge	South Fence	*Aphthona flava*			
BAF	Leafy spurge	South Fence	*Aphthona lacertosa*			
BAF	Leafy spurge	South Fence	*Aphthona nigriscutis*			
BAF	Leafy spurge	Williams Lake	*Aphthona cyparissiae*			
BAF	Leafy spurge	Williams Lake	*Aphthona czwalinae*			

Table 13. Noxious weed biological control sites, target weeds, species released and recoveries at Buckley Air Force Base, Colorado, 2009.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
BAF	Leafy spurge	Williams Lake	*Aphthona flava*			
BAF	Leafy spurge	Williams Lake	*Aphthona lacertosa*			
BAF	Leafy spurge	Williams Lake	*Aphthona nigriscutis*			
BAF	Leafy spurge	Williams Lake	*Spurgia esula*			
BAF	Leafy spurge	Southwest Williams Lake	*Aphthona cyparissiae*			
BAF	Leafy spurge	Southwest Williams Lake	*Aphthona czwalinae*			
BAF	Leafy spurge	Southwest Williams Lake	*Aphthona flava*			
BAF	Leafy spurge	Southwest Williams Lake	*Aphthona lacertosa*			
BAF	Leafy spurge	Southwest Williams Lake	*Aphthona nigriscutis*			
BAF	Dalmatian toadflax	South Aspen Way	*Mecinus janthinus*			
BAF	Dalmatian toadflax	South Fence[3]	*Mecinus janthinus*			

[1] Adventitious recovery, none released at this site
[2] New insect recovered in 2009
[3] Site not mapped this year

Fort Carson Military Post

Eleven biocontrol sites were fully mapped at Fort Carson this summer, covering a total of 46.18 ha (114.12 acres). Seven Canada and musk thistle sites covered 43.66 ha (107.89 acres) and five sites consisted of diffuse and spotted knapweed covering 2.52 ha (6.23 acres) (Table 3). Two sites (CT ARA I and SK Fuel) were not monitored this year because the remaining plants were too few and/or scattered to map. One new diffuse knapweed site (Route 1) was established this year and biocontrol agents were released. Twelve of the 34 established field bindweed sites were randomly sampled for the presence of the mite *Aceria malherbae.*

Efforts last summer to establish larger plots of infested bindweed sites did not appear to have been successful. Of the twelve bindweed sites sampled only two showed evidence of infestation by *A. malherbae* (ARA1 and ARA 2b Table 8). Seventeen of the 34 field bindweed sites were not sampled because either the sites had been covered in sod or access to the site was restricted. We will continue to transfer infested runners to bindweed sites at Fort Carson as they become available throughout the summer and make efforts to coordinate mowing with infestation as mowing increases mite establishment.

Figure 11. Photos of the ARA II site. Left to right from top left; photopoint from 2008; just after the fire in March 2009; the site recovering after rain in April (inset: rosettes of thistles already popping up); the site fully recovered from the fire, complete with Canada thistle heads.

The ARA II thistle site was again the largest site this year, taking up 39.59 ha, an increase from 22.8 ha last year. The site was also subject to a wildfire in March (Figure 11) which may have allowed for easier re-colonization by invasive weeds instead of native vegetation. The Canada thistle ARA I site was also affected by the wildfire but was not mapped this year because there were not enough thistle plants to map. Of the seven mapped thistle sites, three (Duckpond, CT Hwy 115 and CT Reservoir) have declined in area, density and number of plants. Three thistle sites; CT ARAII, MT Hwy 115, and MT Reservoir, increased in area and number of plants decreased in density. Only MT Wildlife increased in density but decreased in area and number of plants.

Figure 11. The new diffuse knapweed site named Route 1, located south of the saltcedar site.

Knapweed sites make up the second largest group of invasive plants under biocontrol at Fort Carson. Only the diffuse knapweed site (Gun Club) had an overall increase in area, density and number of plants since beginning biocontrol efforts. The remaining three knapweed sites (Fuel, Hazmat, and Turkey Creek) all have declined in those measured parameters since beginning biocontrol efforts. This year we were able to collect seedheads and roots from three sites and found evidence of each biocontrol insect (*L. minutus, U. affinis, U. quadrifasciata, M. paucipunctella, C. achates, A. zoegana, S. jugoslavica*) at each of the sites. A new diffuse knapweed site named Route 1 was established this summer and on August 6, 105 *C. achates* and 145 *Larinus obtusus* were released. Next fall we will collect roots and seedheads for dissections to check for the presences of other biocontrol agents. The results of these dissections will be a good indication of how well our agents are dispersing on their own, especially since the Route 1 site is the furthest away from other established knapweed sites. An additional release of *C. achates* and *L. minutus* was made on August 6 by USFWS employee Chris Caris at an unmapped site south of the Turkey Creek site named Little Turkey Ck. Three hundred insects of each species were released and the site will be checked next summer to see if there has been any establishment and to assess the site to see if mapping is appropriate.

Figure 12. Tracy Perfors and Chelsea Chen collect *D. elongata* beetles at the Beaver Creek site in Pueblo, CO to release on saltcedar in Texas (Left). Beetles from this site will hopefully be released at Fort Carson next summer. A masticating Bobcat (right) digs up saltcedar on Fort Carson, another non-chemical method of weed control.

Plans for next year include establishing more biocontrol sites, especially sites of weeds that we are usually able to get biocontrol agents for (knapweed, bindweed). We also plan to make more releases of *Diorhabda elongata* beetles on the Section 36 saltcedar site if they are available. A saltcedar site in Pueblo, CO was used this summer as a source for beetle releases in Texas and we will check back there next year to see if beetles can be released at the site in Section 36.

Figure 13. Schematic diagram of Fort Carson Military Post with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2009.
*new site in 2009

Table 14. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							Canada thistle – ARA I									
2003	6,284	63	6.48	24	61.21	125	1.28	0.07	40720							
2004	13,845	64	13.20	38	50.14	98	1.48	2.5	182754	120.33	103.7	-18.09	348.80			
2005	270,294	31	9.23	24	69.41	105	20.17	0.66	2494814	1852.29	-30.08	38.43	1265.12			
2006	371,111	34	10.09	36	59.86	111	11.86	0.6	3744510	37.3	9.32	-13.76	50.09			
2007	241,585	54	9.06	24	59.5	105	9.69	5.75	2188760	-34.9	-10.21	-0.60	-41.55	3744.45	39.81	5275.11
2008	*(see Note b)*															
2009	*(see Note b)*															
							Canada thistle – ARA II									
1997		23	25.55	42												
1998																
1999		40			62.33	95										
2000	37,062	166	13.96	58	45.87	91			517386			-26.41				
2001	37,061	299	12.94	64	52.98	122	18.95	0.57	479569	0	-7.31	15.50	-7.31			
2002	38,002	386	4.95	40	12.89	84	8.54	0.12	188110	2.54	-61.75	-75.67	-60.78			
2003	14,708	161	0.78	9	12.19	74	1.13	0.15	11472	-61.3	-84.24	-5.43	-93.90			
2004	4,919	75	2.53	19	10.83	37	0.24	0.26	12445	-66.56	224.36	-11.16	8.48			
2005	10,528	34	3.59	14	42.79	62	10.58	0.74	37796	114.03	41.9	295.11	203.70			
2006	22,882	32	1.91	11	29.68	64	6.42	0.71	43705	117.34	-46.8	-30.64	15.63			
2007	*(see Note a)*															
2008	228,744	31	7.03	29	50.7	91	6.74	5.17	1608070	899.67**	2.68**	70.82**	3579.41			
2009	395,877	40	10.23	57	54.25	111	9.47	1.21	4049822	73.07	45.52	7.00	151.84	968.15	-59.96	682.75

Table 14. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							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			268592			8.38				
2001	39,409	26	16.23	70	66.73	136	18.12		639608	36.9	73.95	-13.07	138.13			
2002	38,916	196	7.74	56	21.3	124	11.33	0.23	301210	-1.25	-52.31	-68.08	-52.91			
2003	29,486	147	5.25	29	38.9	143	3.08	0.22	154802	-24.23	-32.17	82.63	-48.61			
2004	20,724	65	14.17	116	26.03	90	1.18	0.62	293659	-29.72	169.9	-33.08	89.70			
2005	21,130	35	9.43	28	61.46	115	25.61	0.74	199256	1.96	-33.45	136.11	-32.15			
2006	17,902	30	8.03	32	47.52	80	20.67	0.72	143753	245.33	-4.97	3.19	-27.86			
2007	6,411	54	11.26	112	92	184	21.02	6.39	72188	-64.19	40.22	93.60	-49.78			
2008	4,992	14	13.36	23	76.14	127	18.5	6.79	66693	-22.13	15.72	-17.24	-7.61			
2009	13,788	40	9.03	28	77.56	133	31.62	1.15	124506	176.2	-32.41	1.86	86.68	-50.35	-74.20	-53.65
							Canada thistle – HWY 115									
2000	1,445	82	12.47	40	53.49	80			18019							
2001	4,239	54	10.22	48	57.87	147	14.51	0.64	43323	193.36	-18.04	8.88	140.43			
2002	1,114	70	1.58	14	7.24	24	2.25	0.06	1760	-73.72	-84.54	-87.49	-95.94			
2003																
2004	1,287	69	6.29	23	38.33	96	7.95	0.47	8095	15.53**	298.10**	429.62**	359.92**			
2005	*(see Note a)*															
2006	91	10	3.70	8	30.25	71	2.75	0.21	337	-92.93**	-41.18**	-21.08**	-95.84**			
2007	965	21	4.43	16	81.47	114	15.37	4.84	4275	960.44	19.73	169.32	1169.66			
2008	*(see Note b)*															
2009	888	10	7.50	13	89.9	120	30.5	1.41	6660	-7.98	69.3**	00.13**	55.79**	-38.55	-39.86	-63.04

Table 14. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							Musk thistle – HWY 115									
2000	1,445	8	7.13	22					10303							
2001	5,082	30	4.00	14	64.3	121	6.53	2.18	20328	251.7	-43.9		97.30			
2002	827	53	2.13	13	6.26	35	0.63	0.43	1762	-83.73	-46.75	-90.26	-91.33			
2003	1,263	61	0.62	5	17.64	127	0.68		783	52.72	-70.89	181.79	-55.55			
2004	9,918	55	1.85	25	24.88	100	3.47	0.97	18348	685.27	198.39	41.04	2243.15			
2005	735	44	1.05	7	42.31	90	1.56	1.51	772	-92.59	-43.24	70.06	-95.79			
2006	*(see Note a)*															
2007	2,101	29	0.69	3	110.65	188	7.23	3.08	1450	185.85**	-34.29**	161.52**	87.84**			
2008	*(see Note b)*															
2009	8748	42	2.90	16	93.67	137	5.33	4.98	25411	316.37	320.29	-15.35	1652.86	505.40	-59.33	146.64
							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		68998							
2002	5,268	101	8.16	32	24.26	65	6.36	0.3	42987	-44.64	12.55	-38.63	-37.70			
2003	3,635	165	6.09	38	41.48	123	6.02	0.38	22137	-31	-25.37	70.98	-48.50			
2004	4,549	68	6.13	28	23.22	57	0.52	0.74	27885	25.13	0.66	-44.02	25.97			
2005	5,184	40	8.45	27	46.05	86	15.06	0.61	43805	13.96	37.85	98.32	57.09			
2006	2,251	35	6.71	24	20.2	39	2.34	0.33	15104	-56.58	-20.59	-56.13	-65.52			
2007	*(see Note b)*															
2008	2,057	14	3.86	16	32.38	49	4.63	4.25	7940	-8.62**	-42.47**	60.30**	-47.43**			
2009	5,290	34	9.79	36	65.25	108	17.5	1.21	51789	157.17	153.63	101.51	552.25	-44.42	-91.65	-24.94

Table 14. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							Musk thistle – Reservoir									
2001	154	10	5.40	14	56.1	84	6.09	4.54	54							
2002	*(see Note a)*															
2003	*(see Note a)*															
2004	*(see Note a)*															
2005	*(see Note a)*															
2006	*(see Note a)*															
2007	1,450	22	0.59	3	81.9	114	2.29	3.33	13	841.56**	-89.07**	45.99**				
2008	*(see Note a)*															
2009	12,617	93	1.80	19	77.7	248	5.08	4.12	167	770.14**	205.08**	-5.13**	118.46**	809.29**	-66.67**	209.26**
							Musk thistle – Wildlife									
1999		59			110.92	175	7.53									
2000	5,035	114	1.76	14	43.14	138			8862							
2001	2,844	68	3.84	21	72.22	174	6.07		10921	-43.52	118.18	67.41	23.24			
2002	1,838	61	2.82	36	8.65	57	8.18	0.22	5183	-35.39	-26.56	-88.02	-52.54			
2003	10,219	77	0.27	3	14.39	124	1.17		2759	456.14	-90.43	66.36	-46.77			
2004	6,777	46	1.23	7	27.46	173	3.5	7.13	8336	-33.68	355.56	90.83	202.11			
2005	3,453	36	1.37	9	98.31	187	8.69	2.75	4731	-49.05	11.38	258.01	-43.25			
2006	390	30	2.73	9	58.77	105	3.42	1.98	1065	-88.71	99.27	-40.22	-77.49			
2007	23,861	44	0.80	6	93.58	147	4.25	3.51	19089	6018.21	-70.7	59.23	1692.88			
2008	1,252	44	1.77	10	37.25	108	4	12.94	2216	-94.75	121.25	-60.19	-88.39			
2009	284	10	2.60	5	101.88	168	8.13	4.09	738	-77.32	46.89	173.50	-66.69	-94.36	47.73	-91.67

Table 14. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							Diffuse knapweed – Gun Club									
2004	14,941	46	1.59	8	21.87	65	36.04	1.43	23756							
2005	9,685	35	3.40	22	41.36	57	42.48	0.45	32929	-35.18	113.84	89.12	38.61			
2006	20,781	30	2.60	12	24.47	40	39.87	0.41	54031	114.57	-23.53	-40.84	64.08			
2007	24,806	41	3.51	6	57.37	88	108.17	4.37	87069	19.37	35	134.45	61.15			
2008	1,978	66	1.47	8	31.56	60	48.09	4.22	2908	-86.76	-58.12	-44.99	-96.66			
2009	23,337	20	9.95	28	33.16	67	253	0.29	232203	1079.83	576.87	5.07	7885.91	56.19	525.79	877.44
							Diffuse knapweed - Route 1									
2009	69	9	1.56	4	74.14	103	1299.71	0.53	108	n/a	n/a	n/a	n/a	n/a	n/a	n/a
							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			34623			-34.86				
2001	2,869	113	55.19	564	55.88	104	134.48	1.88	158340	38.46	230.28	19.68	357.32			
2002	2,375	155	6.04	36	20.56	72	45.6	0.34	14345	-17.22	-89.06	-63.21	-90.94			
2003	2,093	92	5.98	35	64.35	150	52.26	1.92	12516	-11.87	-0.99	212.99	-12.75			
2004	6,830	42	4.64	21	46.64	100	9.39	5	31691	226.41	-22.41	-27.52	153.20			
2005	2,567	41	5.16	26	42.52	74	13.25	0.52	13246	-62.42	11.21	-8.83	-58.20			
2006	9,913	37	4.70	21	31.5	91	12.72	0.42	46591	286.17	-8.91	-25.92	251.74			
2007	1,984	33	3.27	9	70.37	126	42.15	2.23	6488	-79.99	-30.43	123.40	-86.08			
2008	1,692	10	6.60	34	17.38	34	6.75	3.5	11167	-14.72	6	-75.30	72.13	-18.34	-88.06	-67.75
2009	*(see Note a)*															

Table 14. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
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		89189			-46.57				
2001	9,094	143	20.66	140	60.48	100	72.35		187882	7.47	96.02	41.11	110.65			
2002	3,429	92	12.24	58	22.69	81	31.16	0.35	41971	-62.3	-40.46	-62.48	-77.66			
2003	5,254	160	5.26	70	57.42	140	64.85	0.67	27636	53.23	-57.03	153.06	-34.15			
2004	5,779	57	5.37	18	43.07	97	9.41	4.62	31033	10	2.09	-24.99	12.29			
2005	990	50	12.48	53	52.12	90	20.32	0.58	12355	-82.87	132.4	21.01	-60.19			
2006	15,458	33	6.24	29	27.68	65	8.57	0.32	96458	1461.41	-50	46.89	680.71			
2007	27,783	41	7.46	76	63.52	113	39.2	5.07	207261	79.73	19.55	129.48	114.87			
2008	*(see Note b)*															
2009	186	10	7.20	18	61.89	85	86	0.77	1339	-99.33**	-3.49**	-2.57**	-99.35**	-97.80	-85.32	-98.50

Table 14. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							Spotted knapweed – Turkey Creek									
1997		22	16.00	18												
1998																
1999	11,818	25	12.72	20	109.67	132	19.36		150325		-20.5					
2000	16,848	285	17.05	68	59.57	101			287258	42.56	34.04	-45.68	91.09			
2001	30,681	375	8.83	65	54.66	125	44.3		270913	82.1	48.21	-8.24	-5.69			
2002	1,314	79	2.24	27	10.99	73	13.51	0.27	2943	-95.72	-74.63	-79.89	-98.91			
2003	328	48	5.33	43	46.83	118		0.34	1748	-75.01	137.95	326.11	-40.60			
2004	13,218	73	1.42	10	42.76	101	42.94		18770	3929.79	-73.36	-8.69	973.63			
2005	5,937	40	1.70	15	52.47	89	17.67	0.43	10093	-55.08	19.72	22.71	-46.23			
2006	2,711	34	1.26	10	30.67	46	15.93	0.6	3416	-54.34	-25.88	-41.55	-66.16			
2007	29,455	45	2.64	14	87.4	148	58.83	1.21	77761	986.5	109.52	184.97	2176.48			
2008	6,486	47	9.96	39	34.71	57	9.97	5.18	64601	-77.98	2.77	-60.29	-16.92			
2009	1,602	29	1.93	8	70.61	107	53.5	0.69	3092	-75.3	-80.62	103.43	-95.21	-86.44	-87.94	-97.94

n – number of samples or observations

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

Note: Could not map a perimeter, as: a) the few remaining plants at this site were scattered, or b) the site was inaccessible

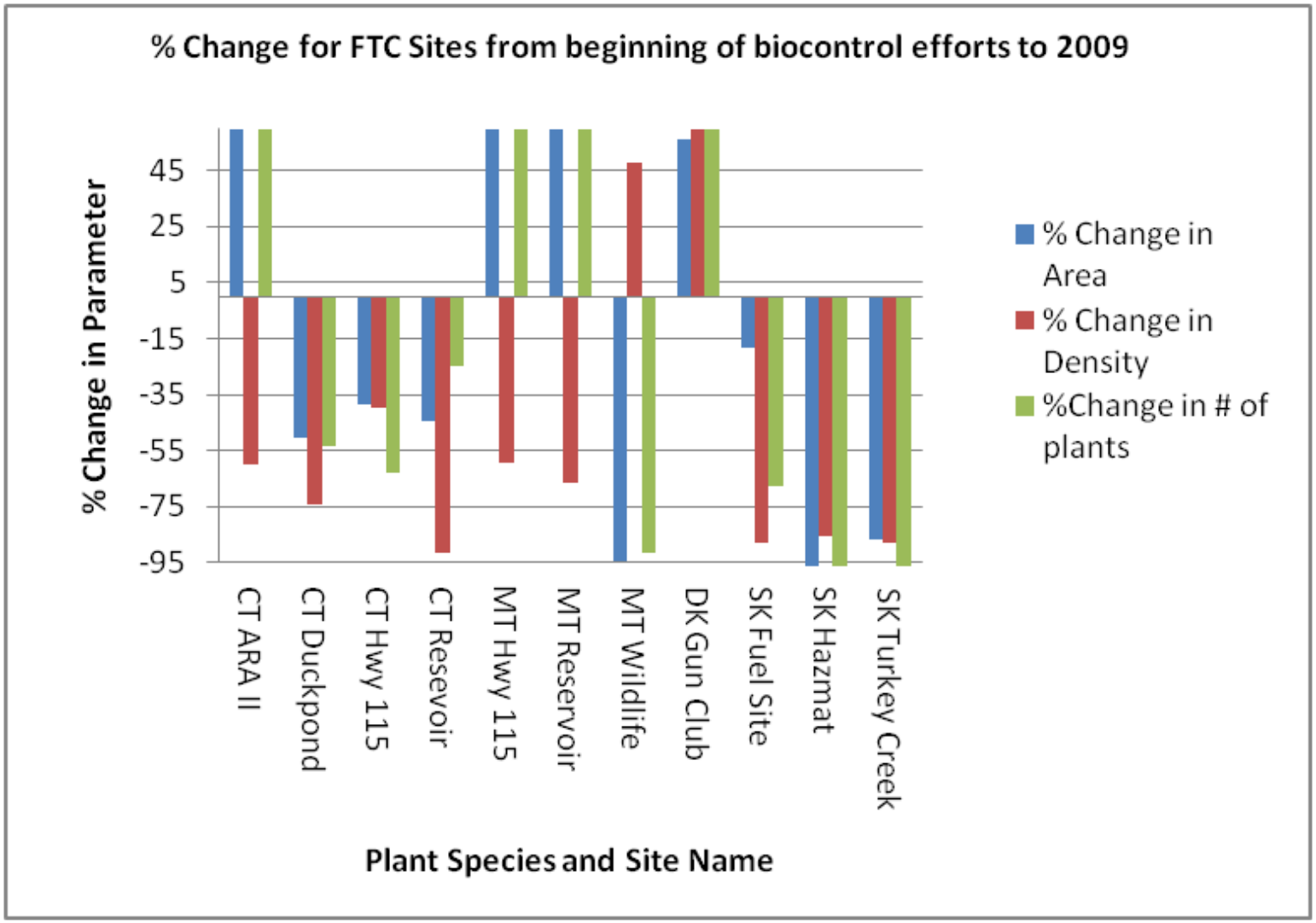


Figure 14. Percent change in area and density of all sites monitored this year at Fort Carson. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year's data by the area or density from this year. The number of years represented vary and depend on when the sites were established.

Table 15. Noxious weed biological control sites, target weeds, species released and recoveries at Fort Carson Military Post, 2008.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
FTC	Canada thistle	ARA I[3]	*Cassida rubiginosa*			
FTC	Canada thistle	ARA I[3]	*Ceutorynchus litura*			
FTC	Canada thistle	ARA I[3]	*Larinus planus*			
FTC	Canada thistle	ARA I[3]	*Trichosirocalus horridus*			
FTC	Canada thistle	ARA I[3]	*Urophora carduii*			
FTC	Canada thistle	ARA II	*Cassida rubiginosa*			
FTC	Canada thistle	ARA II	*Ceutorynchus litura*			
FTC	Canada thistle	ARA II	*Rhinocyllus conicus*			
FTC	Canada thistle	Duckpond	*Cassida rubiginosa*			
FTC	Canada thistle	Duckpond	*Ceutorynchus litura*			
FTC	Canada thistle	Duckpond	*Larinus planus*			
FTC	Canada thistle	Duckpond	*Urophora carduii*			
FTC	Canada thistle & Musk thistle	Highway 115[3]	*Trichosirocalus horridus*			
FTC	Canada thistle & Musk thistle	Highway 115[3]	*Urophora carduii*			
FTC	Canada thistle & Musk thistle	Reservoir	*Cassida rubiginosa*			
FTC	Canada thistle & Musk thistle	Reservoir	*Ceutorynchus litura*			
FTC	Canada thistle & Musk thistle	Reservoir	*Larinus planus*			
FTC	Canada thistle & Musk thistle	Reservoir	*Urophora carduii*			
FTC	Canada thistle & Musk thistle	Wildlife Refuge	*Rhinocyllus conicus*			
FTC	Canada thistle & Musk thistle	Wildlife Refuge	*Trichosirocalus horridus*			
FTC	Diffuse knapweed	Gun Club	*Agapeta zoegana*			
FTC	Diffuse knapweed	Gun Club	*Cyphocleonus achates*			
FTC	Diffuse knapweed	Gun Club	*Larinus minutus*	X		
FTC	Diffuse knapweed	Gun Club	*Metzneria paucipunctella*			
FTC	Diffuse knapweed	Gun Club	*Sphenoptera jugoslavica*			
FTC	Diffuse knapweed	Gun Club	*Urophora affinis*			
FTC	Diffuse knapweed	Gun Club	*Urophora quadrifasciata*			
FTC	Diffuse knapweed	Route 1	*Cyphocleonus achates*		X	X
FTC	Diffuse knapweed	Route 1	*Larinus obtusus*		X	X

Table 15. Noxious weed biological control sites, target weeds, species released and recoveries at Fort Carson Military Post, 2008.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
FTC	Field bindweed	Multiple sites	*Aceria malherbae*	X		
FTC	Spotted knapweed	Fuel Site	*Agapeta zoegana*			
FTC	Spotted knapweed	Fuel Site	*Bangasternus fausti*			
FTC	Spotted knapweed	Fuel Site	*Cyphocleonus achates*			
FTC	Spotted knapweed	Fuel Site	*Larinus minutus*			
FTC	Spotted knapweed	Fuel Site	*Larinus obtusus*			
FTC	Spotted knapweed	Fuel Site	*Metzneria paucipunctella*			
FTC	Spotted knapweed	Fuel Site	*Sphenoptera jugoslavica*			
FTC	Spotted knapweed	Fuel Site	*Urophora affinis*			
FTC	Spotted knapweed	HazMat[3]	*Agapeta zoegana*			
FTC	Spotted knapweed	HazMat[3]	*Bangasternus fausti*			
FTC	Spotted knapweed	HazMat[3]	*Cyphocleonus achates*			
FTC	Spotted knapweed	HazMat[3]	*Larinus minutus*			
FTC	Spotted knapweed	HazMat[3]	*Larinus obtusus*			
FTC	Spotted knapweed	HazMat[3]	*Metzneria paucipunctella*			
FTC	Spotted knapweed	HazMat[3]	*Sphenoptera jugoslavica*			
FTC	Spotted knapweed	HazMat[3]	*Urophora affinis*			
FTC	Spotted knapweed	Turkey Creek	*Agapeta zoegana*			
FTC	Spotted knapweed	Turkey Creek	*Cyphocleonus achates*			
FTC	Spotted knapweed	Turkey Creek	*Larinus minutus*			
FTC	Spotted knapweed	Turkey Creek	*Metzneria paucipunctella*			
FTC	Spotted knapweed	Turkey Creek	*Sphenoptera jugoslavica*	X		
FTC	Spotted knapweed	Turkey Creek	*Urophora affinis*			
FTC	Saltcedar	Section 36	*Diorhabda elongata*	X		

[1] New insect recovered in 2009 [2] Adventitious recoveries, no release made at this site [3] Site not monitored for insects this year

Rocky Flats National Wildlife Refuge

Six biocontrol sites were monitored at Rocky Flats National Wildlife Refuge this year. Two sites were fully mapped for both perimeter and point data. One, a single Canada thistle site (Lindsay Ranch) accounted for 15% of the area under biocontrol covering 0.58 ha (1.45 acres). The remaining 85% of the area under biocontrol was covered by the Dalmatian toadflax Weather site at 3.35 ha (8.28 acres). At the North Buffer knapweed site 108 quadrats were sampled for plant density, height, seedhead number and size and 74 quadrats were sampled at the Dalmatian toadflax South Fence site. The Dalmatian toadflax Original Site was not monitored again this year because too few plants were left to map. Two field bindweed sites (Sites 8 and 9) were monitored for the presence of the bindweed mite *Aceria malherbae* which was present at both sites.

The percent change in area, density and number of plants since the beginning of biocontrol efforts was mixed for the four sites monitored this year (Figure 16). On the whole, these parameters have increased since beginning biocontrol efforts except for density at the Lindsay Ranch, South Fence and North Buffer sites. The Dalmatian toadflax South Fence and diffuse knapweed North Buffer sites are surveyed as transects and therefore have no measurements for area or estimates on the number of plants.

Figure 15. (Left) A dense stand of Canada thistle at the Lindsay Ranch site. (Below) Thistle feeder *Cassida rubiginosa*.

Only the Lindsay Ranch thistle site had insects (*Cassida rubiginosa*) present during the full survey, and only two individuals were found (Figure 15). This is a decline from last year when 216 *C. rubiginosa* were detected during a single survey period. There are a few explanations that may account for this difference. One is that since 2009 was a wetter year and the skies were frequently overcast the beetles hid or fell off the plant and were missed during the counts. It is also possible that we did not conduct the surveys during the peak of the insect emergence, either missing their peak or sampling too soon. Just as in 2008, two other insects (*Larinus planus* and *Rhinocyllus conicus*) which were not released by Texas AgriLife Research at Rocky Flats were noted again this year during the sentinel site surveys.

Though not detected during the field surveys all of the knapweed biocontrol agents were found at the North Buffer knapweed sites after seedheads and roots were dissected (Tables 4 and 5). Collections were made in early October and dissections carried out in Bushland, TX in October/November. We were unable to collect stems of Dalmatian toadflax this spring as

planned because the plants were too small. We plan to make a collection of stems in the spring of 2010 to look for the presence of *Mecinus janthinus.*

Only two field bindweed sites were monitored for the presence of the bindweed mite *Aceria malherbae*, though mite damage was evident at both sites (Table 9). We had planned to make more releases of infested runners at various sites around the installation this summer but we did not get the opportunity due to a shortage of mites to distribute. We do intend to make more releases next summer if we are able to collect mites from some of our nurseries.

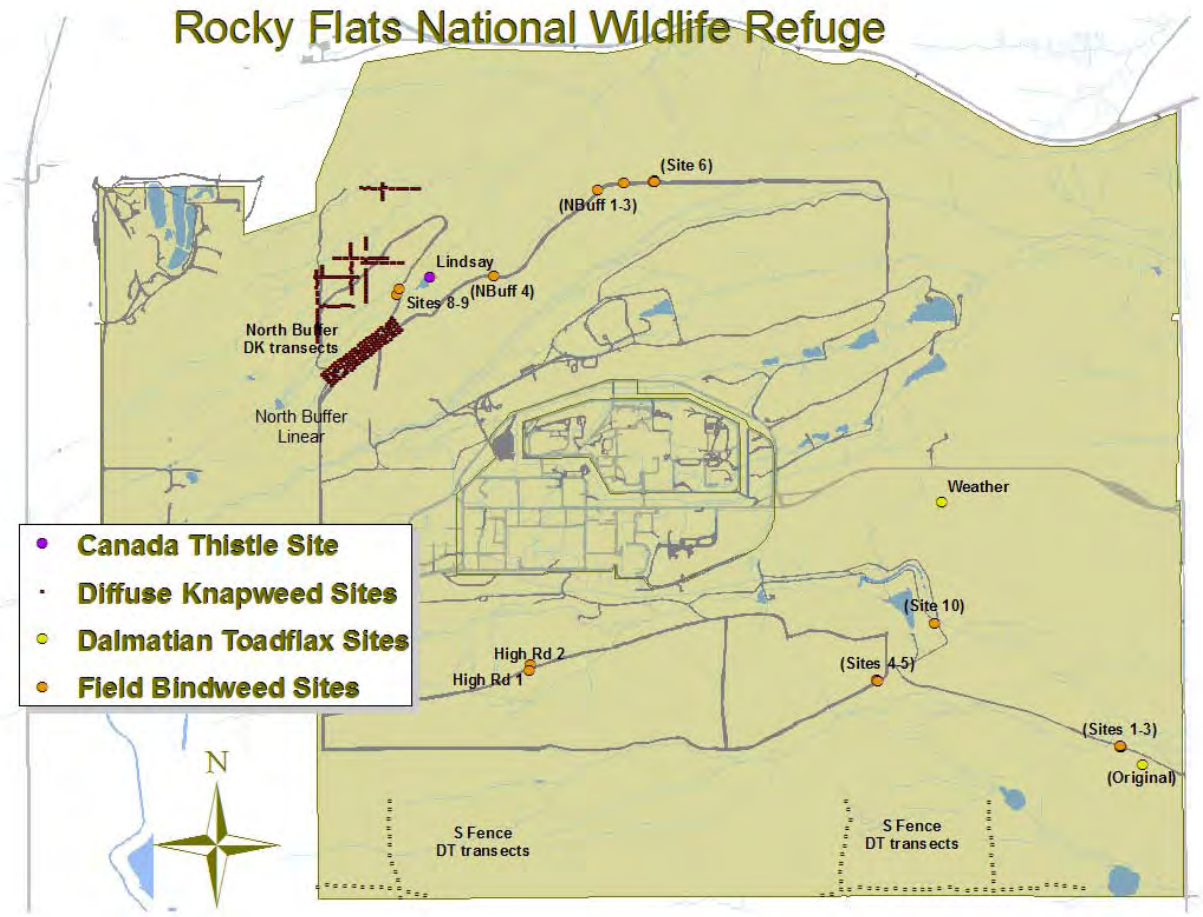


Figure 16: Schematic diagram of Rocky Flats National Wildlife Refuge with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2009.

Table 16. Historic noxious weed infestation parameters, Rocky Flats National Wildlife Refuge, Golden, Colorado, 2001-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							Canada thistle – Lindsay Ranch									
2004	692	43	7.84	34	56.05	104	1.64	0.3	5,425							
2005	2,205	30	5.93	16	94.23	165	18.14	0.72	13,076	218.64	-24.36	68.12	141.01			
2006	5,617	47	5.89	19	46.07	100	9.28	0.51	33,084	154.74	-0.67	-51.11	153.02			
2007	2,560	36	4.53	45	58.45	98	8.09	5.68	11,597	-54.42	-23.09	26.87	-64.95			
2008	6,355	75	4.15	18	46.97	86	5.97	3.27	26,373	148.24	-8.39	-19.64	127.42			
2009	5,877	10	5.90	20	80.9	128	15.2	0.75	34,674	-7.52	42.17	72.24	31.48	749.28	-24.74	539.15
							Dalmatian toadflax – Original Site									
2001	1,688	48	22.43	64	52.94	84			37,862							
2002	7,913	93	3.81	23	12.9	55			30,149	368.78	-83.01	-75.63	-20.37			
2003	*(see Note)*															
2004	*(see Note)*															
2005	2,216	69	8.21	26	43.4	66	16.81		18,193	-71.99	115.48**	236.43**	-39.65**			
2006	1,686	90	1.16	19	12.15	20			1,956	-23.91	-85.87	-72.00	-89.25			
2007	26,077	44	1.45	17	46.23	62			37,812	1446.68	25	280.49	1,833.35			
2008	*(see Note)*															
2009	*(see Note)*															
							Dalmatian toadflax – South Fence *									
2005		71	3.04	29	47.94	74	9.76	1.12								
2006		74	1.31	12	26.5	57	1.4				-56.91	-44.72				
2007		74	2.05	21	49.25	79					56.48	85.84				
2008		24	3.96	20	48.57	74					93.17	-1.38				
2009		73	2.33	51	62	115					-41.16	27.65			-23.36	

Table 16. Historic noxious weed infestation parameters, Rocky Flats National Wildlife Refuge, Golden, Colorado, 2001-2009.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
								Dalmatian toadflax - Weather								
2003			3.24		68.92											
2004			4.97		46.92						53.4	-31.92				
2005																
2006																
2007																
2008	1,516	10	1.50	5	23.17	27			2,274	2,274	-69.82**	-50.92**				
2009	33,517	41	5.49	28	63.67	110			184,008	2,110.9	266	174.79	7991.84	2110.88	398.13	7991.84
								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	0.42			-47.79	-34.98				
2007		123	0.44	11	46.17	73	117.21	3.75			-25.42	34.10				
2008		122	0.67	28	40.61	81	158.89	3.83			52.27	-12.04				
2009		108	0.44	8	38.7	73	318.75	0.36			-34.33	-4.70			-48.24	

n – number of samples or observations
* - infestation was not mapped (a linear transect method was utilized to survey the weed population)
** - values given in the year-to-year change column reflect 2- or 3-year changes, as sampling was not done at all sites all years
Note - site was not mapped, as infestation had been reduced to a few scattered plants

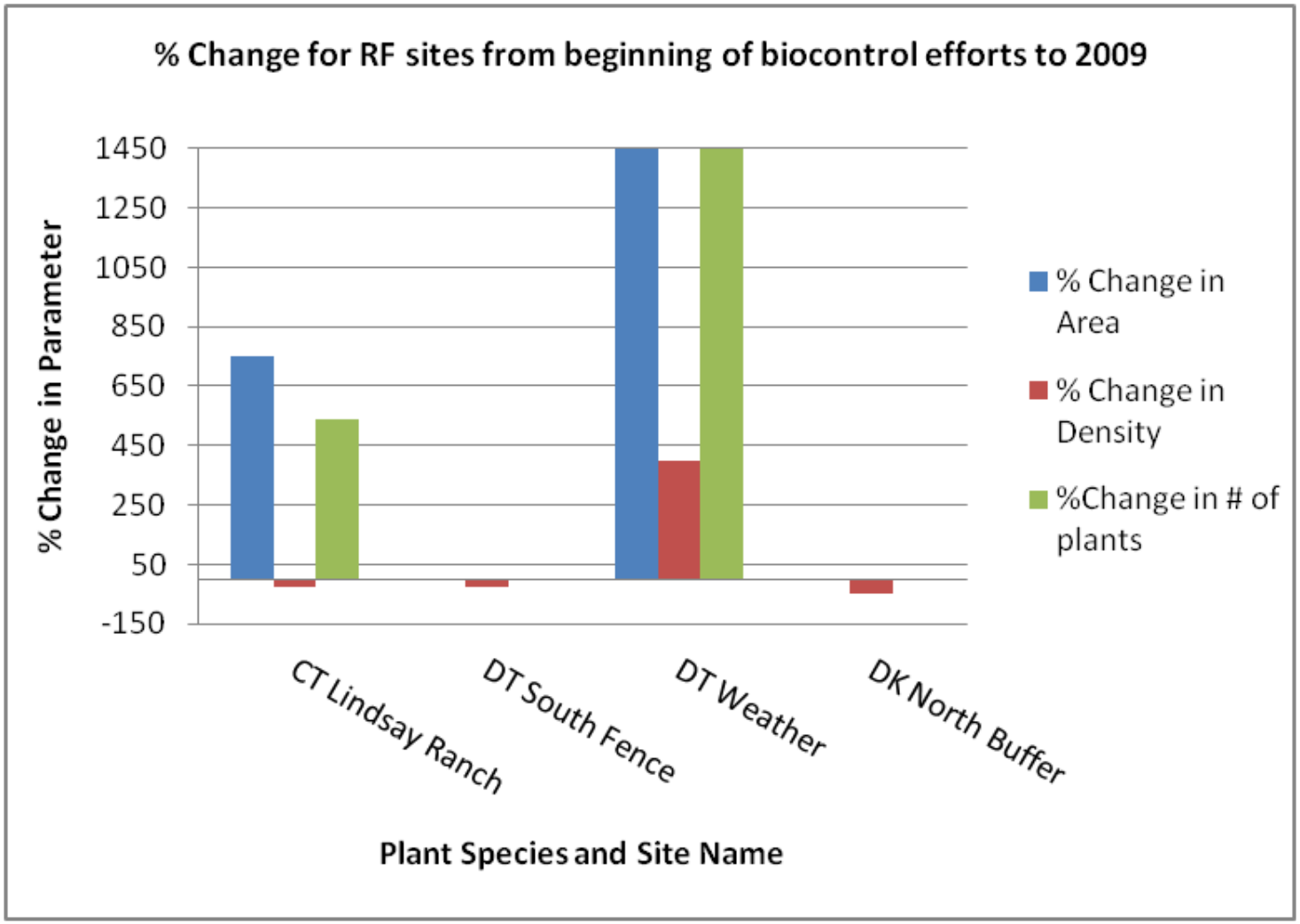


Figure 17. Percent change in area and density of all sites at Rocky Flats. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year's data by the area or density from this year. The number of years represented vary and depend on when the sites were established. The South Fence and North Buffer sites have no area data; the Weather site has area data only for this year.

Table 17. Noxious weed biological control sites, target weeds, species released and recoveries at Rocky Flats National Wildlife Refuge, Golden, Colorado, 2009.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
RF	Canada thistle	Lindsay Ranch	*Cassida rubiginosa*	X		
RF	Canada thistle	Lindsay Ranch	*Larinus planus*			
RF	Canada thistle	Lindsay Ranch	*Rhinocyllus conicus*	X		
RF	Canada thistle	Lindsay Ranch	*Urophora carduii*			
RF	Musk thistle	North Buffer[3]	*Trichosirocalus horridus*			
RF	Diffuse knapweed	Northwest Buffer Zone	*Agapeta zoegana*	X		
RF	Diffuse knapweed	Northwest Buffer Zone	*Cyphocleonus achates*	X		
RF	Diffuse knapweed	Northwest Buffer Zone	*Larinus minutus*	X		
RF	Diffuse knapweed	Northwest Buffer Zone	*Metzneria paucipunctella*	X		
RF	Diffuse knapweed	Northwest Buffer Zone	*Sphenoptera jugoslavica*	X		
RF	Diffuse knapweed	Northwest Buffer Zone	*Urophora affinis*	X		
RF	Diffuse knapweed	Northwest Buffer Zone	*Urophora quadrifasciata*	X		
RF	Dalmatian toadflax	Original Site[3]	*Mecinus janthinus*			
RF	Dalmatian toadflax	Southeast Buffer Zone[3]	*Mecinus janthinus*			
RF	Dalmatian toadflax	Sites III & IV[3]	*Mecinus janthinus*			
RF	Dalmatian toadflax	South Fence	*Mecinus janthinus*	X		
RF	Dalmatian toadflax	Weather[3]	*Mecinus janthinus*			
RF	Field bindweed	Multiple sites	*Aceria malherbae*	X		

[1] New insect recovered in 2009
[2] Adventitious recoveries, no release made at this site
[3] Site not monitored for insects this year

Warren Air Force Base

Five biocontrol sites covering 13.0 ha (31.16 acres) were monitored this year at Warren Air Force Base. These sites were DT Missile, LS Black powder, LS Control, LS Nature 1, and LS Nature 2. The Dalmatian toadflax site accounted for 0.5% of the area under biocontrol while the leafy spurge sites accounted for 99.5% of that area. Eleven leafy spurge sites (Black Powder 1-6, Nature 3 and 4, Bridge 1 and 2 and Propane) were surveyed for biocontrol agents using random sweep samples instead of perimeter mapping.

Figure 18. The Dalmatian toadflax control site in 2006 (Left) and 2009 (Right). This site has been deemed unsuitable for mapping during the past three years, a trend that will hopefully continue indefinitely.

Dalmatian toadflax made a slight comeback this year compared to last year with one site (Missile Drive) having plants large enough and in sufficient numbers to map this year. There has been an increase in density since the beginning of biocontrol efforts at this site but overall height and number of plants has decreased. Three Dalmatian toadflax sites that were not mapped last year (Control, Nature Trail, and Nursery) were checked this year to determine their status but not mapped (Figure 17). We did not have enough insects to do any new releases this year; however, given that none of the sites were dense enough to map last year we do not believe it is as crucial to do rereleases since the sites appear to be on the way to being controlled. We planned to collect stems from the last growing season to dissect in order to look for the presence of biocontrol agents but the stems from last season were too small and stunted to collect. We will try again next spring though we expect the stems will be too small again next year. The Nursery site that was observed to have a leafy spurge infestation last year did not seem to have as dense an infestation of spurge again this year (Figure 18.). We will continue to monitor this site to see if a release of the *Aphthona sp.* complex to control leafy spurge is warranted.

Figure 19. The Dalmatian toadflax Nursery site in 2008 (Left) with yellow leafy spurge visible in the mid-ground. On the right is the site in 2009 with hardly any evidence of a leafy spurge infestation.

As we have done since the releases of the *Aphthona sp.* complex in 2005, eleven leafy spurge sites were monitored using random sweep-net samples. The most commonly found species this summer was *Aphthona flava* and it was the only leafy spurge agent found at eight sites. In contrast, last summer *Aphthona nigriscutis* was the most commonly found species. For the sites that were mapped (Black Powder Road, Control, Nature 1 and Nature 2), all showed an increase in the three measured parameters (density, height and number of plants) since beginning biocontrol efforts except Black Powder Road which had a 15% decrease since 2005. A new leafy spurge agent, *Oberea erythrocephala*, was released at a site at Buckley Air Force Base this summer (Page 42). When this agent is able to establish in sufficient numbers at Buckley we will plan to collect agents from that site and make releases at some leafy spurge sites at Warren depending on which sites have the most vigorous infestation.

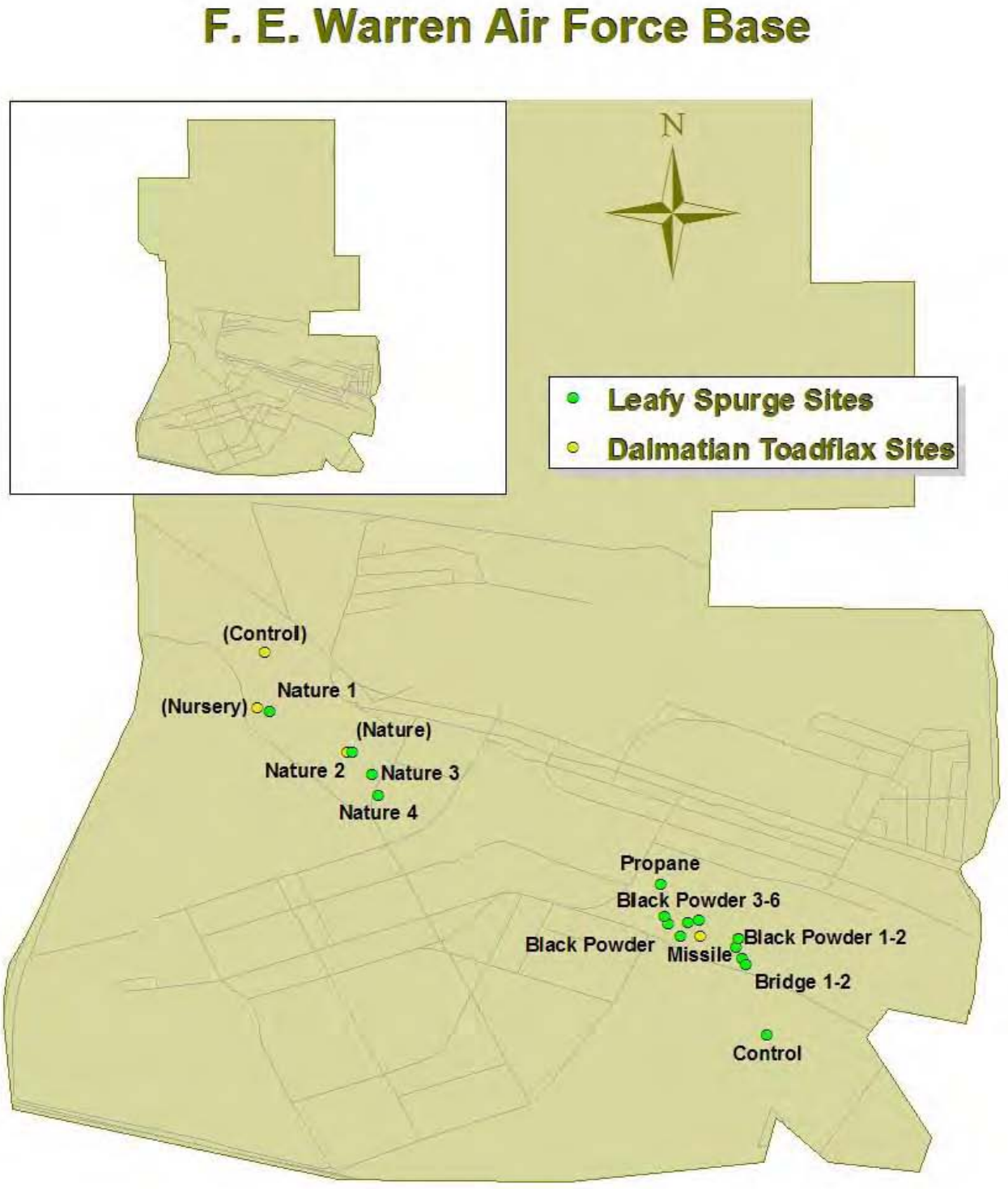


Figure 20. Schematic diagram of F. E. Warren Air Force Base with weed biological control study areas superimposed. Sites listed in parentheses were not surveyed in 2009.

Table 18. Historic noxious weed infestation parameters, F. E. Warren Air Force Base, Cheyenne, Wyoming, 2004-2008.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							Dalmatian toadflax - Control									
2004	18,424	45	2.67	21	32.73	91			49192							
2005	23,234	44	3.66	25	49.36	74	13.57		85036	26.11	37.08	50.81	72.87			
2006	10,540	37	0.35	6	43.13	60	4.25		3689	-54.64	-90.44	-12.62	-95.66	-42.79	-86.89	-92.50
2007	*(see Note a)*															
2008	*(see Note b)*															
2009	*(see Note b)*															
							Dalmatian toadflax – Missile									
2004	20,356	49	0.63	3	24.14	80			12824							
2005	27,247	54	4.35	54	53.52	91	10.22		118524	33.85	590.48	121.71	824.22			
2006	9,601	41	0.30	9	53.5	58	16		2880	-64.76	-93.1	-0.04	-97.57			
2007	19,406	110	0.68	16	57.96	84			13196	102.12	126.67	8.34	358.15			
2008	*(see Note b)*															
2009	692	15	1.47	4	63.43	88			1017	-96.43**	116.18**	9.44**	-92.29**	-96.60	133.33	-92.07
							Dalmatian toadflax – Nature									
2004	45,471	80	1.16	8	25.01	84			52746							
2005	49,471	63	4.61	29	55.15	98	14.26		228061	8.8	297.41	120.51	332.37			
2006	49,727	84	2.28	49	33.26	76	3.66		113378	0.52	-50.54	-39.69	-50.29			
2007	51,205	130	1.48	43	42.78	76			75783	2.97	-35.09	28.62	-33.16	12.61	27.59	43.68
2008	*(see Note b)*															
2009	*(see Note b)*															

Table 18. Historic noxious weed infestation parameters, F. E. Warren Air Force Base, Cheyenne, Wyoming, 2004-2008.

			Density (1/2m^2)		Height (cm)					Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max	Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
							Leafy spurge – Black Powder Road									
2005	2,797	28	48.82	127	64.93	91			136550							
2006	32,077	96	35.80	178	45.8	91			1148357	1046.84	-26.67	-29.46	740.98			
2007	36,874	129	69.35	534	47.79	110			2557212	14.95	93.71	4.34	122.68			
2008	7,310	27	31.26	144	41.79	87			228511	-80.18	-54.92	-12.55	-91.06			
2009	48,845	10	41.30	107	59.67	91			2017299	568.19	32.12	42.79	782.80	1646.33	-15.40	1377.34
							Leafy spurge – Control									
2004	5,526	31	41.70	98	48.71	69			230434							
2005	60,606	50	59.80	362	63.03	94			3624239	996.74	43.41	29.40	1472.79			
2006	55,476	64	35.97	118	48.86	81			1995472	-8.46	-39.85	-22.48	-44.94			
2007	*(see Note a)*															
2008	*(see Note c)*															
2009	70,176	31	55.58	156	37.5	71			3900382	26.5**	54.52**	-23.25**	95.46**	1169.92	33.29	1592.62
							Leafy spurge – Nature I									
2004	1,849	44	36.95	88	67.14	95			68321							
2005	1,547	35	45.77	250	68.35	97			70806	-16.33	23.87	1.80	3.64			
2006	2,120	54	23.41	59	66.98	105			49629	37.04	-48.85	-2.00	-29.91			
2007	2,382	60	63.68	217	57.55	93			151686	12.36	172.02	-14.08	205.64			
2008	*(see Note b)*															
2009	2,371	16	39.25	87	74.38	126			93062	-0.46**	-38.36**	29.24**	-38.65**	28.23	6.22	36.21
							Leafy spurge – Nature II									
2004	1,703	42	66.19	129	55.98	81			112722							
2005	1,463	38	85.30	184	62.35	80			124794	-14.09	28.87	11.38	10.71			
2006	2,071	54	48.30	125	53.87	90			100029	41.56	-43.38	-13.60	-19.84			
2007	1,940	62	68.55	211	52.68	92			132987	-6.33	41.93	-2.21	32.95			

Table 18. Historic noxious weed infestation parameters, F. E. Warren Air Force Base, Cheyenne, Wyoming, 2004-2008.

			Density (1/2m^2)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Tot. estimated # of plants	Year to year % change				% Change to date		
Year	Area (m^2)	n	Avg.	Max	Avg.	Max				Area (m^2)	Avg. density	Avg. height	# of Plants	Area	Avg. Density	# of plants
2008	*(see Note b)*															
2009	4015	10	67.70	106	77.2	98			271816	106.96**	-1.24**	46.55**	104.39**	135.76	2.28	141.13

n – number of samples or observations

Note: site was not mapped, as a) goat grazing prevented an accurate survey b) infestation had been reduced to a few scattered plants c) site was destroyed

.

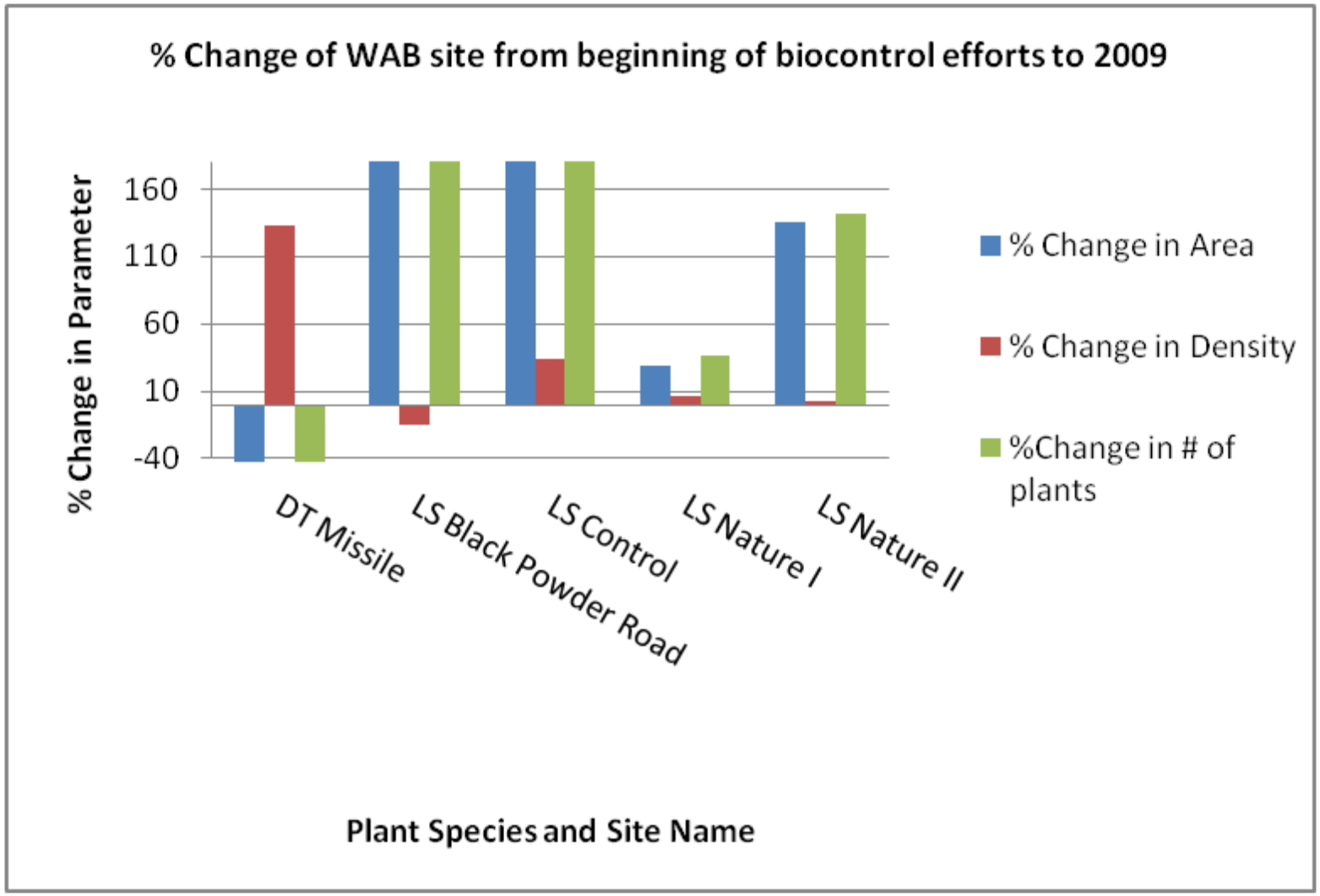


Figure 30. Percent change in area and density of all sites at Rocky Flats. The percent change is calculated by dividing the difference in the parameters between the first year they were monitored and this year's data by the area or density from this year. The number of years represented vary and depend on when the sites were established. The South Fence and North Buffer sites have no area data; the Weather site has area data only for this year.

Table 19. Noxious weed biological control sites, target weeds, species released and recoveries at, F. E. Warren Air Force Base, Cheyenne, Wyoming, 2009.

Release Location	Target Weed	Release Site	Species	Species recovered	New releases	New site
WAB	Leafy spurge	Black Powder	*Aphthona* sp. complex[2]	X[3]		
WAB	Leafy spurge	Black Powder I[1]	*Aphthona* sp. complex[2]	X[4]		
WAB	Leafy spurge	Black Powder II[1]	*Aphthona* sp. complex[2]	X[4]		
WAB	Leafy spurge	Black Powder III[1]	*Aphthona* sp. complex[2]	X[4]		
WAB	Leafy spurge	Black Powder IV[1]	*Aphthona* sp. complex[2]	X[3]		
WAB	Leafy spurge	Black Powder V[1]	*Aphthona* sp. complex[2]	X[4]		
WAB	Leafy spurge	Black Powder VI[1]	*Aphthona* sp. complex[2]			
WAB	Leafy spurge	Bridge I[1]	*Aphthona* sp. complex[2]			
WAB	Leafy spurge	Bridge II[1]	*Aphthona* sp. complex[2]	X[3]		
WAB	Leafy spurge	Control	*Aphthona czwalinae*			
WAB	Leafy spurge	Control	*Aphthona lacertosa*			
WAB	Leafy spurge	Control	*Aphthona nigriscutis*			
WAB	Leafy spurge	Control	*Aphthona flava*	X		
WAB	Leafy spurge	Nature I	*Aphthona* sp. complex[2]	X[4]		
WAB	Leafy spurge	Nature Ib[1]	*Aphthona* sp. complex[2]			
WAB	Leafy spurge	Nature II	*Aphthona* sp. complex[2]	X[4]		
WAB	Leafy spurge	Nature IIa[1]	*Aphthona* sp. complex[2]			
WAB	Leafy spurge	Nature III[1]	*Aphthona* sp. complex[2]			
WAB	Leafy spurge	Nature IV[1]	*Aphthona* sp. complex[2]			
WAB	Leafy spurge	Propane[1]	*Aphthona* sp. complex[2]	X[4]		
WAB	Dalmatian toadflax	Control	*Mecinus janthinus*			
WAB	Dalmatian toadflax	Nature	*Mecinus janthinus*			
WAB	Dalmatian toadflax	Nursery [1]	*Mecinus janthinus*			
WAB	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*.

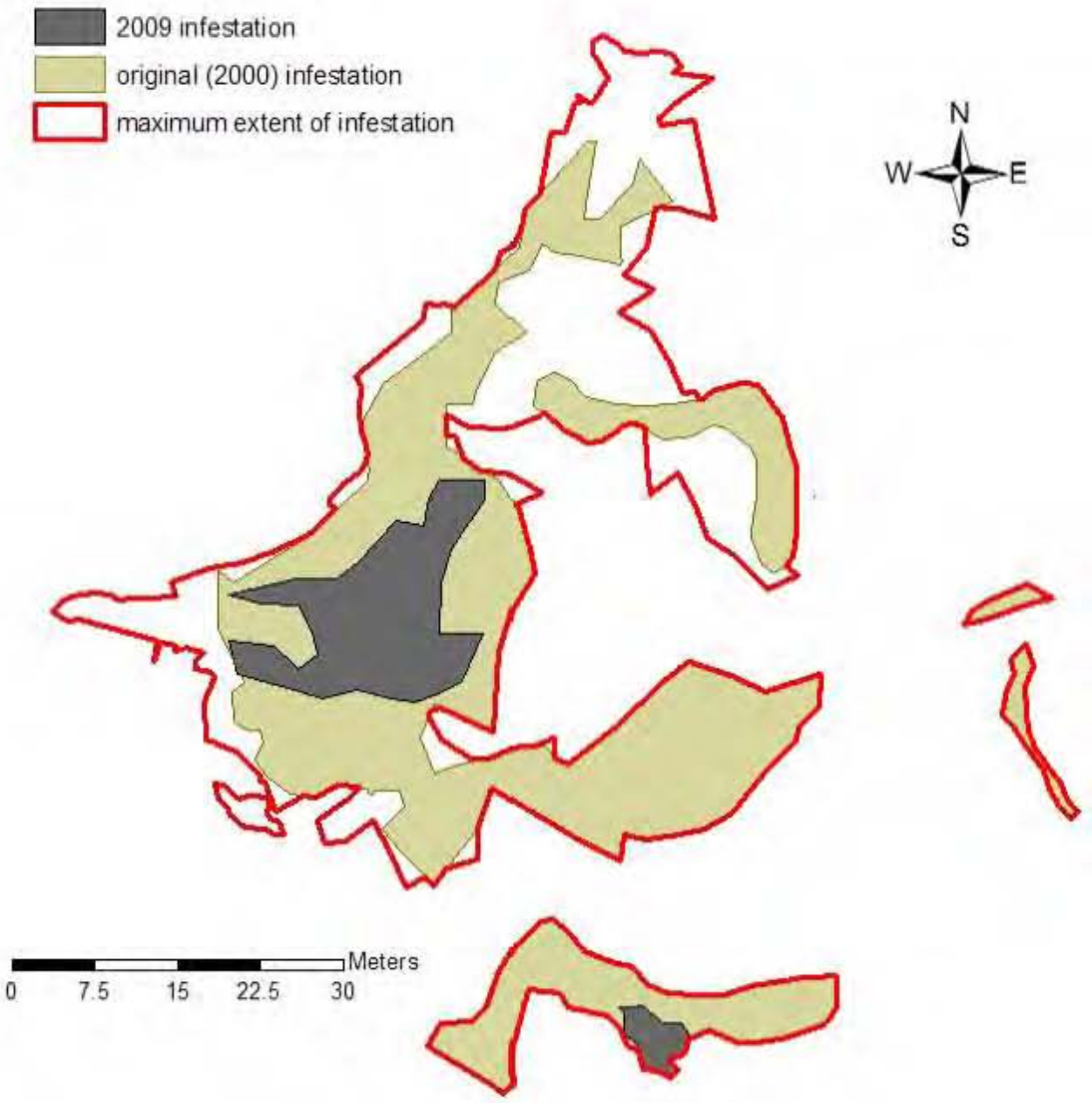
[3] Only *Aphthona flava* and *A. nigriscutis* recovered.

[4] Only *Aphthona flava* recovered.

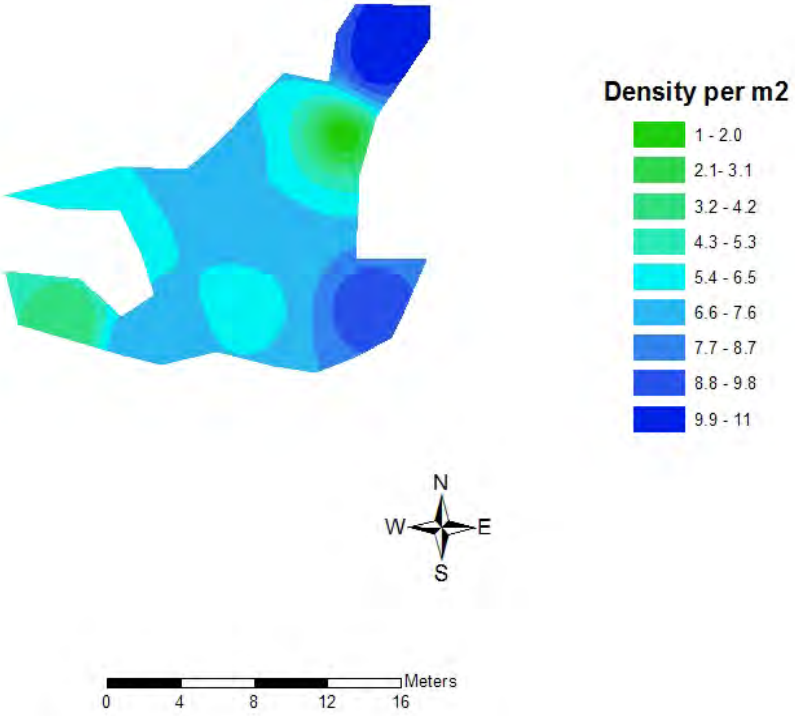
Appendix

The Appendix contains maps and graphs illustrating changes in area, perimeter, density and height. The information is arranged by installation, then sites within an installation, and then by weed species. The first map for a given site illustrates the original extent of the weed infestation (tan area) when biocontrol was initiated, the maximum extent of the weed infestation (red line) since the inception of biocontrol efforts until 2009, and the extent of the infestation in 2009 (black area). The second map illustrates the density of the weed infestation in 2009, and includes a graph indicating historical weed density bounded by the 95% confidence interval. The final map and graph are laid out in the same manner as the density data, but illustrate weed height.

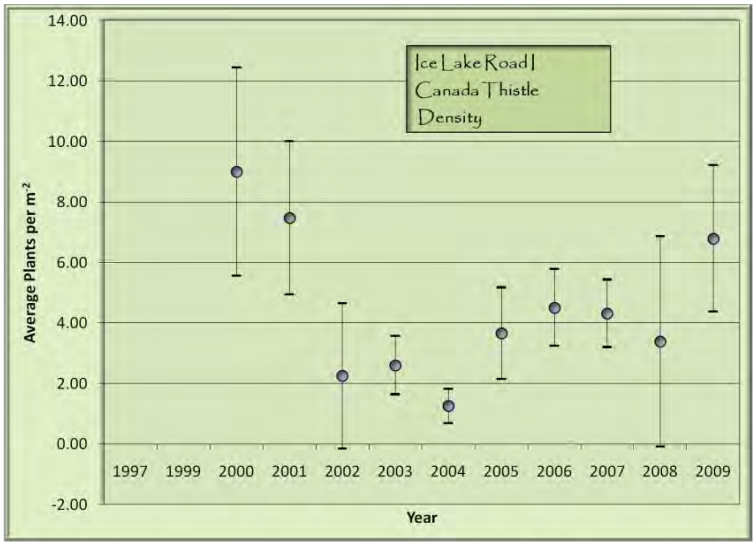
When using the information presented in the Appendix, it is important to understand that area, density and plant height are interrelated. For a given year, these parameters do not necessarily respond in the same way. Sites with a large area of a weed may have low density, or small areas may have high density. Fluctuations in the parameters can indicate the effectiveness of biological control or may be influenced by climatic conditions; especially rainfall and temperature. We include plant height as an indicator of plant vigor. This parameter can be looked at in association with density and area to get a better idea of the overall status of an infestation. An extensive area with sparse, short plants is assumed to be in poorer health than a small area with a high density of tall plants. In 2010, it is a priority to assemble a comprehensive set of weather data and analyze this in conjunction with our plant and insect data to perhaps draw more definitive conclusions regarding these interactions.

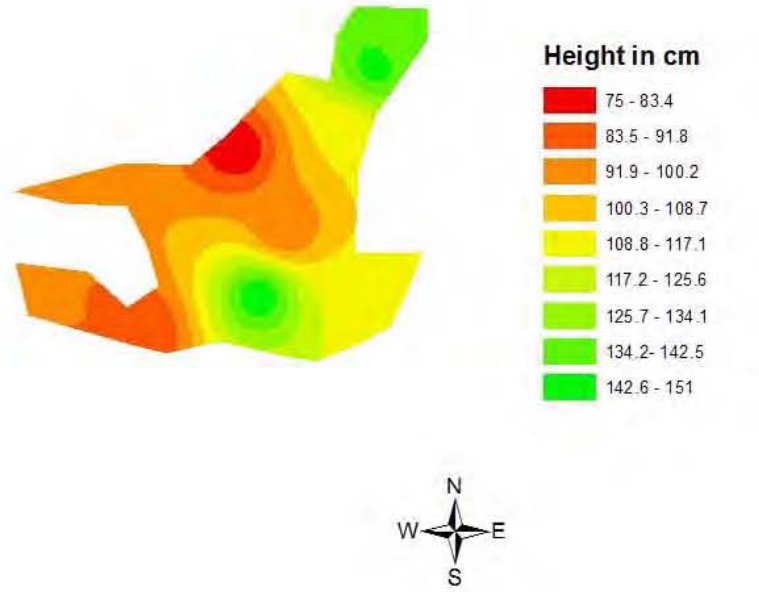


Ice Lake Road I Canada thistle perimeter in 2009.

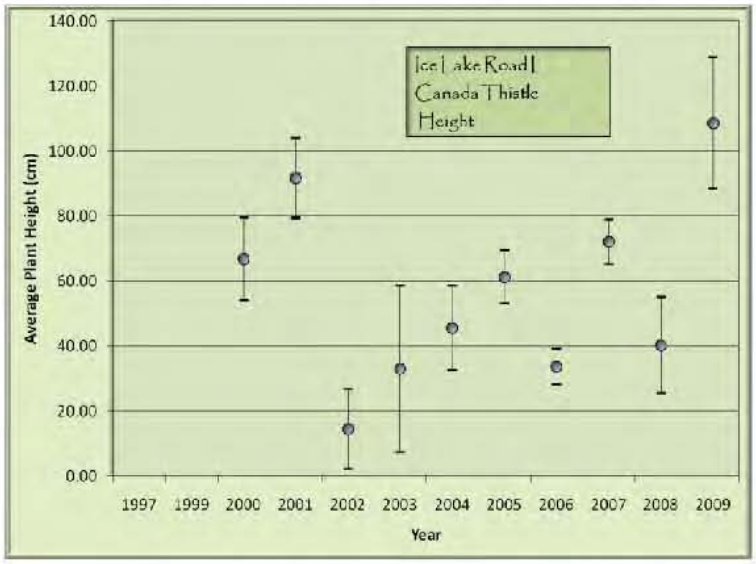


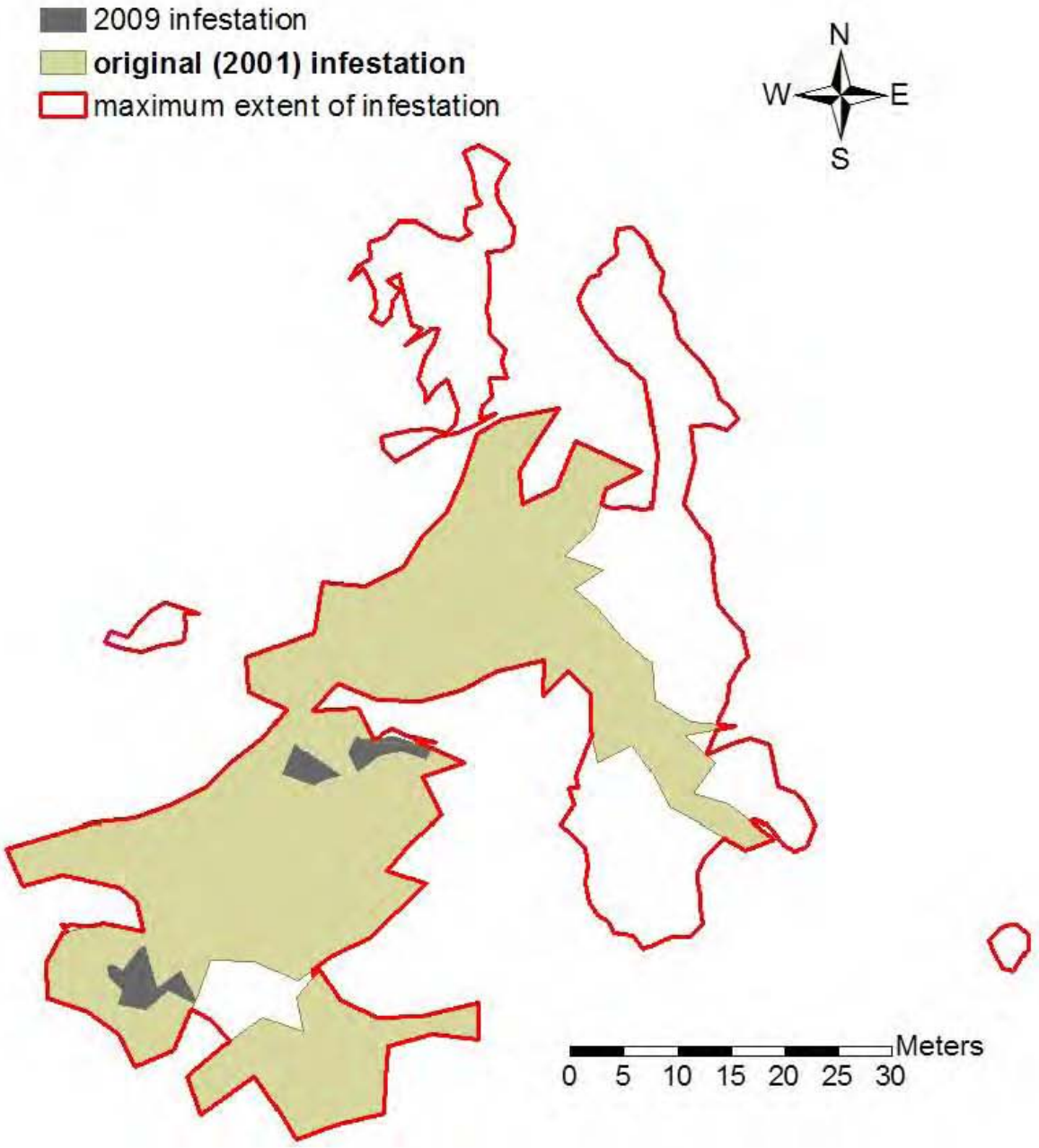
Ice Lake Road I Canada thistle density in 2009.



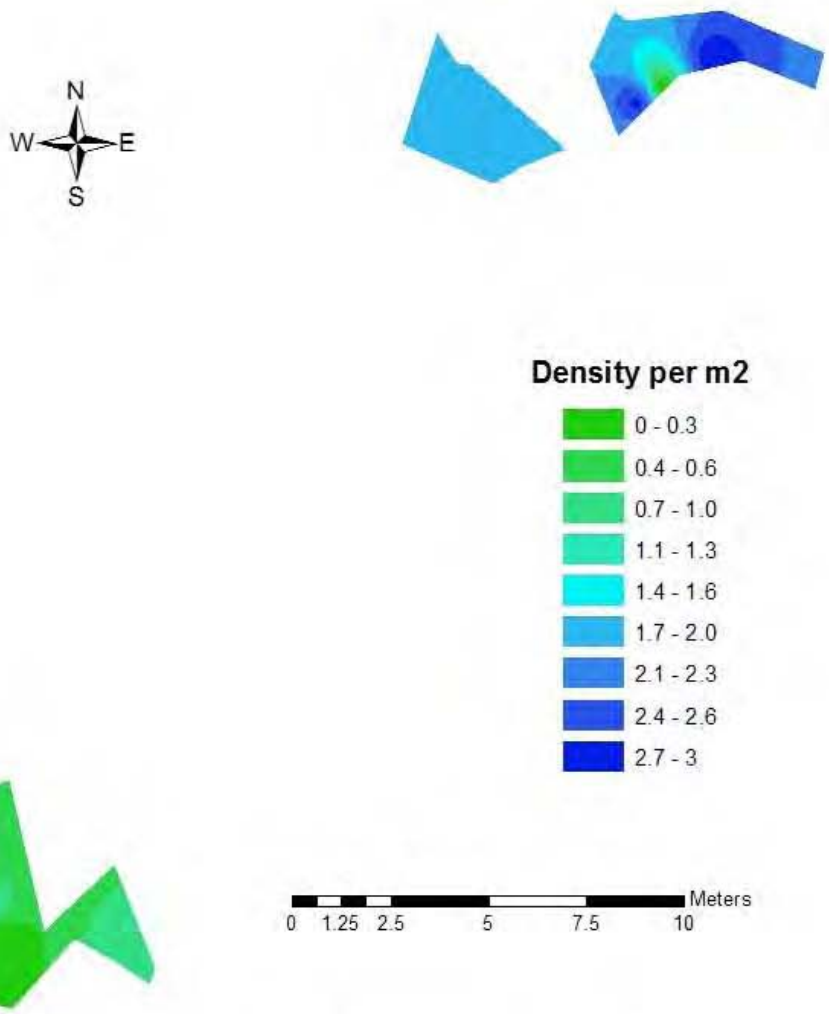


Ice Lake Road I Canada thistle height in 2009.

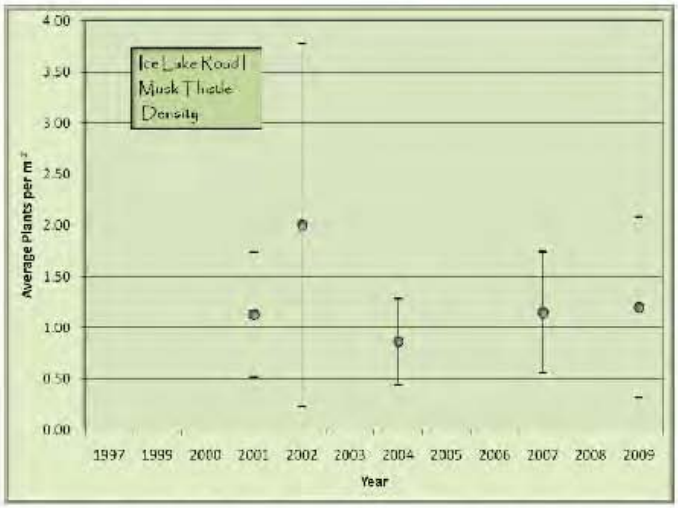


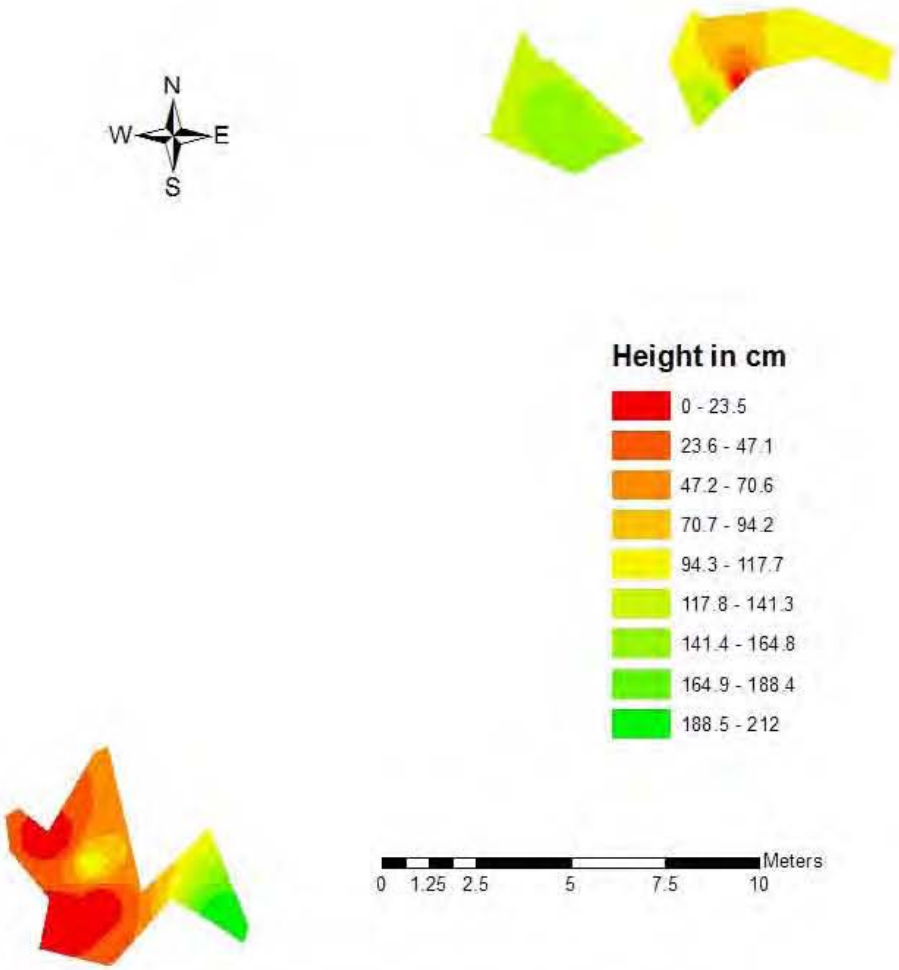


Ice Lake 1 musk thistle perimeter in 2009.

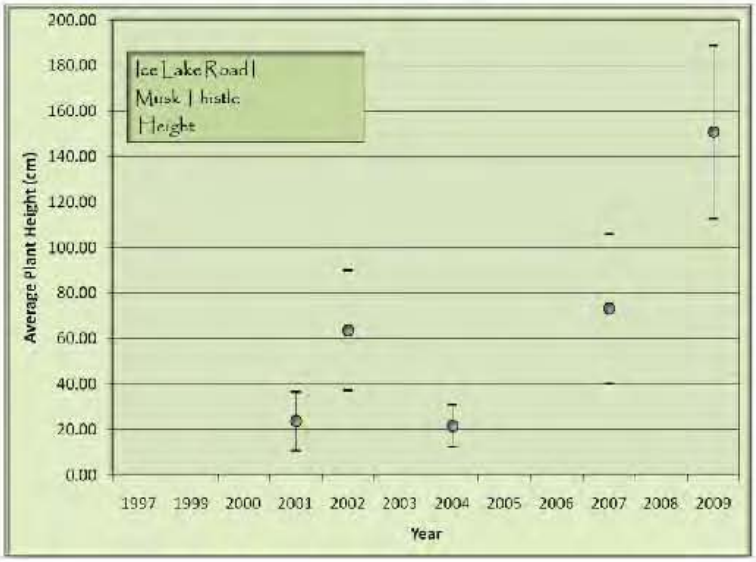


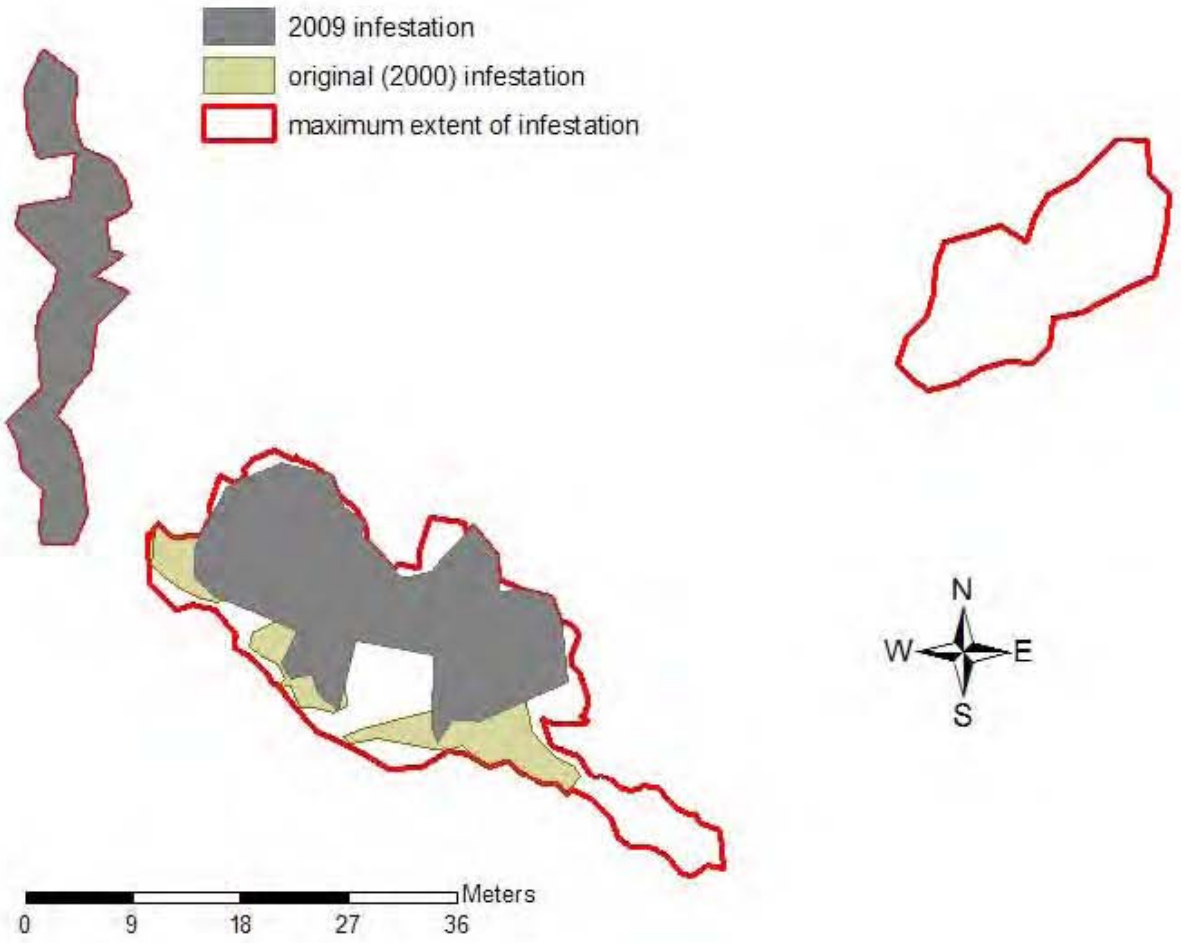
Ice Lake 1 musk thistle density in 2009.



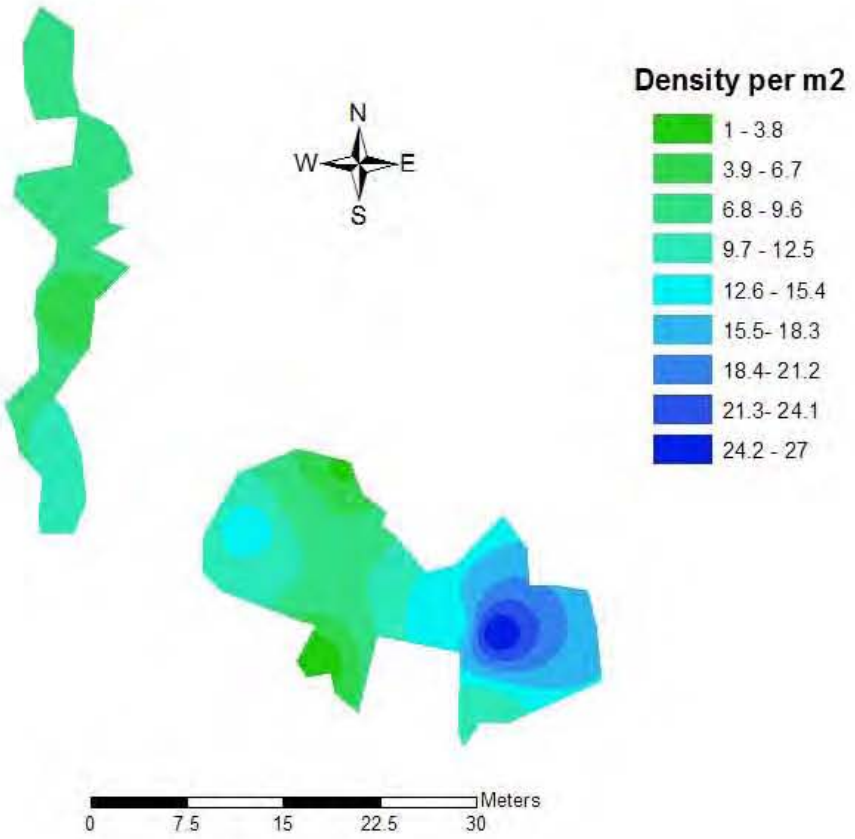


Ice Lake 1 musk thistle height in 2009.

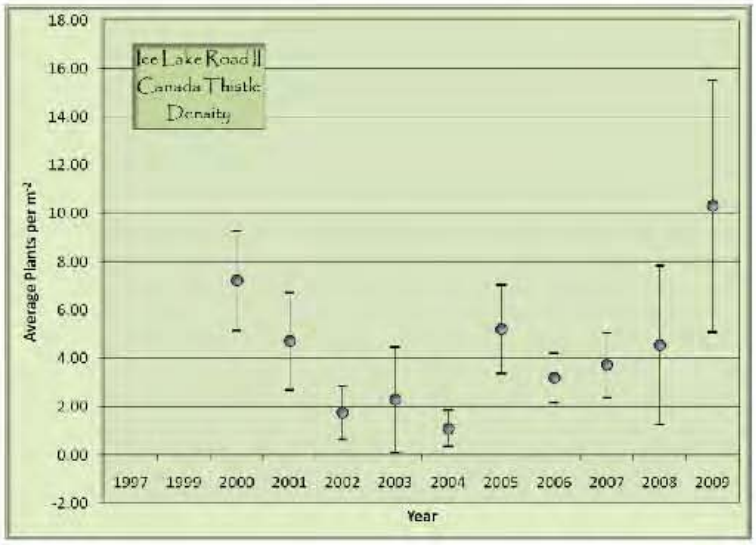


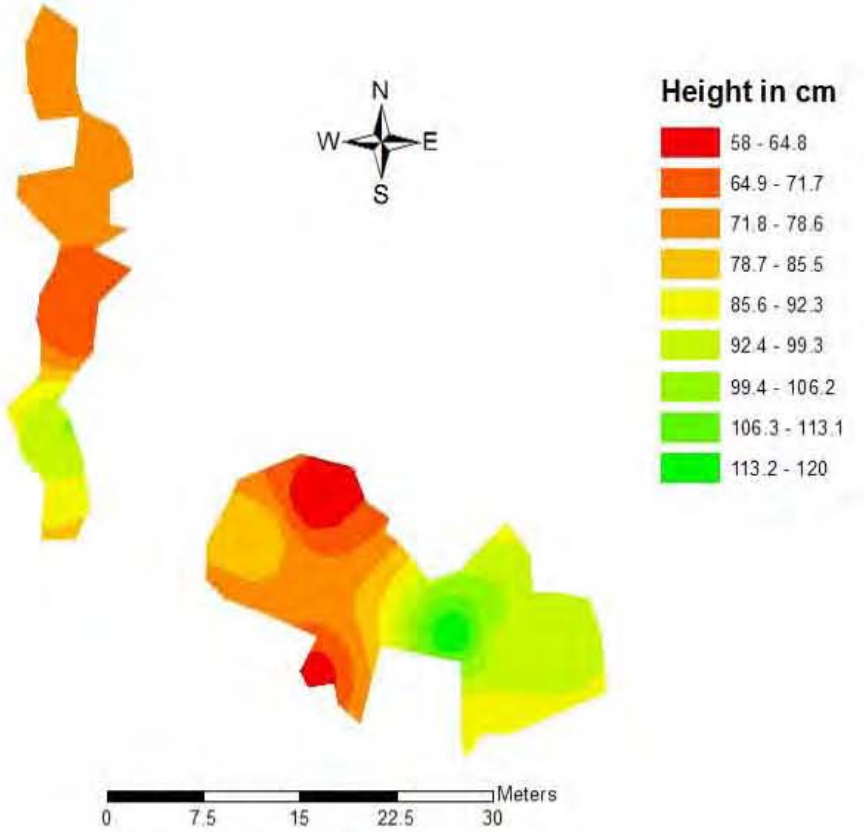


Ice Lake Road II Canada thistle perimeter in 2009.

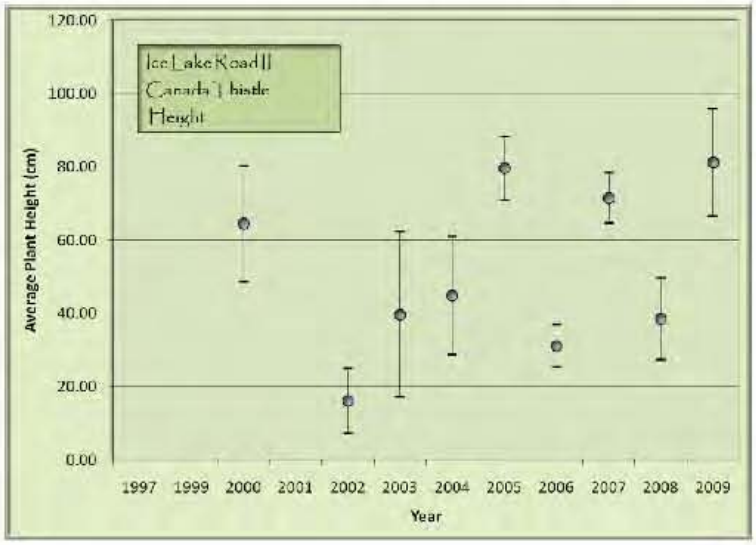


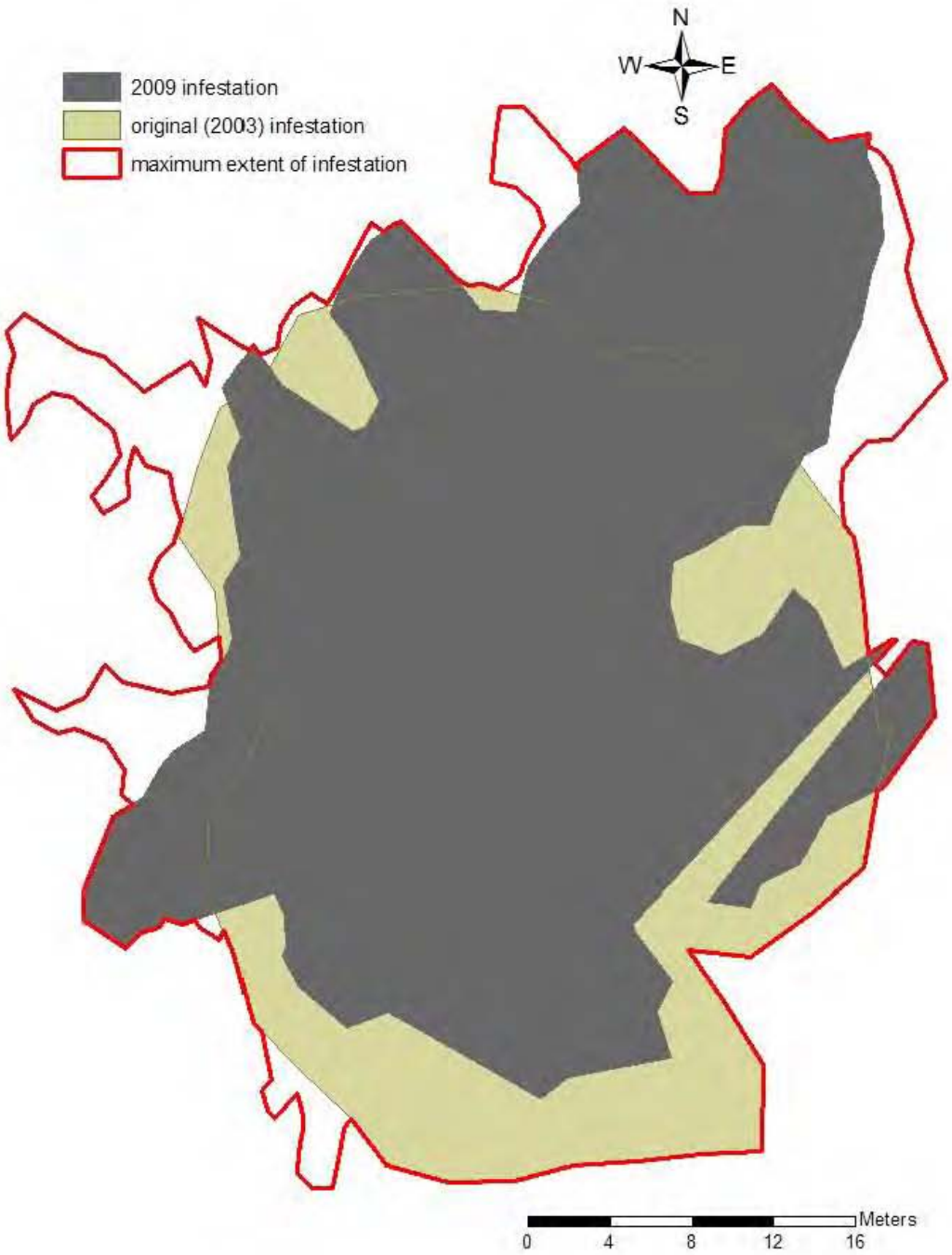
Ice Lake Road II Canada thistle density in 2009.



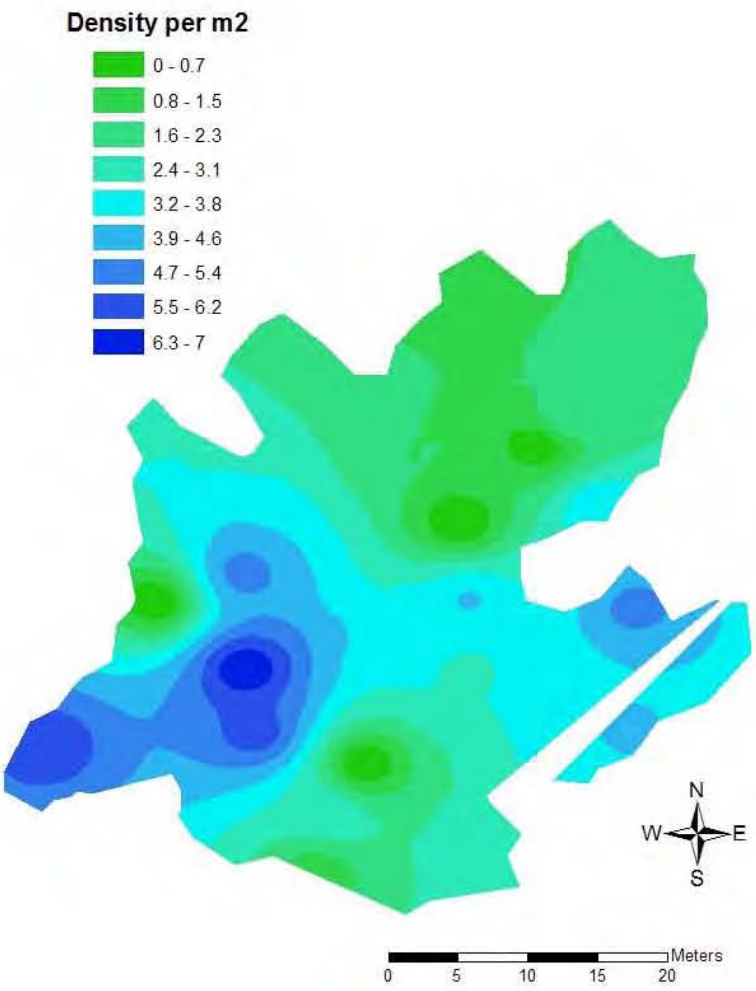


Ice Lake Road II Canada thistle height in 2009.

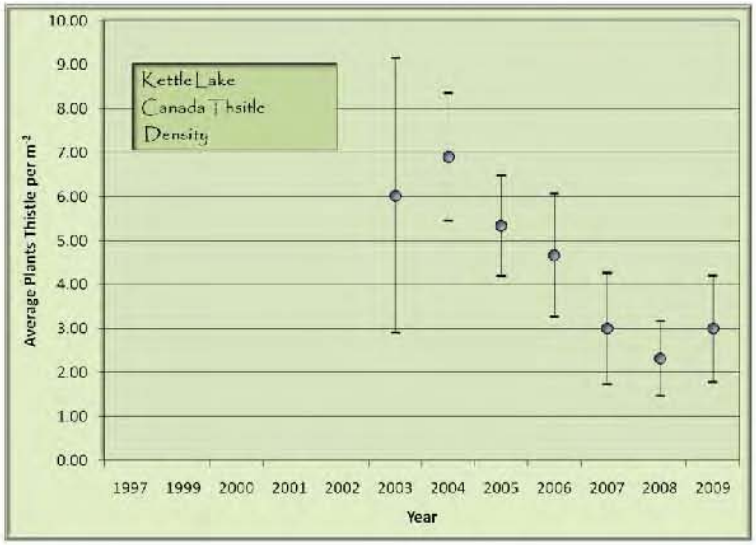


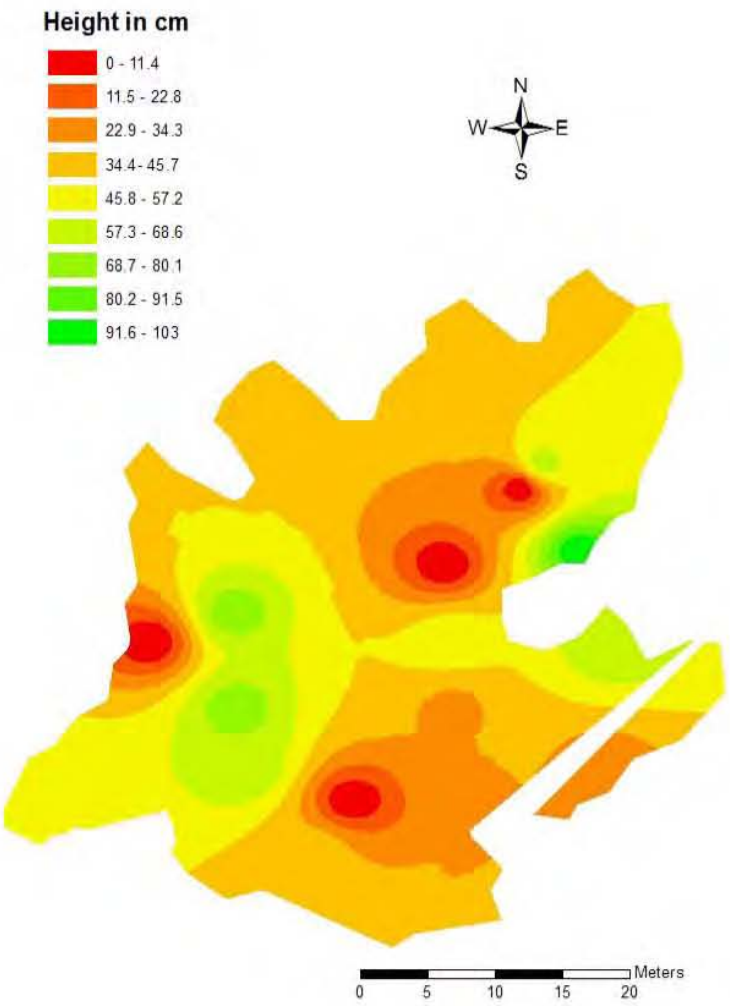


Kettle Lake Canada thistle perimeter in 2009.

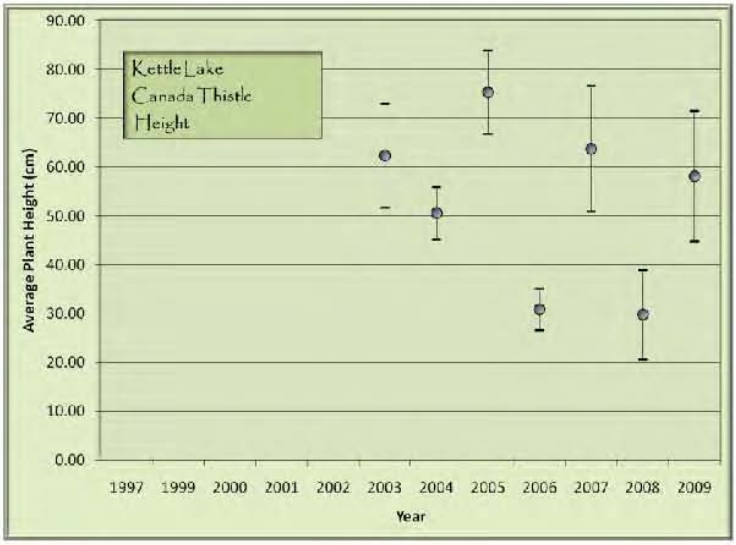


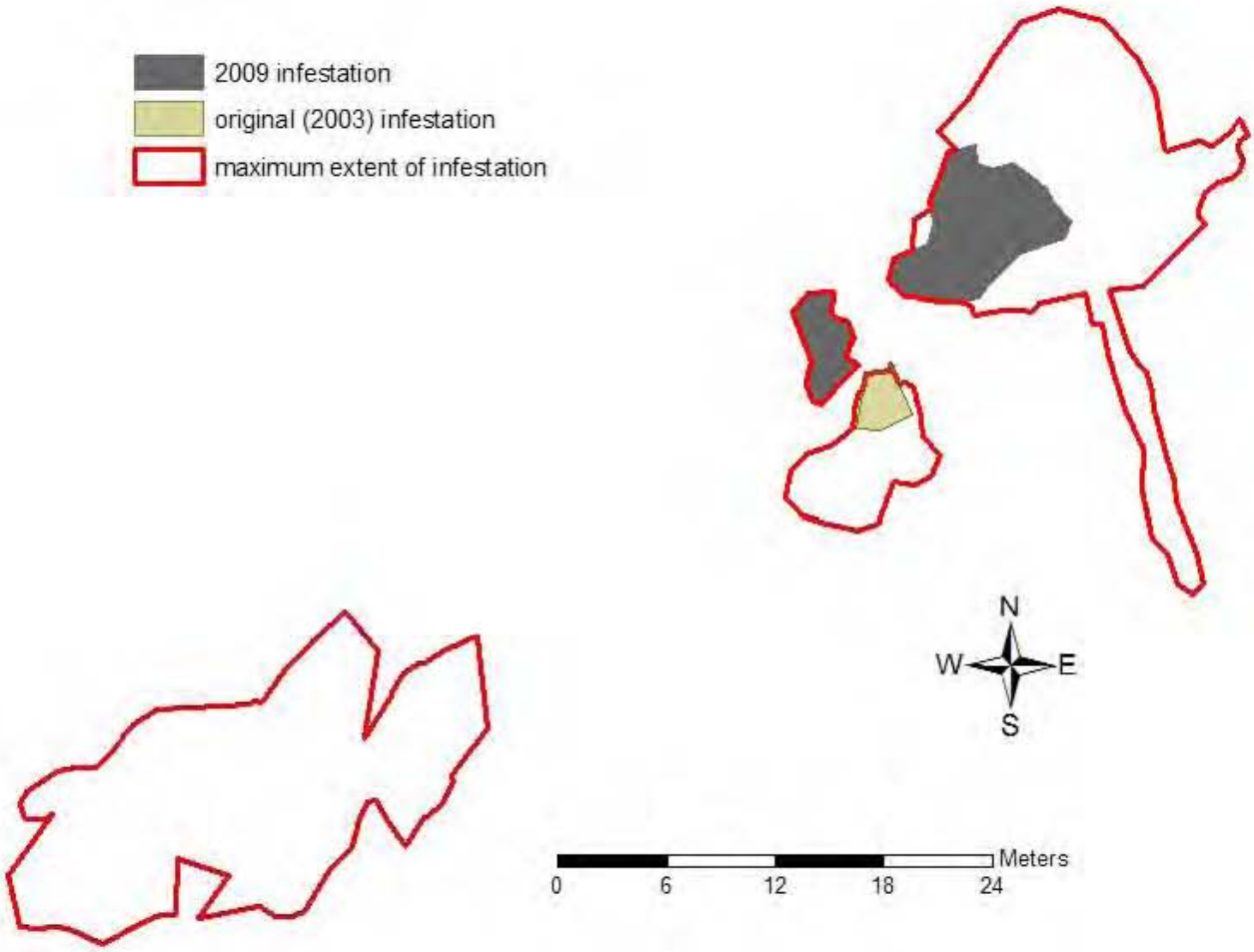
Kettle Lake Canada thistle density in 2009.



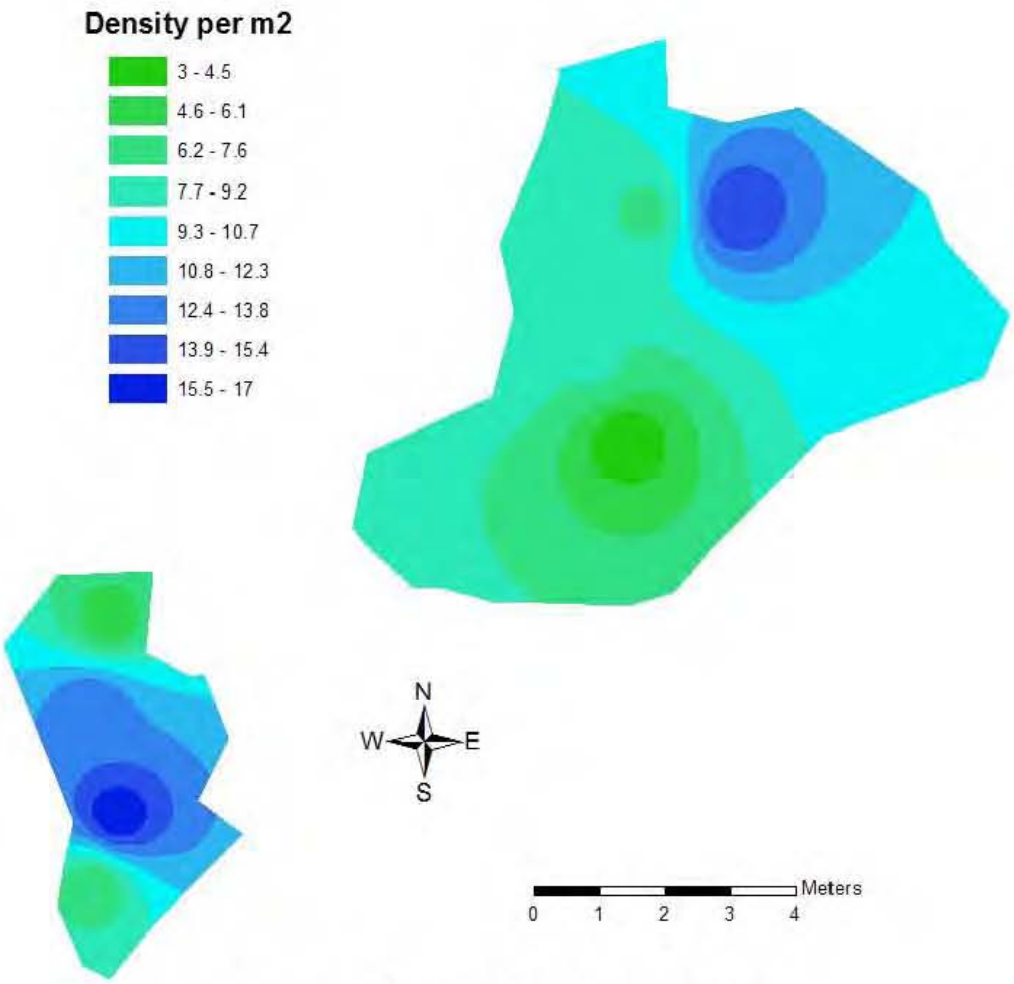


Kettle Lake Canada thistle height in 2009.

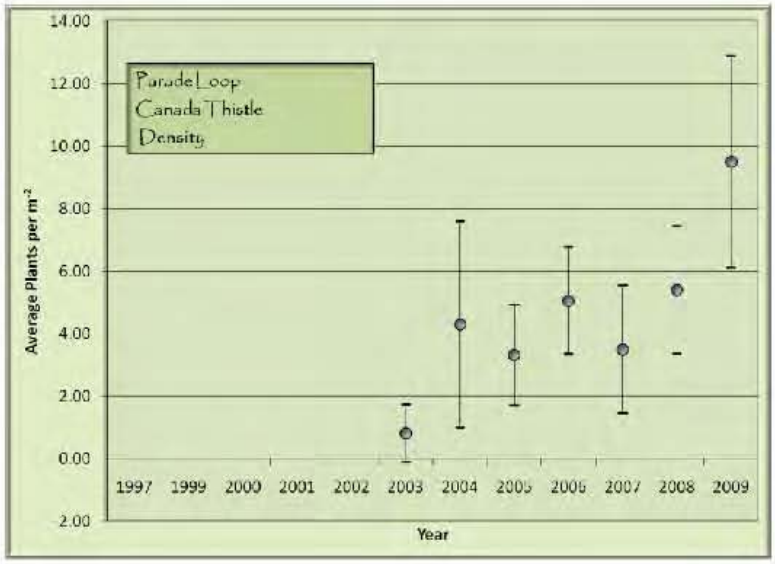


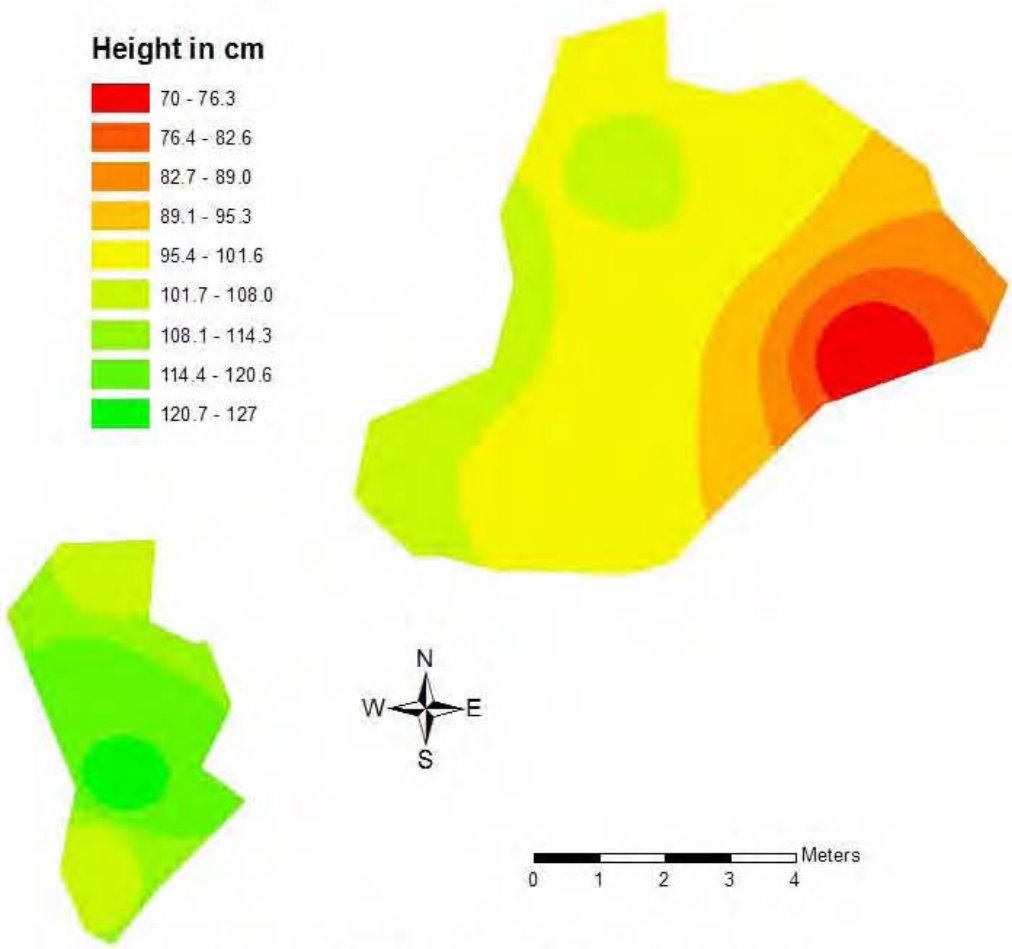


Parade Loop Canada thistle perimeter in 2009.

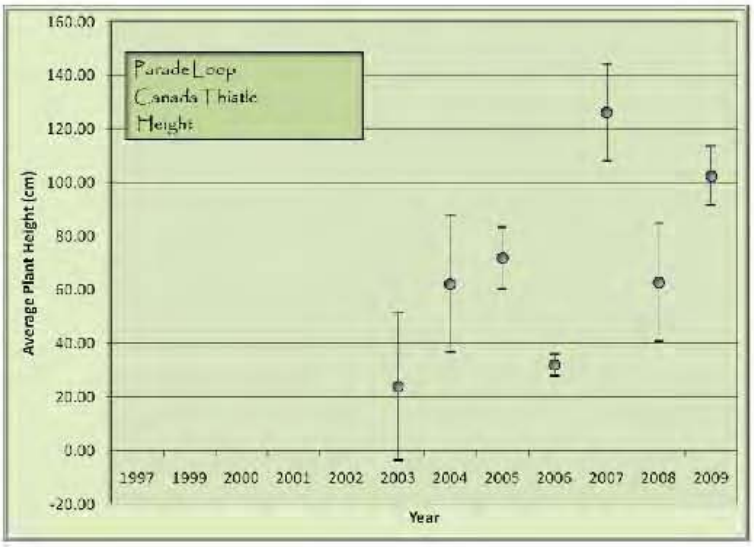


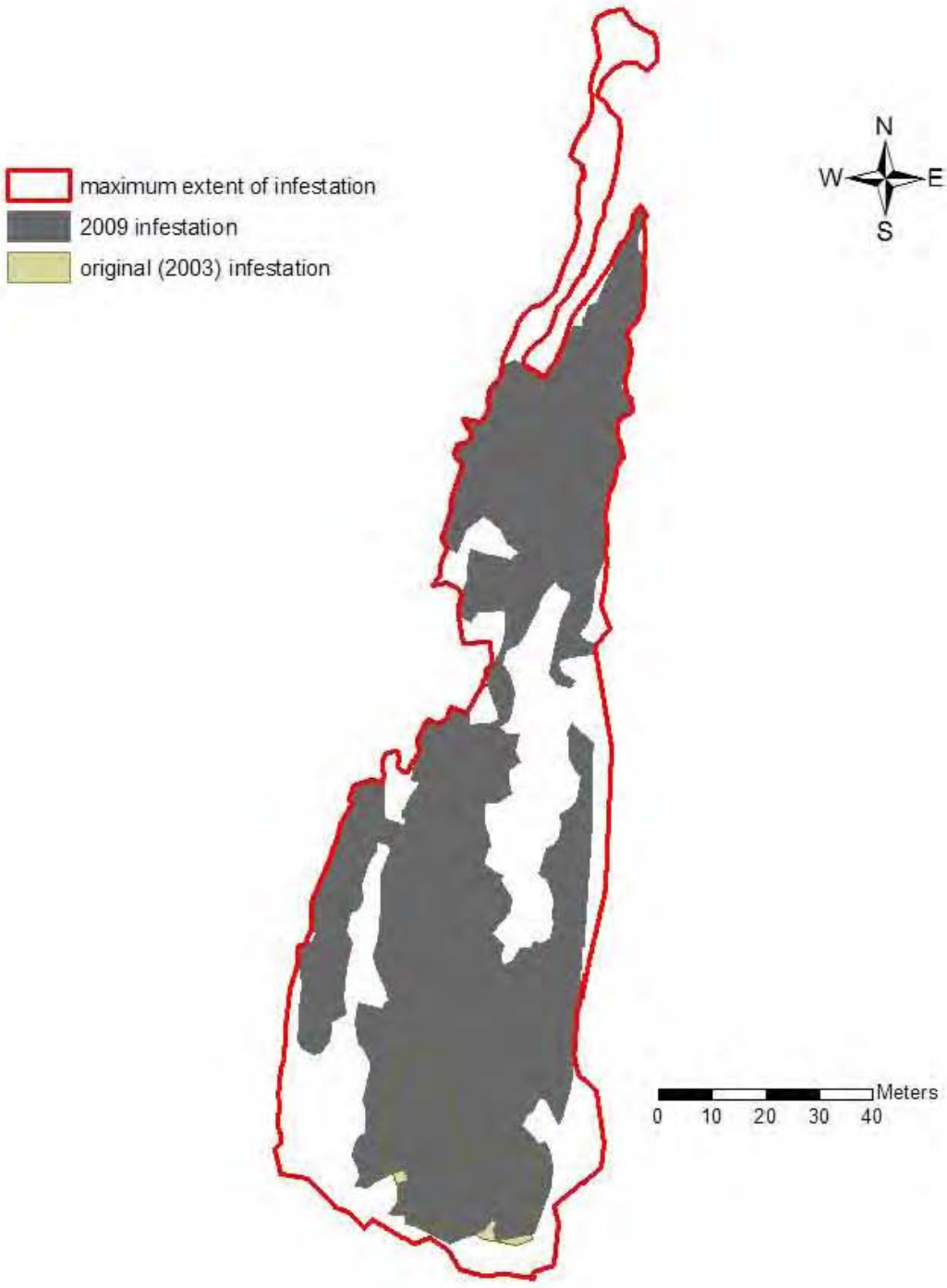
Parade Loop Canada thistle density in 2009.



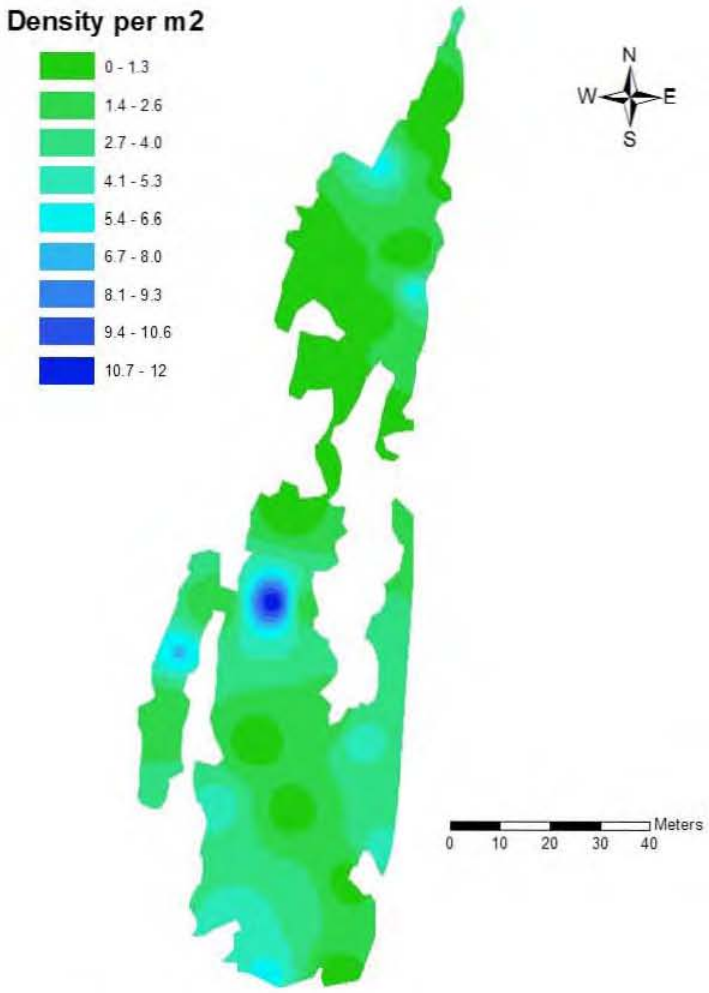


Parade Loop Canada thistle height in 2009.

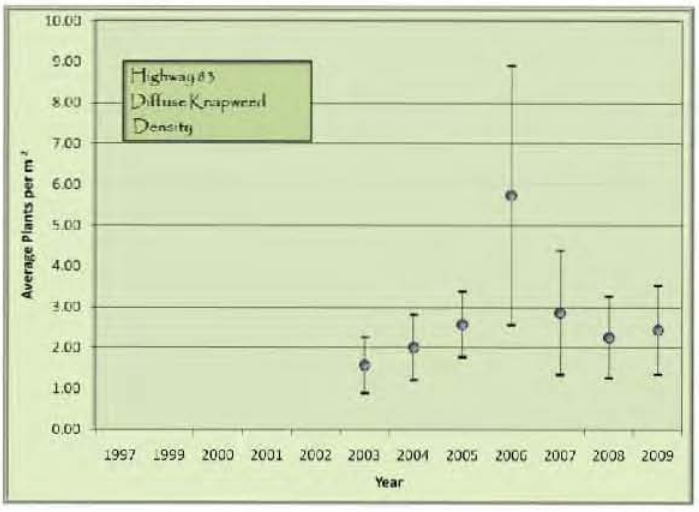


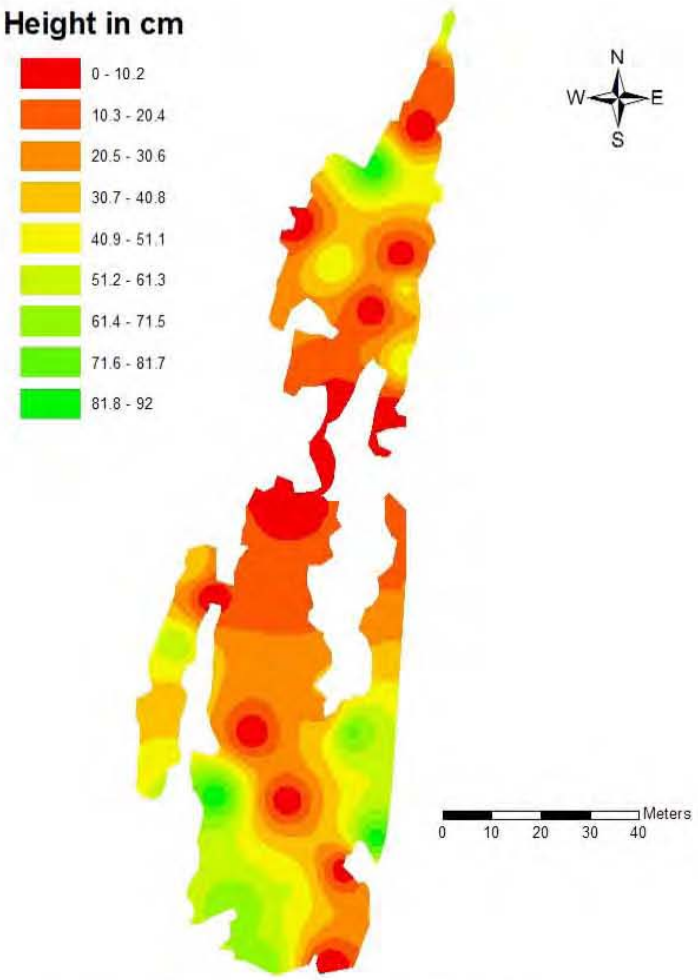


Highway 83 diffuse knapweed perimeter in 2009.

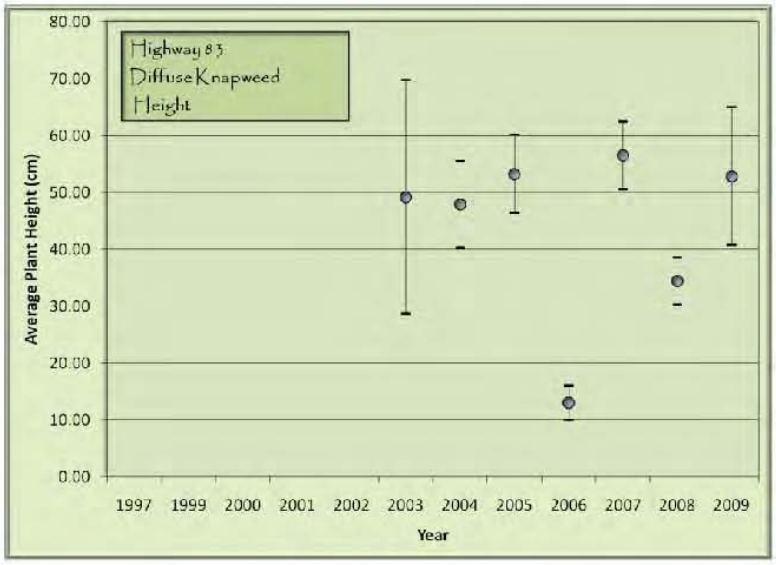


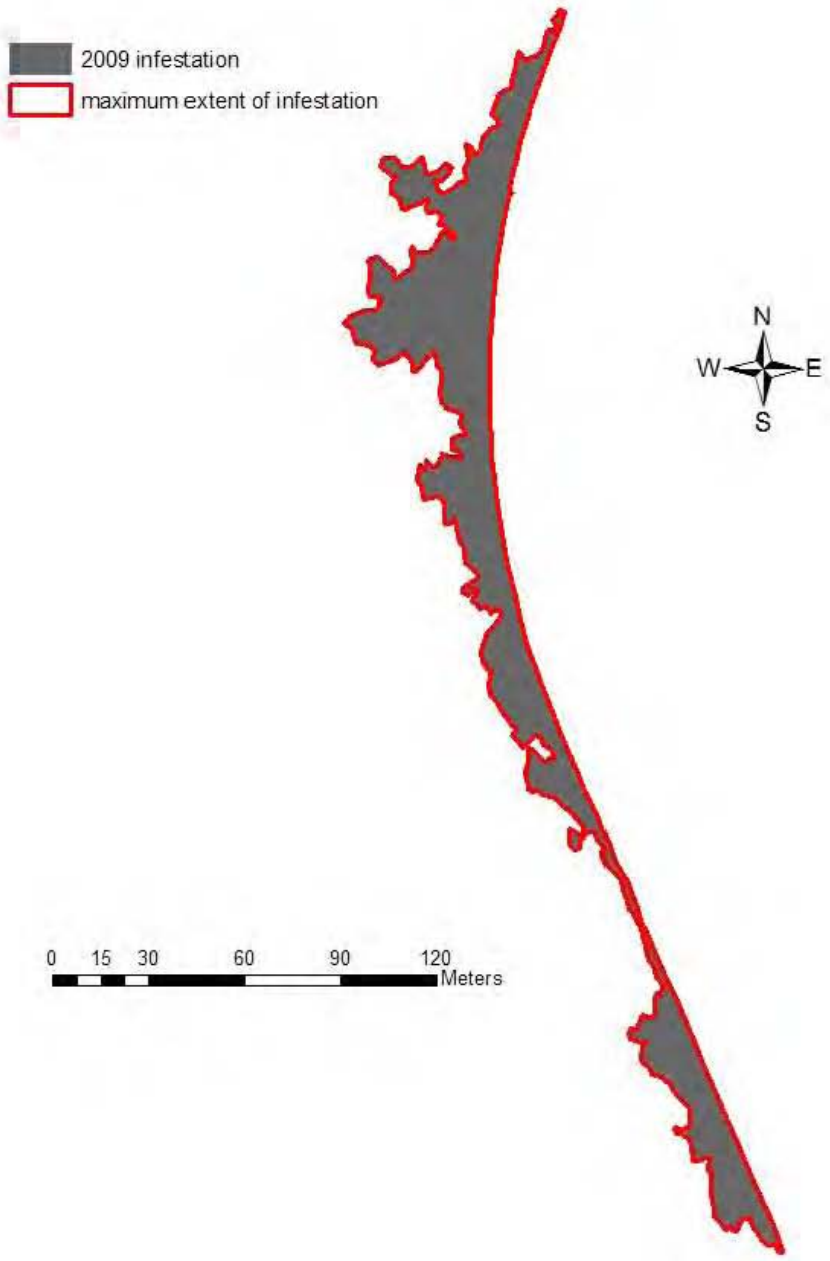
Highway 83 diffuse knapweed density in 2009



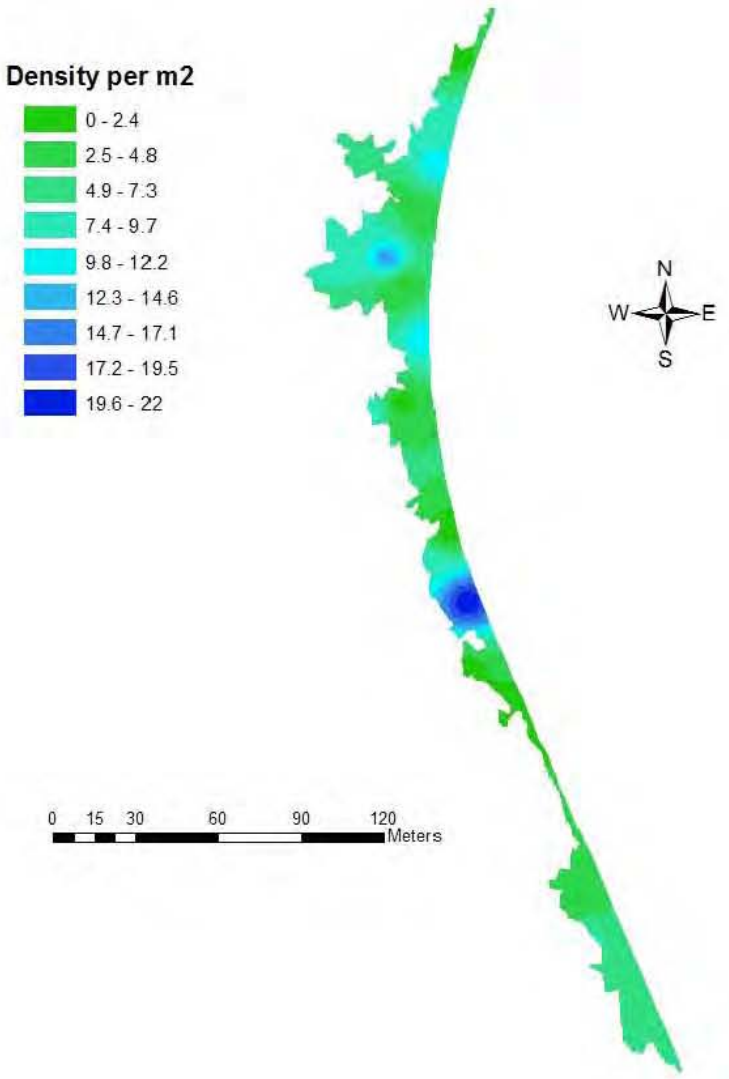


Highway 83 diffuse knapweed height in 2009.

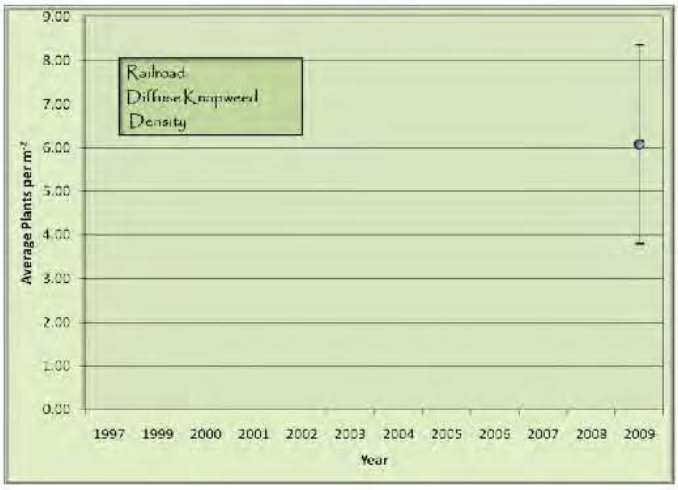


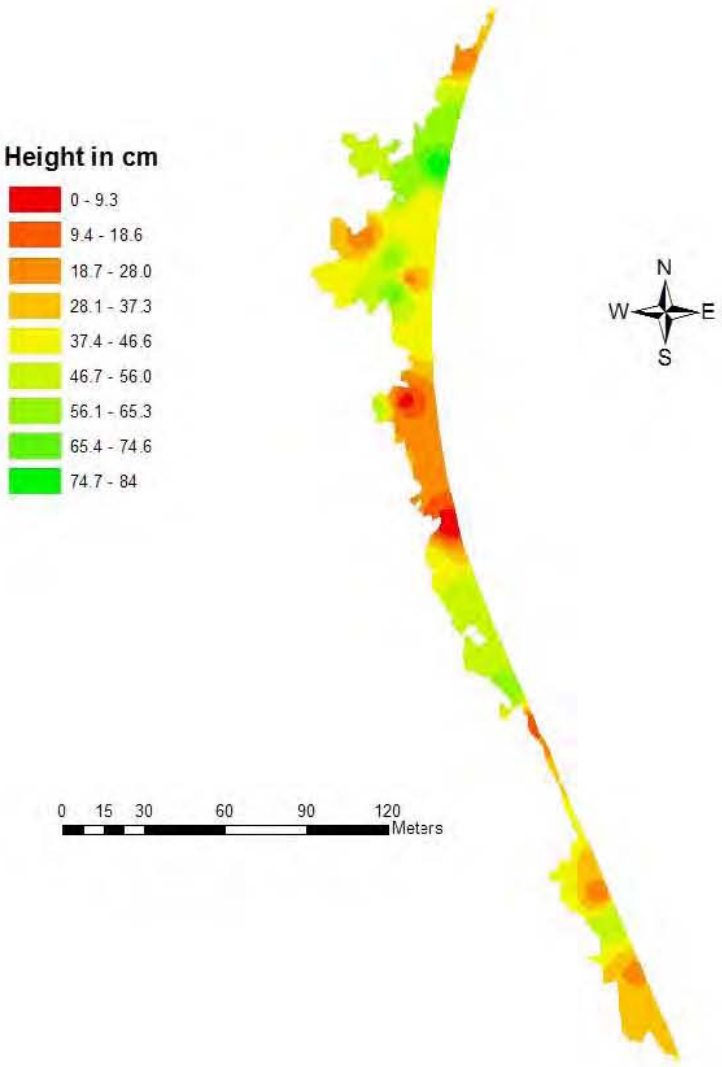


Railroad diffuse knapweed perimeter in 2009.

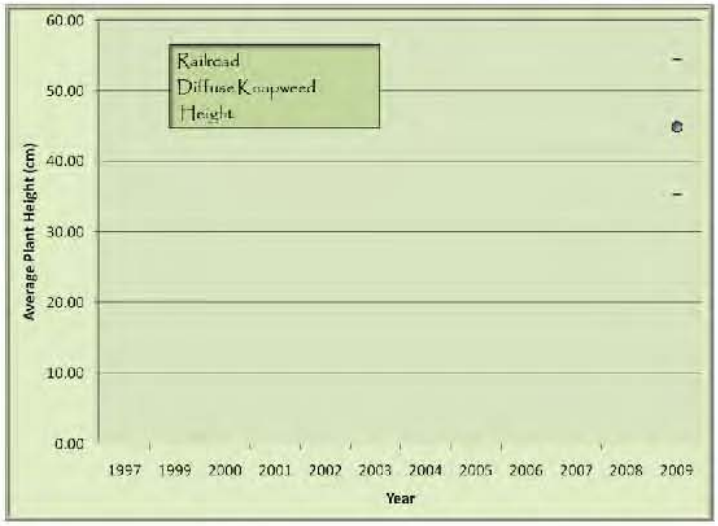


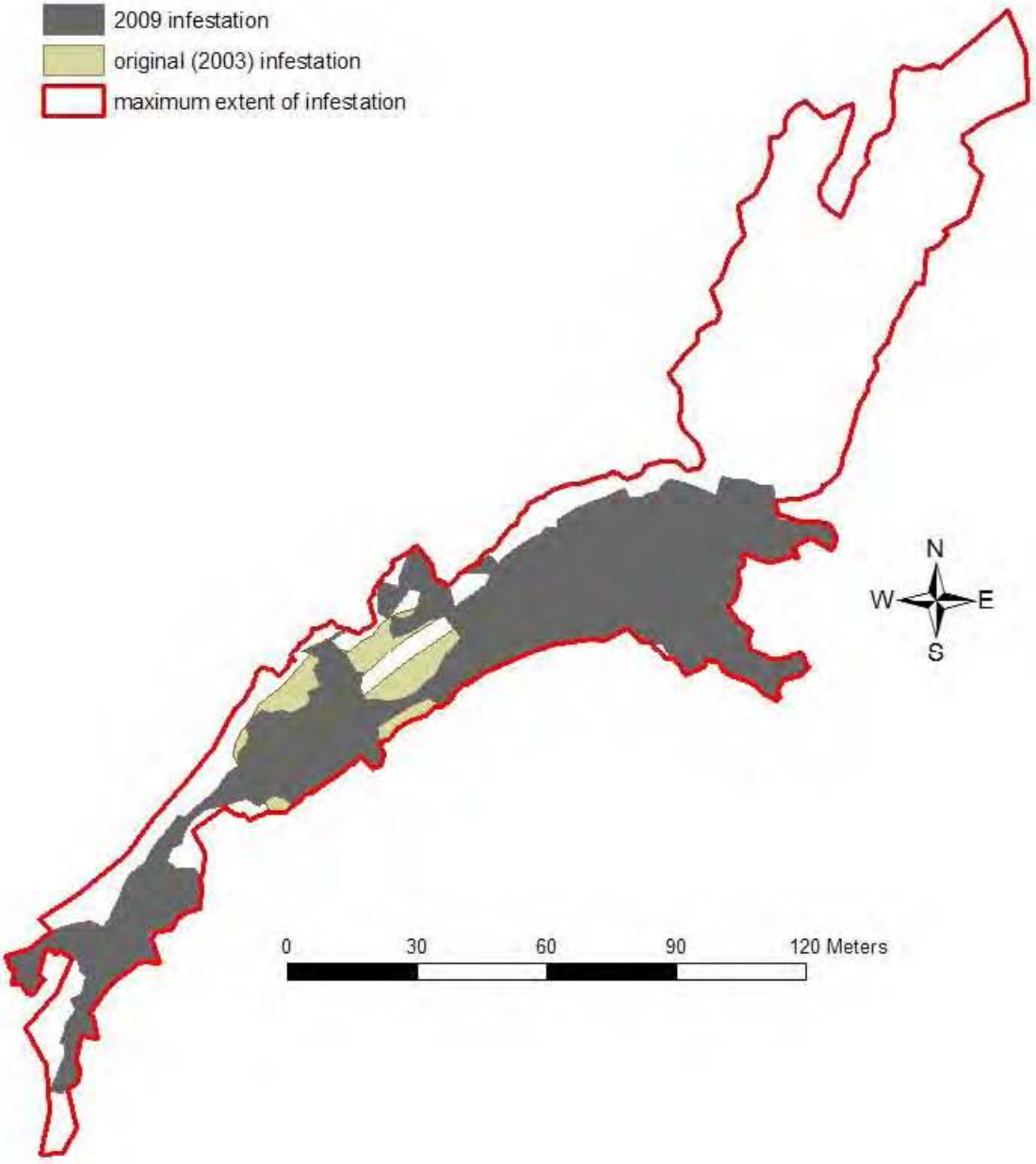
Railroad diffuse knapweed density in 2009.



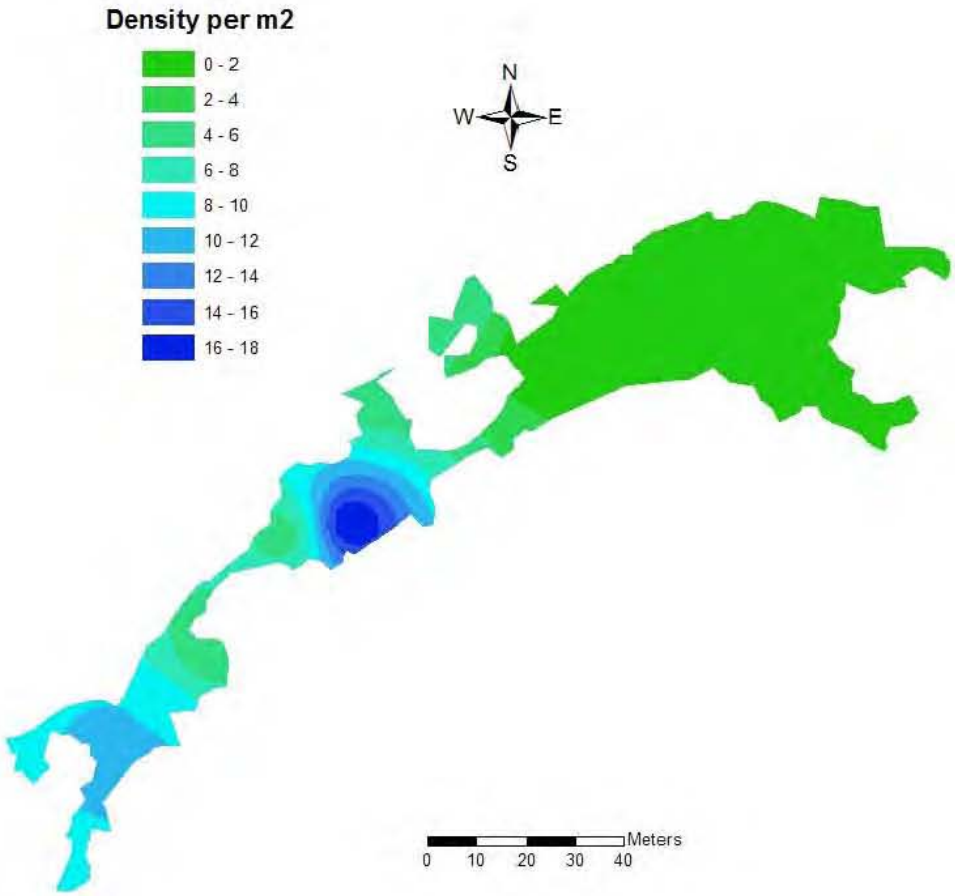


Railroad diffuse knapweed height in 2009.

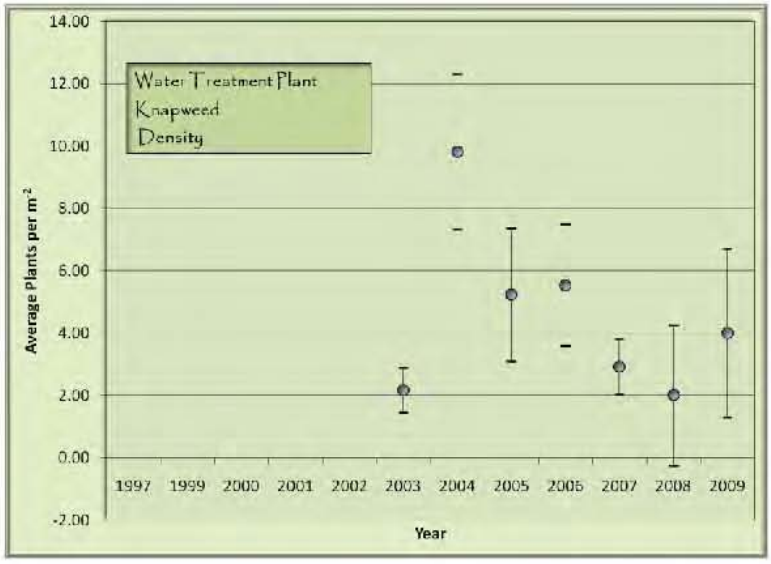


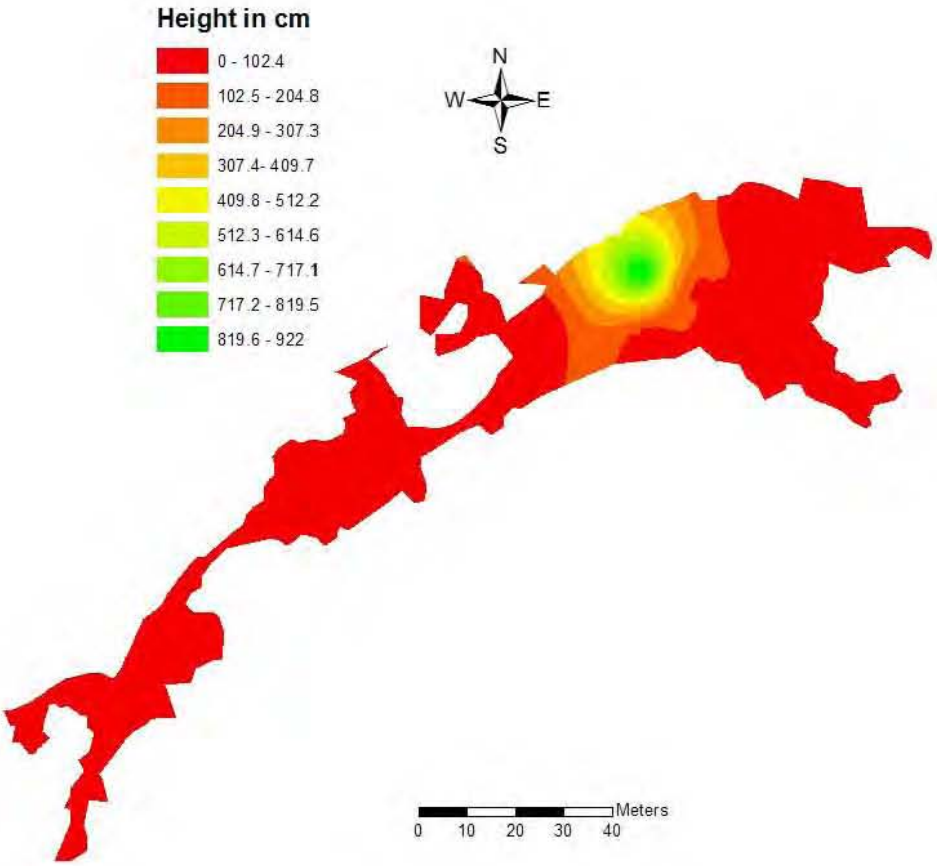


Water Treatment Plant diffuse and spotted knapweed perimeter in 2009.

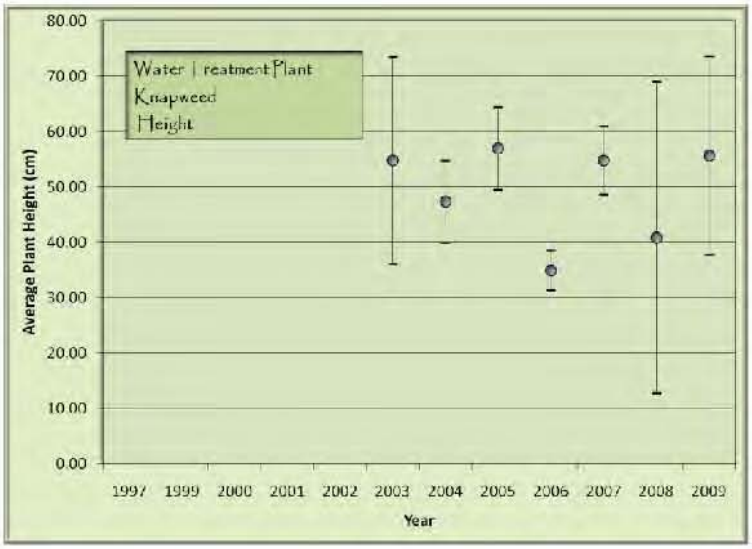


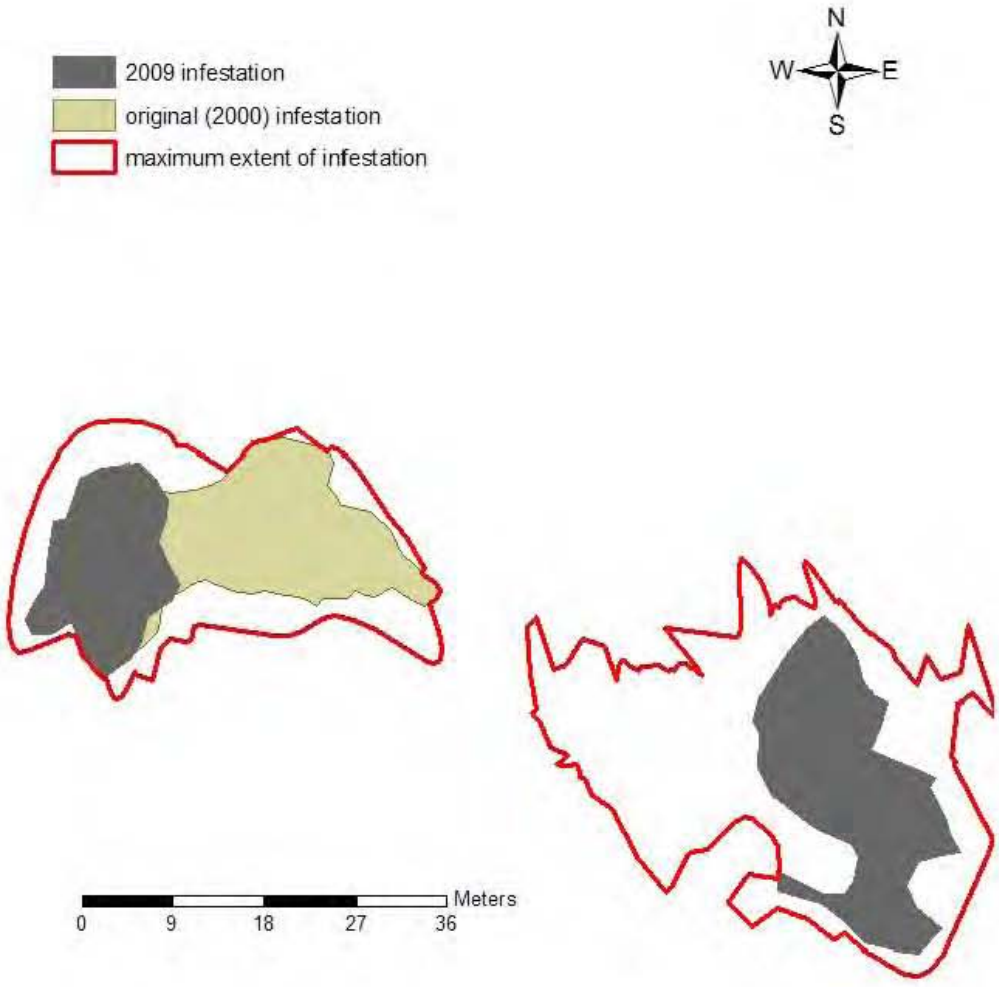
Water Treatment Plant diffuse and spotted knapweed density in 2009.



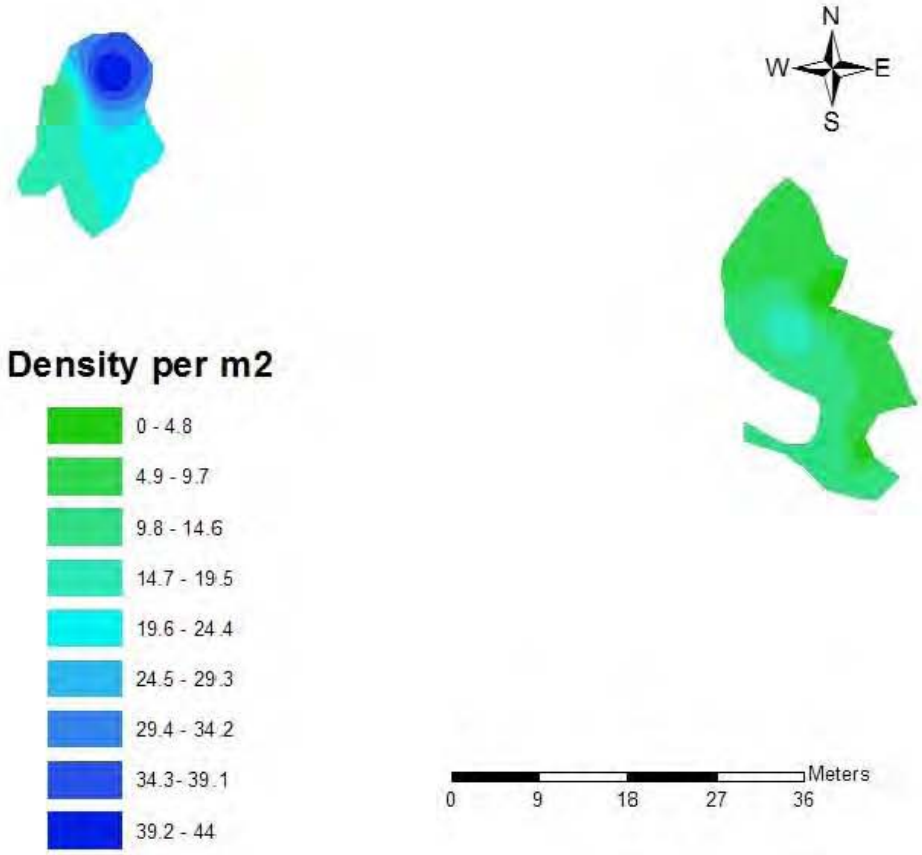


Water Treatment Plant diffuse and spotted knapweed height in 2009.

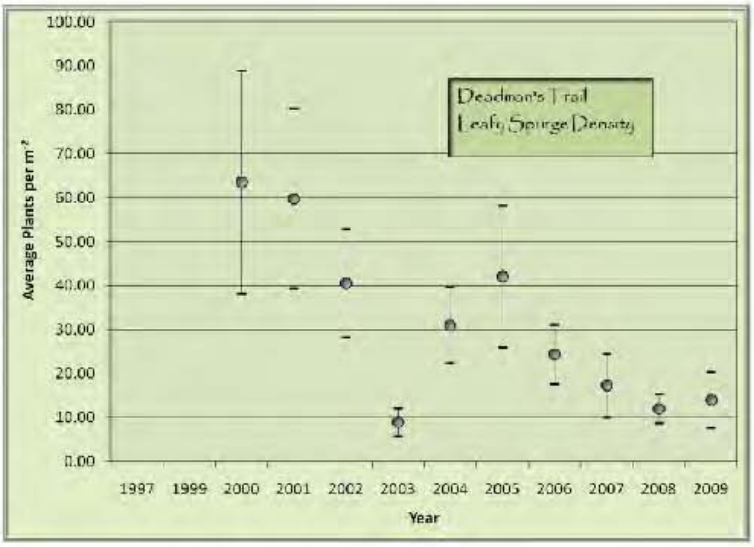


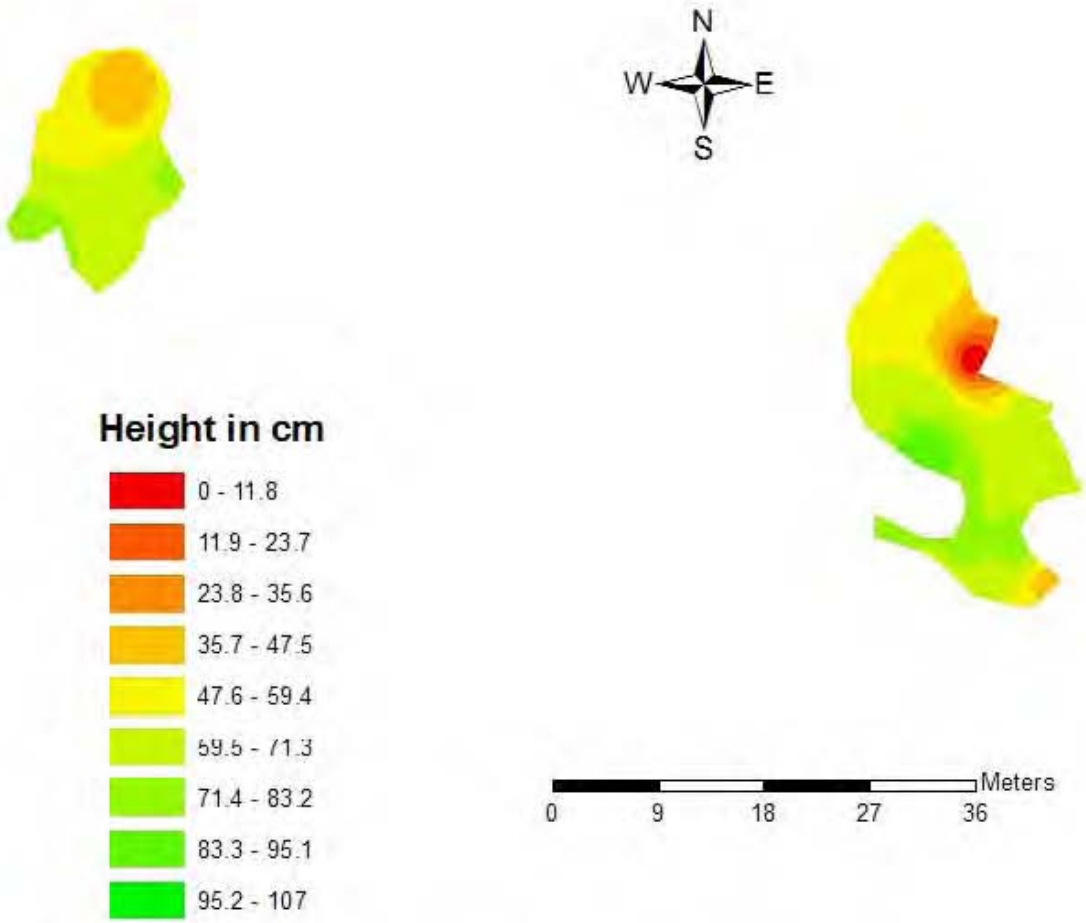


Deadman's Trail leafy spurge perimeter in 2009.

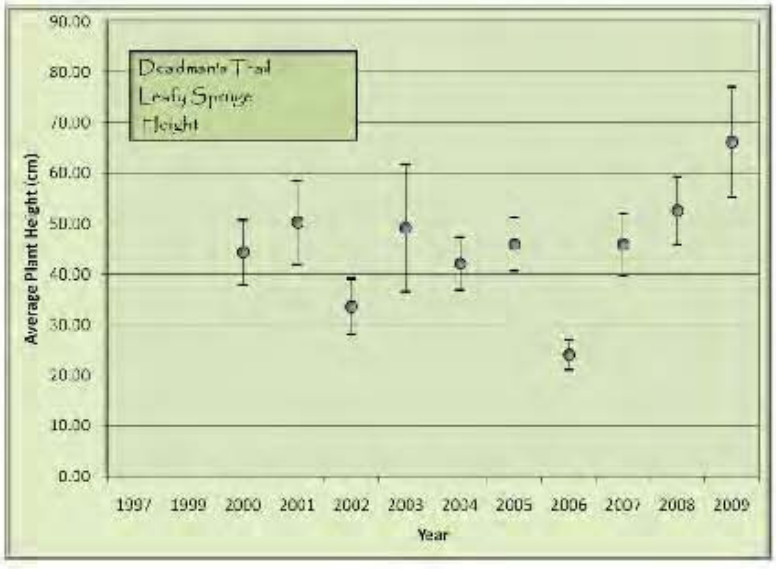


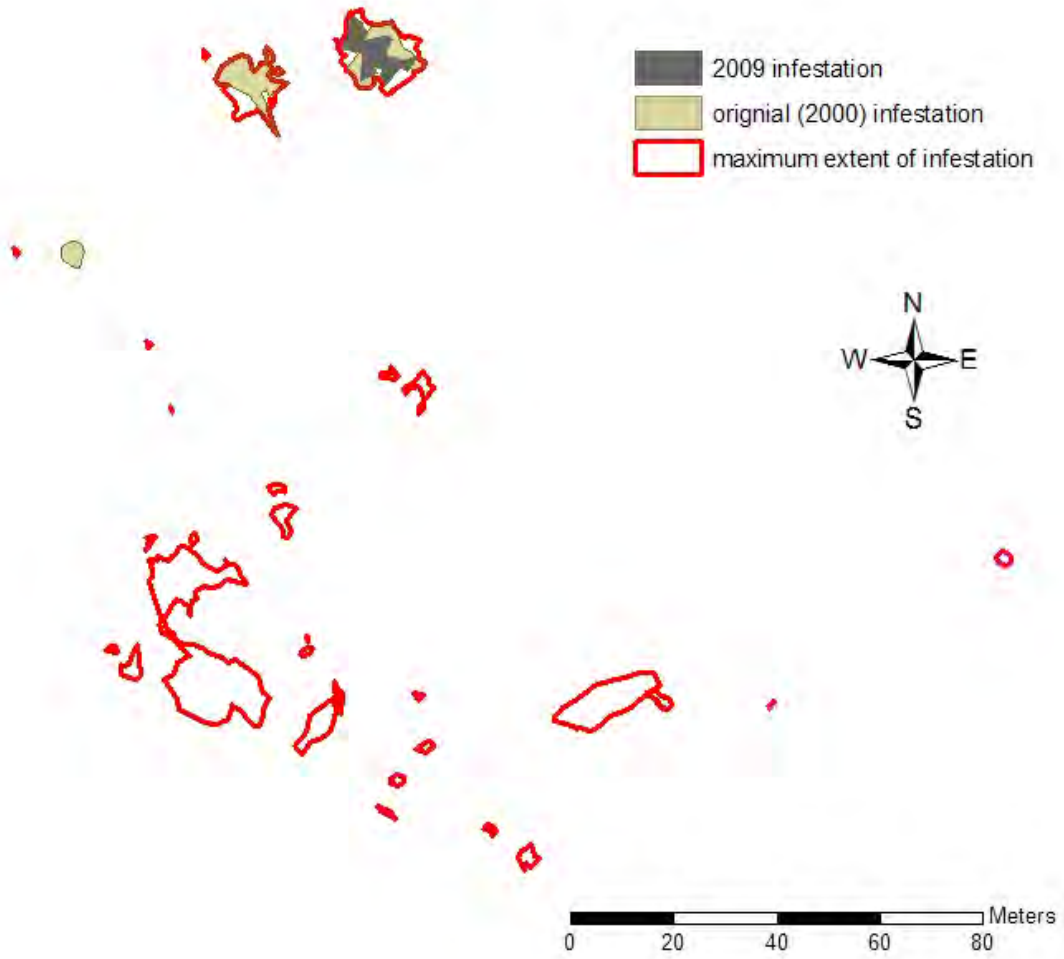
Deadman's Trail leafy spurge density in 2009.



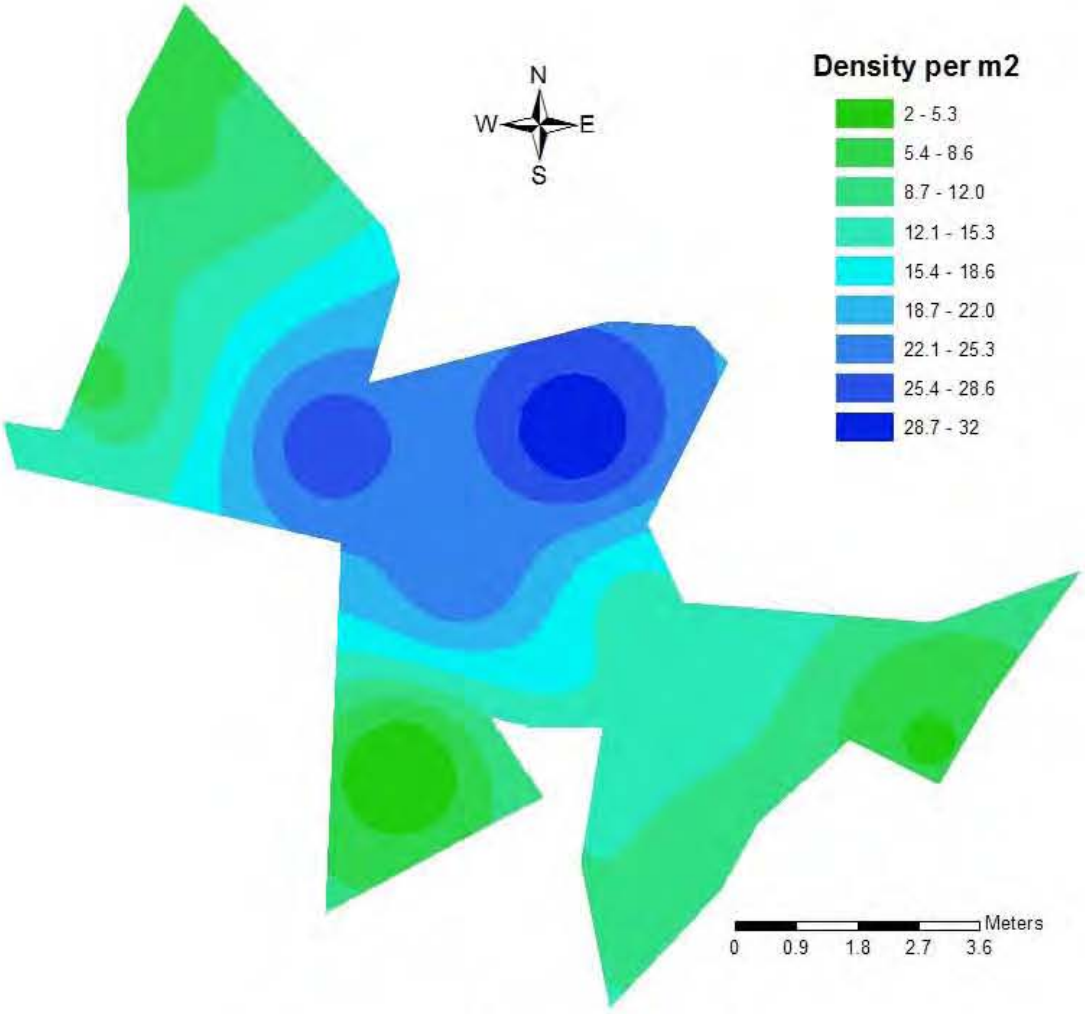


Deadman's Trail leafy spurge height in 2009.

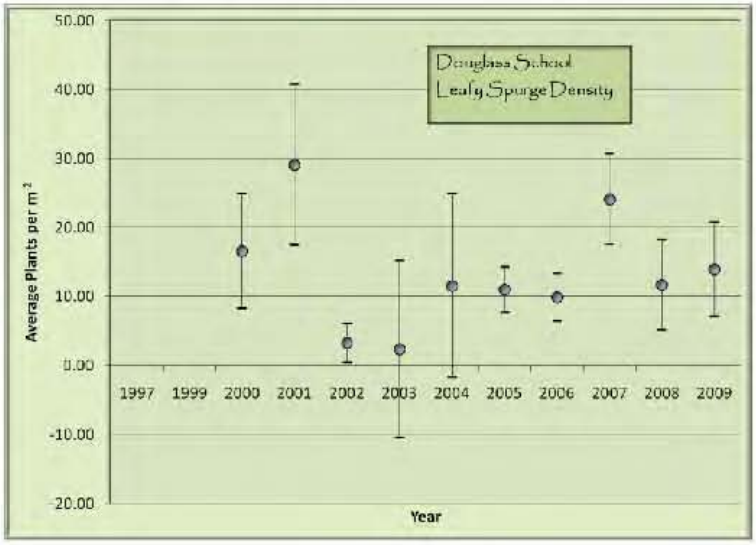


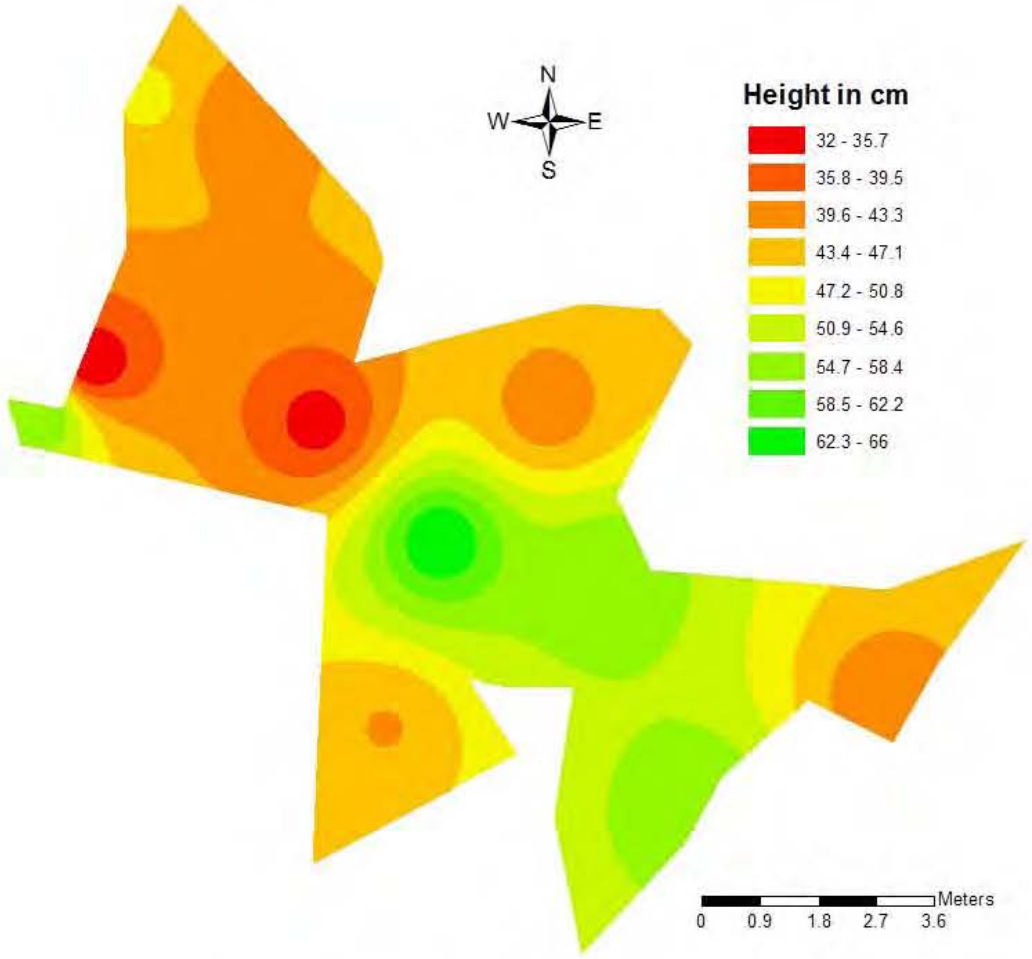


Douglass School leafy spurge perimeter in 2009.

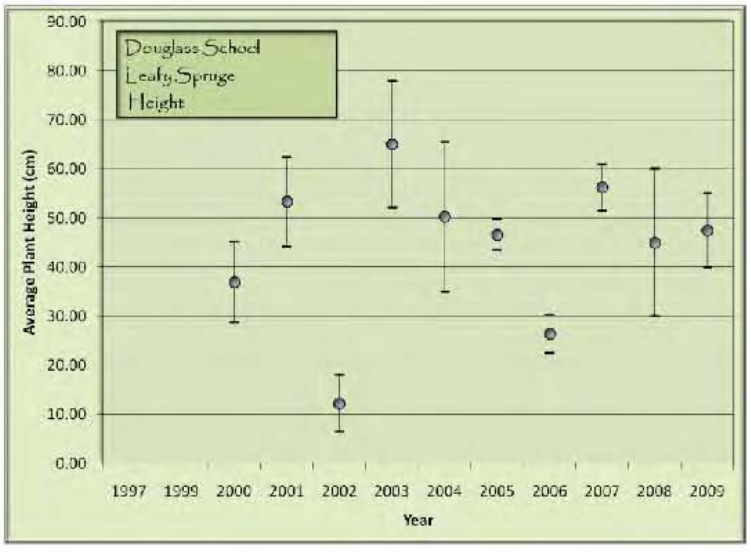


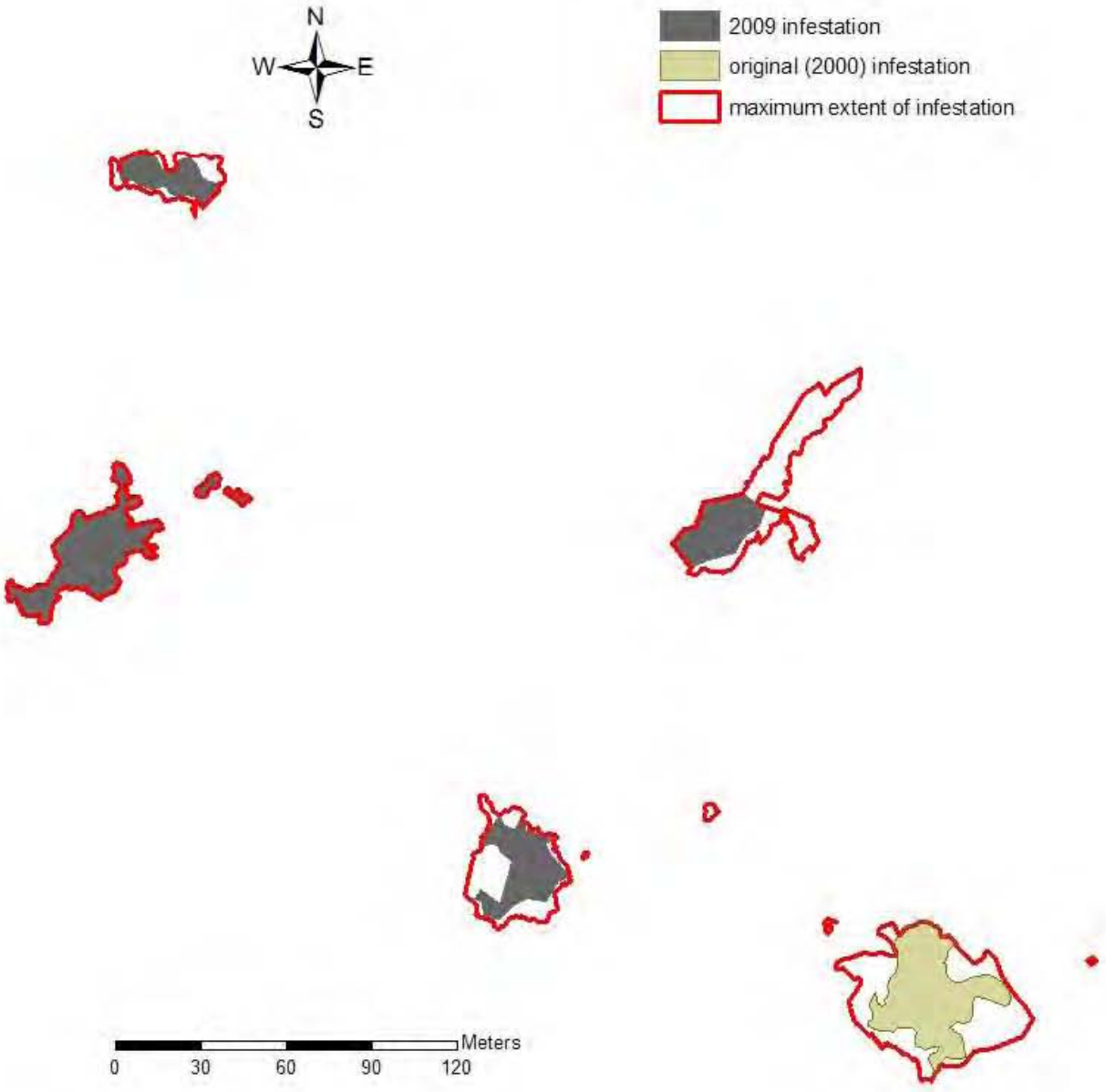
Douglass School leafy spurge density in 2009.



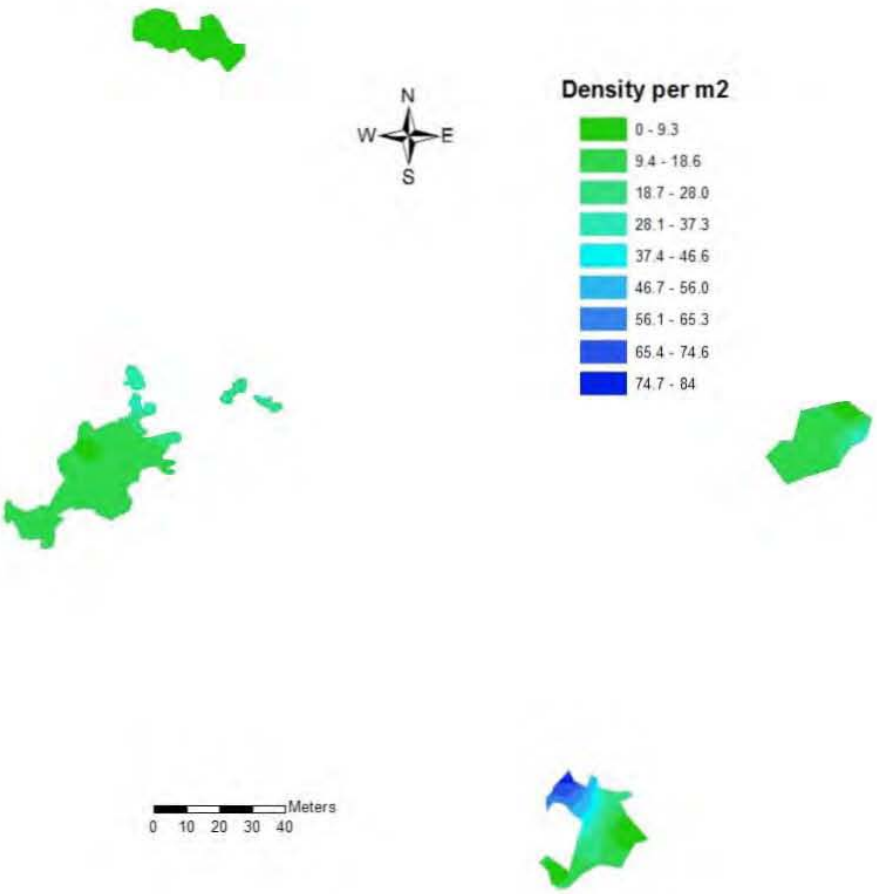


Douglass School leafy spurge height in 2009.

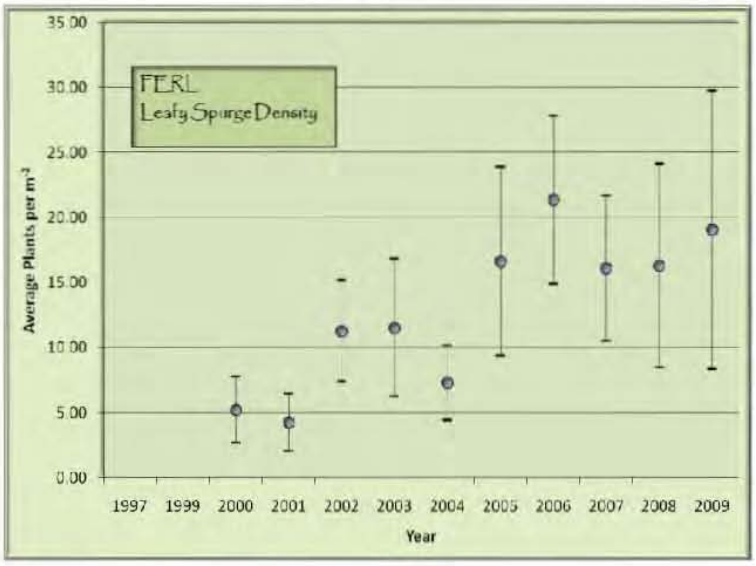


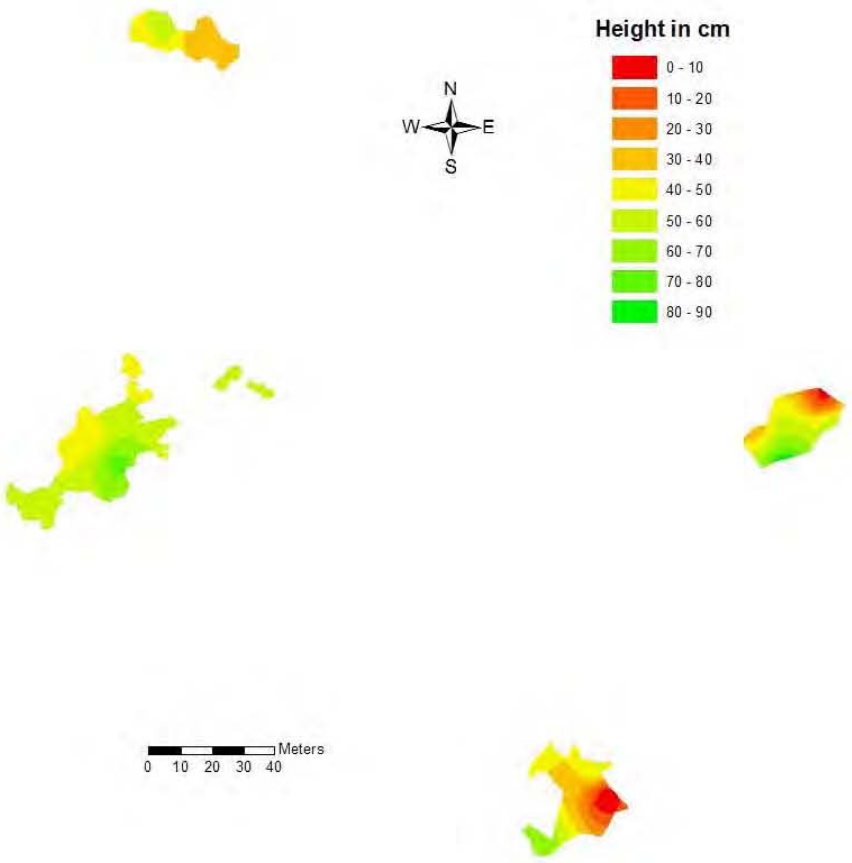


FERL Leafy spurge perimeter in 2009.

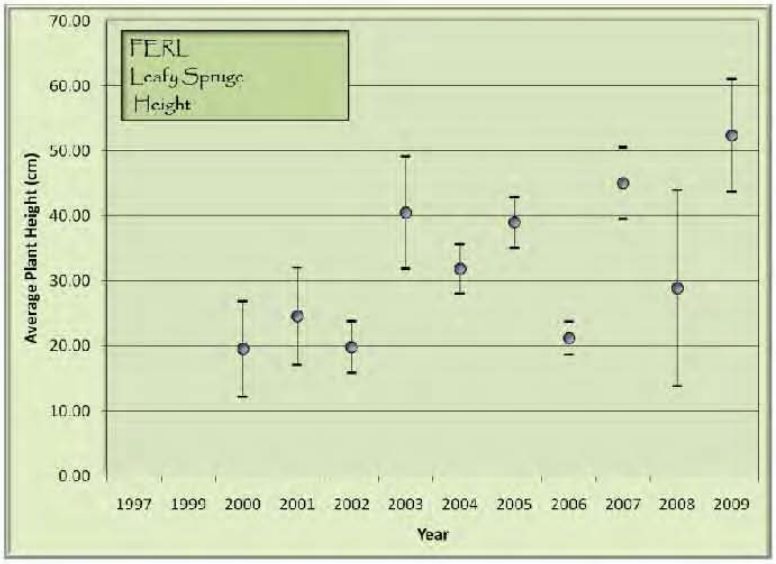


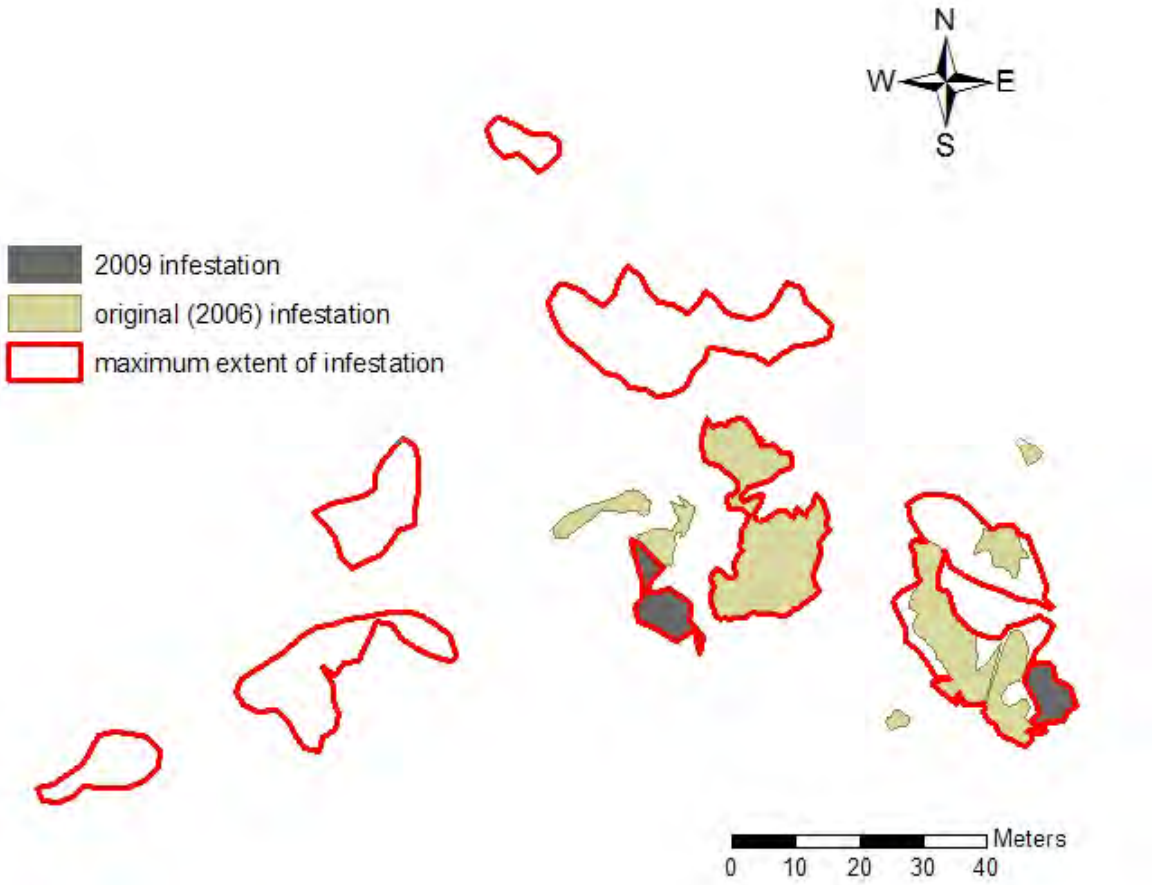
FERL leafy spurge density in 2009.



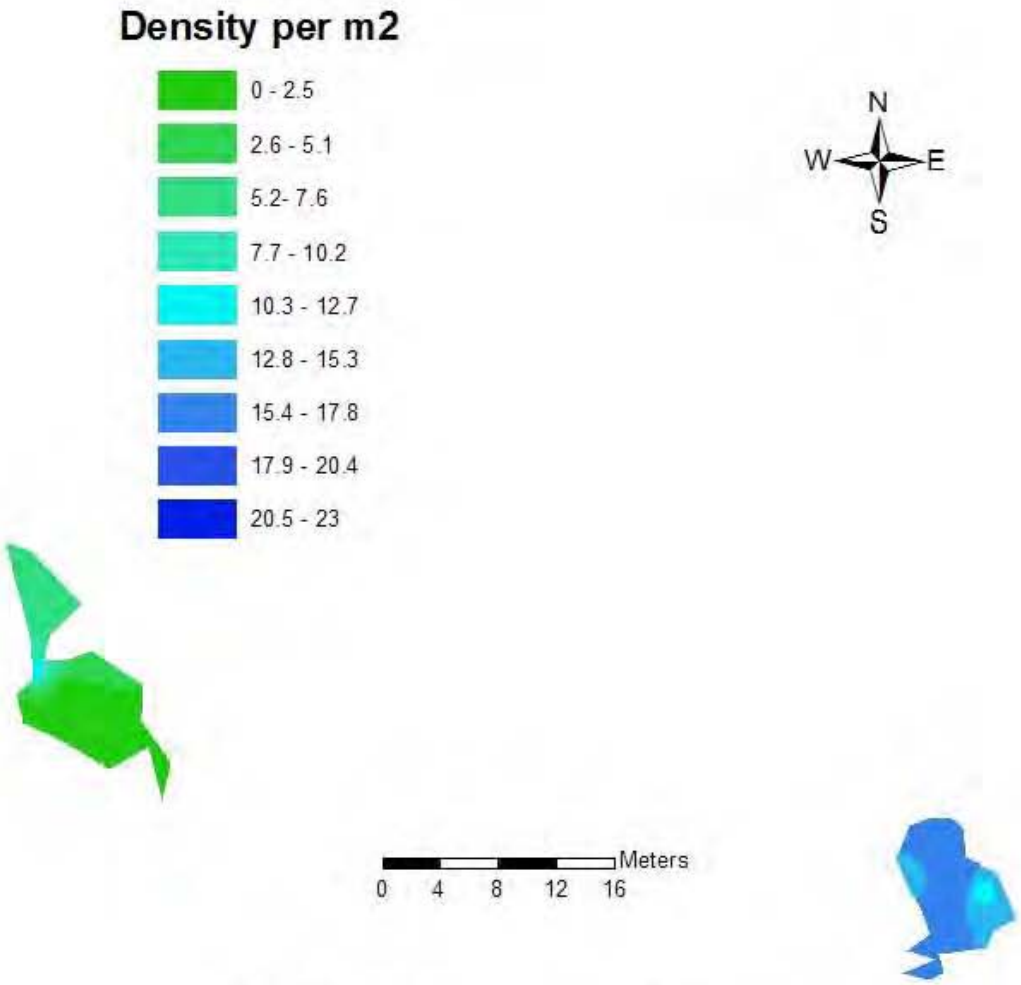


FERL leafy spurge height in 2009.

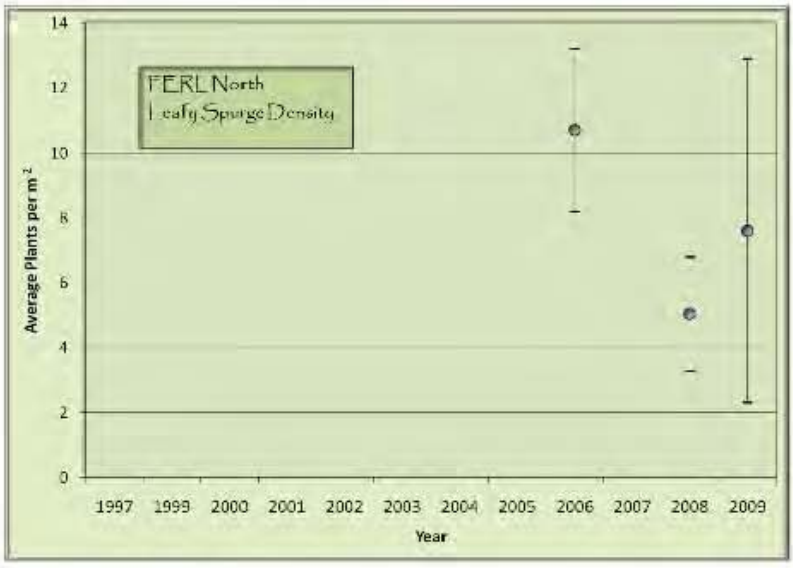


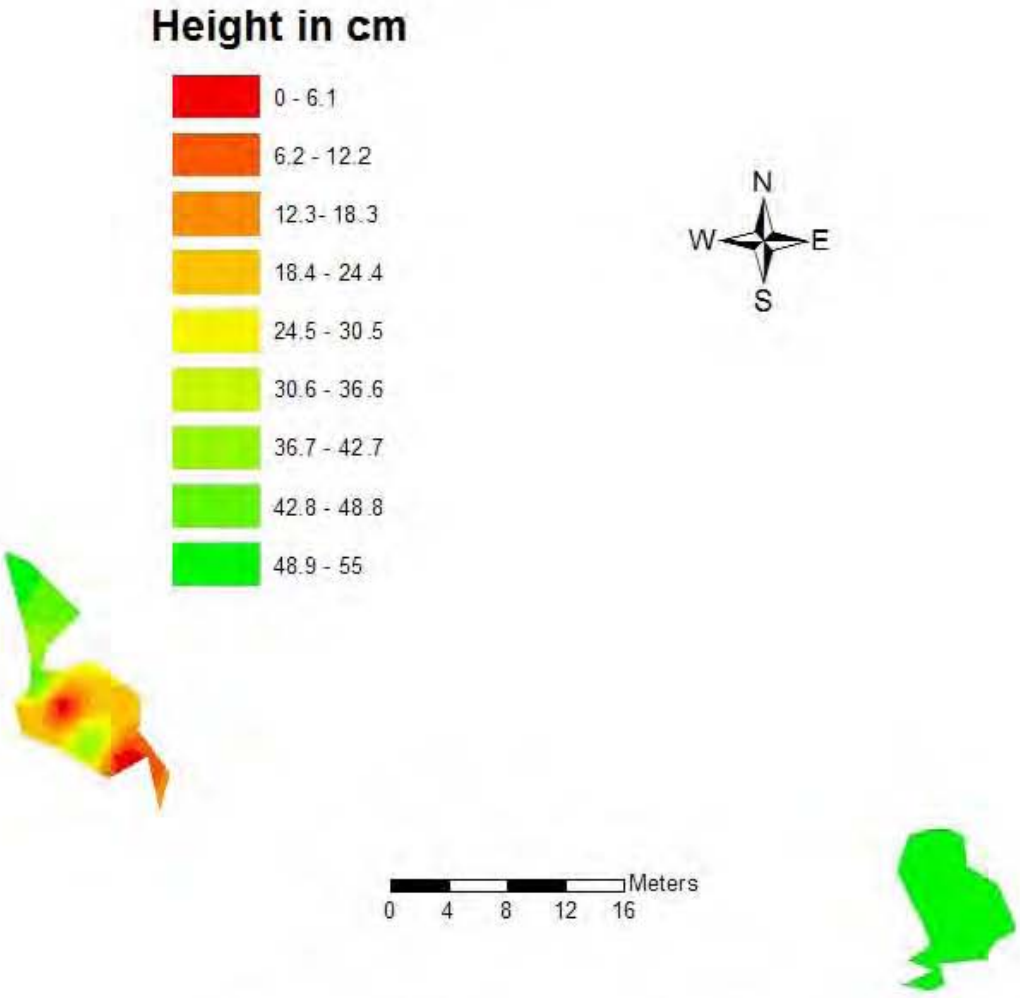


FERL North leafy spurge perimeter in 2009.

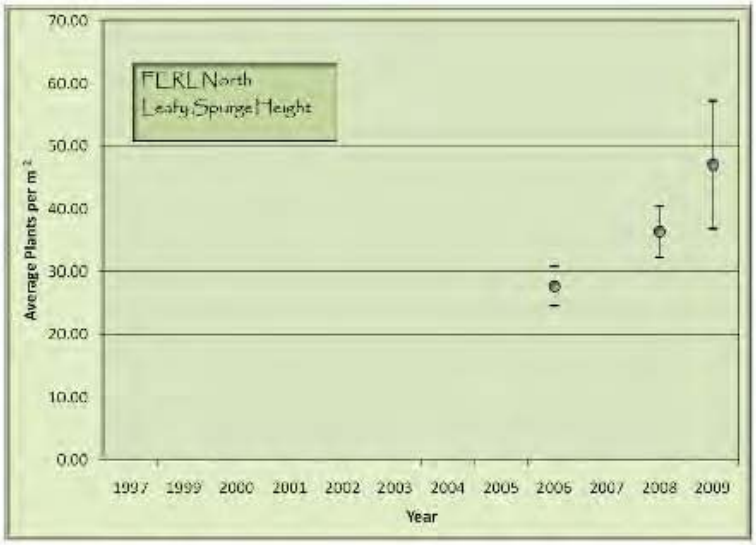


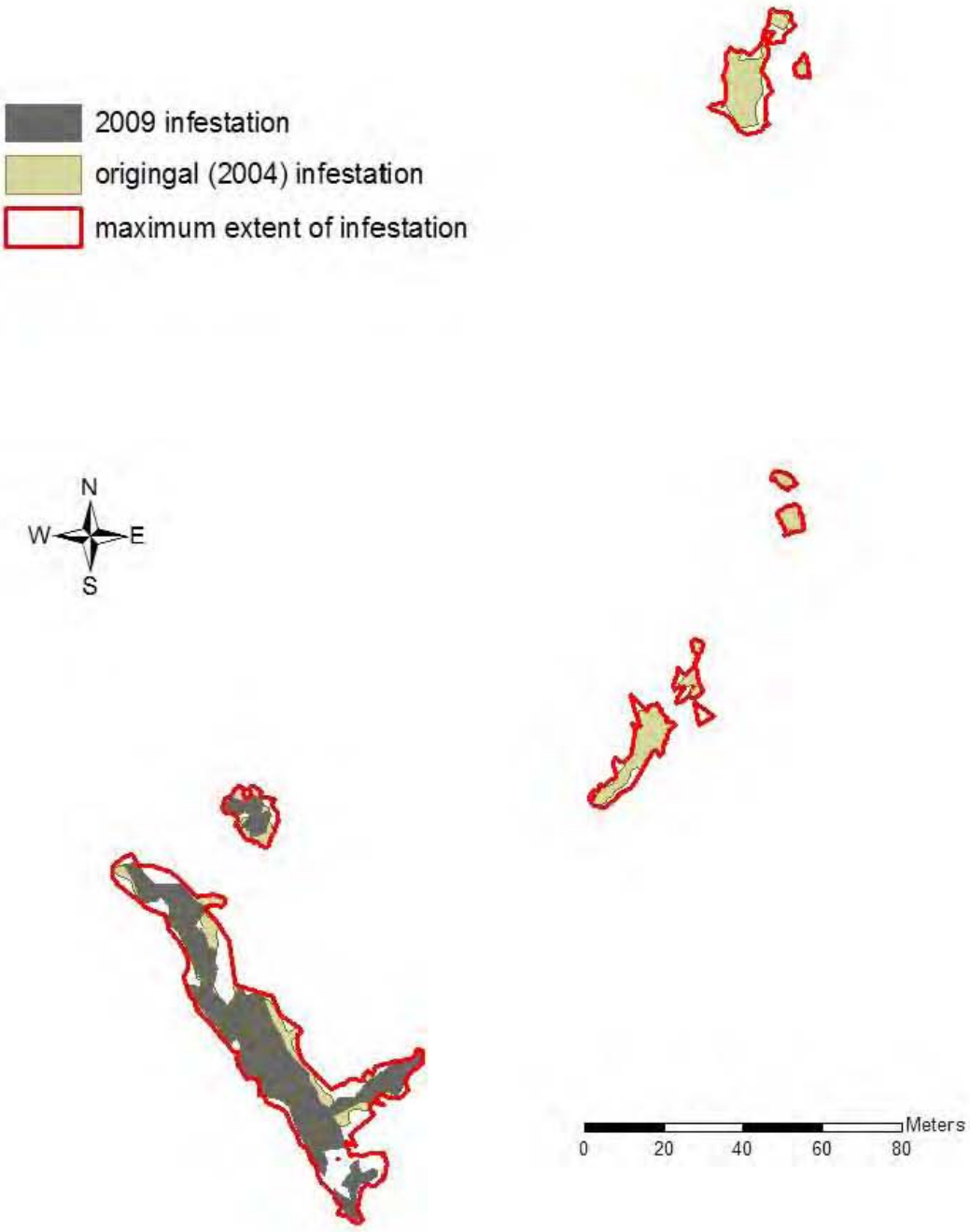
FERL North leafy spurge density in 2009.



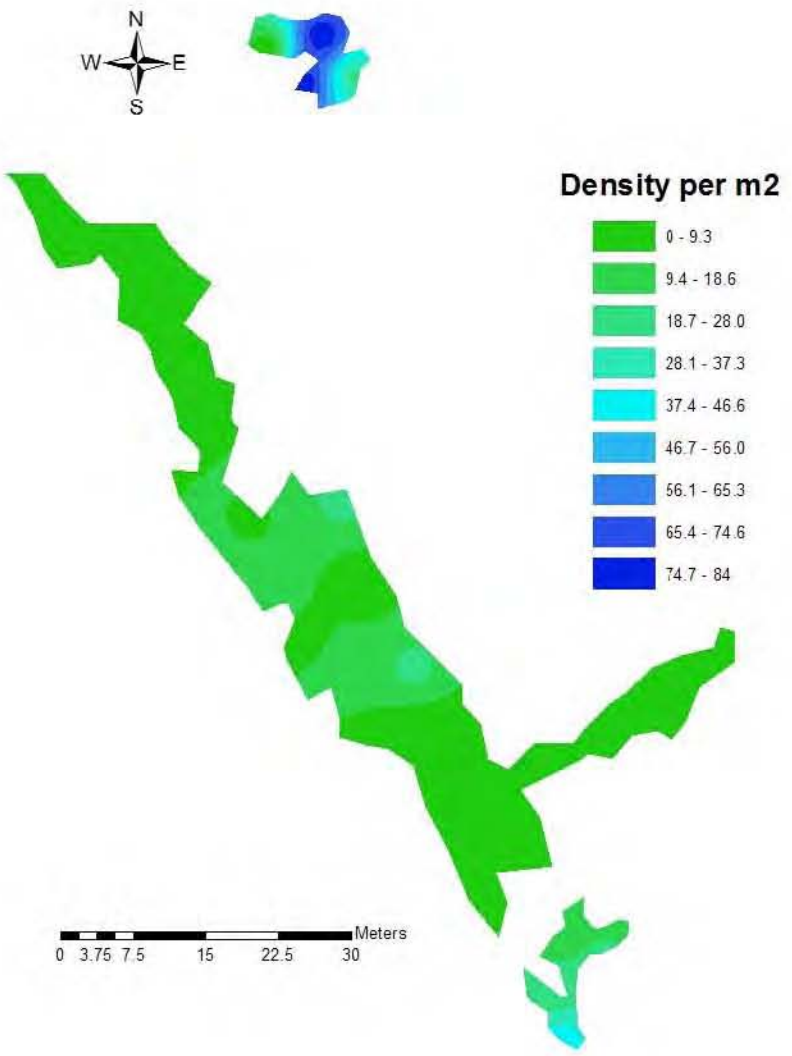


FERL North leafy spurge height in 2009.

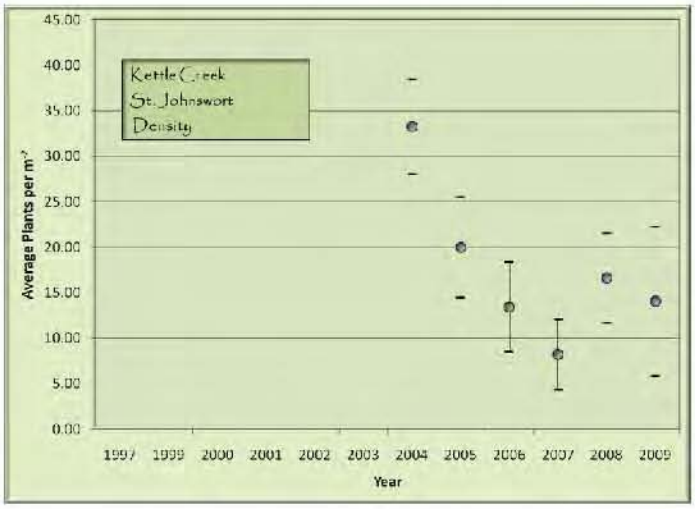


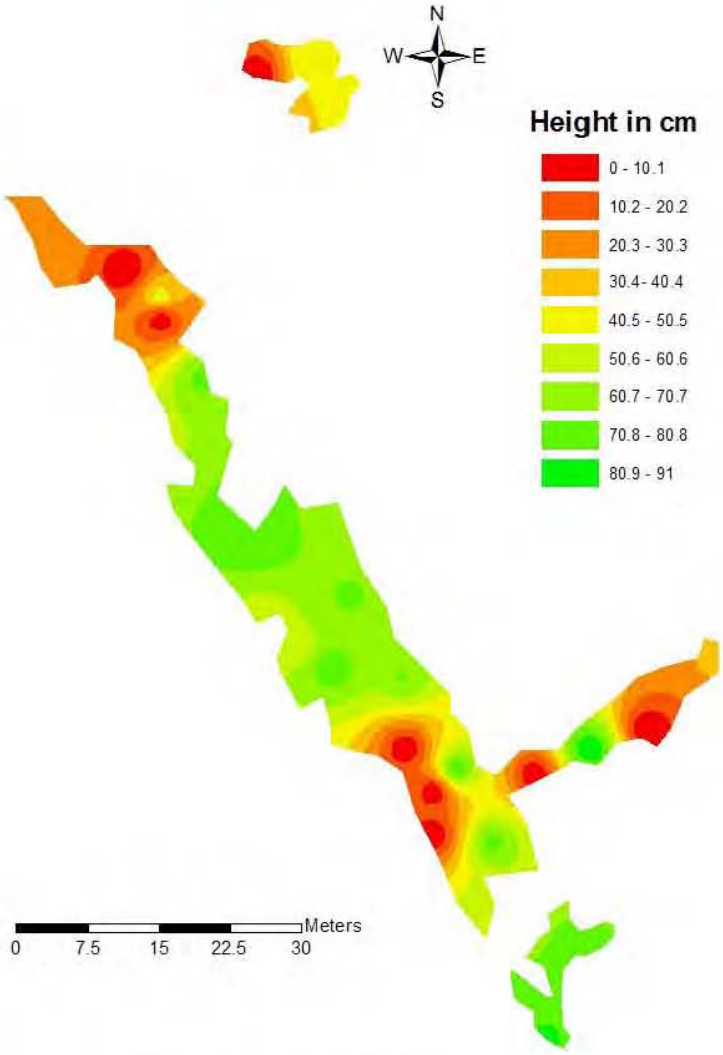


Kettle Creek St. Johnswort perimeter in 2009.

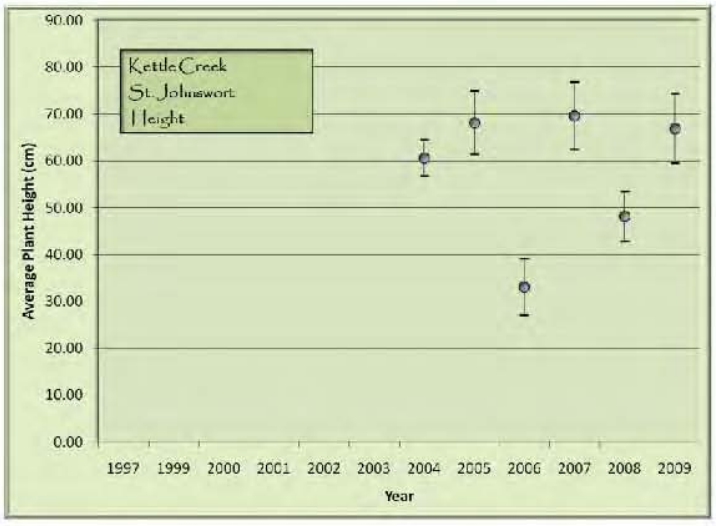


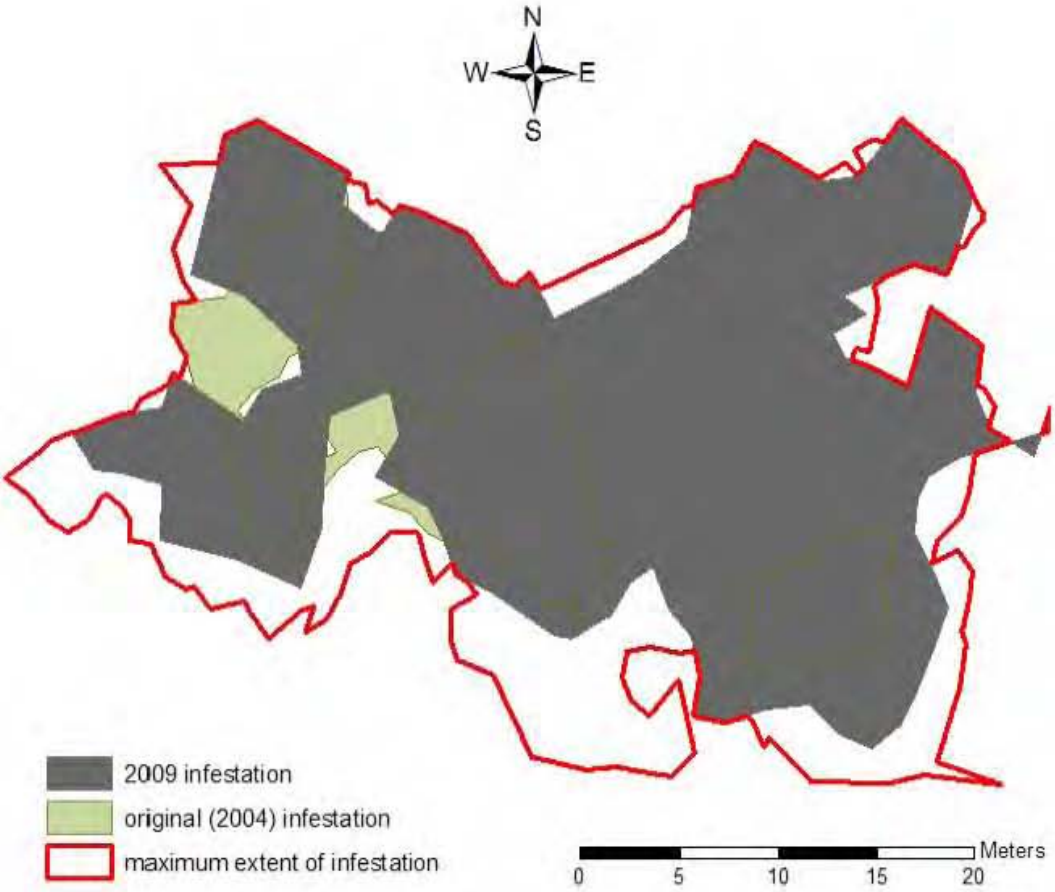
Kettle Creek St. Johnswort density in 2009.



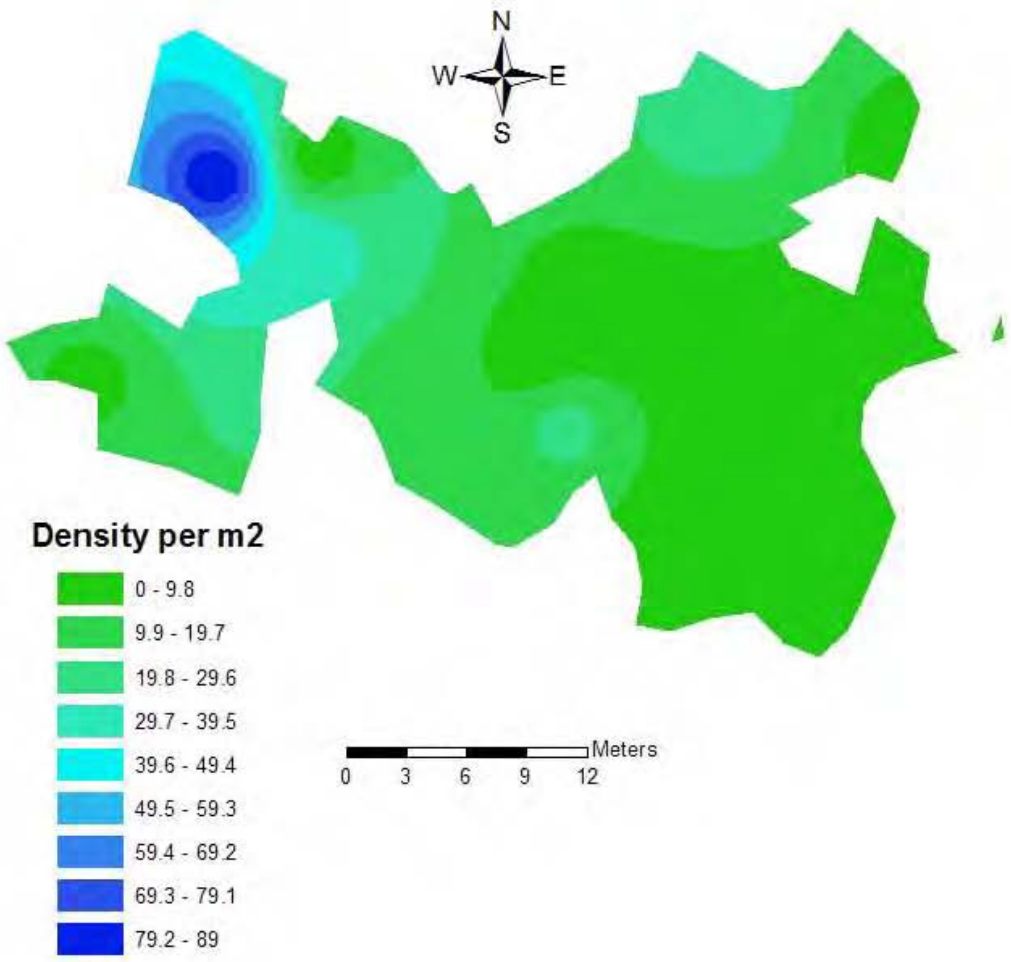


Kettle Creek St. Johnswort height in 2009.

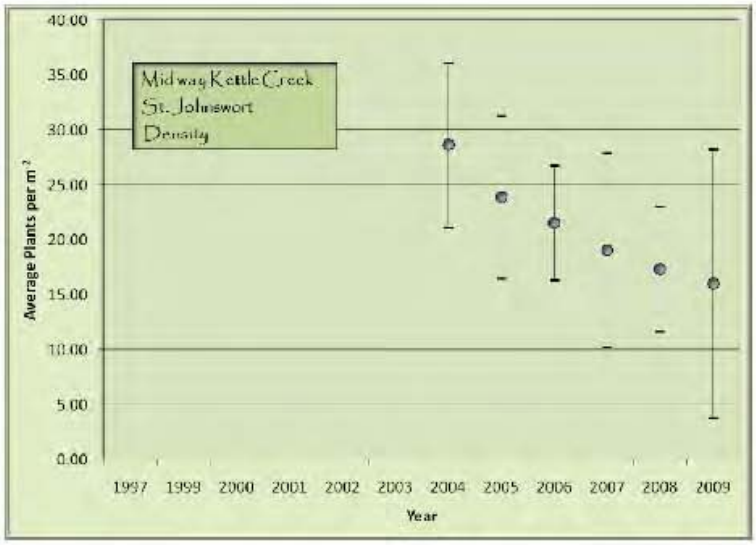


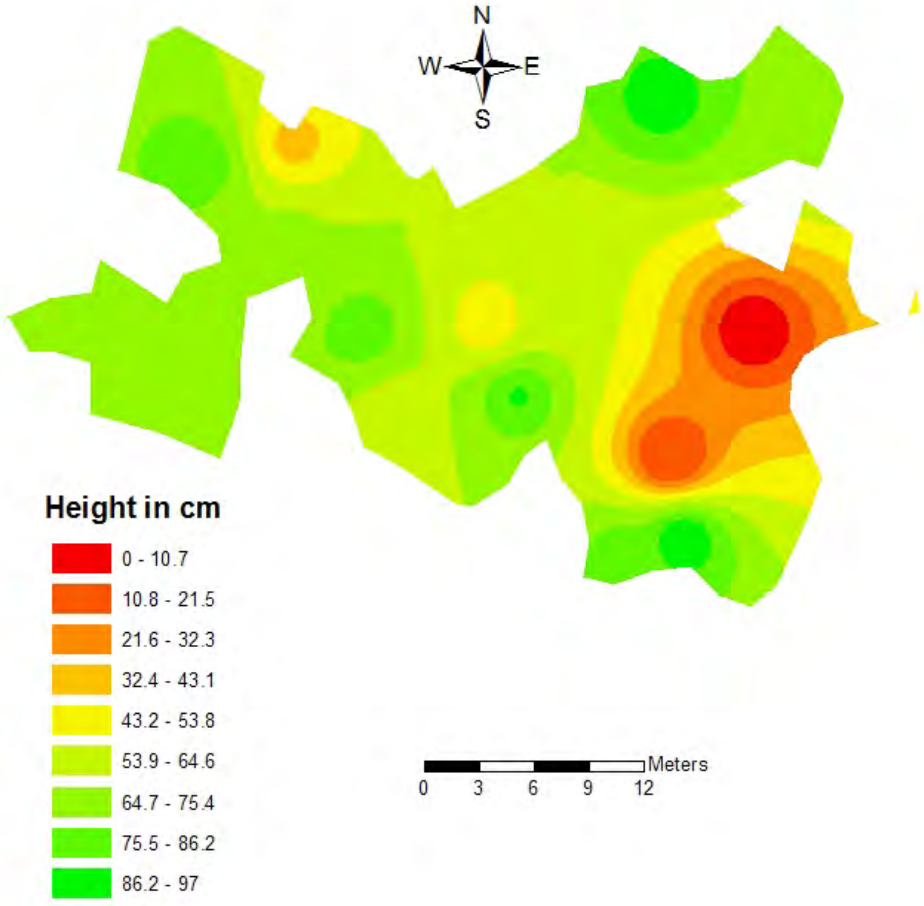


Midway Kettle Creek St. Johnswort perimeter in 2009.

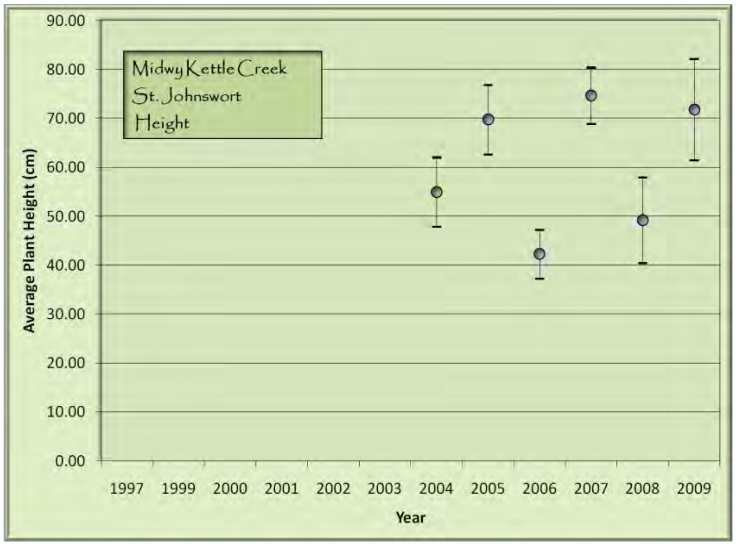


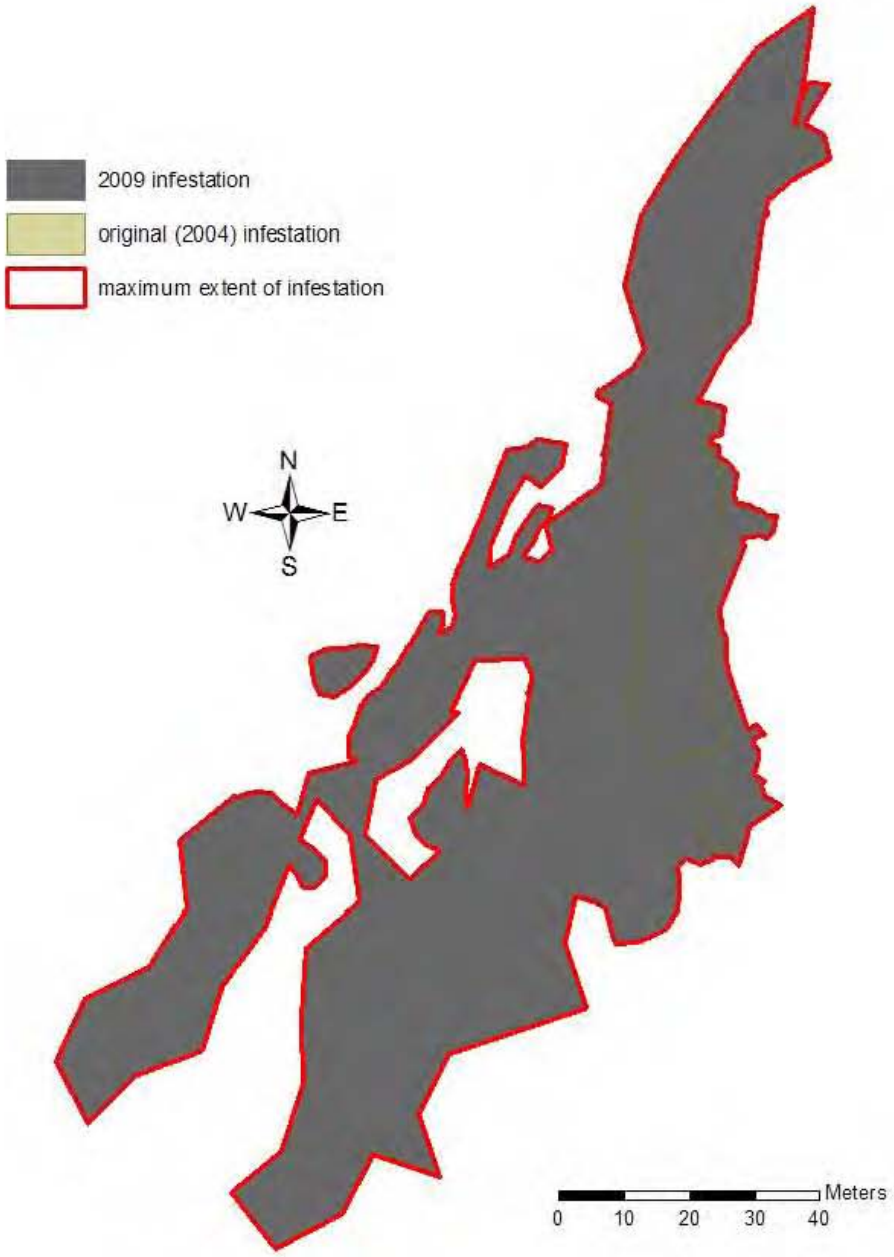
Midway Kettle Creek St. Johnswort density in 2009.



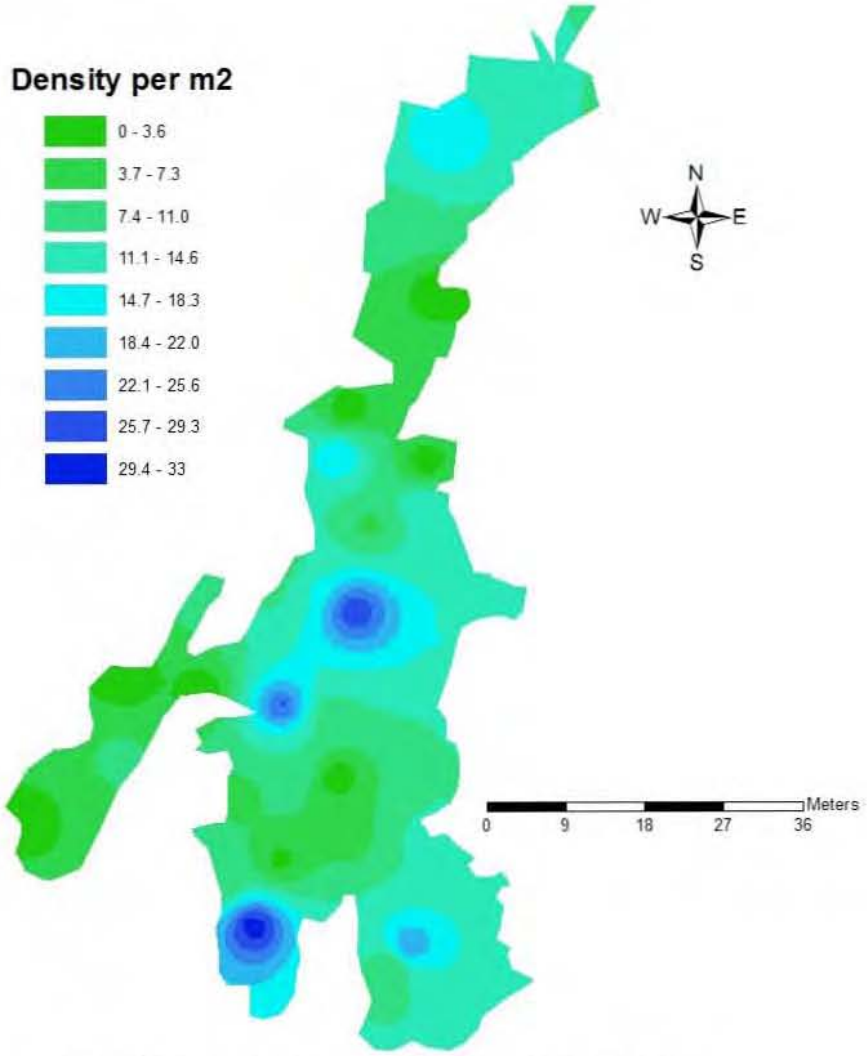


Midway Kettle Creek St. Johnswort height in 2009.

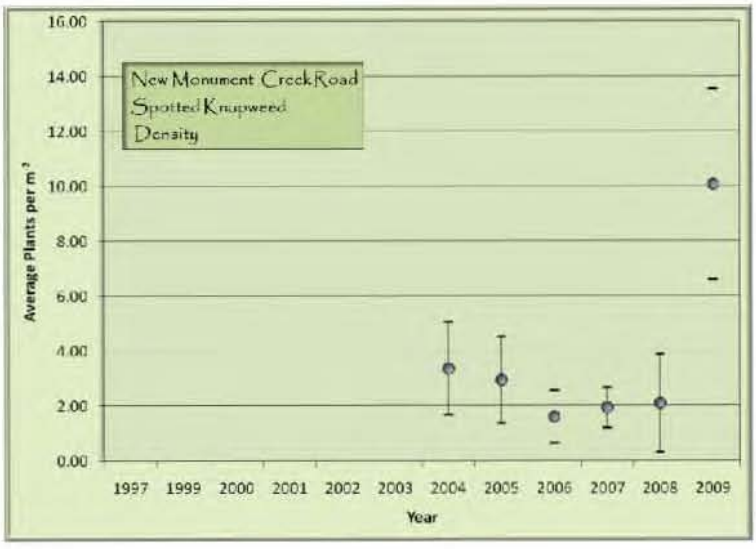


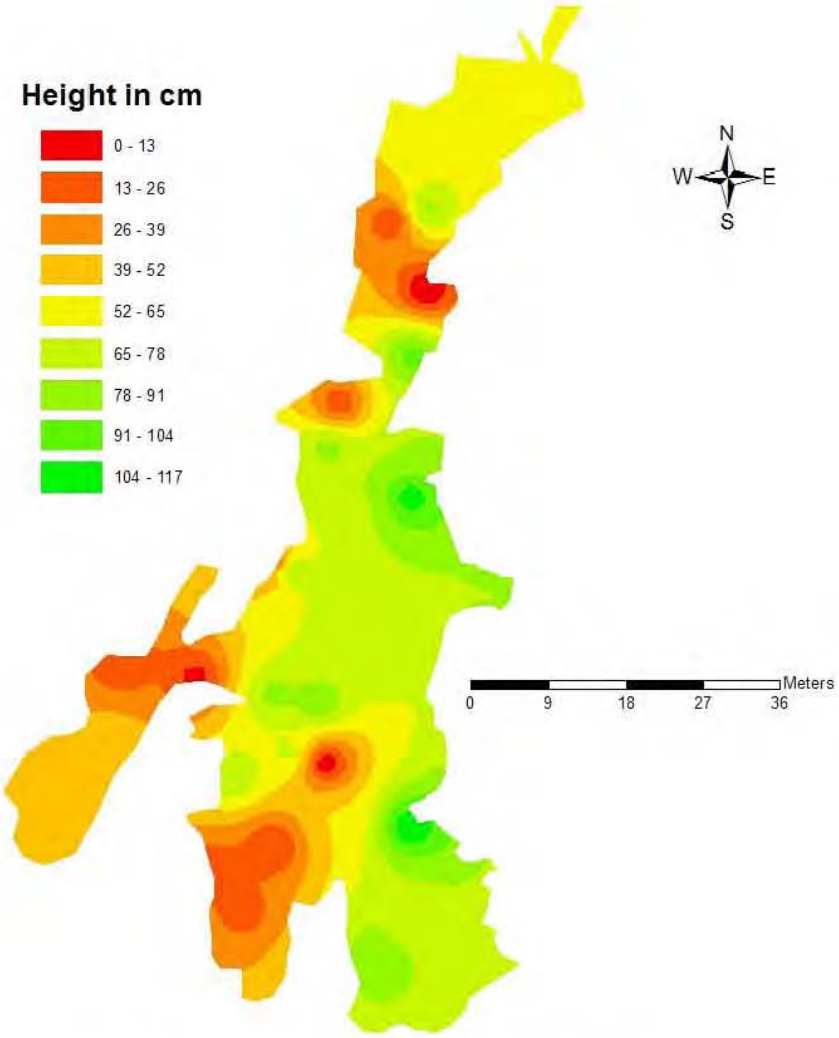


New Monument Creek spotted knapweed perimeter in 2009.

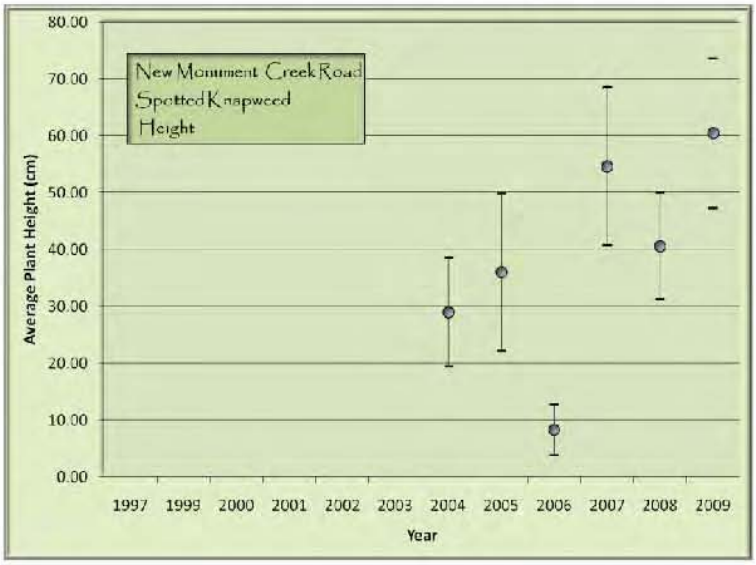


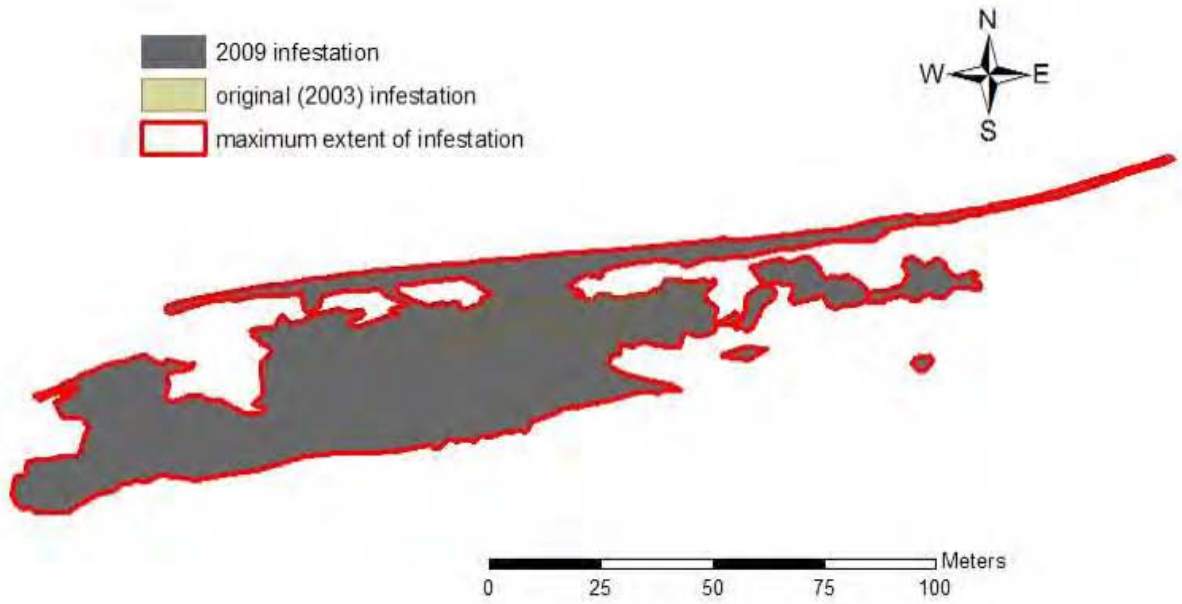
New Monument Creek spotted knapweed density in 2009.



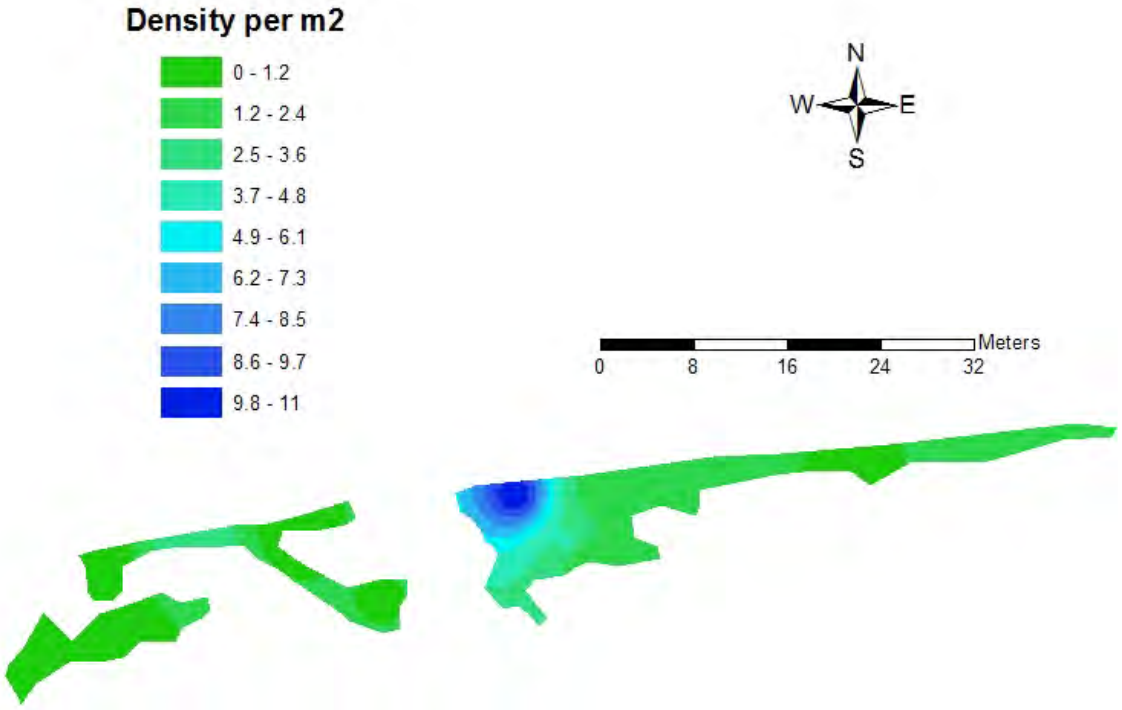


New Monument Creek spotted knapweed height in 2009.

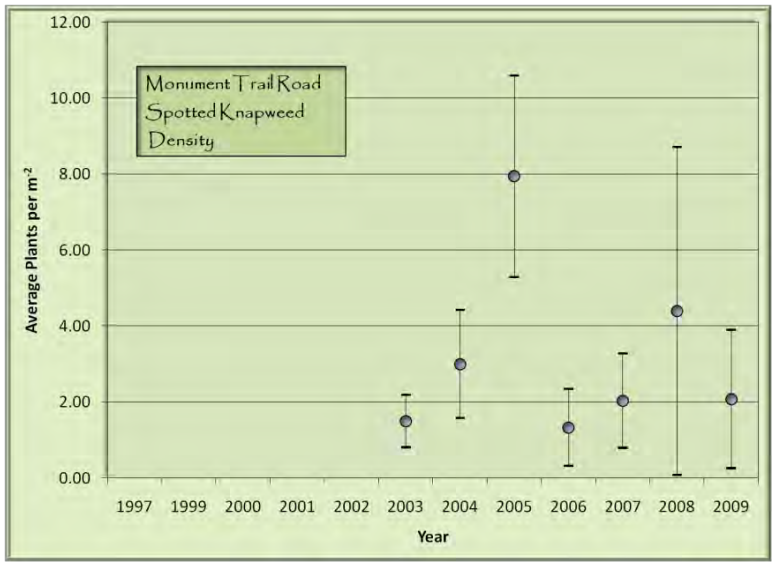


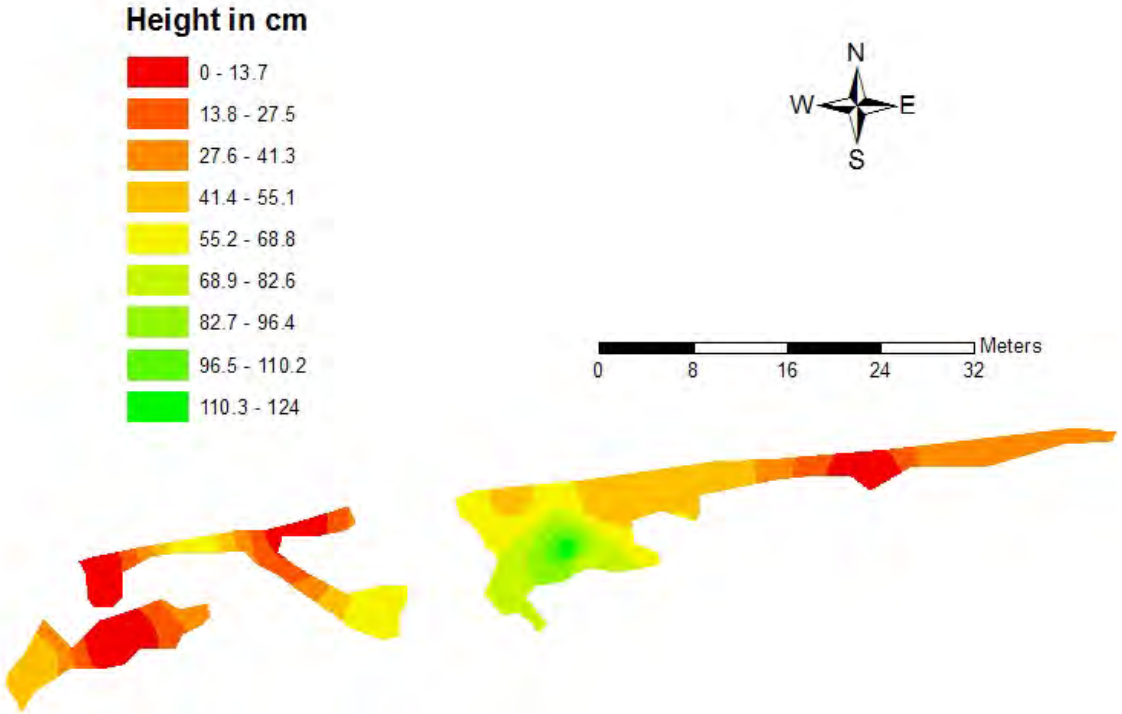


Monument Trail Road spotted knapweed perimeter in 2009.

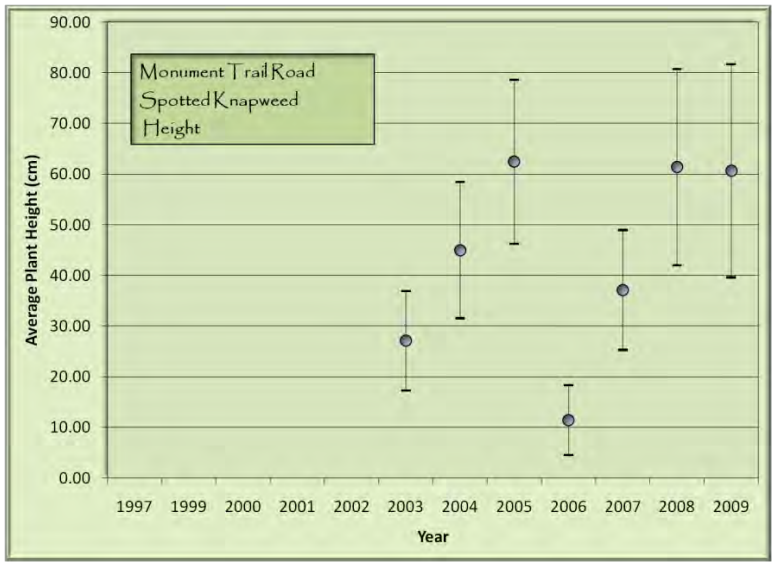


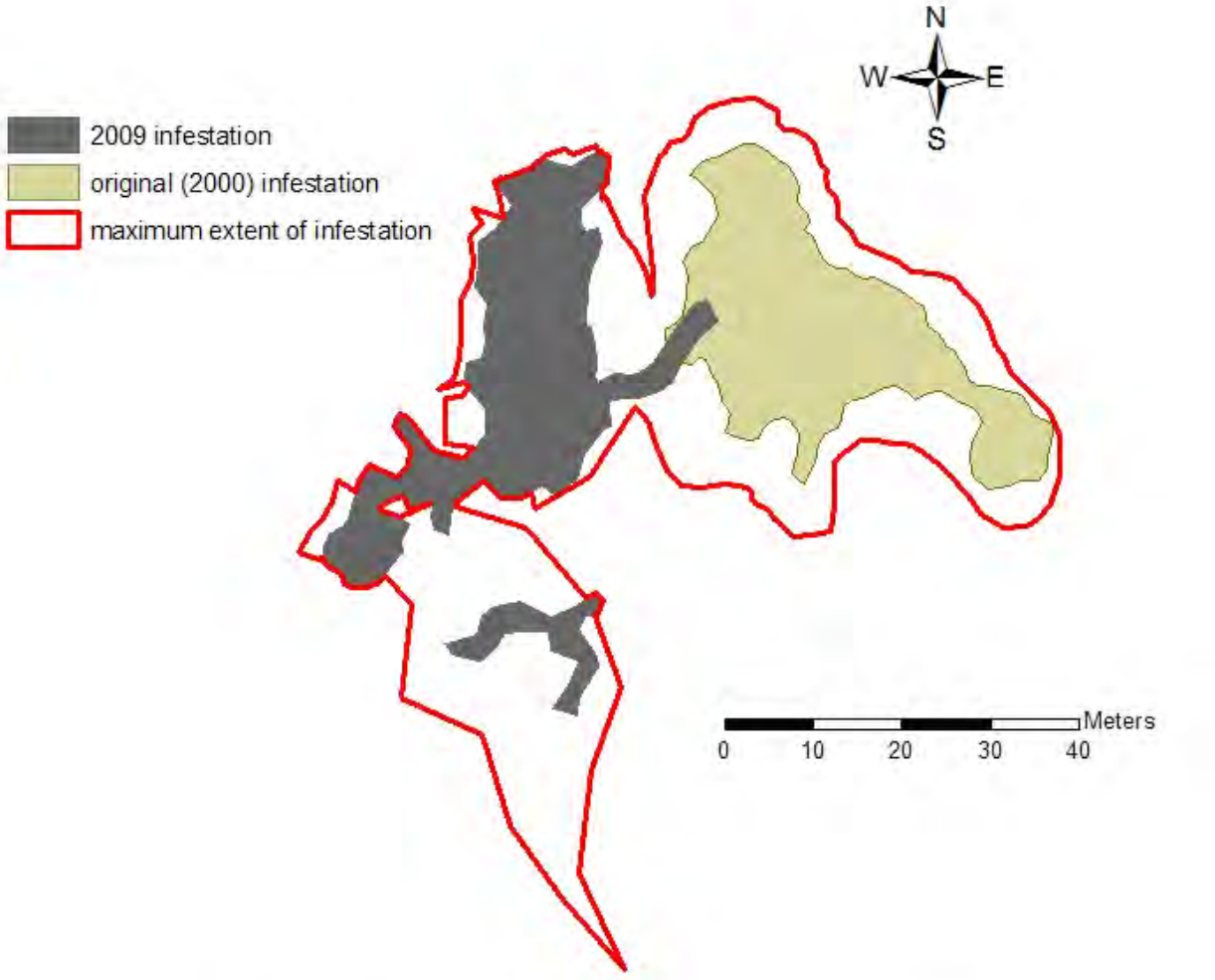
Monument Trail Road spotted knapweed density in 2009.



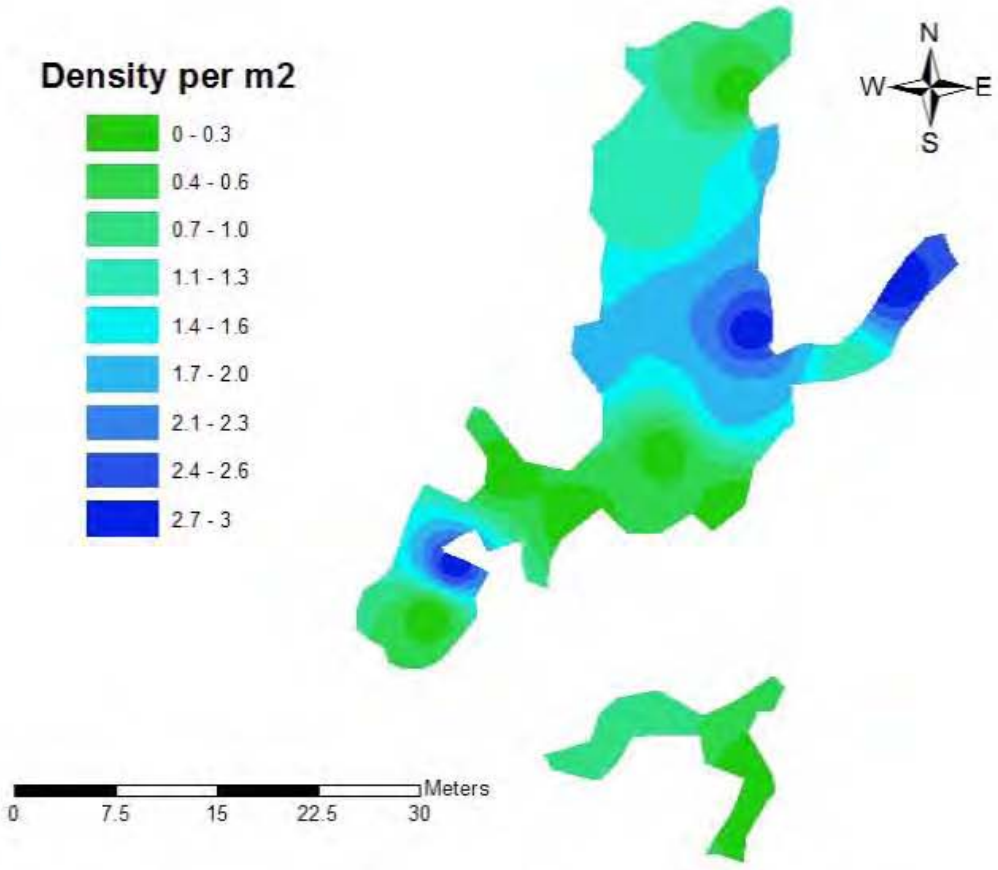


Monument Trail Road spotted knapweed height in 2009.

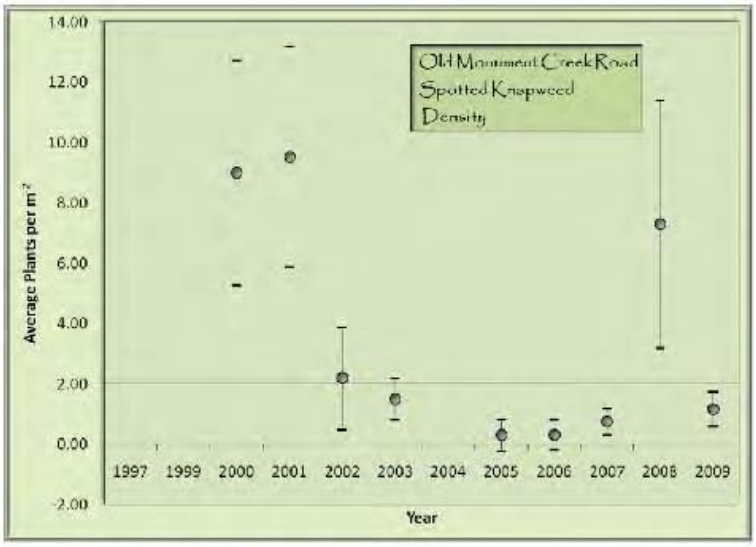


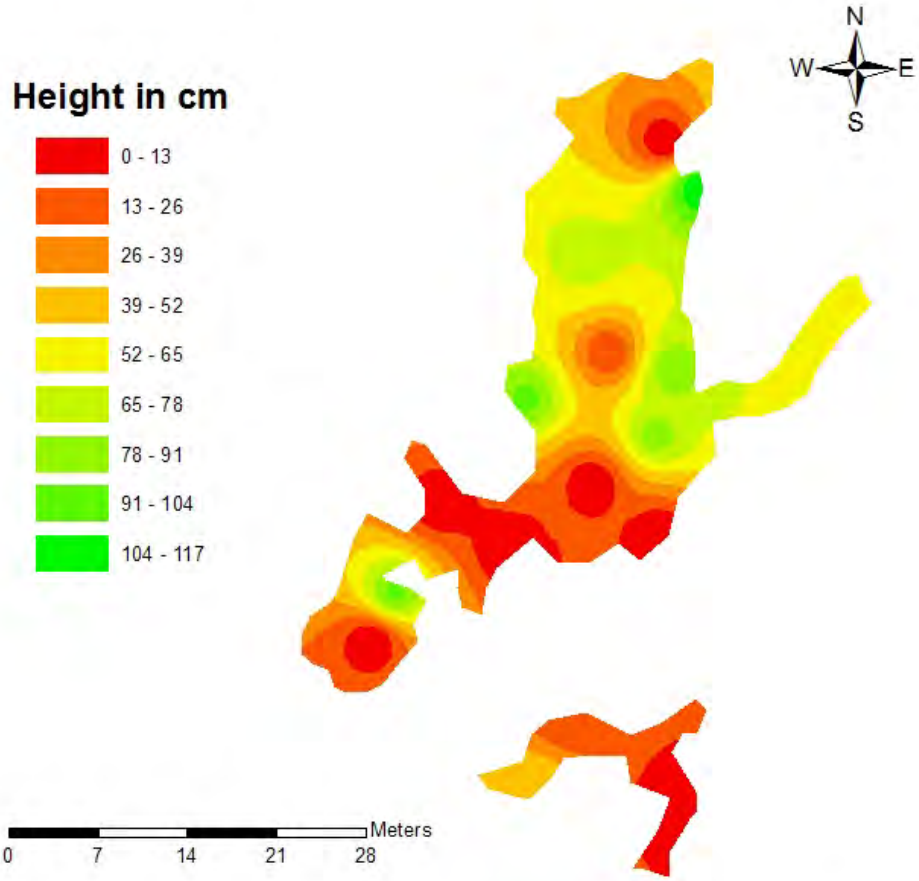


Old Monument Creek spotted knapweed perimeter in 2009.

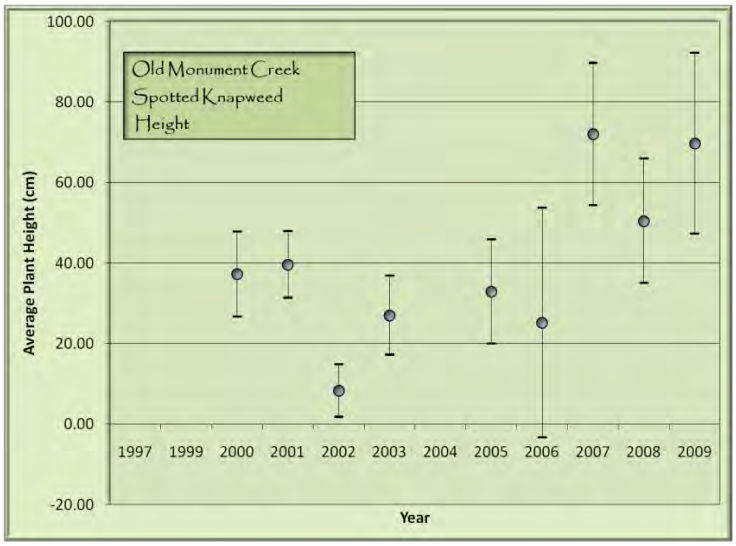


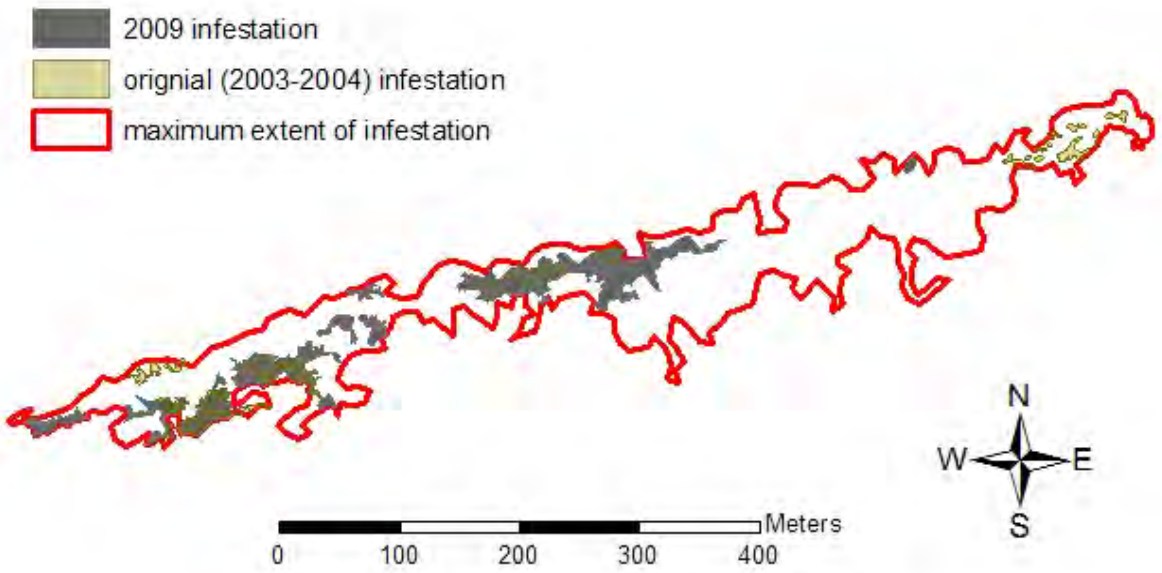
Old Monument Creek spotted knapweed density in 2009.



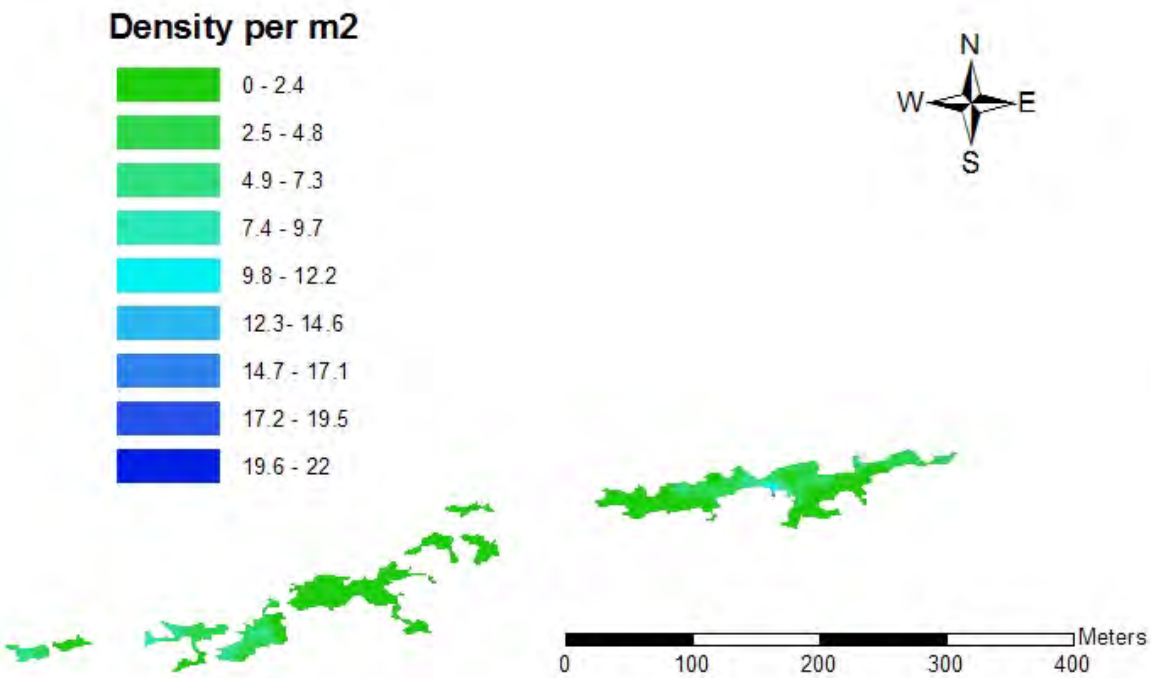


Old Monument Creek spotted knapweed height in 2009.

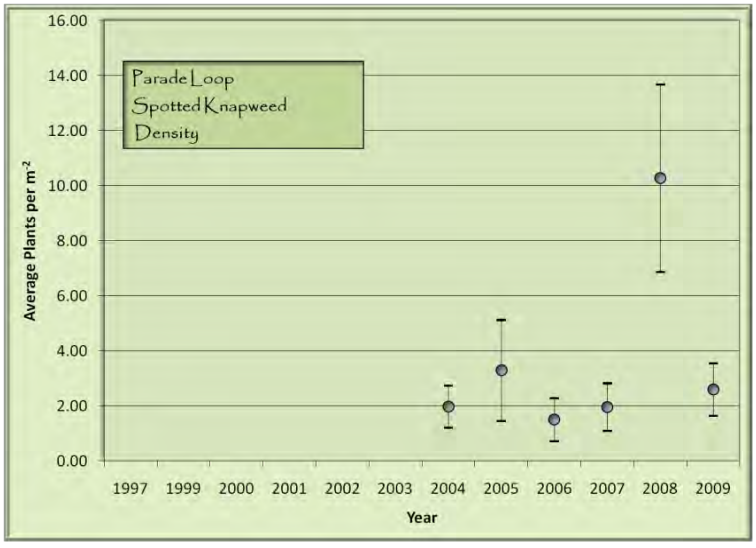


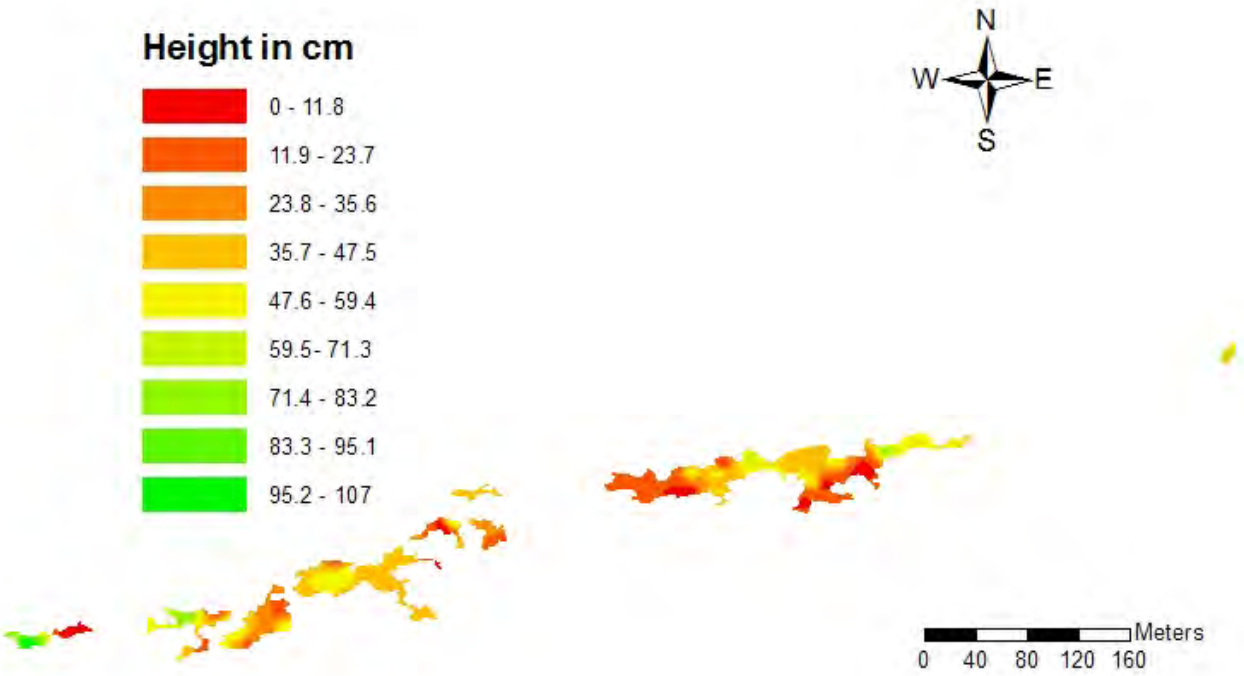


Total Parade Loop spotted knapweed perimeter in 2009.

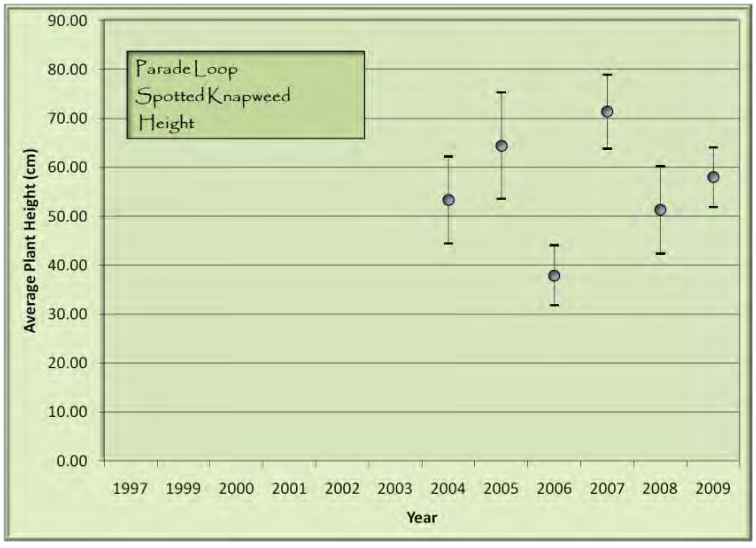


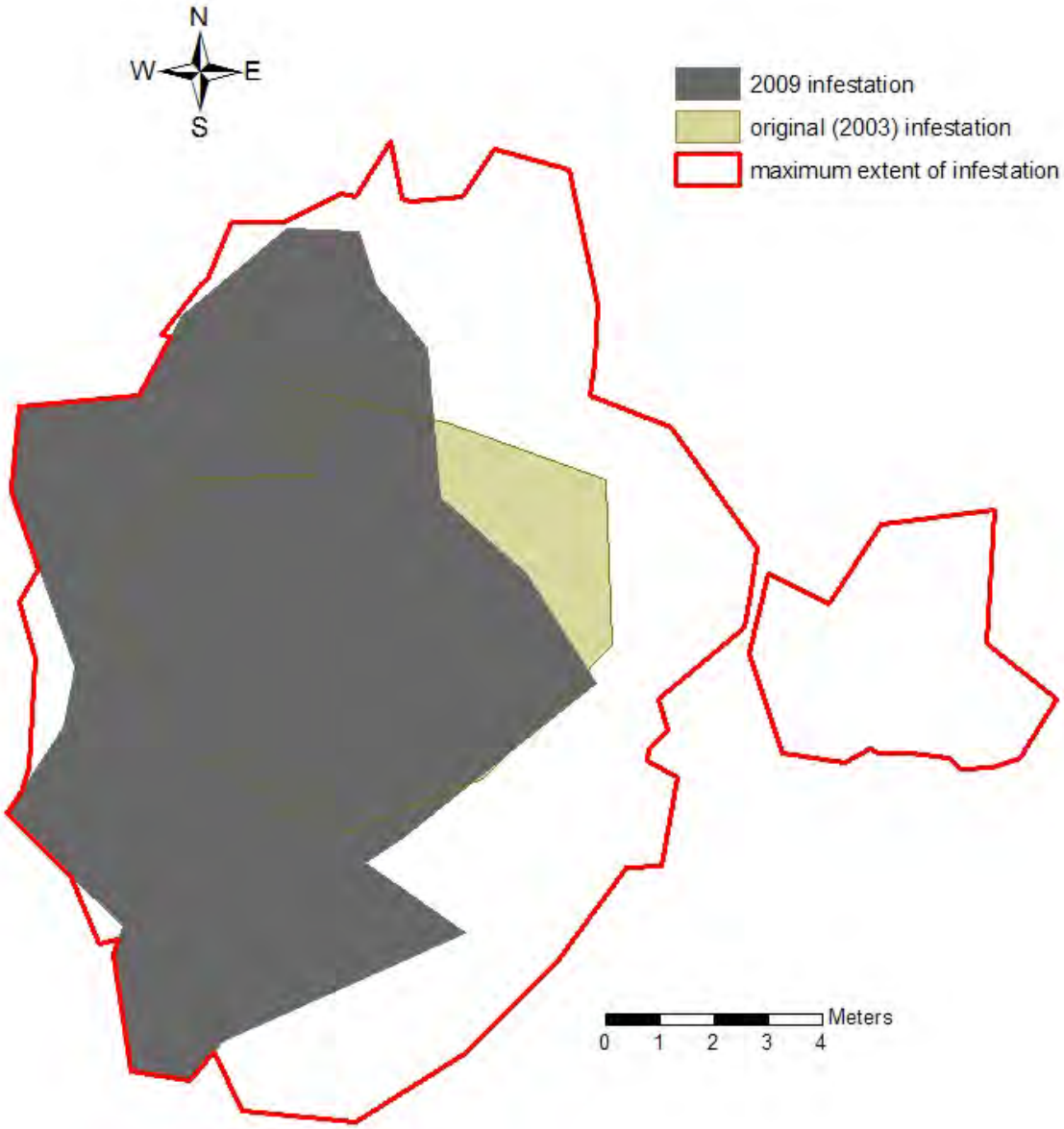
Parade loop spotted knapweed density in 2009.



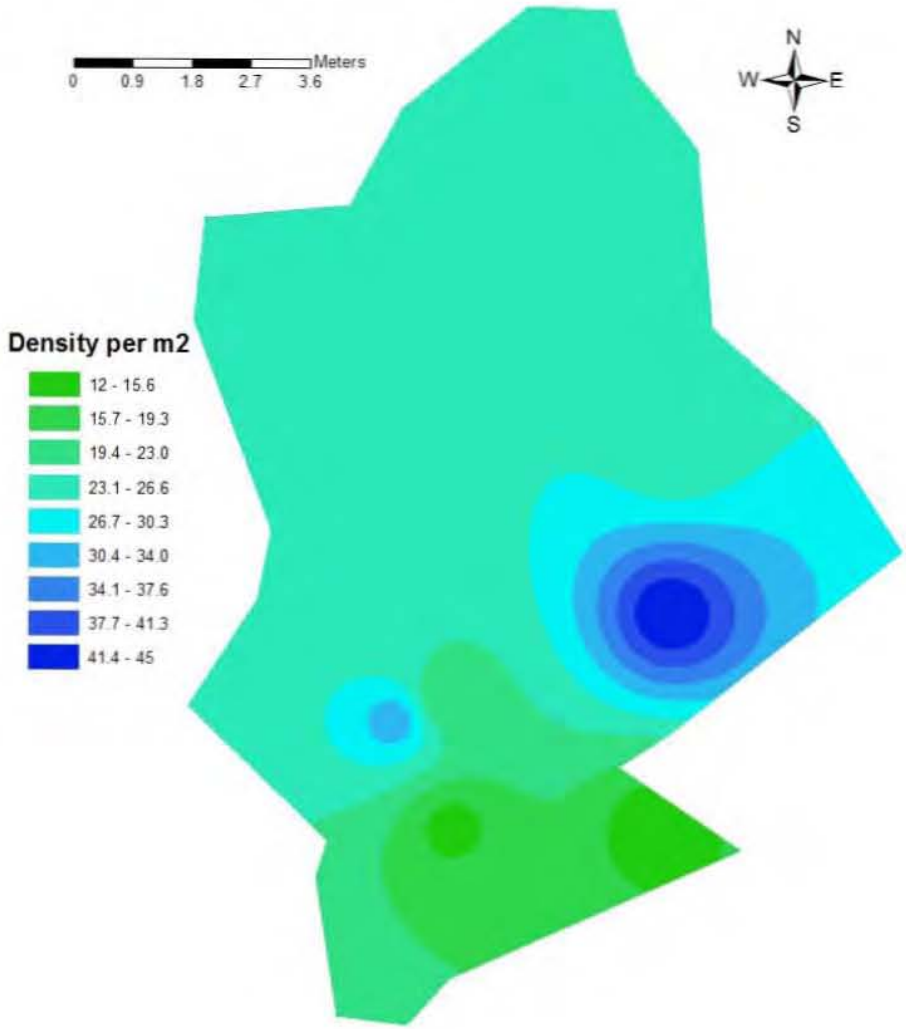


Parade loop spotted knapweed height in 2009.

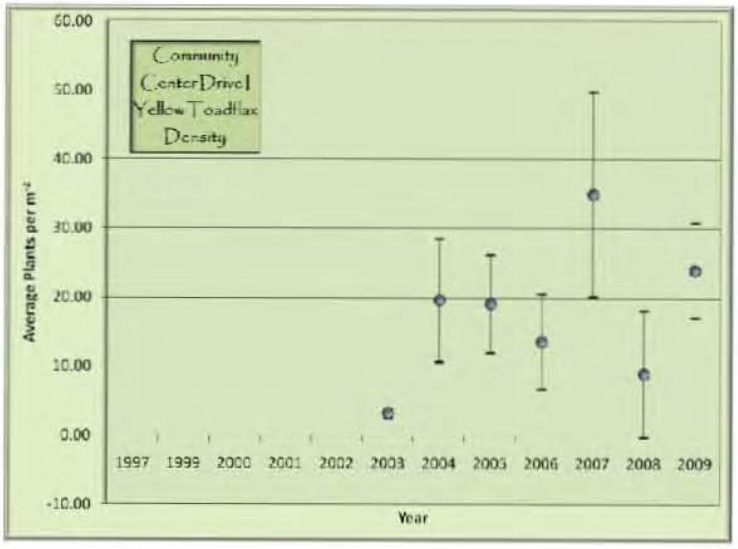


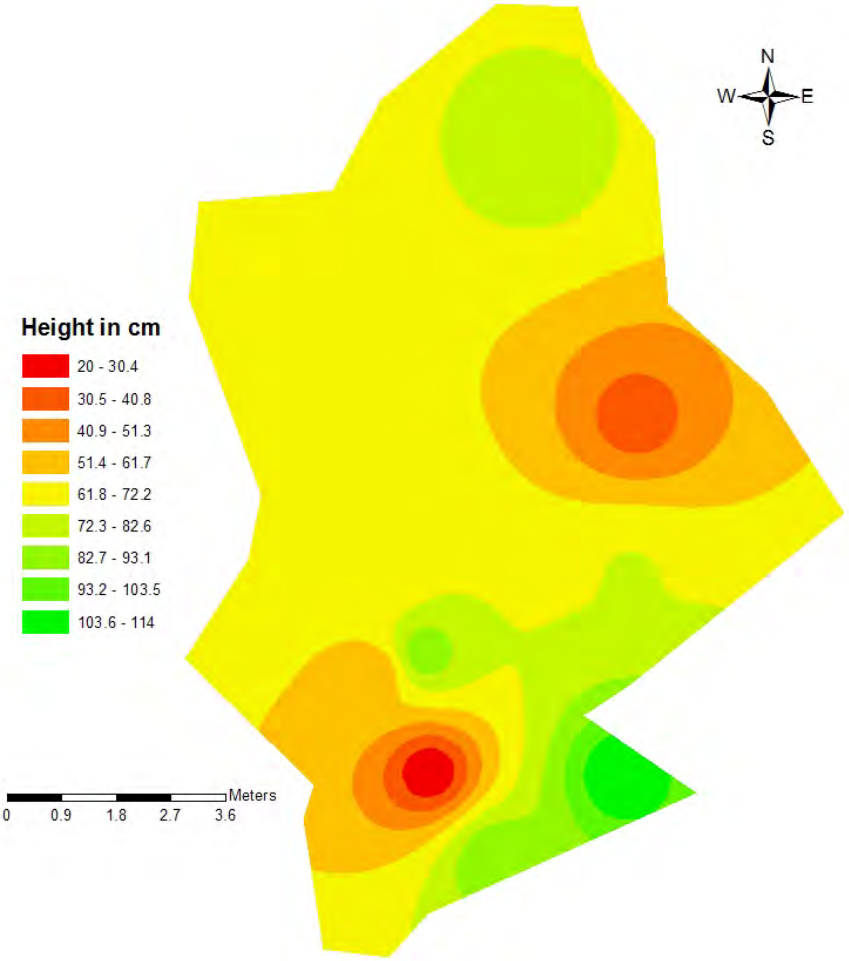


Community Center Drive I yellow toadflax perimeter in 2009.

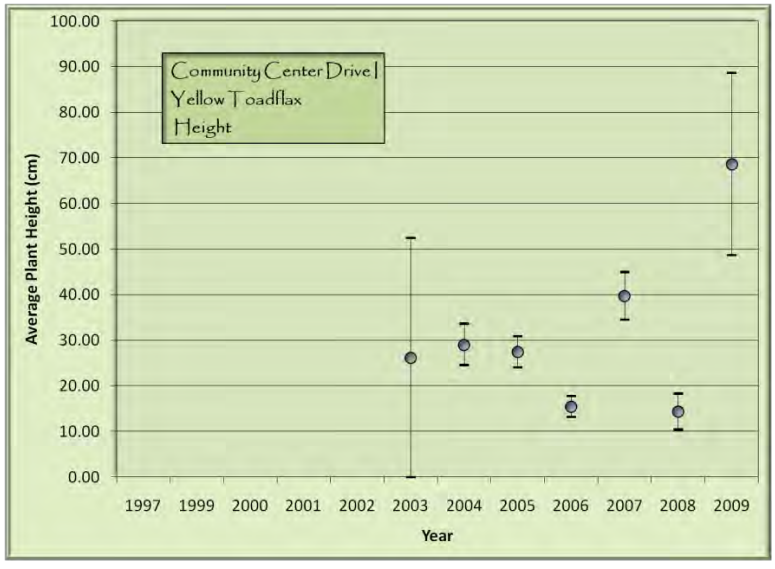


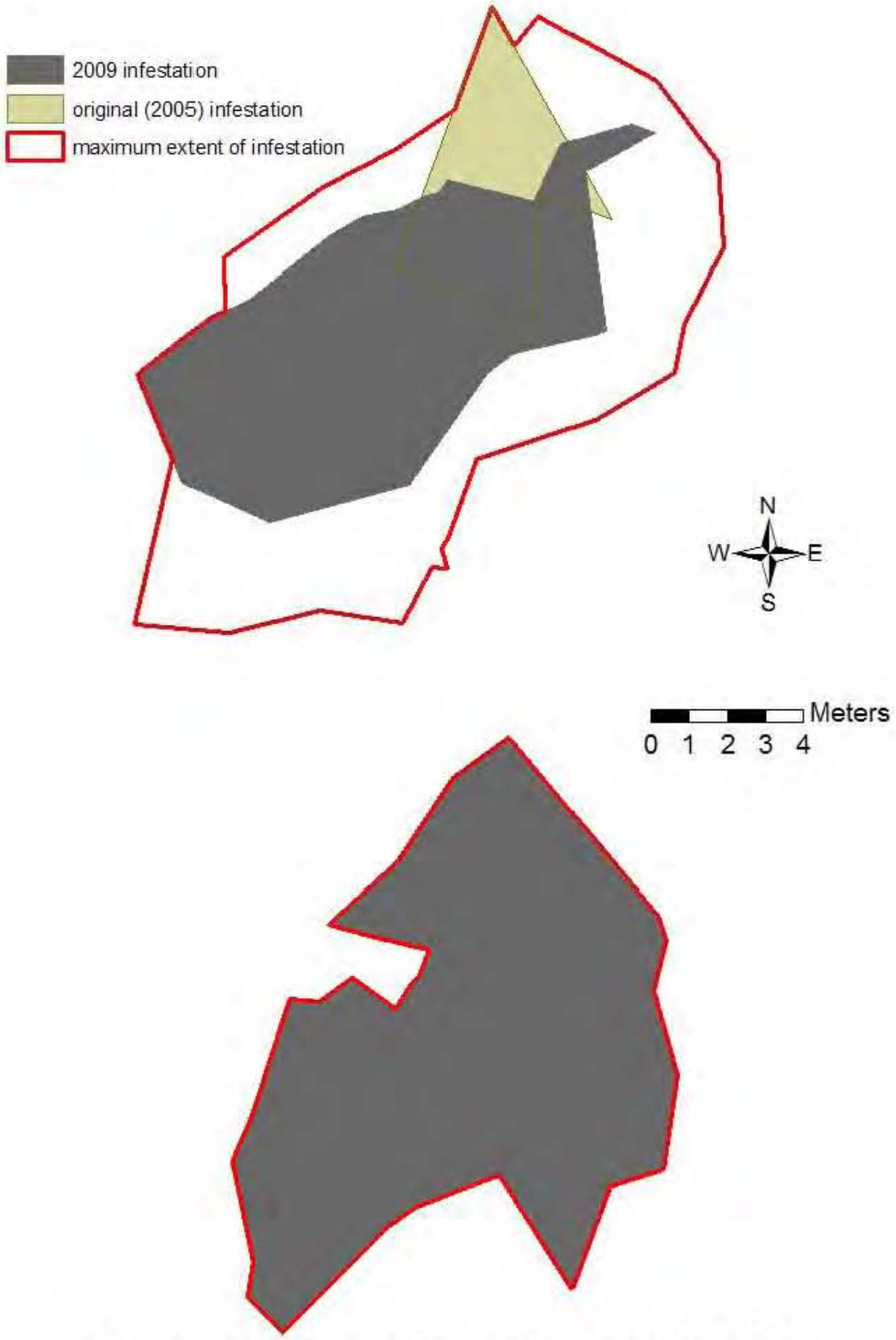
Community Center Drive I yellow toadflax density in 2009.



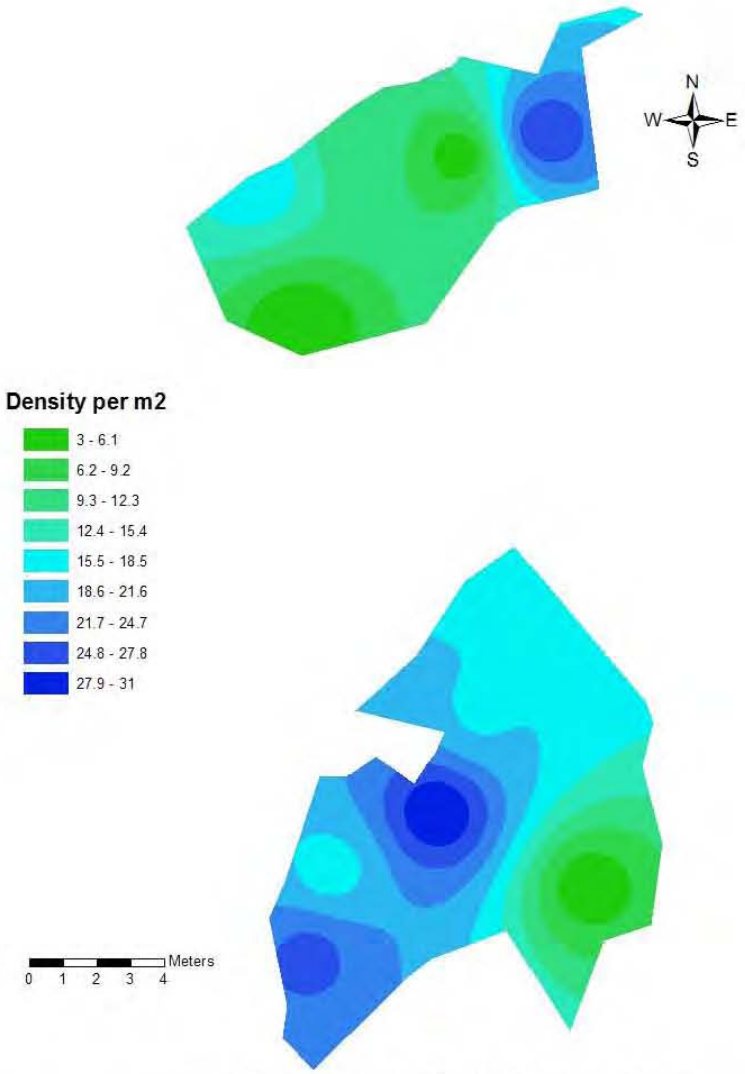


Community Center Drive I yellow toadflax height in 2009.

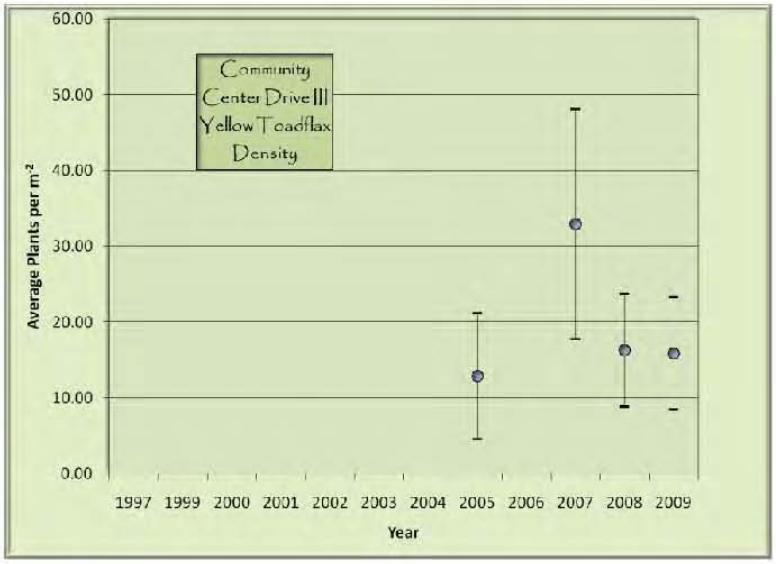


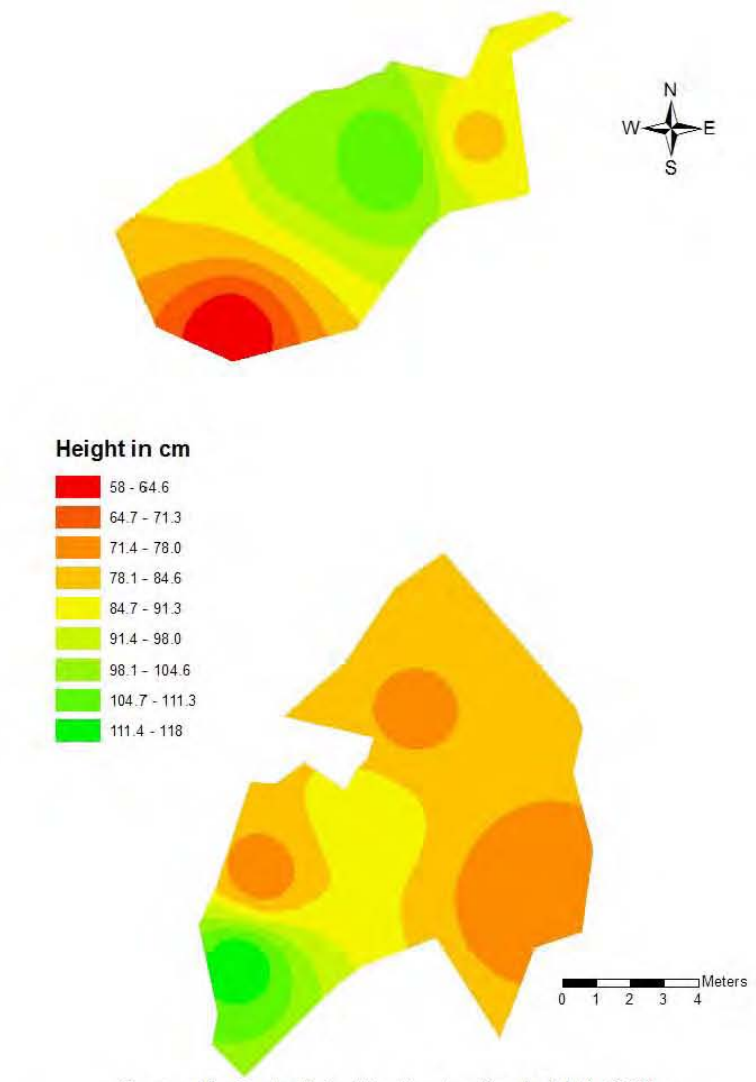


Community Center Drive III yellow toadflax perimeter in 2009.

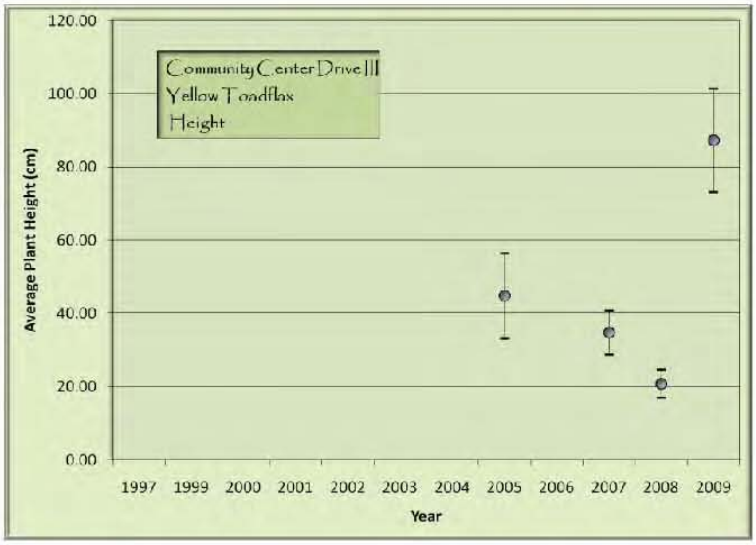


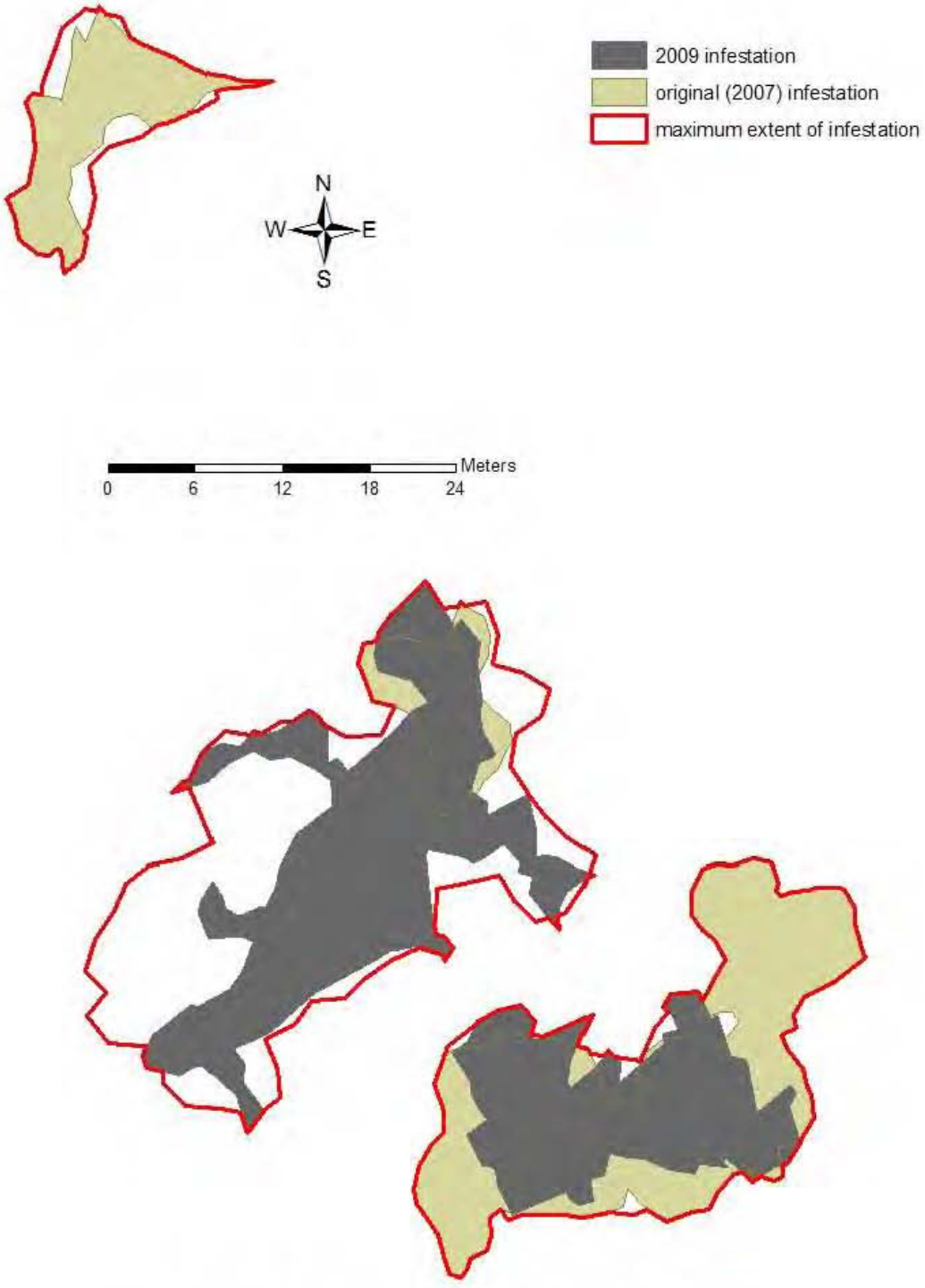
Community Center Drive III yellow toadflax density in 2009.



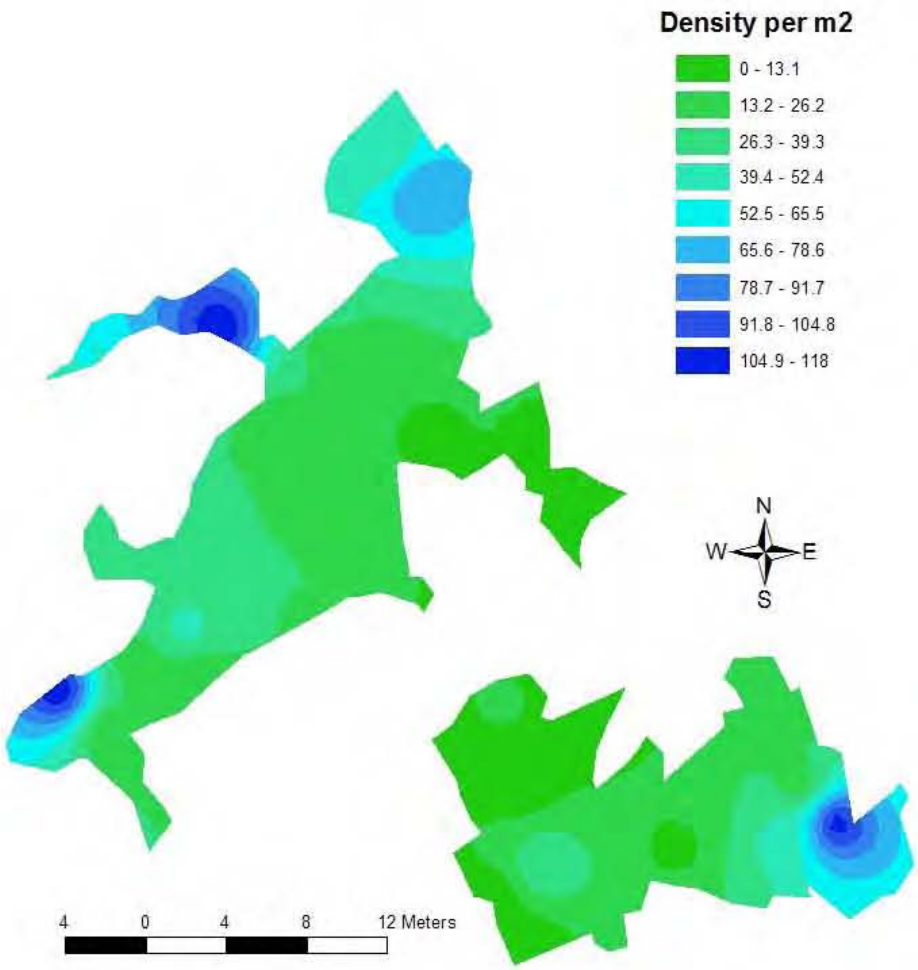


Community Center Drive III yellow toadflax height in 2009.

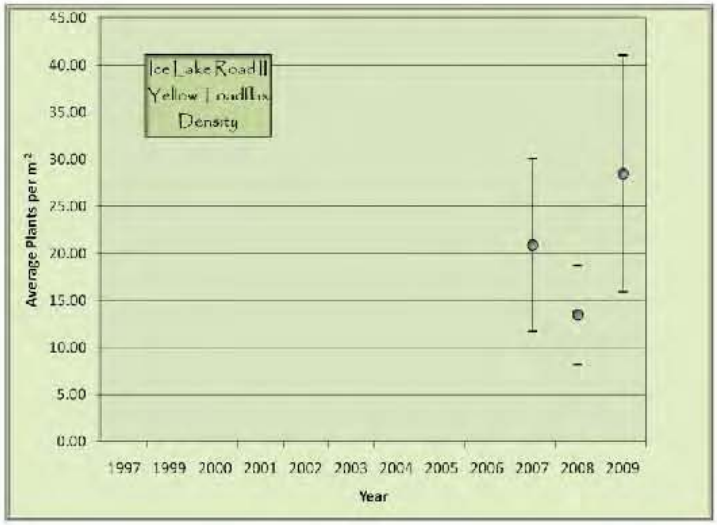


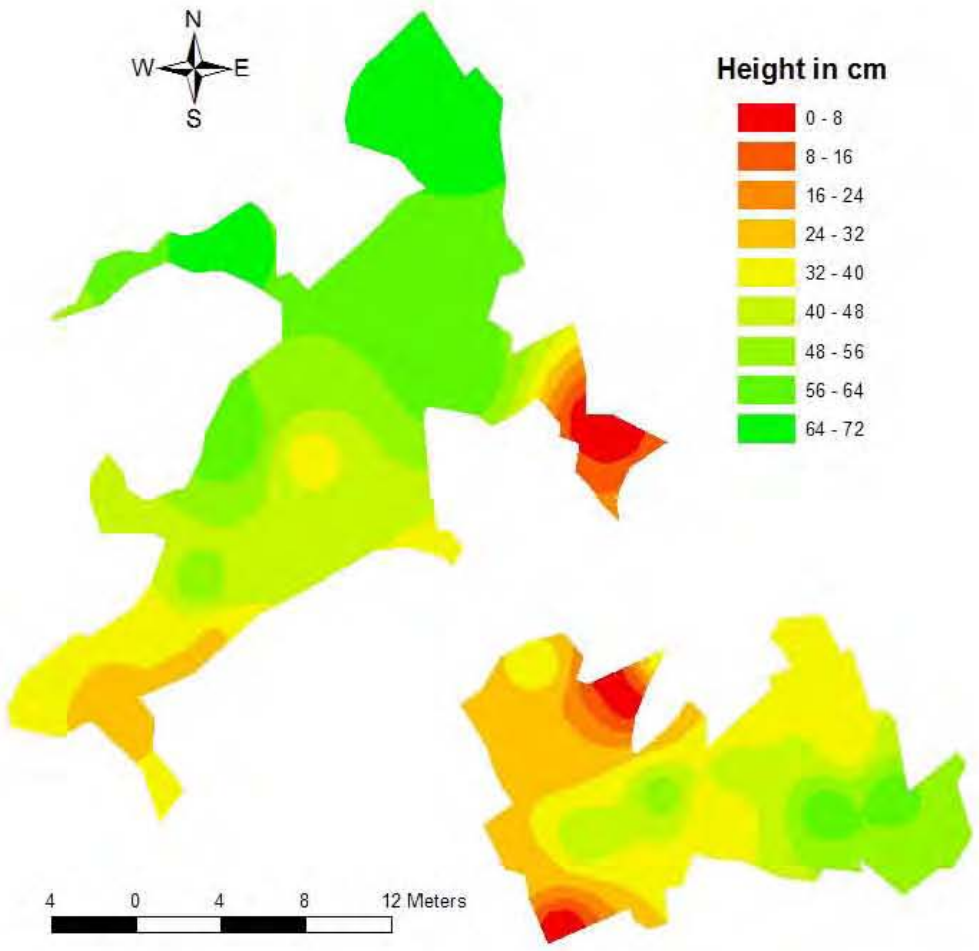


Ice Lake Road II yellow toadflax perimeter in 2009.

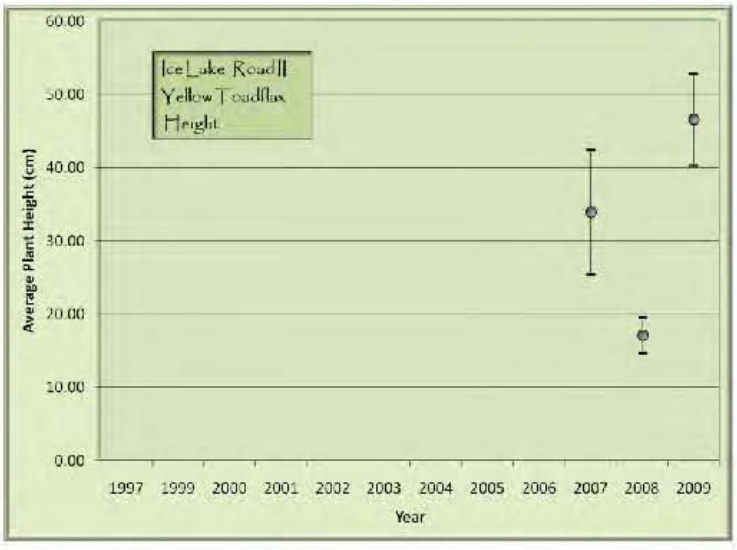


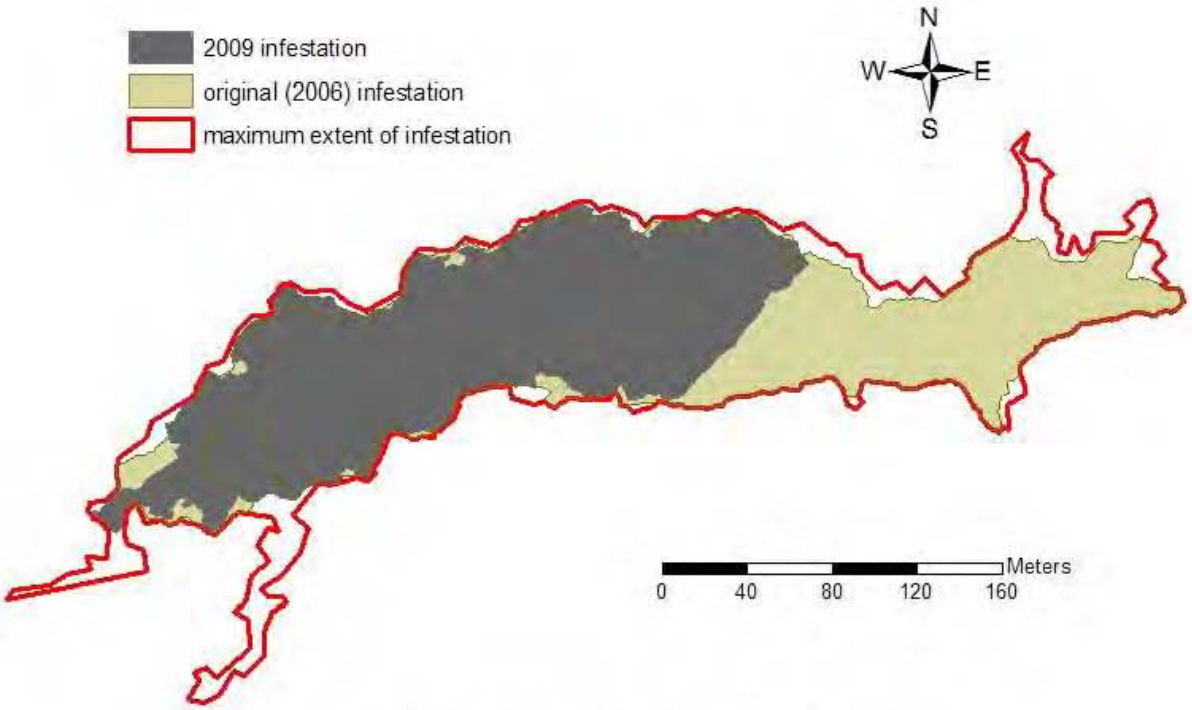
Ice Lake Road II yellow toadflax density in 2009.



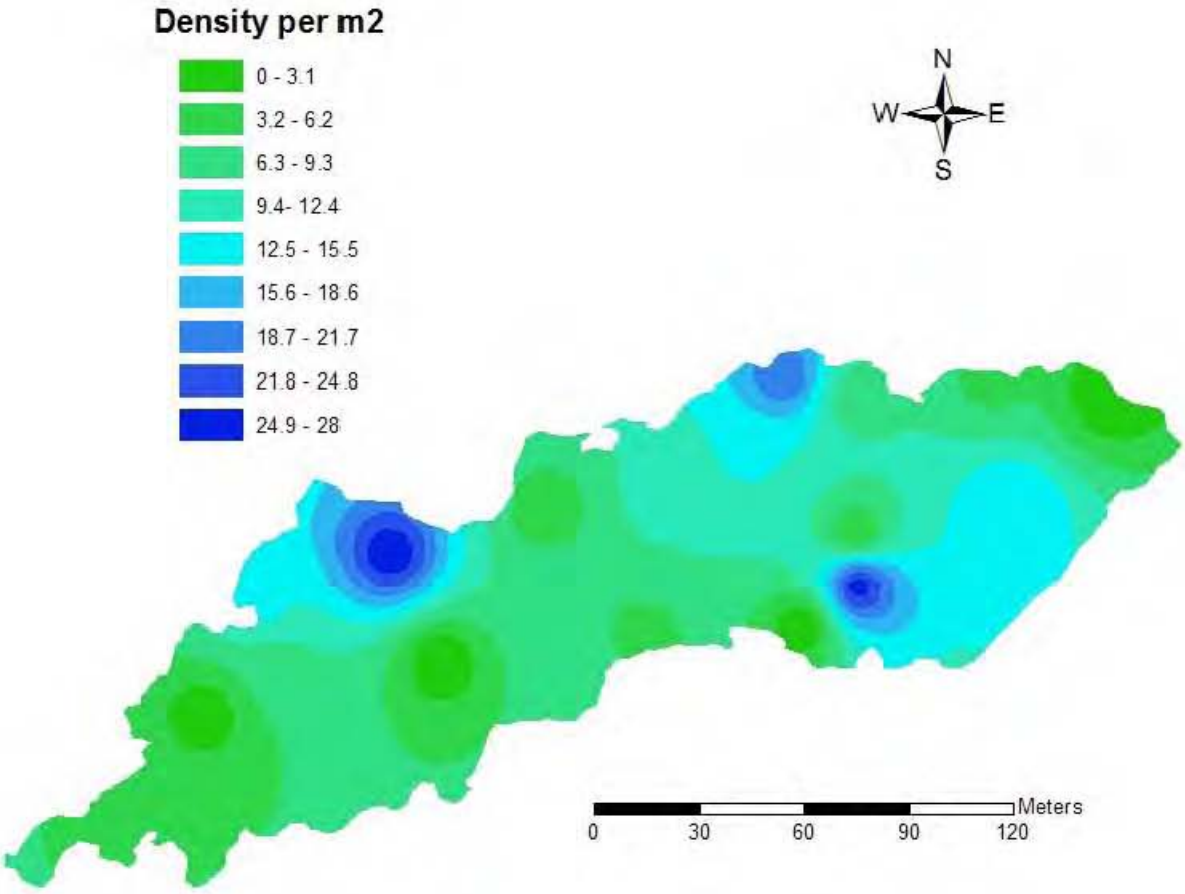


Ice Lake Road II yellow toadflax height in 2009.

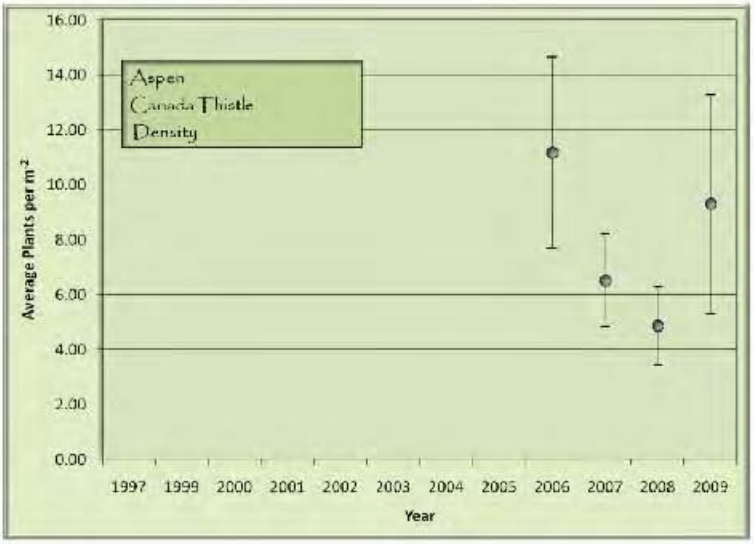


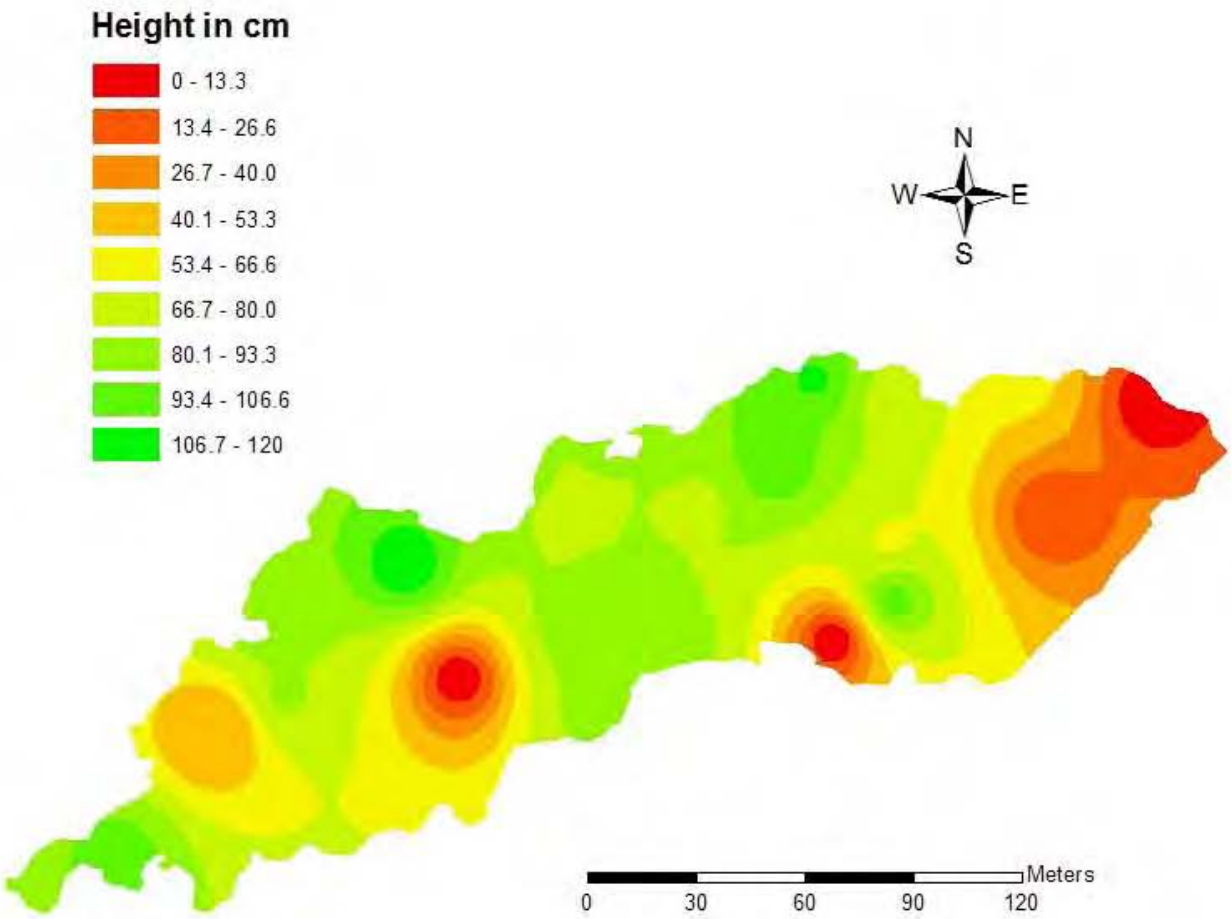


Aspen Canada thistle perimeter in 2009.

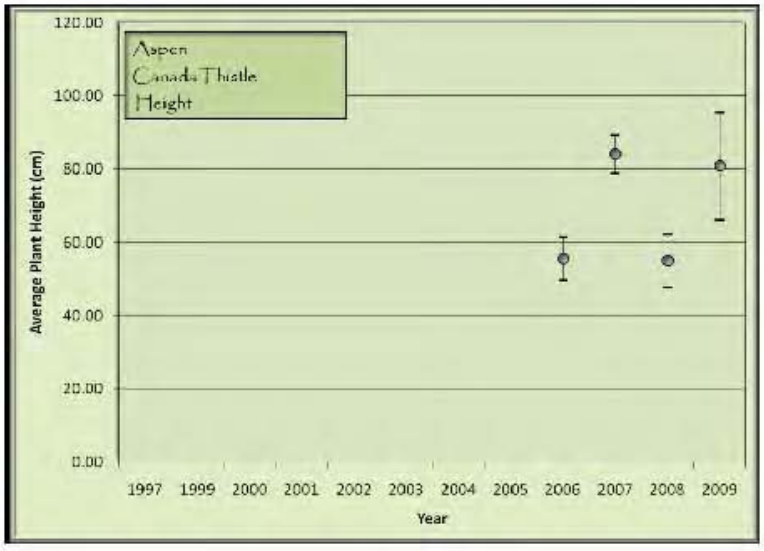


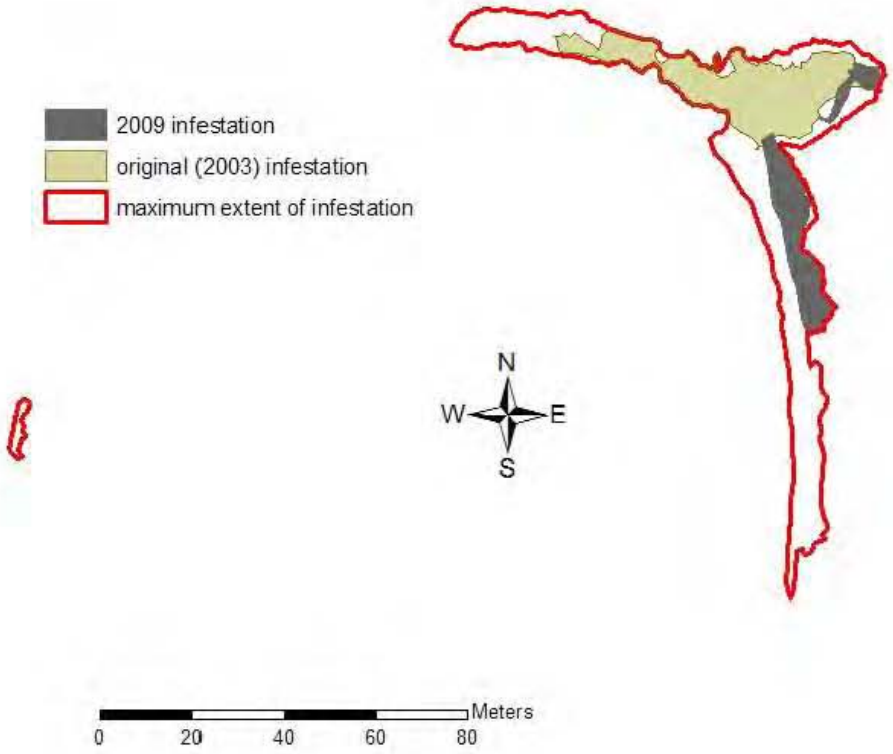
Aspen Canada thistle density in 2009.



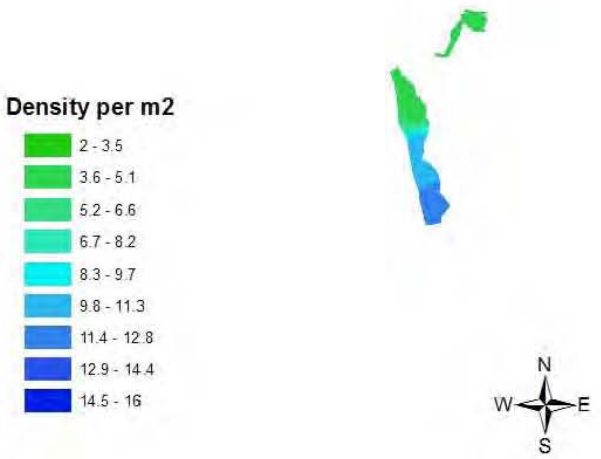


Aspen Canada thistle height in 2009.

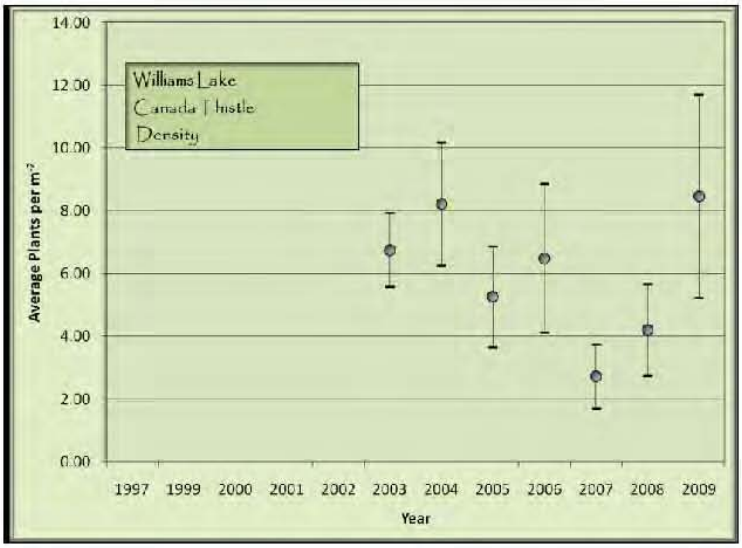


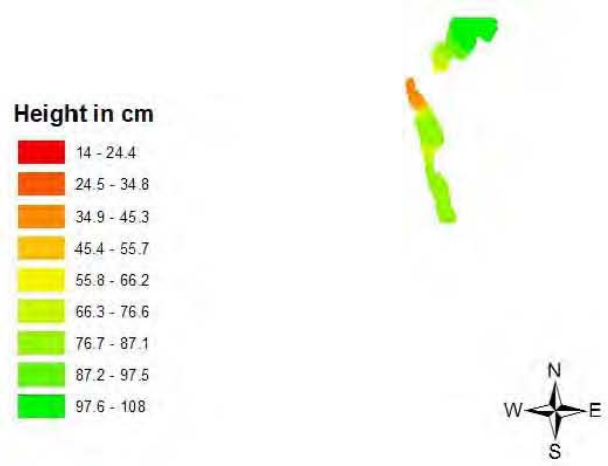


Williams Lake Canada thistle perimeter in 2009.

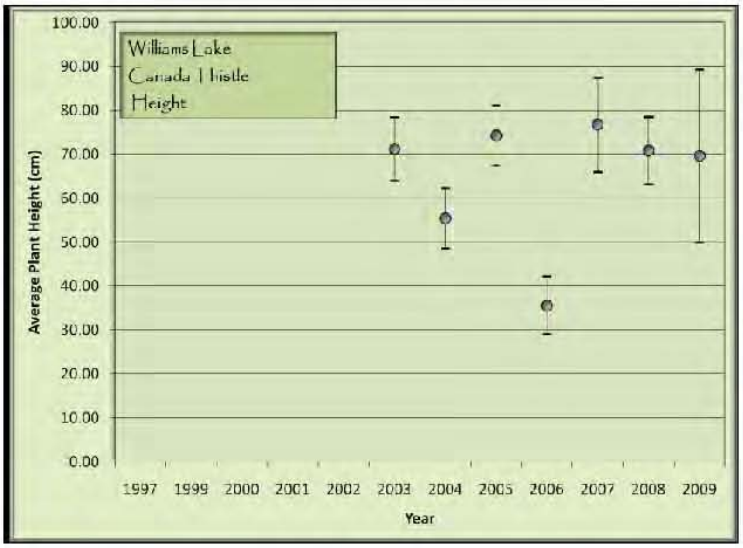


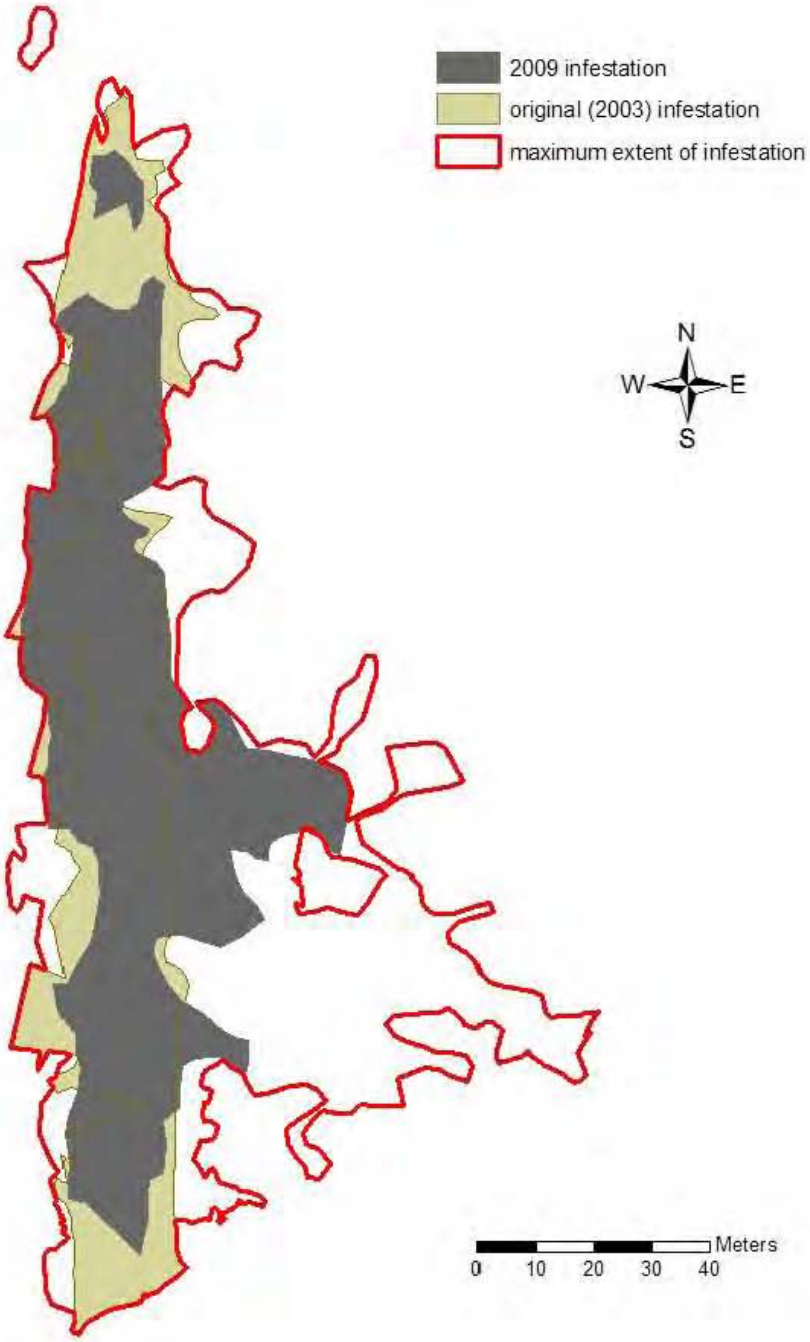
Williams Lake Canada thistle density in 2009.



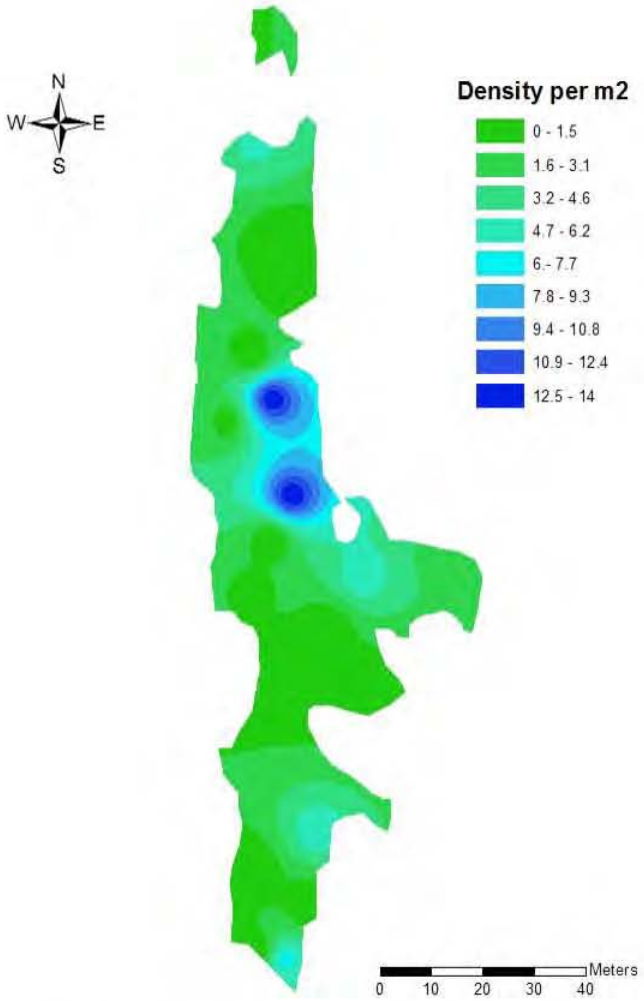


Williams Lake Canada thistle height in 2009.

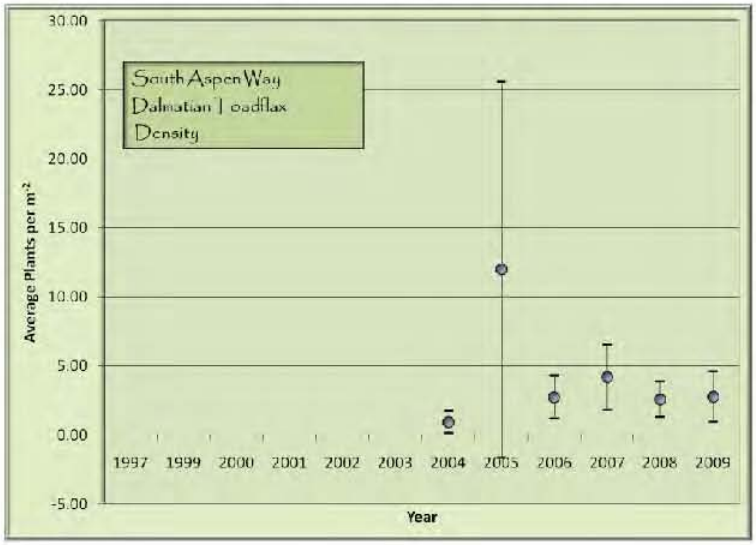


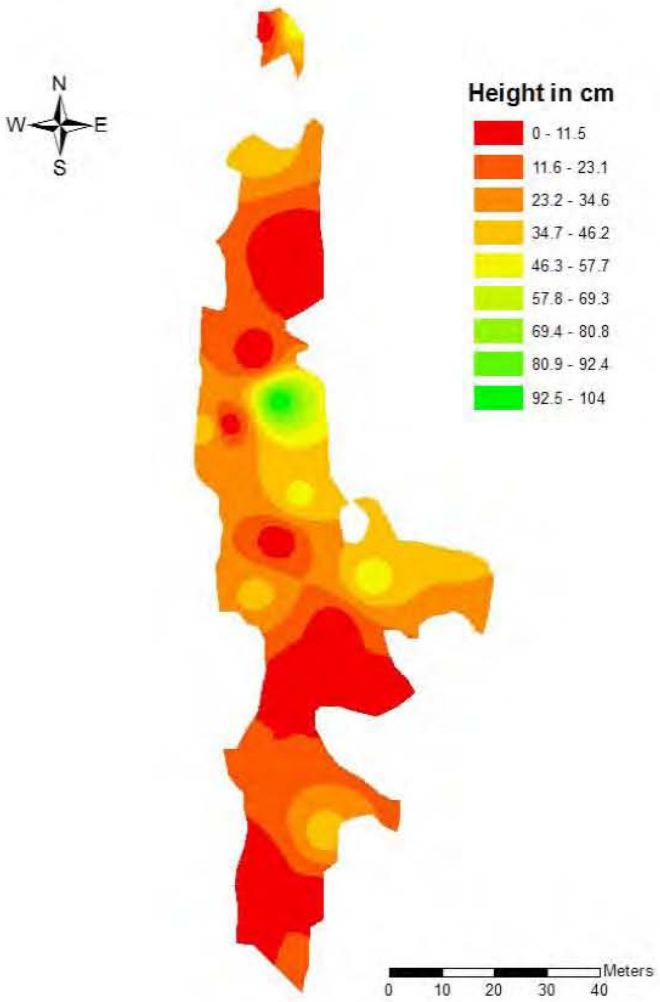


South Aspen Way Dalmatian toadflax perimeter in 2009.

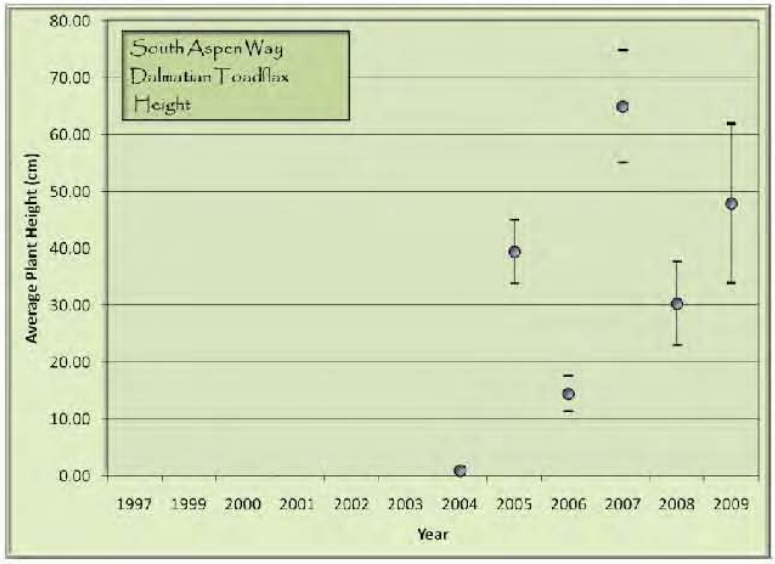


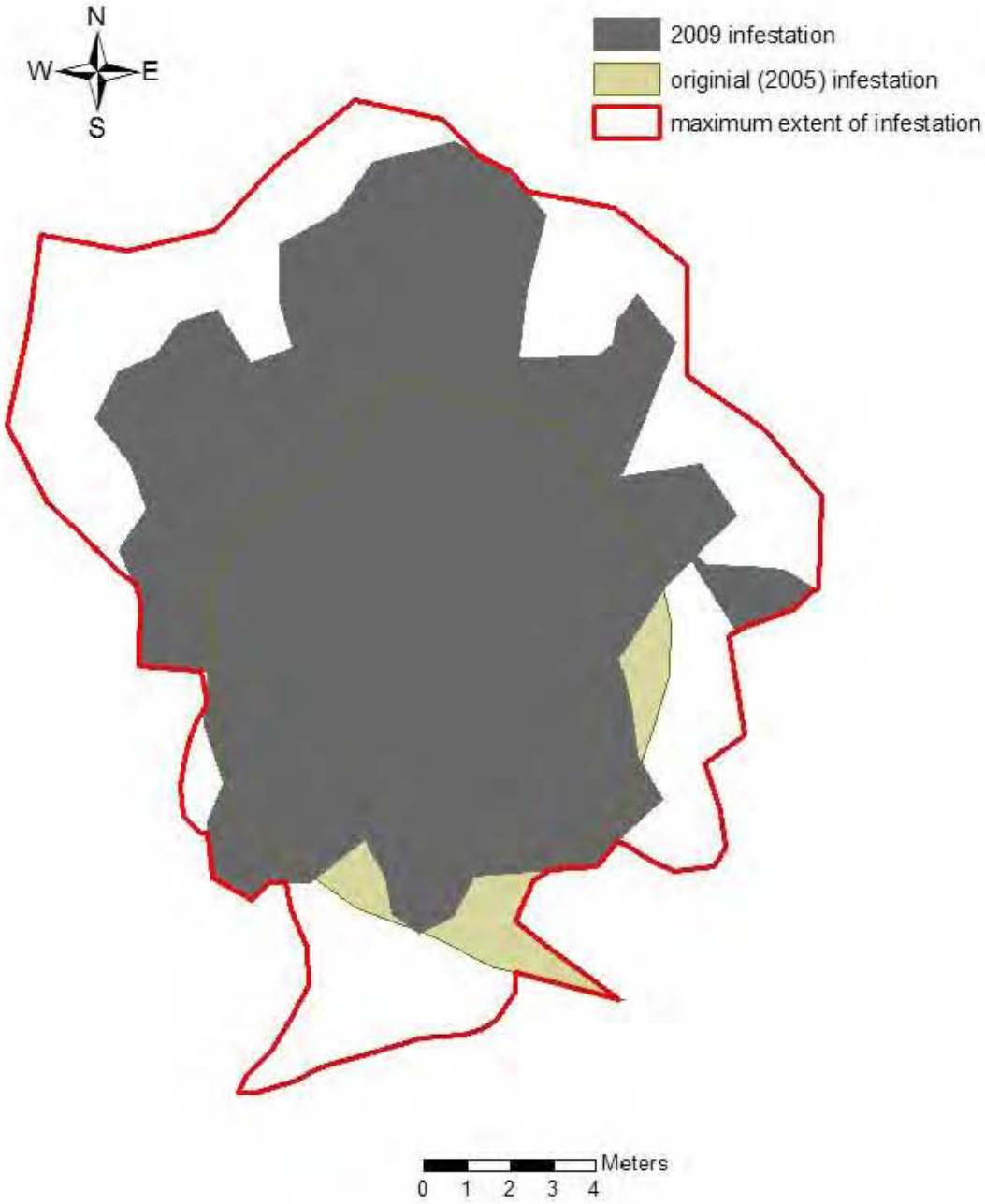
South Aspen Way Dalmatian toadflax density in 2009.



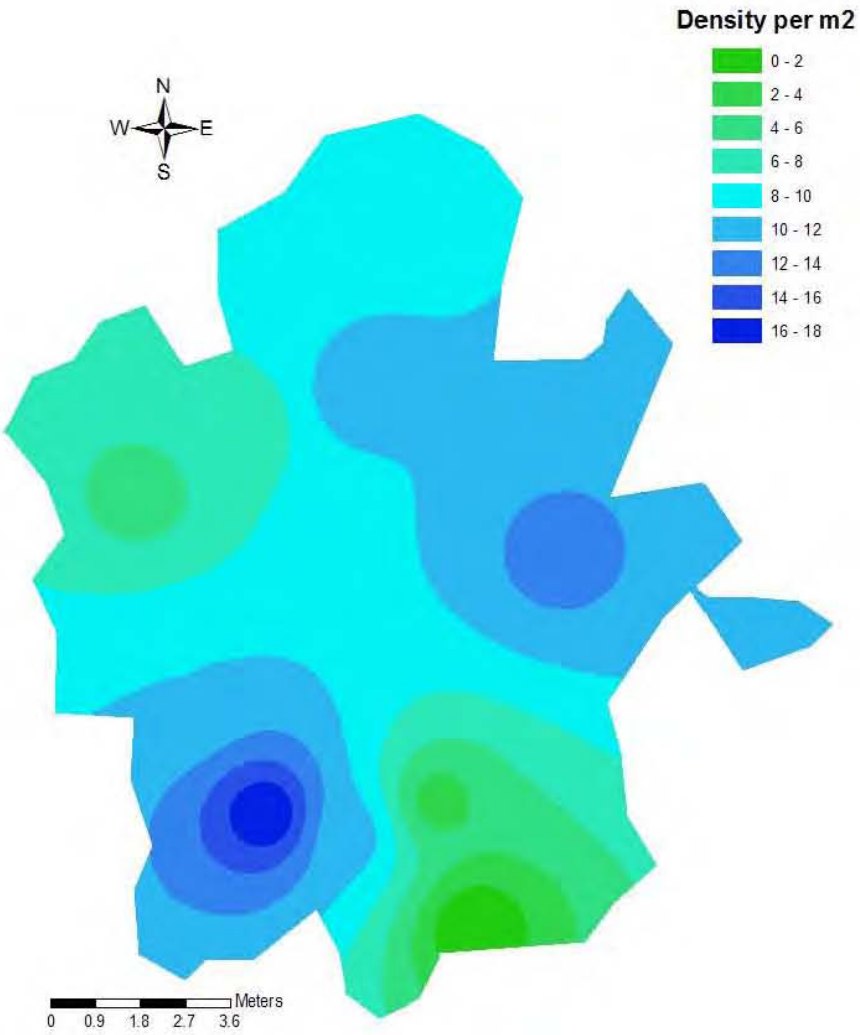


South Aspen Way Dalmatian toadflax height in 2009.

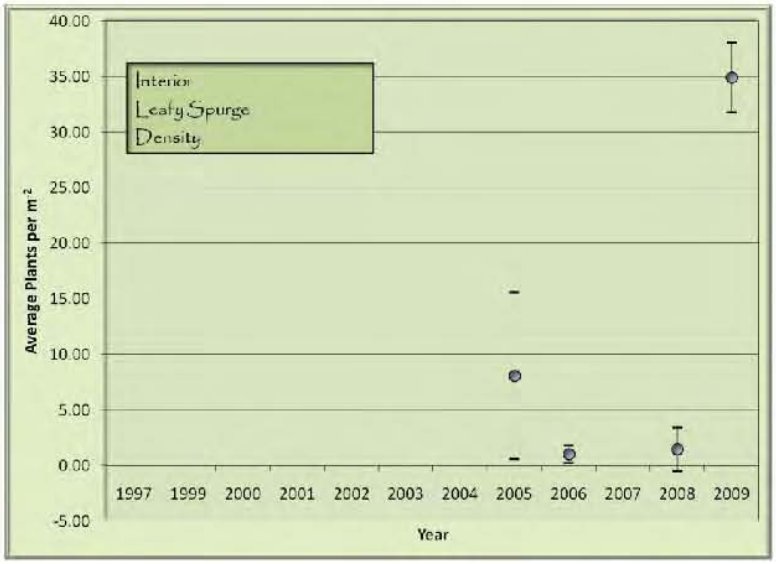


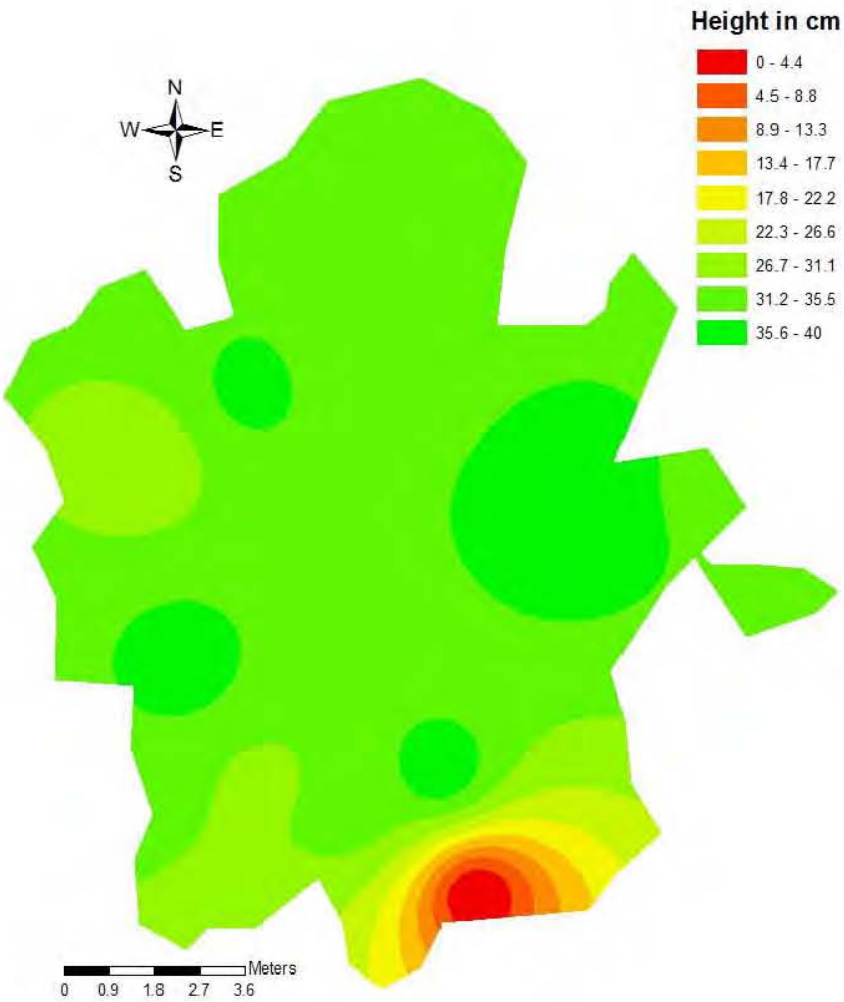


Interior leafy spurge perimeter in 2009.

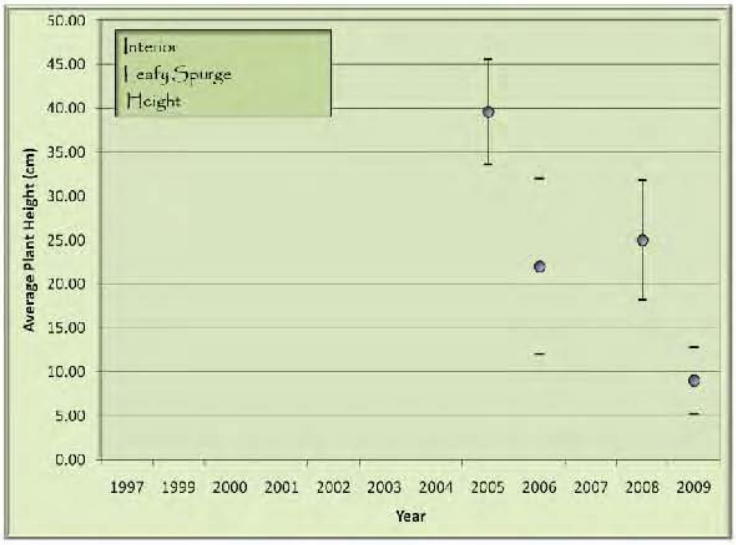


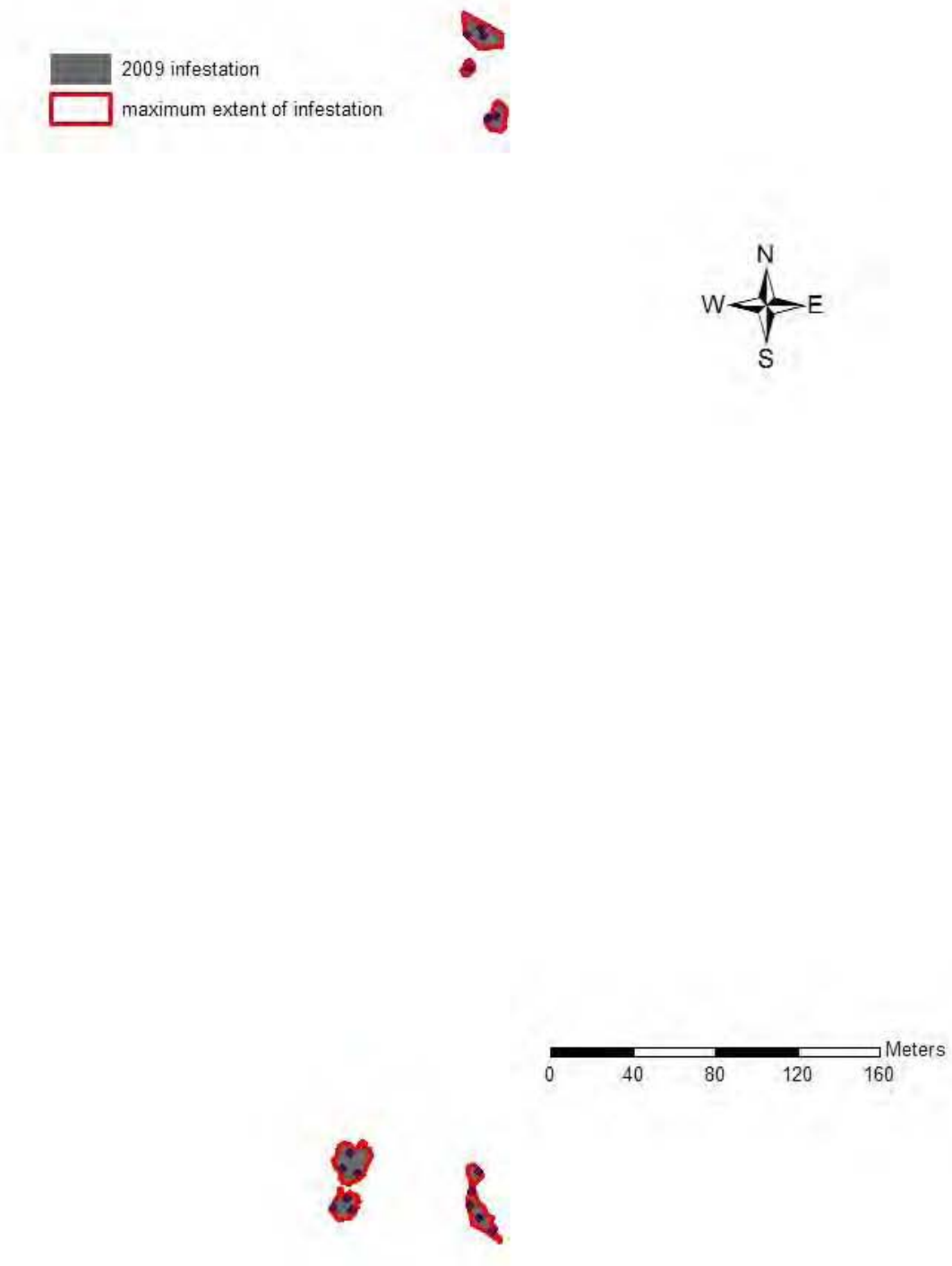
Interior leafy spurge density 2009.



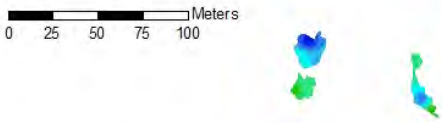


Interior leafy spurge height 2009.

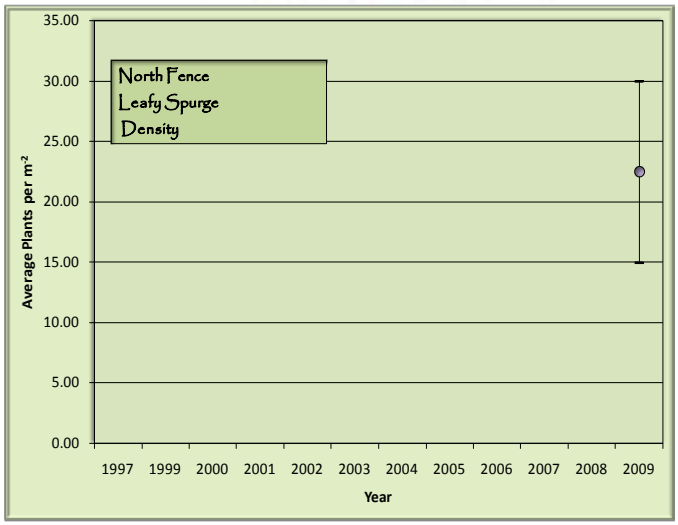


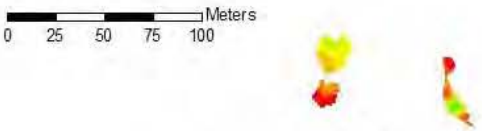


North fence leafy spurge perimeter in 2009.

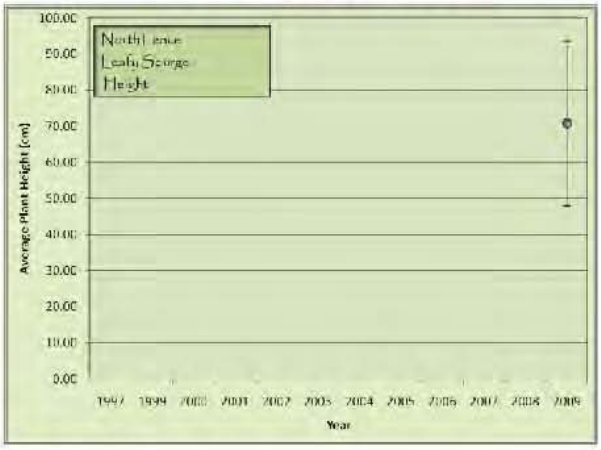


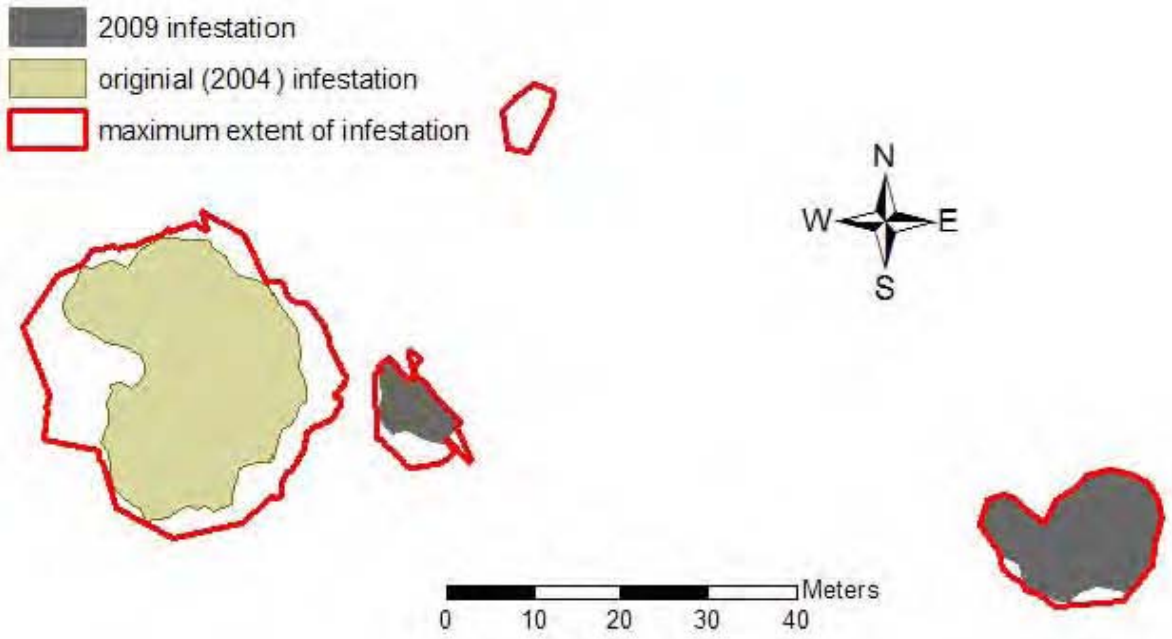
North fence leafy spurge density in 2009.



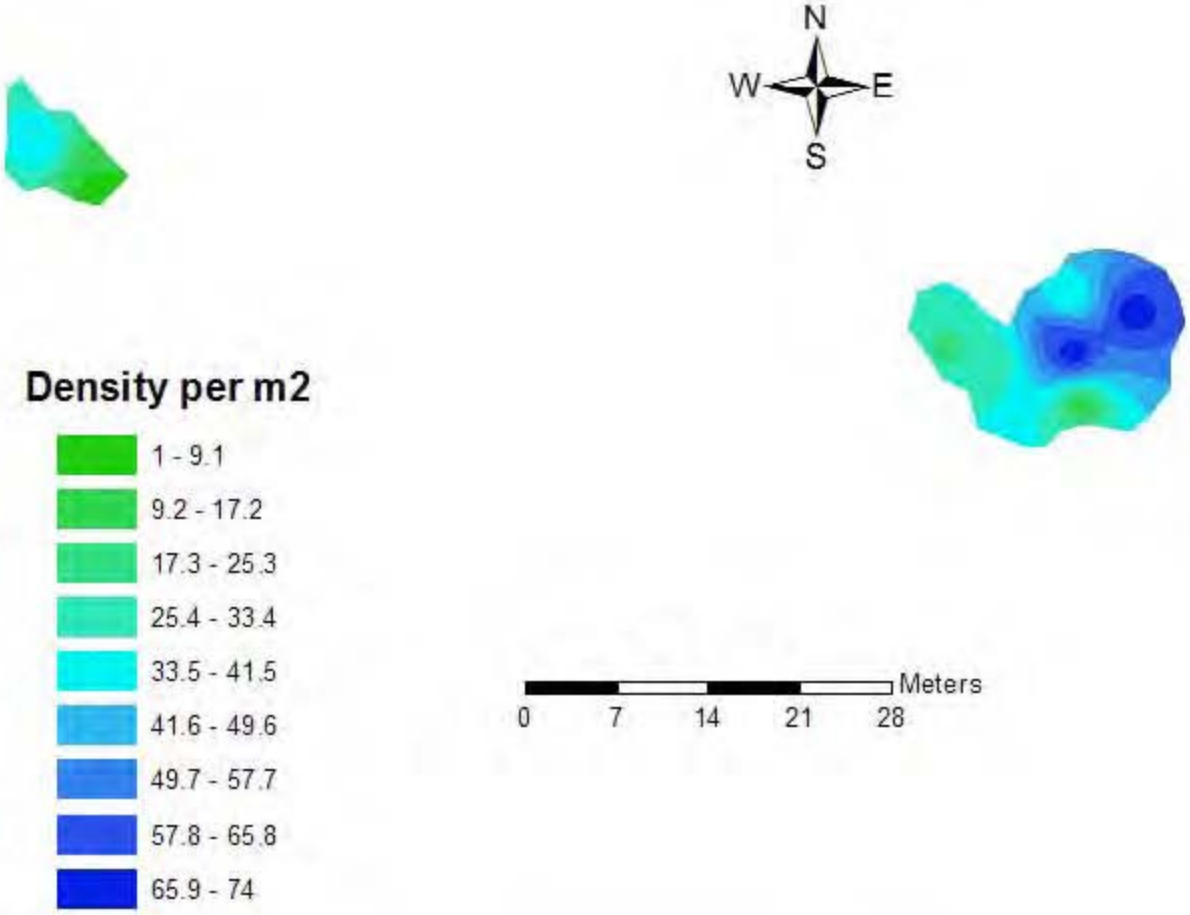


North fence leafy spurge height in 2009.

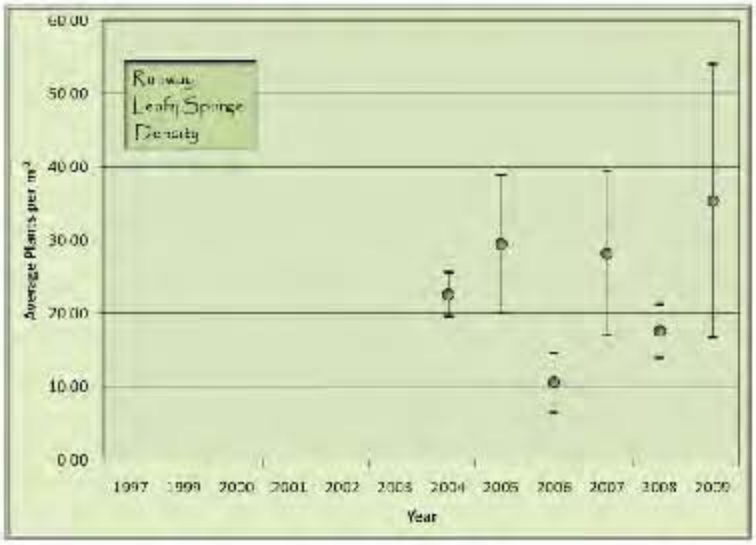


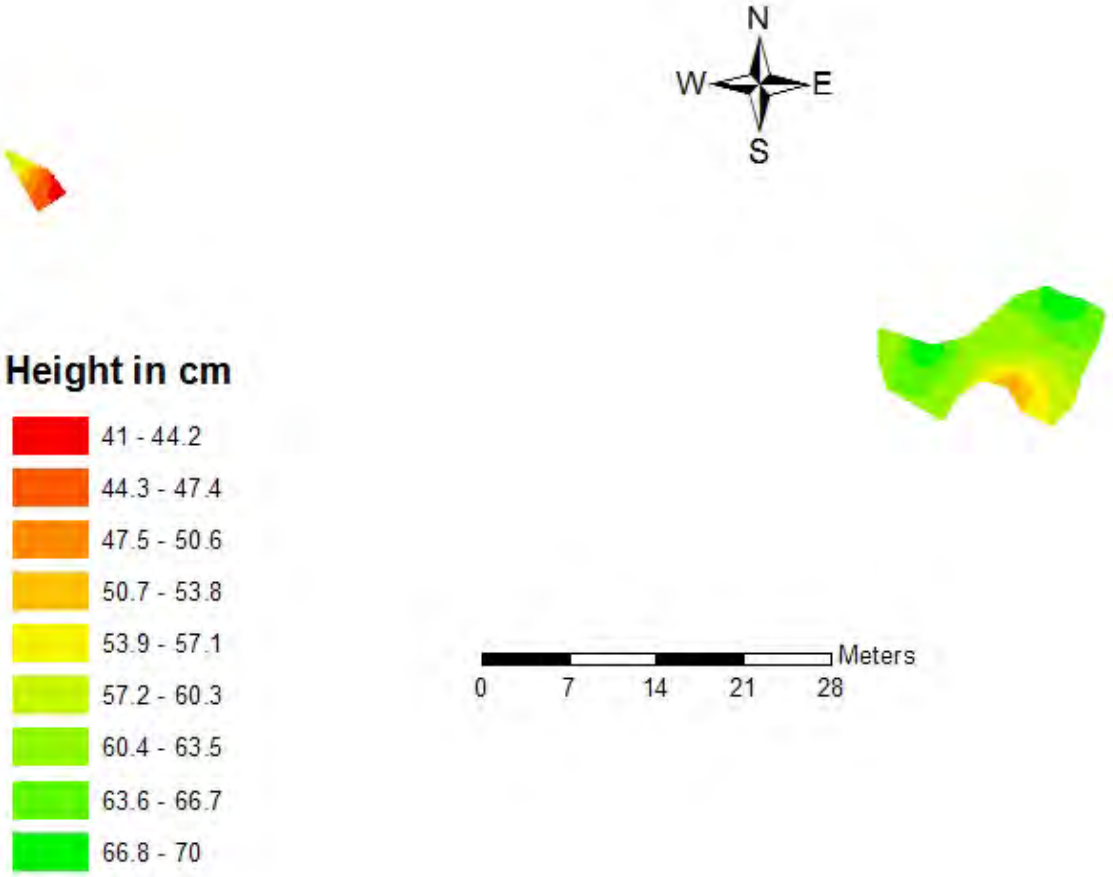


Runway leafy spurge perimeter in 2009.

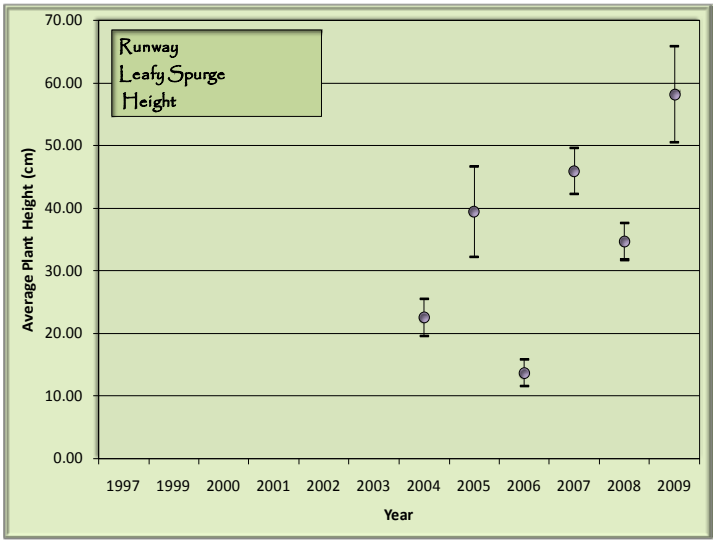


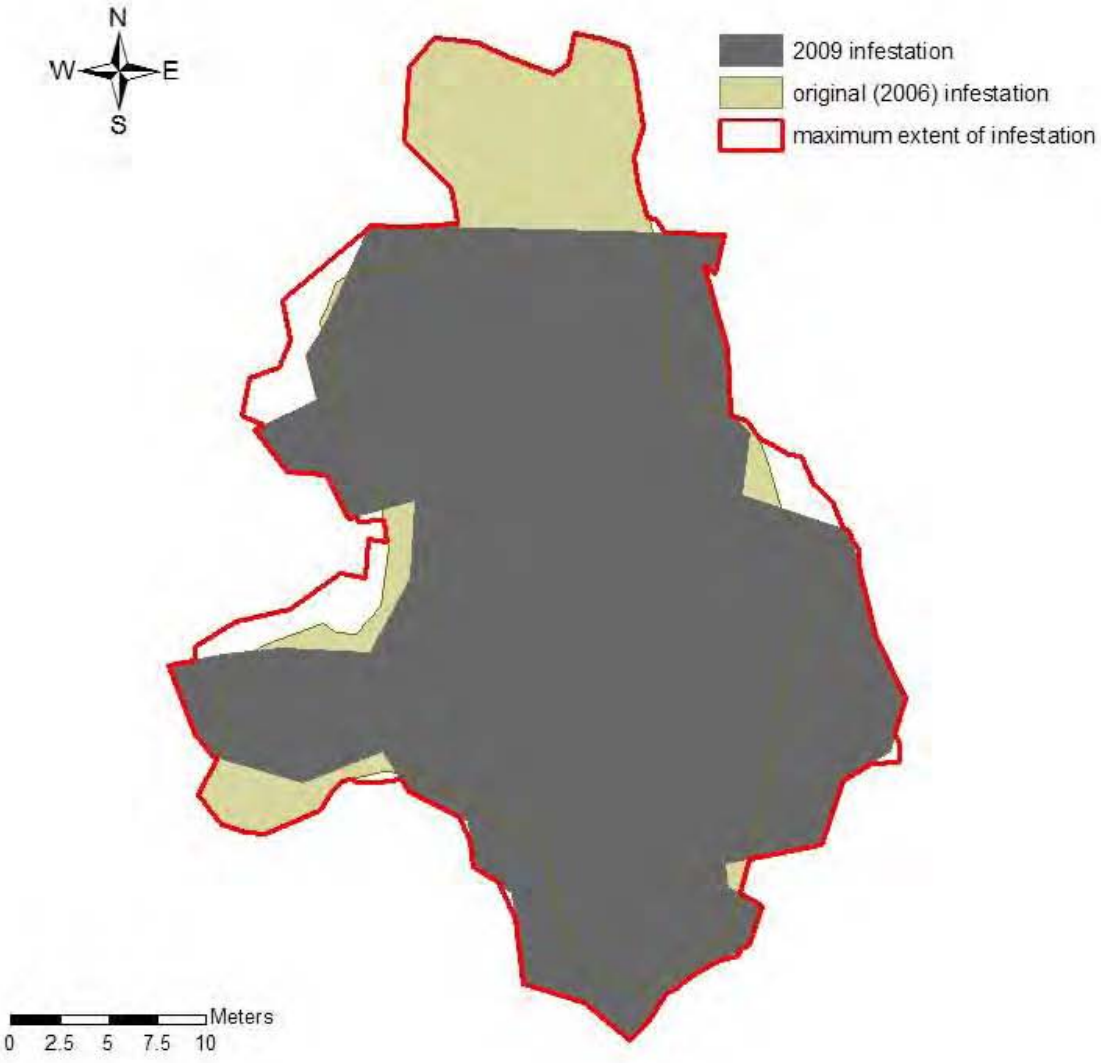
Runway leafy spurge density in 2009.



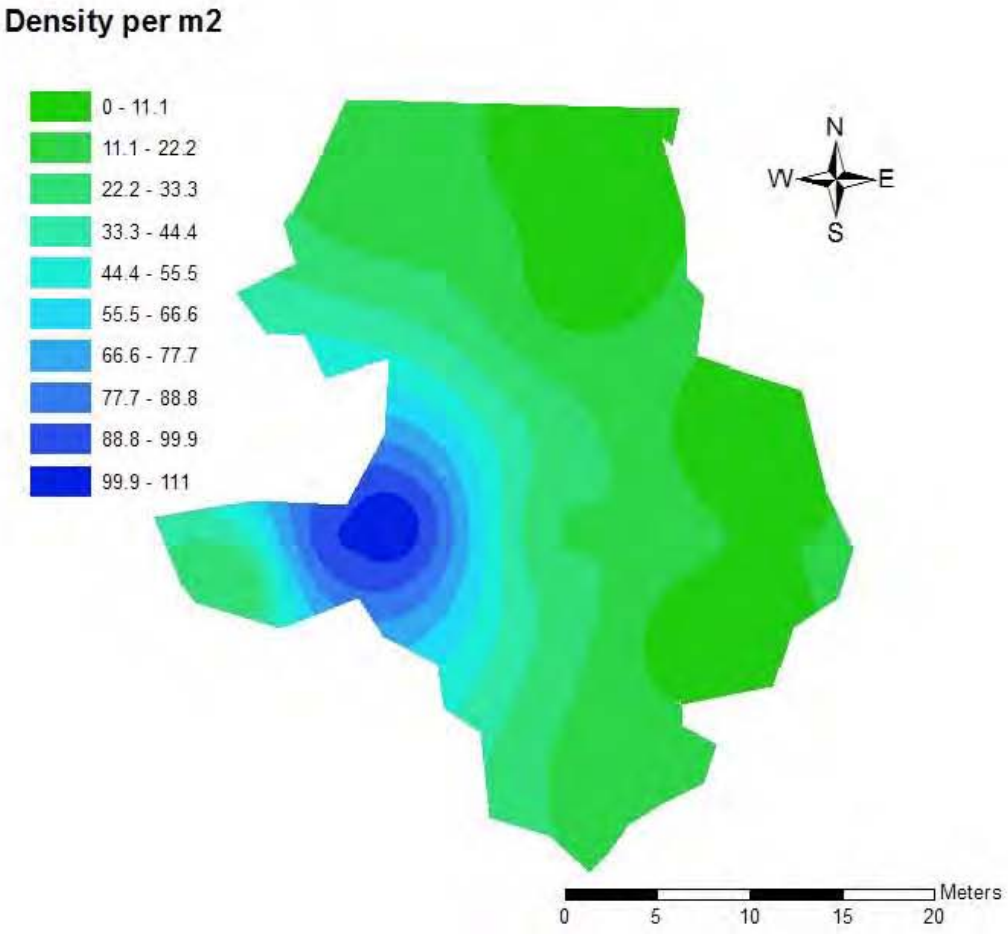


Runway leafy spurge height in 2009.

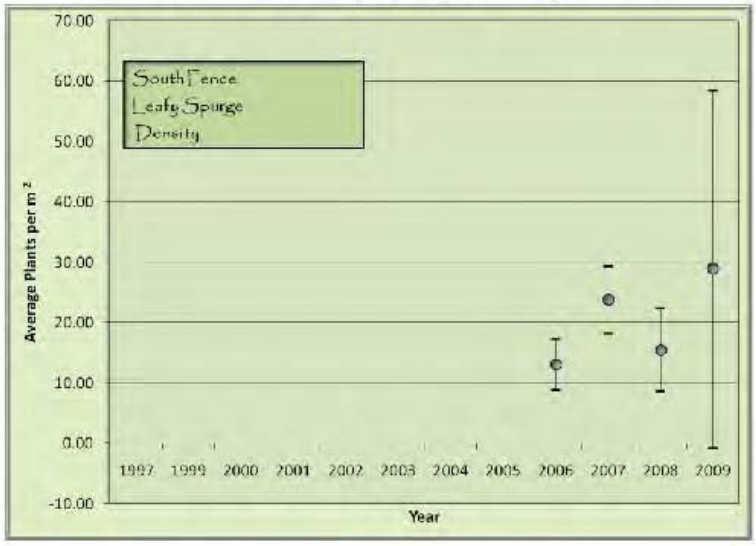


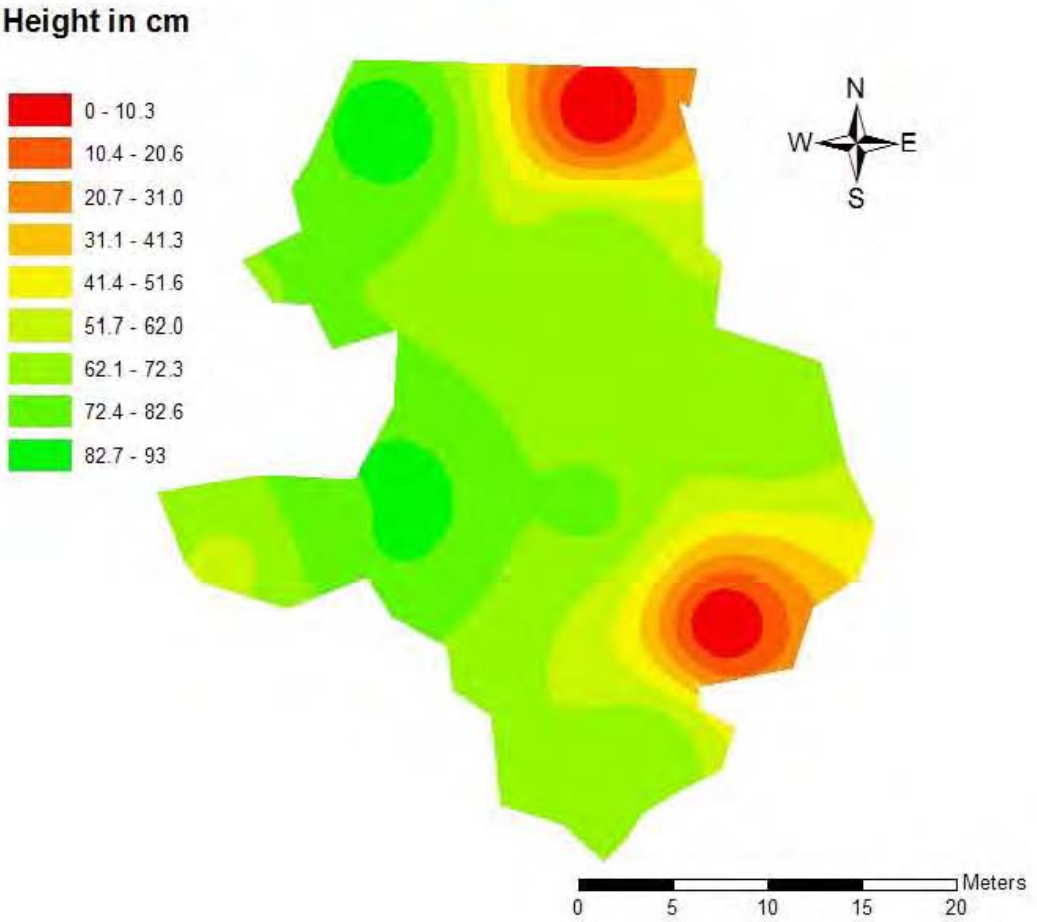


South Fence leafy spurge perimeter in 2009.

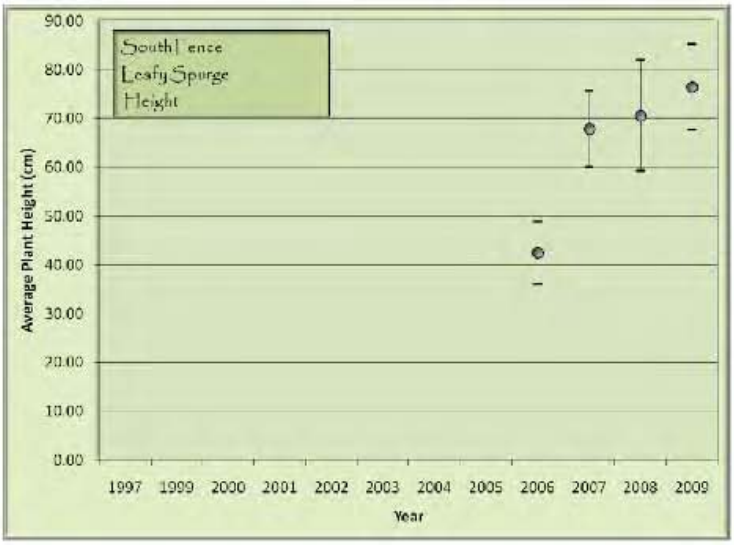


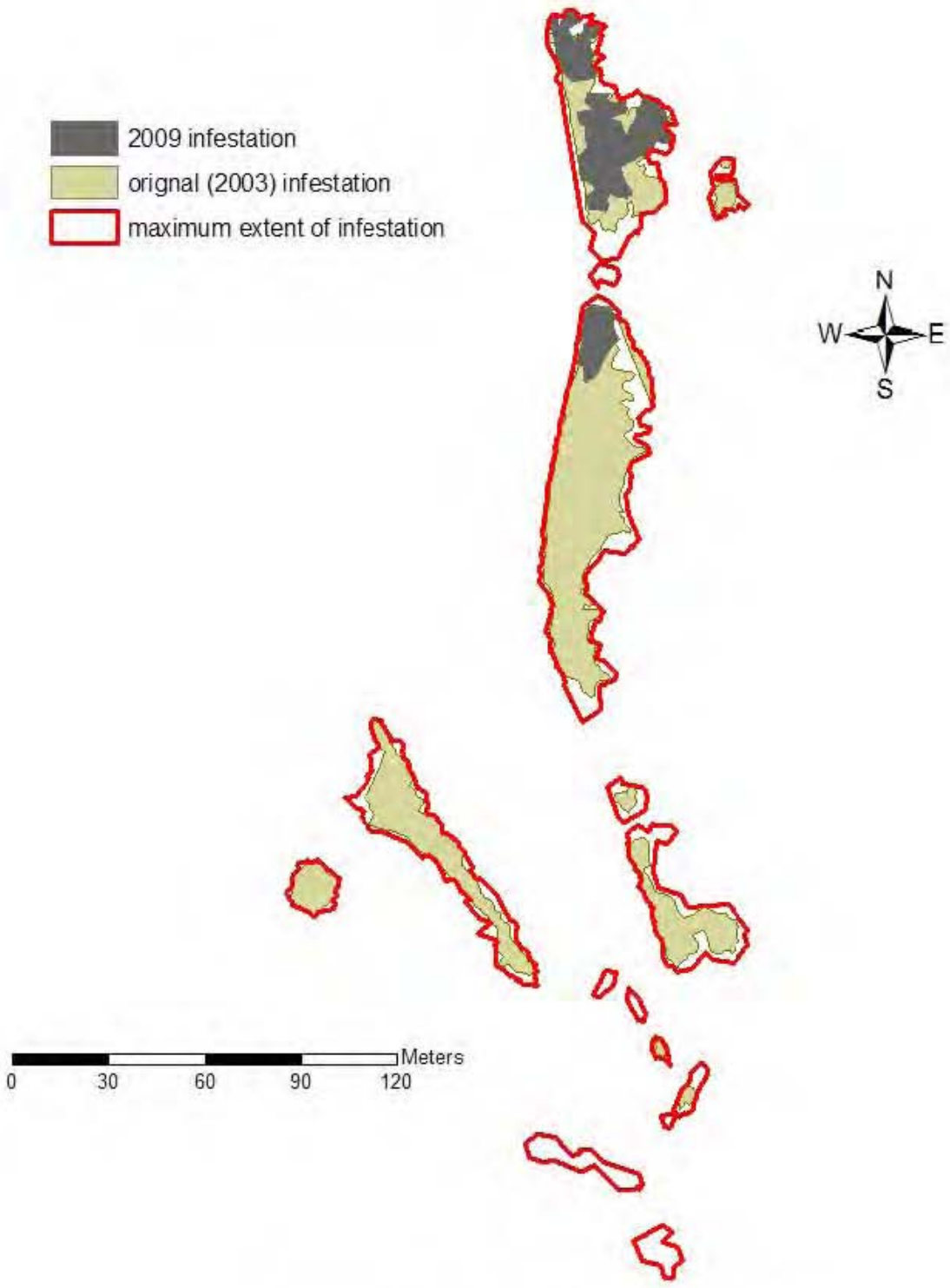
South Fence leafy spurge density in 2009.



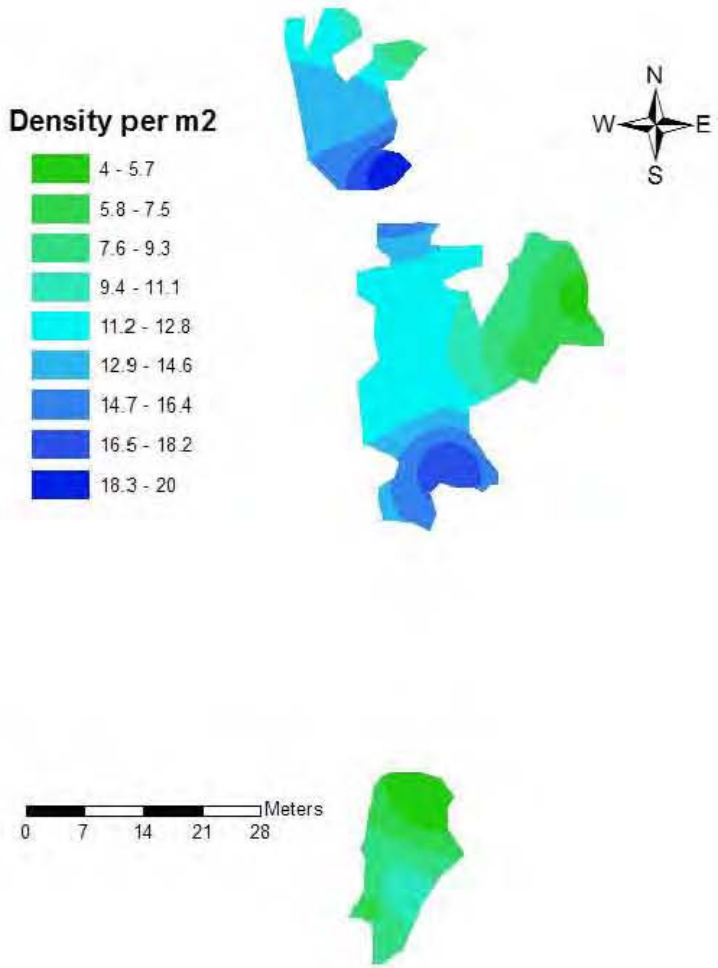


South Fence leafy spurge height in 2009.

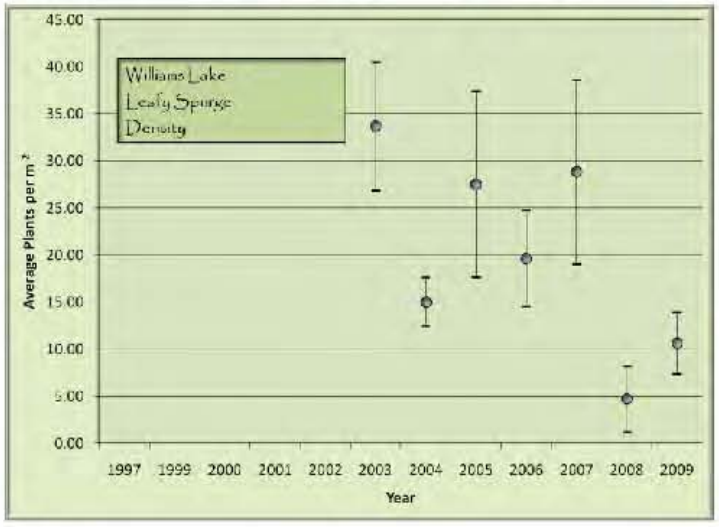


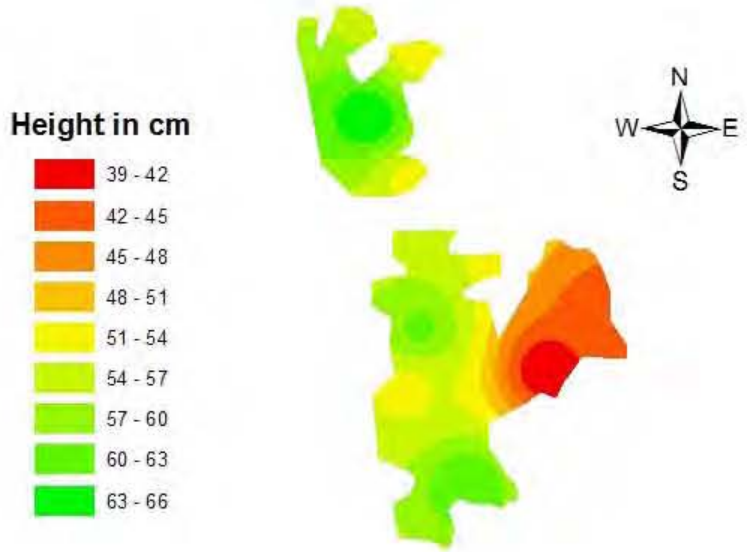


Williams Lake leafy spurge perimeter in 2009.

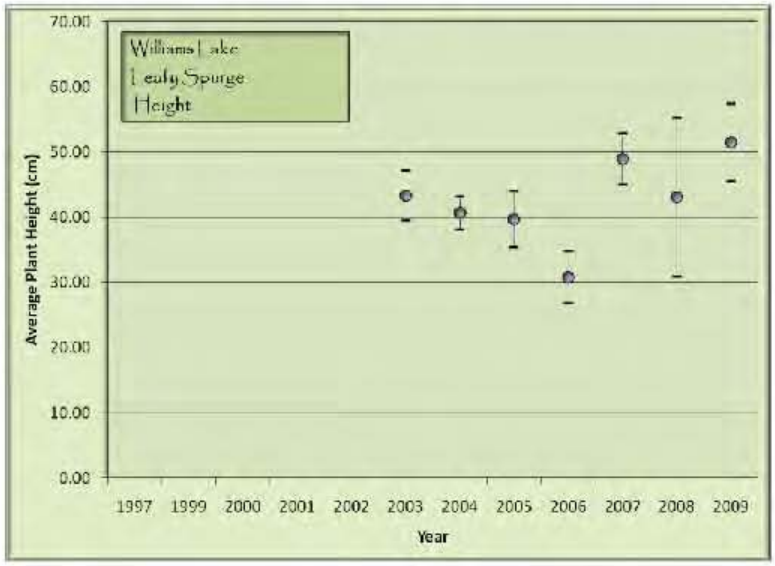


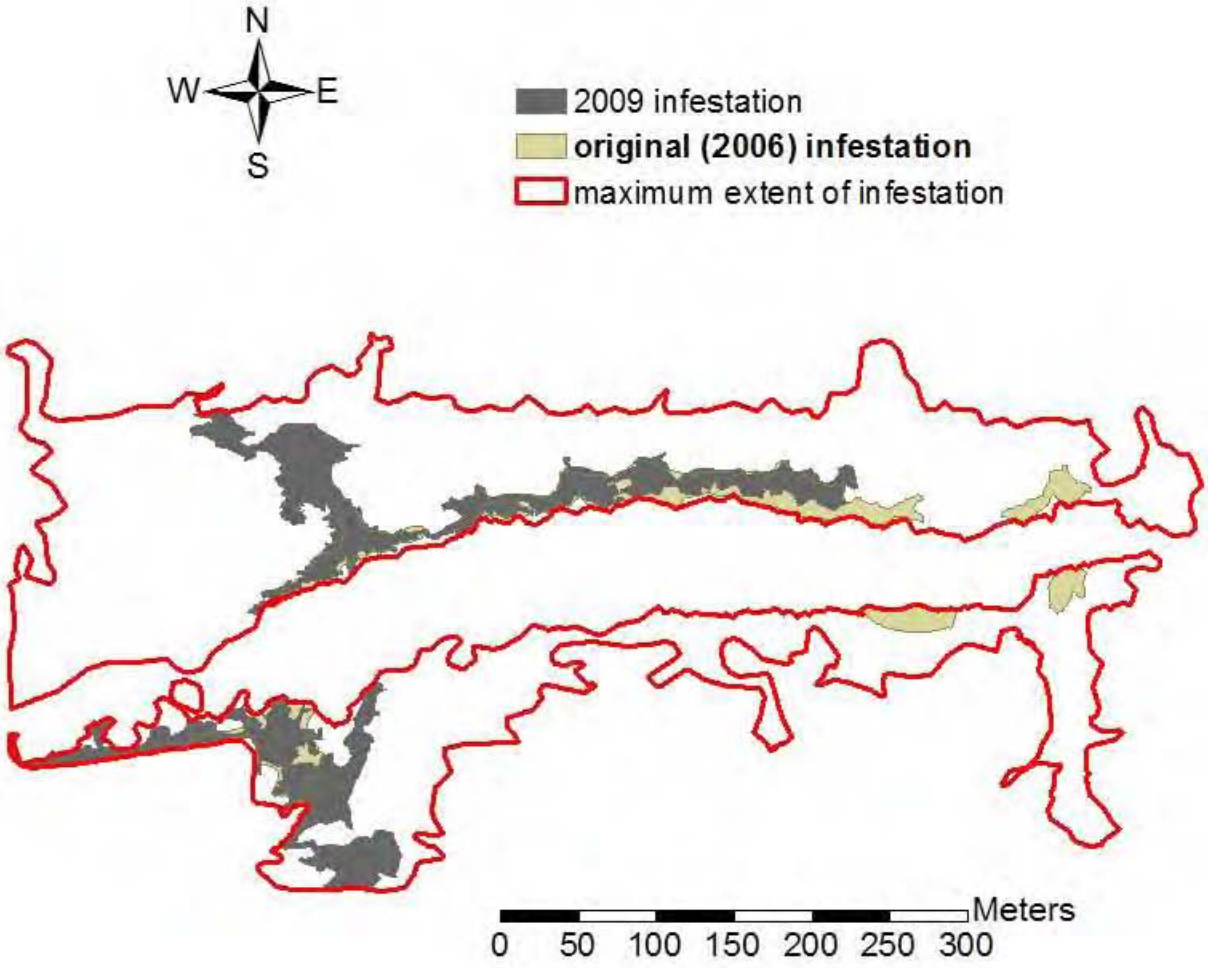
Williams Lake leafy spurge density in 2009.



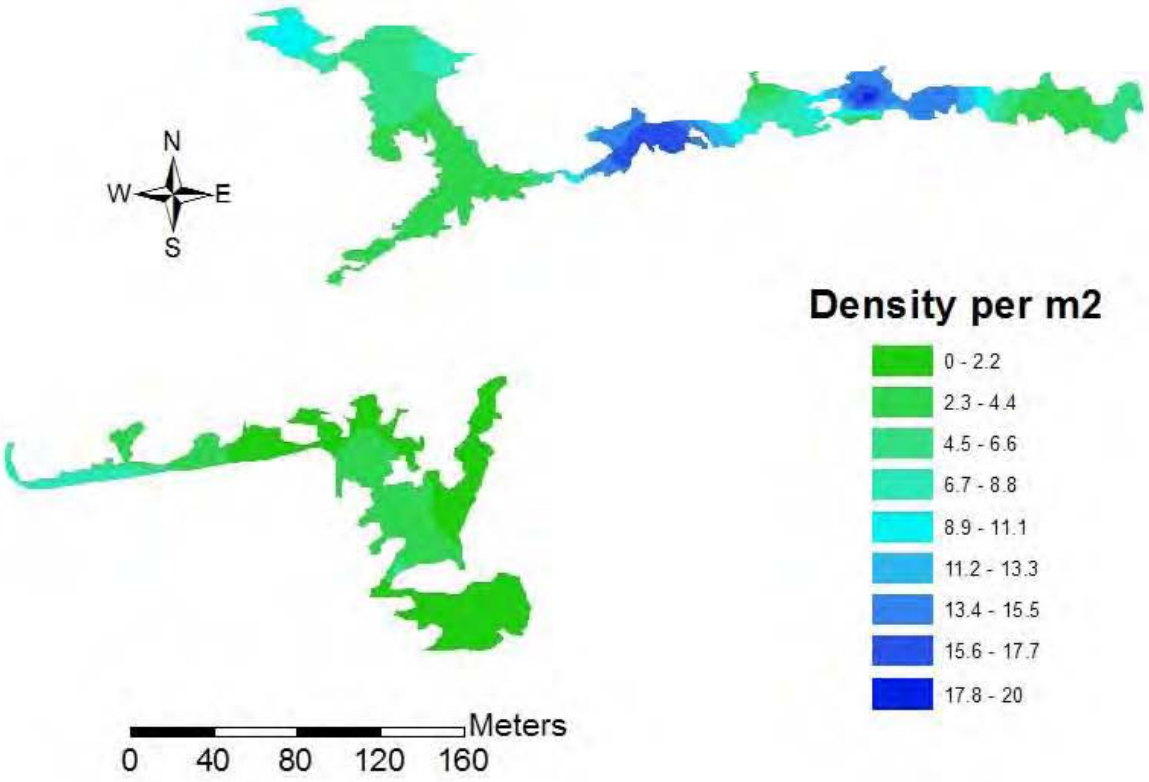


Williams Lake leafy spurge height in 2009.

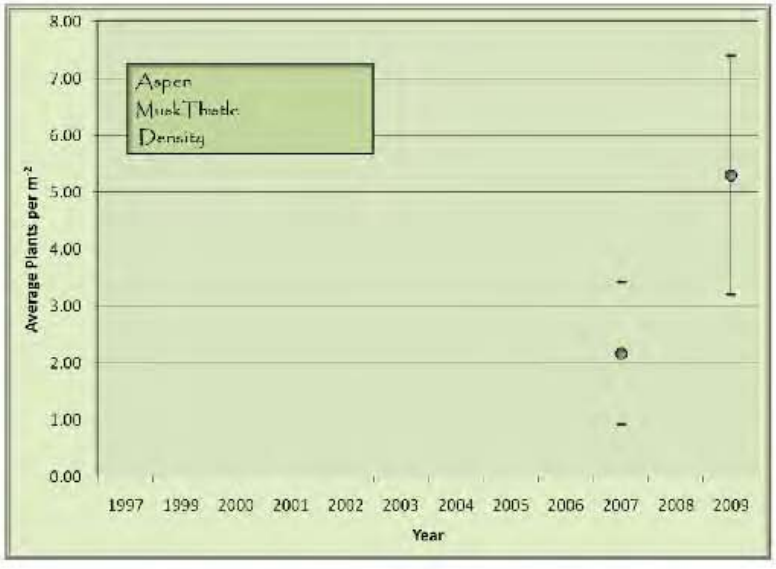


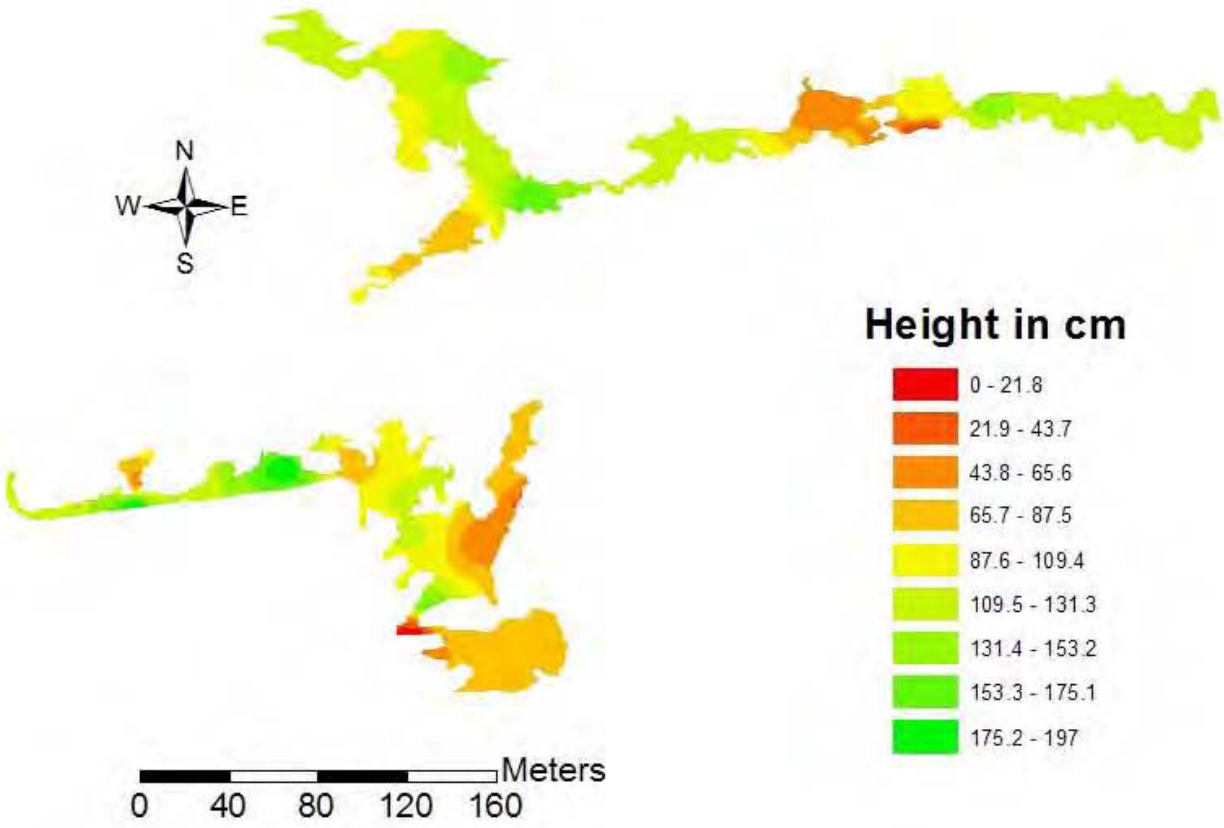


Aspen musk thistle perimeter in 2009.

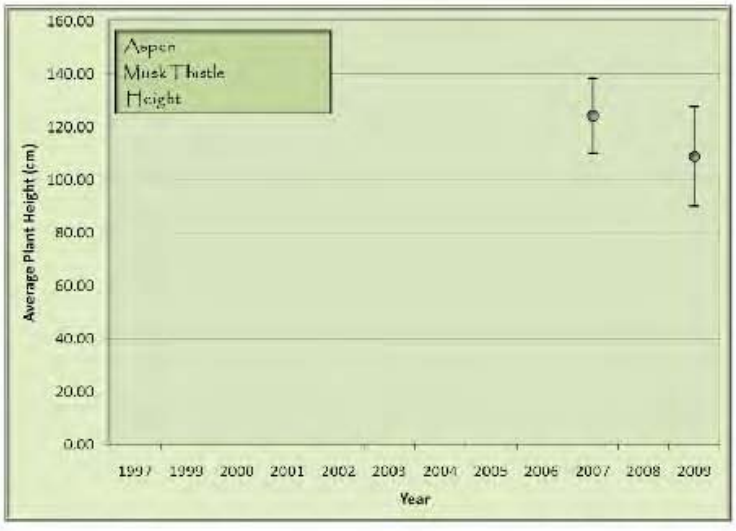


Aspen musk thistle density in 2009.

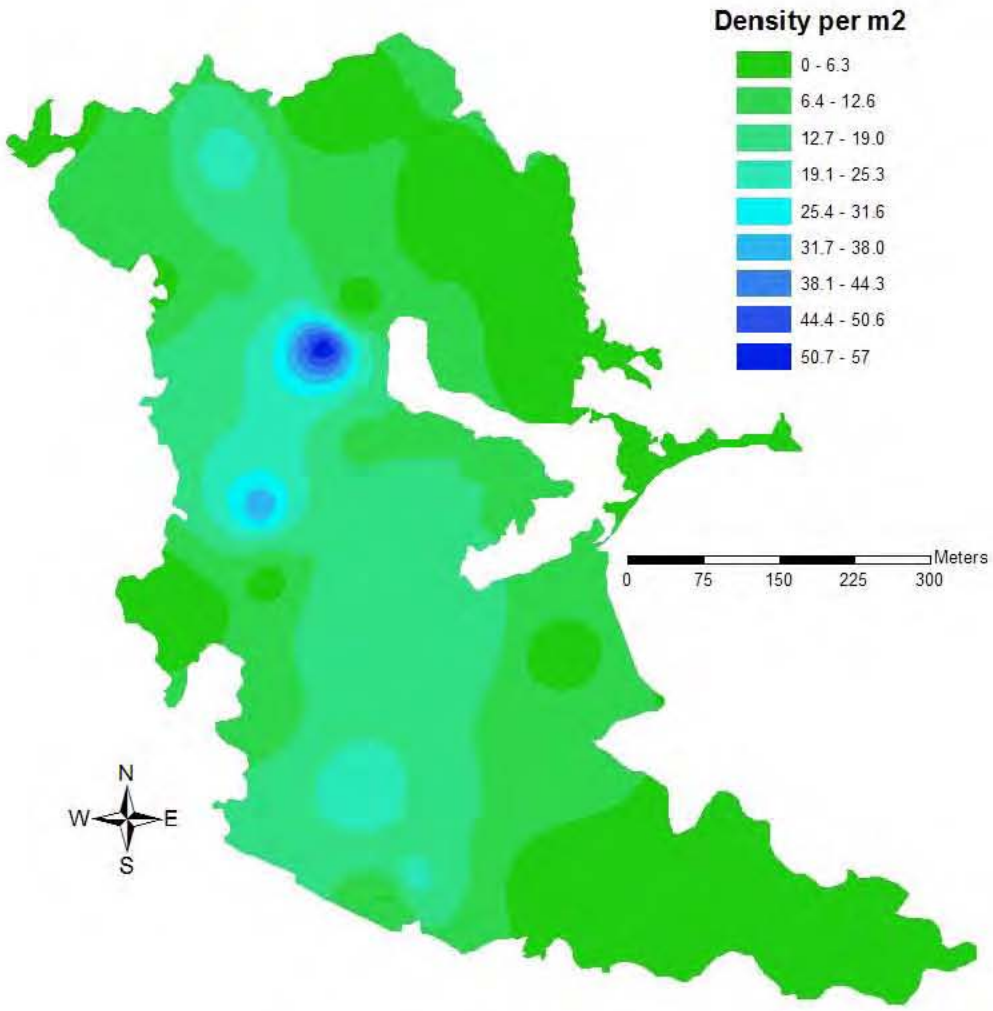




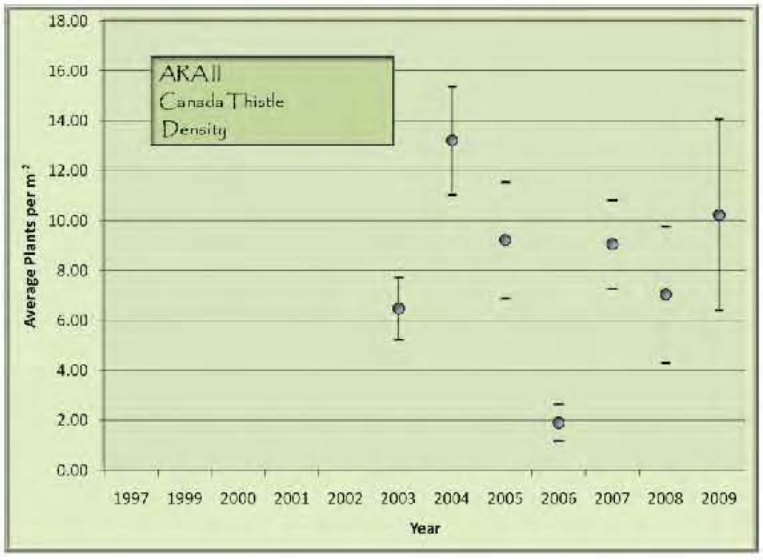
Aspen musk thistle height in 2009.

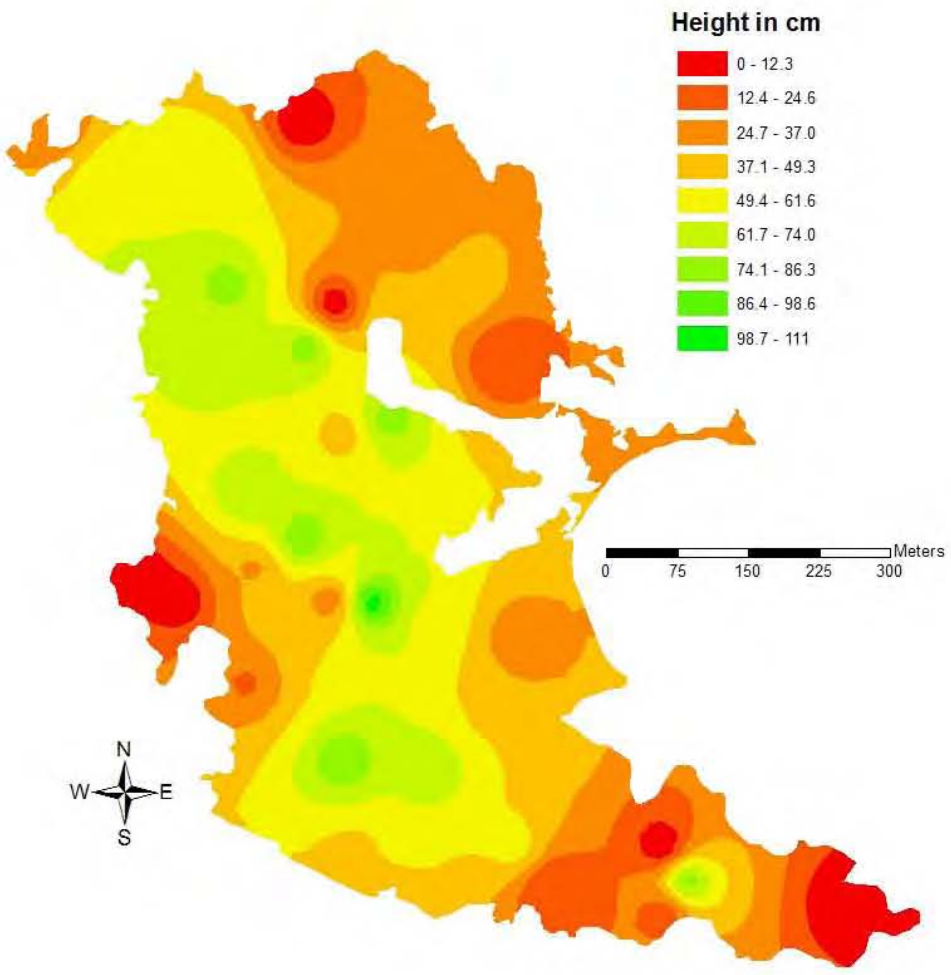


ARA II Canada thistle perimeter in 2009.

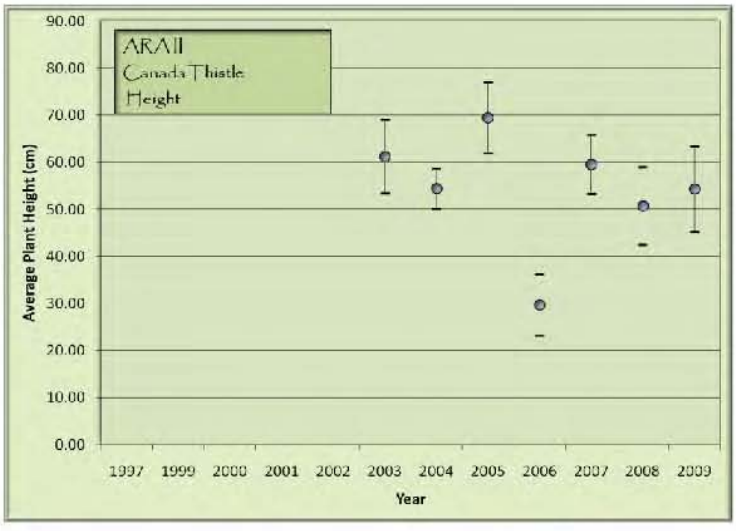


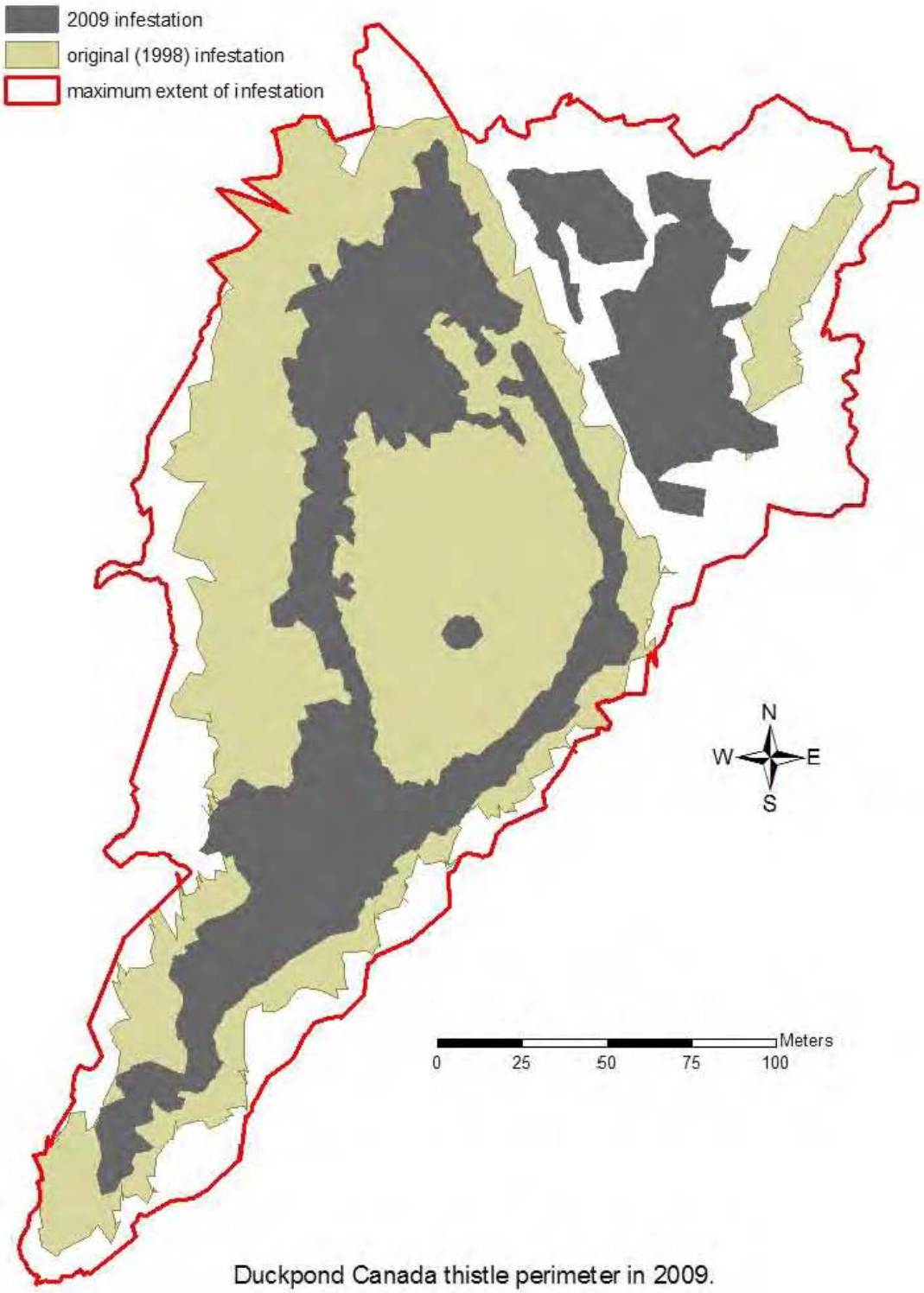
ARA II Canada thistle density in 2009.



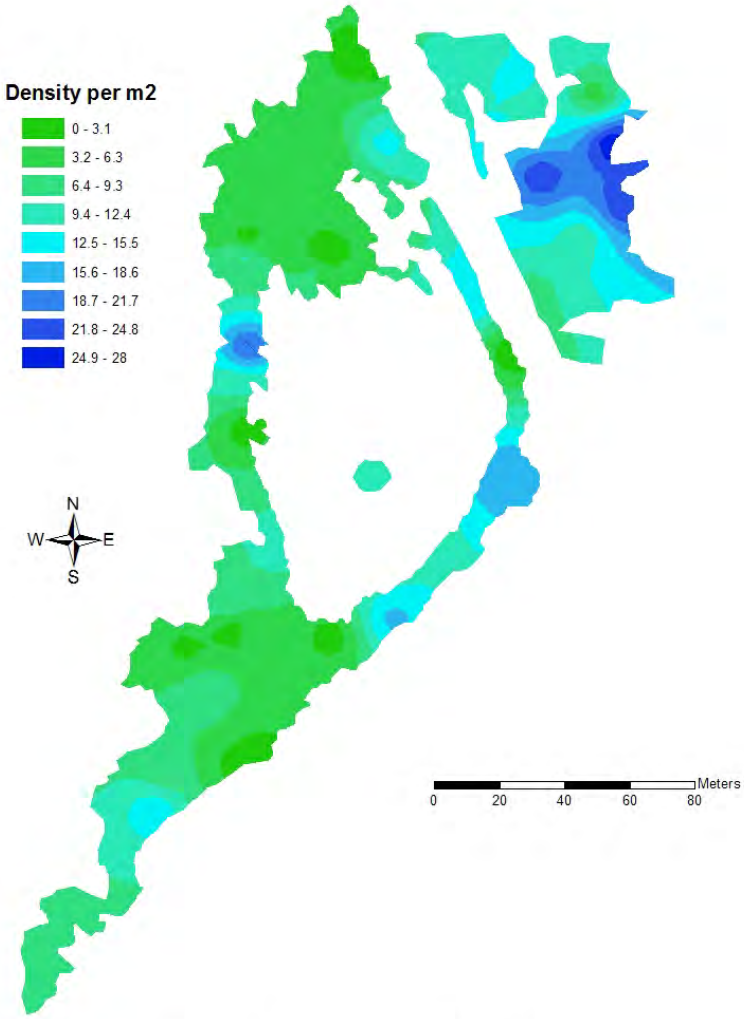


ARA II Canada thistle height in 2009.

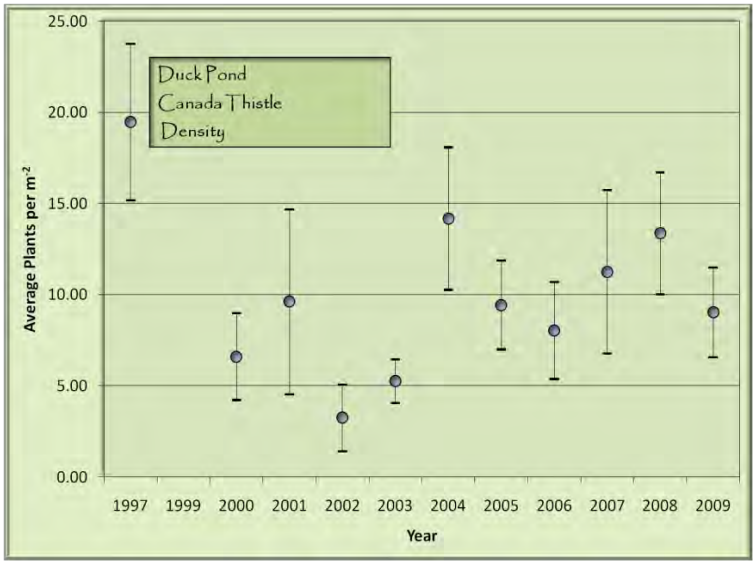


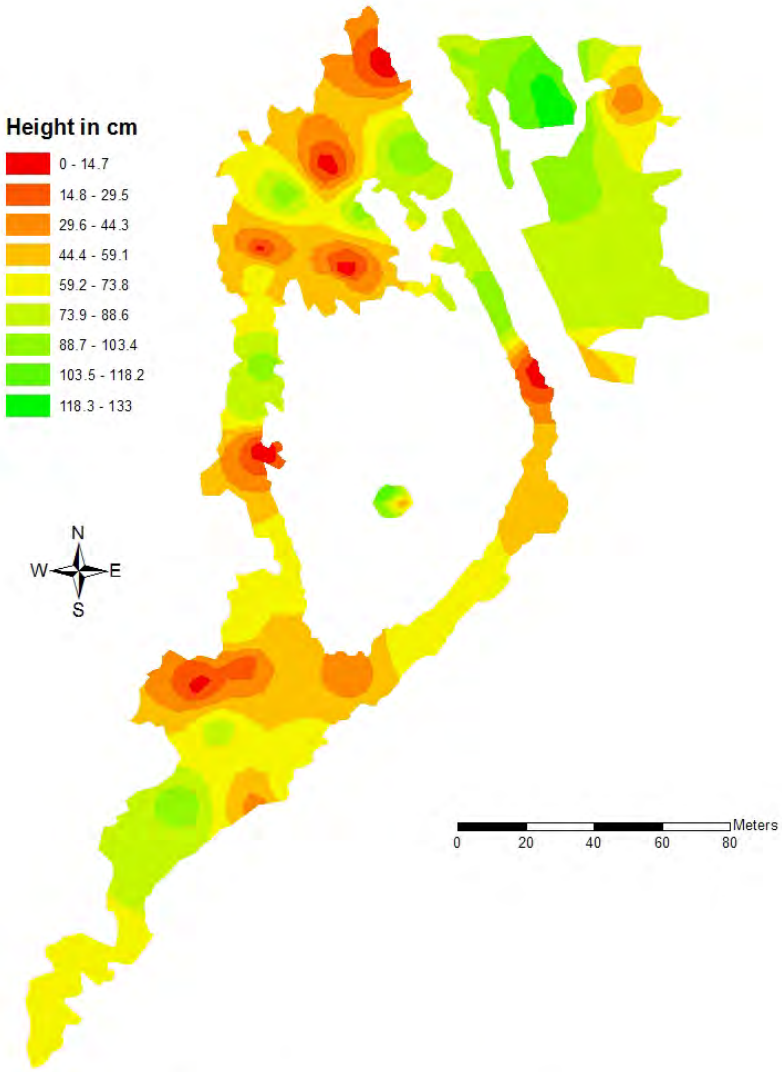


Duckpond Canada thistle perimeter in 2009.

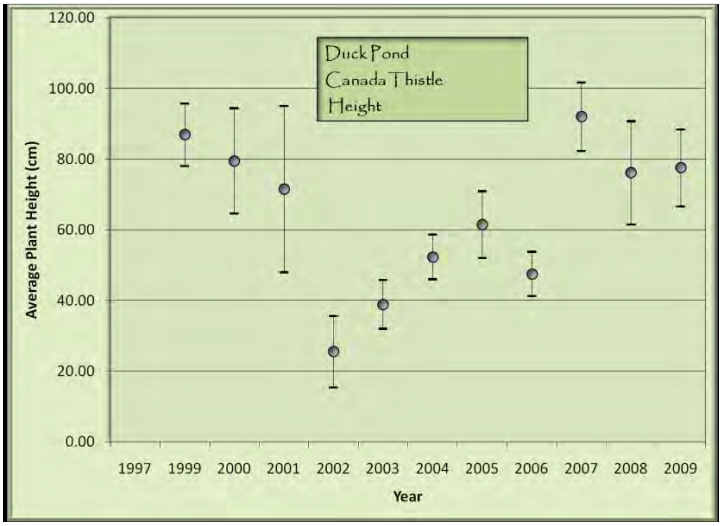


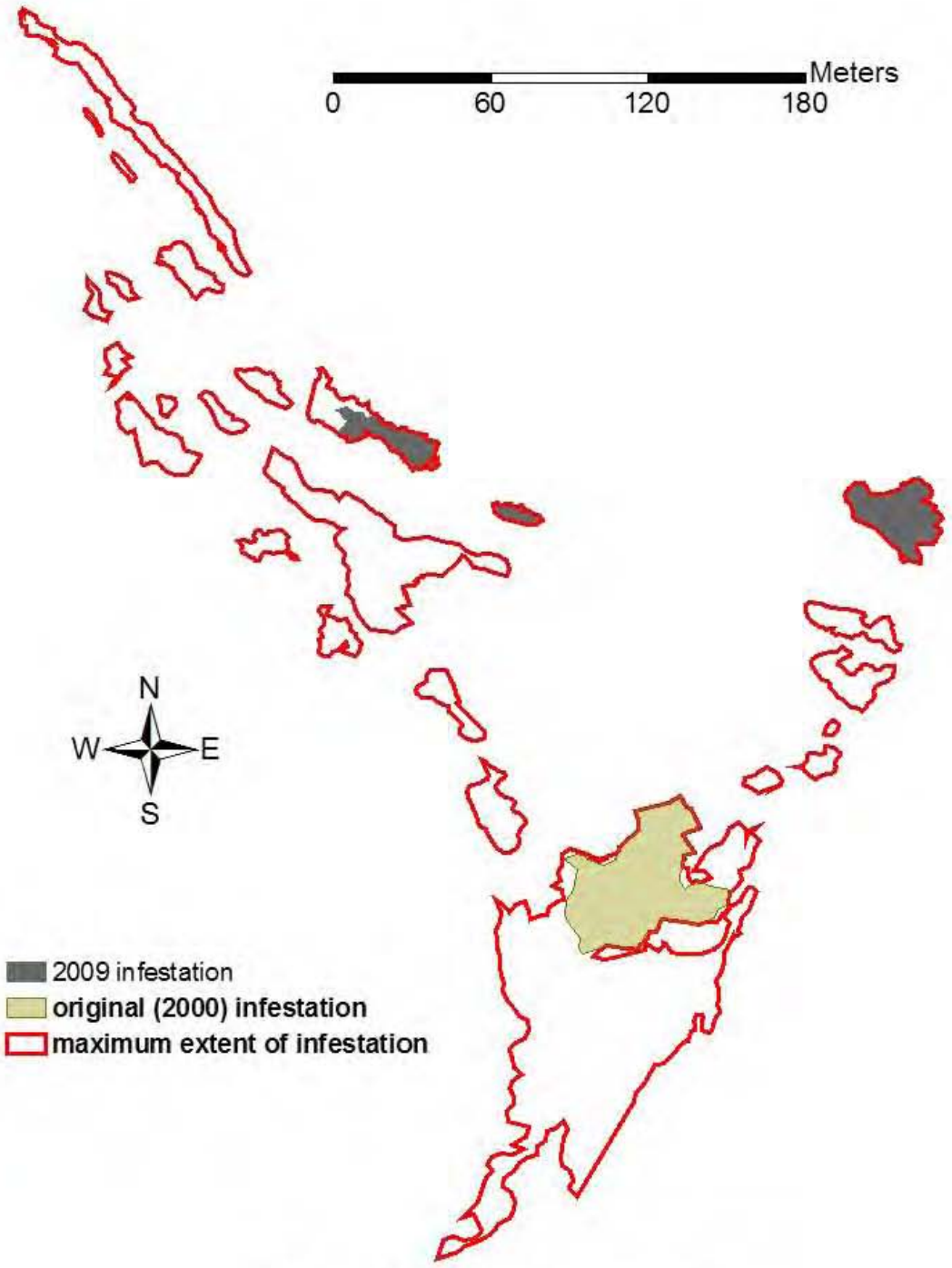
Duckpond Canada thistle density in 2009.



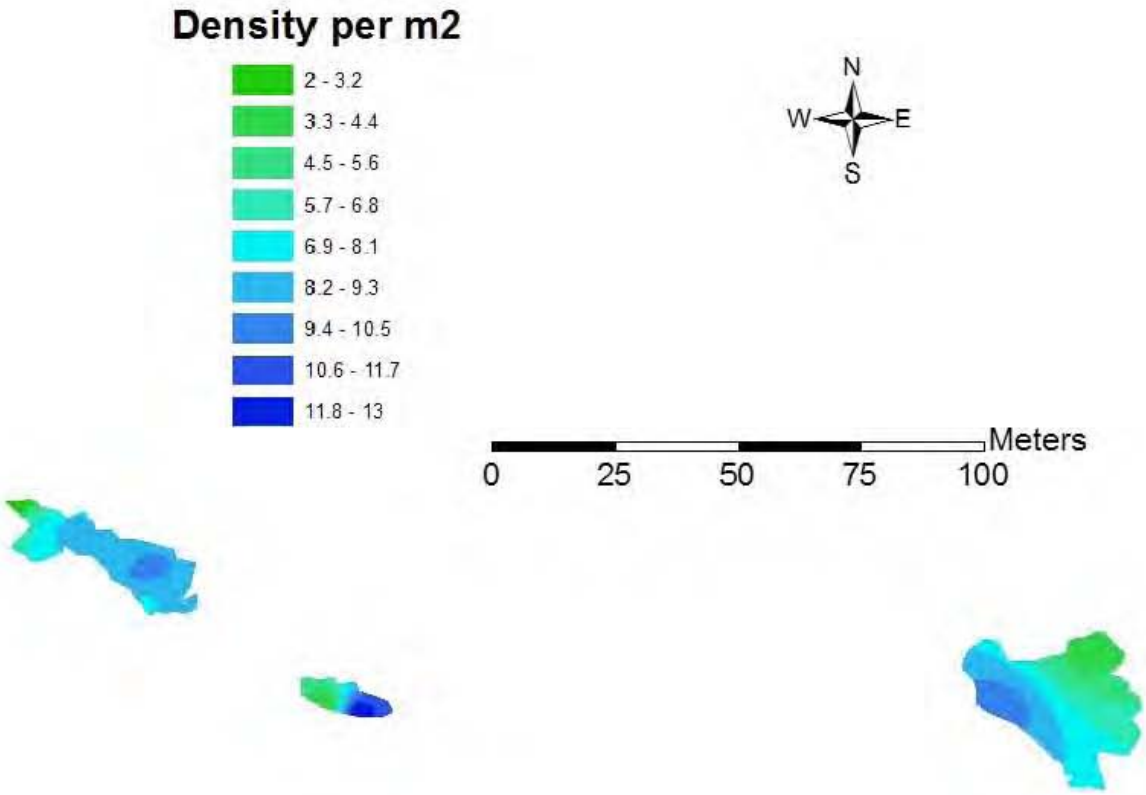


Duckpond Canada thistle height in 2009.

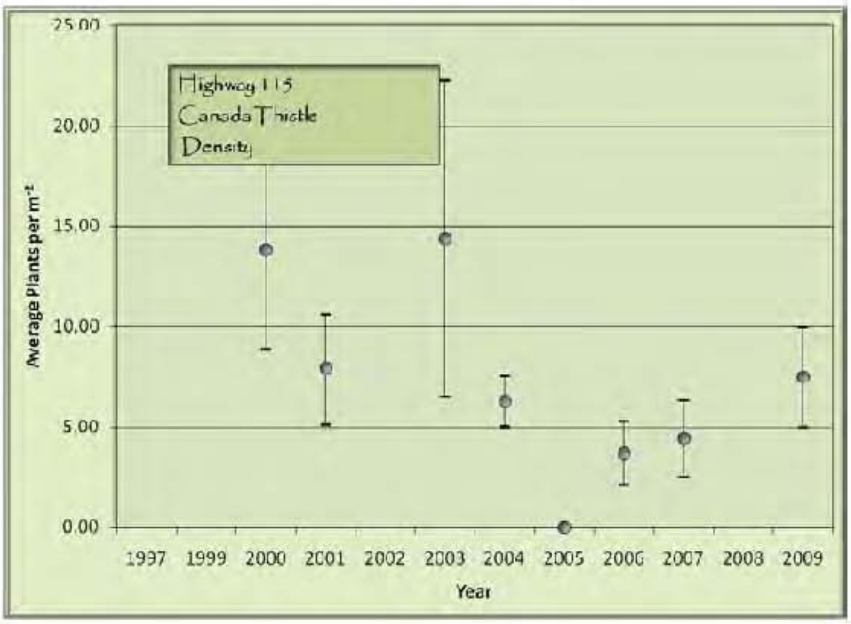


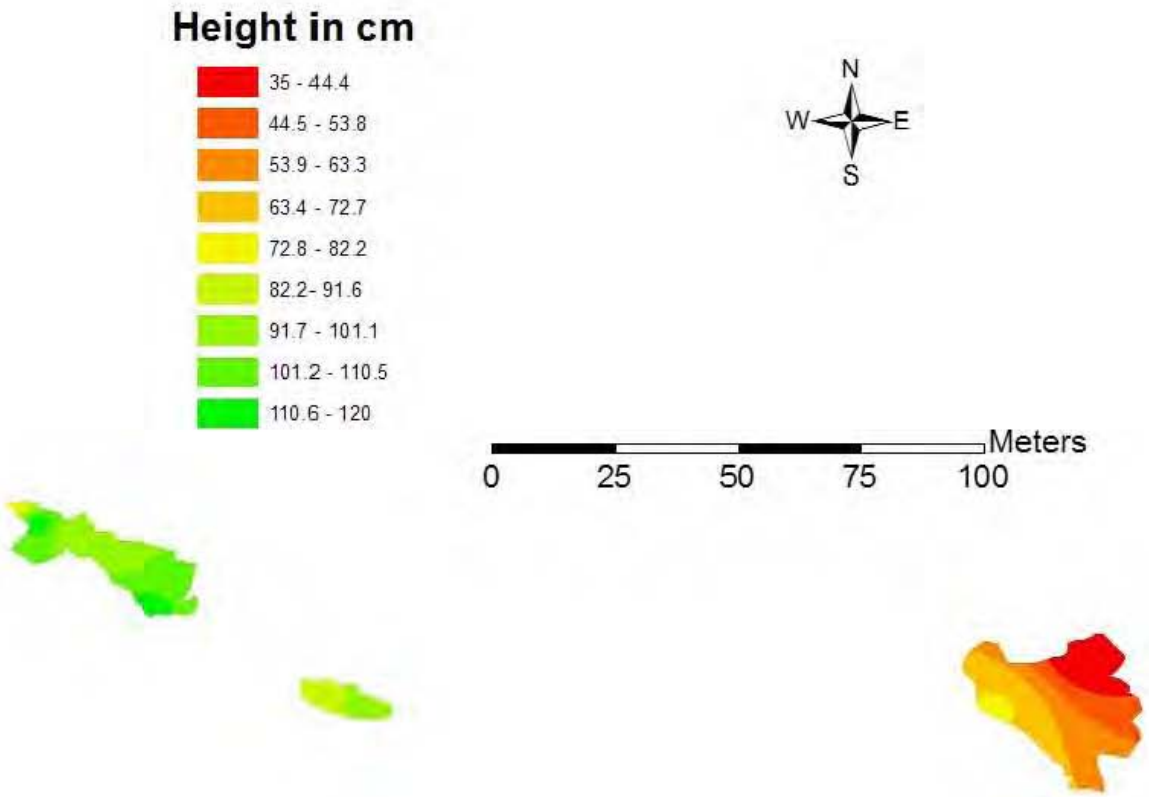


Highway 115 Canada thistle perimeter in 2009.

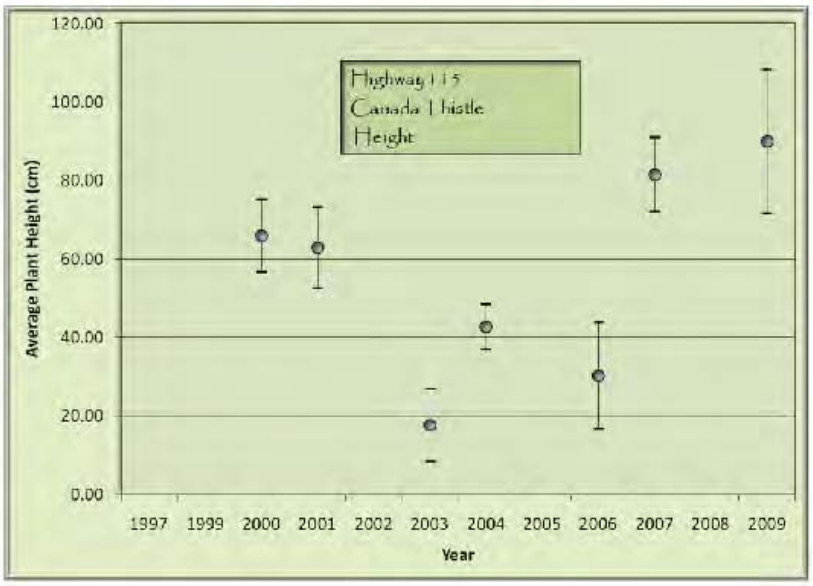


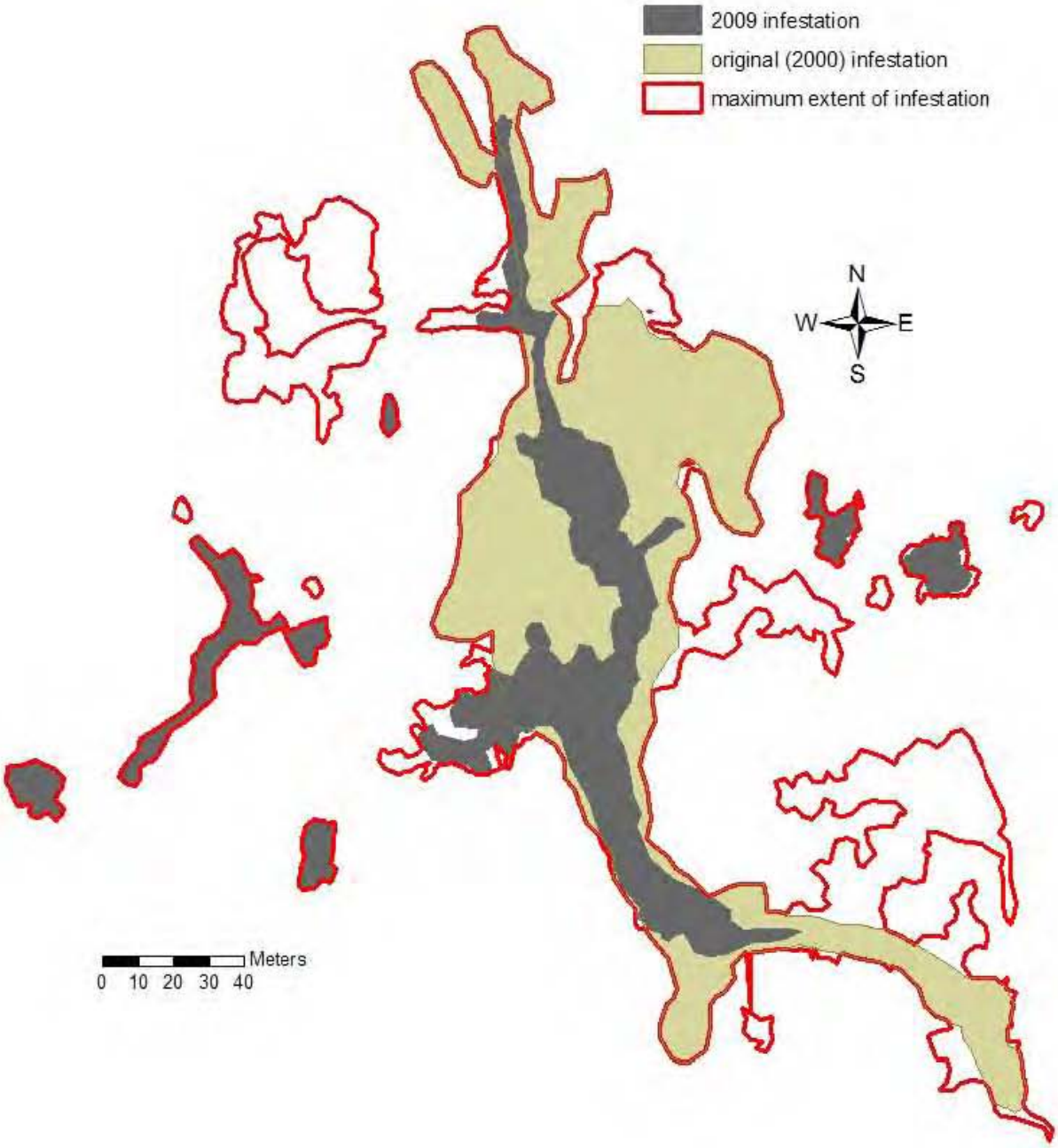
Highway 115 Canada thistle density in 2009.



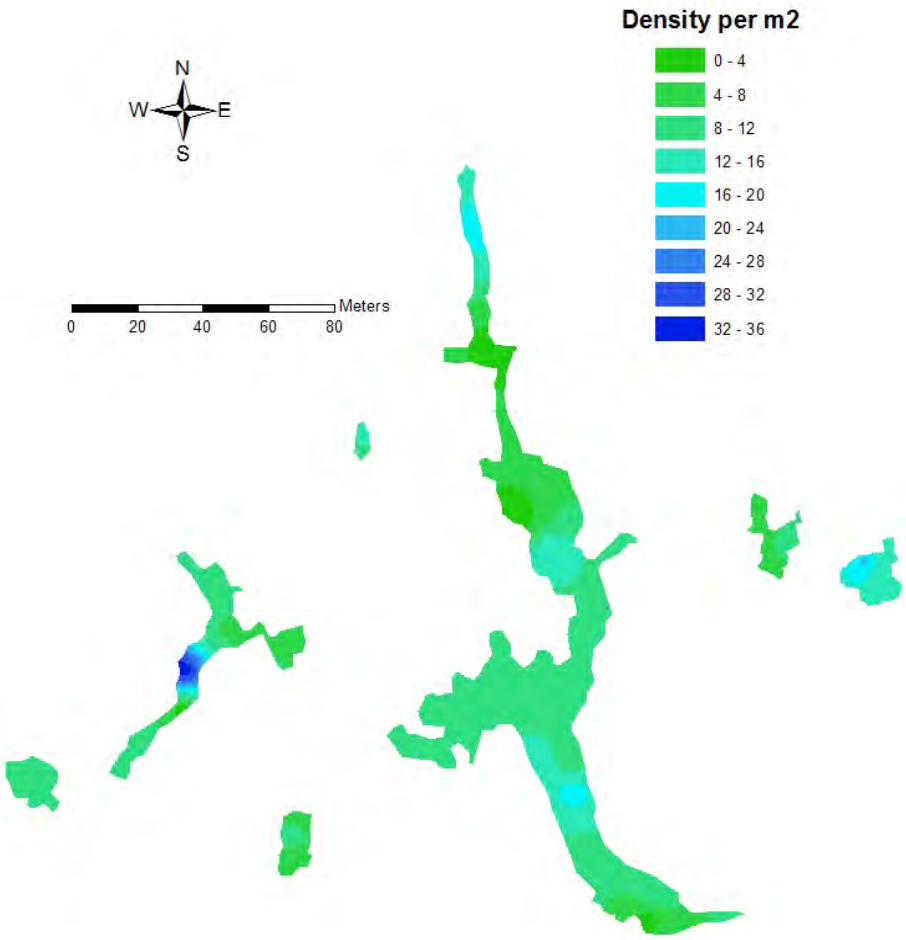


Highway 115 Canada thistle height in 2009.

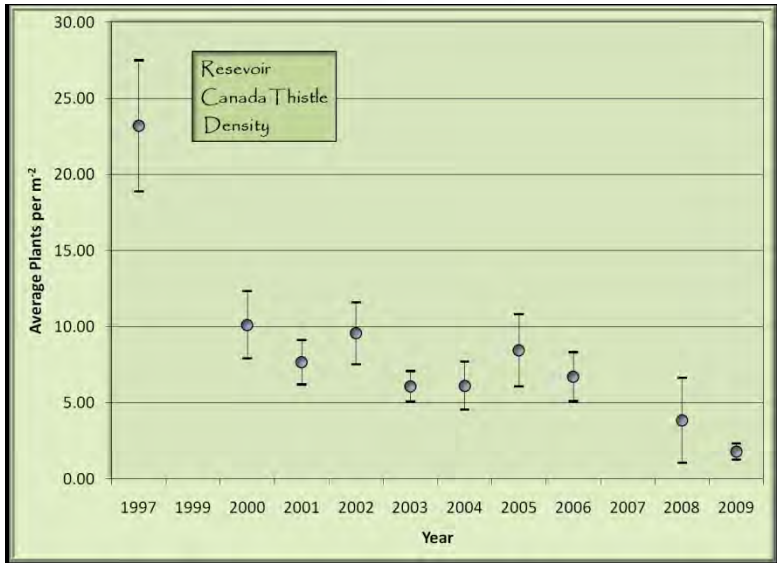


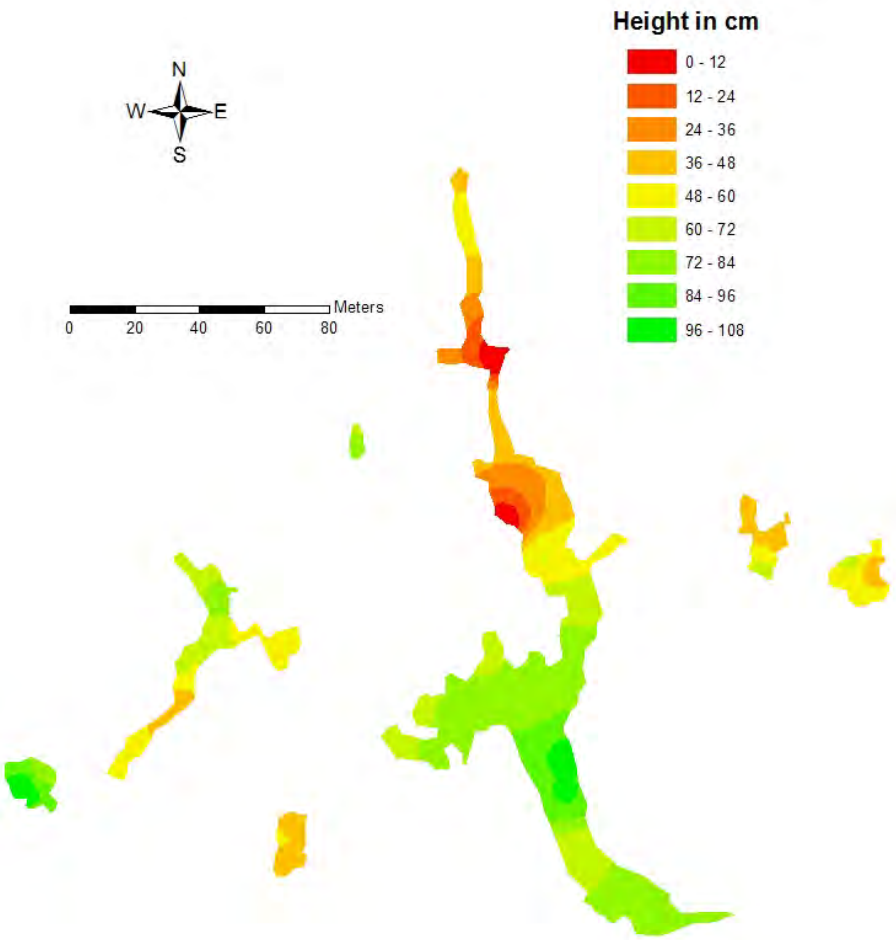


Reservoir Canada thistle perimeter in 2009.

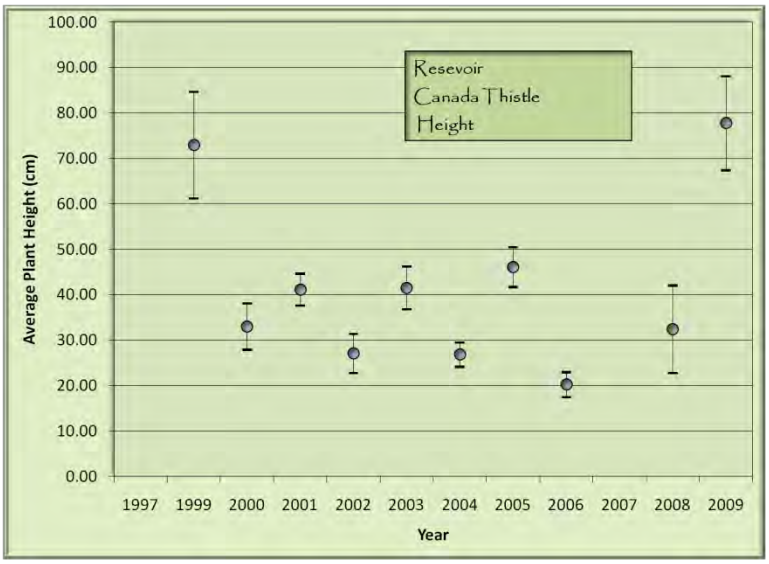


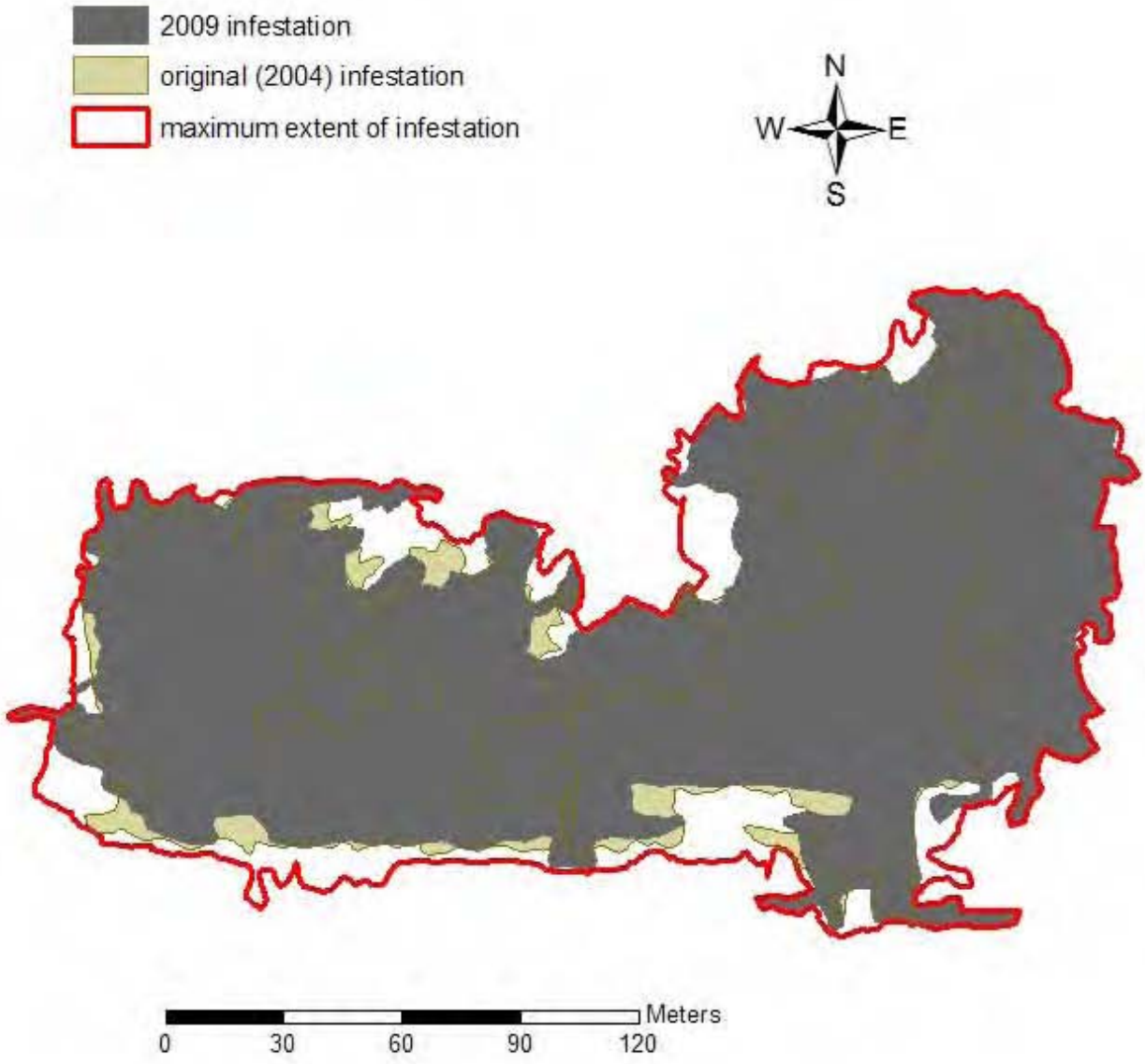
Reservoir Canada thistle density in 2009.



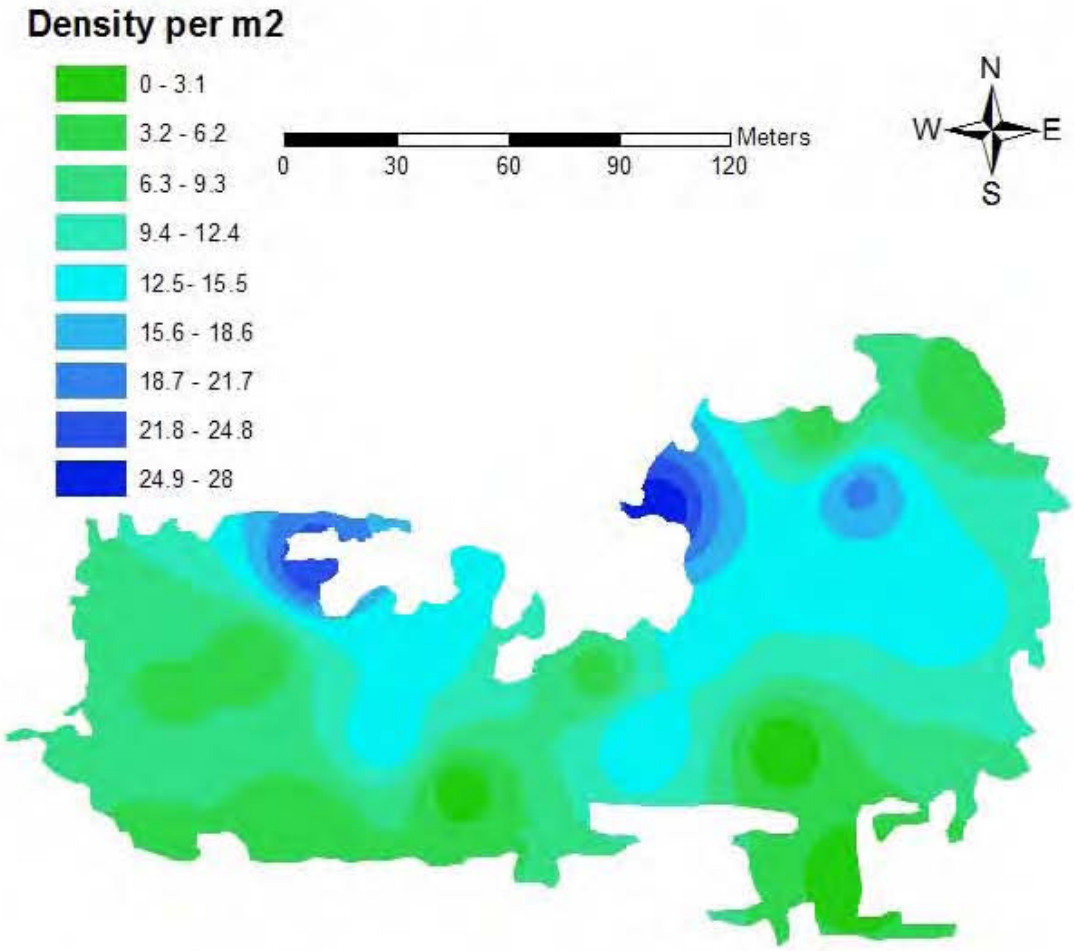


Reservoir Canada thistle height in 2009.

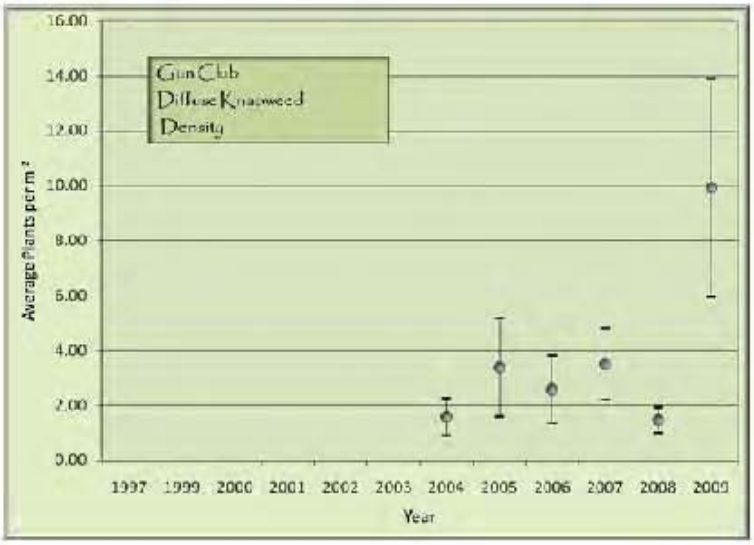


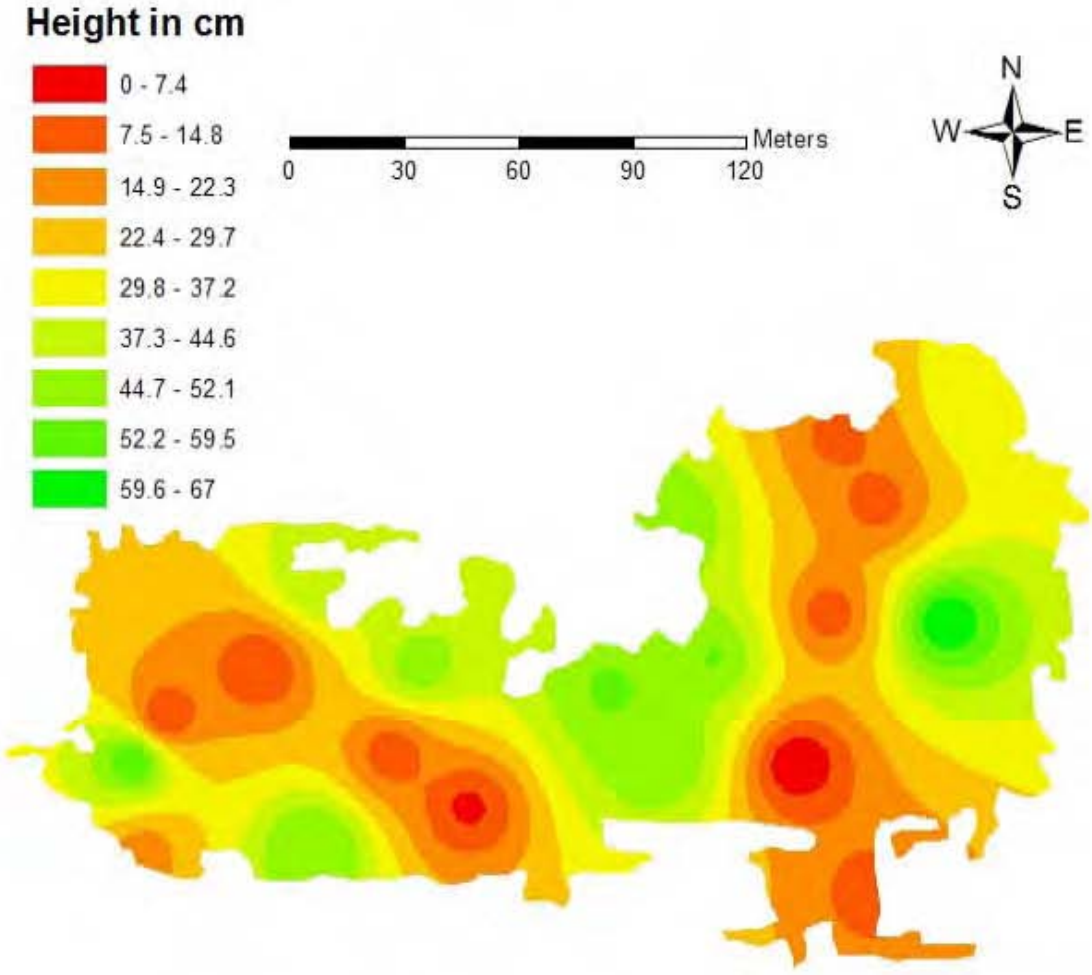


Gun Club diffuse knapweed perimeter in 2009.

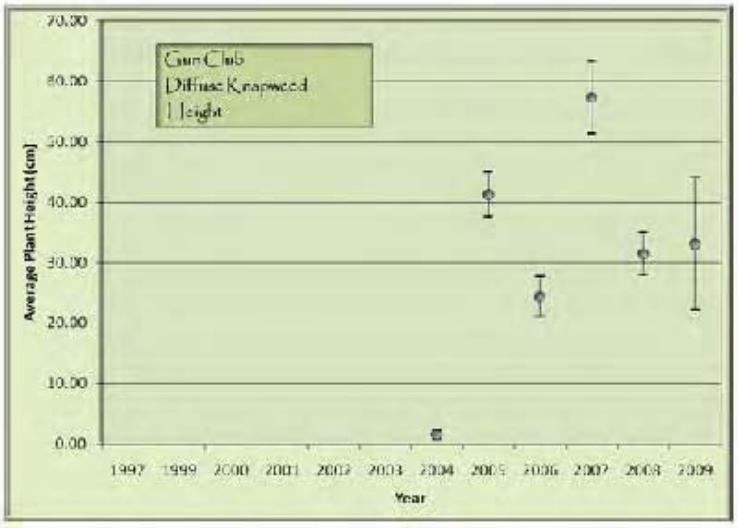


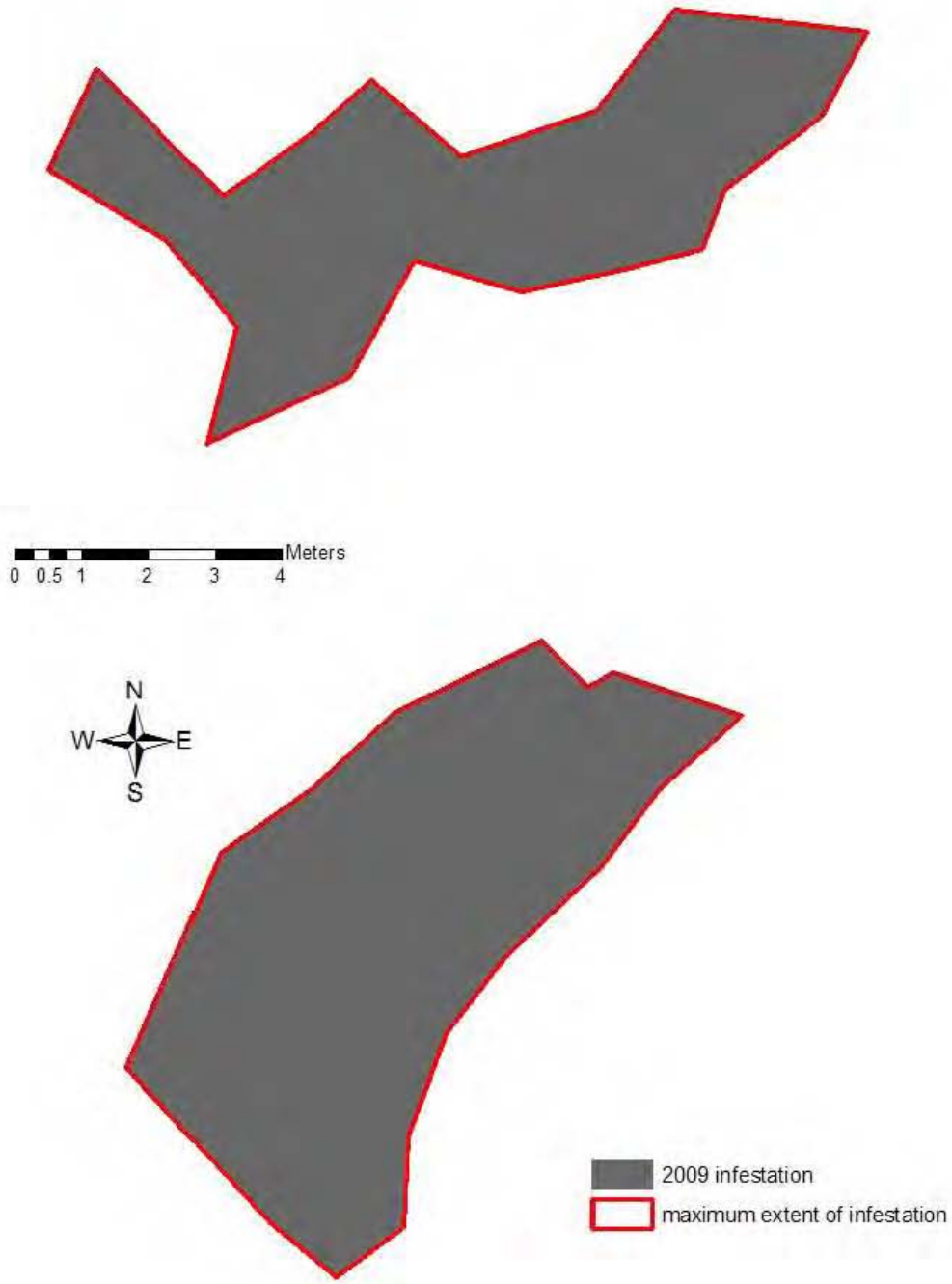
Gun Club diffuse knapweed density in 2009.



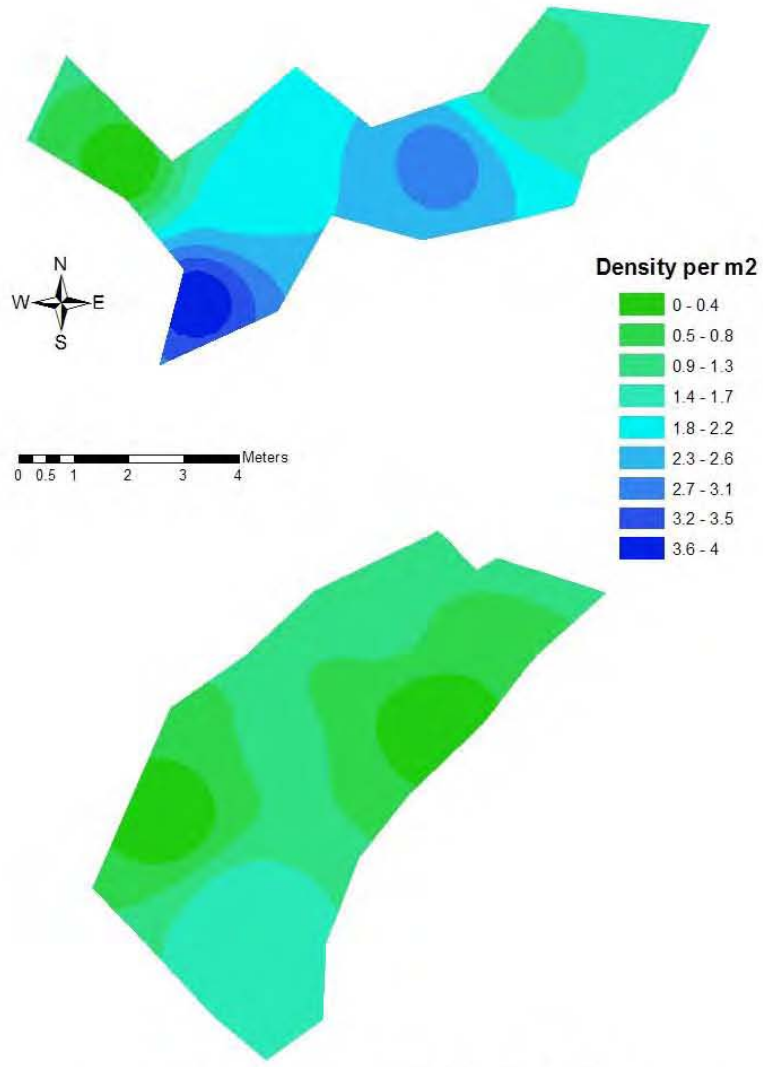


Gun Club diffuse knapweed height in 2009.

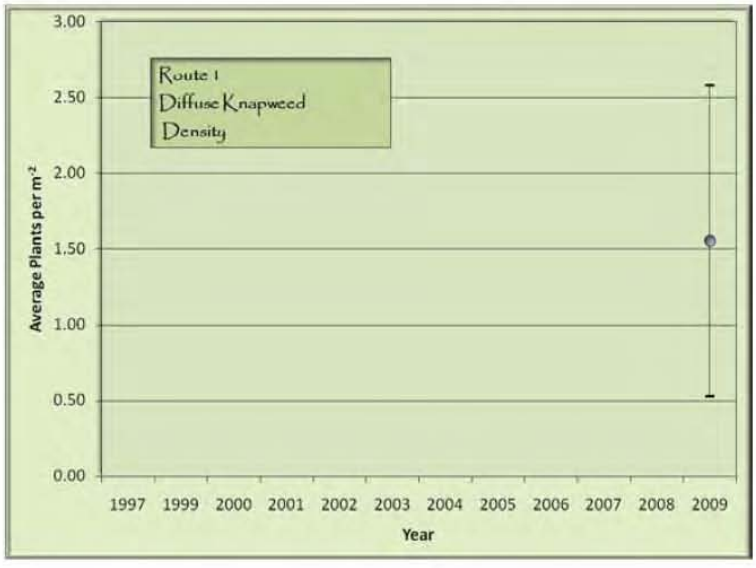


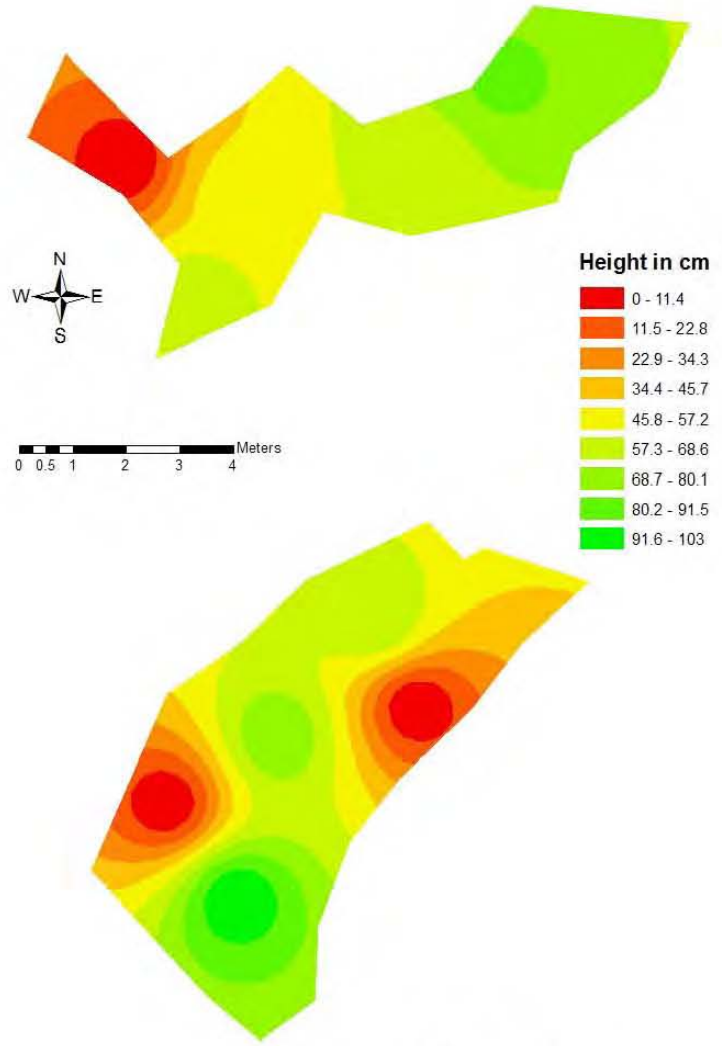


Route 1 diffuse knapweed perimeter in 2009.

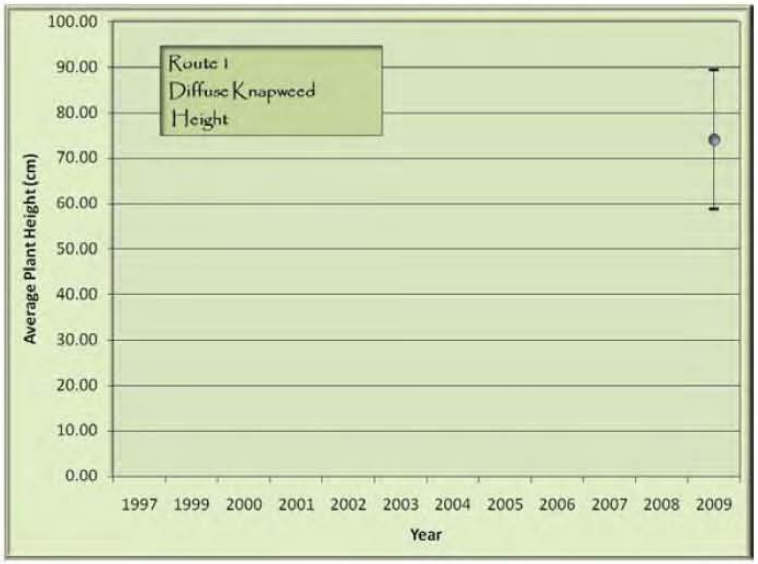


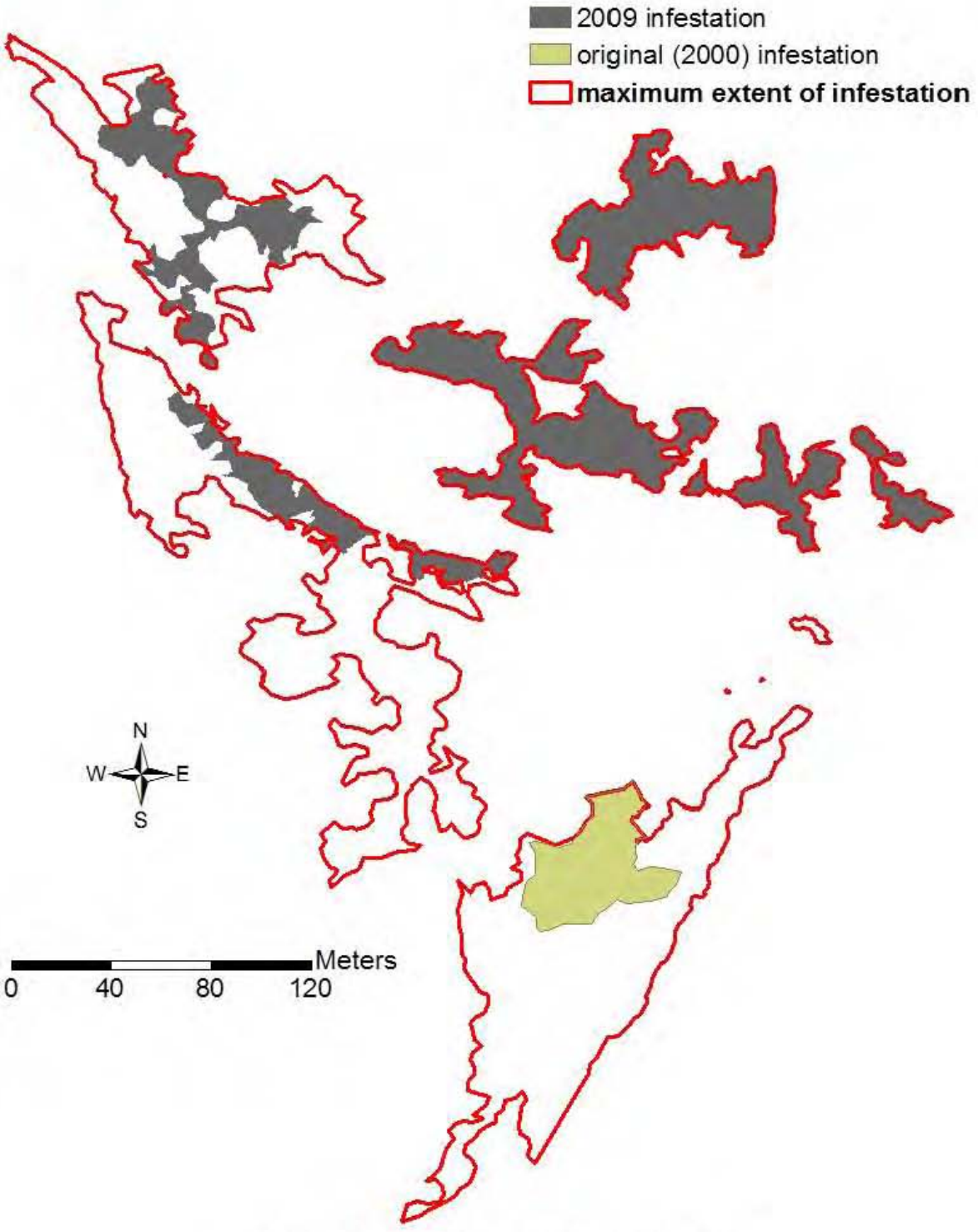
Route 1 diffuse knapweed density in 2009.



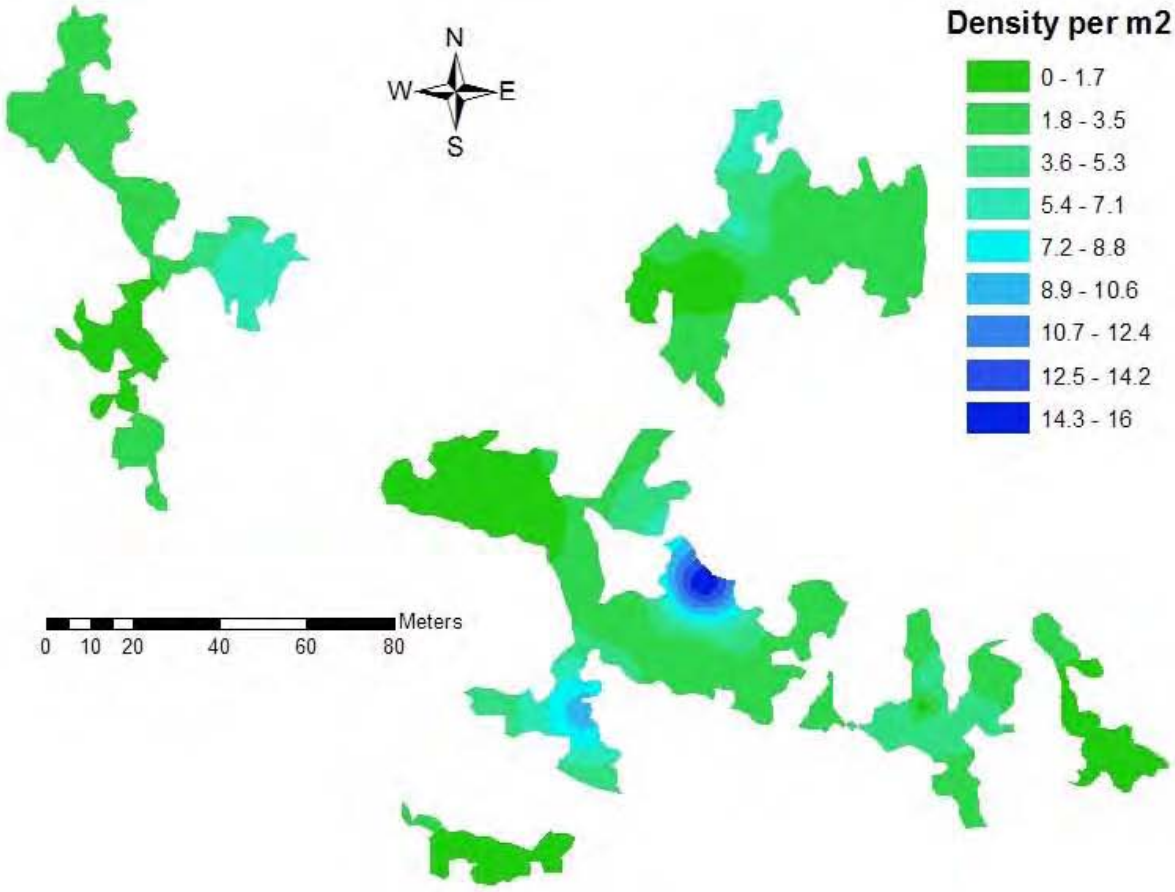


Route 1 diffuse knapweed height in 2009.

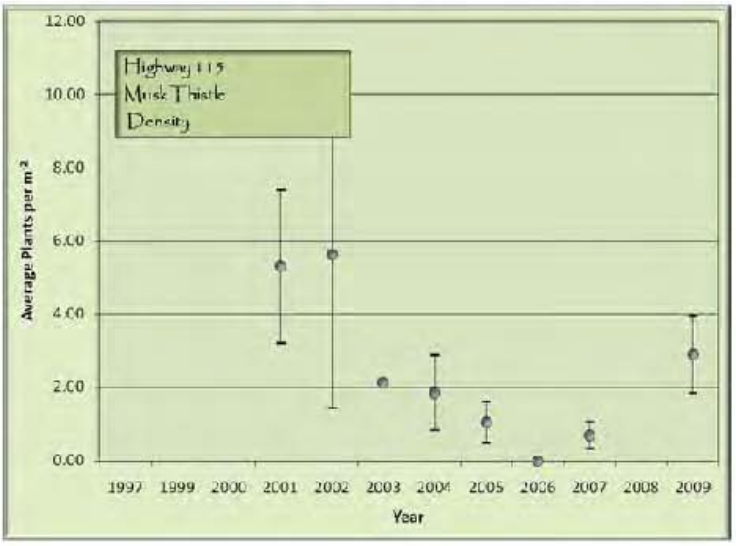


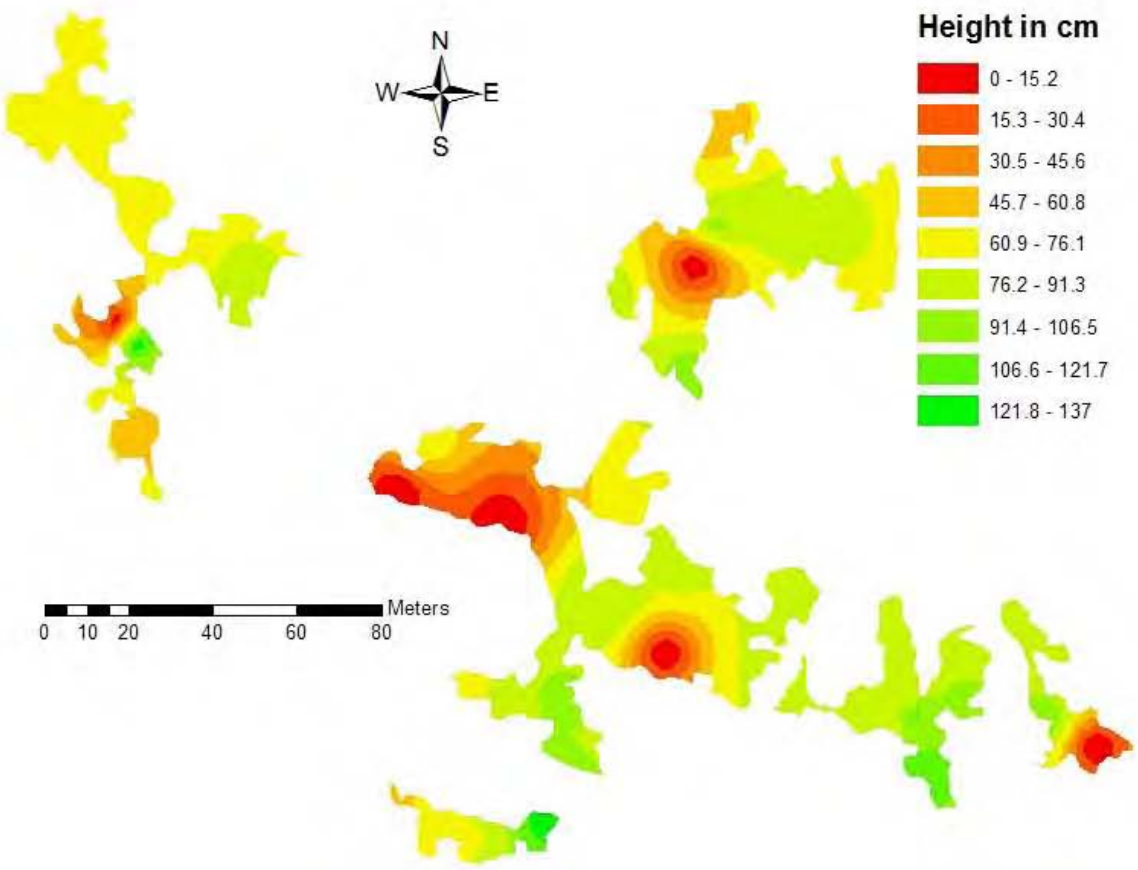


Highway 115 musk thistle perimeter in 2009.

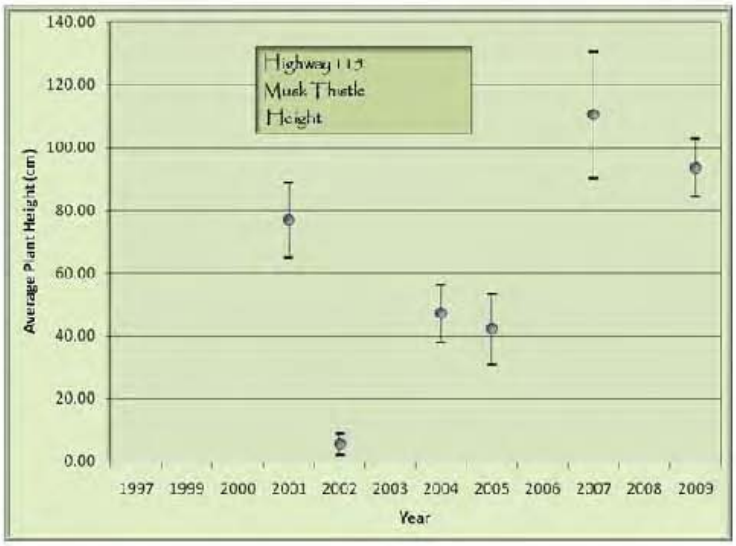


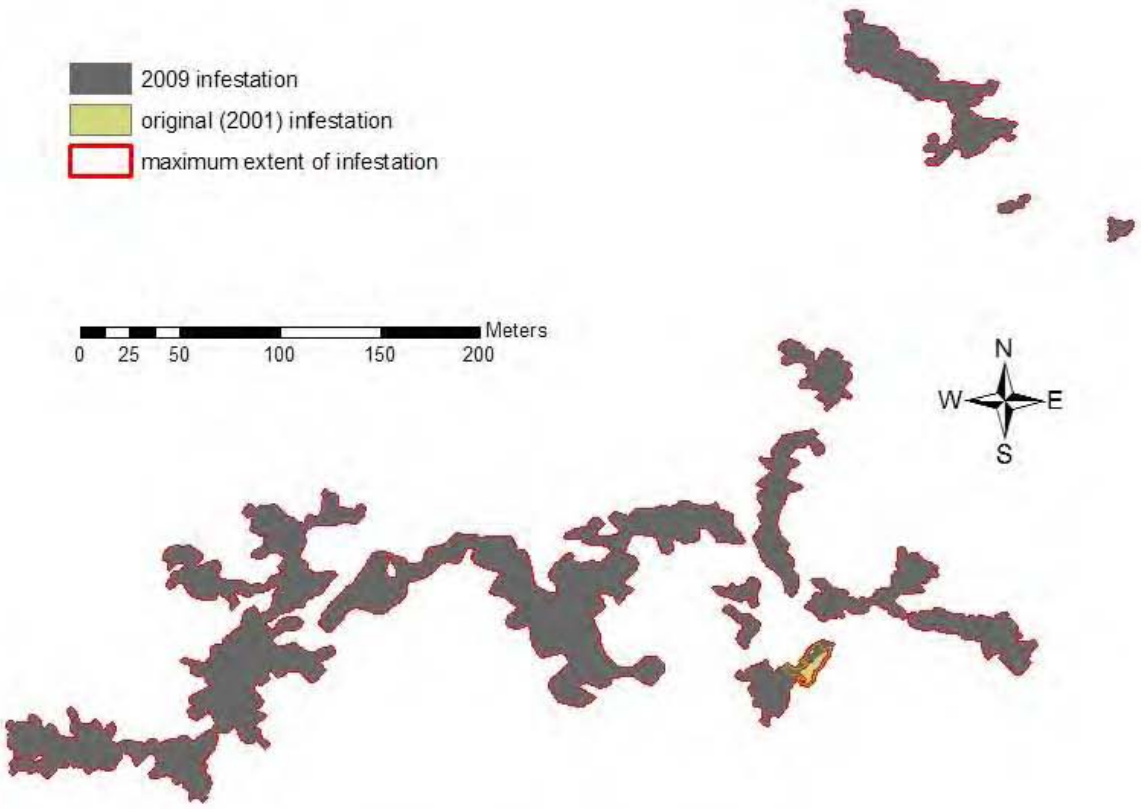
Highway 115 musk thistle density in 2009.



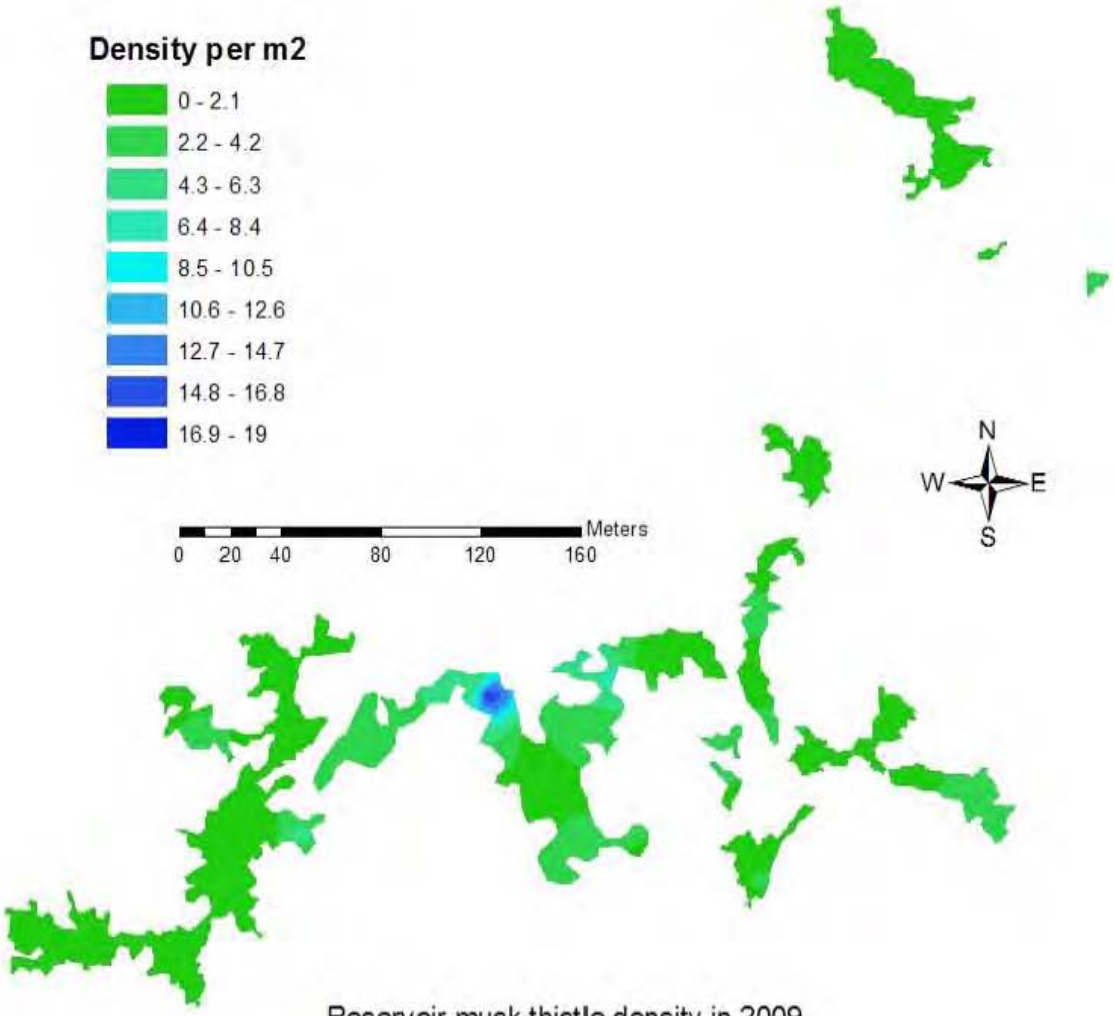


Highway 115 musk thistle height in 2009.

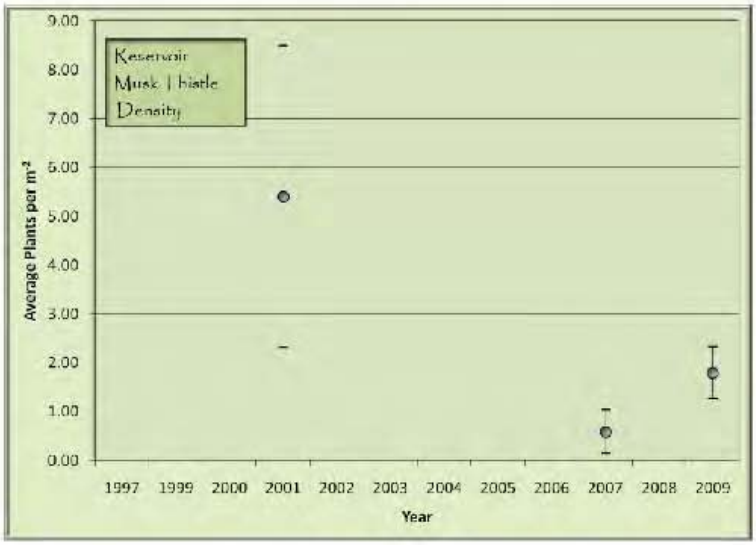


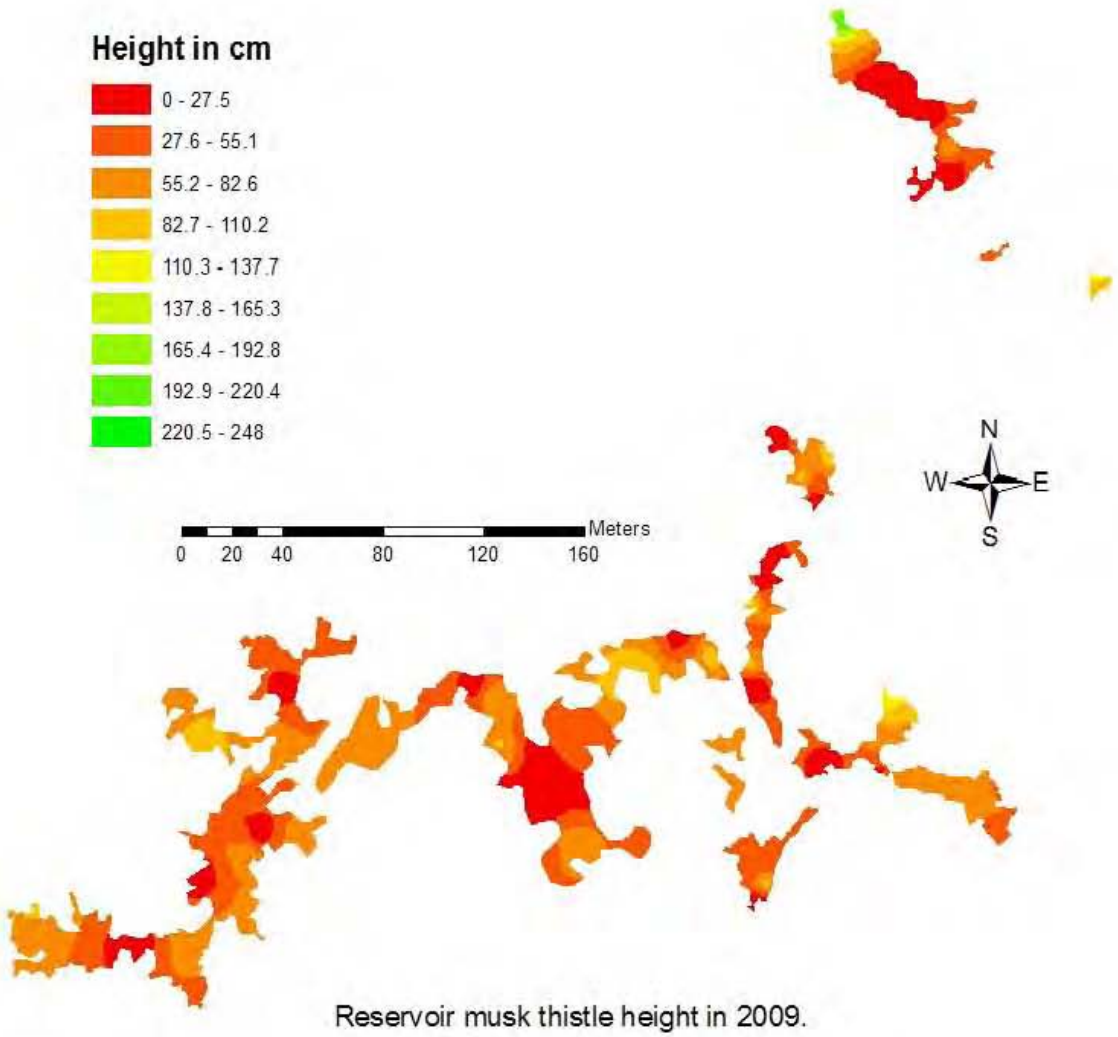


Reservoir musk thistle perimeter in 2009.

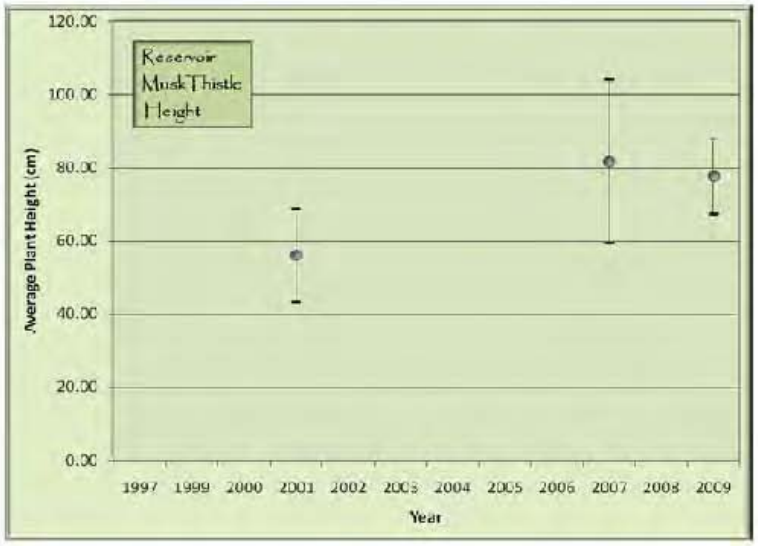


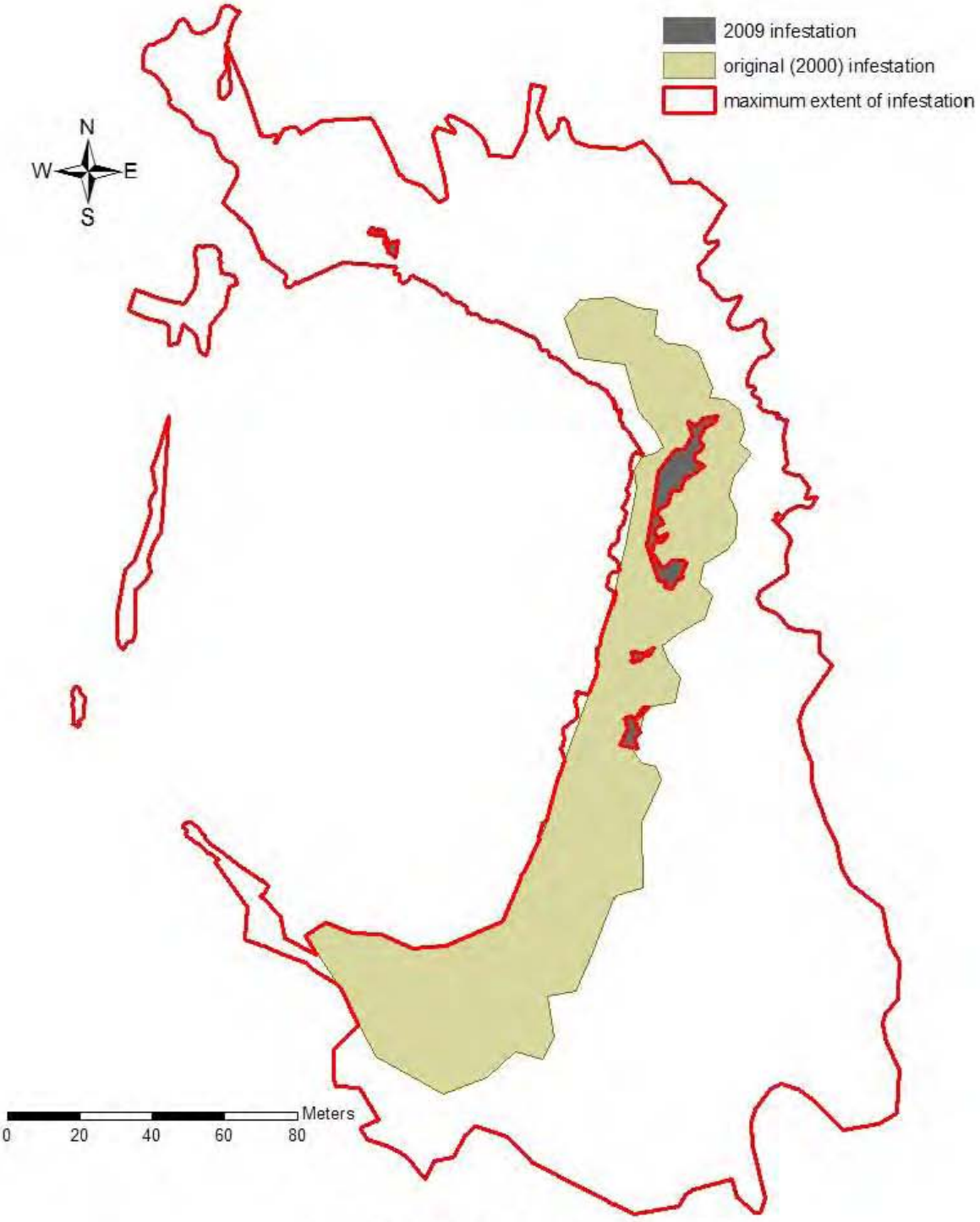
Reservoir musk thistle density in 2009.



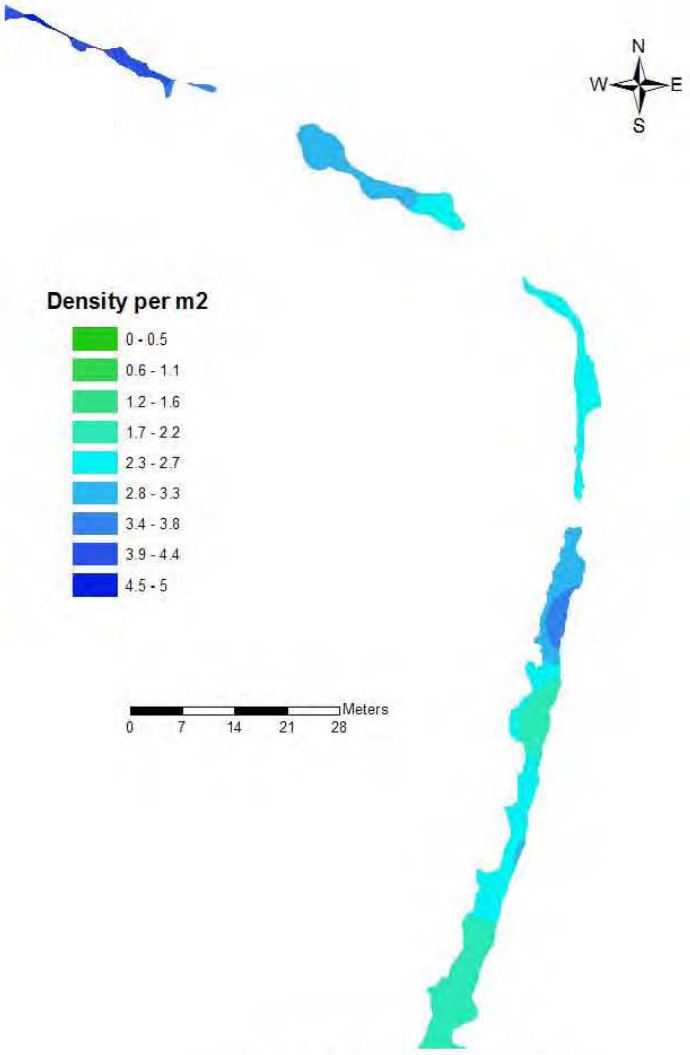


Reservoir musk thistle height in 2009.

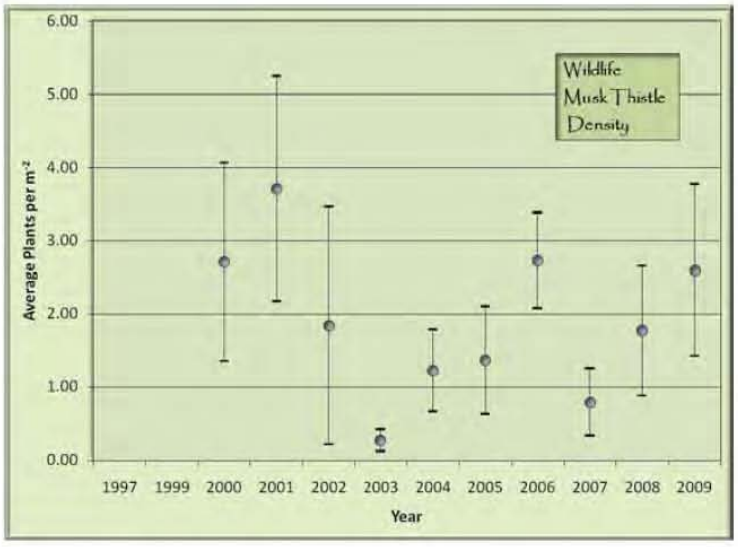


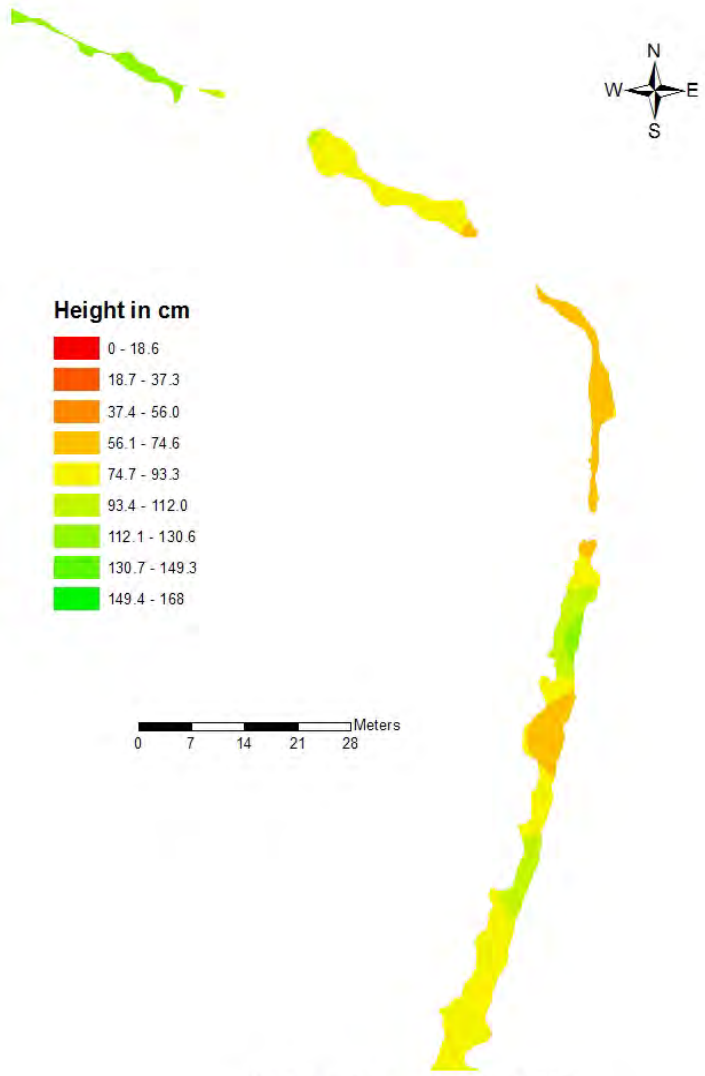


Wildlife musk thistle perimeter in 2009.

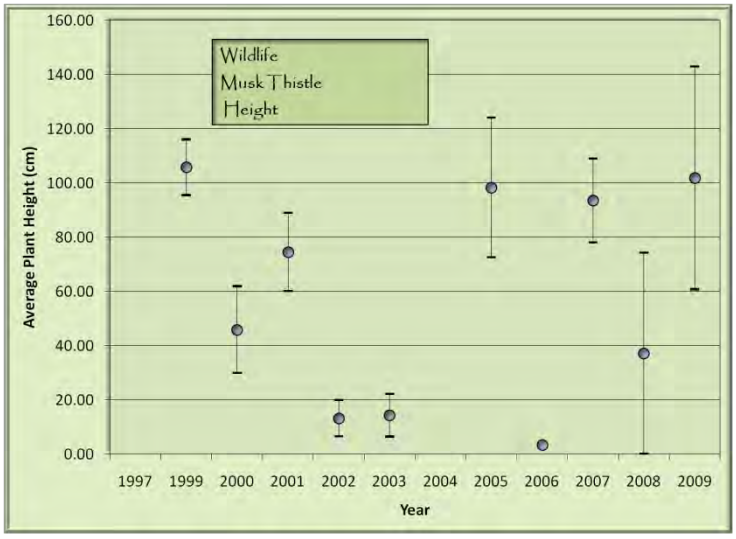


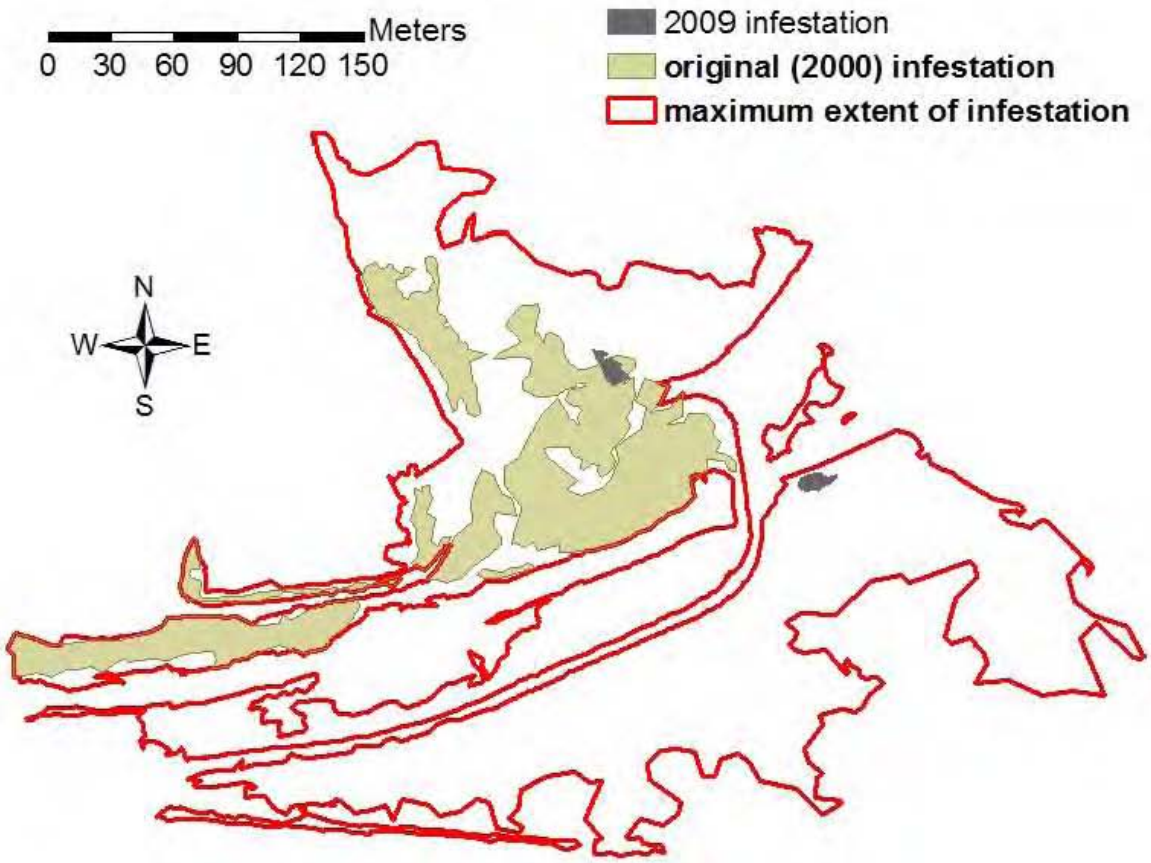
Wildlife musk thistle density in 2009.



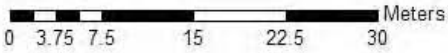


Wildlife musk thistle height in 2009.

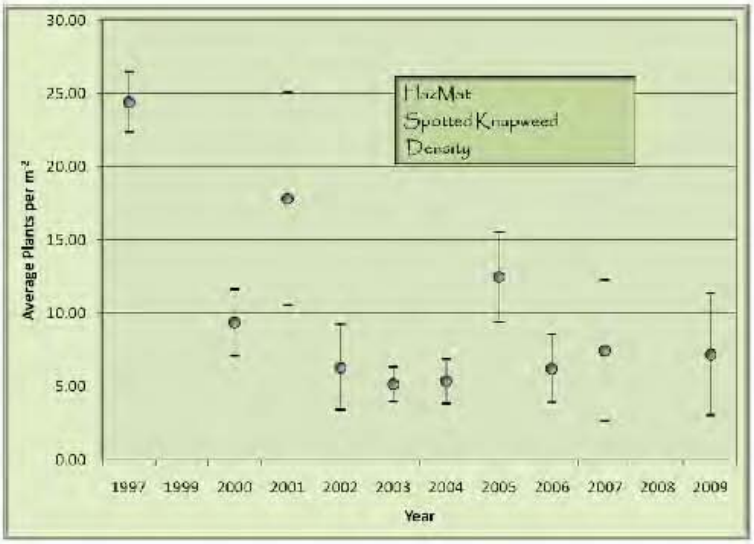


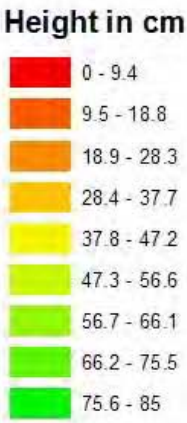


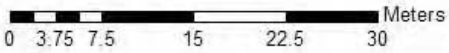
HazMat spotted knapweed perimeter in 2009.



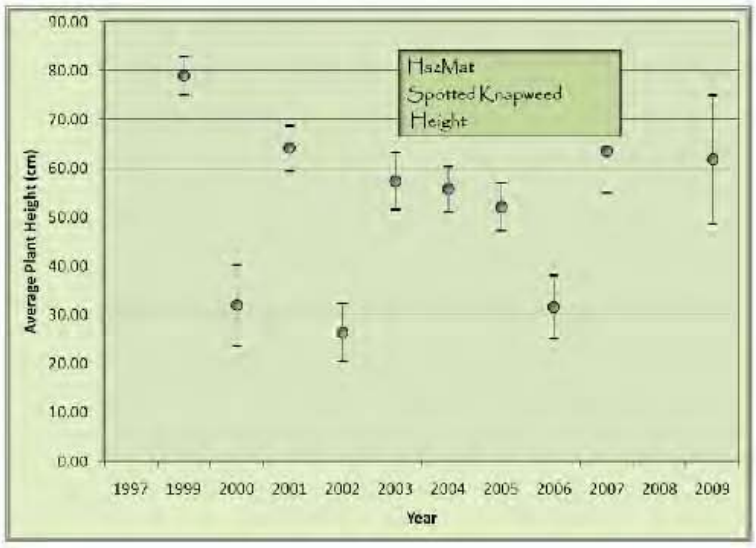
HazMat spotted knapweed density in 2009.

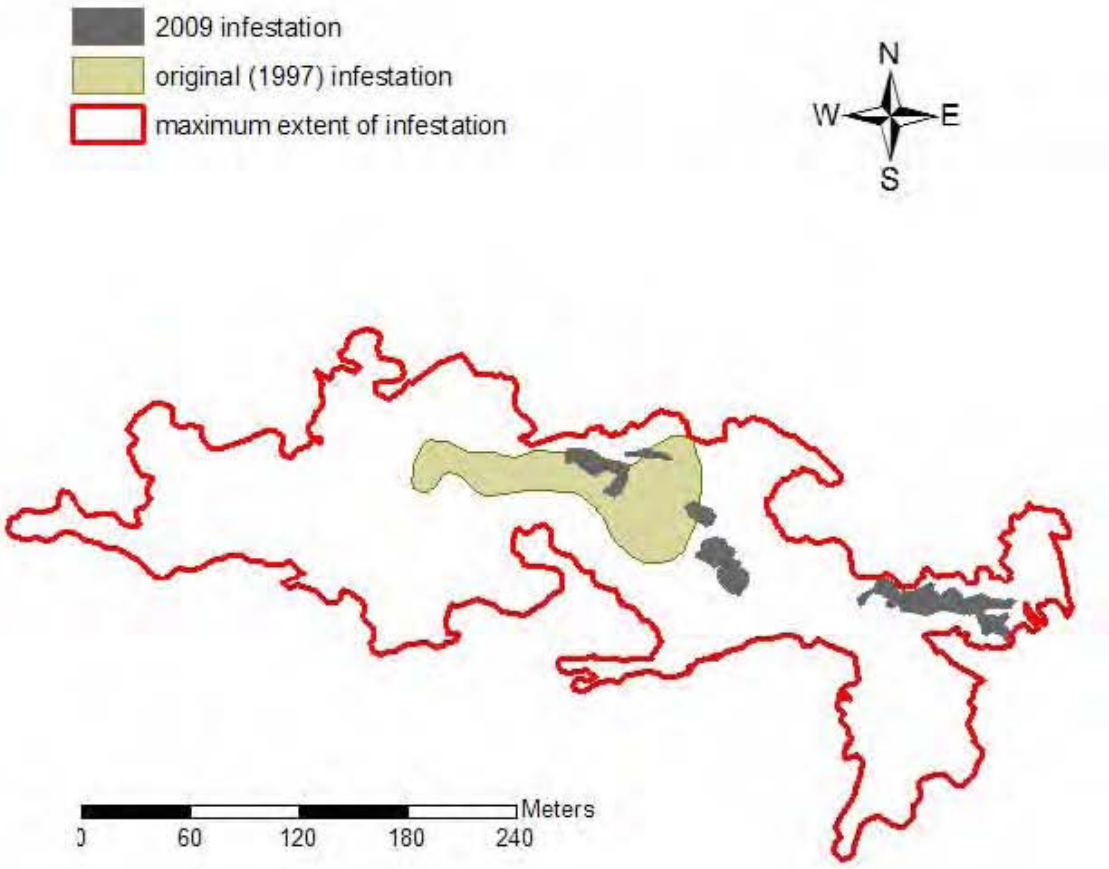




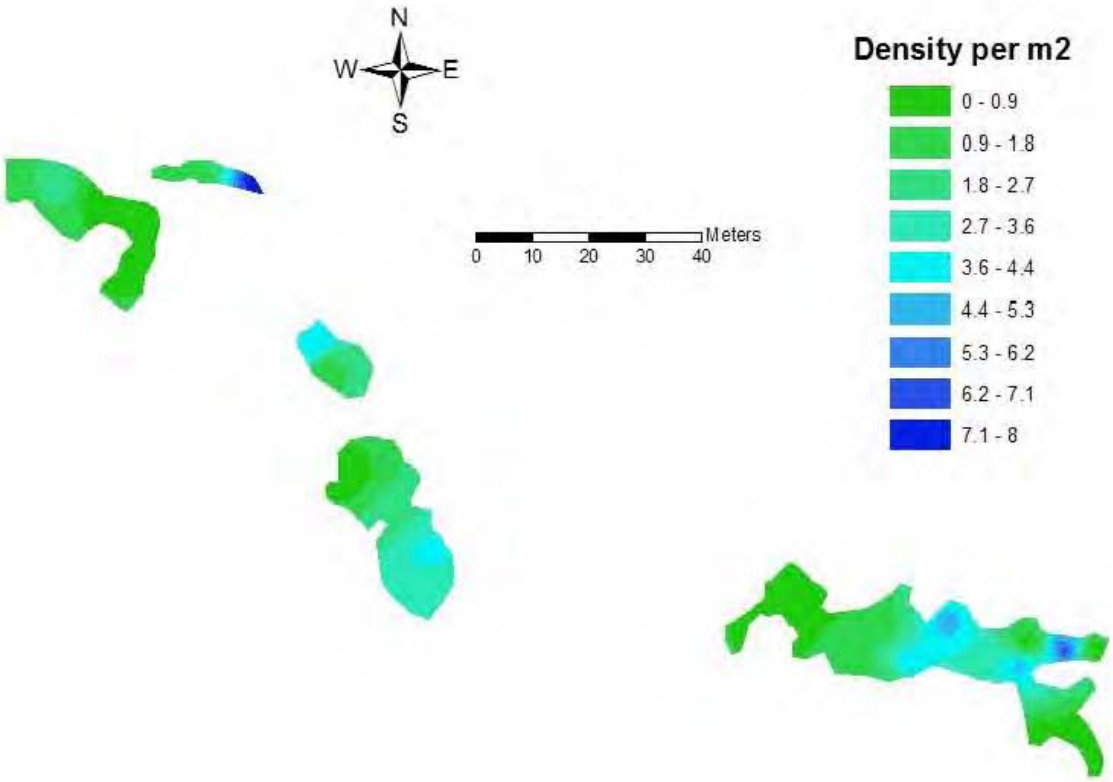


HazMat spotted knapweed height in 2009.

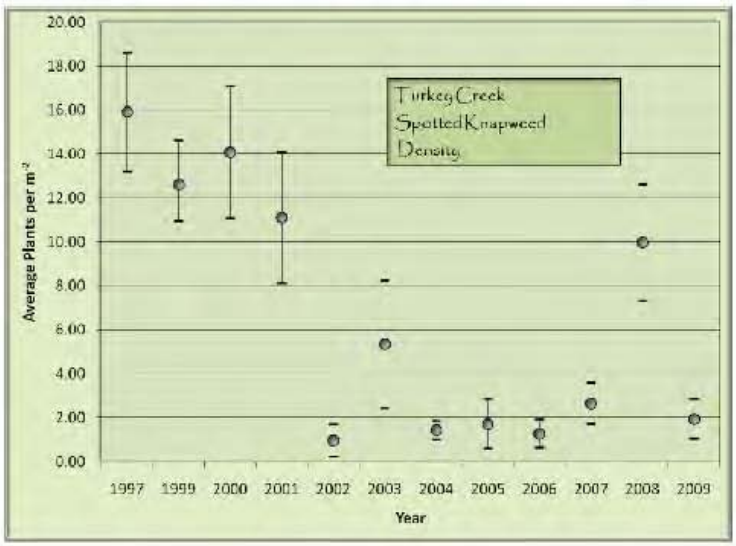


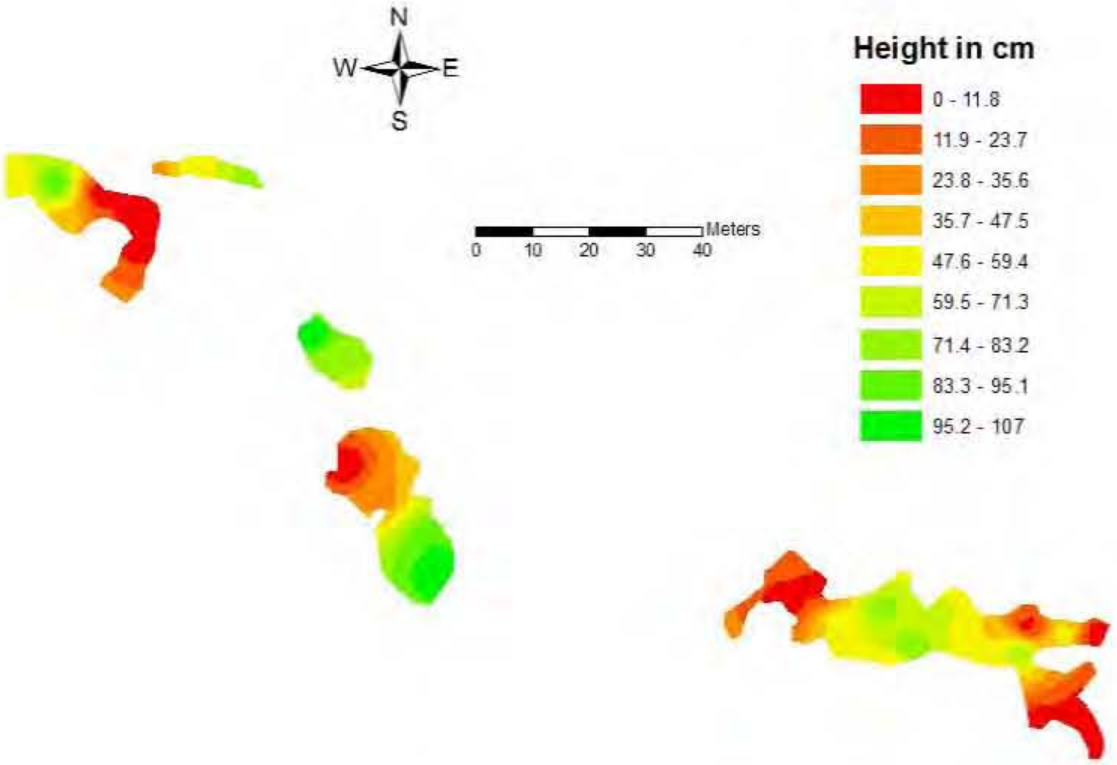


Turkey Creek spotted knapweed perimeter in 2009.

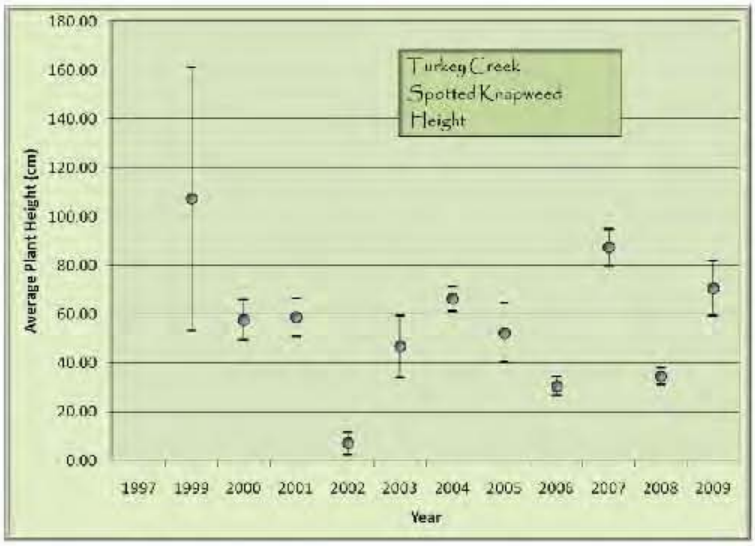


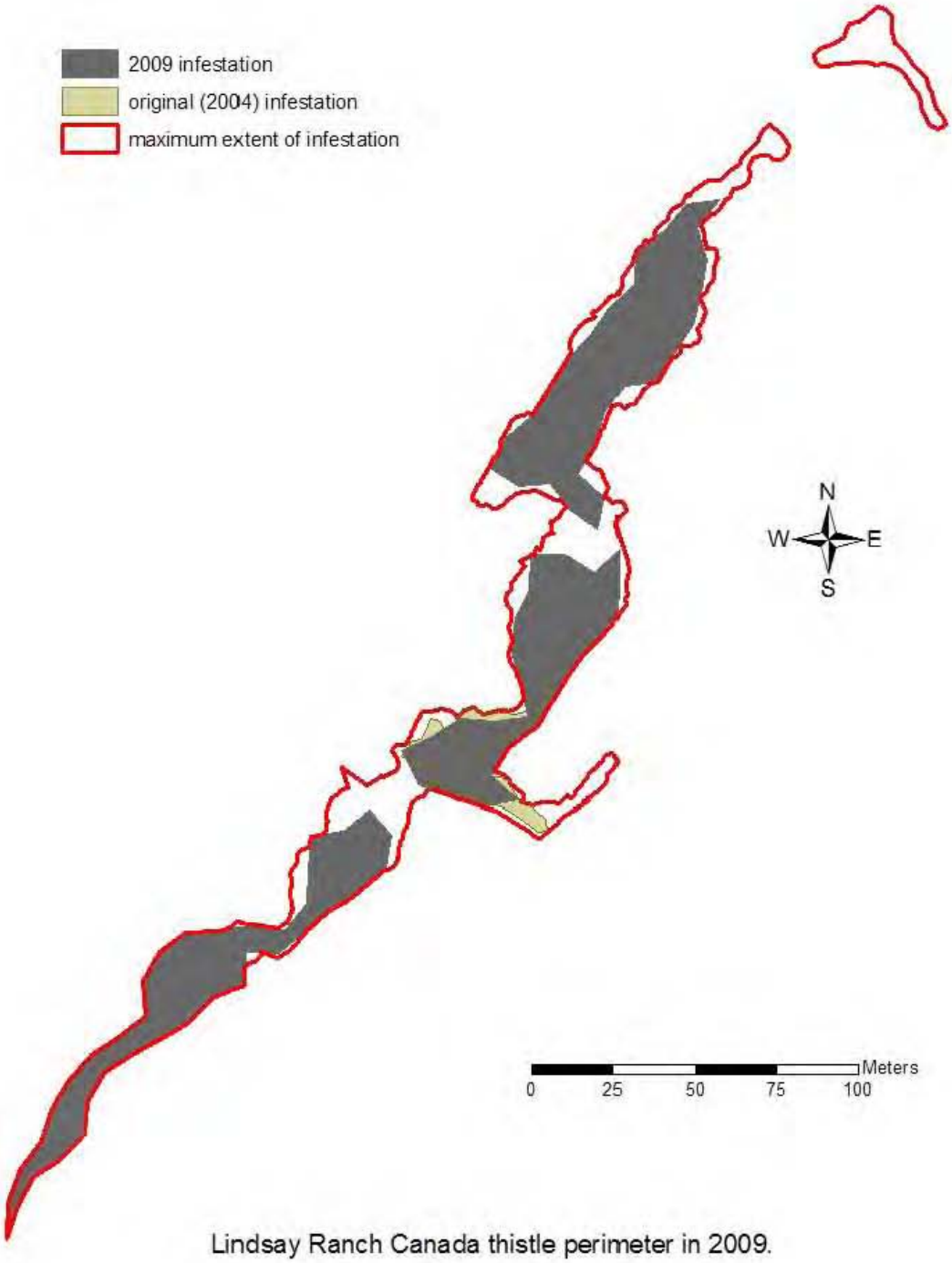
Turkey Creek spotted knapweed density in 2009.



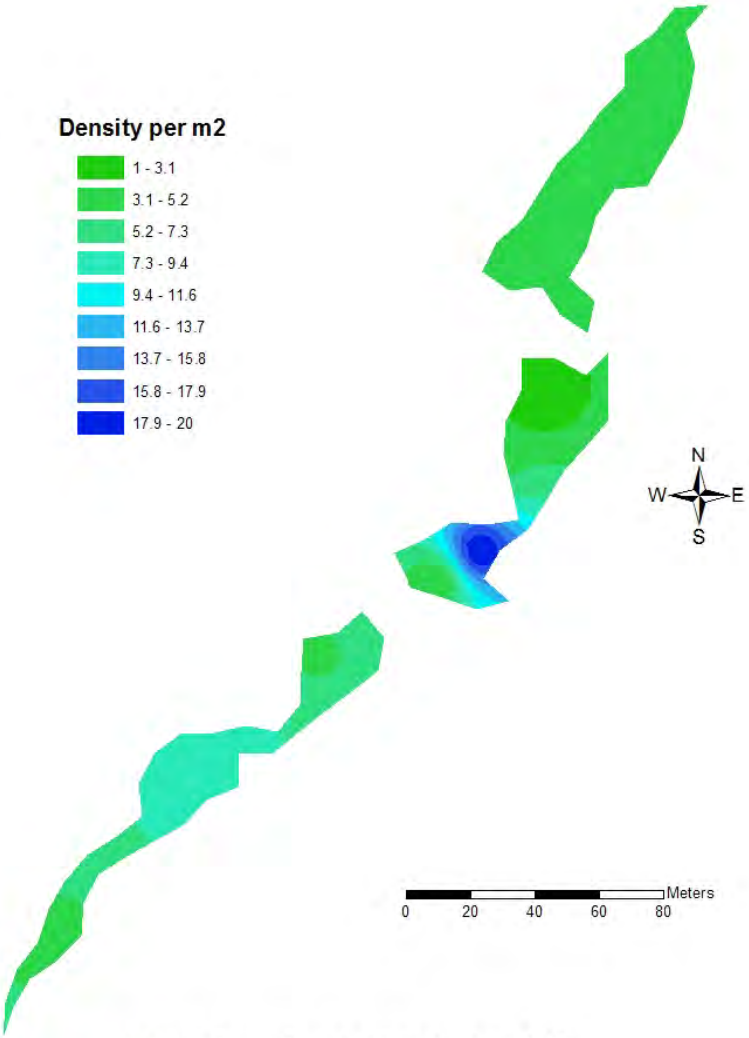


Turkey Creek spotted knapweed height in 2009.

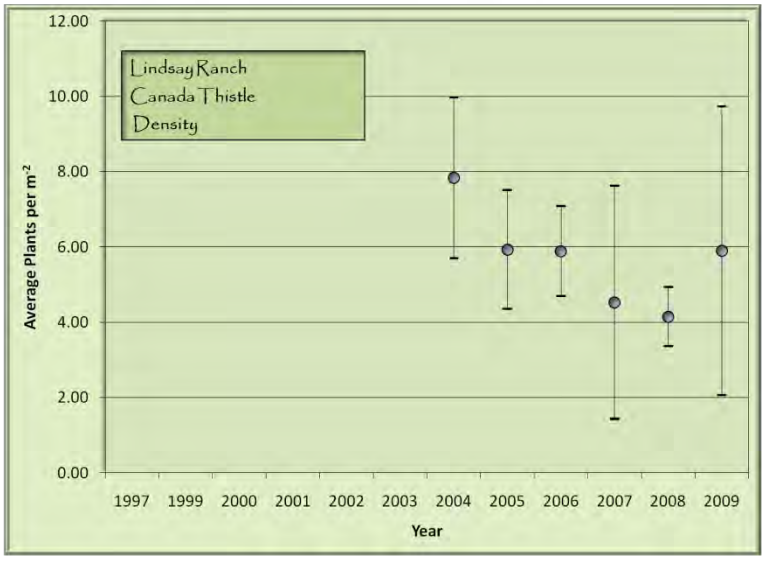


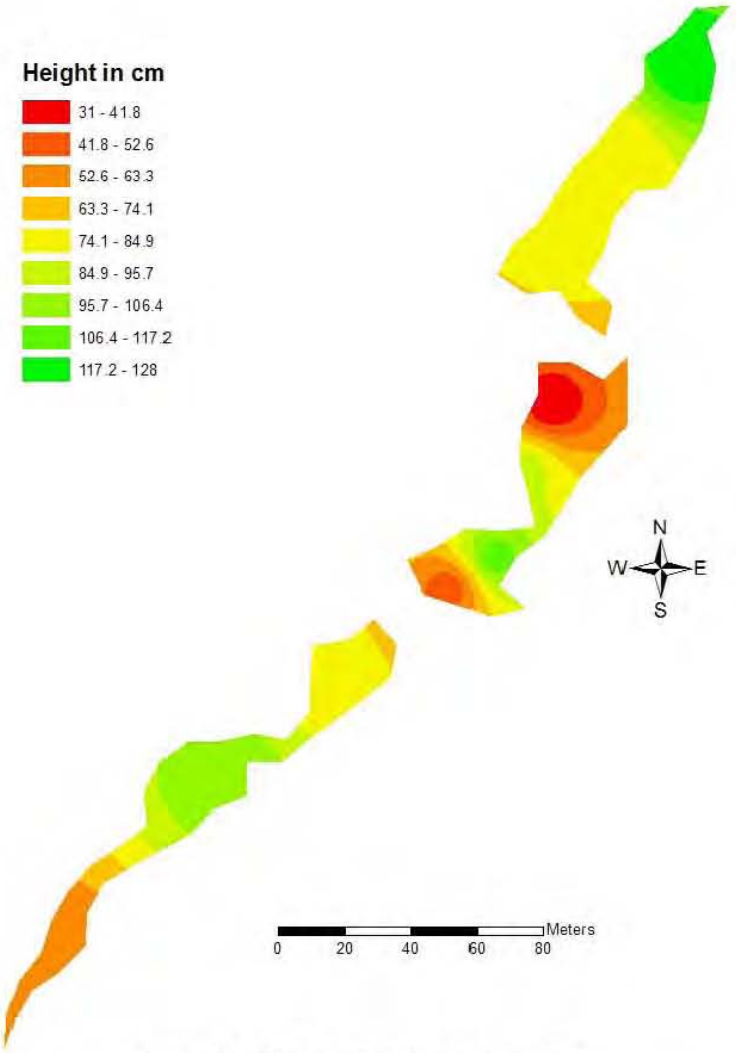


Lindsay Ranch Canada thistle perimeter in 2009.

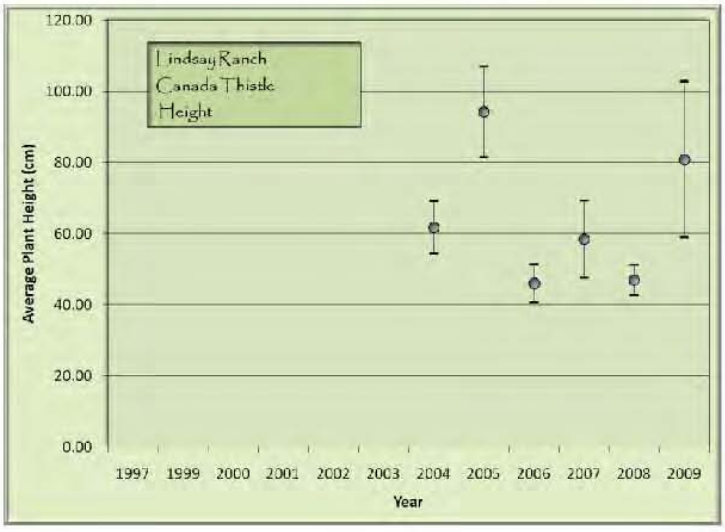


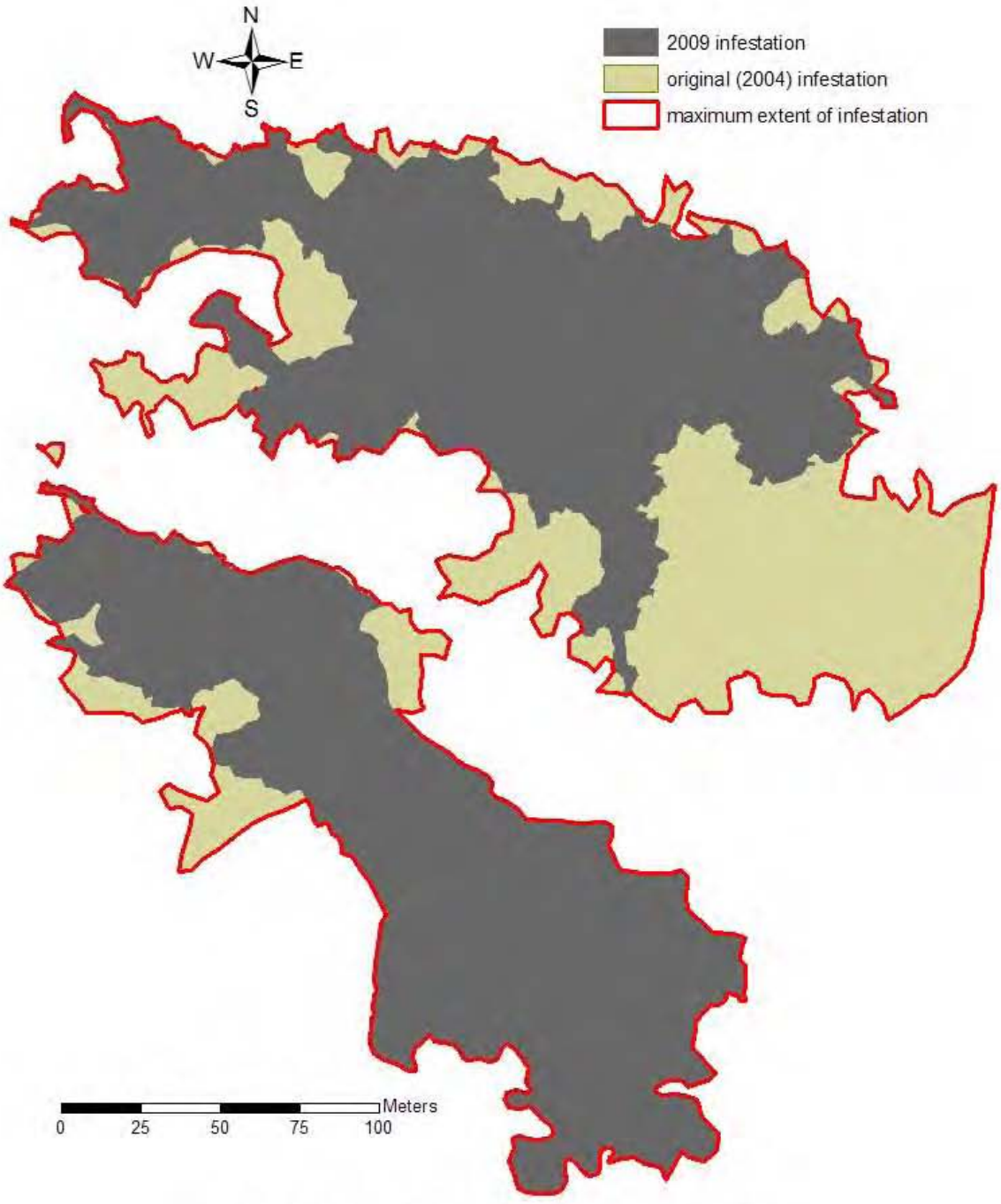
Lindsay Ranch Canada thistle density in 2009.



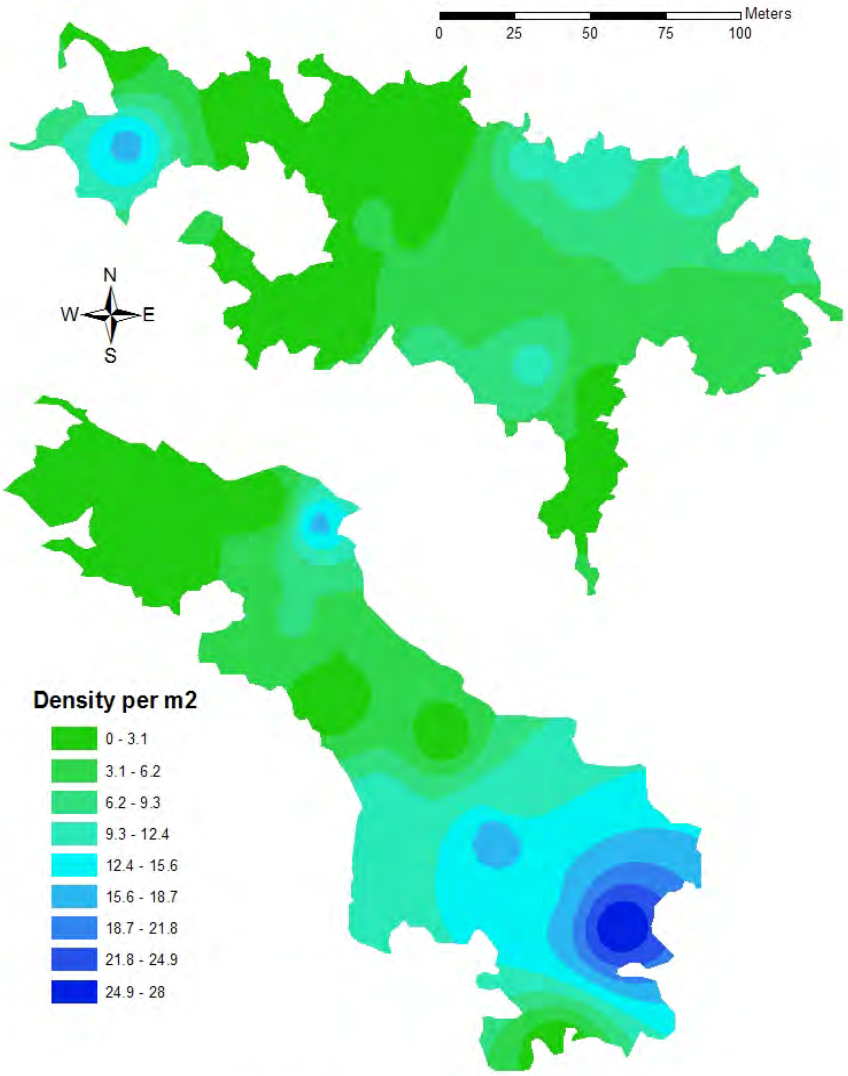


Lindsay Ranch Canada thistle height in 2009.

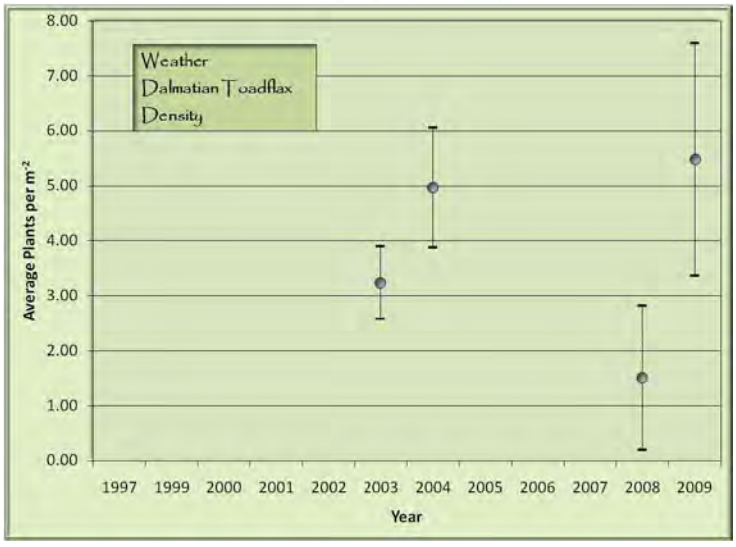


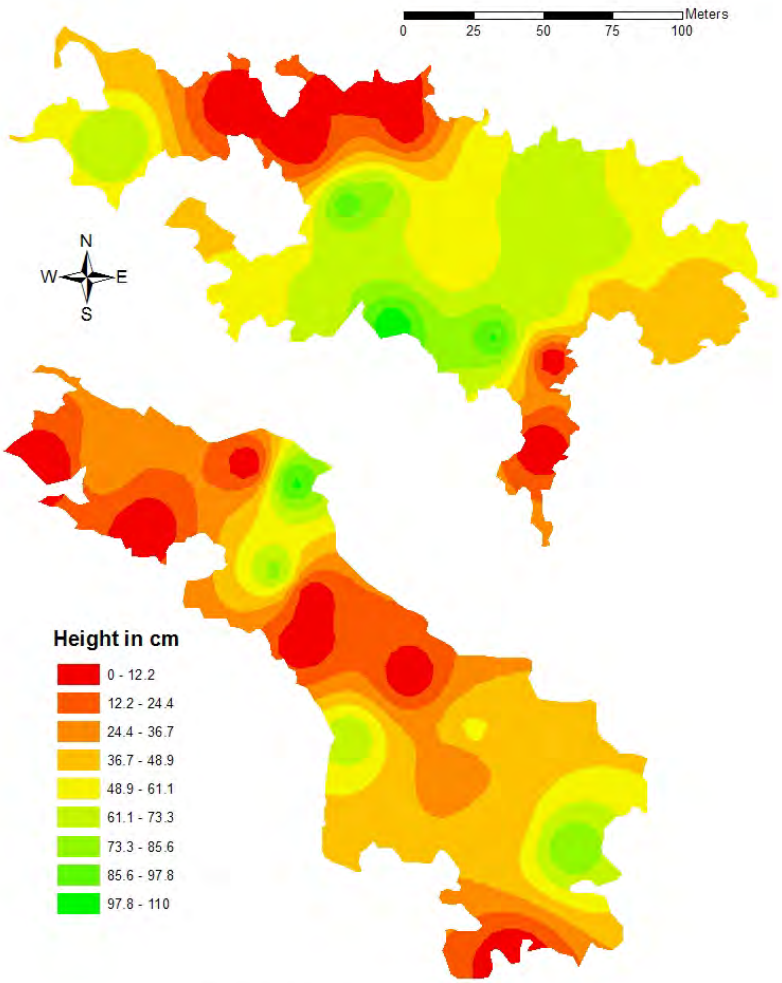


Weather Dalmatian toadflax perimeter in 2009.

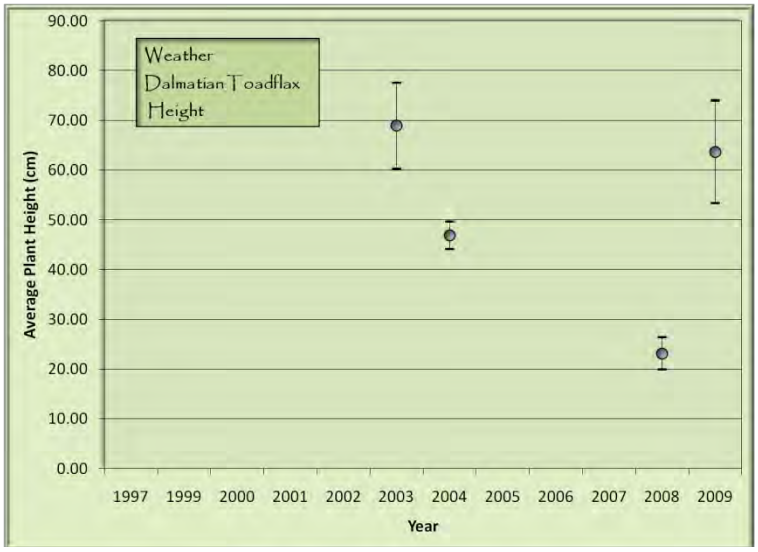


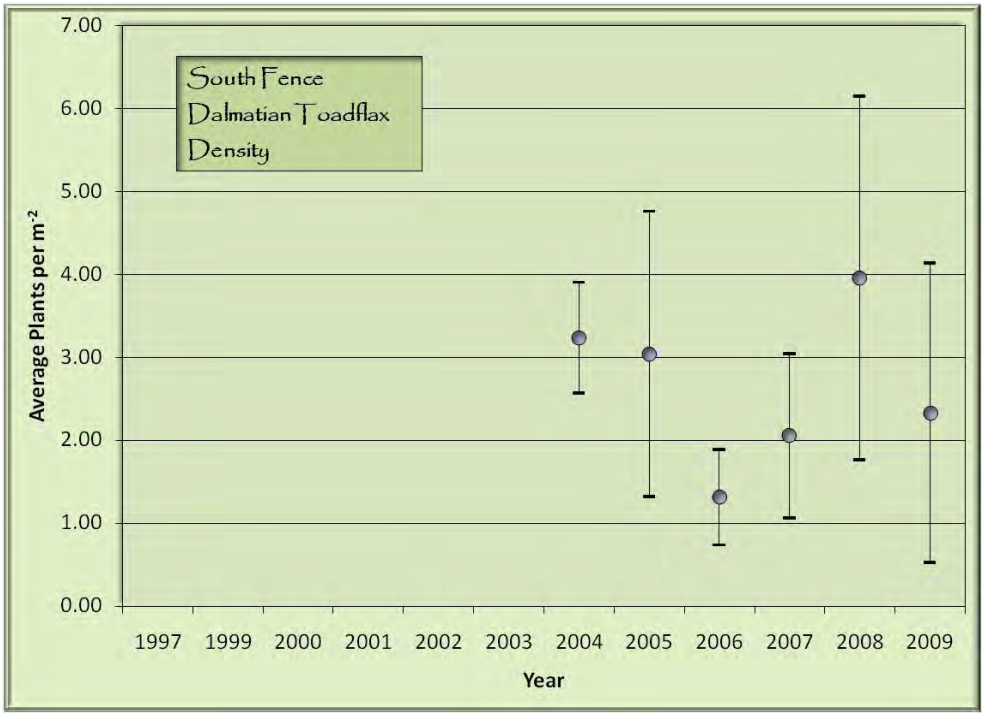
Weather Dalmatian toadflax density in 2009.



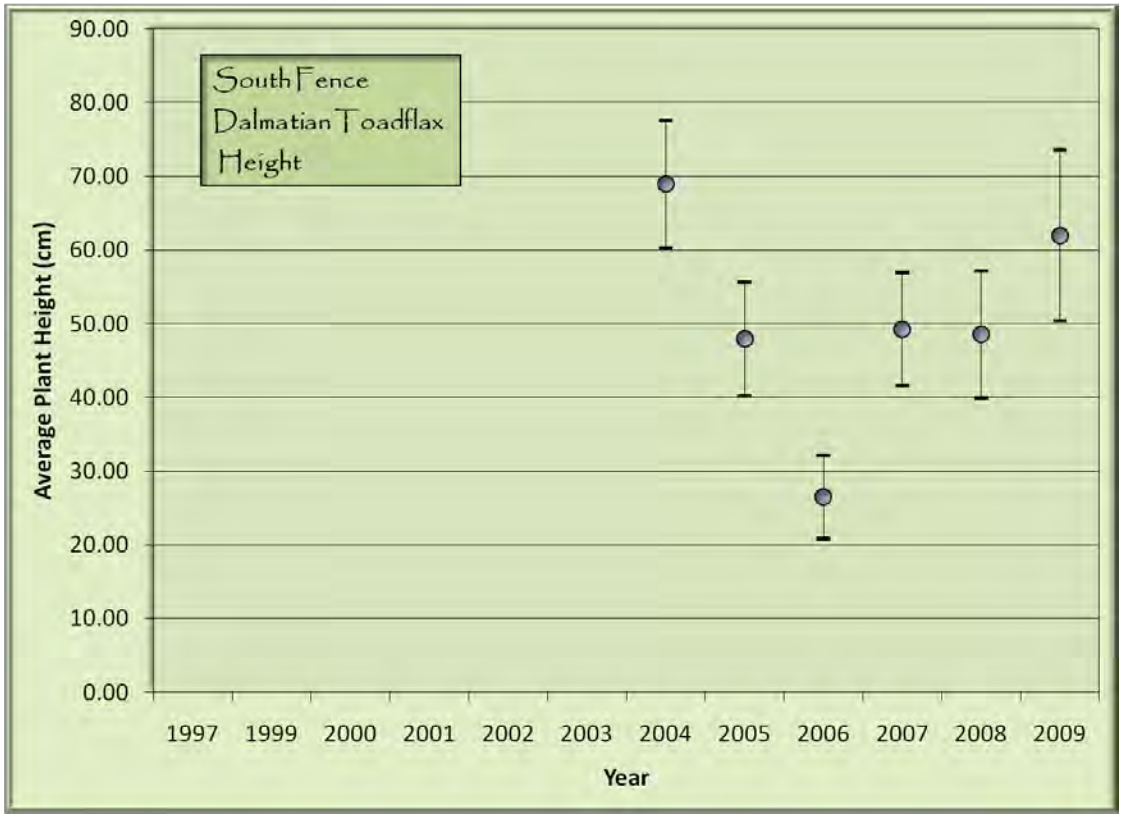


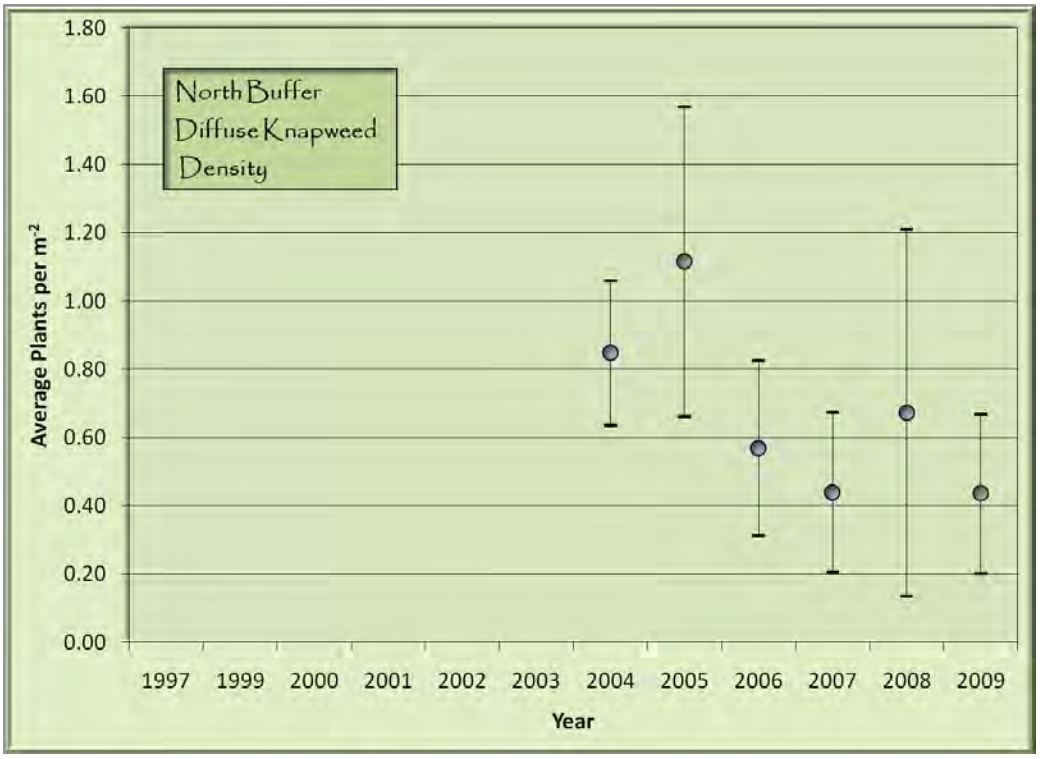
Weather Dalmatian toadflax height in 2009.



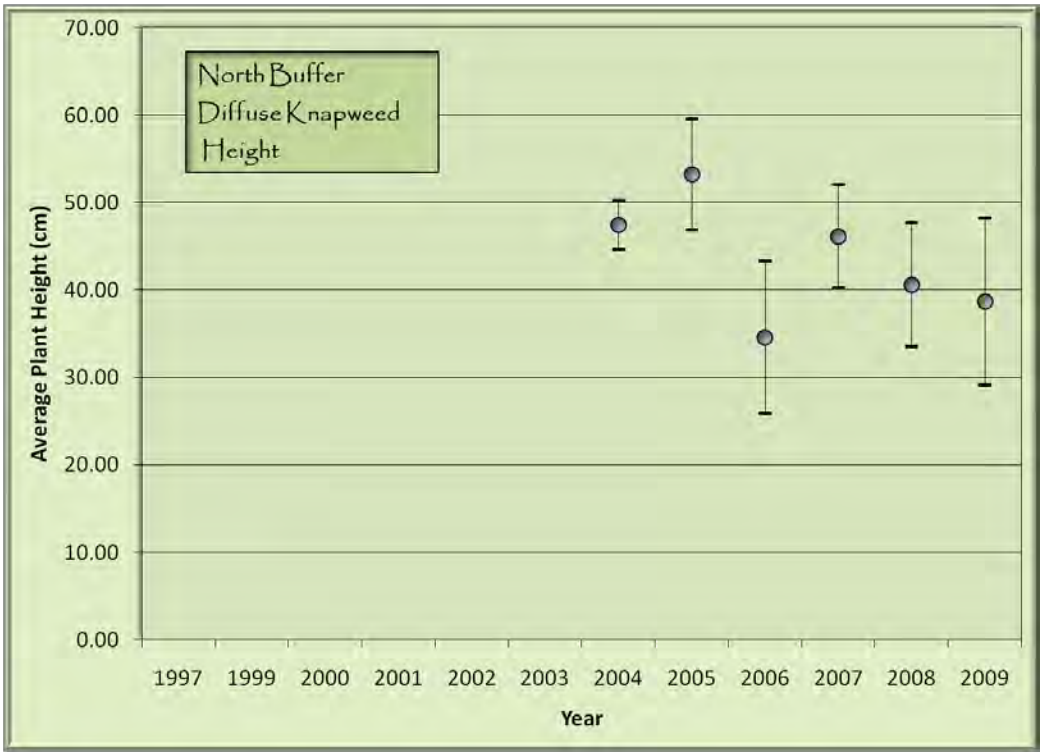


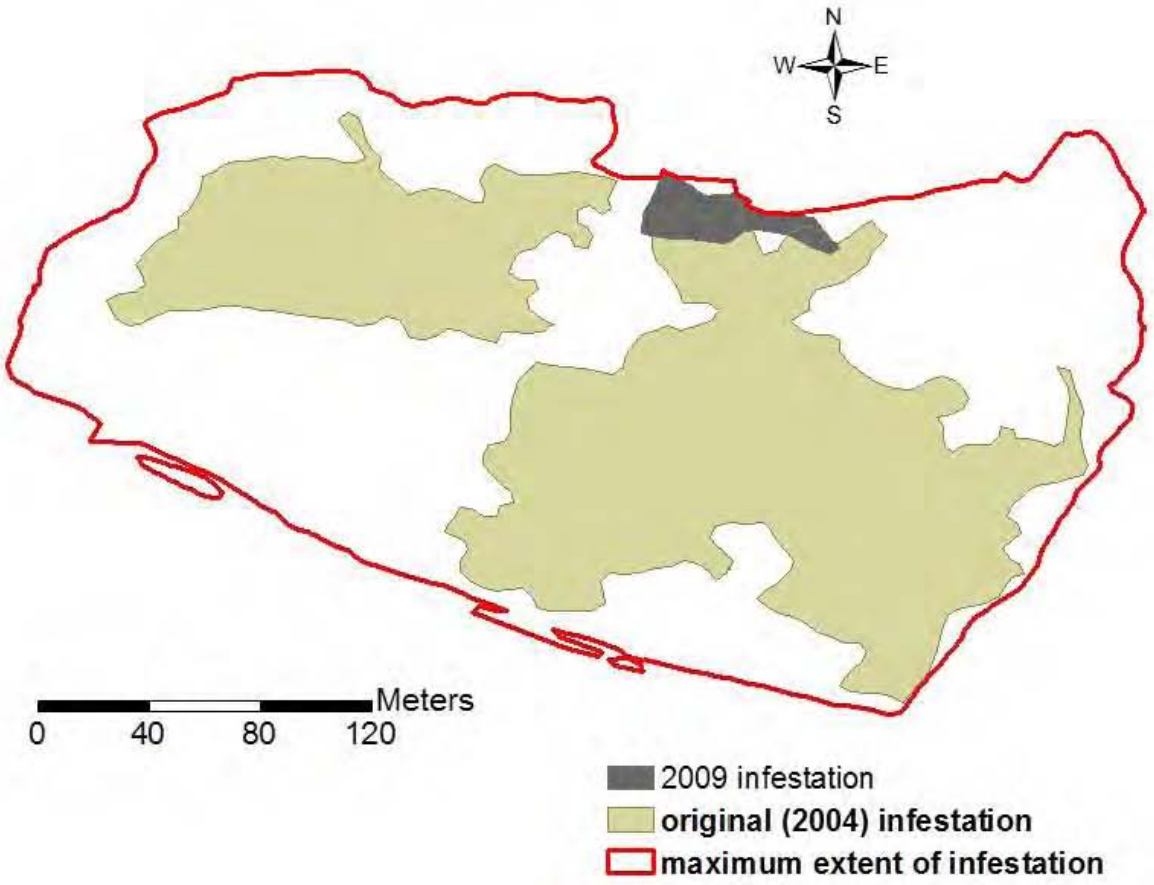
History of the South Fence Dalmatian toadflax densities (above) and height (below), sampled between 2005 and 2009.



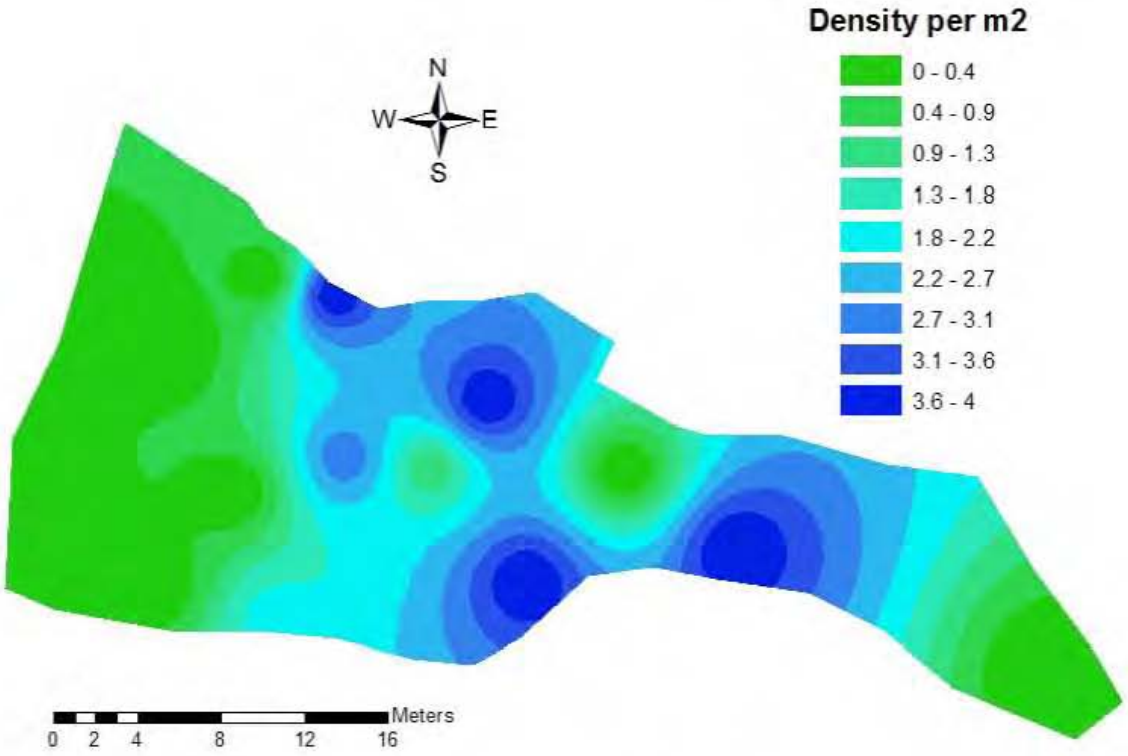


History of the North Buffer diffuse knapweed densities (above) and height (below), sampled between 2005 and 2009.

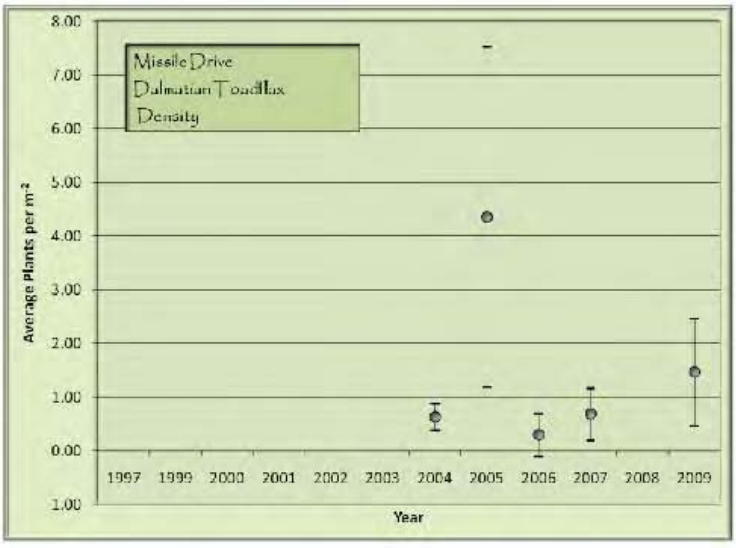


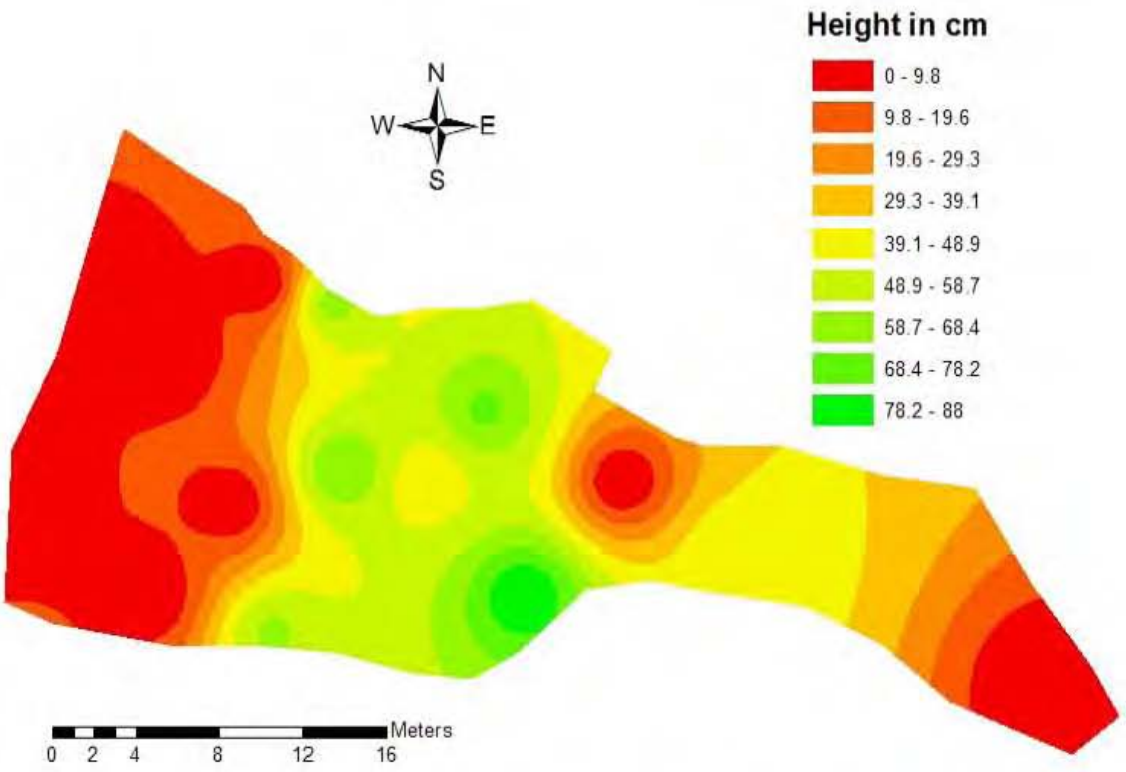


Missile Dalmatian toadflax perimeter in 2009.

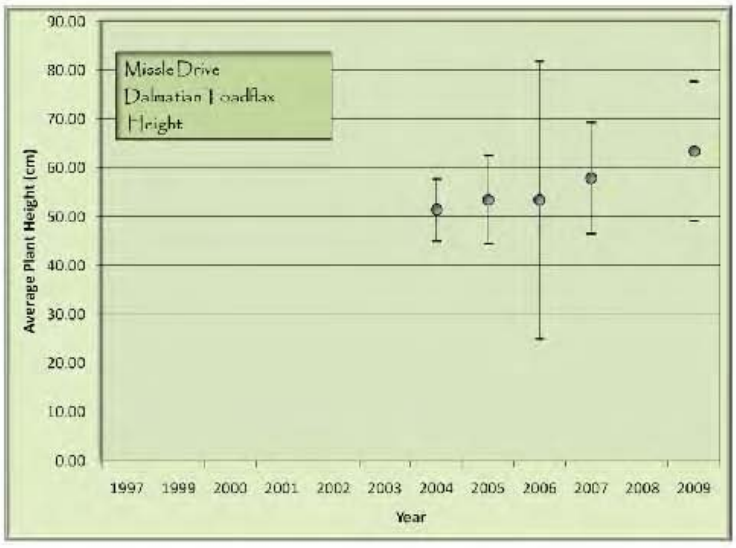


Missile Dalmatian toadflax density in 2009.

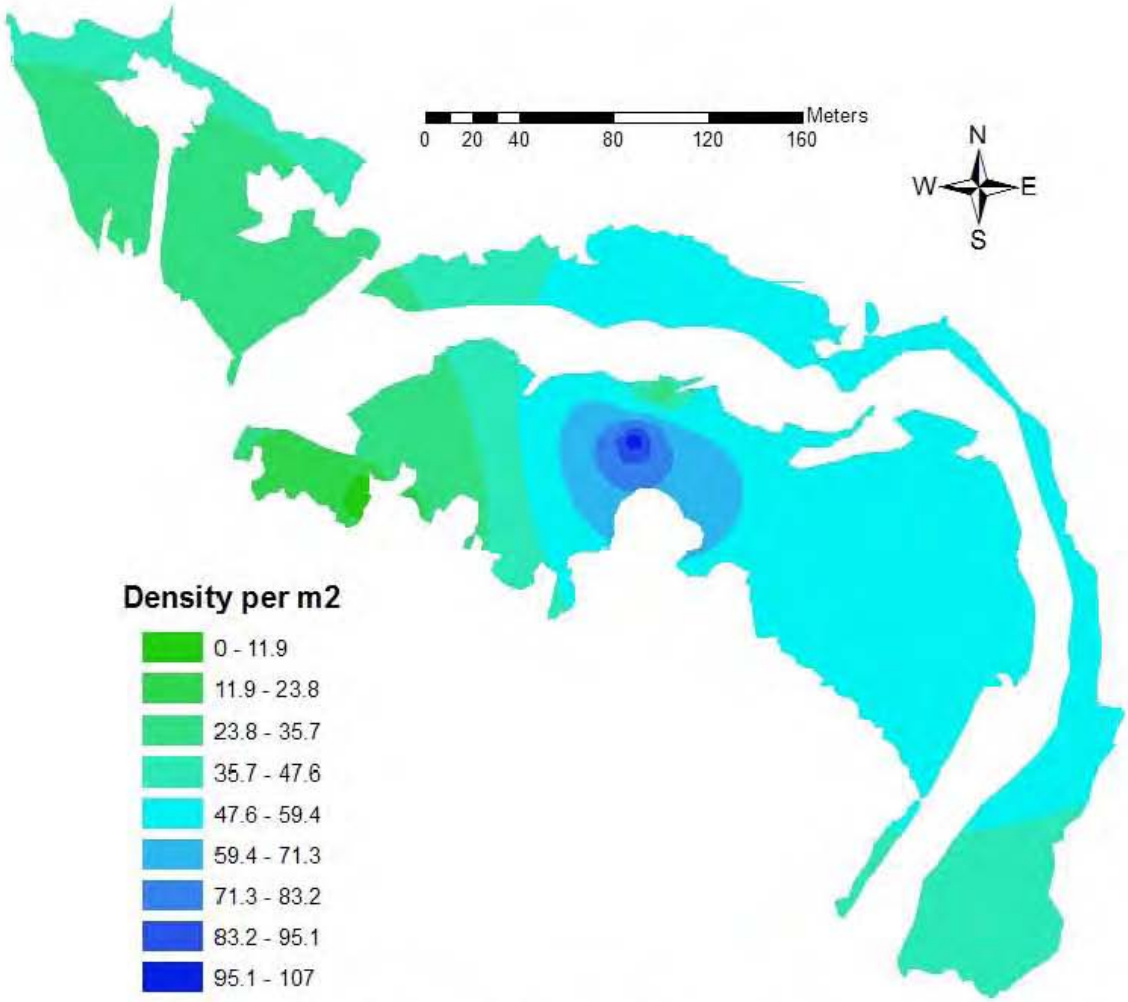




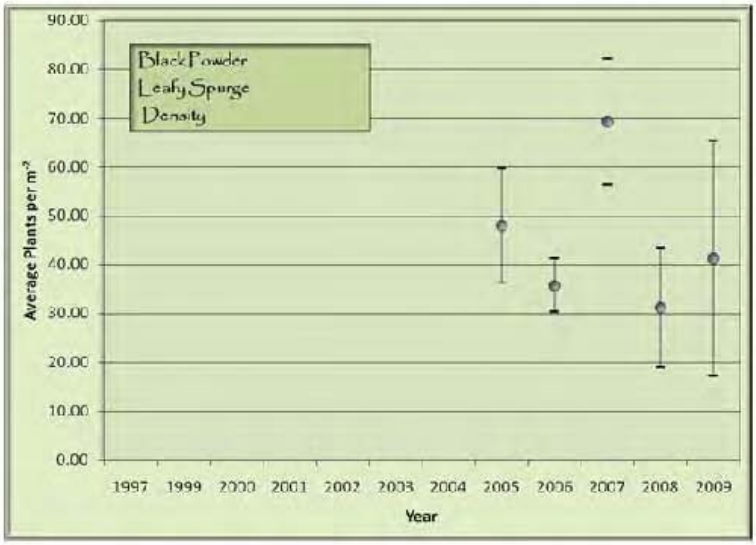
Missile Dalmatian toadflax height in 2009.

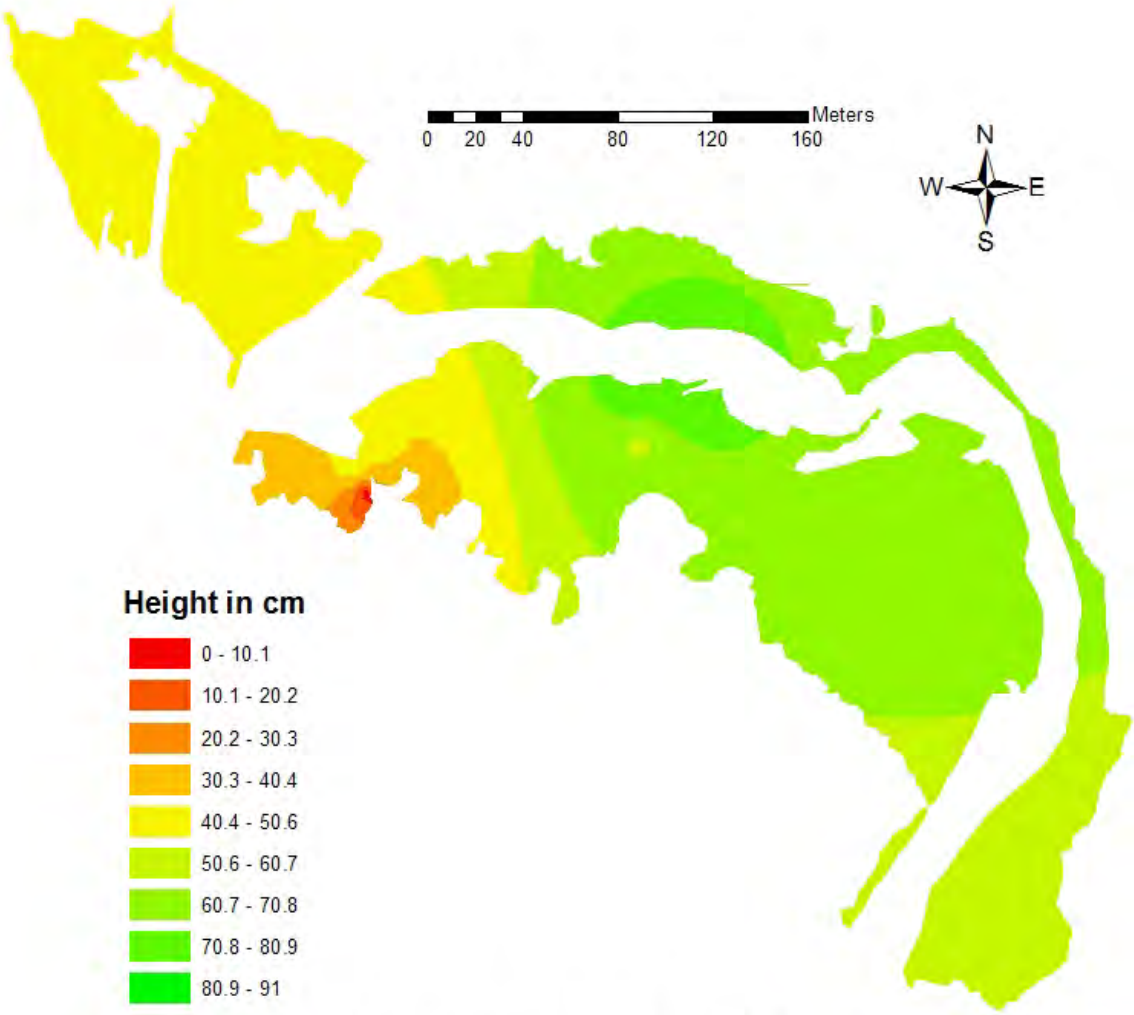


Black Powder leafy spurge perimeter in 2009.

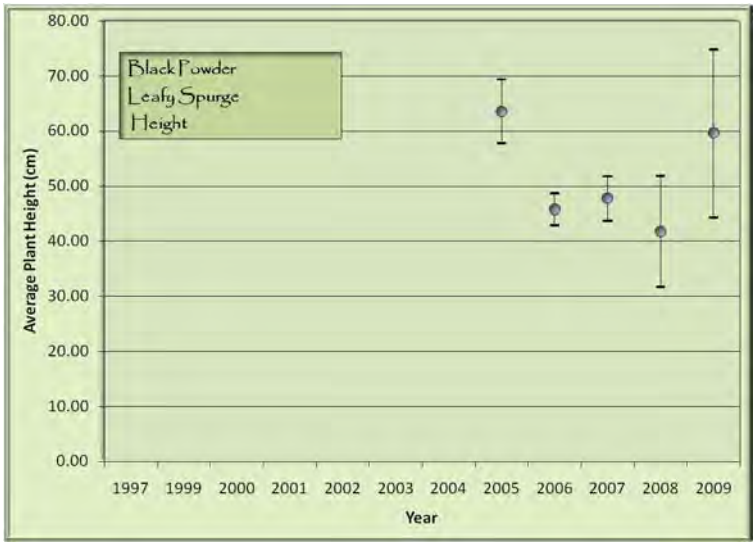


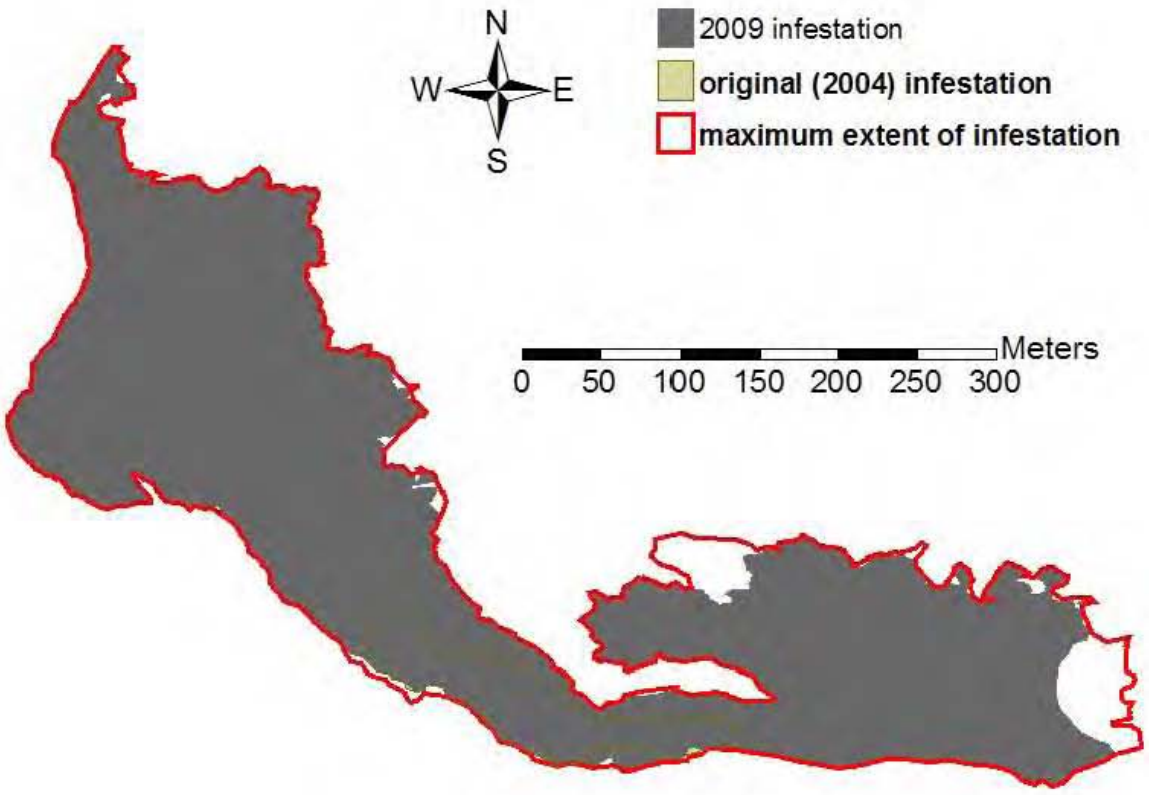
Black Powder leafy spurge density in 2009.



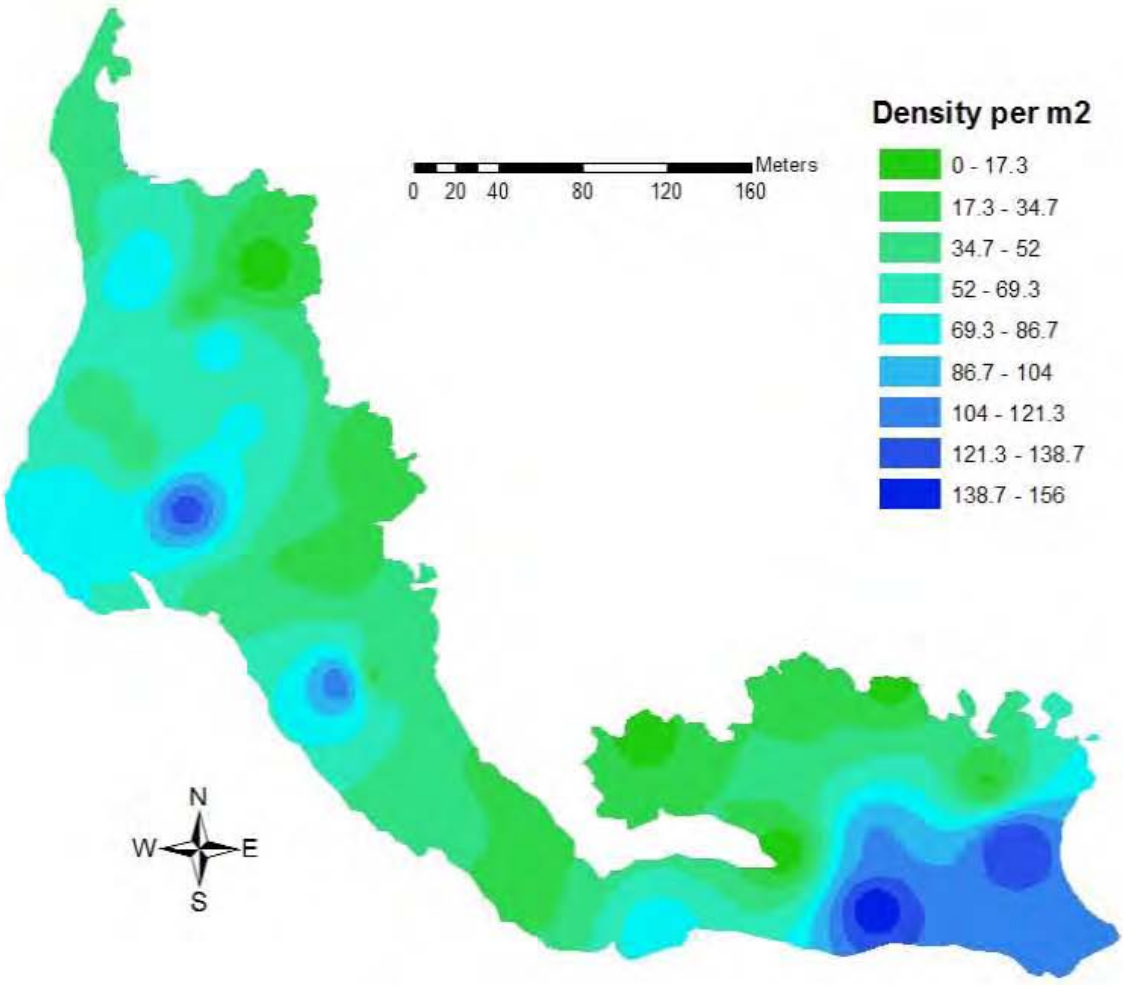


Black Powder leafy spurge height in 2009.

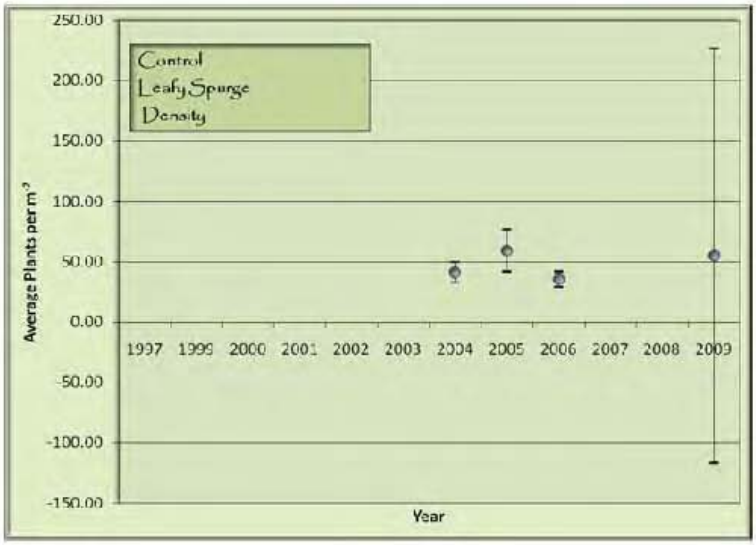


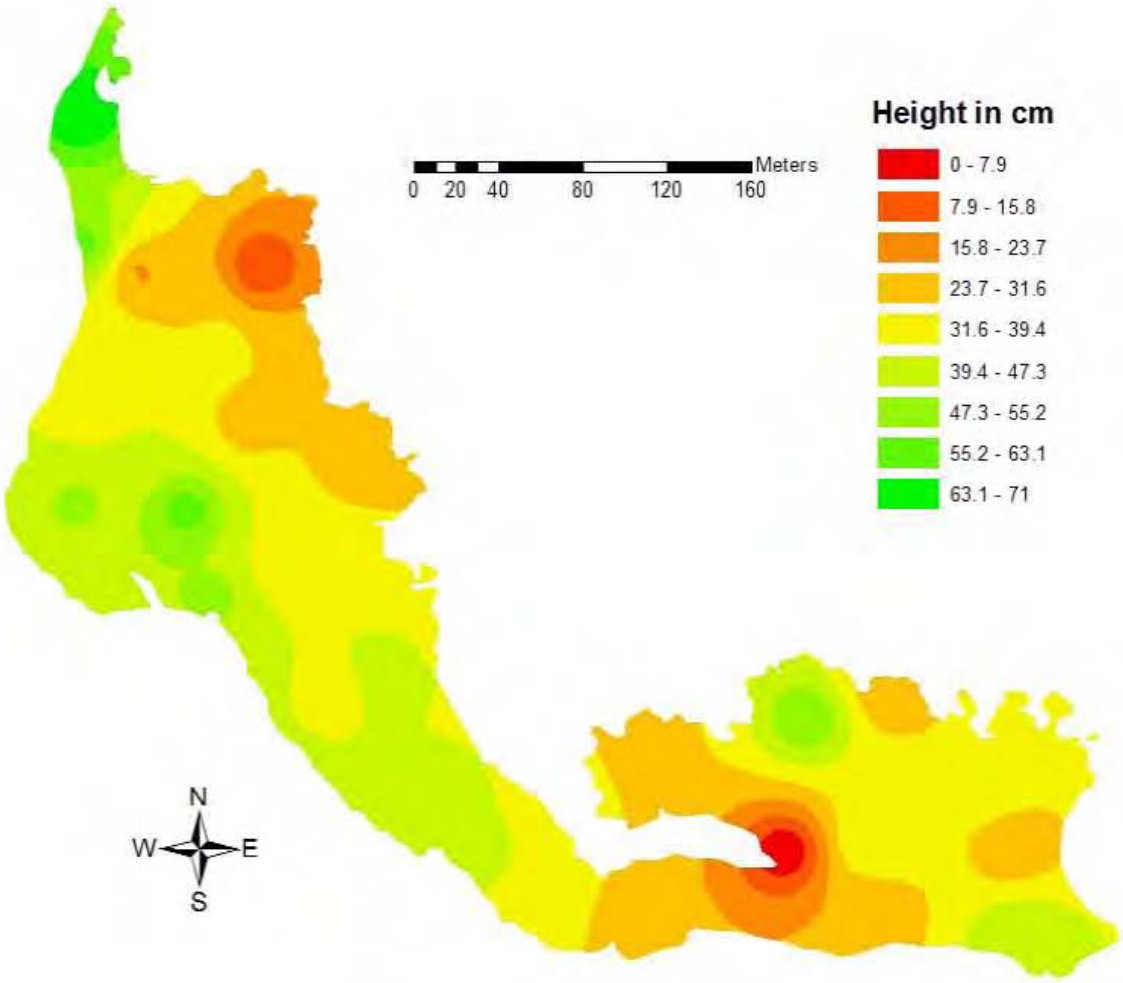


Control leafy spurge perimeter in 2009.

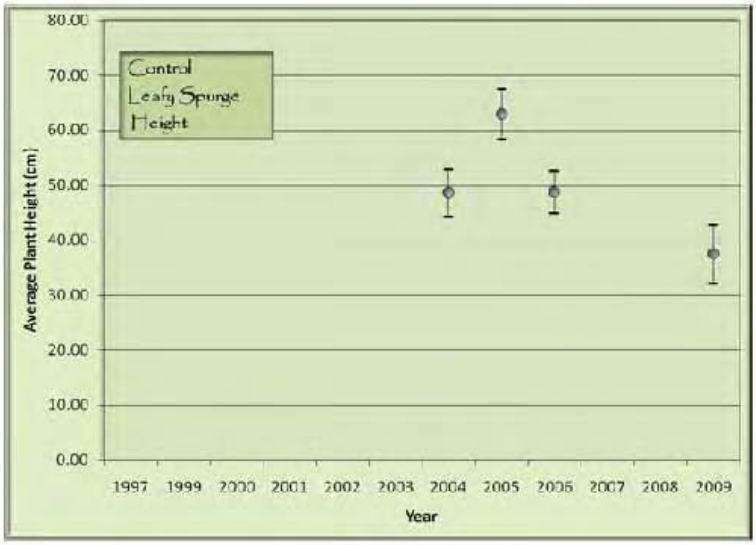


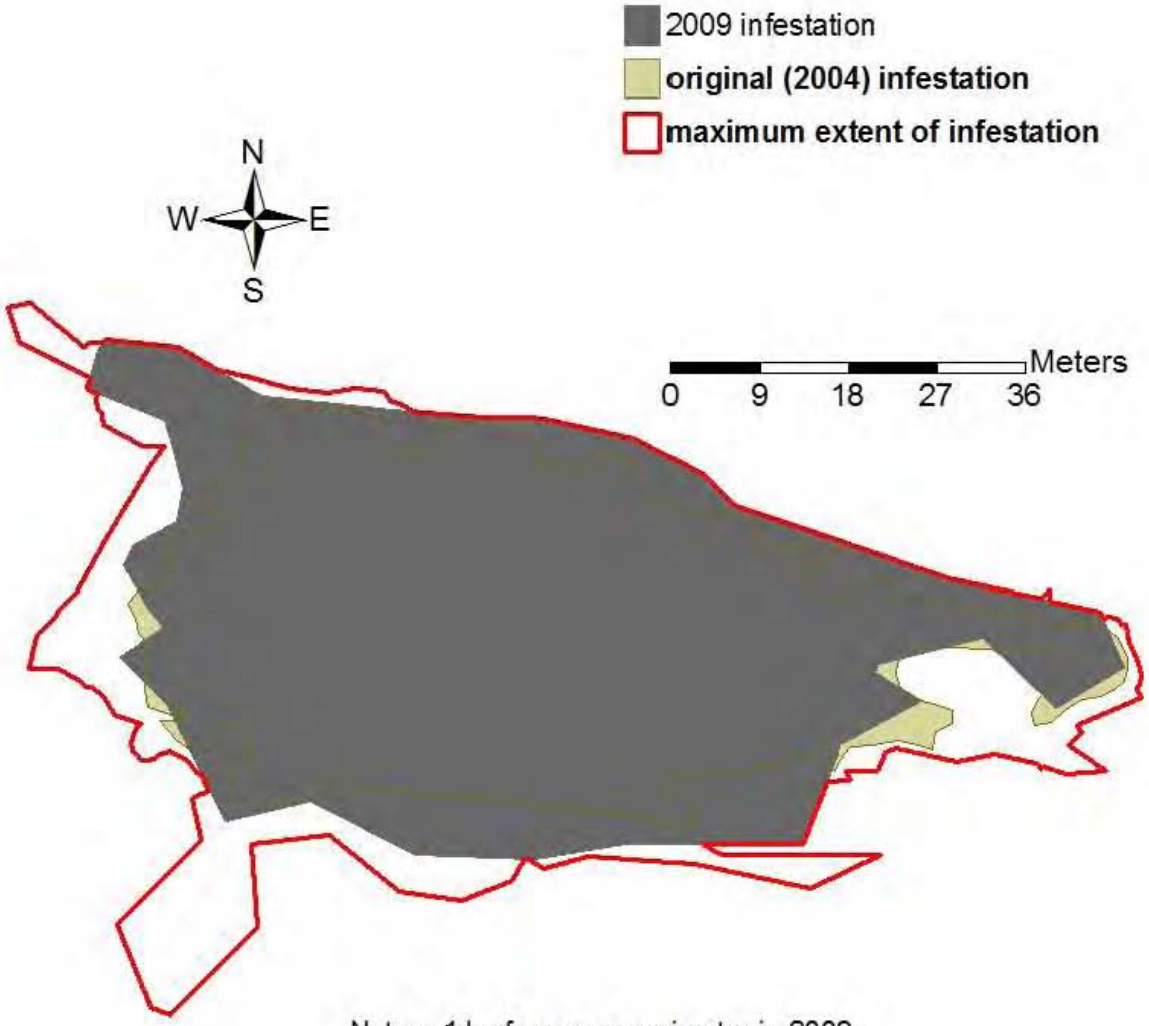
Control leafy spurge density in 2009.



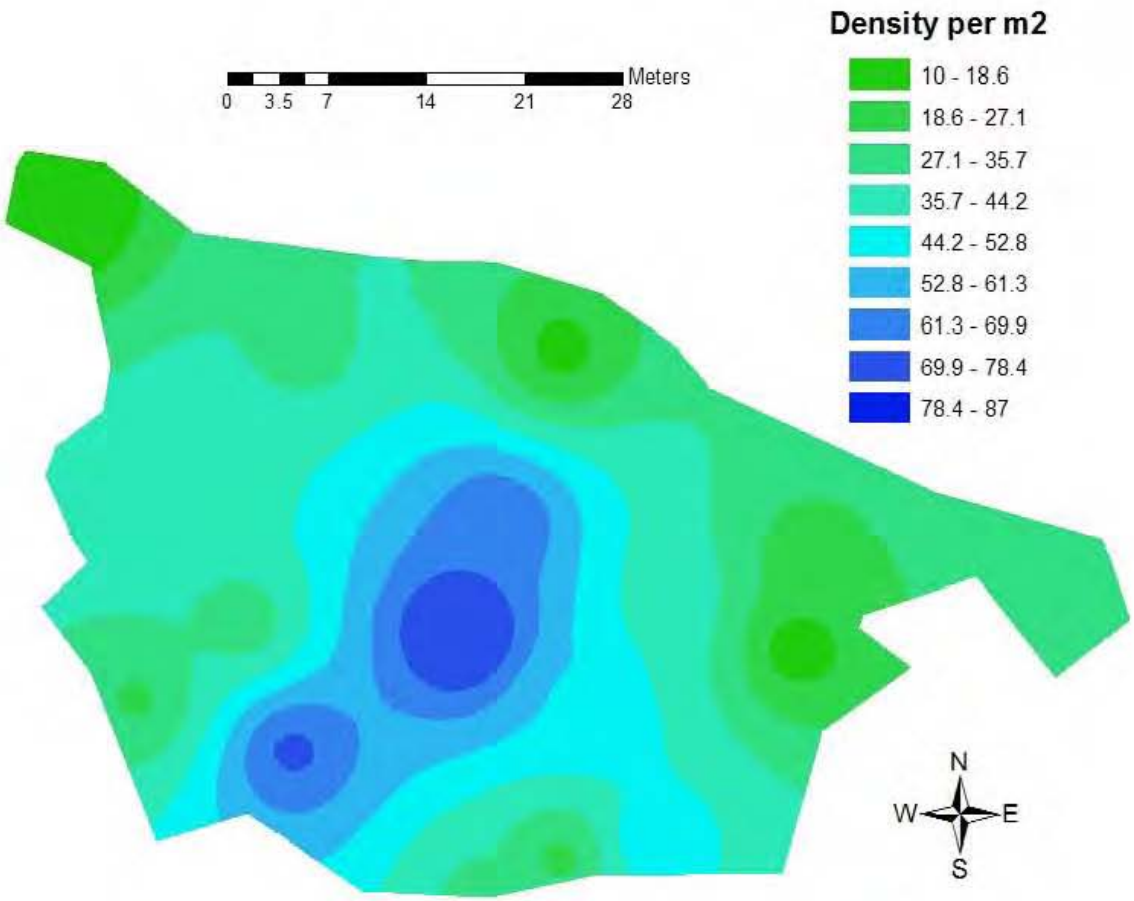


Control leafy spurge height in 2009.

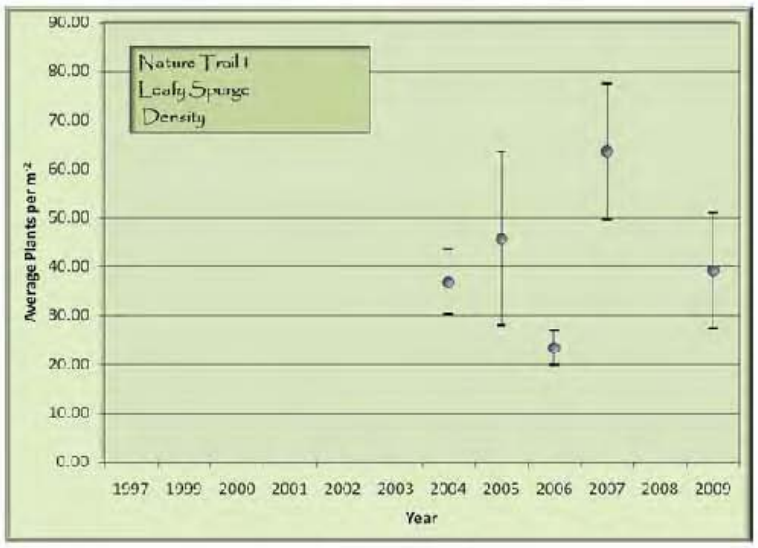


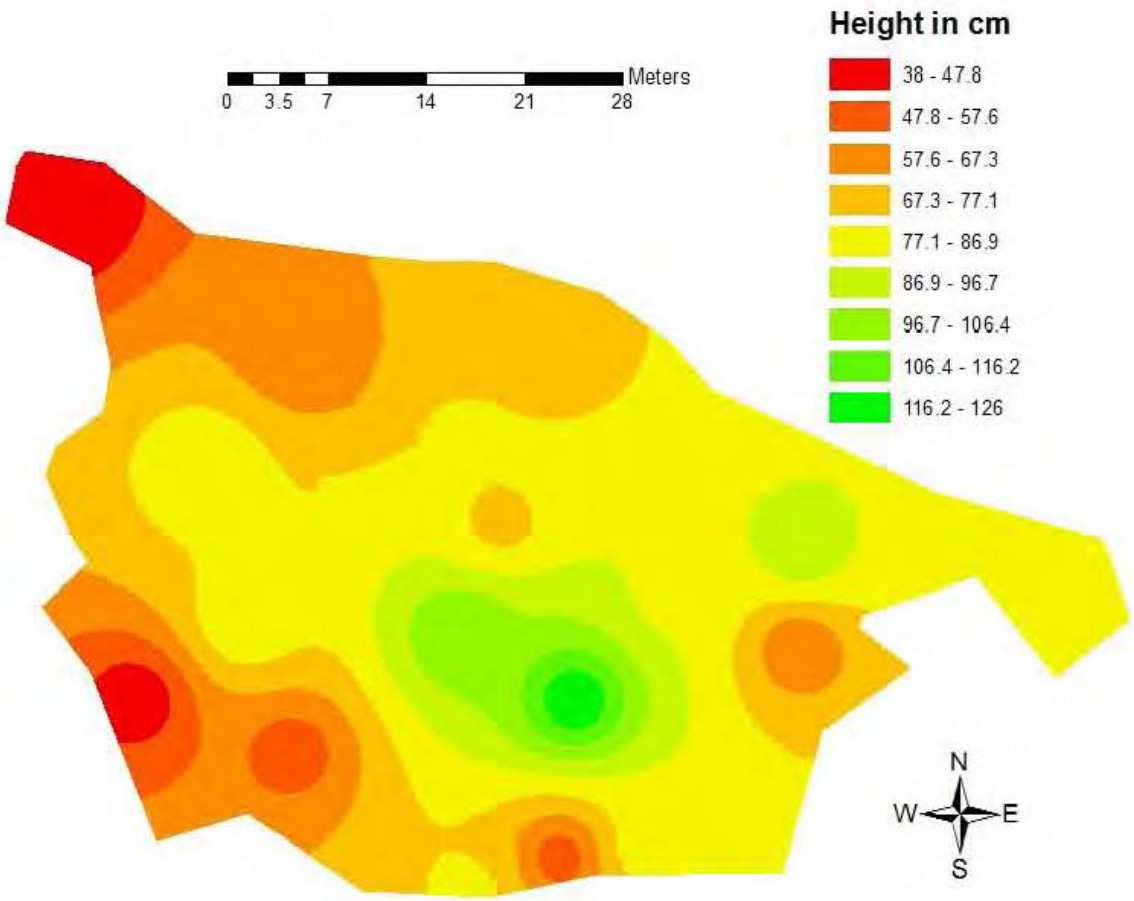


Nature 1 leafy spurge perimeter in 2009.

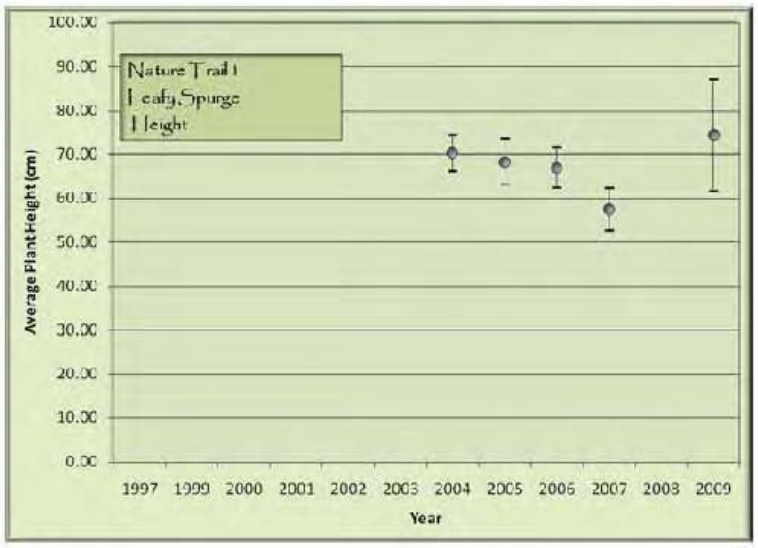


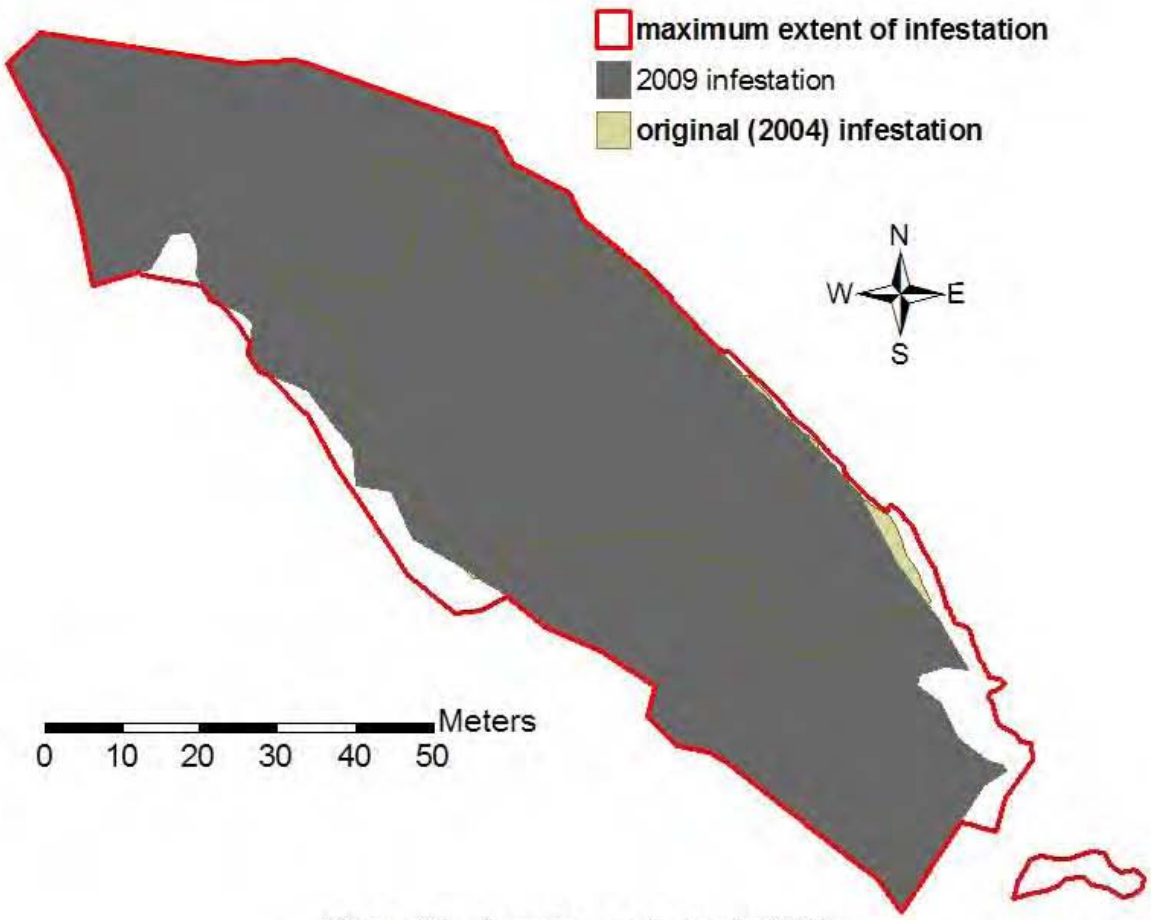
Nature 1 leafy spurge density in 2009.



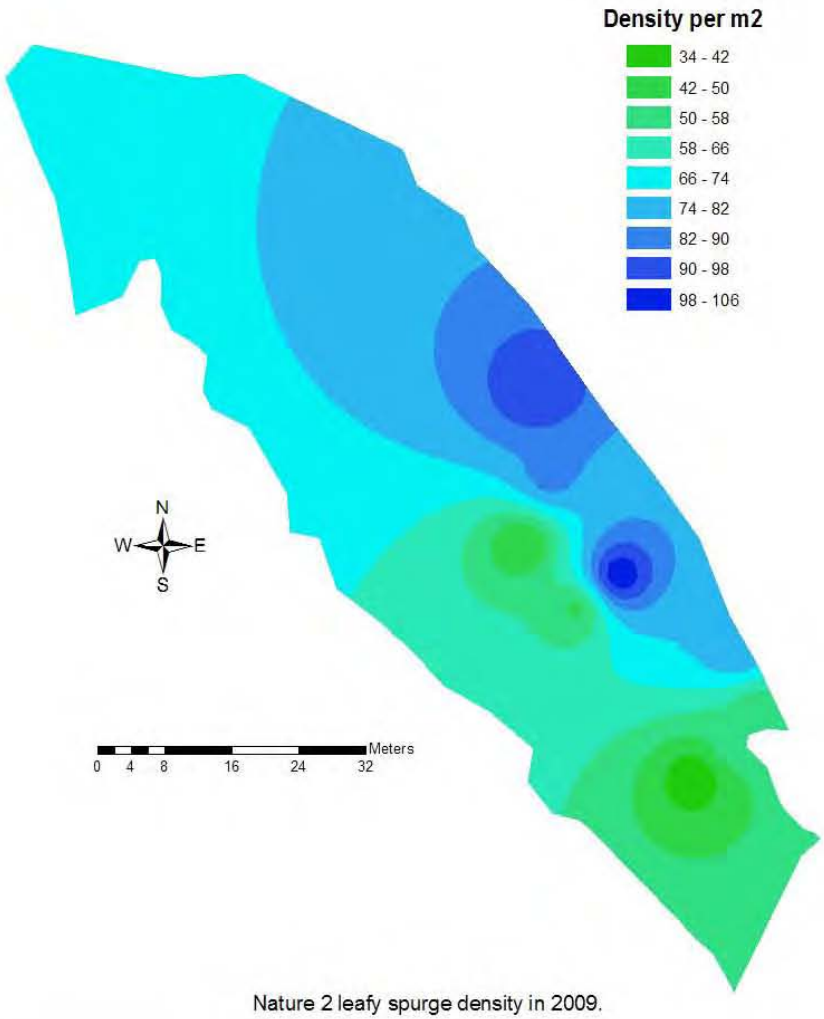


Nature 1 leafy spurge height in 2009.

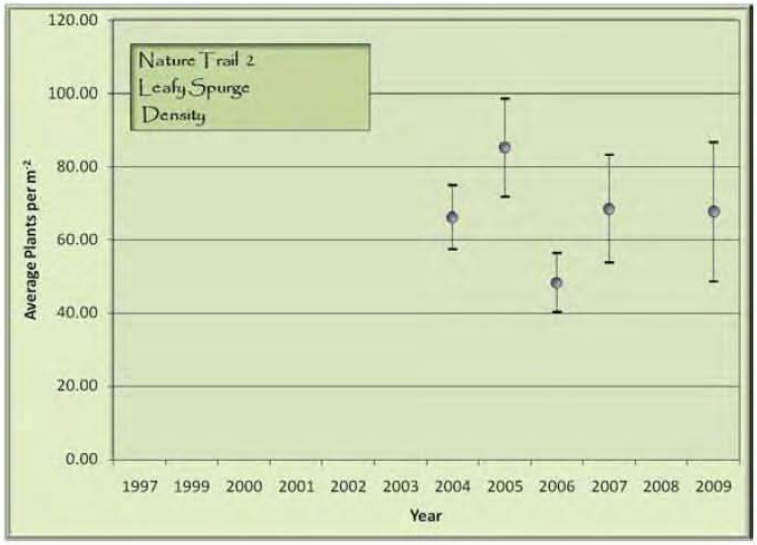


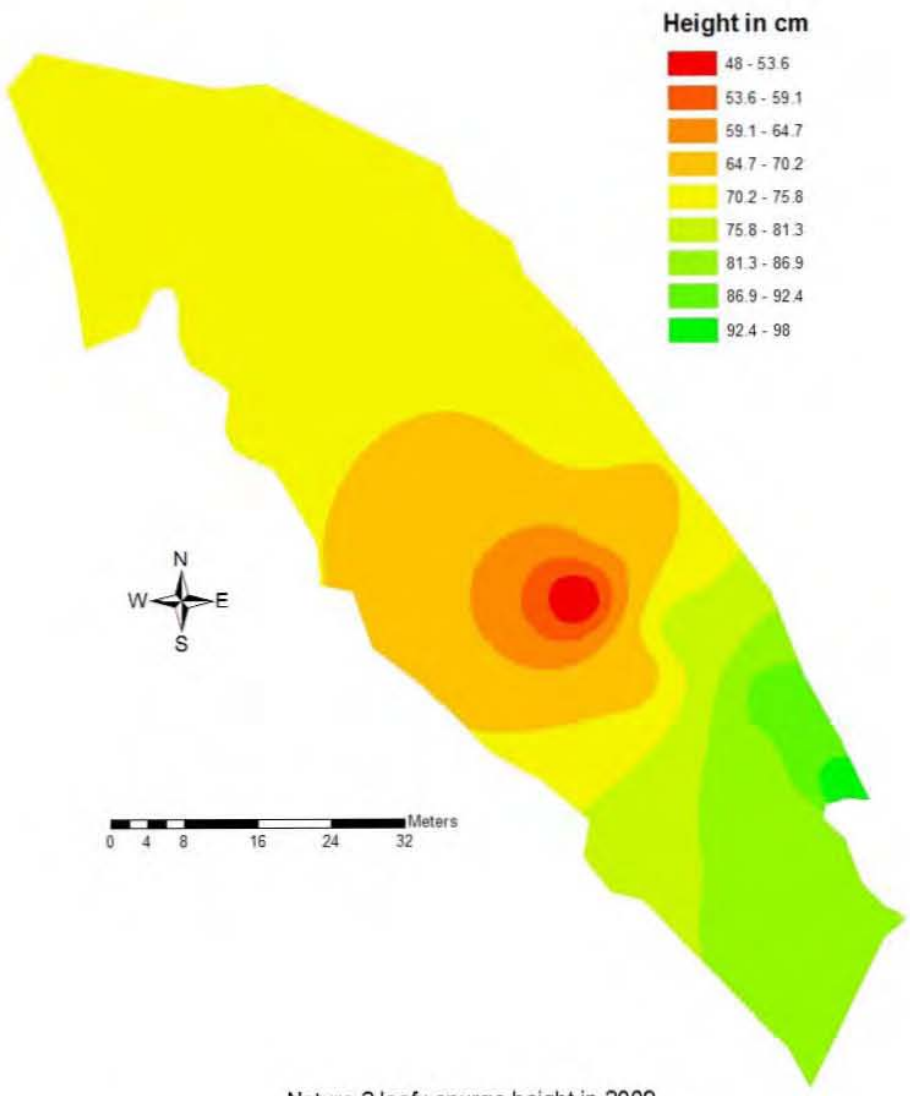
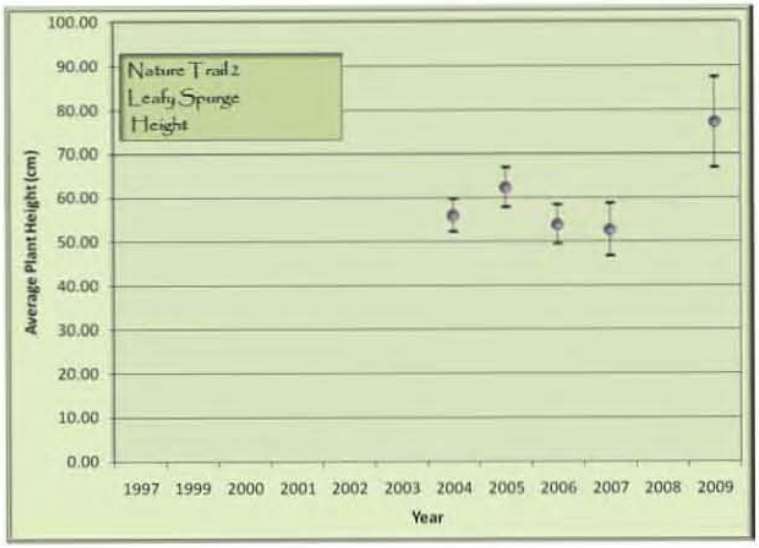


Nature 2 leafy spurge perimeter in 2009.



Nature 2 leafy spurge density in 2009.





Nature 2 leafy spurge height in 2009.