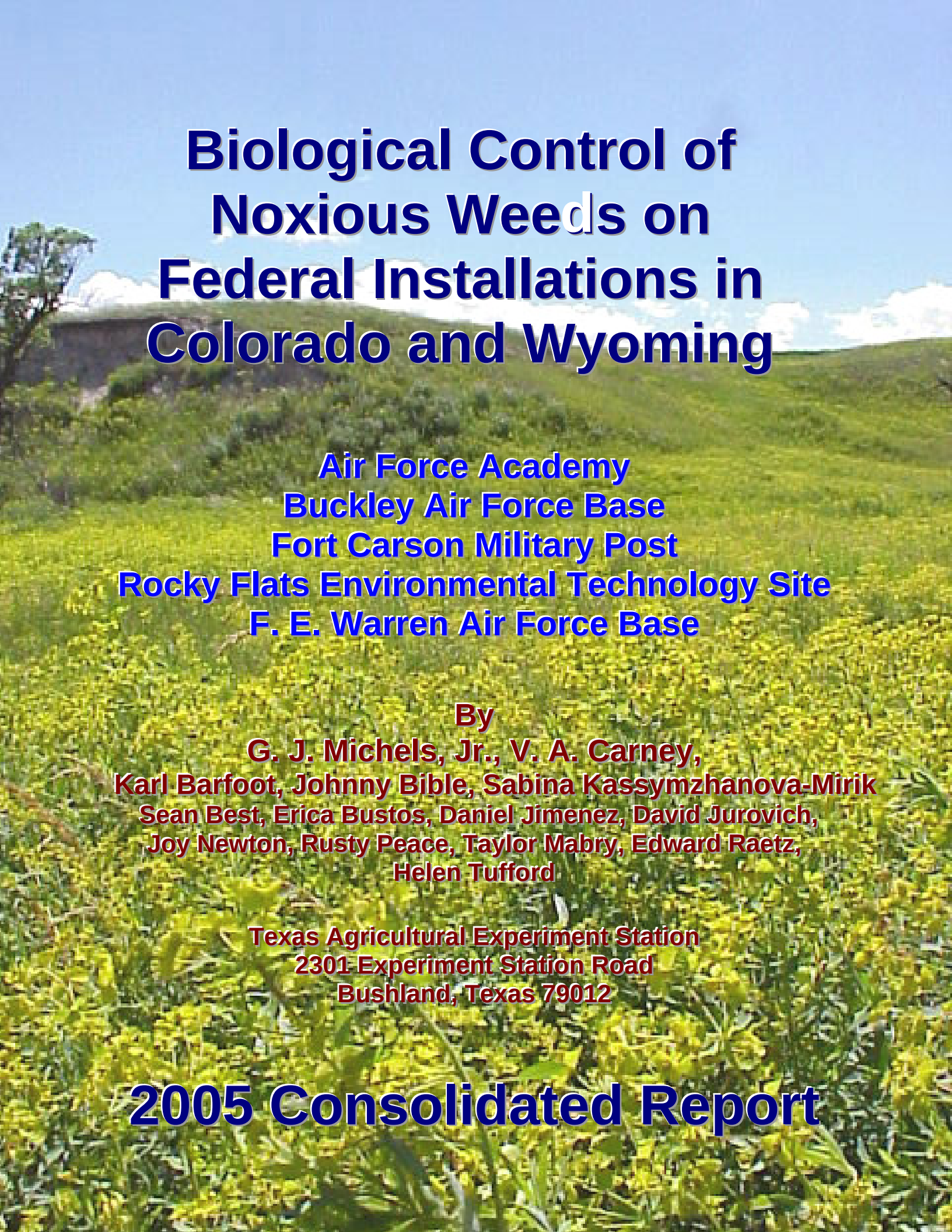

Biological Control of Noxious Weeds on Federal Installations in Colorado and Wyoming

Air Force Academy
Buckley Air Force Base
Fort Carson Military Post
Rocky Flats Environmental Technology Site
F. E. Warren Air Force Base

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2005 Consolidated Report

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Introductory Notes

The summer of 2005 marked the ninth year of the program to control noxious weeds at Ft. Carson, the sixth year at the Air Force Academy, the fifth year at Rocky Flats, the third at Buckley Airbase, and the second at Warren Airbase. As stated in previous years, the program's focus is threefold:

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

In this consolidated report, the locations are listed alphabetically, beginning with the Air Force Academy and ending with Warren Airbase. The format is arranged to provide a written narrative of each site within a location, followed by tabular material with historic site data and plant parameters, and then maps and graphs. The first map presents the historic weed infestation perimeters, illustrating the change in the infestation from the initiation of monitoring to present. This is followed by maps illustrating the weed infestation density and plant maximum height for 2005, along with historic graphs of both weed measurements at each site.

As the weed biological control program progresses and continues to expand on Colorado and Wyoming federal installations, the methods by which data is represented in annual reports will be evolving. Ideally, the goal is to accurately and in a visually concise manner document the year-to-year reduction of weed populations and to reflect the impact of bio-agents. Because the data collected at some weed infestations has been accumulating for up to nine years, simply presenting overlays of each year's weed infestation perimeter in one diagram is becoming less and less suitable as a means of illustrating the decline of weed infestations where biological control is successfully applied. One major change to the appearance of this year's consolidated report is that figures showing the area infested by each weed display the current (2005) infestation perimeter contrasting against the entire area mapped in previous years.

As in previous years' reports, the characteristics of weed infestations (i.e. total area covered by weeds, density of patches, height of plants, seedhead production) are summarized within tables specific to each installation. Measurements for density are taken from counts of individual stems/plants within a given number of $0.5m^2$ quadrat samples (n). Density level and height estimates represented in their respective figures for each site are determined by spatial interpolation using the sampled quadrats as reference points. Additional tables presented for each installation outline which biological control agents have been released and recovered in each weed location to date.

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 difference is statistically significant.

Other features within the 2005 report include tables detailing the population levels of individual bio-agents found by dissecting weed tissues collected in the 2004 field season. Included in this analysis were diffuse and spotted knapweed seedheads, dissected and evaluated under a microscope for seed-feeders, *Larinus minutus*, *L. obtusus*, *Metzneria paucipunctella*, *Urophora affinis* and *U. quadrifasciata* (Table 2). Similarly, Canada and musk thistle heads were collected in 2004 from several weed infestations and dissected to determine the resident population levels of seed-feeders *Rhinocyllus conincus* and *Larinus planus* (Table 3). Dalmatian toadflax dissections from the 2004 field season revealed that populations of *Mecinus janthinus*

were low to non-existent at all sites surveyed (this survey did not include the Original toadflax site at Rocky Flats Environmental Technology Site, where adults were visible on the few available toadflax plants). No table was generated to illustrate *M. janthinus* population levels.

During the course of mapping weed infestations, population estimates of *Aphthona* spp. leafy spurge beetles and *Chrysolina* sp. St. Johnswort beetles were made (Tables 4 and 5, respectively). Knapweed roots were also evaluated in situ to detect the presence of root-borers *Agapeta zoegana, Cyphocleonus achates* and *Sphenoptera jugoslavica*. The only full results from the root evaluations came from Rocky Flats. In 2004, *C. achates* was found in 100% of the quadrats surveyed in the North Buffer zone, with each sample containing at least one larva/quadrat. The mean number of larvae found per five root samples was 3.12. Thirty-eight percent of the quadrats surveyed in the same area also contained *S. jugoslavica* that year. The populations appeared to be lower in 2005, with 36% of the quadrats containing *C. achates* and no *S. jugoslavica* detected.

Due to the breadth of the program, and the various stages of control which exist at specific sites, it is difficult to make sweeping conclusions about the overall success of the program. Each installation and sites within each installation should be evaluated separately for efficacy. A number of our "older" sites indicate near total control of the noxious weeds originally present. Spotted knapweed reductions at Ft. Carson and Air Force Academy, as well as musk thistle declines at these installations, are good examples of control success. Canada thistle control at Ft. Carson and Air Force Academy also look good, but this requires a more complete explanation presented below under the section on *Aceria anthocoptes*. At some sites sampled in 2005, the results indicate a fluctuating situation where the weed density and perimeters have rebounded since 2003 or 2004. Leafy spurge at the Air Force Academy is an example. The change in the total area infested since the initial releases dropped by 56.7% at the Douglas School site, but increased 92.1% at the Deadman's Trail site.

Changes in weed density may be associated with the recent drought. Referring to Figure 1, at all locations, 2002 seems to have been the low point for precipitation within the last nine years. The general trend seems to be upward since 2002. It is unclear exactly how a yearly increase or decrease in rainfall affects a given year. It is also unclear if 2004 was an anomaly and the drought will continue. Precipitation in 2005 was generally lower than 2004, but not as low as 2003 or 2002. How these fluctuating precipitation patterns influence the weed and insect parameters across the program locations is unclear, and, as far as the weeds are concerned, may need to be looked at on a species by species basis. There is a good chance that some of the rebounding weed densities and heights at some locations may indeed be due to more rainfall in 2004 which resulted in a better weed "crop" in 2005. What we find in 2006 could very well reflect the rainfall in 2005. At the current time we have no doubt that biological control is working quite well at some sites regardless of the drought.

Generally, we are pleased with the results at most sites. We believe that we have the right insects or combinations of insects for good weed control at all sites on the major weeds. We are very excited about the possibility for Canada thistle control with *A. anthocoptes*. We will be expanding our efforts to study and redistribute this mite on Canada thistle throughout 2006. Until late in 2004, we did not believe there was a good biocontrol agent for Canada thistle, but the unexpected advent of *A. anthocoptes* has changed that opinion. Dalmatian toadflax is another problem weed at three locations. The biocontrol agent *Mecinus janthinus* should be effective on this weed, but to date our efforts have been mixed. We had very good control at our original Rocky Flats site, but poor results at Buckley and Warren Airbases. We are examining the release sites, methodologies of release and the impact climate might play on establishing *M. janthinus* in Colorado and Wyoming.

As always, we appreciate the opportunity to carry on this important work and would welcome any comments you might have.

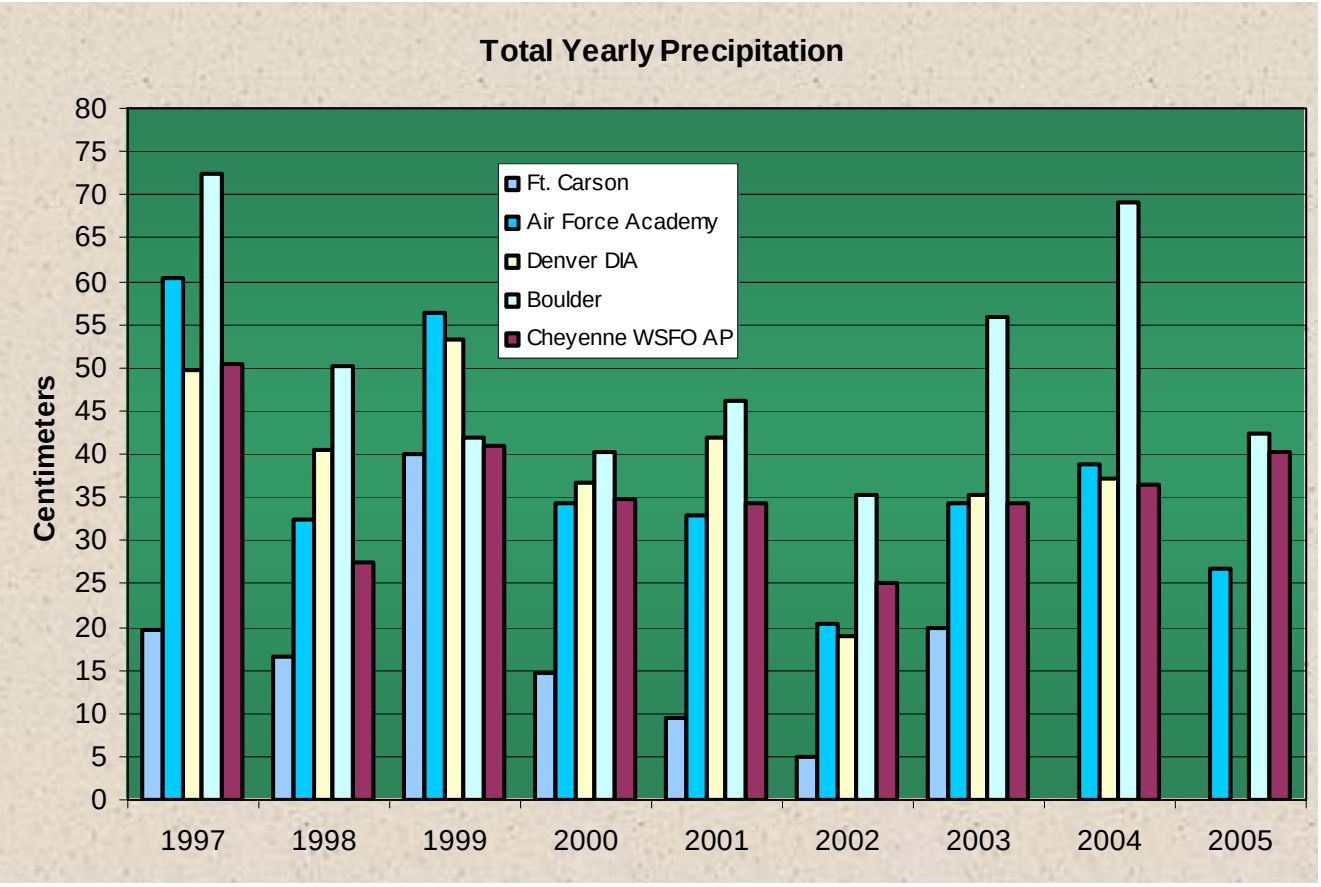


Figure 1. Yearly annual precipitation at five locations in Colorado and Wyoming 1997-2005, not all years available for all locations.

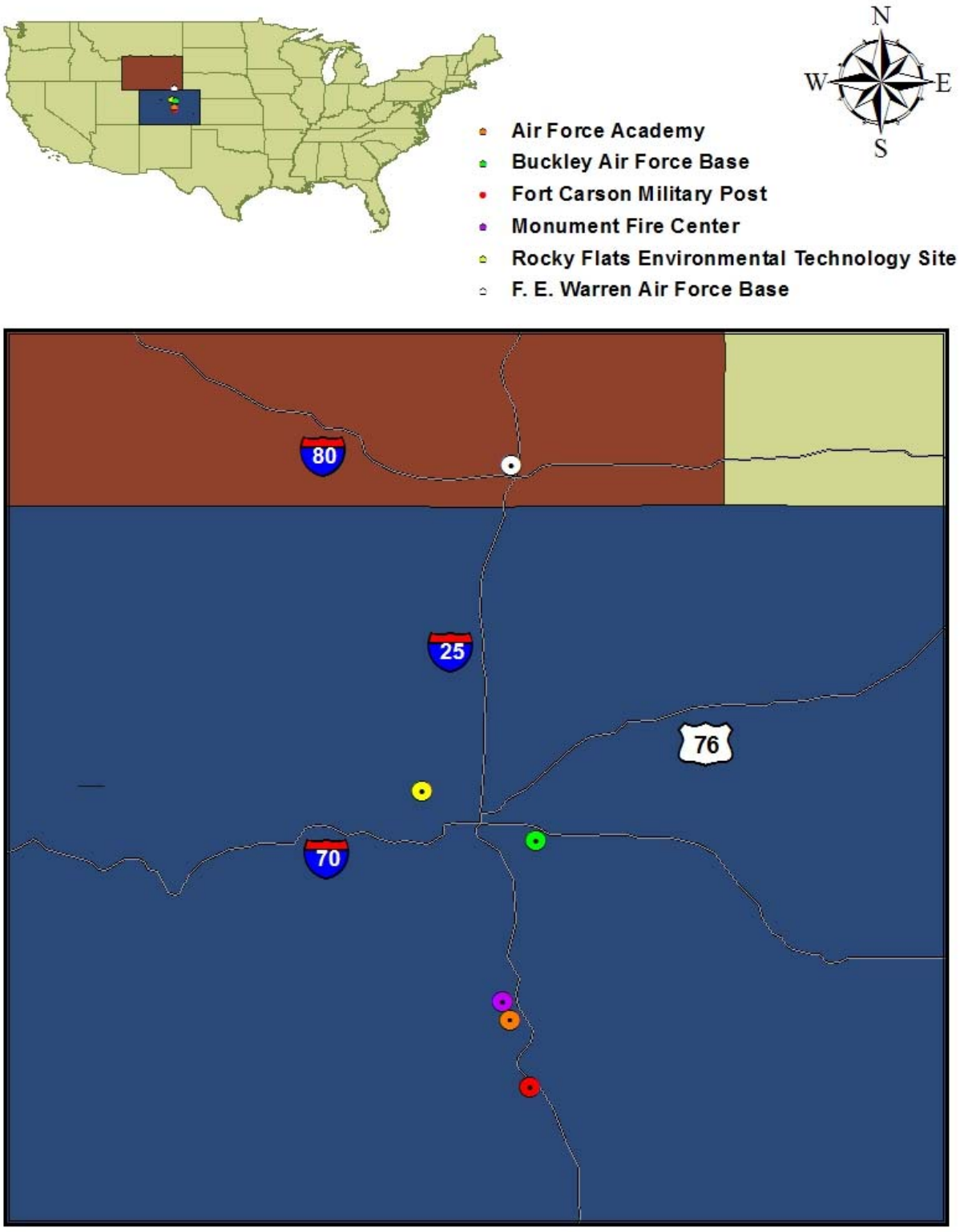


Figure 2. Map showing the federal installations in Colorado and Wyoming on which noxious weed biological control efforts are being made by Texas Agricultural Experiment Station.

Potential Biological Control Agent, *Aceria anthocoptes*

This season, a survey of Canada thistle across all five federal installations was made to supplement the information on the distribution of potential biological control agent, *Aceria anthocoptes*, gained in 2004. We discovered the presence of an Eriophyid mite, *A. anthocoptes*, commonly known as the thistle rust mite, at Fort Carson Military Post, F. E. Warren Air Force Base and many other locations in Colorado, Wyoming and Nebraska in 2004. This year's sampling focused on current and future biocontrol sites at the five installations contained in this report. The results from this sampling (Table 1) indicated that mites were found on randomly-collected Canada thistle tissue at every sample location, with the exceptions of the original Canada thistle infestation area at ARA I, Fort Carson, and Ice Lake I, Air Force Academy. These sites have very little remaining thistle and, consequently, provided difficulties when trying to gather sufficient Canada thistle tissue for analysis.

Otherwise, moderate populations of the mite, a close relative to the successful and highly host-specific bindweed biocontrol agent, *Aceria malherbae*, were found at most sites. A patch of highly deformed, sickly Canada thistle at ARA II (see Table 1 for a list of symptoms observed) revealed extremely high densities of *A. anthocoptes* when Canada thistle tissue samples from this site were evaluated. We continue to work with Drs. John Lydon and Ronald Ochoa to confirm the identity of this mite (Figure 3) and plan to study the biology, behavior and distribution of the mites further in 2006.

Figure 3. (L to R) Chris Frye (Maryland DNR), Ron Ochoa and John Lydon (USDA-ARS) inspect Canada thistle for signs of *Aceria anthocoptes* mites (inset).

Table 1. Occurrence of Eryophyid mites, suspected to be *Aceria anthocoptes*, at federal biological control sites in Colorado and Wyoming, 2005 [1].

Installation Name	Sample Site Name	Sample Date	Eryophyid Mites Detected
Air Force Academy	Ice Lake Road I	07/29/05	no mites
Air Force Academy	Ice Lake Road II	07/29/05	moderate densities
Air Force Academy	Kettle Lake	07/29/05	moderate densities
Air Force Academy	Parade Loop	08/25/05	moderate densities
Buckley Airbase	Runway	07/28/05	moderate densities [2]
Buckley Airbase	South Aspen Way	07/28/05	high densities [2]
Buckley Airbase	Williams Lake	07/28/05	low densities
Fort Carson	ARA I	08/08/05	no mites [3]
Fort Carson	ARA II	08/31/05	extremely high densities [4]
Fort Carson	Duckpond	08/02/05	moderate densities
Fort Carson	Haymes Reservoir	08/23/05	no mites
Fort Carson	Highway 115	08/23/05	low densities
Fort Carson	Reservoir	08/02/05	low densities
Rocky Flats	Lindsey Ranch	08/01/05	low densities [2]
Warren Airbase	Nature Trail III	07/28/05	high densities

[1] Mites have been recovered from thistle tissue samples and visually confirmed as belonging to the family Eriophyidae. They are awaiting DNA analysis to confirm their identity as *A. anthocoptes*.
[2] Unidentified nematodes were also collected from these sample sites.
[3] Data from this sample site reflects the collection of a single, stunted plant from the original biocontrol release area.
[4] Plants were collected from a patch of Canada thistle showing abnormal growth: stunting, hypertrophy of leaf tissue, chlorosis.

Table 2. Knapweed seedhead dissections taken from samples in 2004 at Air Force Academy (AFA), Fort Carson Military Post (FTC) and Rocky Flats Environmental Technology Site (RF), identifying the levels of knapweed seedhead attack (%) and the seed-feeding agents responsible.

Installation Abbreviation	Sample Site Name	n	Percent Heads Attacked	Proportion of Total Insects Found in Seedheads (%)			
				L. minutus	*U. affinis*	*U. quadrifasciata*	*M. jugoslavica*
AFA	Highway 83	40	40	0	3	1	0
AFA	New Monument Ck	673	34	13	2	60	0
AFA	NPWR	80	41	0	5	2	0
AFA	Parade Loop III	38	66	0	16	9	0
FTC	Fuel Site	80	76	16	4	3	1
FTC	Gun Club	437	40	41	7	53	10
FTC	Hazmat	849	54	7	12	77	0

Table 3. Thistle seedhead dissections, collected from Canada and musk thistle at various federal release sites in 2004, identifying the levels of seedhead attack and the seed-feeding agents responsible.

Thistle Type Dissected	Installation Name	Sample Site Name	n	Seedheads Attacked (%)	Total Insects Attacking Heads(%) *R. conicus*	*L. planus*
Canada	Air Force Academy	Ice Lake Road I	179	34	94	6
Canada	Air Force Academy	Ice Lake Road II	173	21	93	7
Canada	Air Force Academy	Kettle Lake	319	34	92	8
Canada	Air Force Academy	Parade Loop	22	0	--	--
Canada	Buckley Airbase	Williams Lake	659	27	91	9
Canada	Fort Carson	ARA I	278	22	85	15
Canada	Fort Carson	ARA II	1564	22	99	1
Canada	Fort Carson	Duck Pond	1032	11	93	7
Canada	Fort Carson	Highway 115	479	1	100	0
Canada	Rocky Flats	Lindsey Ranch	612	14	89	11
musk	Air Force Academy	Ice Lake Road I	35	89	100	0
musk	Fort Carson	Highway 115	85	15	79	21
musk	Fort Carson	Wildlife	163	21	75	25

Table 4. Proportion of leafy spurge 0.25m^2 quadrats populated by *Aphthona* species biological control agents, as identified through sweep net captures in 2004 and 2005 at various federal installations.

Installation Name	Sample Site Name	2005 Sweep Samples n (quadrats)	2005 Sweep Samples % Inhabited	2004 Sweep Samples n (quadrats)	2004 Sweep Samples % Inhabited
Air Force Academy	Deadman's Trail	30	37	31	45
Air Force Academy	Douglass School	36	3	5	20
Air Force Academy	FERL	45	6	30	20
Buckley Airbase	Interior [1]	28	36	--	--
Buckley Airbase	Runway [2]	32	31	44	0
Buckley Airbase	Southwest William's Lake [2]	42	57	24	0
Buckley Airbase	William's Lake	31	32	77	9
Warren Airbase	Black Powder Road [1]	28	0	--	--
Warren Airbase	Control [2]	50	54	31	0
Warren Airbase	Nature I [2]	35	34	44	0
Warren Airbase	Nature II [2]	37	73	42	0

[1] Site new in 2005 [2] Site new in 2004

Table 5. Proportion of St. Johnswort 0.25m^2 quadrats populated by *Chrysolina* species biological control agents, as identified through visual counts in 2004 and 2005.

Installation Name	Sample Site Name	2005 Visual Insect Counts n (quadrats)	2005 Visual Insect Counts % Inhabited	2004 Visual Insect Counts n (quadrats)	2004 Visual Insect Counts % Inhabited
Air Force Academy	Kettle Creek	33	49	71	10
Air Force Academy	Midway Kettle Creek	40	48	19	32
Air Force Academy	Santa Fe	40	68	24	8

Note: All of the St. Johnswort sites were new in 2004. High levels of biocontrol agent recovery in the year of release is likely attributed to ambient populations of *Chrysolina* sp. beetles established at each site from prior insect releases on nearby St. Johnswort stands.

Air Force Academy

A total of 21 noxious weed infestations were monitored on Air Force Academy in 2005, comprising a total mapped area of 1.33 ha. Diffuse and spotted knapweed, as in previous years, accounted for the bulk of infested area in 2005 (8 sites, 0.94 ha total mapped area). This was followed by 0.13 ha each of Canada thistle (4 sites) and St. Johnswort (3 sites), 0.11 ha of leafy spurge (3 sites) and 0.02 ha of yellow toadflax (3 sites, including the newly identified Community Center Drive III). In addition to mapping the extent of each weed infestation mentioned above, estimates of mean plant density, maximum height, seed production and weed cover were made and compared against previous years' infestations (Table 6).

Over the past couple of years at Air Force Academy, we have observed a promising trend of significant biological control agent establishment at several of the monitored weed infestations, particularly the knapweed sites. Monitoring at many of these sites was initiated as recently as two years ago. Visual observation of biological control insects on knapweed plants in 2005 (Table 7), along with knapweed seedhead destructive sampling, performed in fall 2004 and winter 2005 (Table 2, Introduction), show that many of the biocontrol agents released at or near study sites are achieving high levels of dispersal and establishment across target areas.

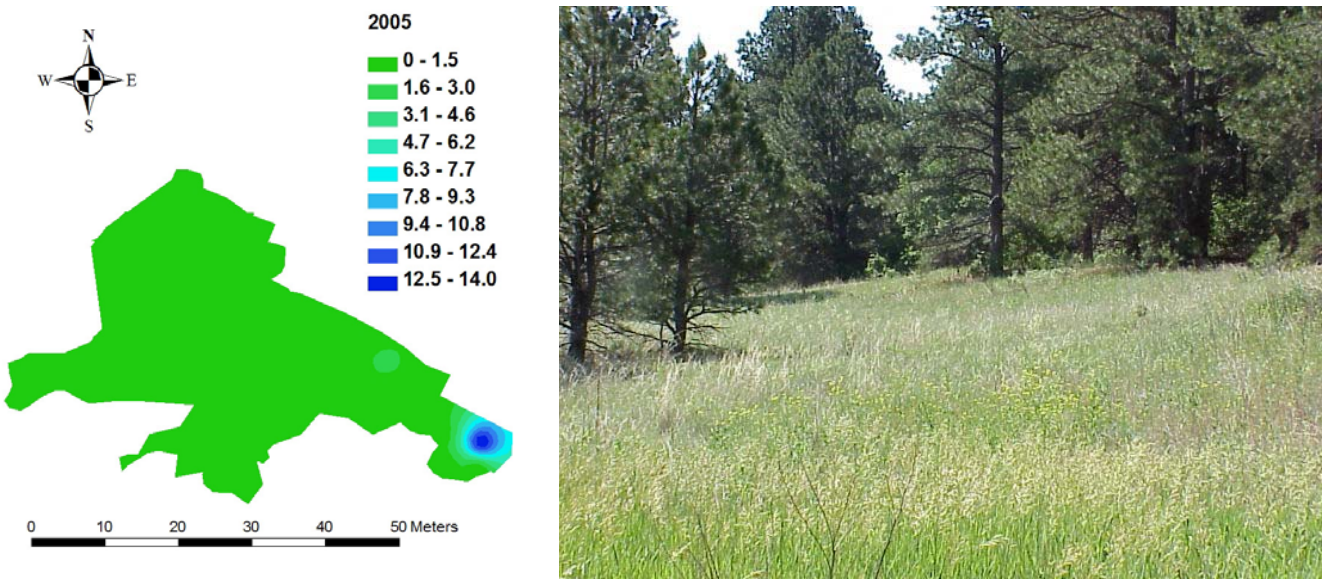


Figure 4. Spotted knapweed densities taken in 2005 at the Old Monument Creek site (left) within its historic infestation perimeter (i.e. a combined total area of infestation from 2000-2003 maps). A 2005 photo of the site (right), demonstrates the reclamation of this once heavily knapweed-infested field.

A number of the weed infestations that were chosen for initial monitoring and release of biocontrol insects in 2000 have become so small and/or discontinuous that an accurate infestation map can no longer be constructed. A prime example can be found at the original Monument Creek spotted knapweed site, herein referred to as Old Monument Creek to distinguish it from the nearby patch discovered and mapped in 2004, New Monument Creek

(Figure 4). We were unable to map a weed infestation perimeter at Old Monument Creek in 2004. All that remained of the initial 0.62 ha weed patch that year were a handful of individual plants near the initial biocontrol release site, on which both root-feeder, *Cyphocleonus achates*, and seedhead agent, *Larinus minutus*, were observed. There were too few knapweed plants at this site to map a discrete weed patch this season, so we opted to take weed quality and quantity data from quadrats within the combined total area of spotted knapweed infestation using perimeter maps constructed in 2000-2003. In 2005, knapweed plants at Old Monument Creek were scarce (found only in 4% of quadrats surveyed). The volume of knapweed plants was also much reduced from the original patch density in 2000 (9 plants/m^2) to 0.3 plants/m^2 in 2005 (Table 6). The knapweed plants that were found this season, presumably liberated from the competitive pressures experienced during heavy infestation in previous years, were slightly taller than in years past (Table 6). We will continue to monitor this site in the future for possible knapweed seedling establishment and patch development and will re-distribute biocontrol agents back into the area, if necessary.

A similar observation was made at the single infestation of musk thistle that we monitor on Air Force Academy, Ice Lake Road I. We could not map musk thistle in 2005 due to the reduction in the infestation to a few, scattered plants. Populations of the seedhead weevil, *Rhinocyllus conicus*, were extremely high at this site in 2004 (89% of the seedheads were attacked by *R. conicus*) (Table 3, Introduction). This insect, though not deliberately released as part of this weed biological control program, may be chiefly responsible for the dramatic reduction in both musk (90% decrease since 2000) and Canada thistle (75% decrease from 2001) observed at this site (Table 6). As with Old Monument Creek, we intend to continue monitoring this site for any re-occurrence of musk thistle at Ice Lake Road I.

Figure 5. New biological control release area in 2005, FERL North. Leafy spurge plants growing in shade were chosen for this release to maximize the establishment and efficacy of the different *Aphthona* species released.

There are two biological control sites that we were unable to map in their entirety in 2005 due largely to weather conditions this season. Leafy spurge mapping began later this year than in the past, as it can be extremely difficult to differentiate this weed from surrounding vegetation until the characteristic flower becomes apparent. As a result, only a part of the FERL site was mapped, as flowering coincided with the period of time that cadets train/camp on a large portion of the weed infestation. Consequently, the total area of infestation recorded at the FERL site is significantly under-represented in 2005. Similarly, the full extent of the Parade Loop III spotted knapweed infestation was not fully assessed in 2005, as it was partially under water when mapping was initiated. All of the Parade Loop spotted knapweed sites run along a drainage and risk flooding from year to year.

A total of 7,775 biocontrol insects were released at Air Force Academy in 2005. These included a single release of 275 stem-mining weevils, *Ceutorhynchus litura*, onto Canada thistle at Kettle Lake. This is the first attempt to establish *C. litura* at Air Force Academy. The weevil causes minimal direct feeding damage to its target host, but can have significant indirect impact by increasing a thistle's susceptibility to pathogens and rot in hollowed-out portions of the stems, caused by larval tunneling. This agent has struggled to establish in the dry conditions presented at nearby Fort Carson. However, Kettle Lake may provide a more suitable nursery site with high Canada thistle densities and a sheltered, moist environment.

Additionally in 2005, we were able to obtain 7,500 *Aphthona* spp. flea beetles to release at the FERL site and a newly identified infestation of leafy spurge, labeled FERL North (Figure 5). The batch of insects we obtained was a mixed complex of known proportions of *A. cyparissiae*, A. *czwalinae*, *A. lacertosa* and *A. nigriscutis*. Flea beetle releases were made in a variety of microhabitats, as our current understanding of these bio-agents suggests that these species have variable tolerances to and preferences for shade, soil and moisture levels. We have seen from releases at Air Force Academy, Buckley and Warren Airbases that *A. lacertosa* and *A. nigriscutis* appear to establish well in hot, dry, open fields. The remaining *Aphthona* species may be of better use in more shaded, moist conditions. Monitoring these releases, along with others made this year should allow us to better predict efficacy of these agents by knowing the species composition of releases and establishments.

Figure 6. Spotted knapweed seedheads from the Water Treatment Plant site show numerous emergence holes made by seed-destroying *Larinus minutus* (left). Root-feeder, *Cyphocleonus achates* (below), has now been released at 5 of the 9 knapweed biocontrol sites at Air Force Academy.

As mentioned above, we are observing the wide dispersal of knapweed biological control agents, particularly seedhead-feeding flies *Urophora affinis, U. quadrifasciata* (the latter ubiquitous and not released in this program) and the moth *Metzneria paucipunctella* (Table 7). Although generally not viewed as highly effective, these insects contribute to some seed reduction in both spotted and diffuse knapweed. Between 34-66% of seedheads sampled in 2004 were attacked (Table 2, Introduction), mostly by the fly larvae. We are also seeing excellent establishment of more promising agents, *L. minutus* and *C. achates*, particularly at the Water Treatment Plant site first mapped in 2003 (Figure 6).

Two other trends in insect biological control agent establishment at Air Force Academy are noteworthy. *Mecinus janthinus* were released in 2003 in fairly low number at the two small Community Center Drive yellow toadflax sites and although they have been found at Community Center Drive I, populations are not thriving. Additional releases of *M. janthinus* or an alternative agent such as *Gymnetron antirrhini*, are likely necessary in order to begin achieving some control over yellow toadflax at these sites. The other bio-agent worth mentioning from Air Force Academy is a large, metallic defoliating beetle, *Chrysolina* sp., released in 2004 on three infestations of St. Johnswort. Since is such a recent release, it is unlikely that these beetles will have caused a significant impact to their target host within a single growing season. Establishment of the insect at each of the three release sites, however, does not appear to be an issue, with between 48-68% of St. Johnswort plant quadrats containing *Chrysolina* beetles (Table 5, Introduction) and large numbers of insects observed on individual plants (Figure 7).

Figure 7. Established populations of *Chrysolina* sp., a beetle defoliator of St. Johnswort, at the Kettle Creek release site in 2005 (left). Feeding damage on young flower-heads is apparent in the photo on the right.

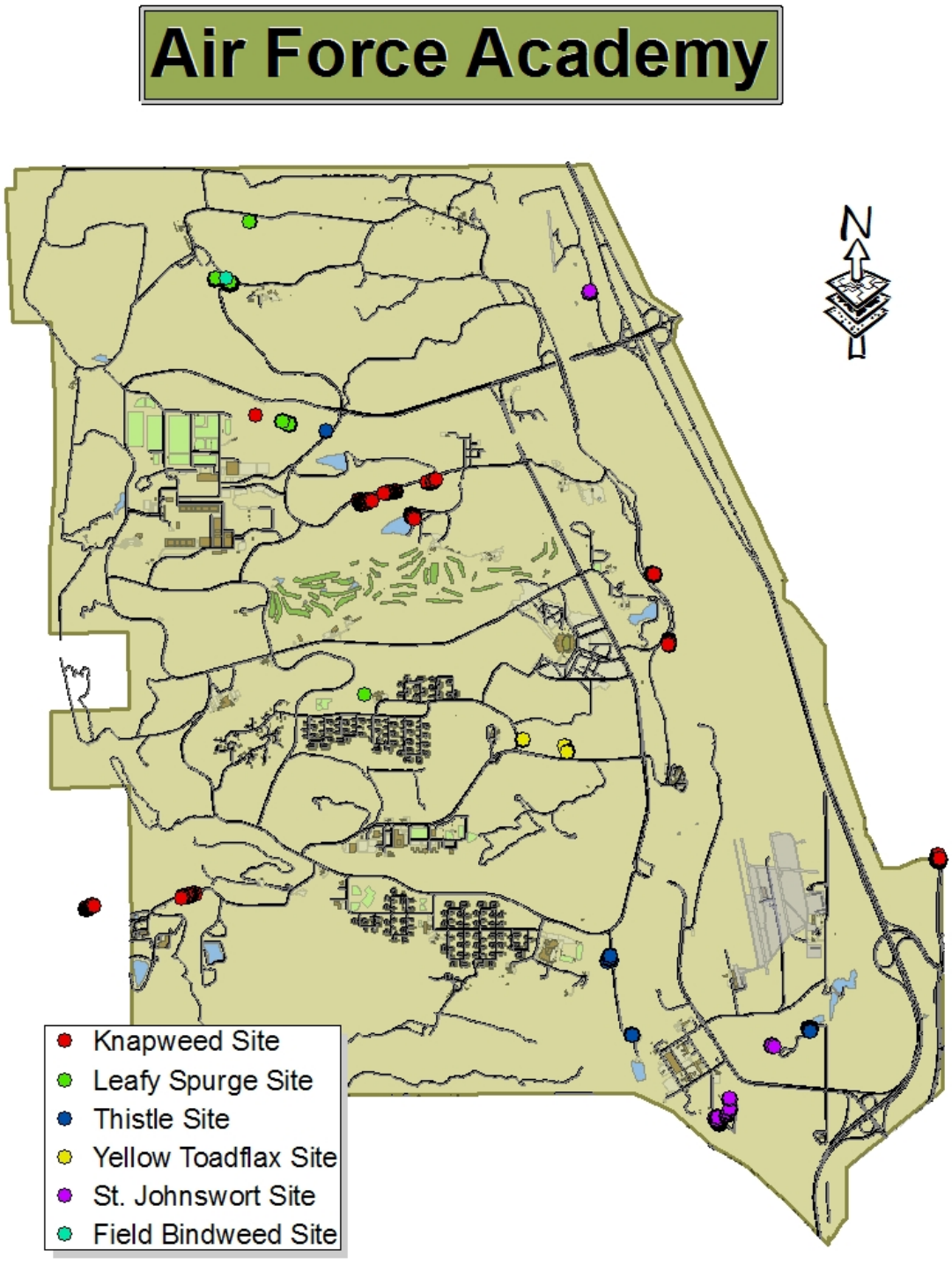


Figure 8. Schematic diagram of Air Force Academy with weed biological control study areas superimposed.

Table 6. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Canada Thistle – Ice Lake Road I												
2000			9.00		66.83							
2001	976	39	7.48	40	91.80	143	47.38	0.52		-16.89	37.36	
2002	449	33	2.26	21	14.56	97	0.46	0.90	-54.00	-69.79	-84.14	
2003	80	49	2.61	14	33.02	107	6.78	0.25	-82.22	15.49	126.79	
2004	244	45	1.27	16	45.62	74	3.23	0.54	205.84	-51.34	38.16	
2005	244	30	3.67	17	49.04	82	7.30	0.39	0	188.97	7.50	-74.99
Canada Thistle – Ice Lake Road II												
2000	341	65	7.21	36	64.53	115						
2001	434	32	4.70	46		79			27.45	-34.81		
2002	214	27	1.74	18	16.12	124	3.85	0.21	-50.78	-62.97		
2003	46	18	2.28	16	39.72	100	10.33	0.27	-78.45	31.03	146.40	
2004	145	31	1.09	11	44.85	145	5.76	3.50	214.94	-52.19	12.92	
2005	114	24	5.21	17	79.69	110	25.91	2.05	-21.38	377.98	77.68	-66.57
Canada Thistle – Kettle Lake												
2003	1,153	72	6.03	110	62.35	132	9.32	0.38				
2004	1,165	52	6.90	23	50.53	87	9.06	0.94	1.07	14.43	-18.96	
2005	917	31	5.34	13	75.25	121	12.86	0.61	-21.27	-22.61	48.92	-20.47
Canada Thistle – Parade Loop												
2003	6	1	0.82	10	24.09	70						
2004	36	10	4.30	13	62.29	87	6.00	2.40	483.36	424.39	158.57	
2005	61	26	3.32	14	71.92	105	18.2	0.62	69.44	-22.79	15.46	916.67
Musk Thistle – Ice Lake Road I												
2000	1,016	129	7.76	82	58.87	171						

Table 6. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
2001	976	39	1.13	6	23.82	158	2.57	0.90	-3.95	-85.44	-59.54	
2002	449	7	2.00	6	63.66	111	9.00	2.18	-54.00	76.99	167.25	
2003												
2004	98	30	1.26	8	31.93	131	1.11	10.40	-78.17**	-37.00**	-49.84**	-90.33
2005	*(see Note)*											
						Leafy Spurge – Deadman's Trail						
2000	406	28	63.50	195	44.33	76						
2001	1,148	66	59.78	214	50.25	97			182.75	-5.86	13.35	
2002	1,145	117	40.51	196	33.66	89			-0.27	-32.23	-33.01	
2003	249	21	9.00	22	49.25	85			-78.24	-77.78	46.32	
2004	494	31	31.03	93	42.10	80			98.21	244.78	-14.52	
2005	780	30	42.10	169	45.96	70			57.89	35.68	9.17	92.11
						Leafy Spurge – Douglass School						
2000	187	30	16.62	56	36.96	62						
2001	290	93	29.11	103	53.32	82			55.43	75.15	44.26	
2002	380	72	3.33	60	12.24	66			31.03	-88.56	-77.04	
2003	67	5	2.40	3	65.00	80			-82.35	-27.93	431.05	
2004	52	10	11.60	23	50.25	62			-23.20	383.33	-22.69	
2005	81	36	11.05	39	46.62	65			55.77	-4.74	-7.22	-56.68
						Leafy Spurge – FERL						
2000	1,139		5.21		19.54							
2001	1,528	24	4.26	194	24.59	67			34.15	-18.23	25.84	
2002	796	66	11.29	66	19.85	49			-47.89	165.92	-19.28	
2003	329	28	11.54	51	40.54	85			-58.71	2.21	104.23	

Table 6. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
2004	2,145	103	7.31	88	31.85	54			551.95	-36.66	-21.44	
2005	196*	45	16.64	141	39.00	61			-90.86*	127.63	22.45	-82.79*
Diffuse Knapweed – Highway 83												
2003	606	61	1.58	3	49.17	97	46.31	0.07				
2004	2,601	41	2.02	12	47.93	108	88.28	2.60	329.06	27.85	-2.52	
2005	3,001	35	2.58	8	53.23	82	65.36	0.38	15.38	27.72	11.06	395.22
Diffuse/Spotted Knapweed – Water Treatment Plant												
2003	1,162	97	2.16	23	54.75	107	36.13	0.13				
2004	1,539	42	9.81	38	47.28	91	9.00	2.60	32.47	354.17	-13.64	
2005	2,118	32	5.22	22	56.89	100	49.43	0.42	37.62	-46.79	20.33	82.27
Spotted Knapweed – Monument Trail Road												
2003	484	20	1.50	7	27.09	115	23.02					
2004	1,937	32	3.00	17	69.57	112	48.24	4.00	300.26	100.00	153.12	
2005	2,074	39	7.94	25	93.65	148	49.17	0.60	7.07	164.67	34.61	328.51
Spotted Knapweed – New Monument Creek												
2004	700	44	3.36	23	28.96	90	35.07	1.70				
2005	629	35	2.94	16	74.22	111	51.19	0.42	-10.14	-12.50	156.28	-10.14
Spotted Knapweed – Non-potable Water Reservoir (NPWR)												
2003	124	29	0.97	5	24.43	100	9.62	0.61				
2004	491	31	1.35	13	44.25	78	26.33	2.70	295.03	39.18	81.13	
2005	234	30	4.37	29	49.48	89	18.39	0.61	-52.34	223.70	11.82	88.71
Spotted Knapweed – Old Monument Creek												
2000	622	35	9.00	25	37.30	80						
2001	948	45	9.52	68	39.70	98	133.15		52.36	5.78	6.43	

Table 6. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
2002	746	41	2.19	26	8.40	73	2.62	0.26	-21.32	-77.00	-78.84	
2003	236	44	1.50	9	27.09	93	23.02	0.28	-68.37	-31.51	222.50	-62.08
2004	*(see Note)*											
2005		49	0.30	14	33.00	39	0.50	2.00		-80.00**	21.82**	
Spotted Knapweed – Parade Loop I												
2003	1,437	65	0.81	4	34.18	130	7.10	0.39				
2004	921	43	3.58	13	45.07	97	7.51	3.00	-35.91	341.98	31.86	
2005	941	30	3.93	25	59.44	89	13.87	0.51	2.17	9.78	31.88	-34.52
Spotted Knapweed – Parade Loop II												
2004	578	33	0.79	3	34.15	118	118.11	2.90				
2005	282	28	3.24	13	57.71	88	9.59	0.31	-51.21	310.13	68.99	-51.21
Spotted Knapweed – Parade Loop III												
2004	1,412	41	1.53	11	21.37	73	11.68	2.60				
2005	106*	22	2.68	14	76.17	117	18.00	0.59	-92.49*	75.16	256.43	-92.49*
St. Johnswort – Kettle Creek												
2004	1,254	90	30.94	85	53.92	85						
2005	224	33	20.00	53	68.18	94			-82.14	-35.36	26.45	-82.14
St. Johnswort – Midway Kettle Creek												
2004	196	19	28.63	60	54.95	70						
2005	678	40	23.88	73	69.72	93			245.92	-16.59	26.88	245.92
St. Johnswort – Santa Fe												
2004	266	24	33.96	96	46.75	73						

Table 6. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
2005	420	40	35.35	130	71.41	85			57.89	4.09	52.75	57.89
Yellow Toadflax – Community Center Drive I												
2003	52	4	9.25	15	26.25	40						
2004	30	18	19.61	57	21.00	44			-42.21	112.00	-20.00	
2005	100	32	19.11	65	27.45	46	0		233.33	-2.55	30.71	92.31
Yellow Toadflax – Community Center Drive II												
2003	96	8	8.63	34	29.88	95						
2004	112	34	6.44	47	9.18	44			16.82	-25.38	-6 9.28	
2005	59	23	11.00	40	23.25	60	0	1.31	-47.32	70.81	153.27	-38.54
Yellow Toadflax – Community Center Drive III												
2005	21	10	12.90	28	44.77	57	0		na	na	na	na

n – number of samples or observations
na – not applicable, data represent first year of sampling
* - a complete weed 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 actually reflect 2-year changes, as sampling was not done at all sites all years
Note: Could not map a perimeter, as the few remaining plants at this site were scattered

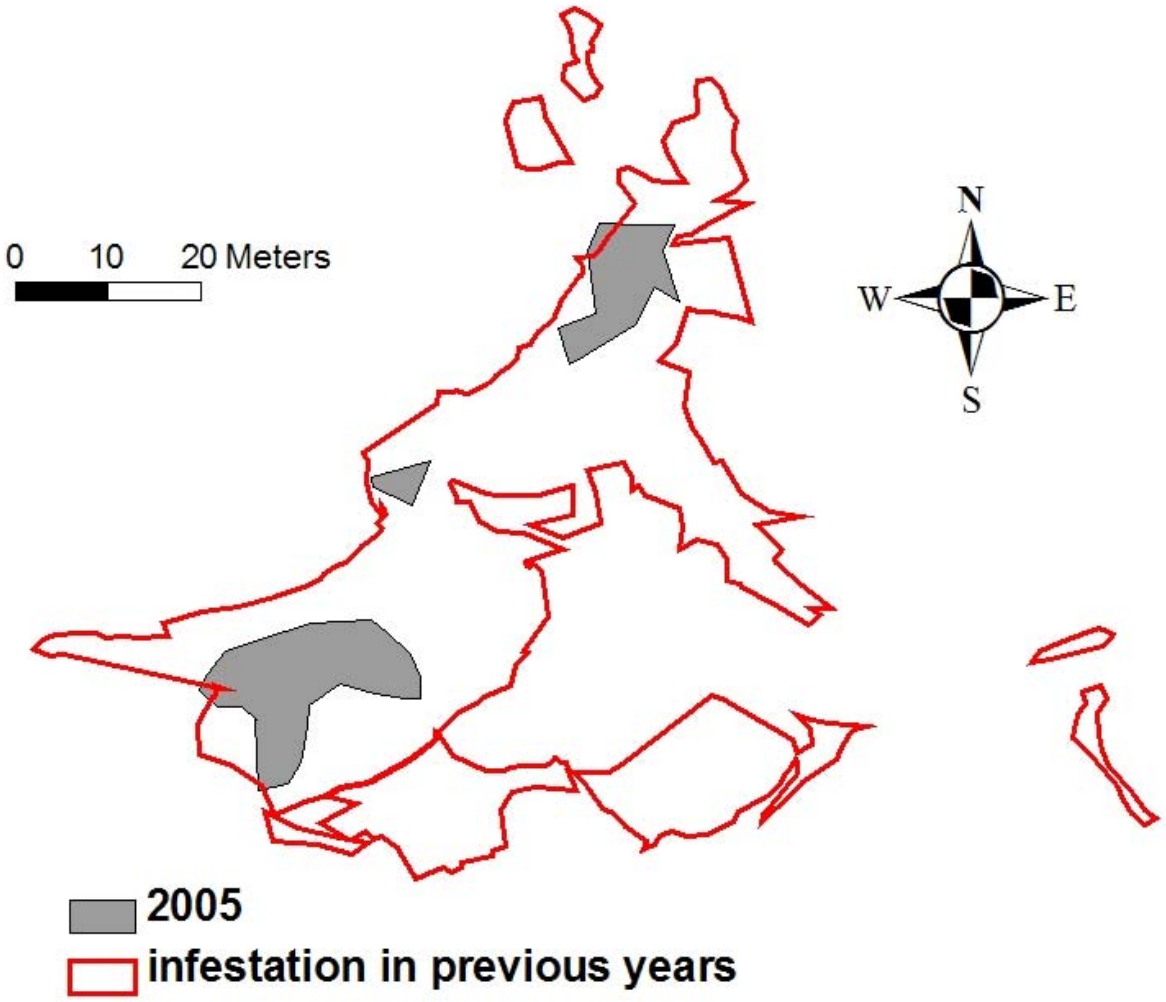
Table 7. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2005.

Release Location	Target Weed	Release Site	Species released	Species recovered	New releases	New site
Air Force Academy	Canada & musk thistle	Ice Lake Road I	*Trichosirocalus horridus*	X		
Air Force Academy	Canada thistle	Ice Lake Road I	*Urophora cardui*			
Air Force Academy	Canada thistle	Ice Lake Road II	*Cassida rubiginosa*	X		
Air Force Academy	Canada thistle	Ice Lake Road II	*Larinus planus*	X		
Air Force Academy	Canada thistle	Ice Lake Road II	*Urophora cardui*			
Air Force Academy	Canada thistle	Kettle Lake	*Cassida rubiginosa*			
Air Force Academy	Canada thistle	Kettle Lake	*Ceutorhynchus litura*		X	
Air Force Academy	Canada thistle	Parade Loop	*Urophora cardui*			
Air Force Academy	Field bindweed	FERL	*Aceria malherbae*			
Air Force Academy	Leafy spurge	Deadman's Trail	*Aphthona czwalinae*	X		
Air Force Academy	Leafy spurge	Deadman's Trail	*Aphthona lacertosa*	X		
Air Force Academy	Leafy spurge	Deadman's Trail	*Aphthona nigriscutis*	X		
Air Force Academy	Leafy spurge	Douglas School	*Aphthona czwalinae*	X		
Air Force Academy	Leafy spurge	Douglas School	*Aphthona lacertosa*	X		
Air Force Academy	Leafy spurge	Douglas School	*Aphthona nigriscutis*	X		
Air Force Academy	Leafy spurge	FERL	*Aphthona cyparissiae*	X	X	
Air Force Academy	Leafy spurge	FERL	*Aphthona czwalinae*		X	
Air Force Academy	Leafy spurge	FERL	*Aphthona lacertosa*	X	X	
Air Force Academy	Leafy spurge	FERL	*Aphthona nigriscutis*	X	X	
Air Force Academy	Leafy spurge	FERL North	*Aphthona cyparissiae*		X	X [1]
Air Force Academy	Leafy spurge	FERL North	*Aphthona czwalinae*		X	X [1]
Air Force Academy	Leafy spurge	FERL North	*Aphthona lacertosa*		X	X [1]
Air Force Academy	Leafy spurge	FERL North	*Aphthona nigriscutis*		X	X [1]
Air Force Academy	Diffuse knapweed	Highway 83	*Cyphocleonus achates*			
Air Force Academy	Spotted knapweed	Deadman's Creek	*Larinus minutus*			

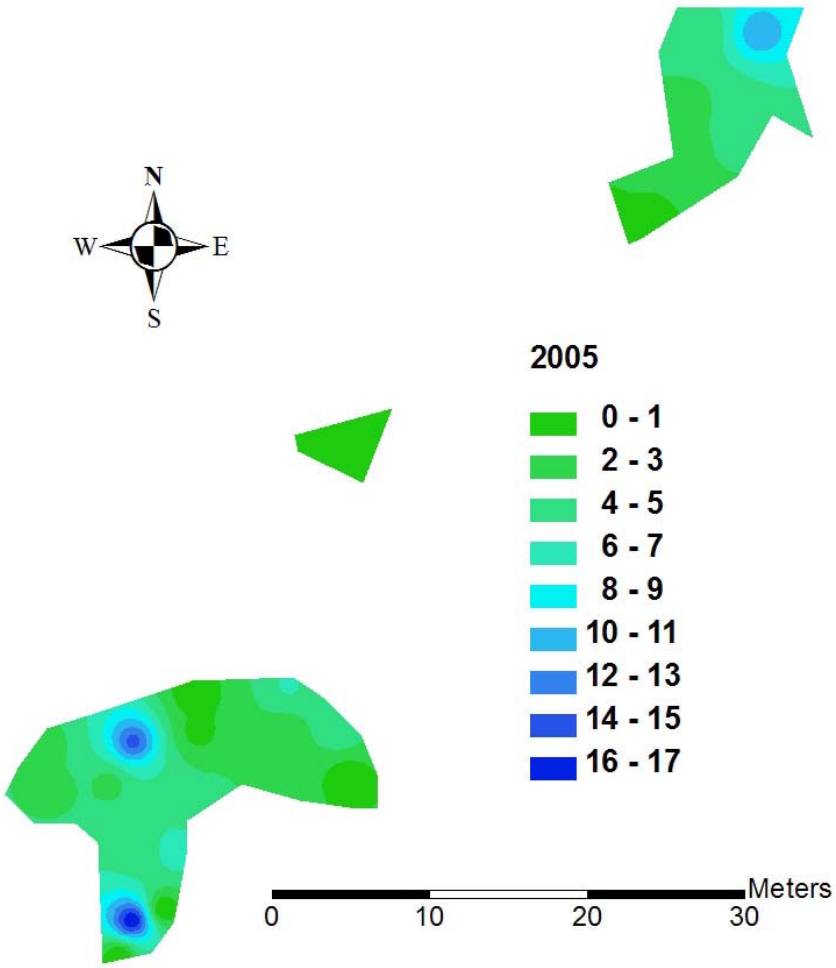
Table 7. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, Colorado, 2005.

Release Location	Target Weed	Release Site	Species released	Species recovered	New releases	New site
Air Force Academy	Spotted knapweed	Monument Trail Road	*Cyphocleonus achates*			
Air Force Academy	Spotted knapweed	Monument Trail Road	*Larinus minutus*	X [2]		
Air Force Academy	Spotted knapweed	New Monument Creek	*Cyphocleonus achates*			
Air Force Academy	Spotted knapweed	New Monument Creek	*Larinus minutus*	X		
Air Force Academy	Spotted knapweed	NPWR	*Larinus minutus*			
Air Force Academy	Spotted knapweed	NPWR	*Urophora affinis*	X [3]		
Air Force Academy	Spotted knapweed	Old Monument Creek	*Cyphocleonus achates*	X		
Air Force Academy	Spotted knapweed	Old Monument Creek	*Larinus minutus*	X		
Air Force Academy	Spotted knapweed	Old Monument Creek	*Metzneria paucipunctella*			
Air Force Academy	Spotted knapweed	Parade Loop I				
Air Force Academy	Spotted knapweed	Parade Loop II				
Air Force Academy	Spotted knapweed	Parade Loop III				
Air Force Academy	Diffuse & spotted knapweed	Water Treatment Plant	*Cyphocleonus achates*	X [2]		
Air Force Academy	Diffuse & spotted knapweed	Water Treatment Plant	*Larinus minutus*	X		
Air Force Academy	St. Johnswort	Kettle Creek	*Chrysolina sp.*	X [4]		
Air Force Academy	St. Johnswort	Midway Kettle Creek	*Chrysolina sp.*	X [4]		
Air Force Academy	St. Johnswort	Santa Fe	*Chrysolina sp.*	X [4]		
Air Force Academy	Yellow toadflax	Comm Center Drive I	*Mecinus janthinus*	X		
Air Force Academy	Yellow toadflax	Comm Center Drive II	*Mecinus janthinus*			
Air Force Academy	Yellow toadflax	Comm Center Drive III				X

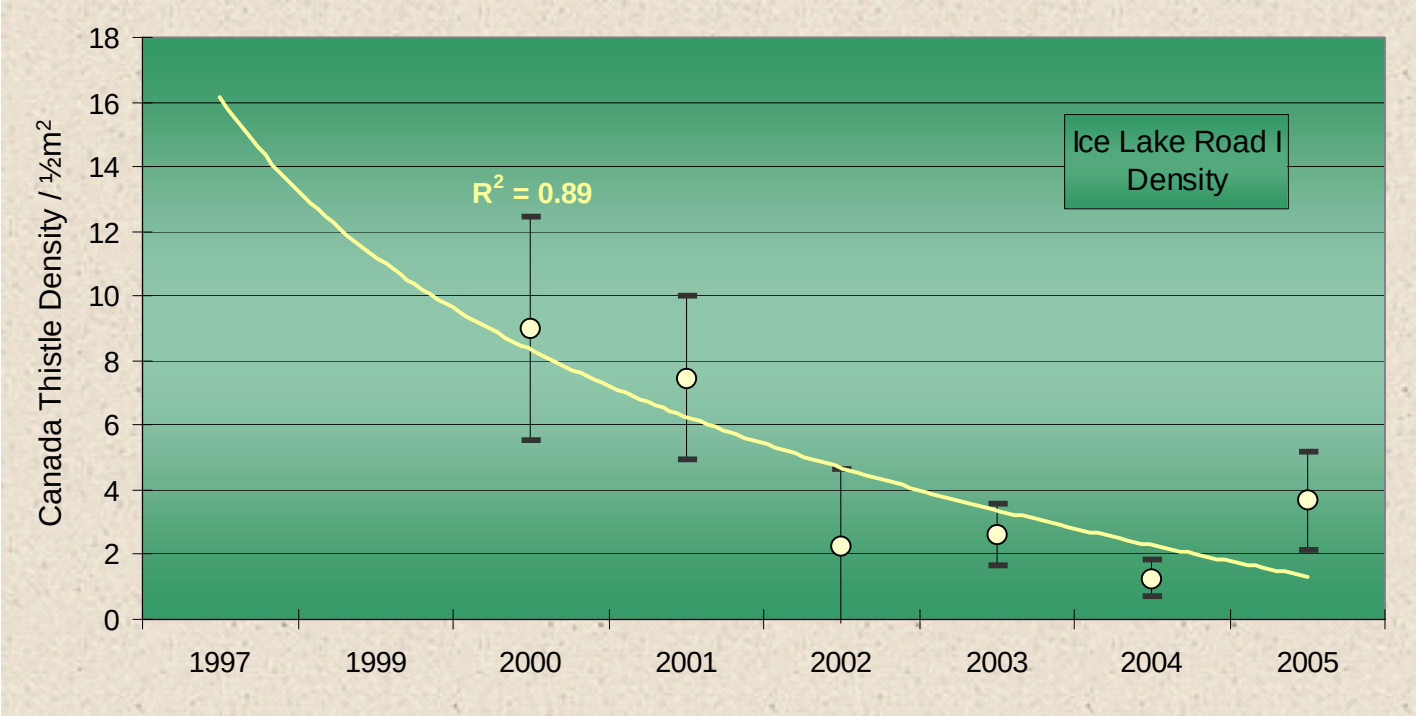
[1] Area not mapped, release only
[2] New insect recovery in 2005
[3] Adventitious recovery, no release made at this site
[4] Releases made on St. Johnswort nearby in previous years, area newly mapped in 2004

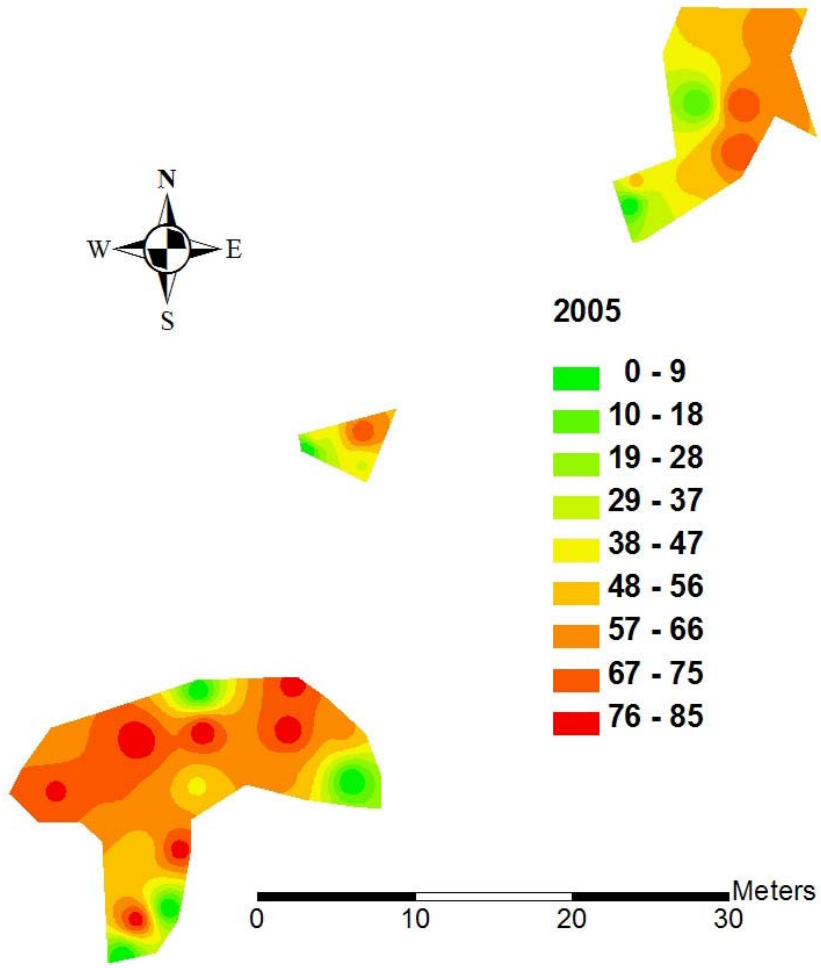


Ice Lake I Canada thistle perimeter in 2005.

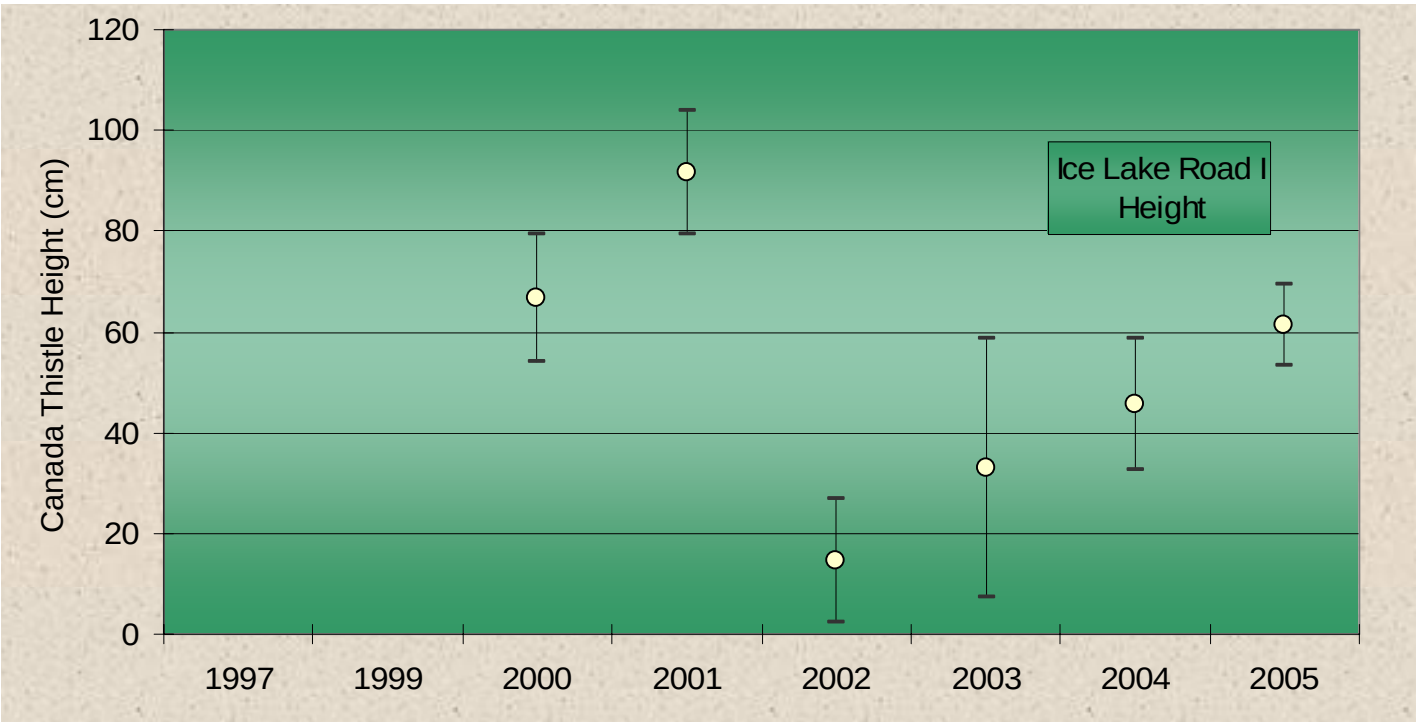


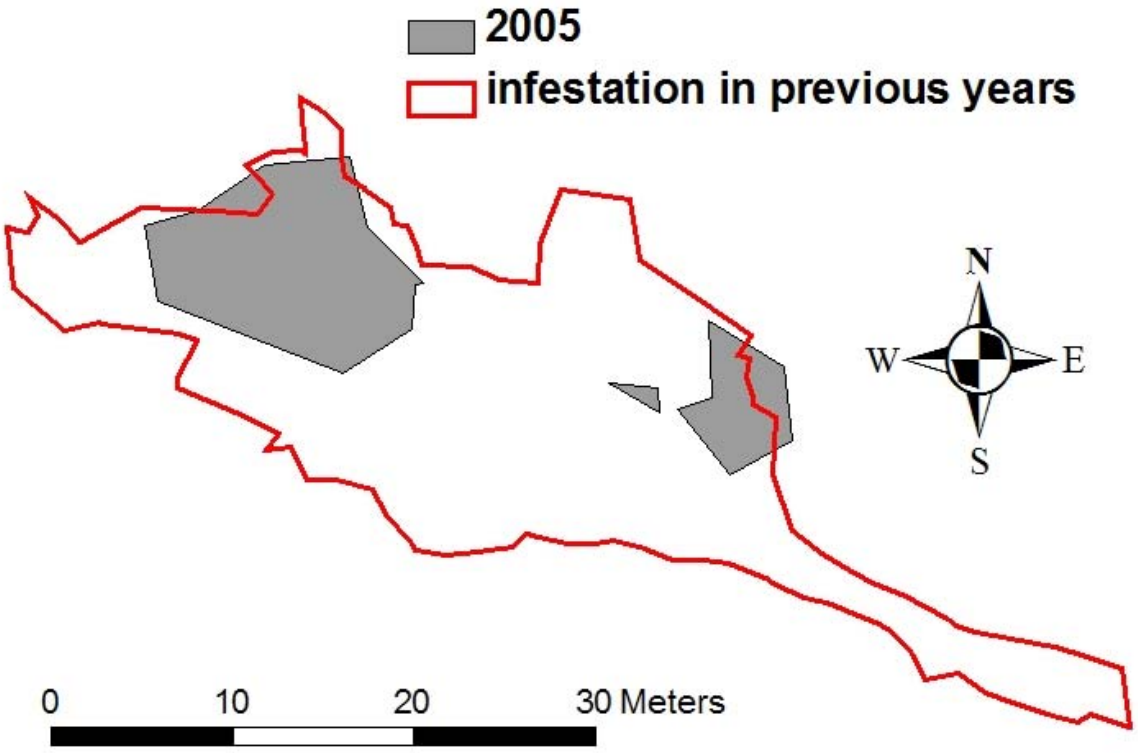
Ice Lake I Canada thistle density in 2005.



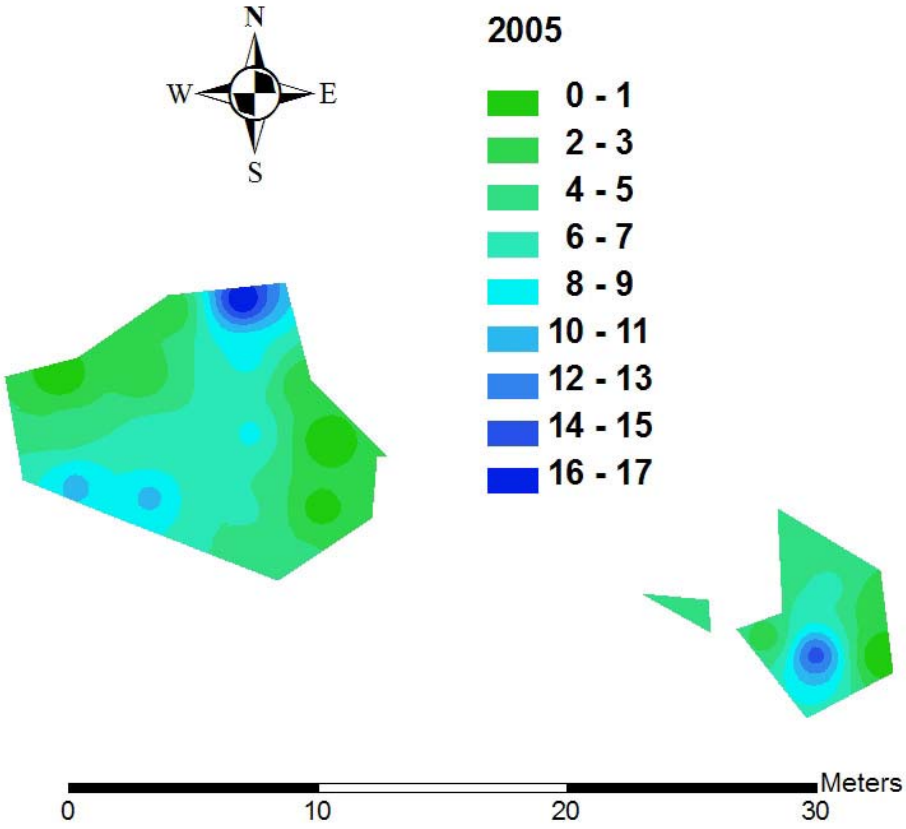


Ice Lake I Canada thistle height in 2005.

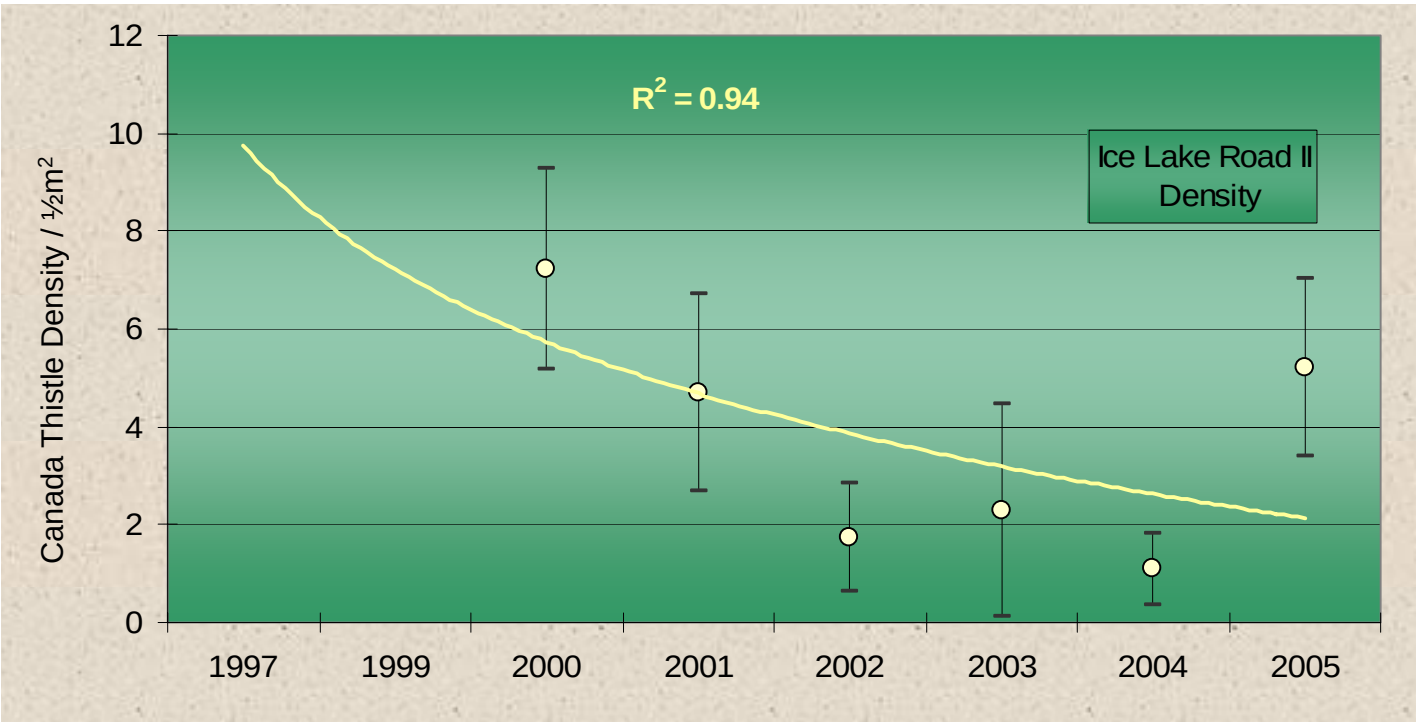


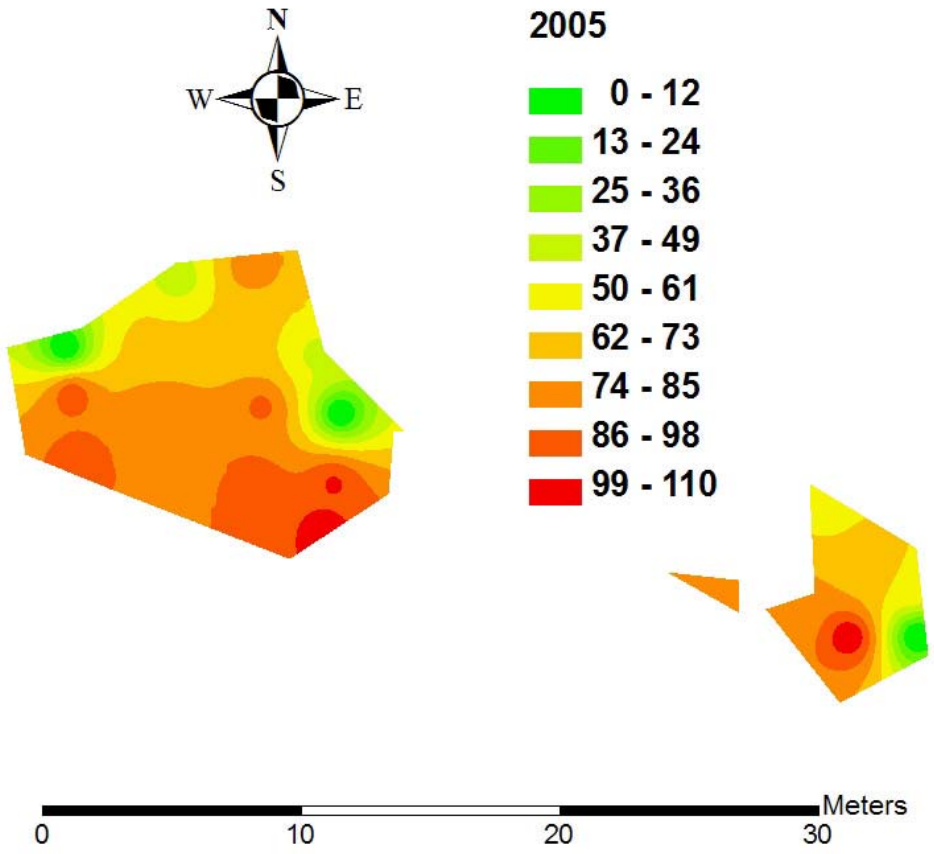


Ice Lake II Canada thistle perimeter in 2005.

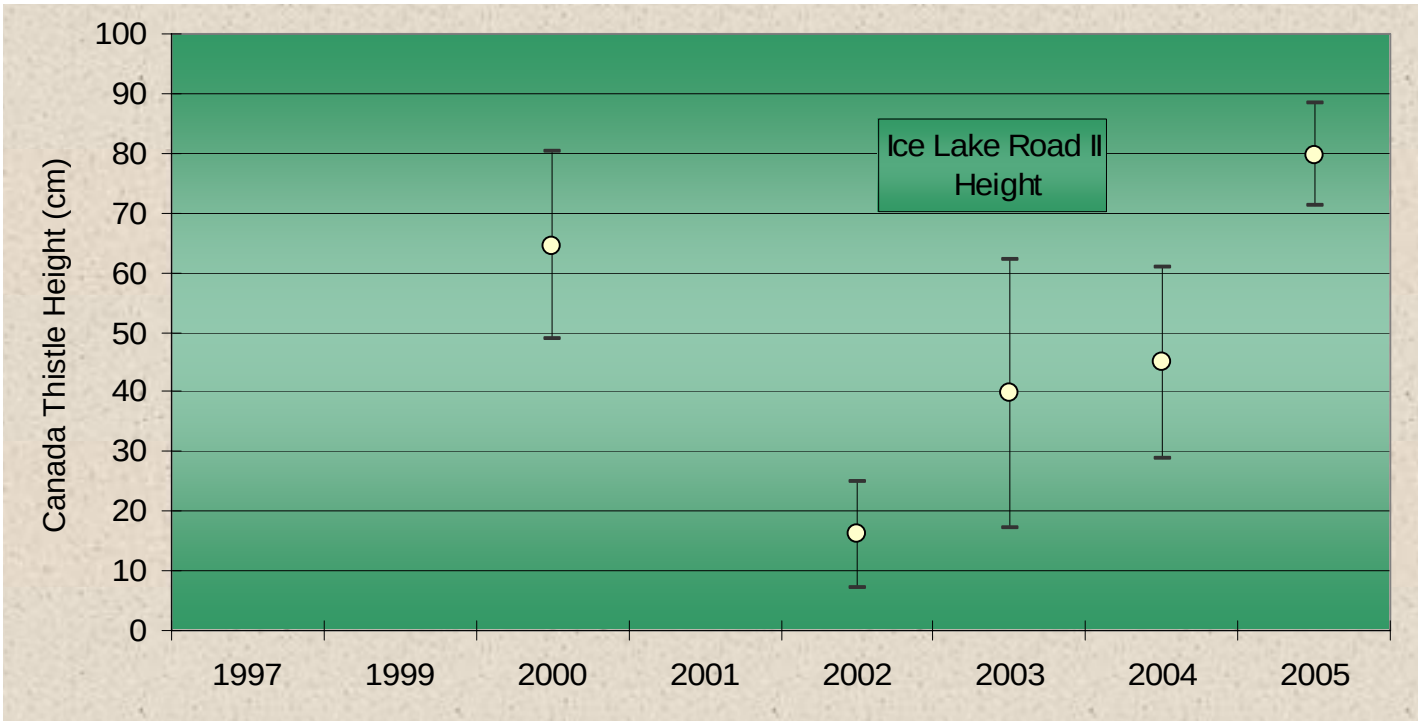


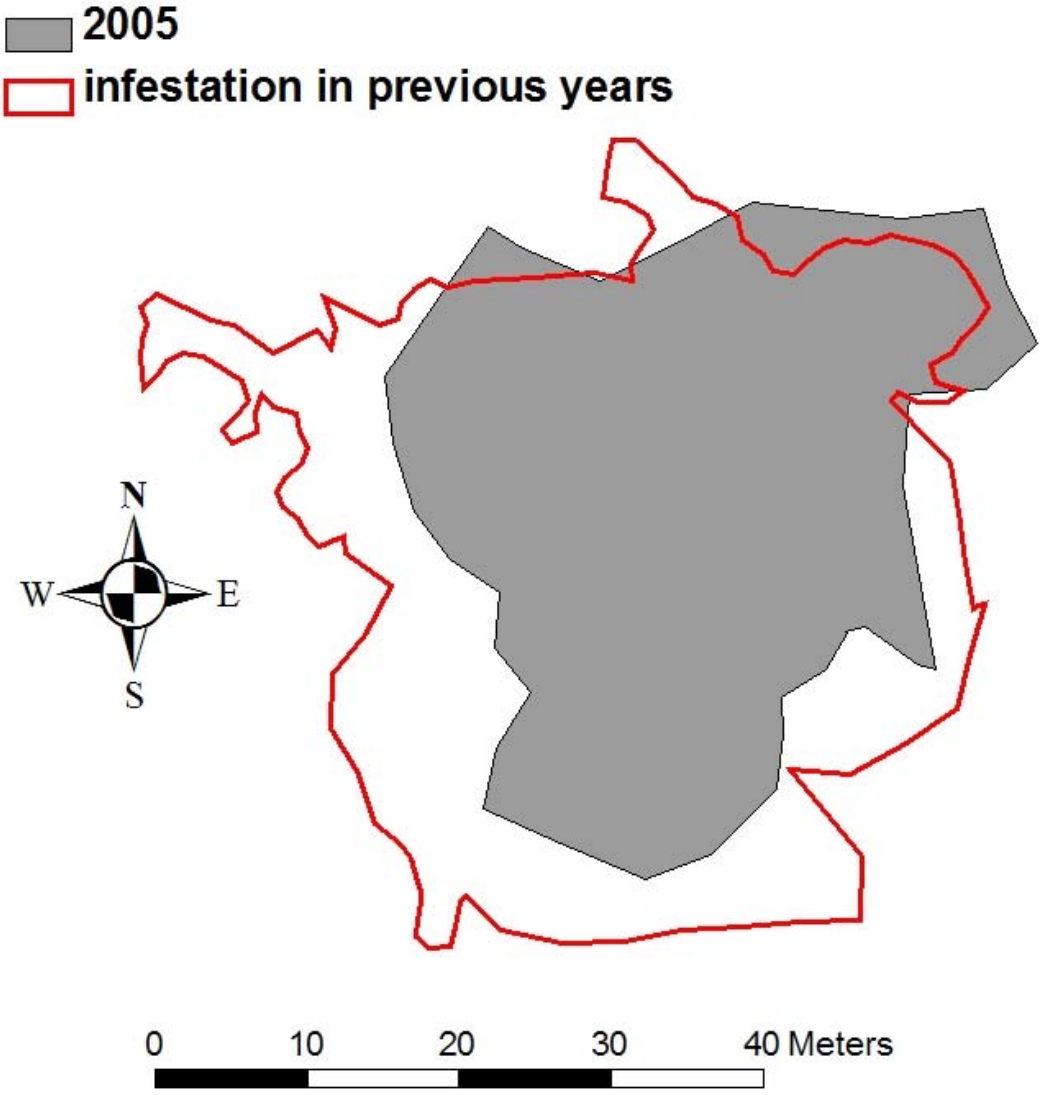
Ice Lake II Canada thistle density in 2005.



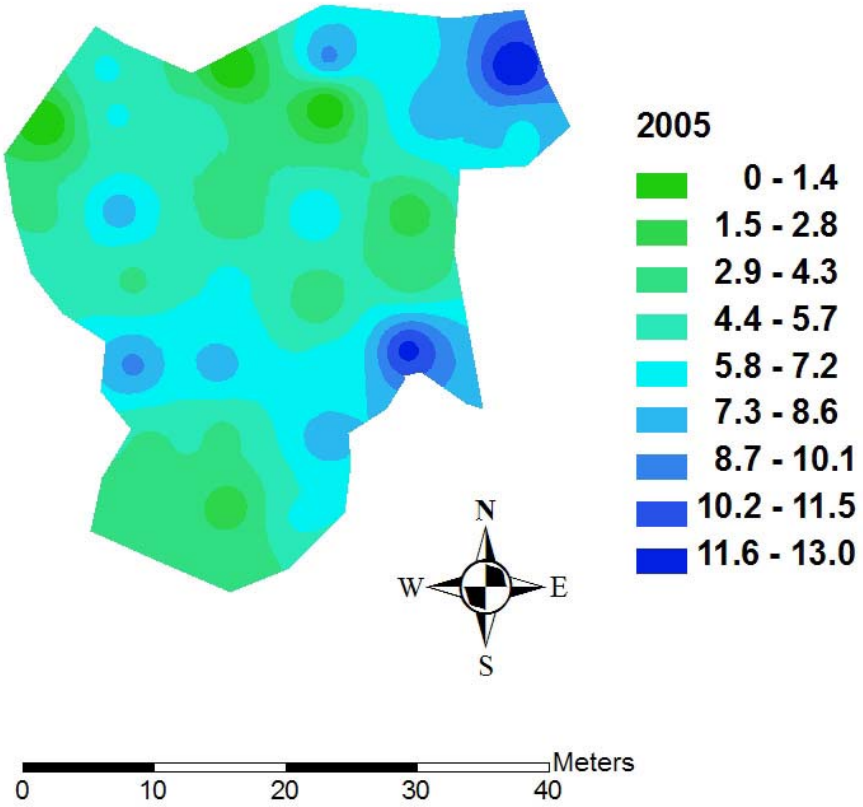


Ice Lake II Canada thistle height in 2005.

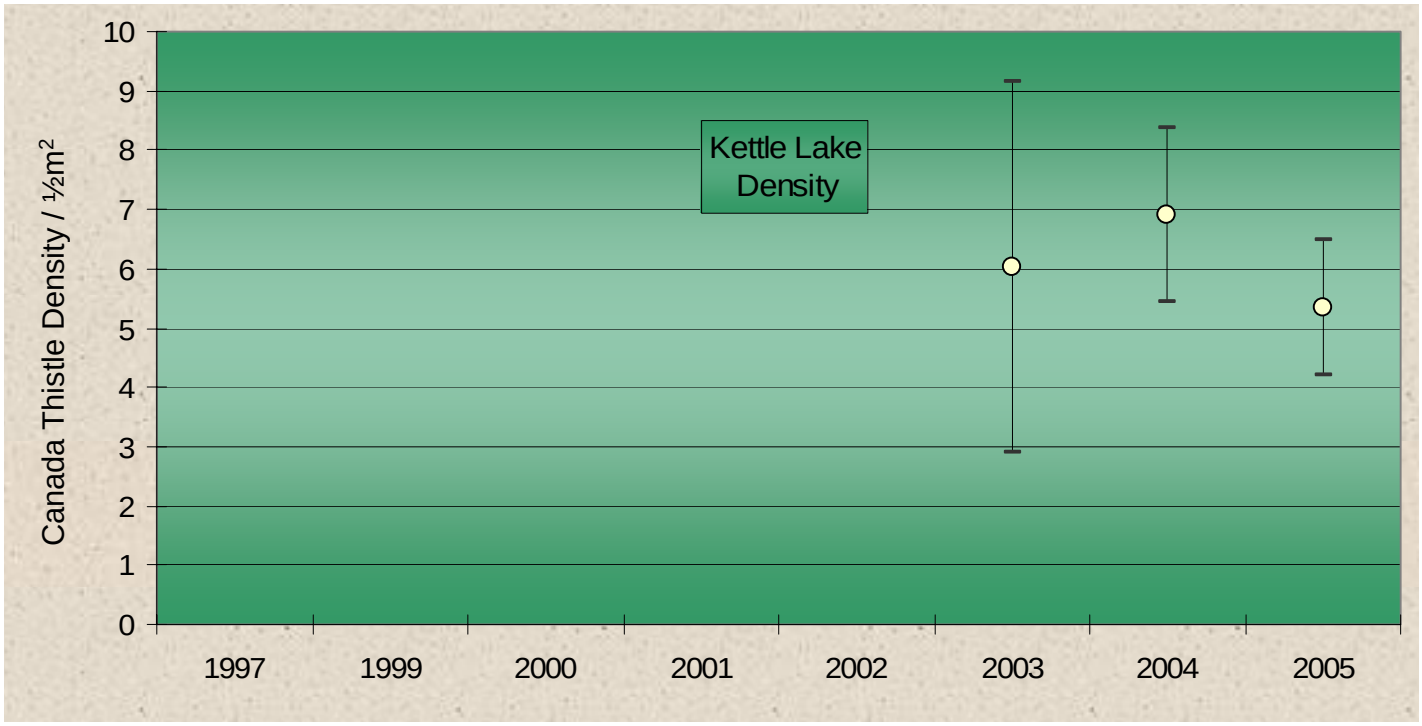


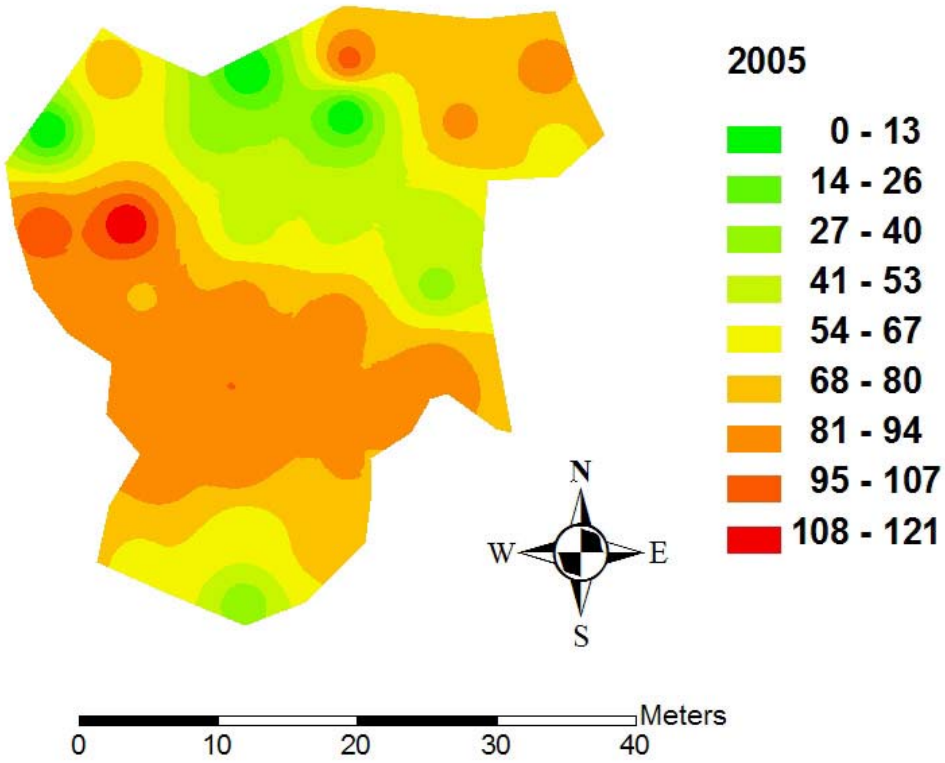


Kettle Lake Canada thistle perimeter in 2005.

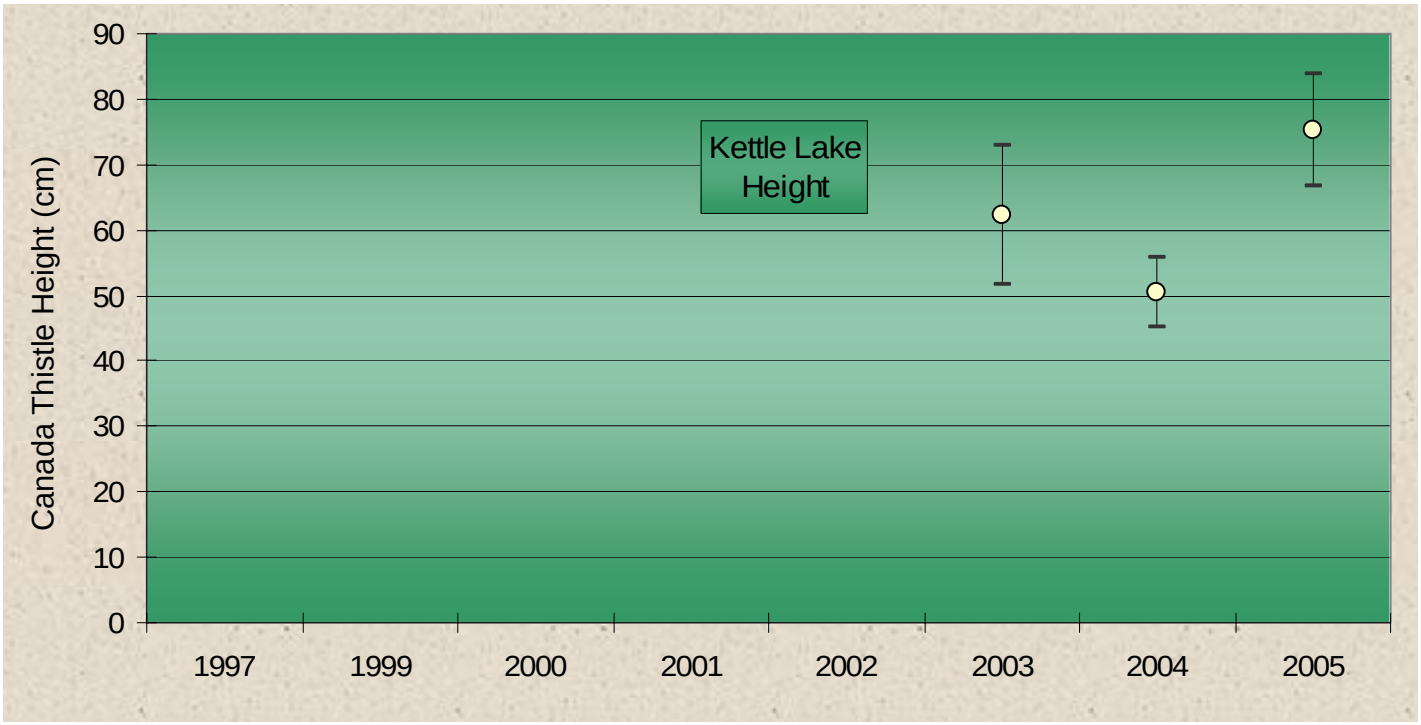


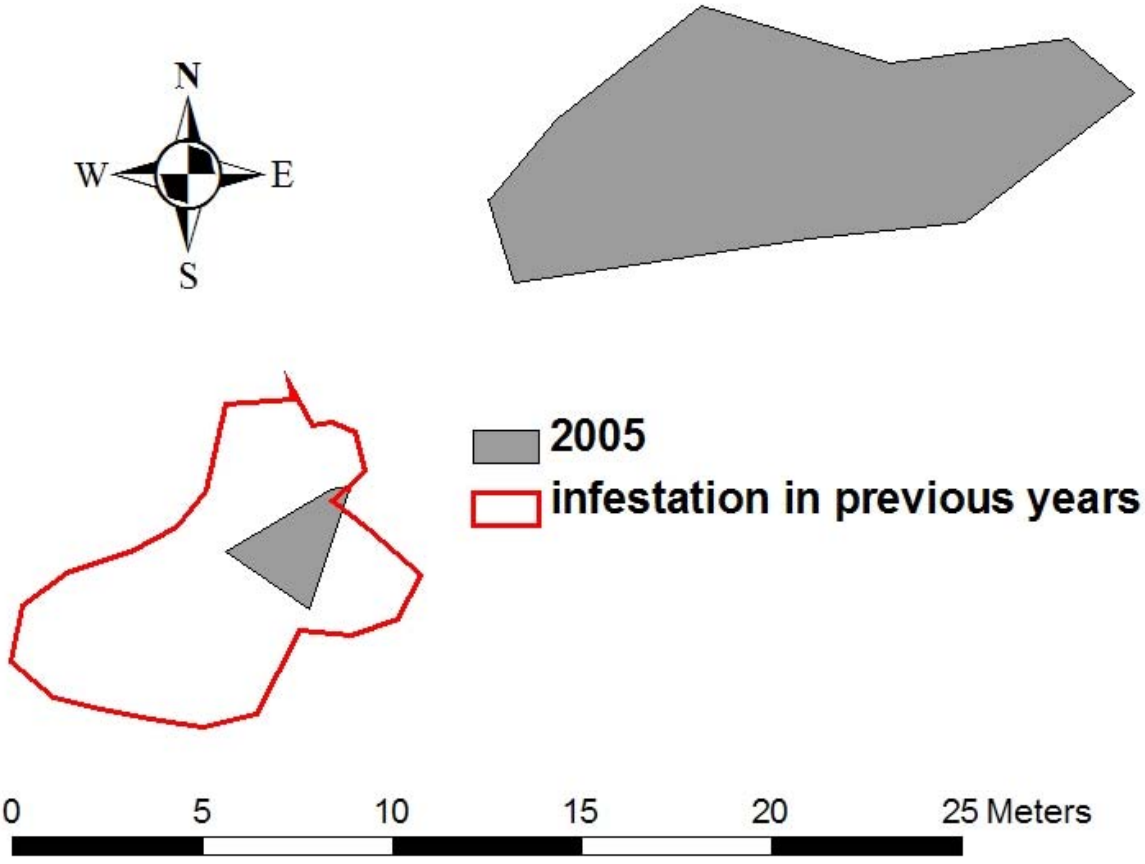
Kettle Lake Canada thistle density in 2005.



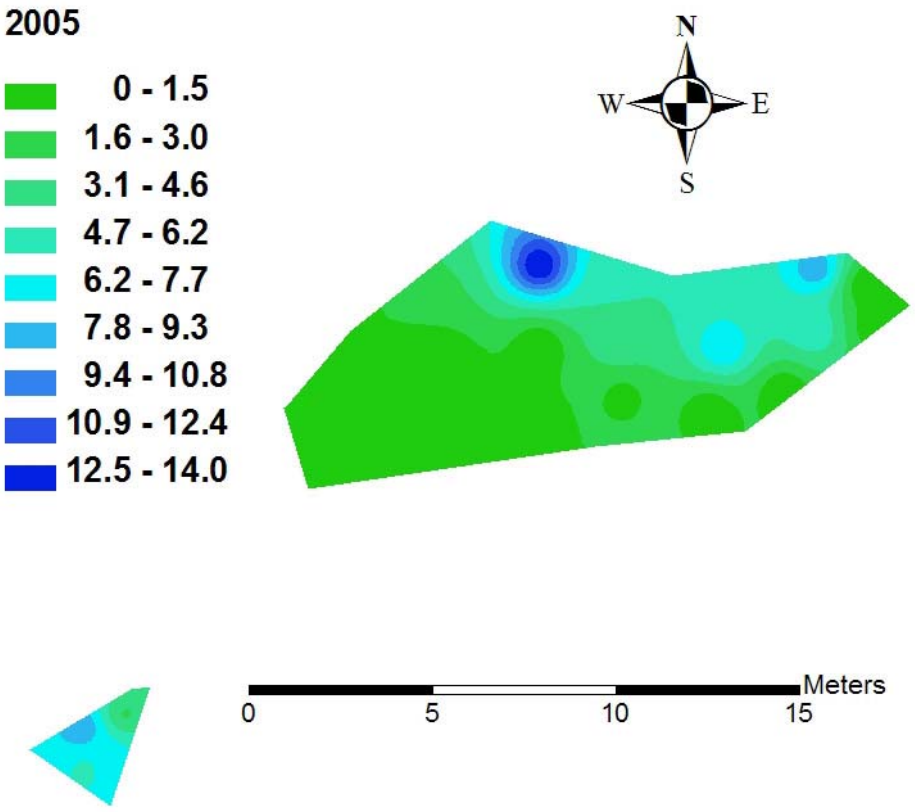


Kettle Lake Canada thistle height in 2005.

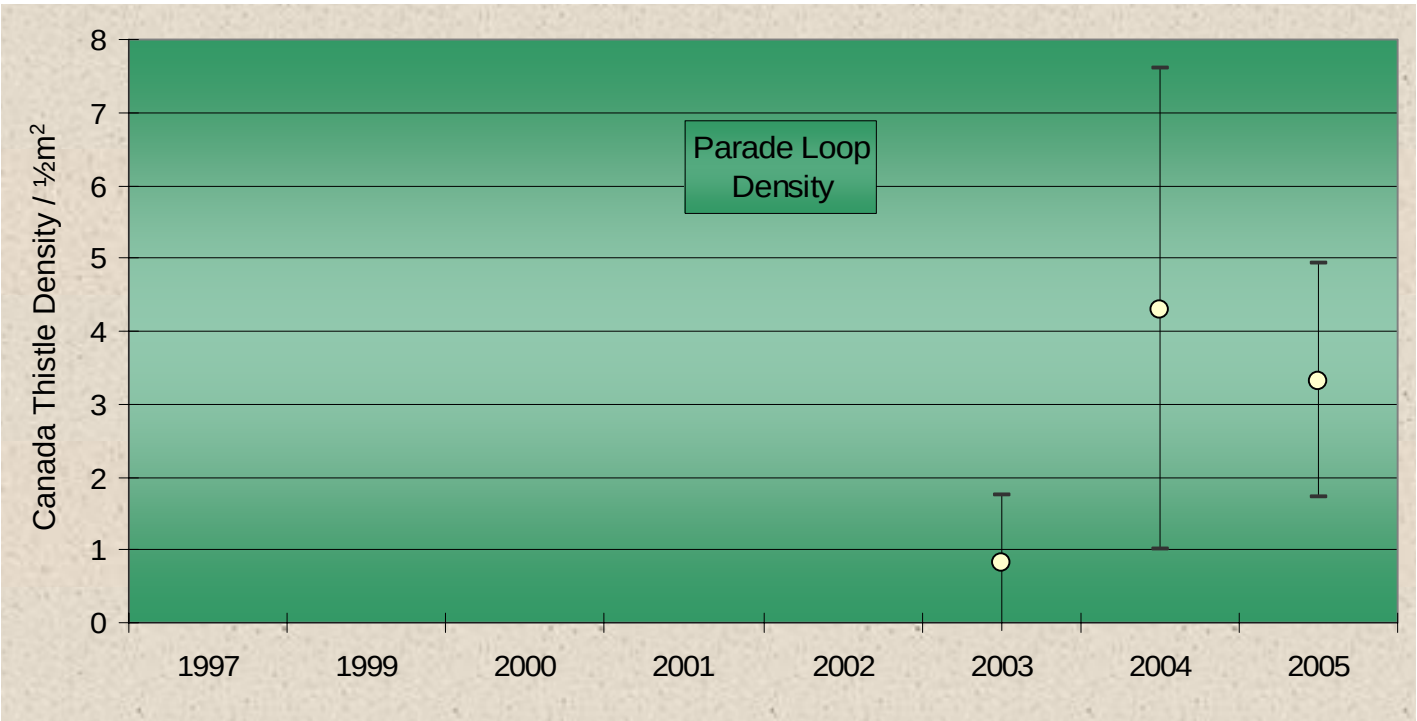


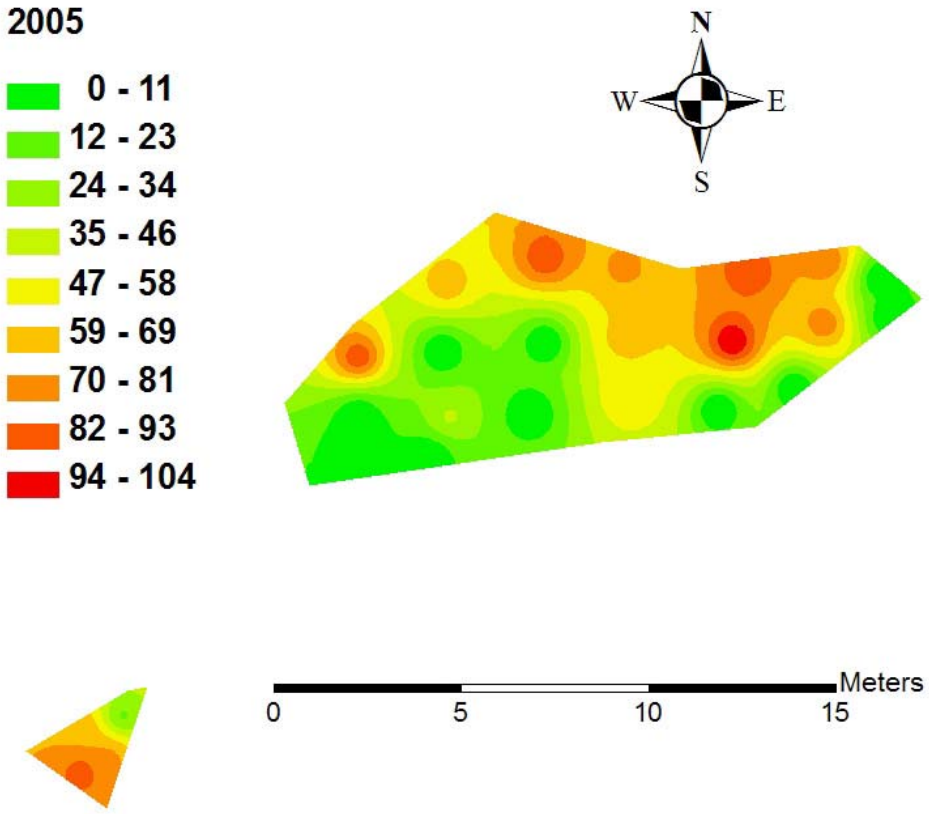


Parade Loop Canada thistle perimeter in 2005.

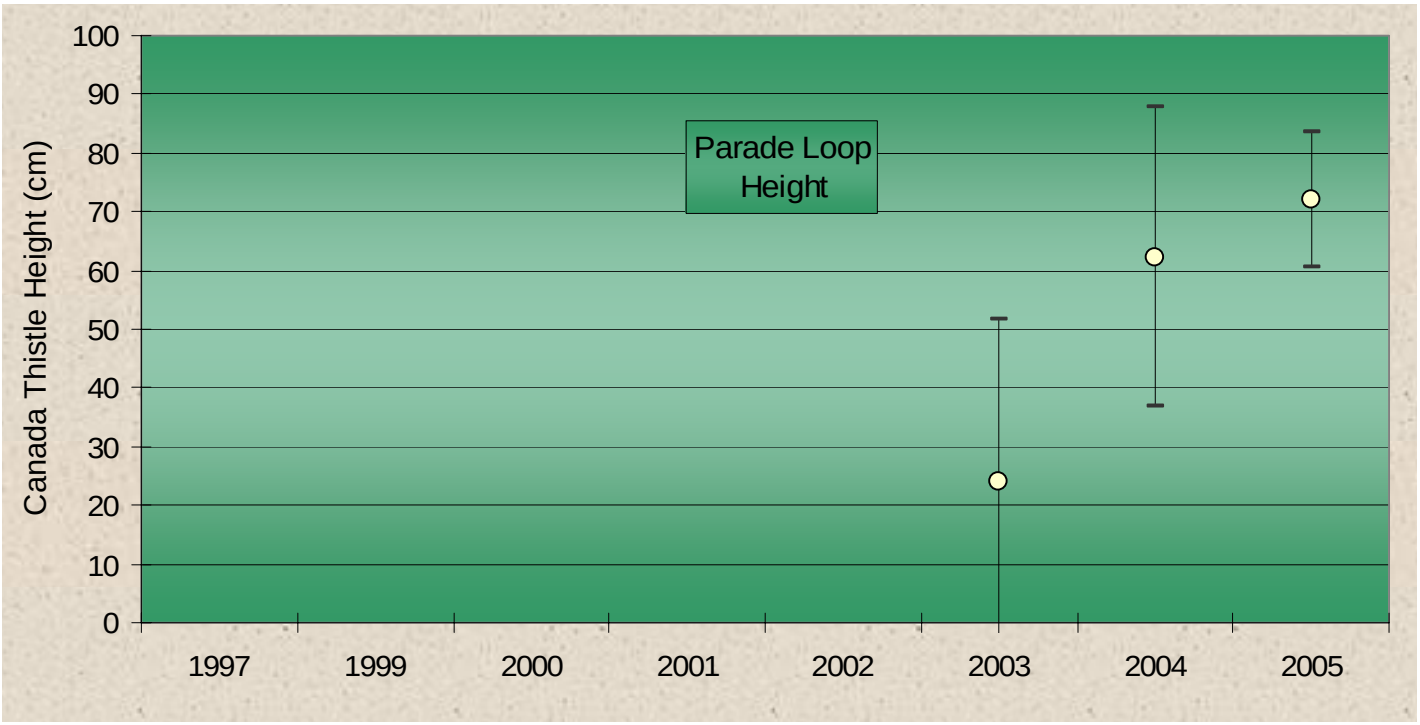


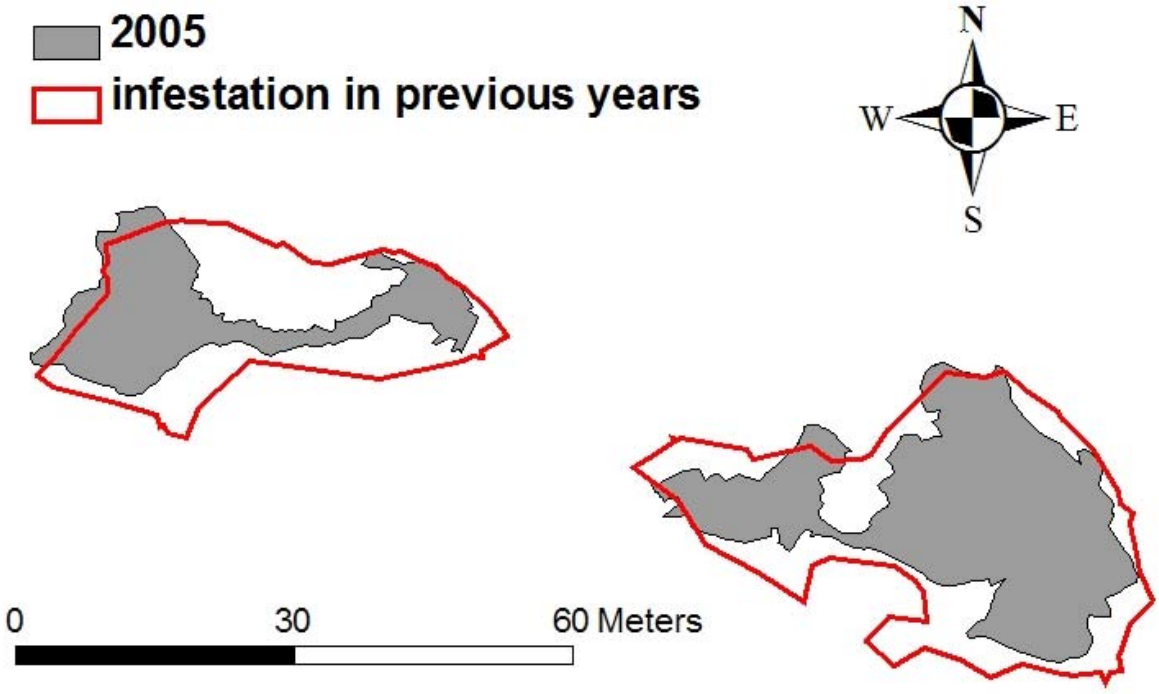
Parade Loop Canada thistle density in 2005.



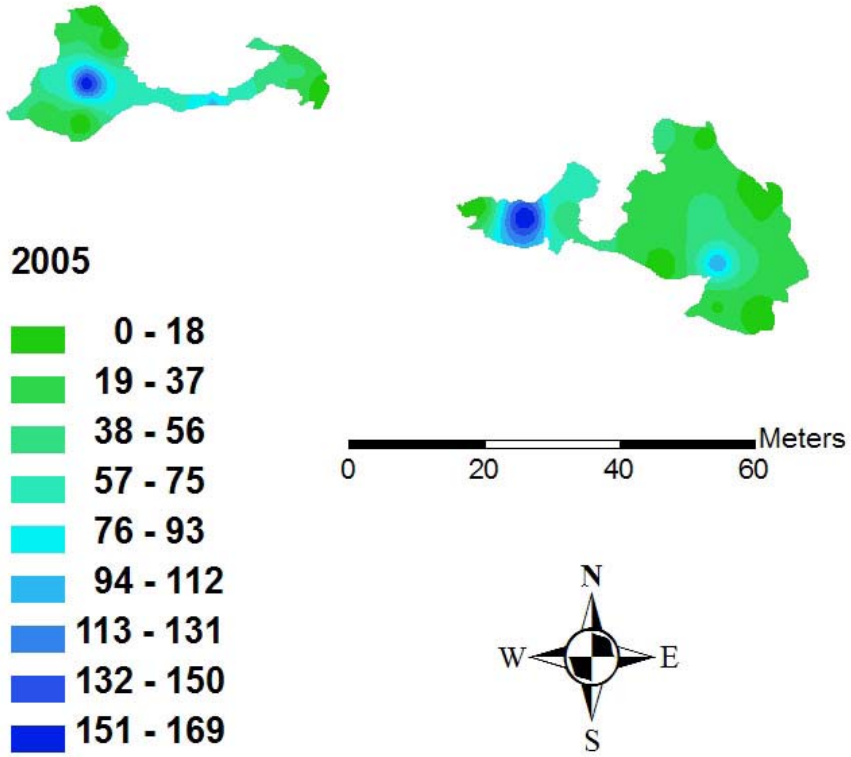


Parade Loop Canada thistle height in 2005.

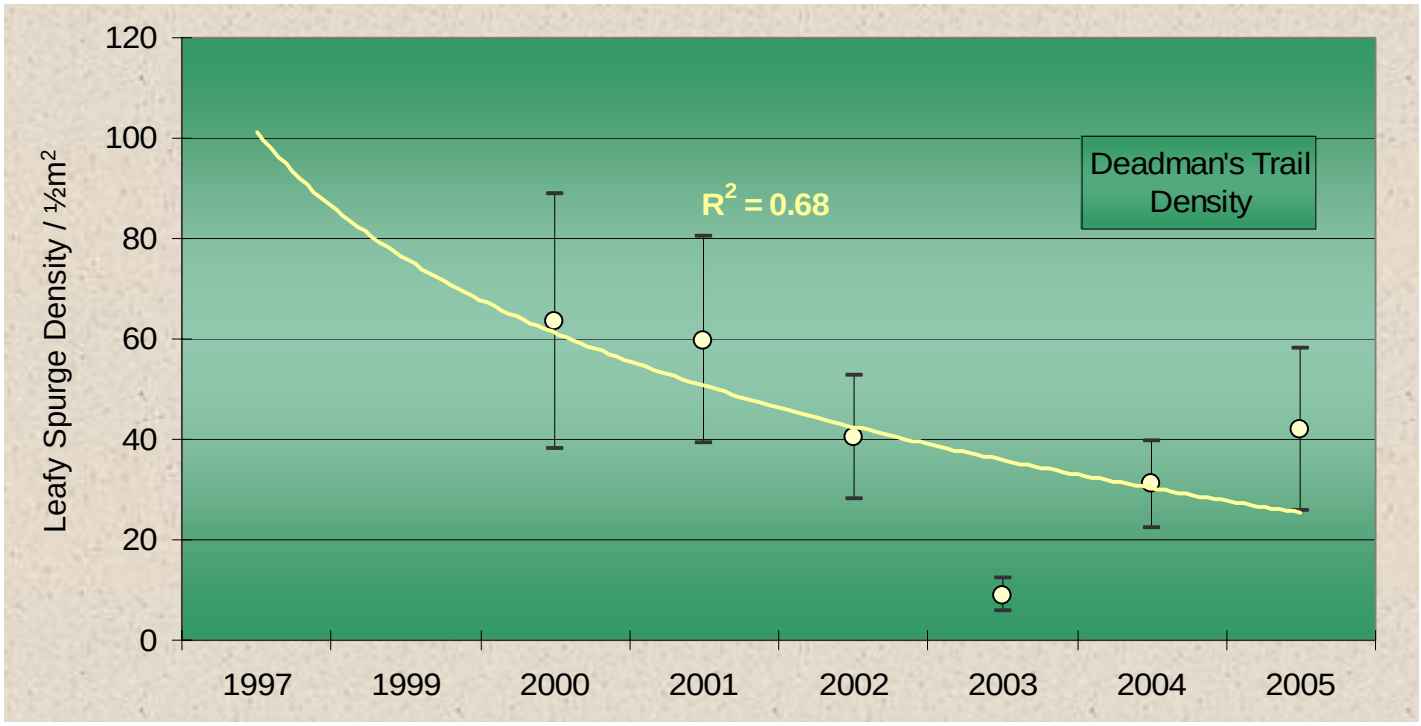


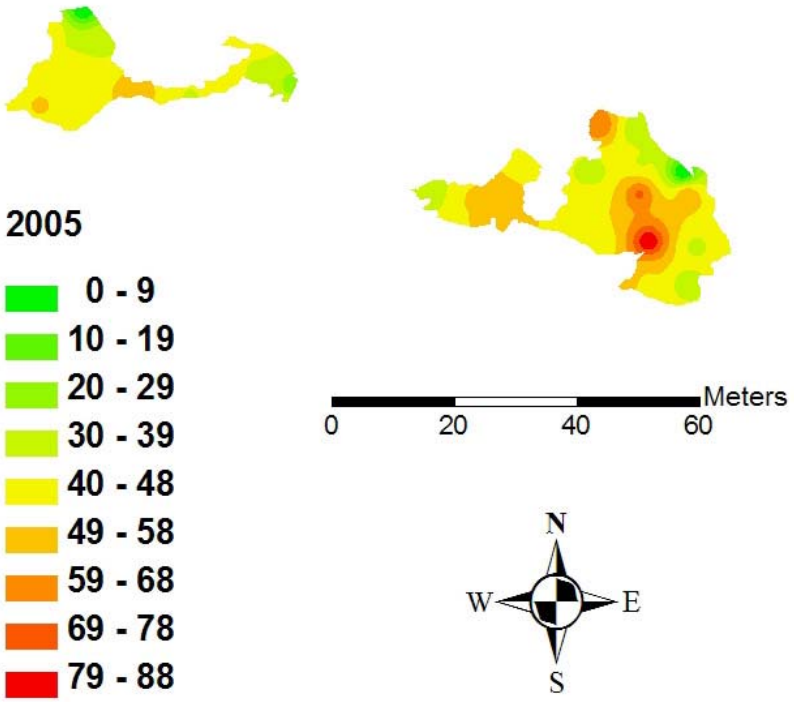


Deadman's Trail leafy spurge perimeter in 2005.

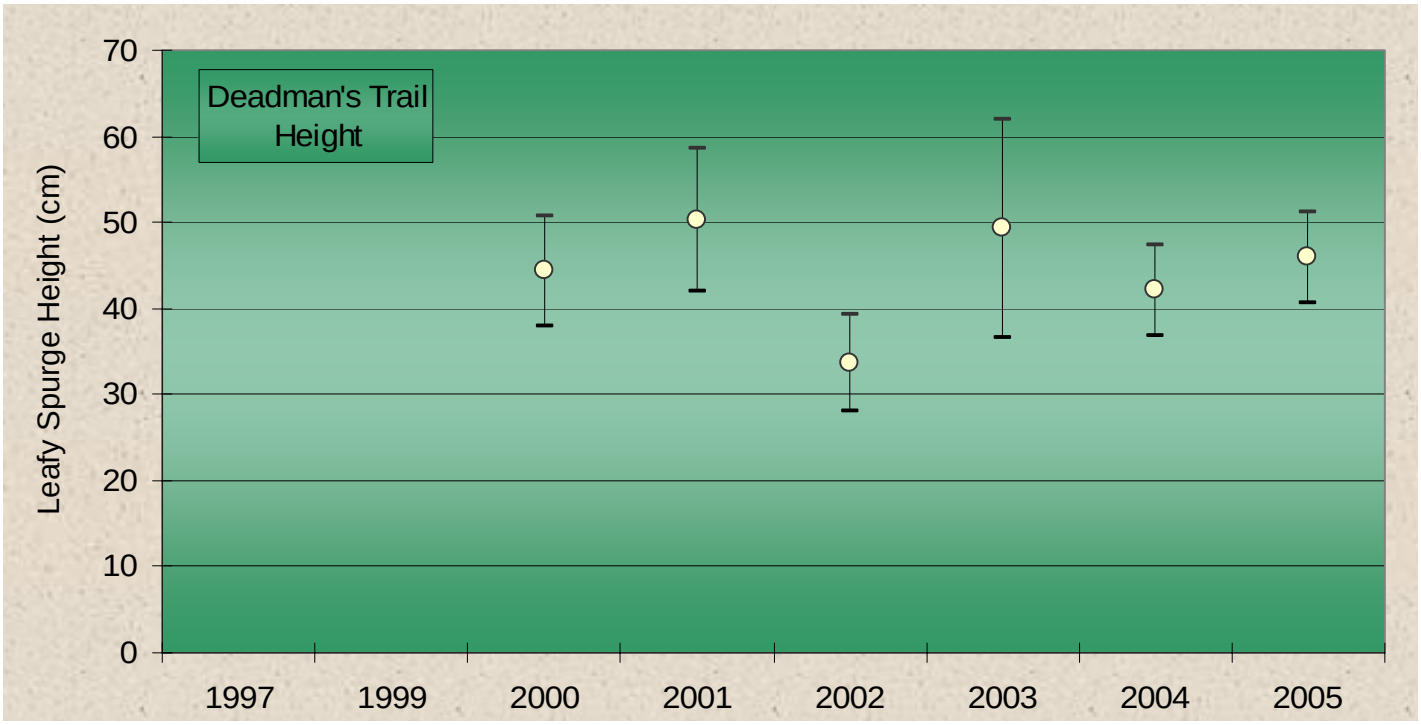


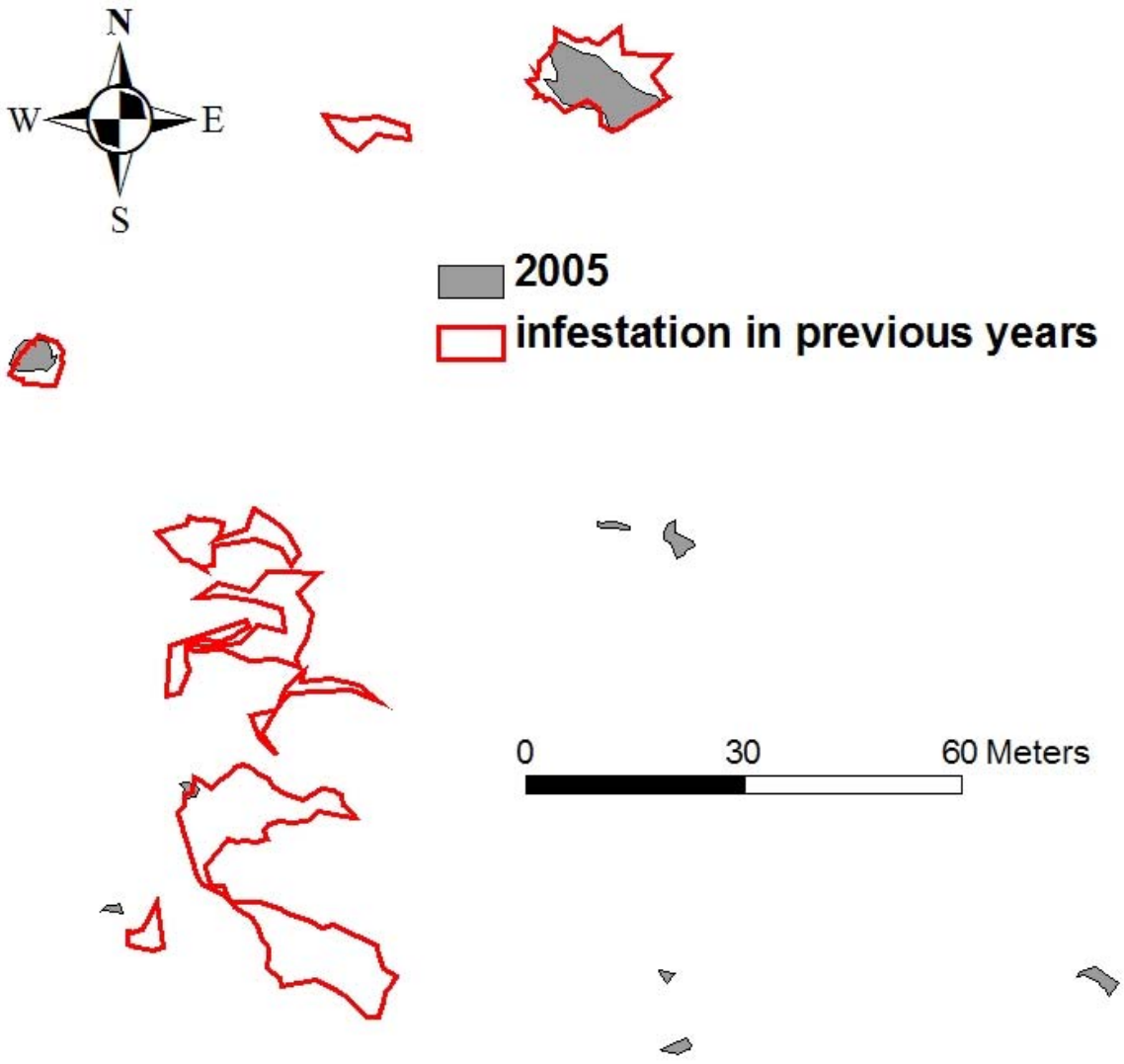
Deadman's Trail leafy spurge density in 2005.



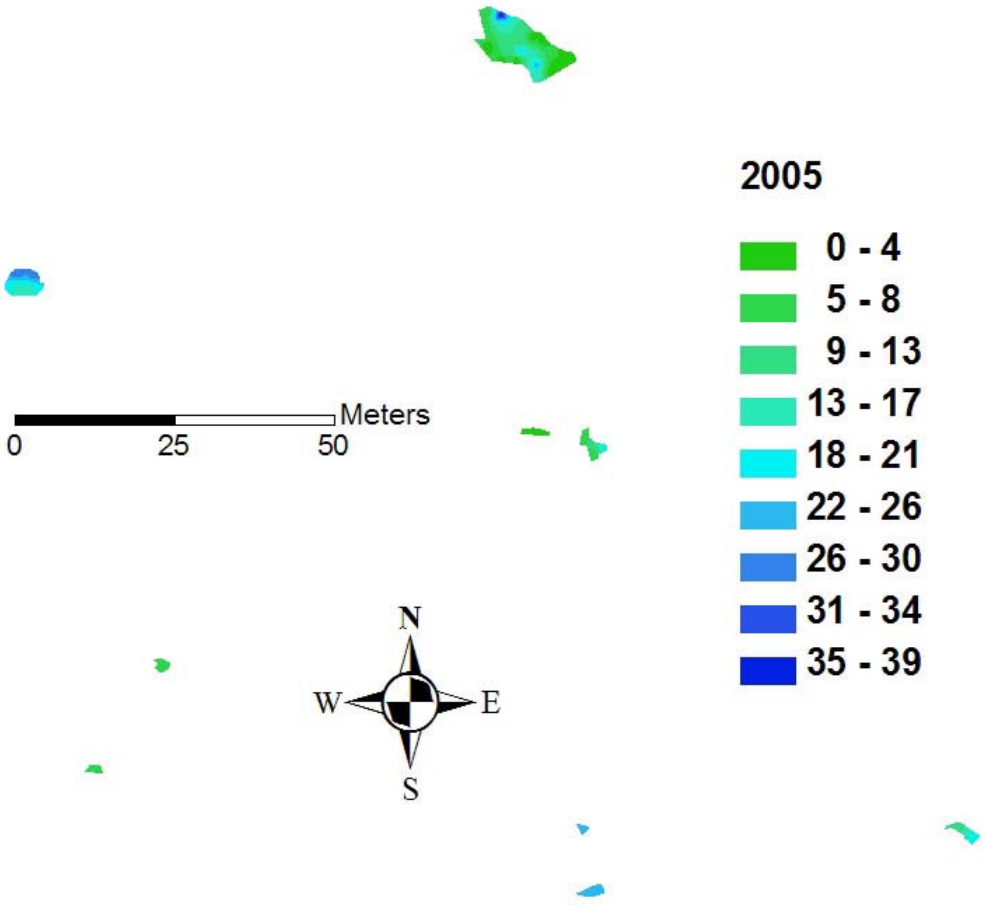


Deadman's Trail leafy spurge height in 2005.

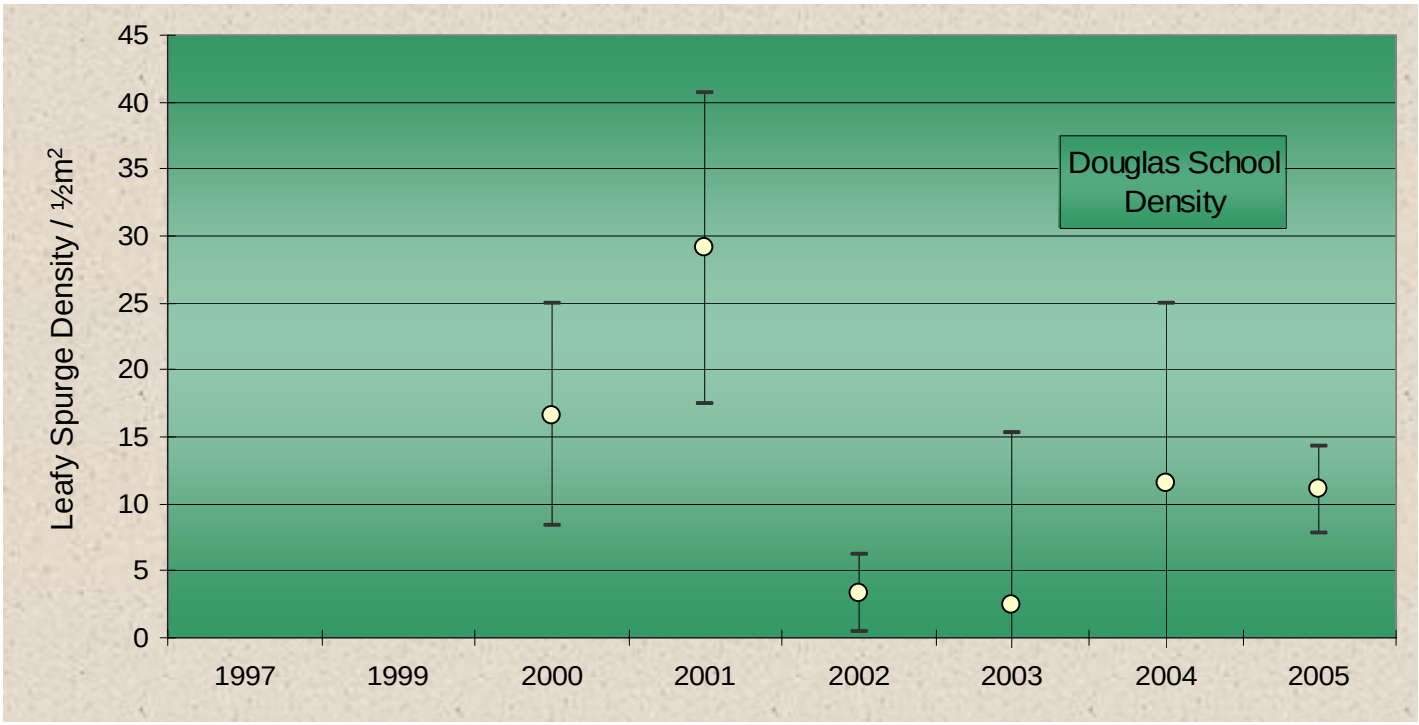


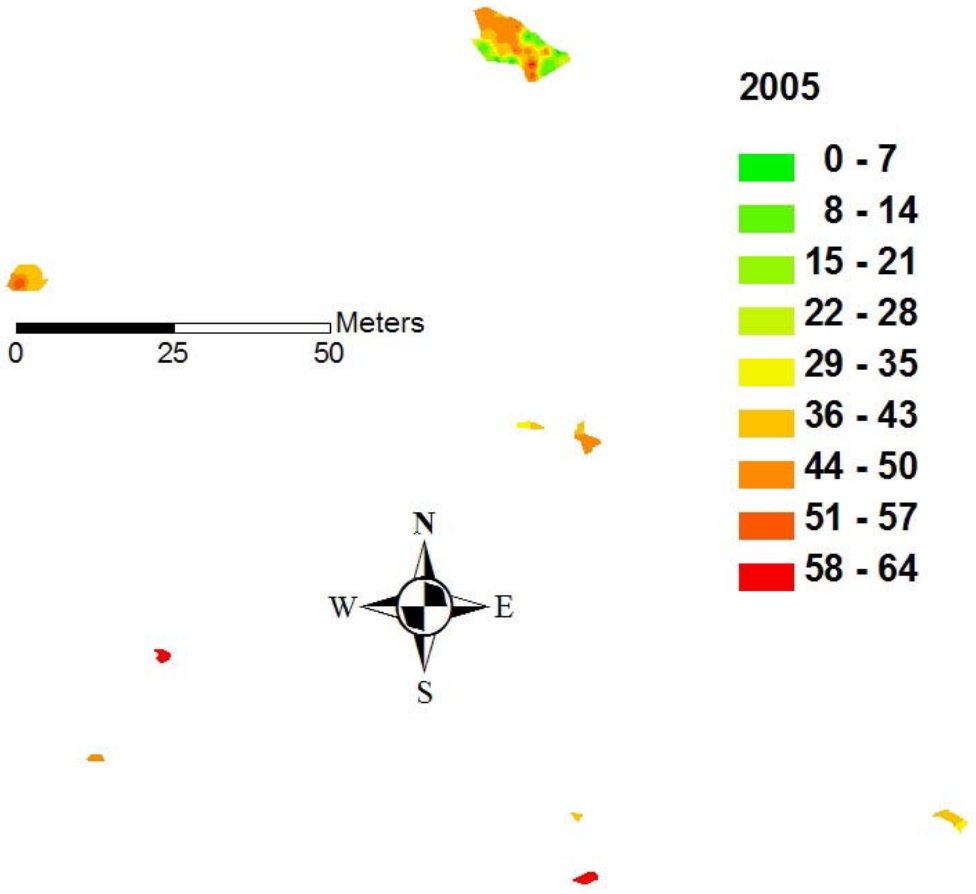


Douglass School leafy spurge perimeter in 2005.

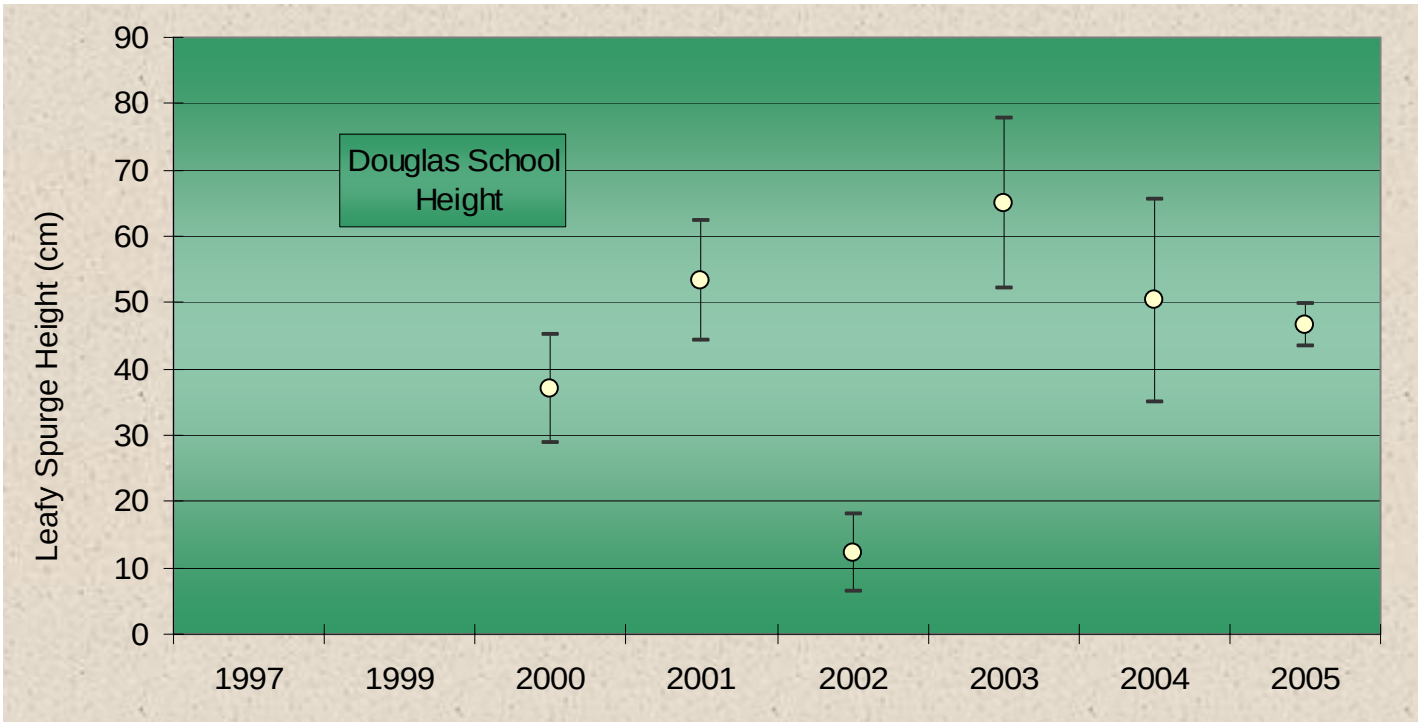


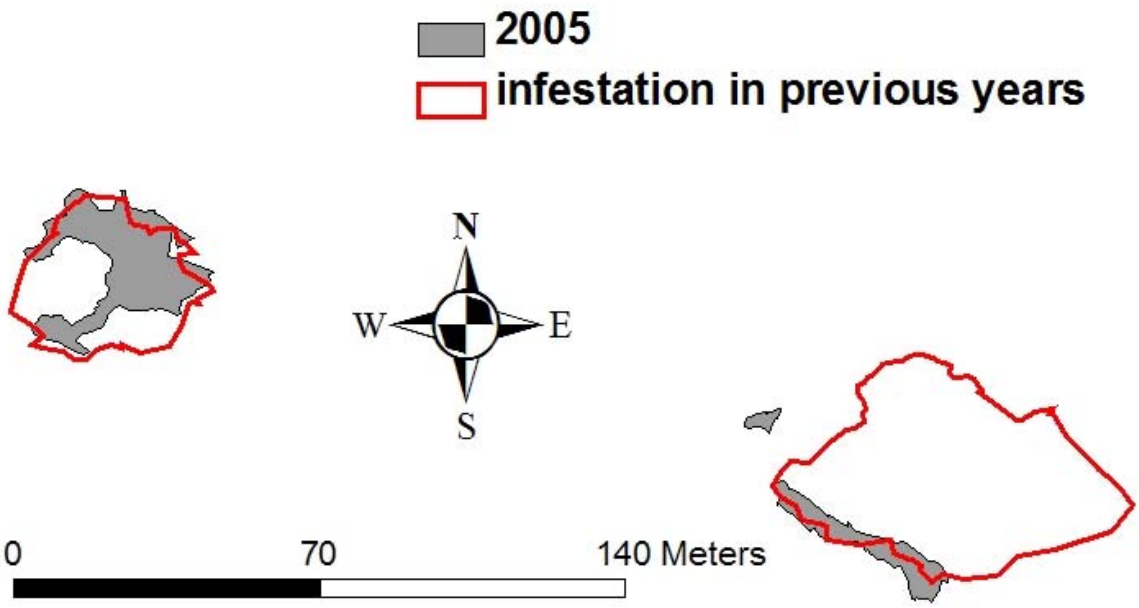
Douglass School leafy spurge density in 2005.



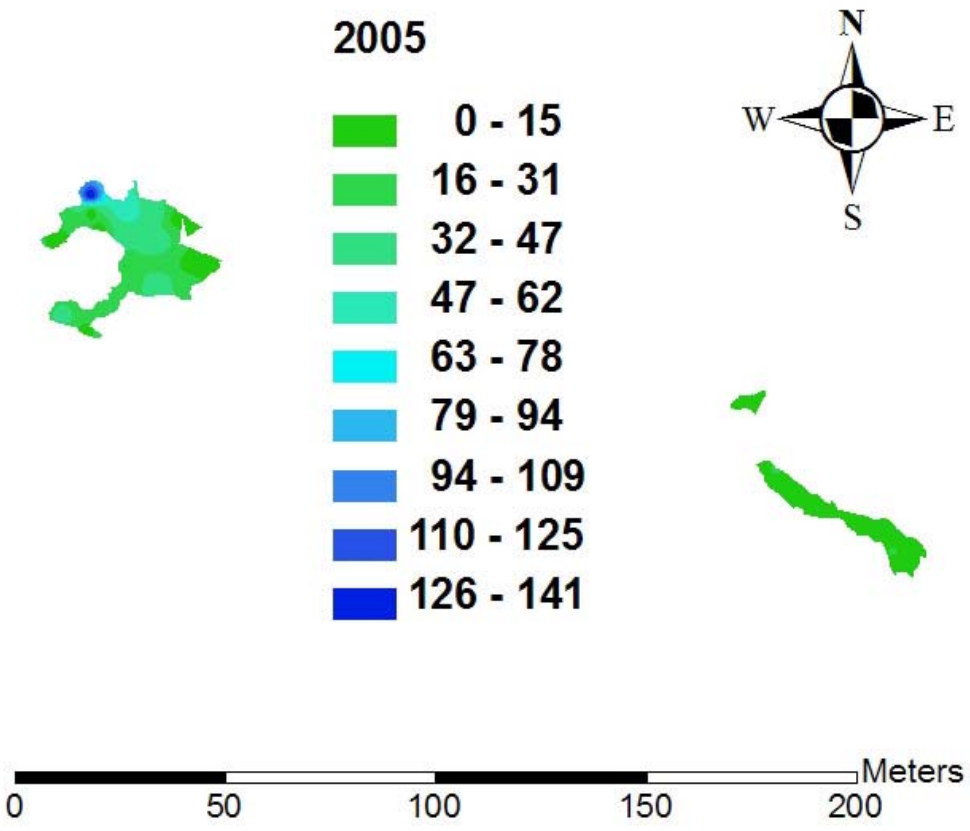


Douglass School leafy spurge height in 2005.

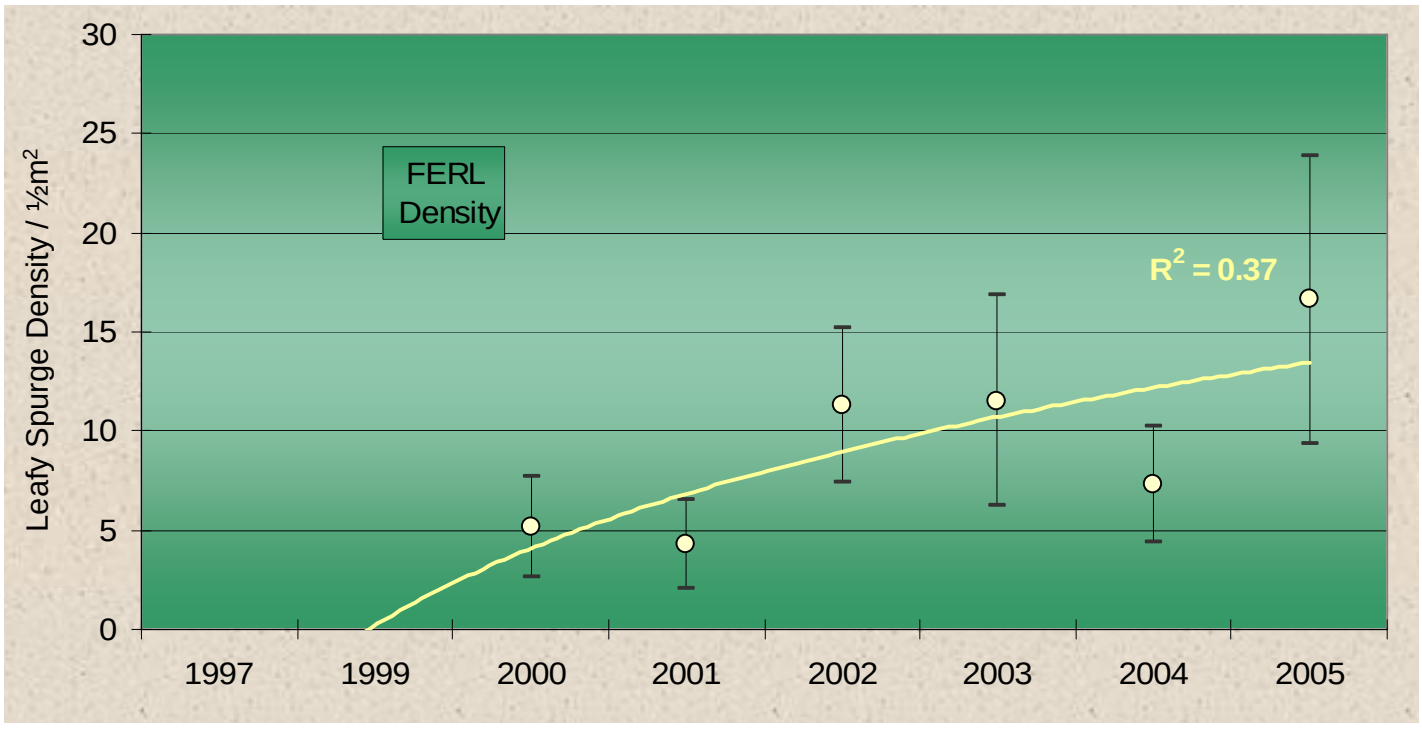


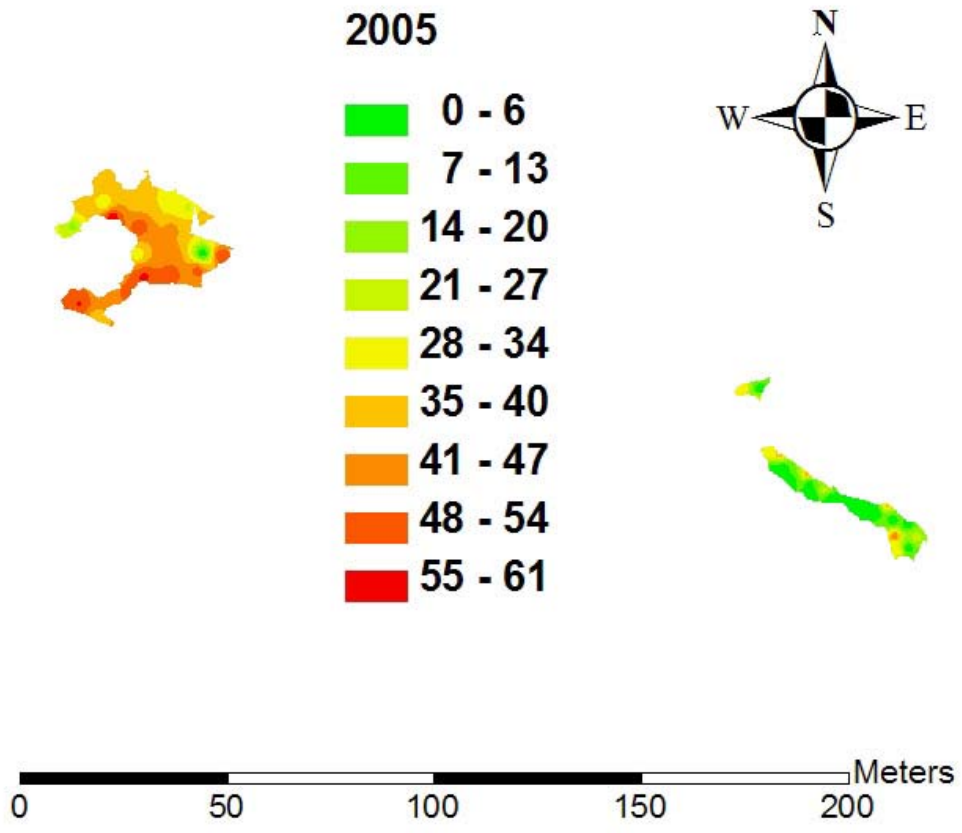


FERL leafy spurge perimeter in 2005.

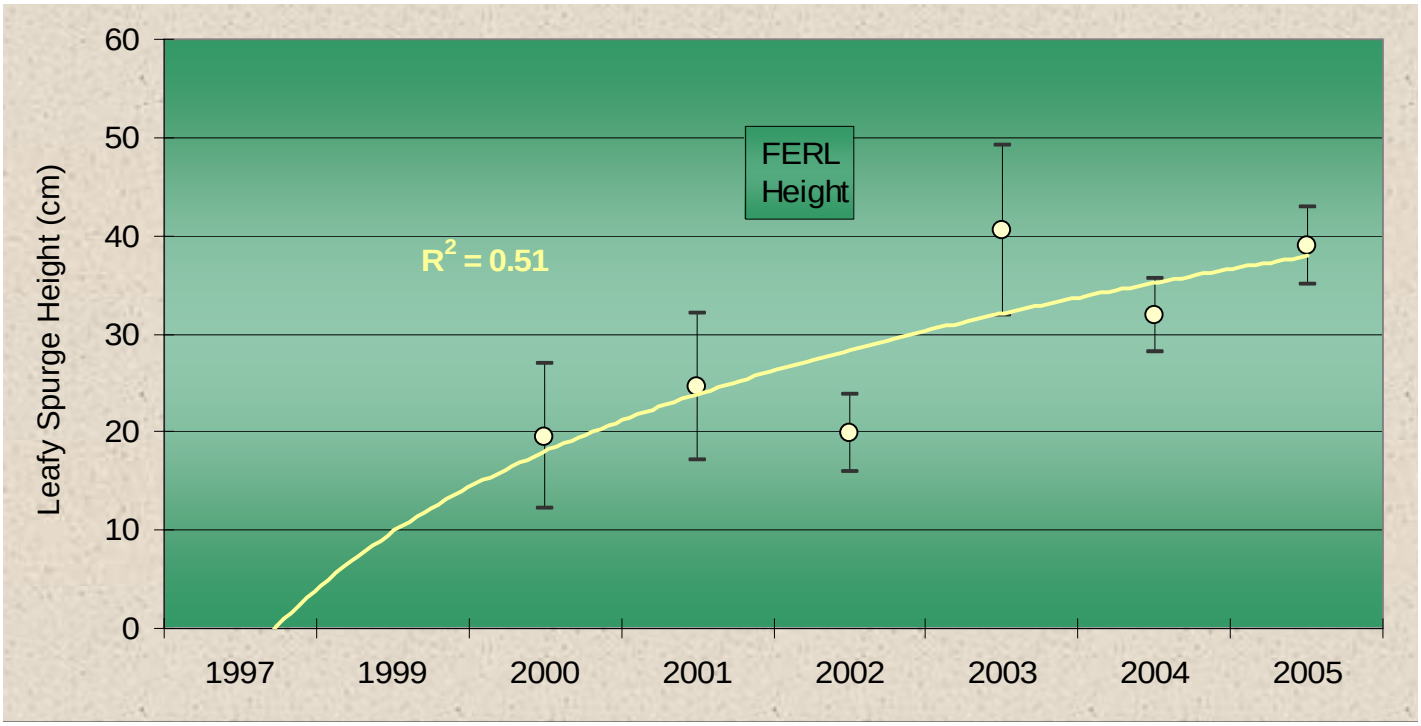


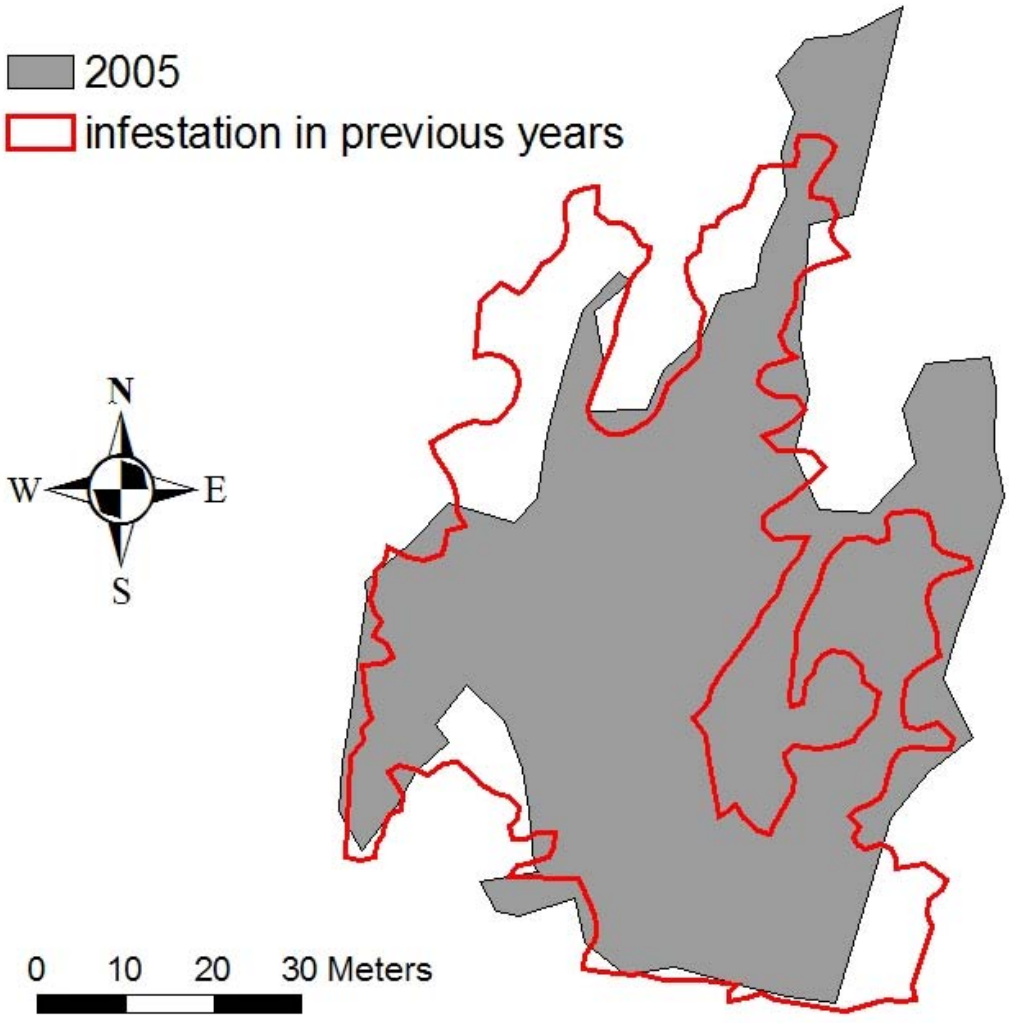
FERL leafy spurge density in 2005.



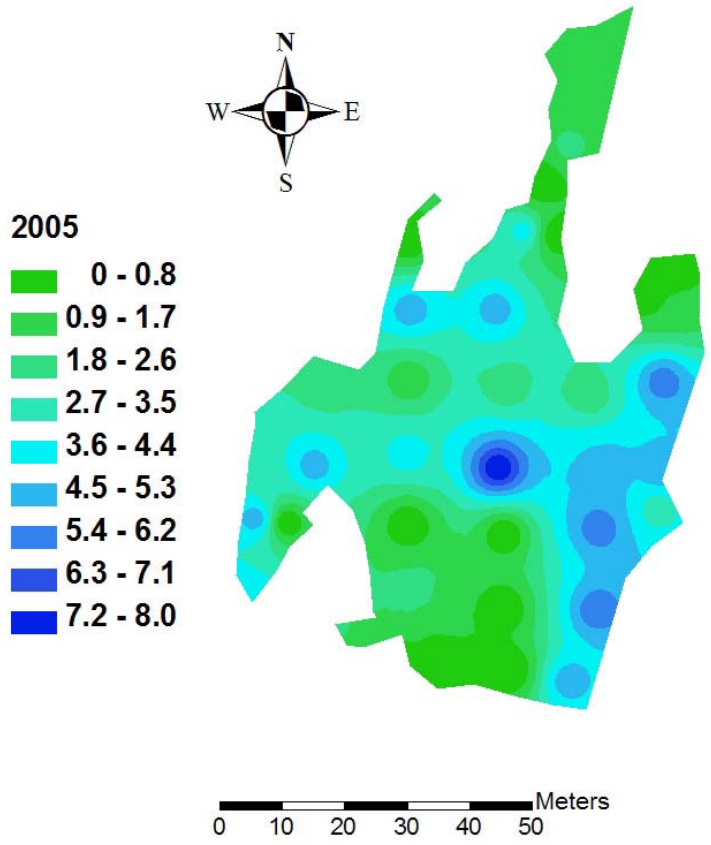


FERL leafy spurge height in 2005.

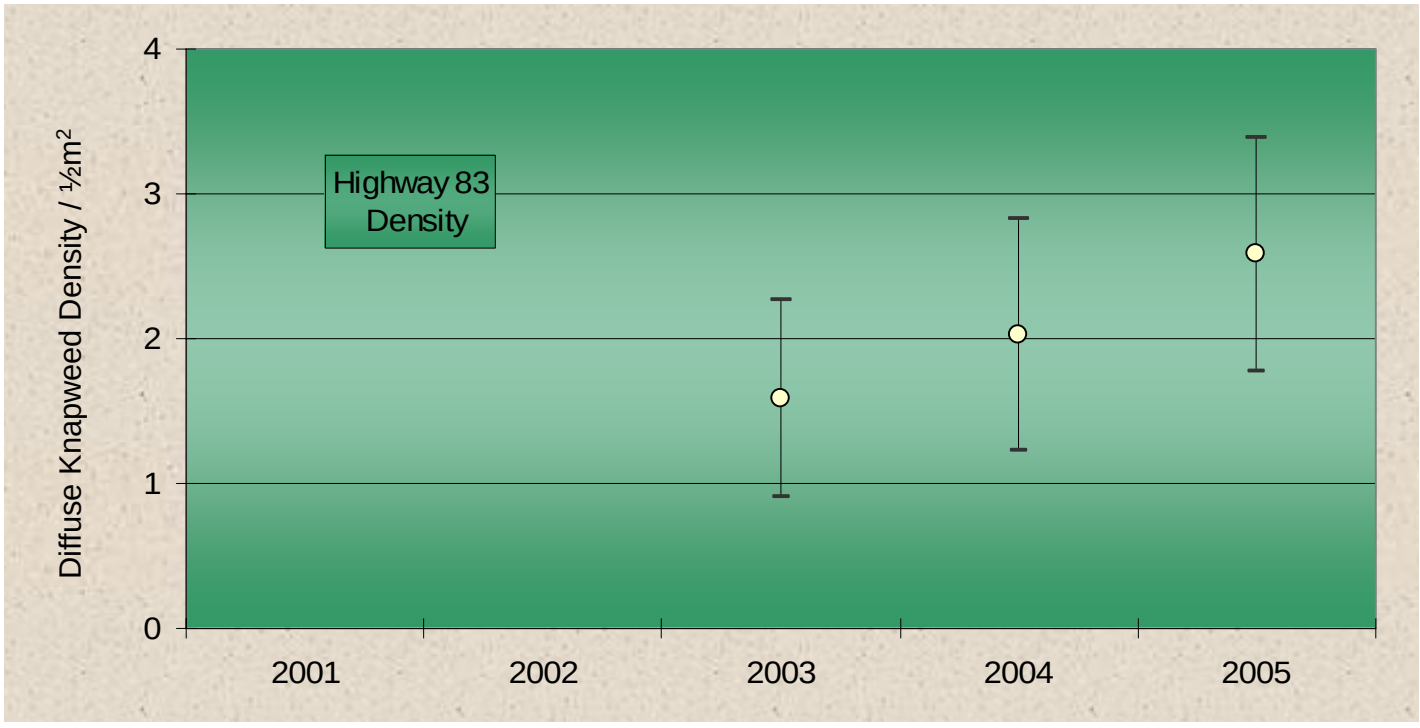


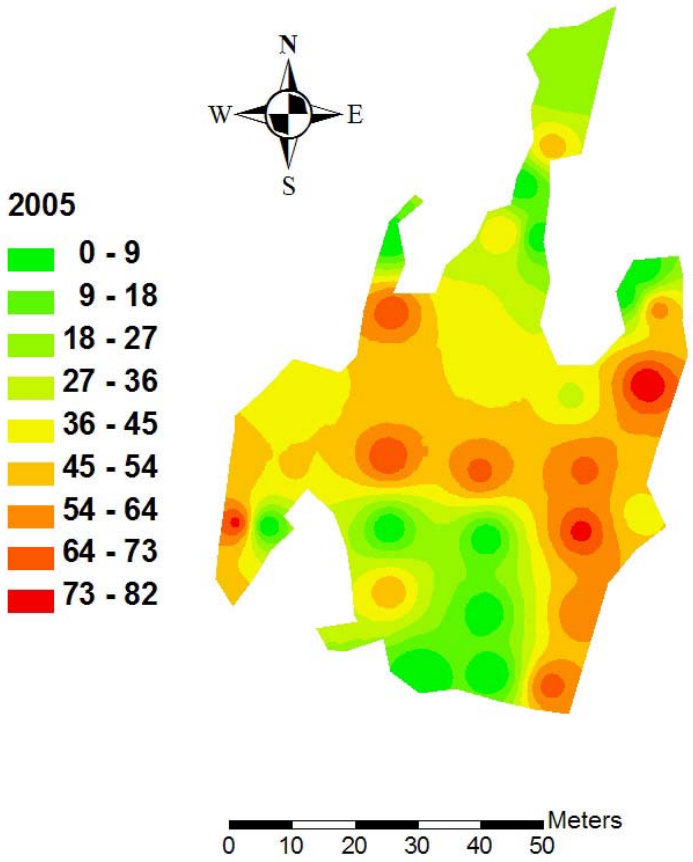


Highway 83 diffuse knapweed perimeter in 2005.

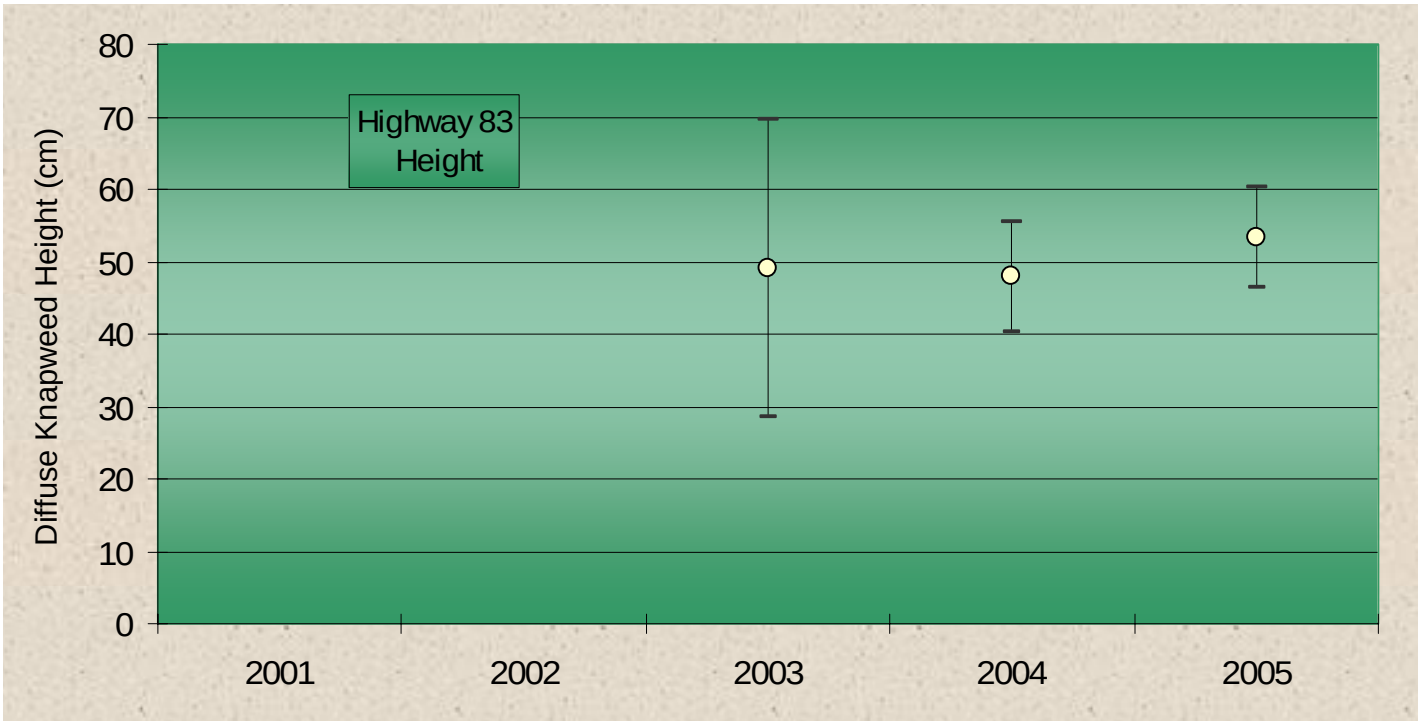


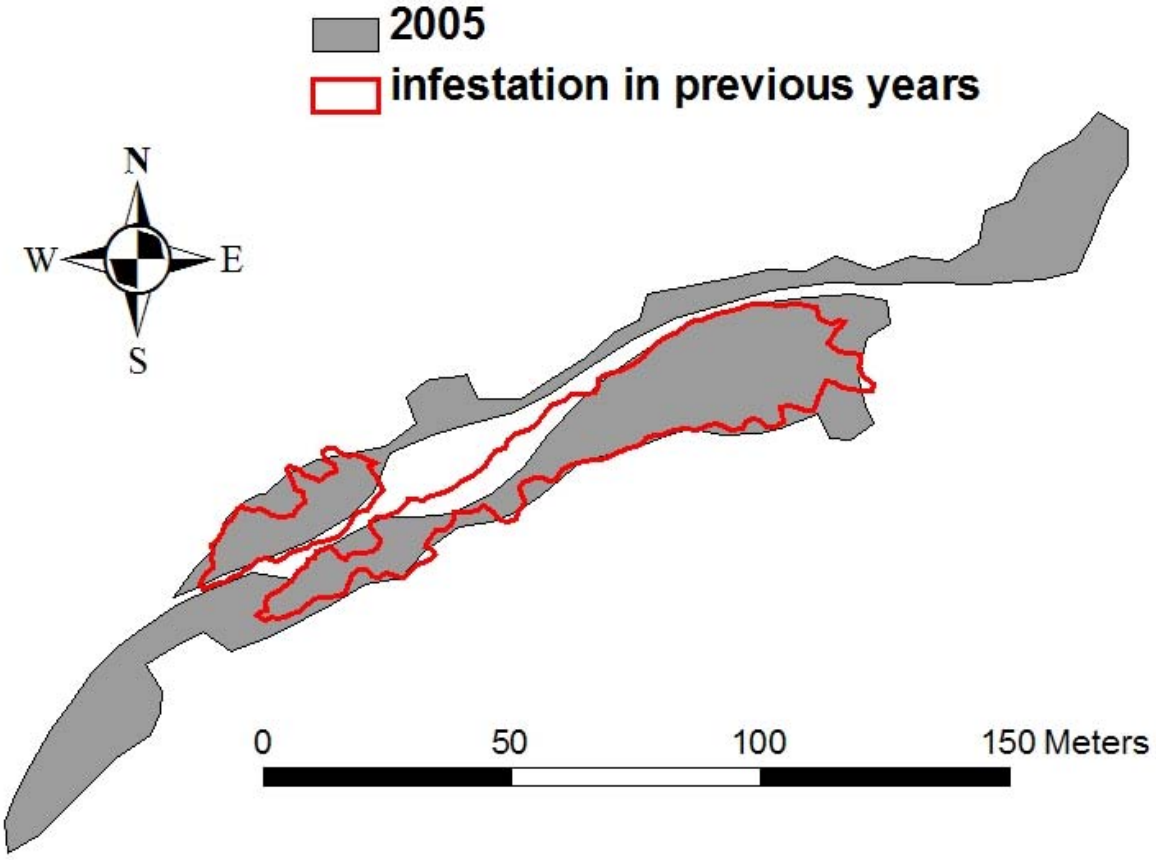
Highway 83 diffuse knapweed density in 2005.



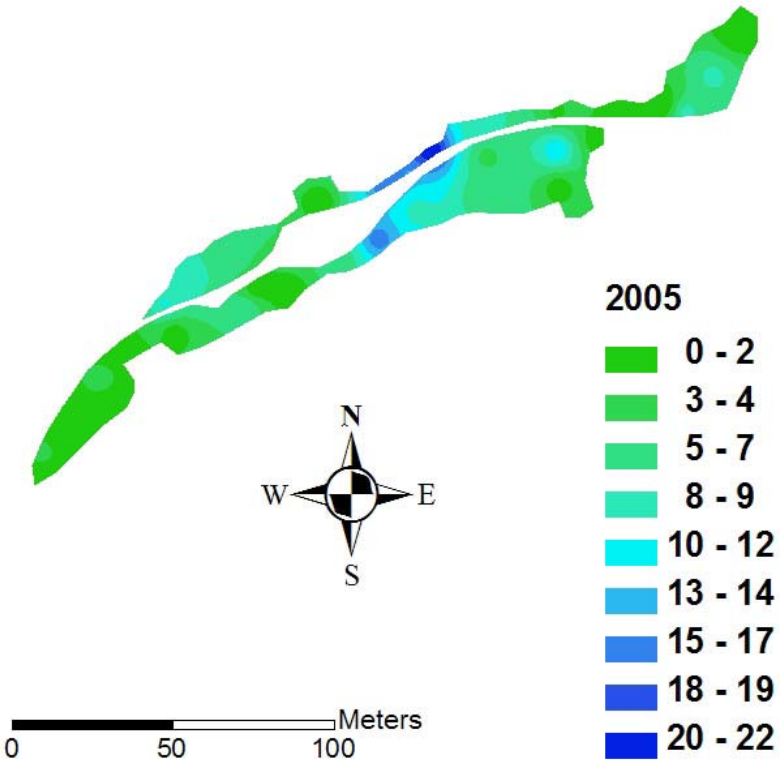


Highway 83 diffuse knapweed height in 2005.

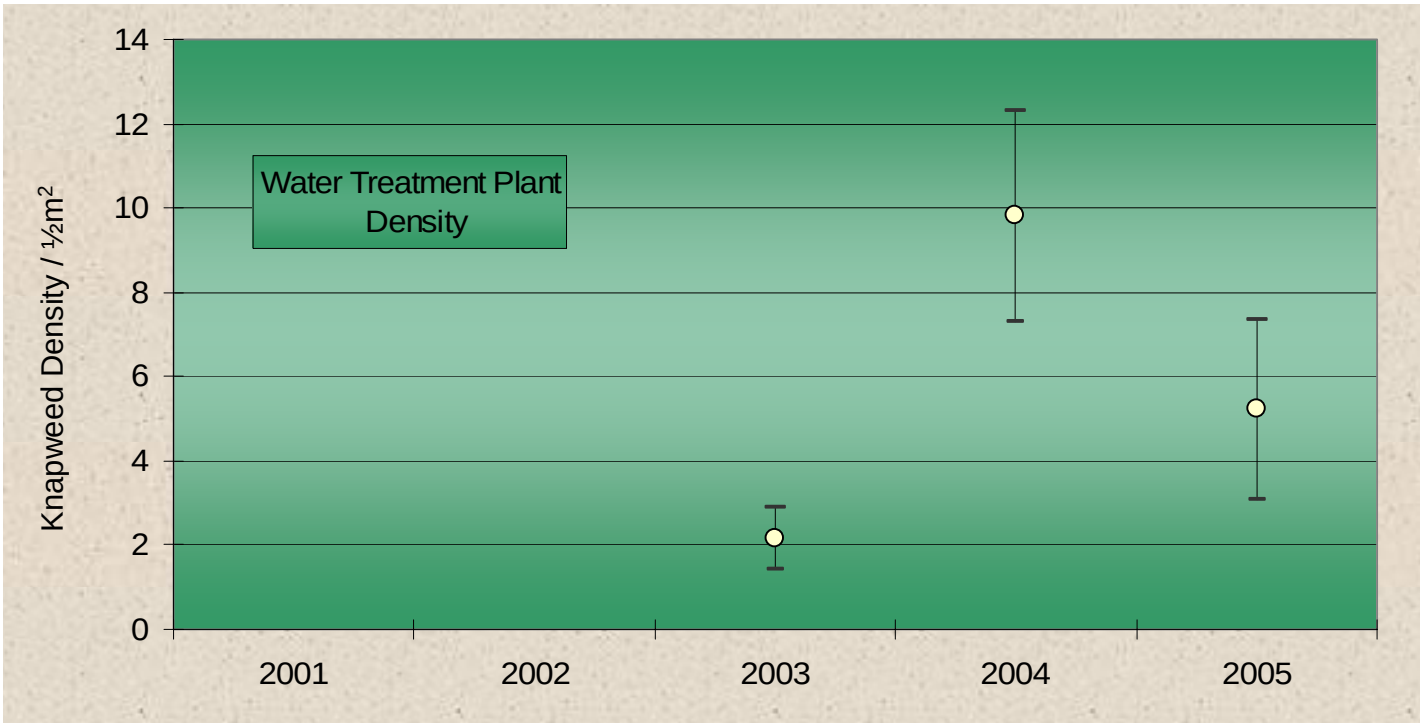


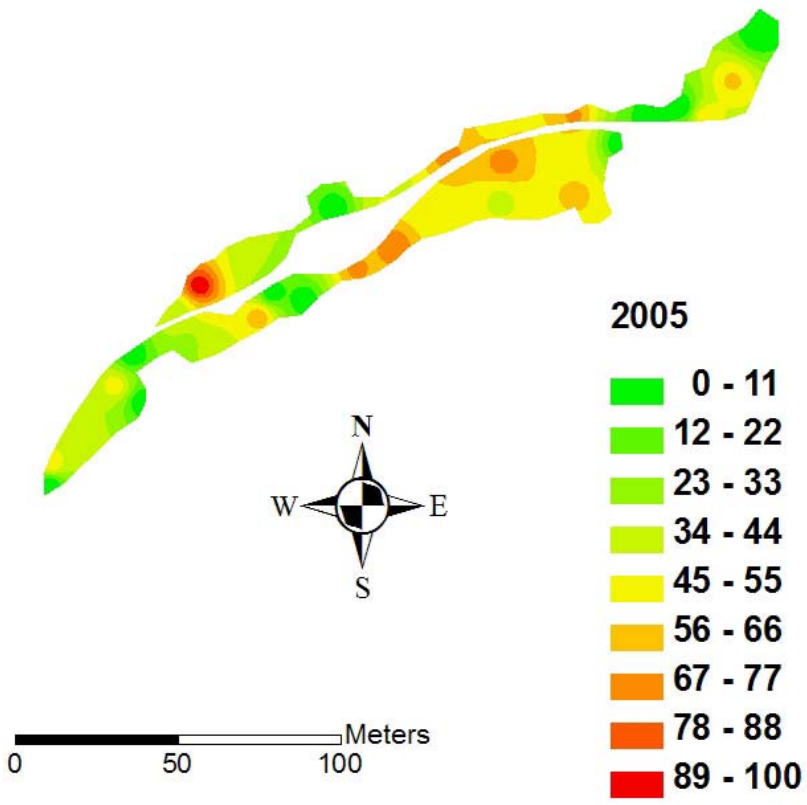


Water Treatment Plant diffuse and spotted knapweed perimeter in 2005.

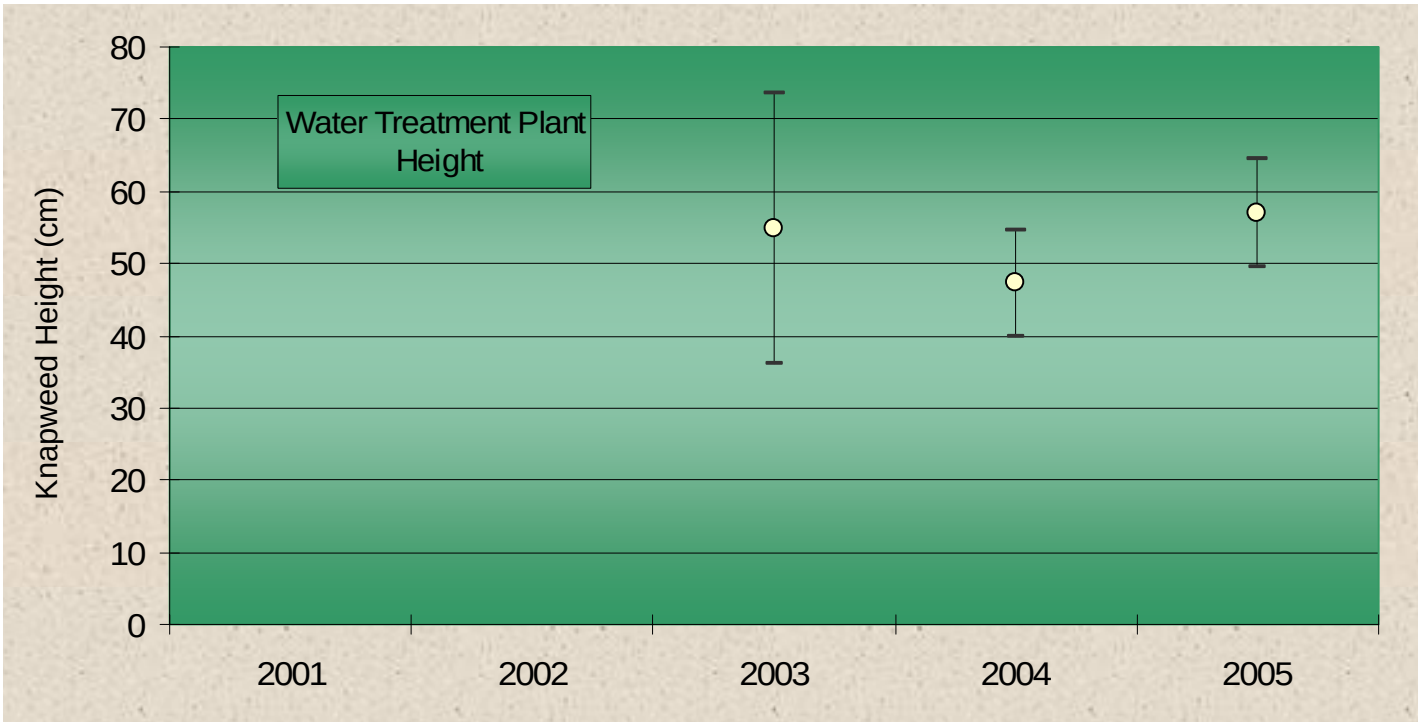


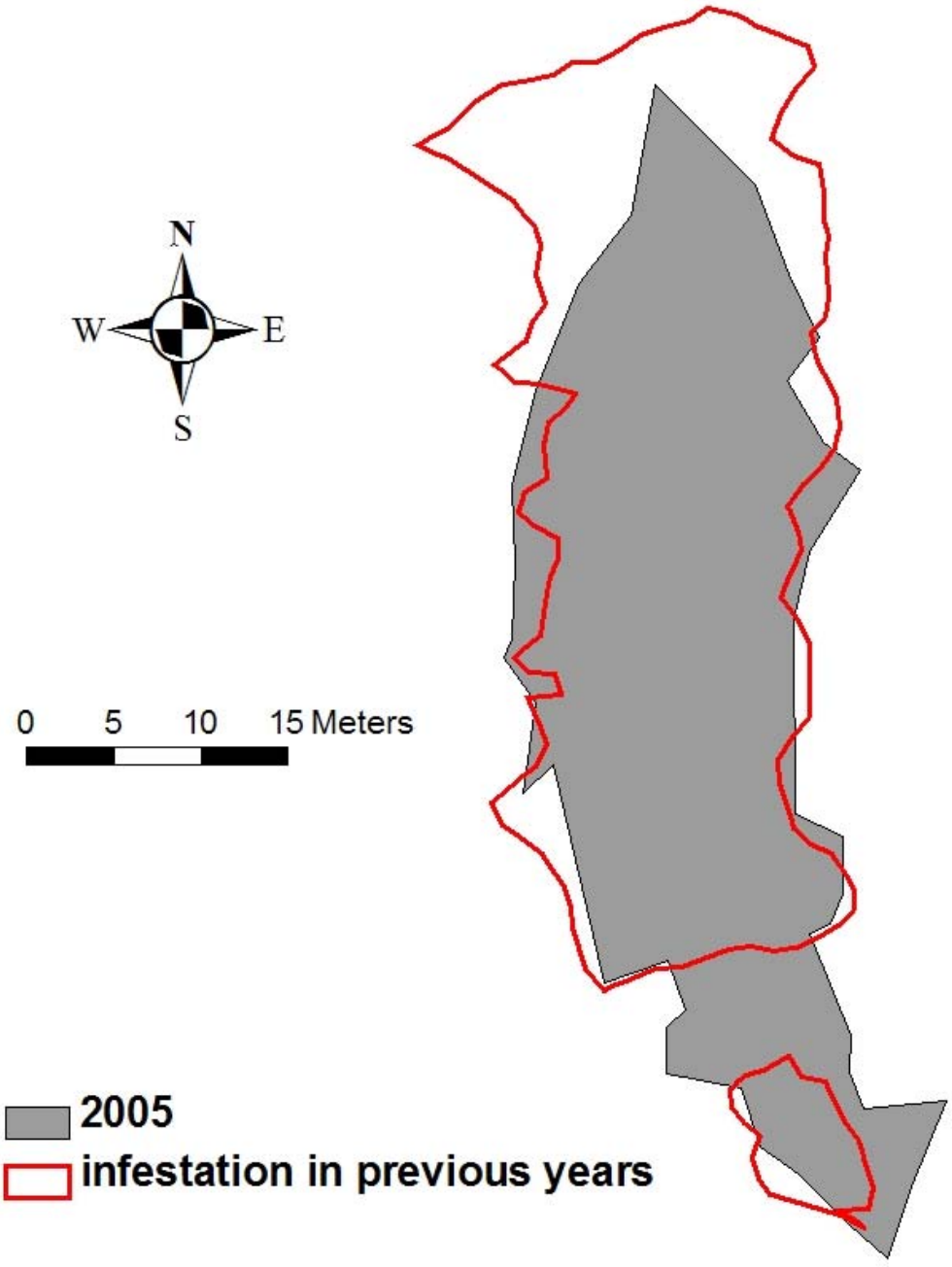
Water Treatment Plant diffuse and spotted knapweed density in 2005.



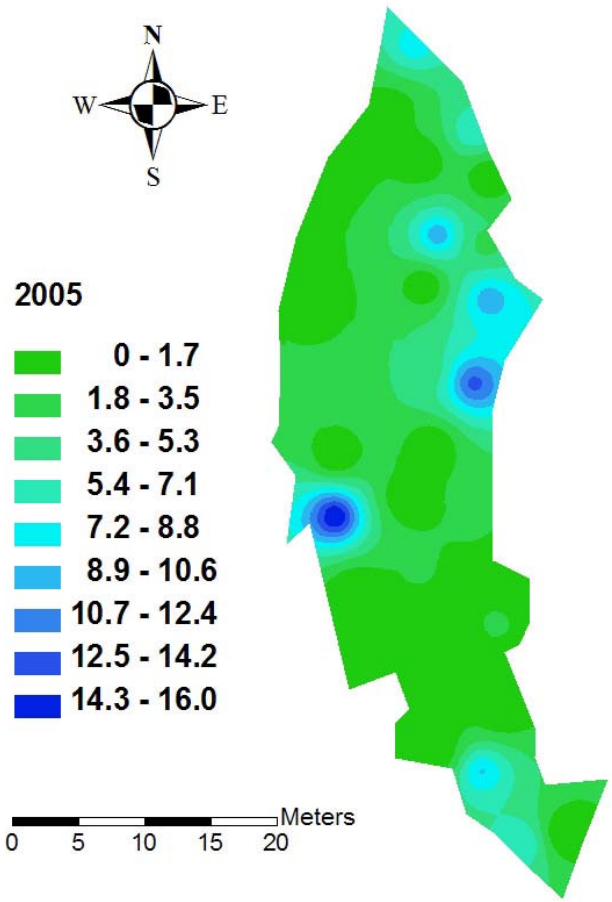


Water Treatment Plant diffuse and spotted knapweed height in 2005.

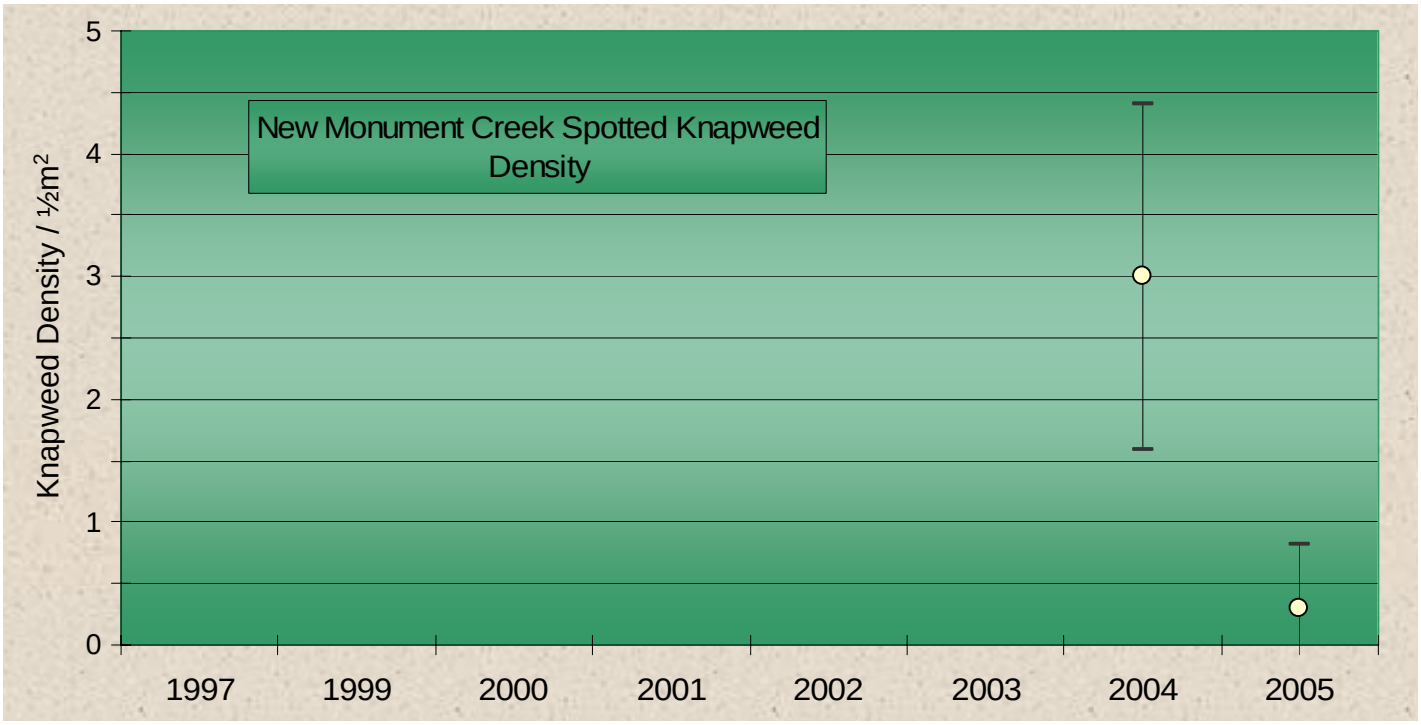


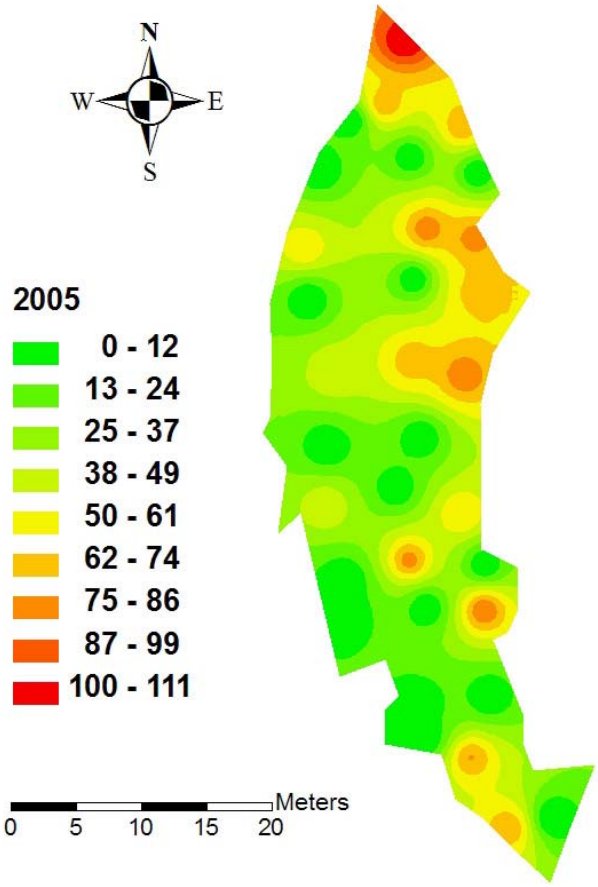


New Monument Creek spotted knapweed perimeter in 2005.



New Monument Creek spotted knapweed density in 2005.





New Monument Creek spotted knapweed height in 2005.

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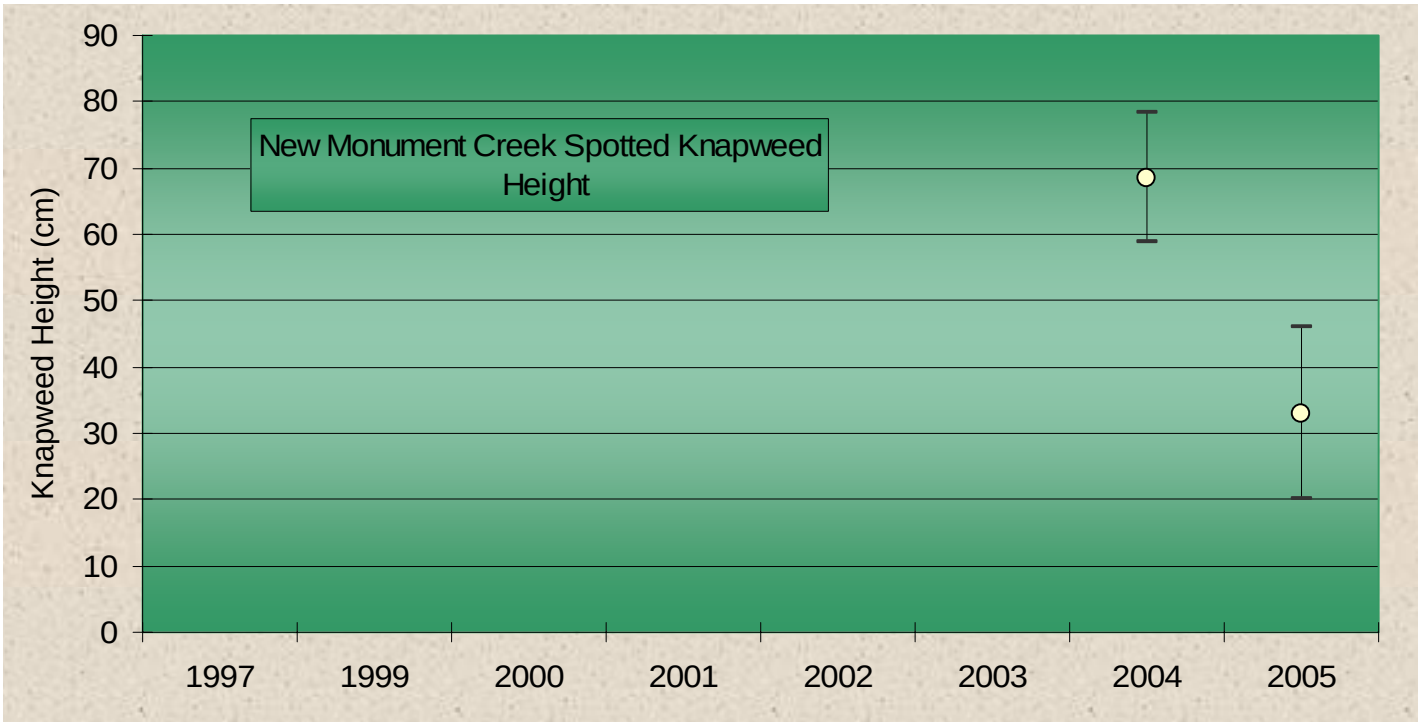
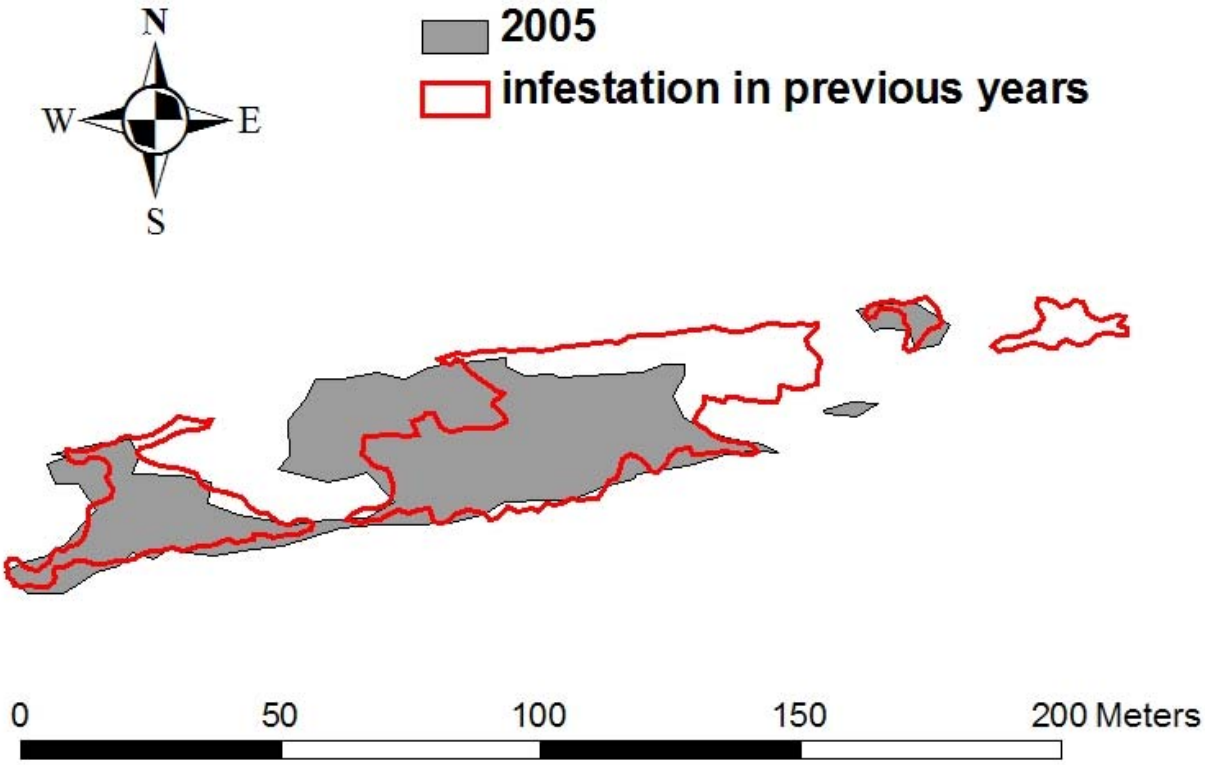
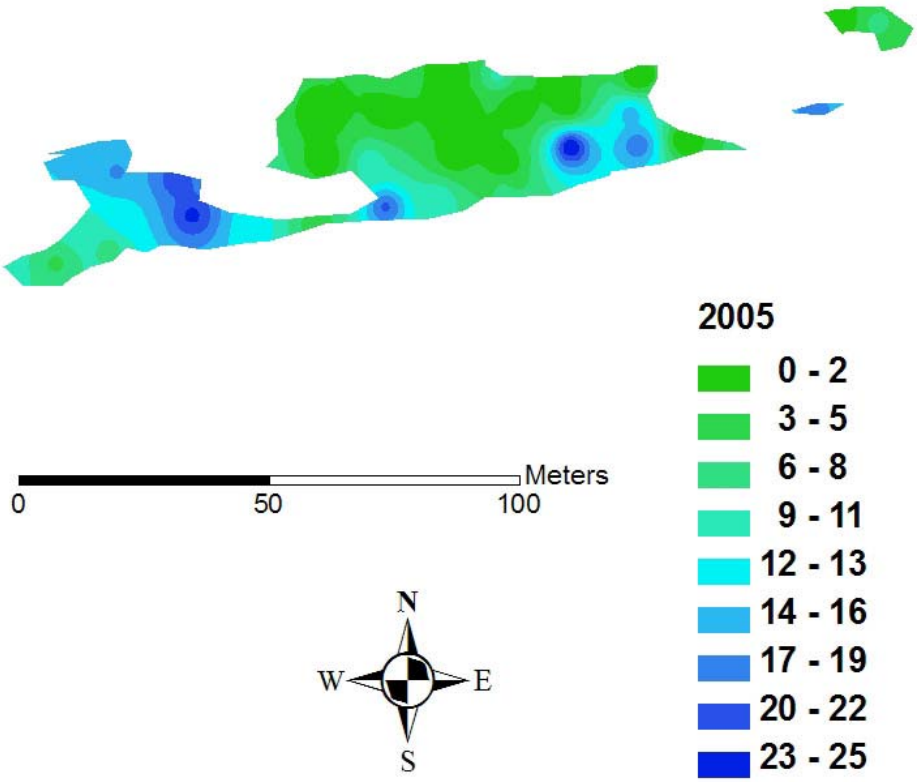
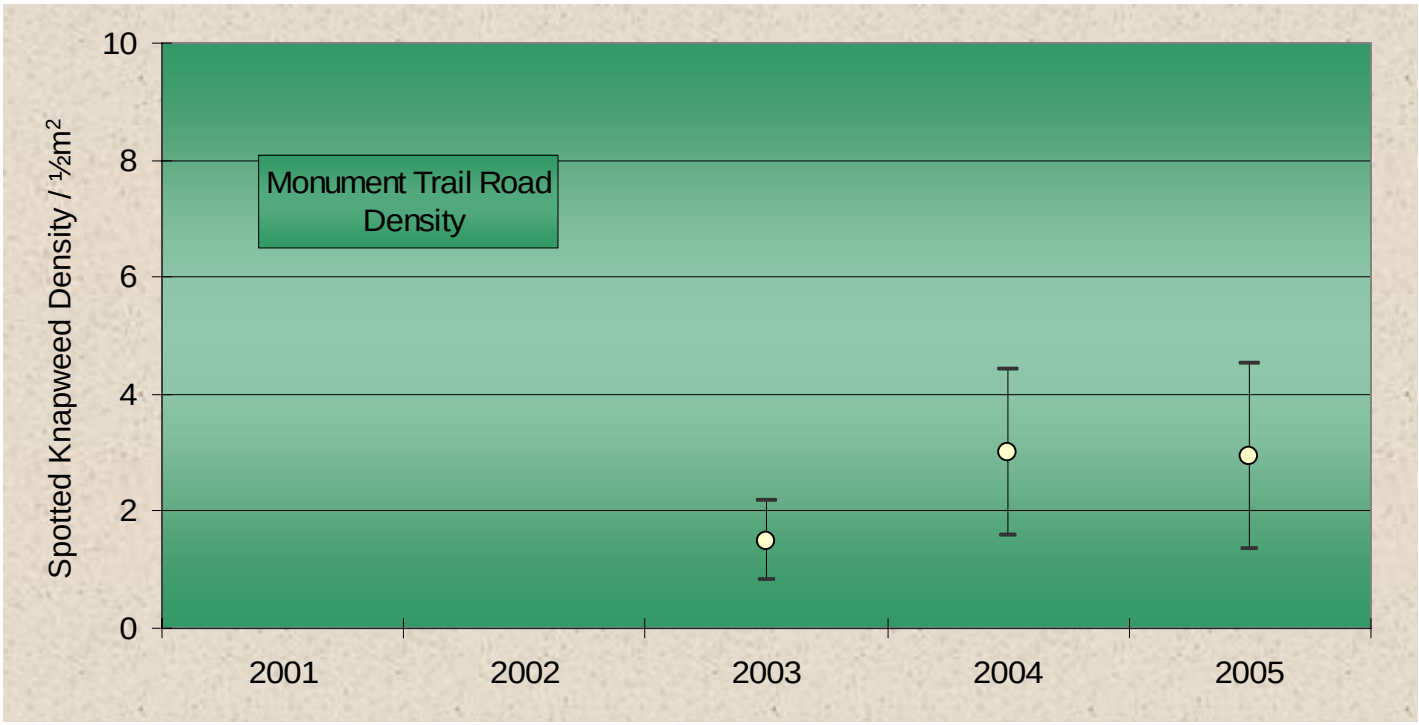


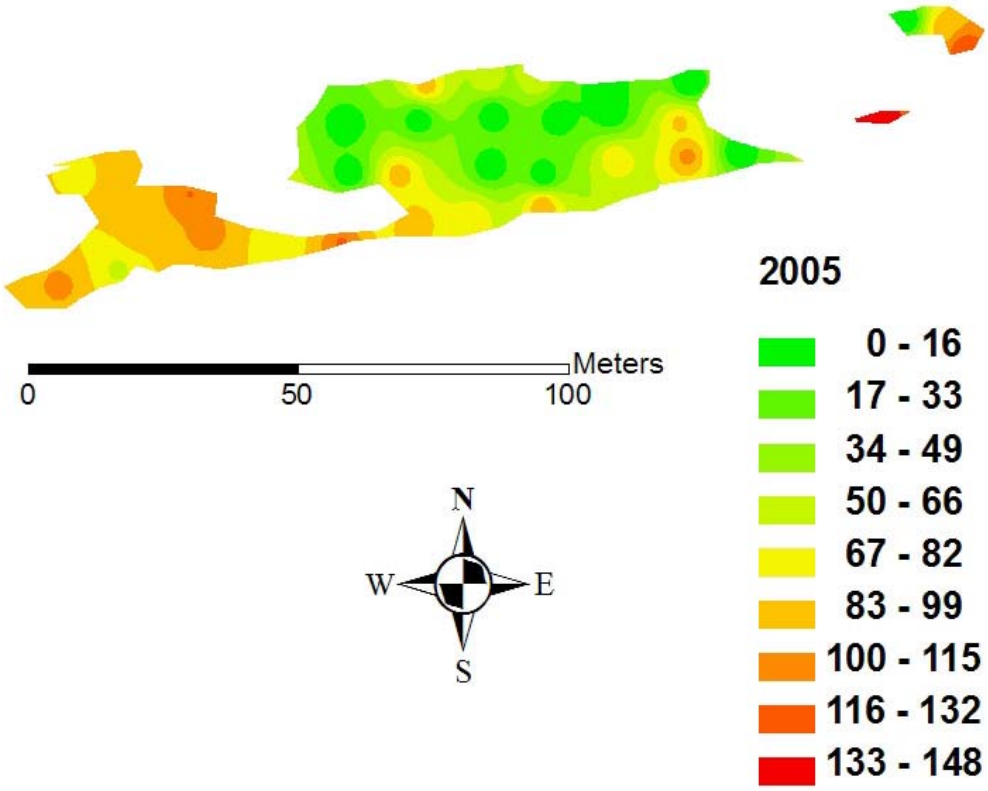


Monument Trail Road spotted knapweed perimeter in 2005.

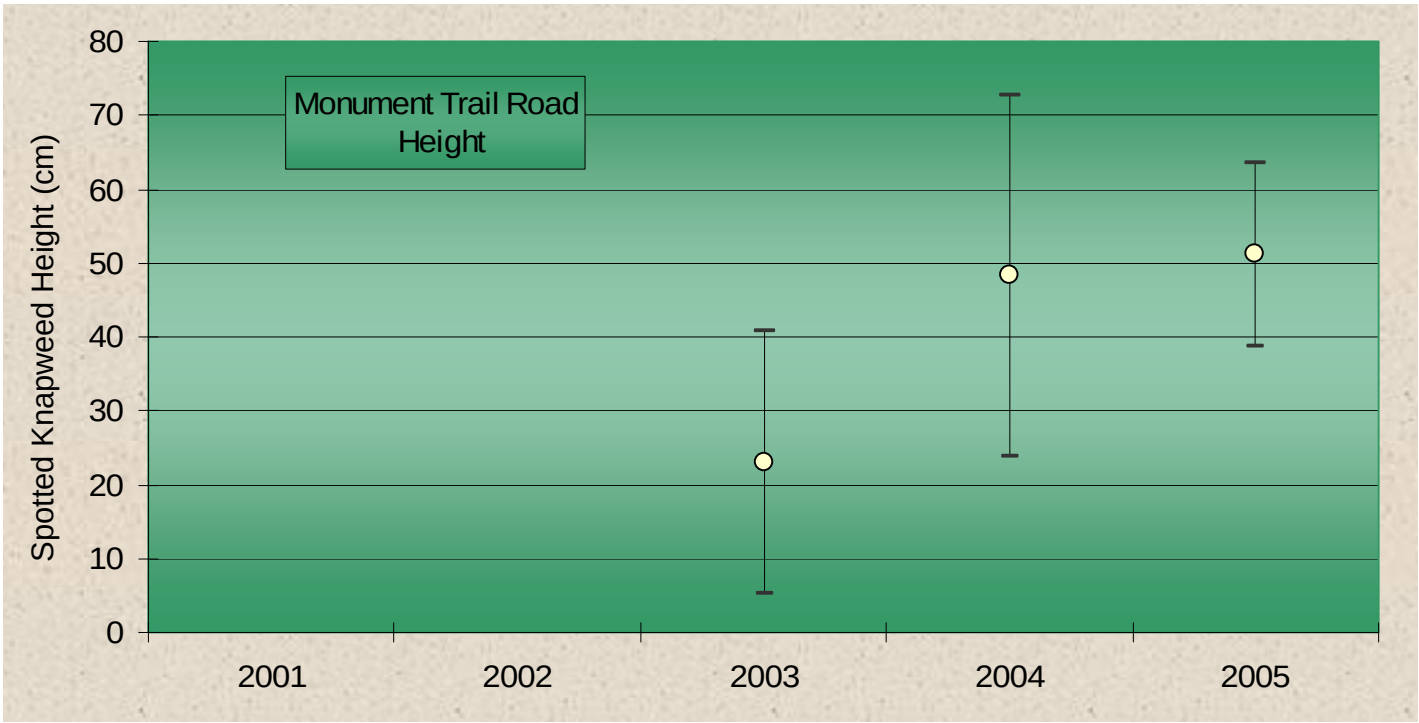


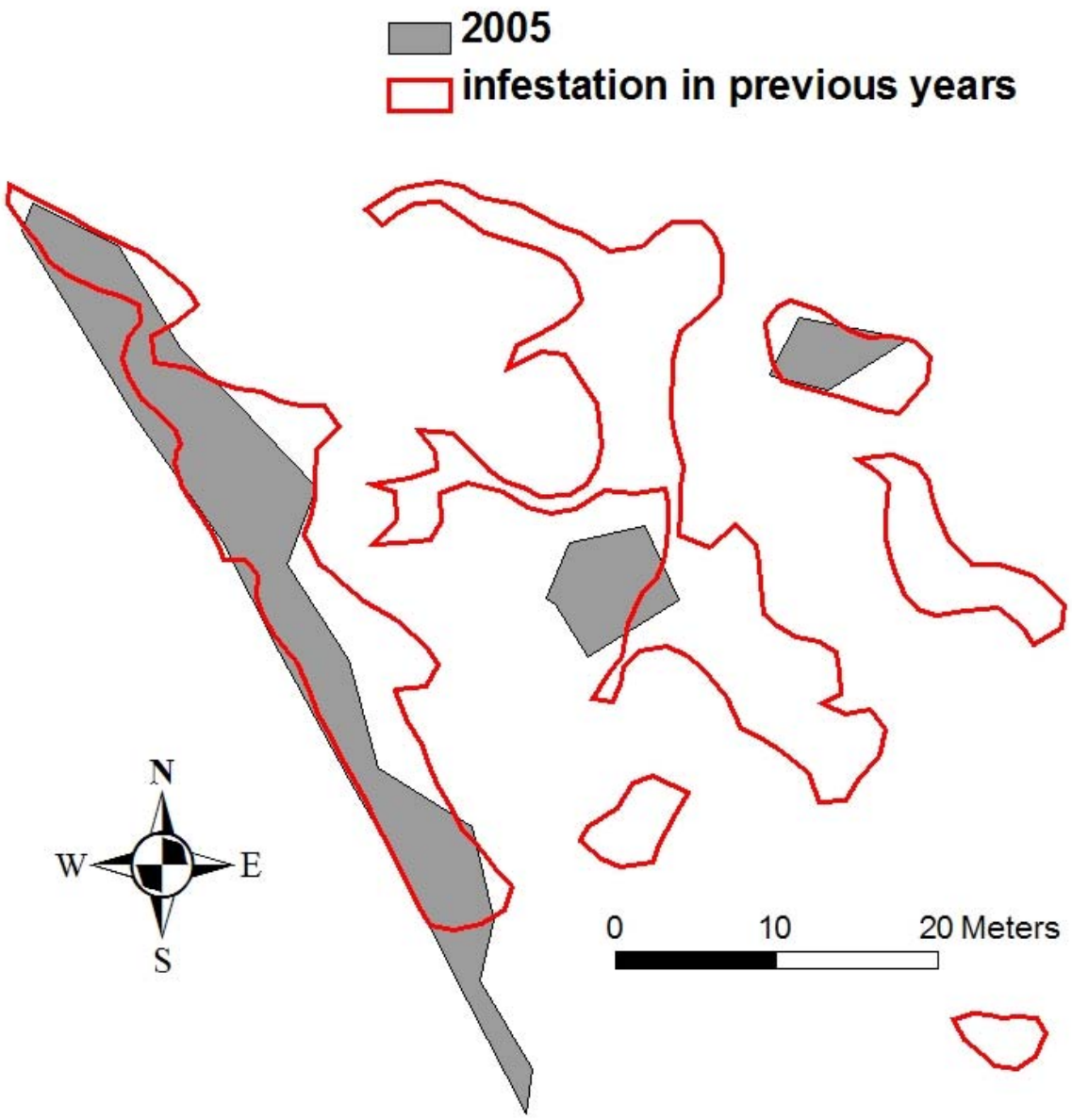
Monument Trail Road spotted knapweed density in 2005.



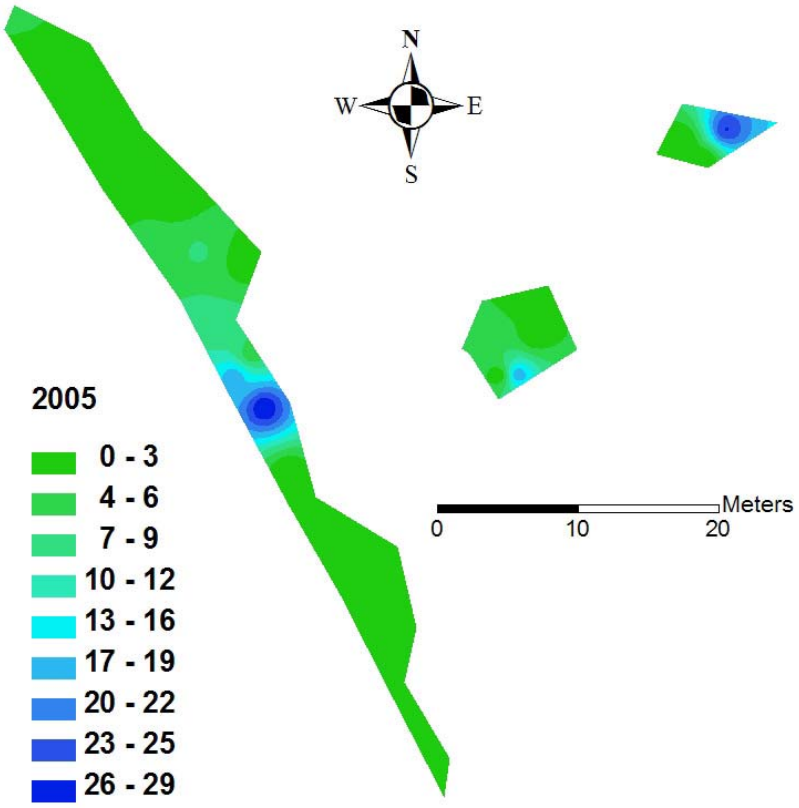


Monument Trail Road spotted knapweed height in 2005.

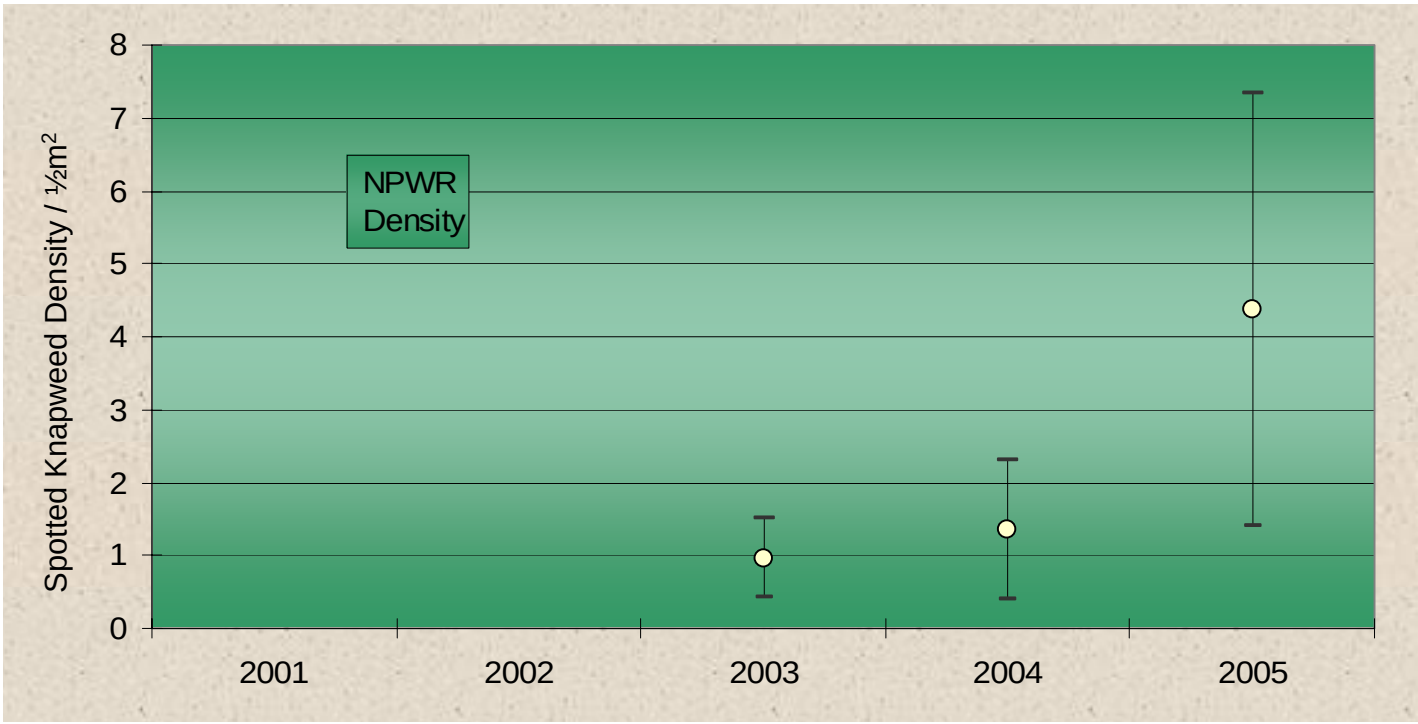


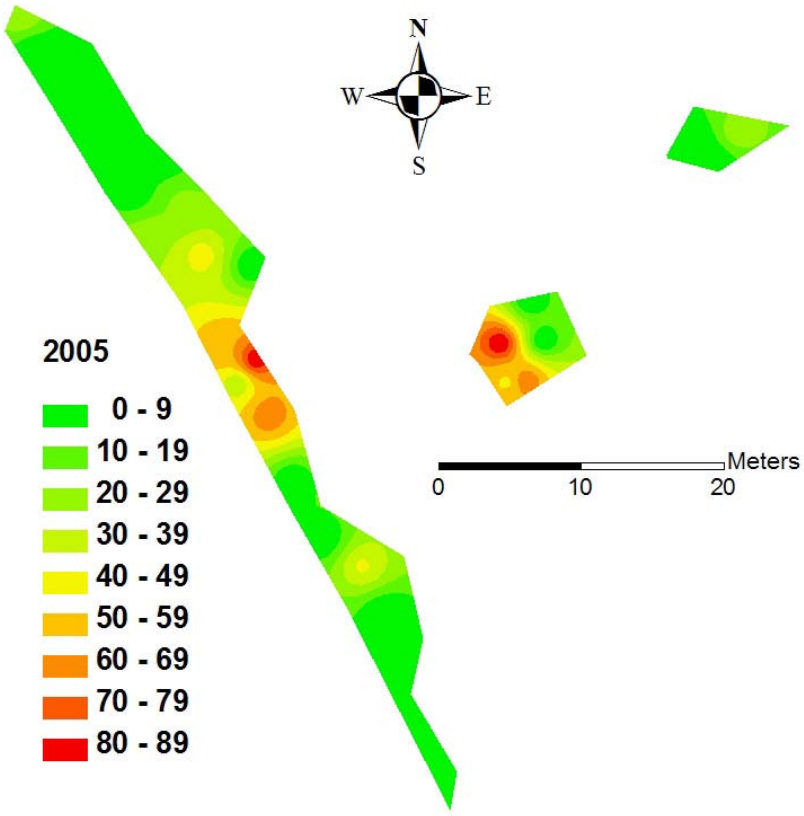


Non-potable Water Reservoir (NPWR) spotted knapweed perimeter in 2005.

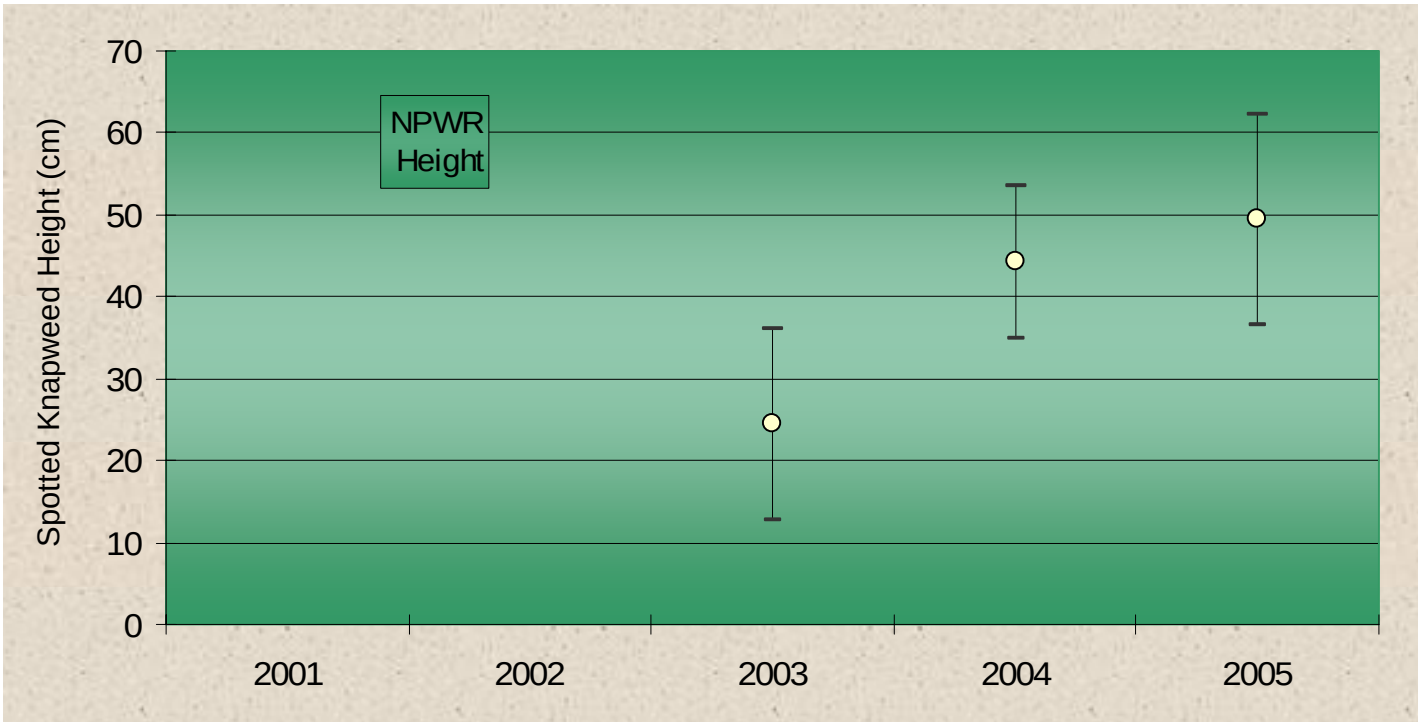


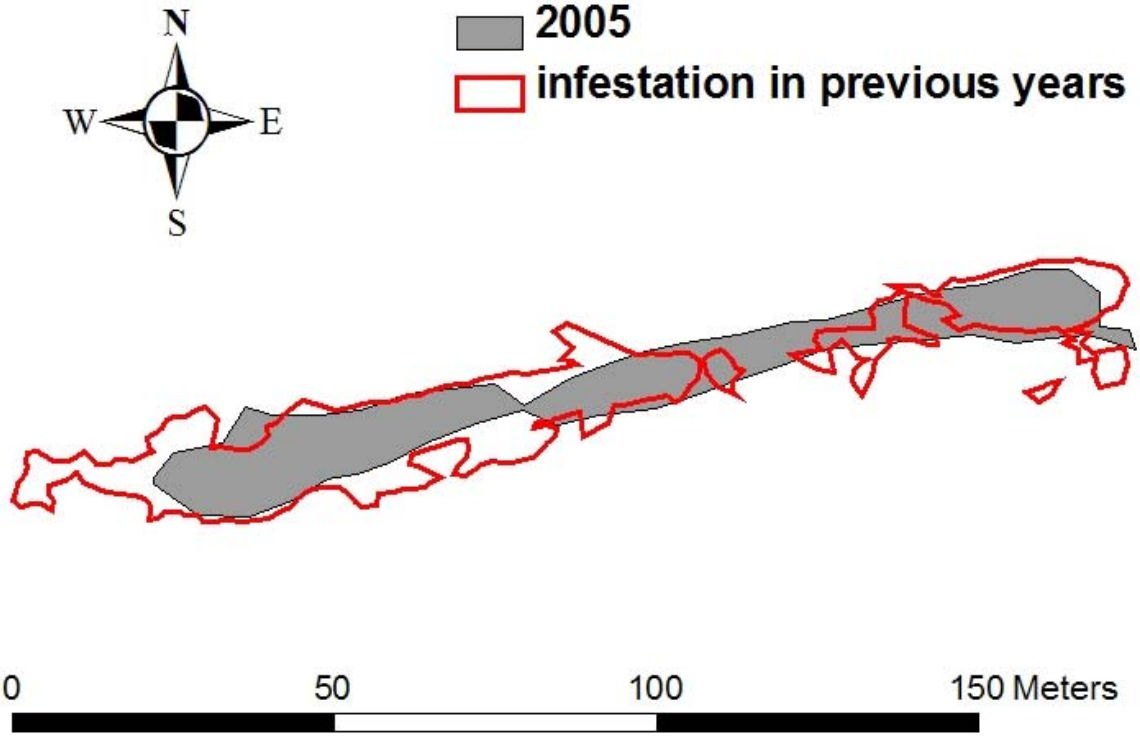
Non-potable Water Reservoir (NPWR) spotted knapweed density in 2005.



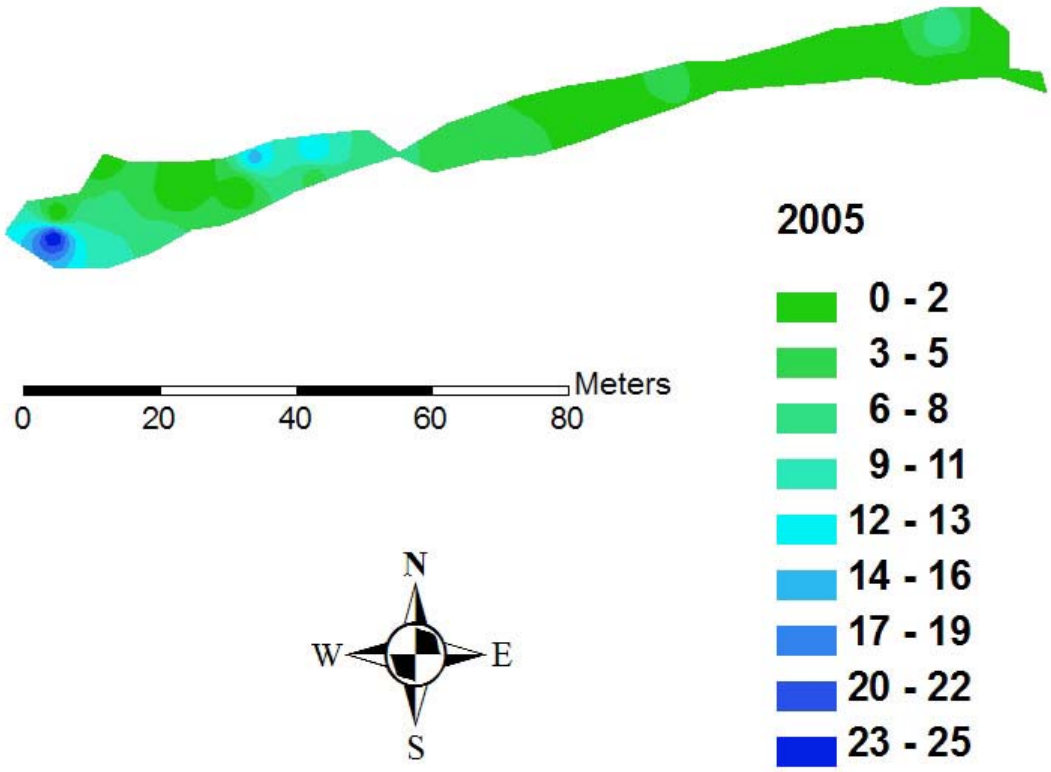


Non-potable Water Reservoir (NPWR) spotted knapweed height in 2005.

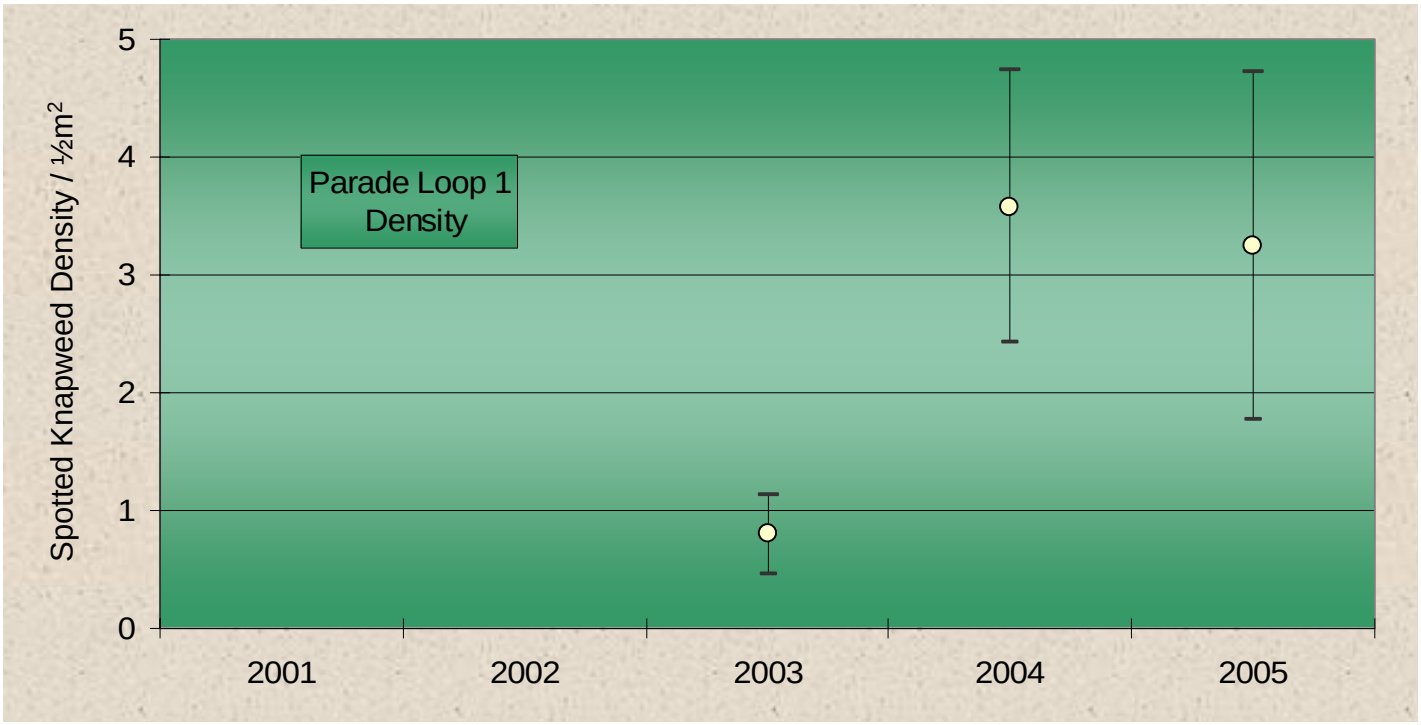


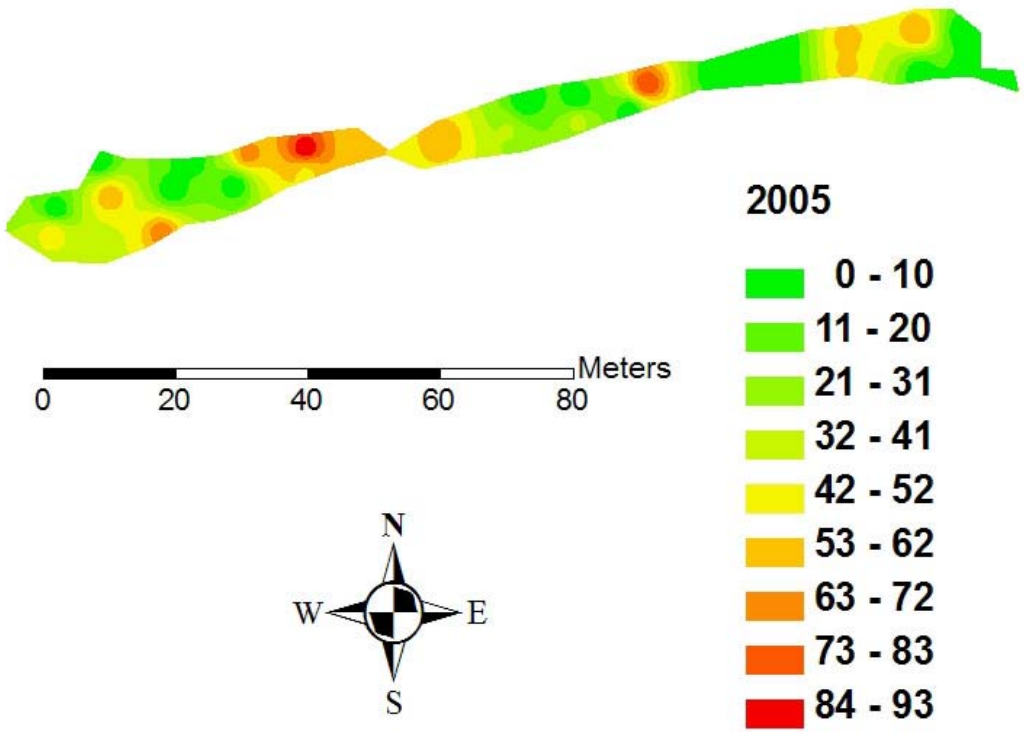


Parade Loop I spotted knapweed perimeter in 2005.

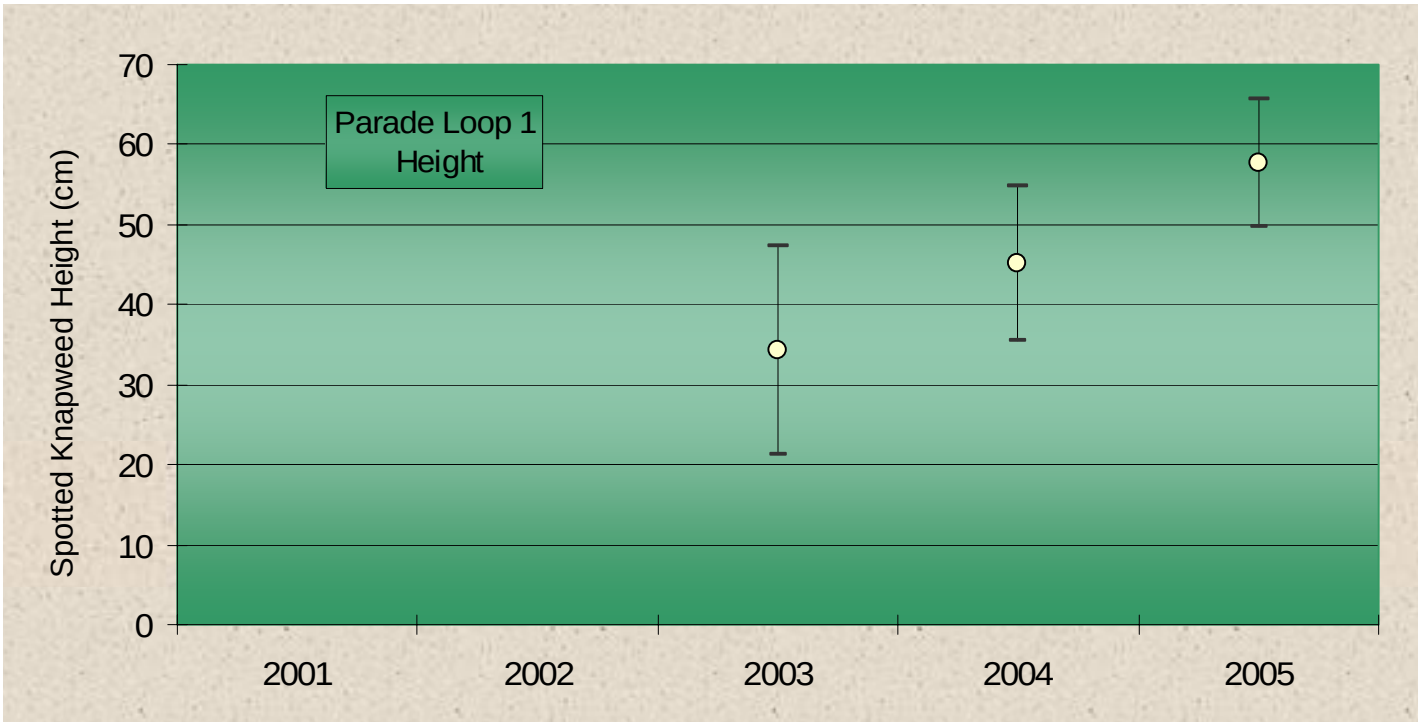


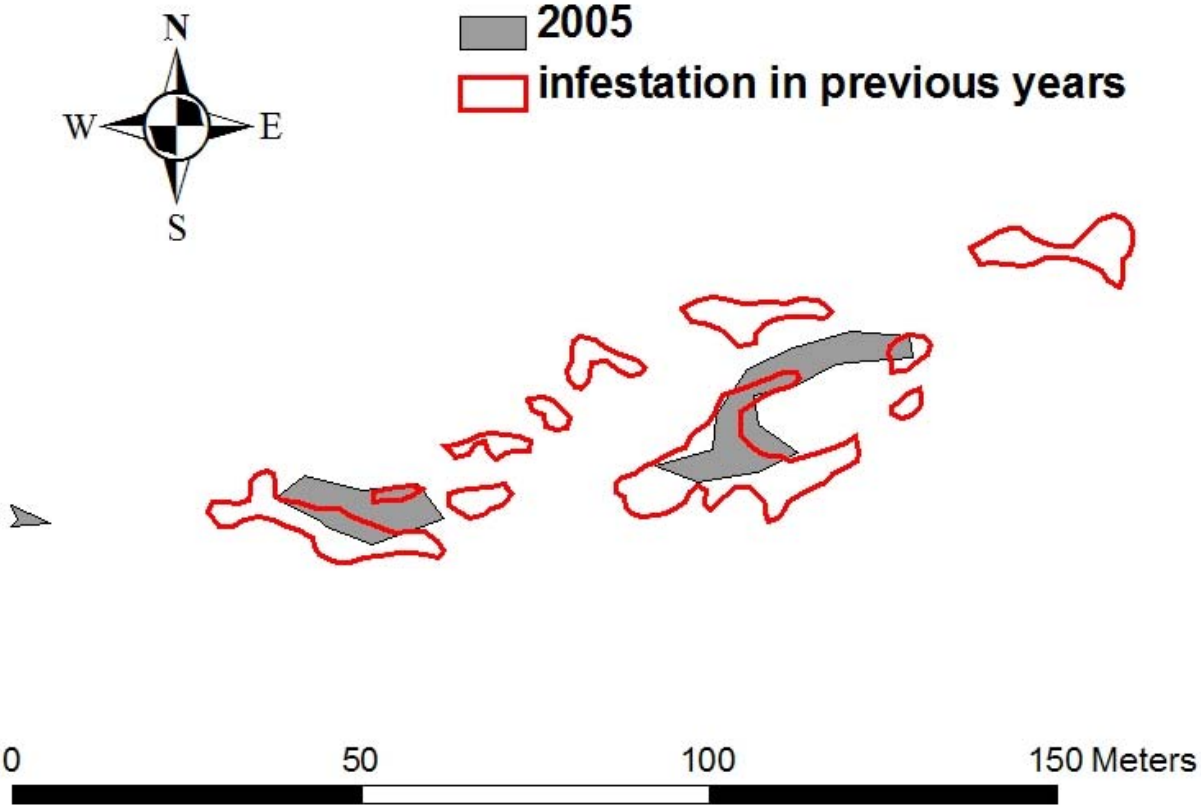
Parade Loop I spotted knapweed density in 2005.



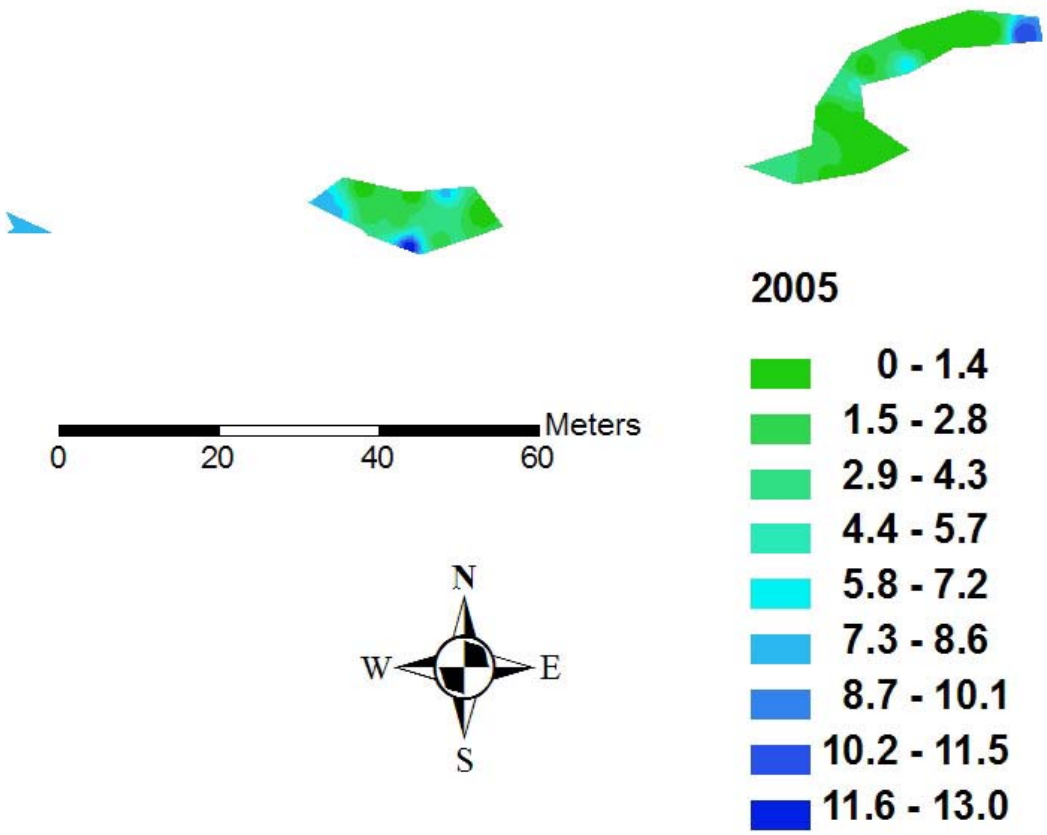


Parade Loop I spotted knapweed height in 2005.

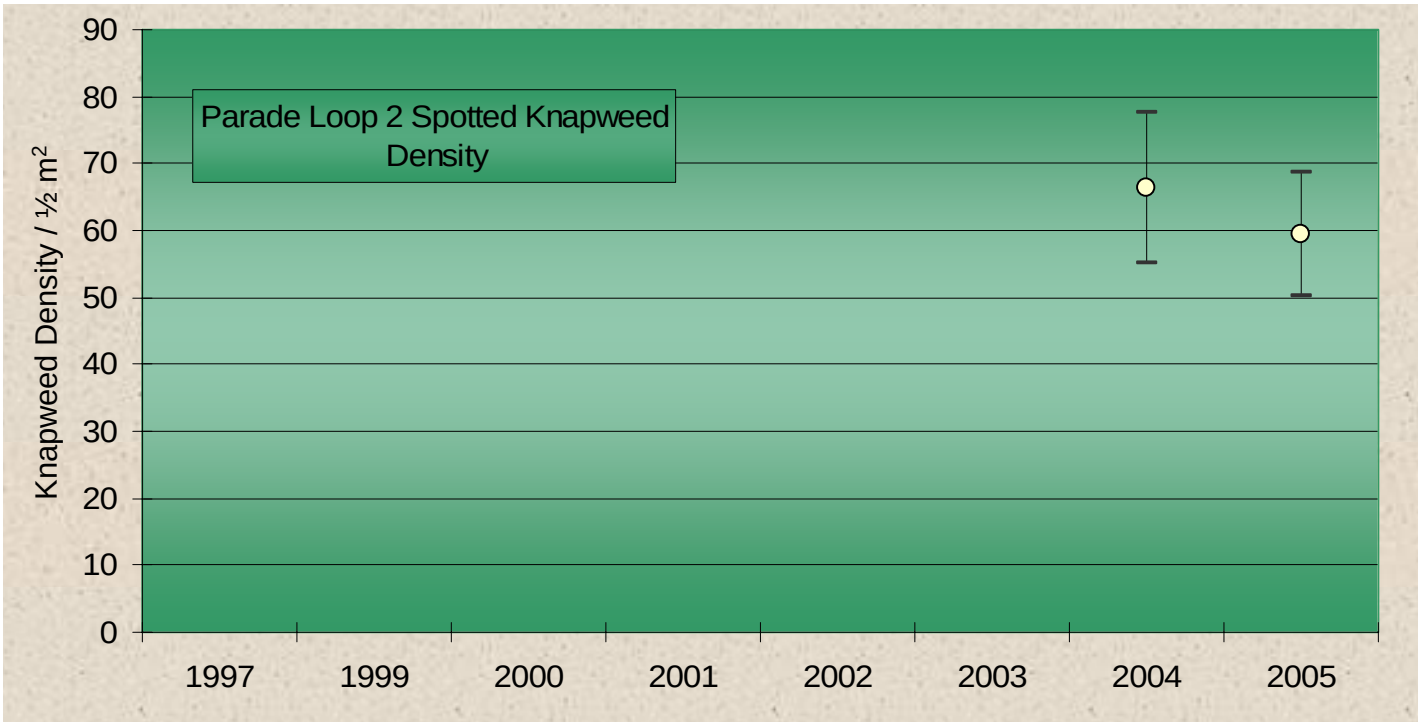


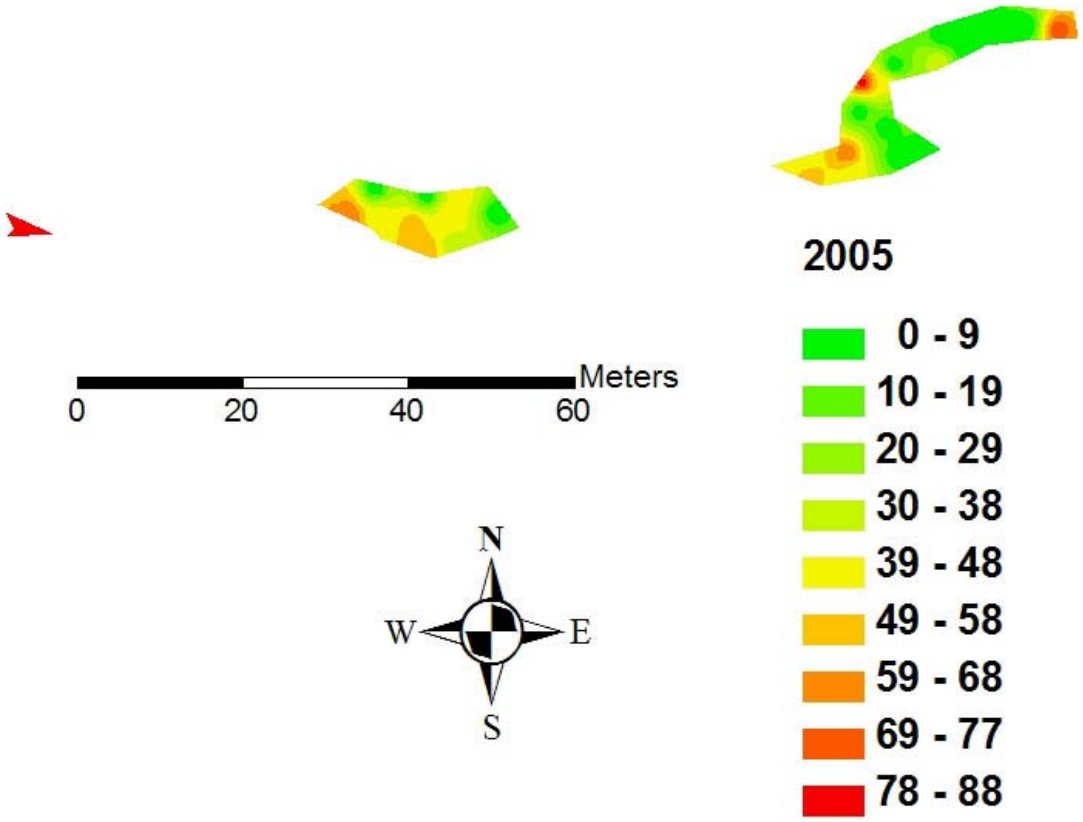


Parade Loop II spotted knapweed perimeter in 2005.

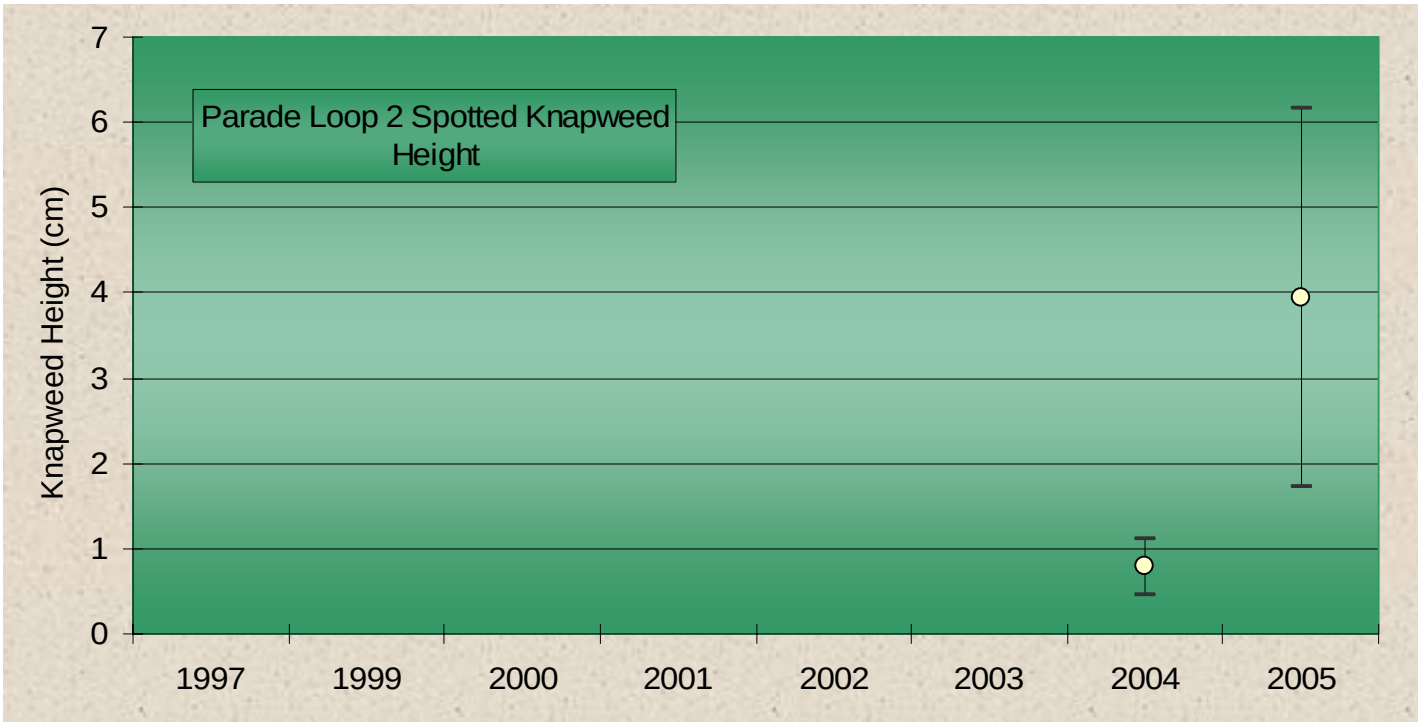


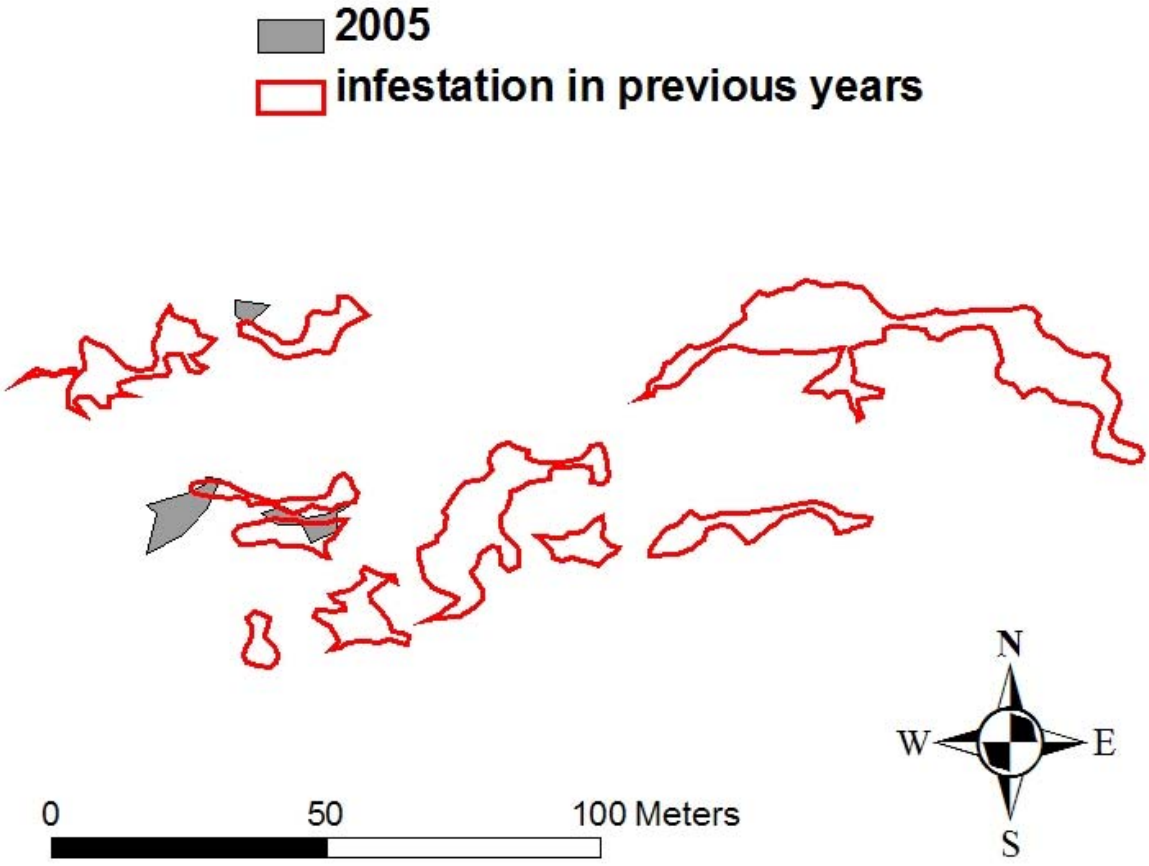
Parade Loop II spotted knapweed density in 2005.



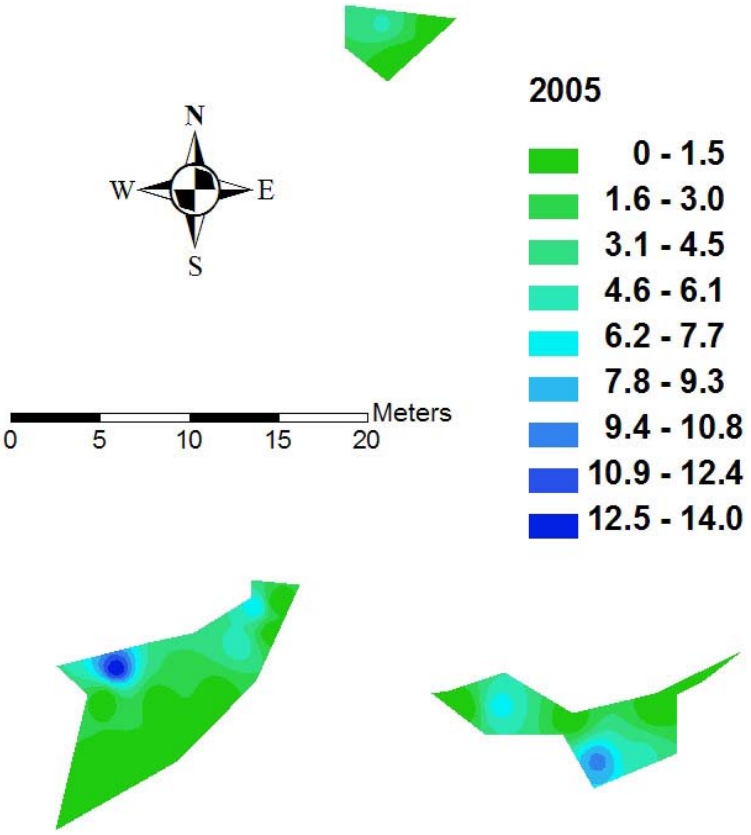


Parade Loop II spotted knapweed height in 2005.

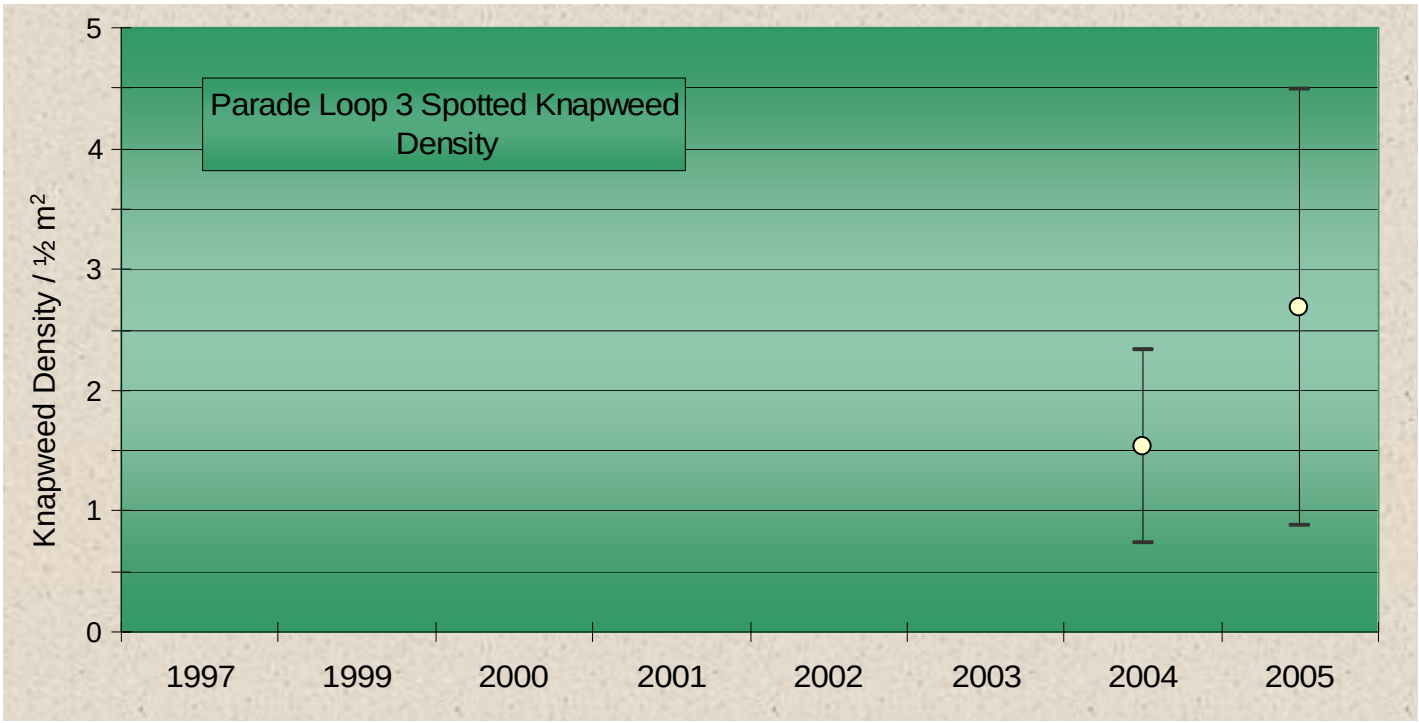


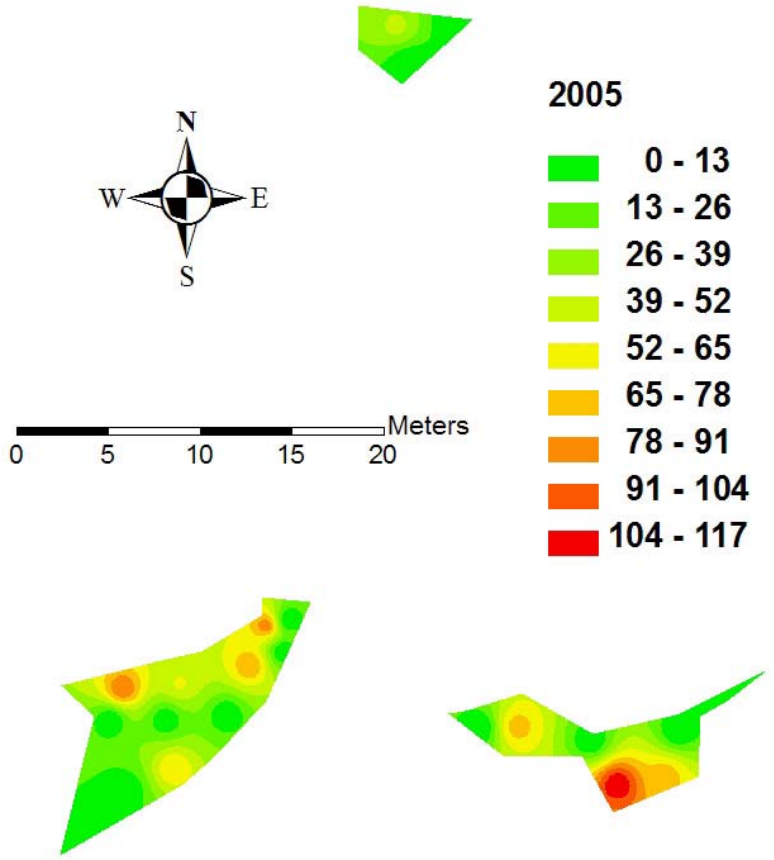


Parade Loop III spotted knapweed perimeter in 2005.

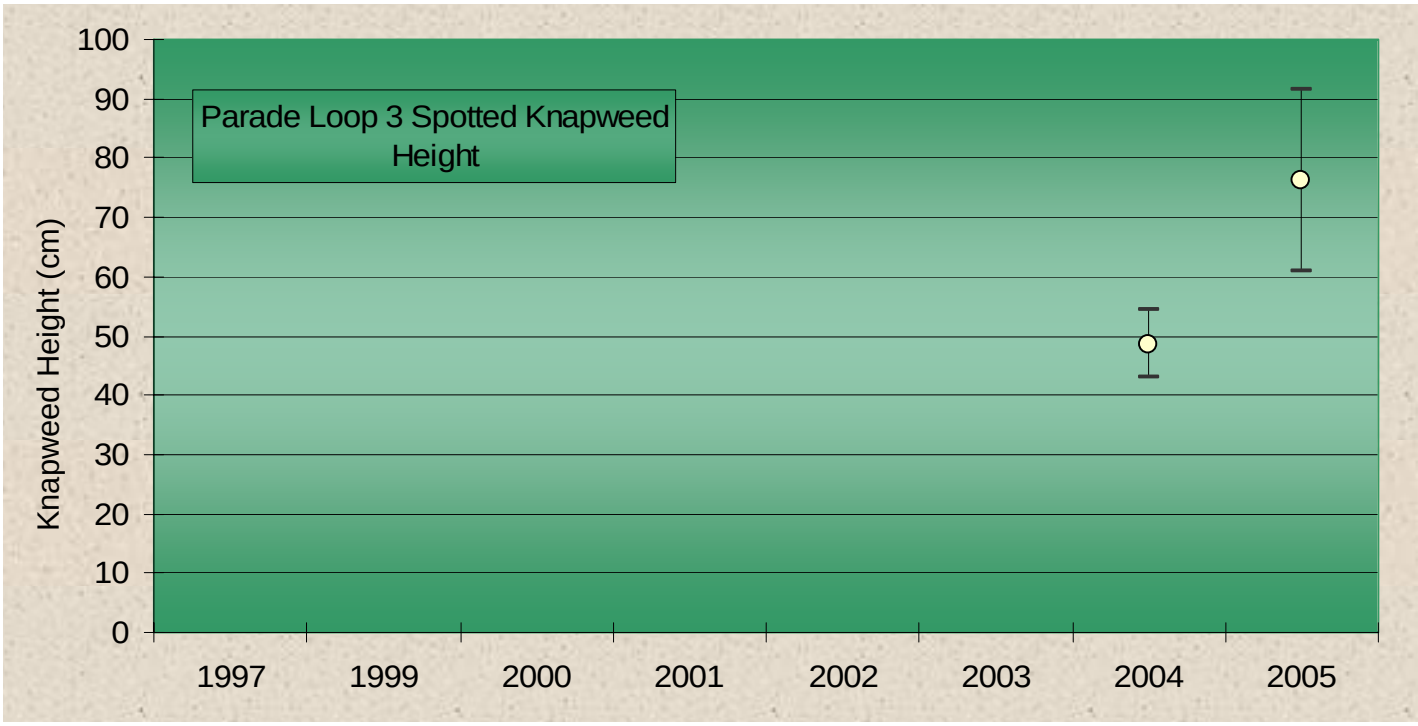


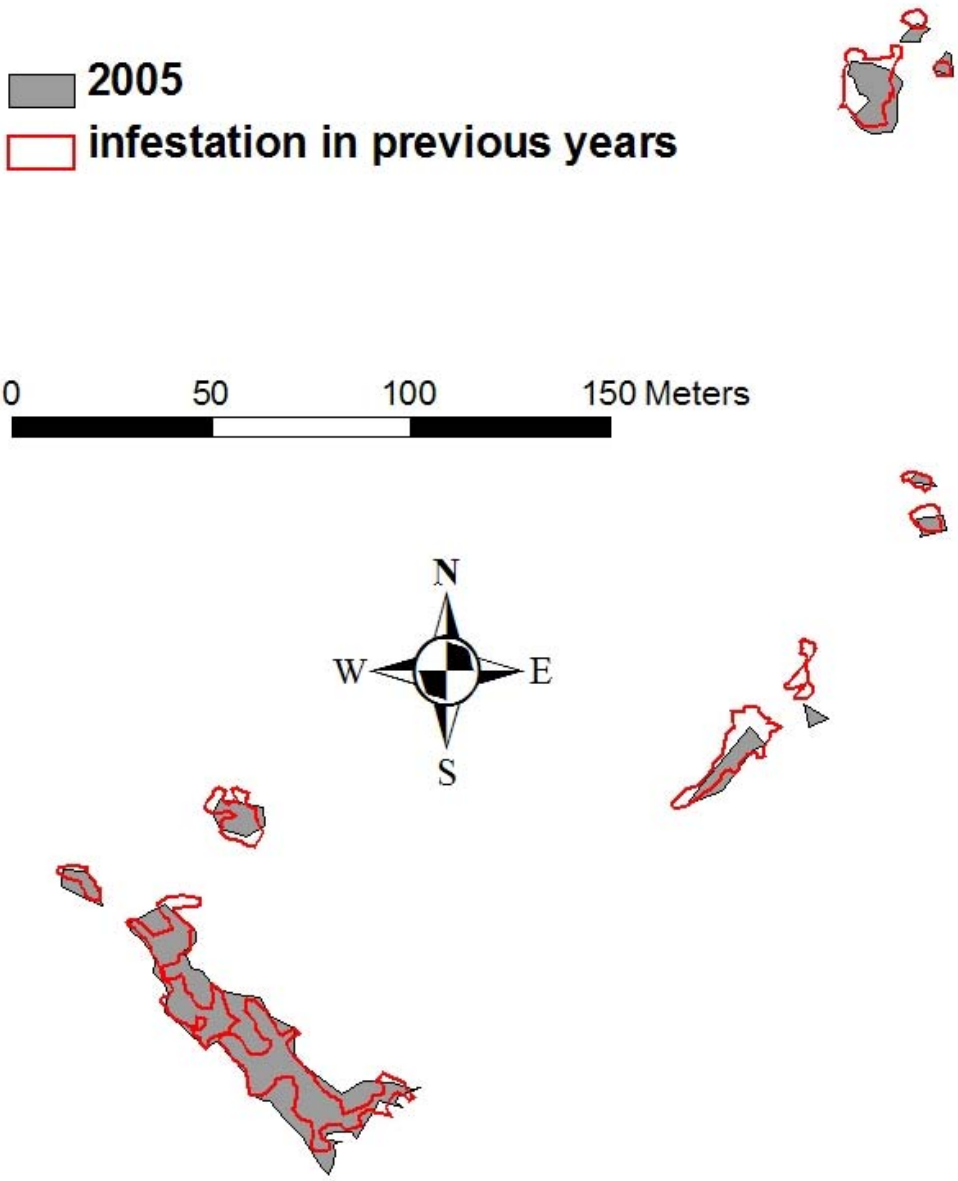
Parade Loop III spotted knapweed density in 2005.



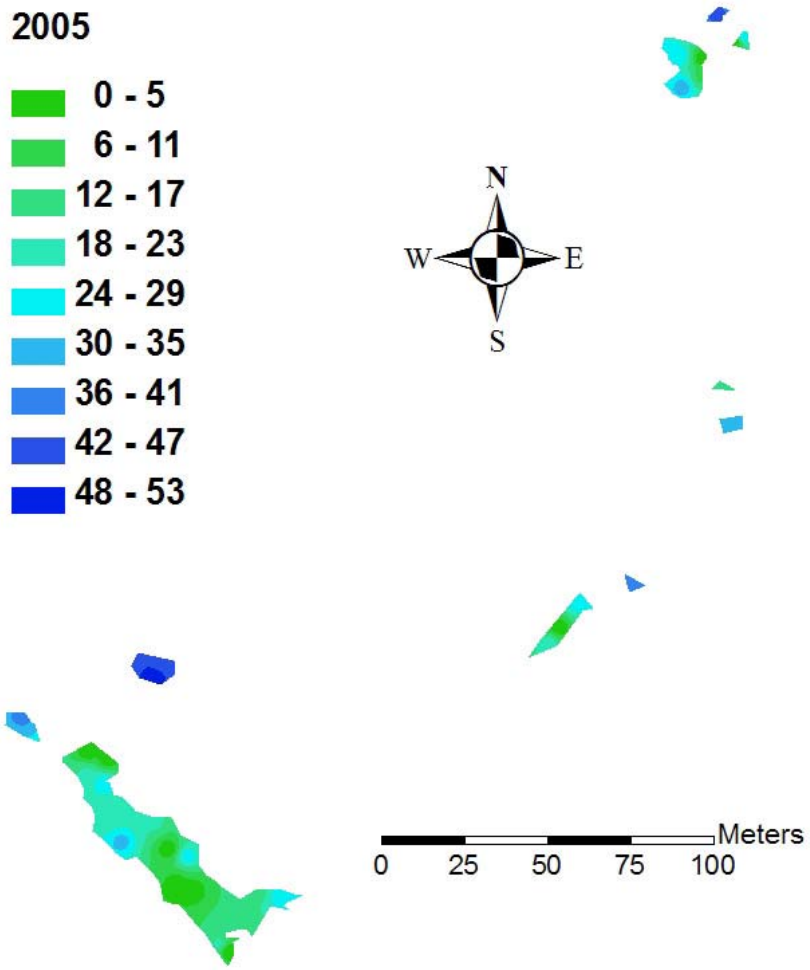


Parade Loop III spotted knapweed height in 2005.

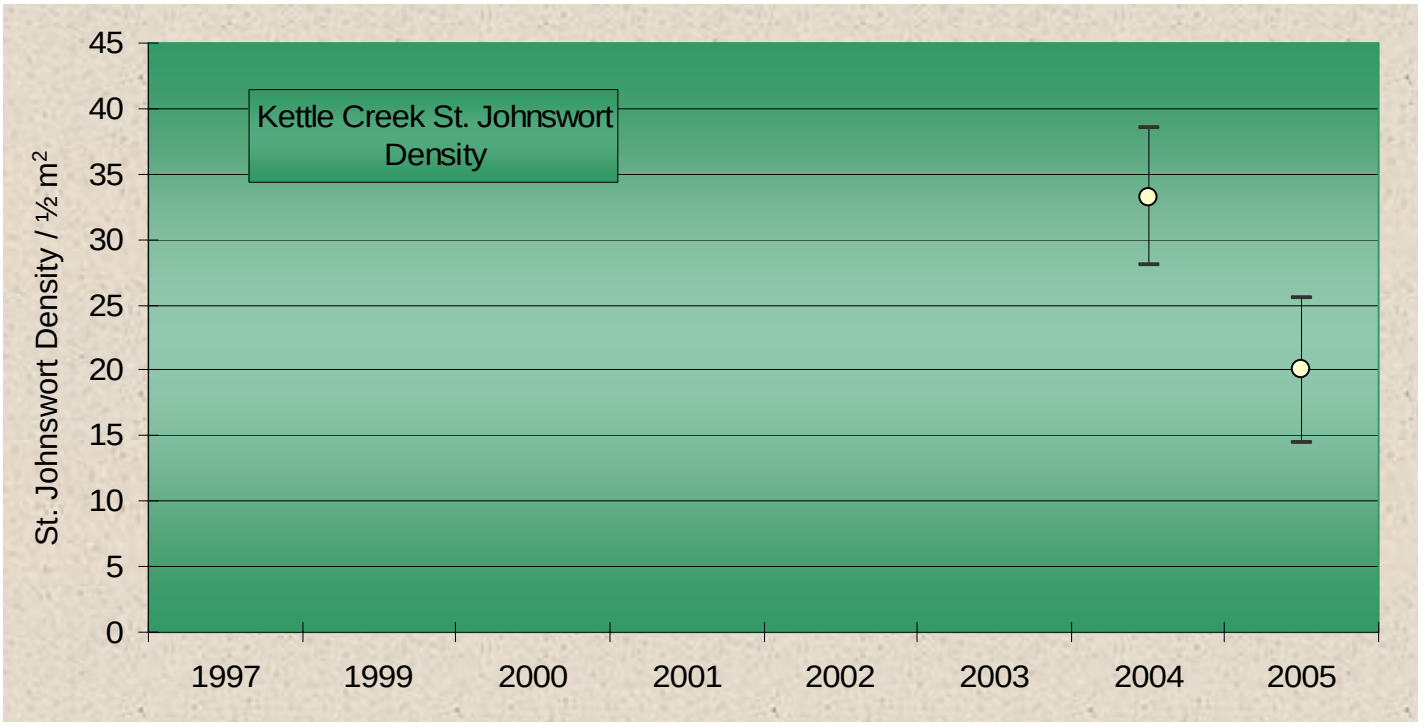


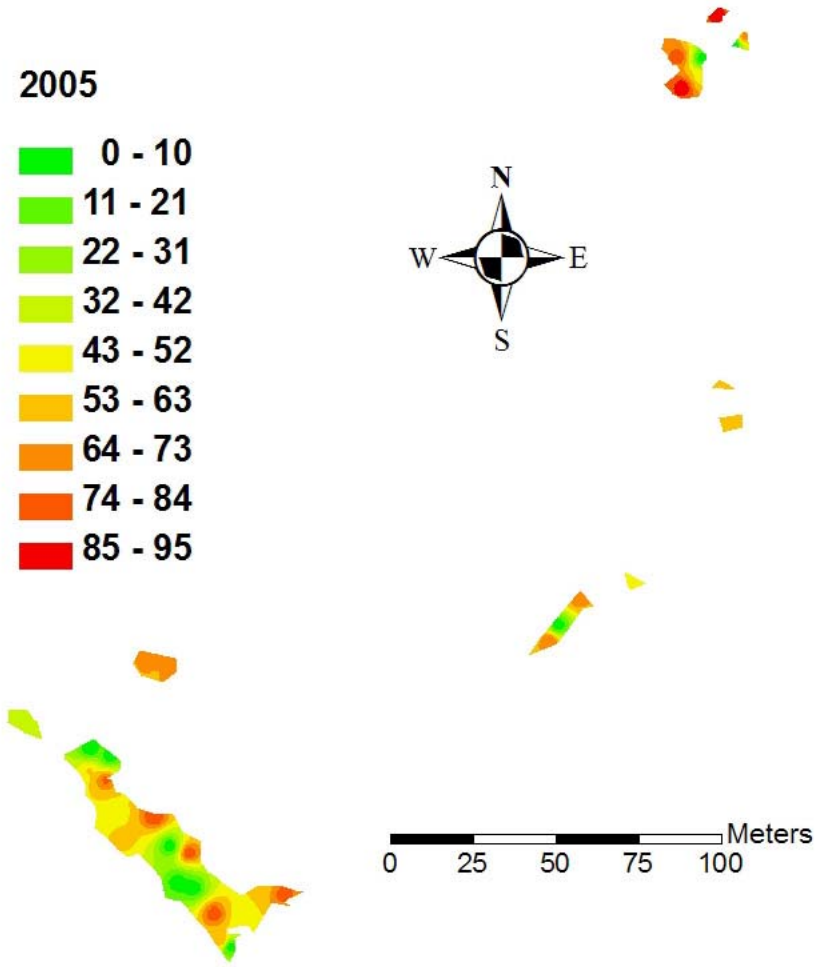


Kettle Creek St. Johnswort perimeter in 2005.

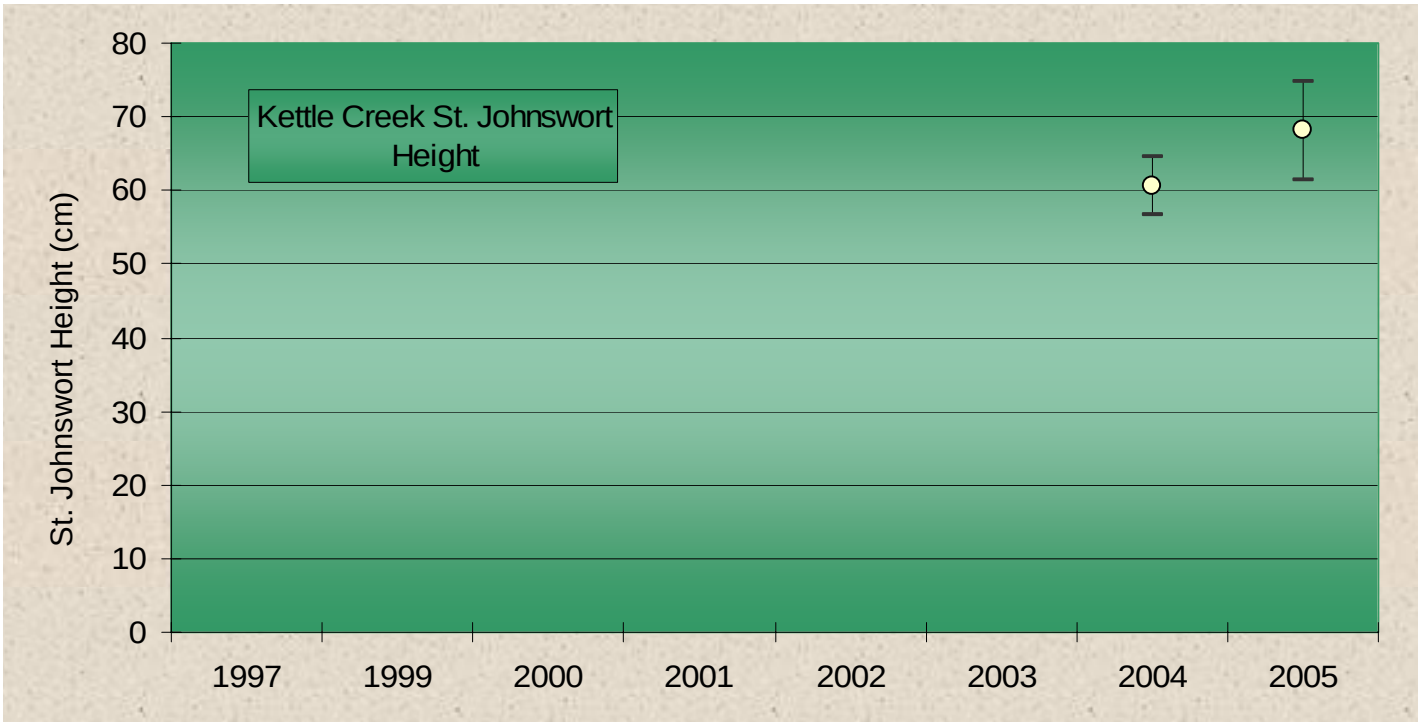


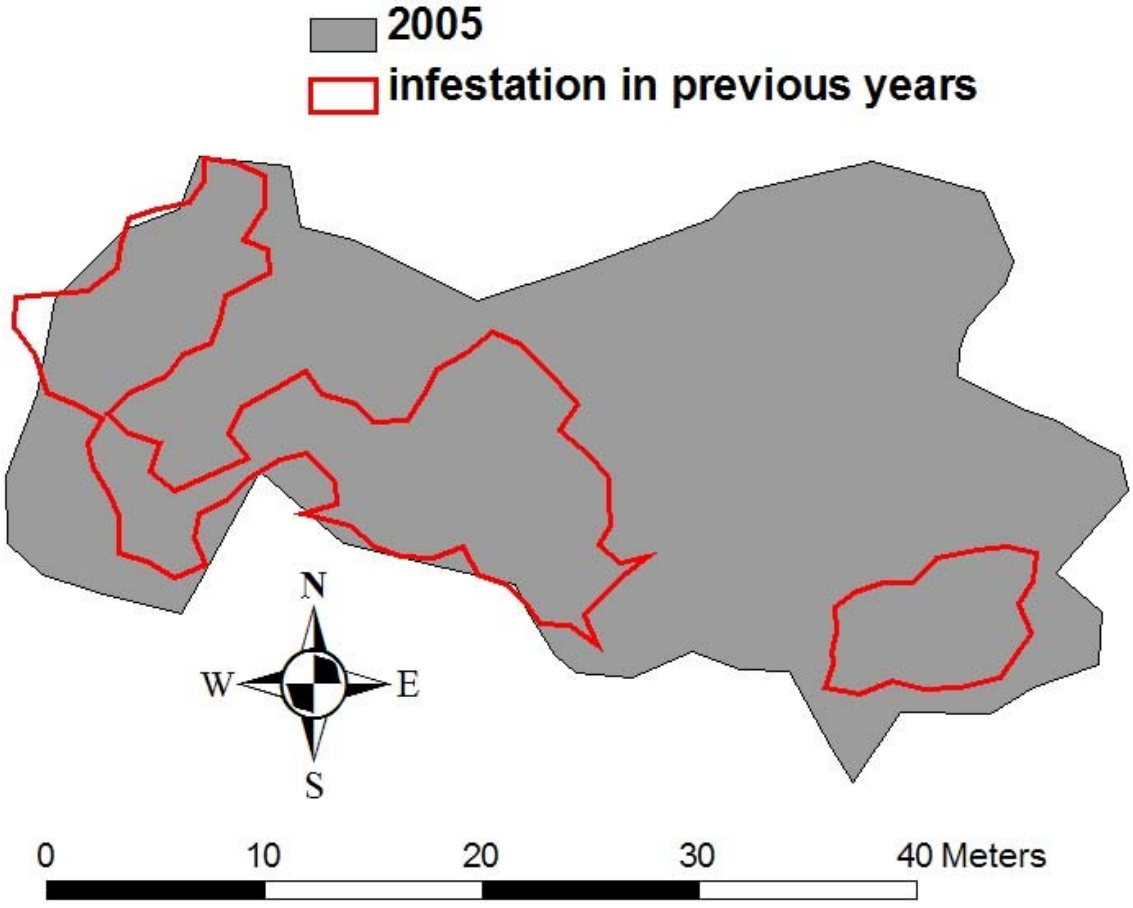
Kettle Creek St. Johnswort density in 2005.



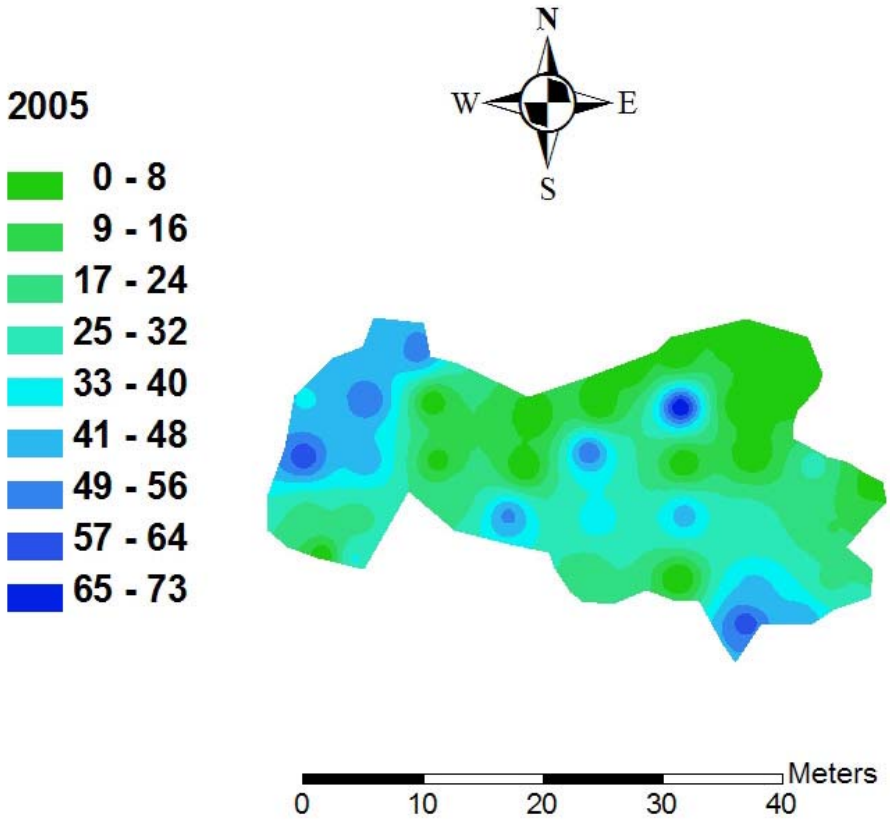


Kettle Creek St. Johnswort height in 2005.

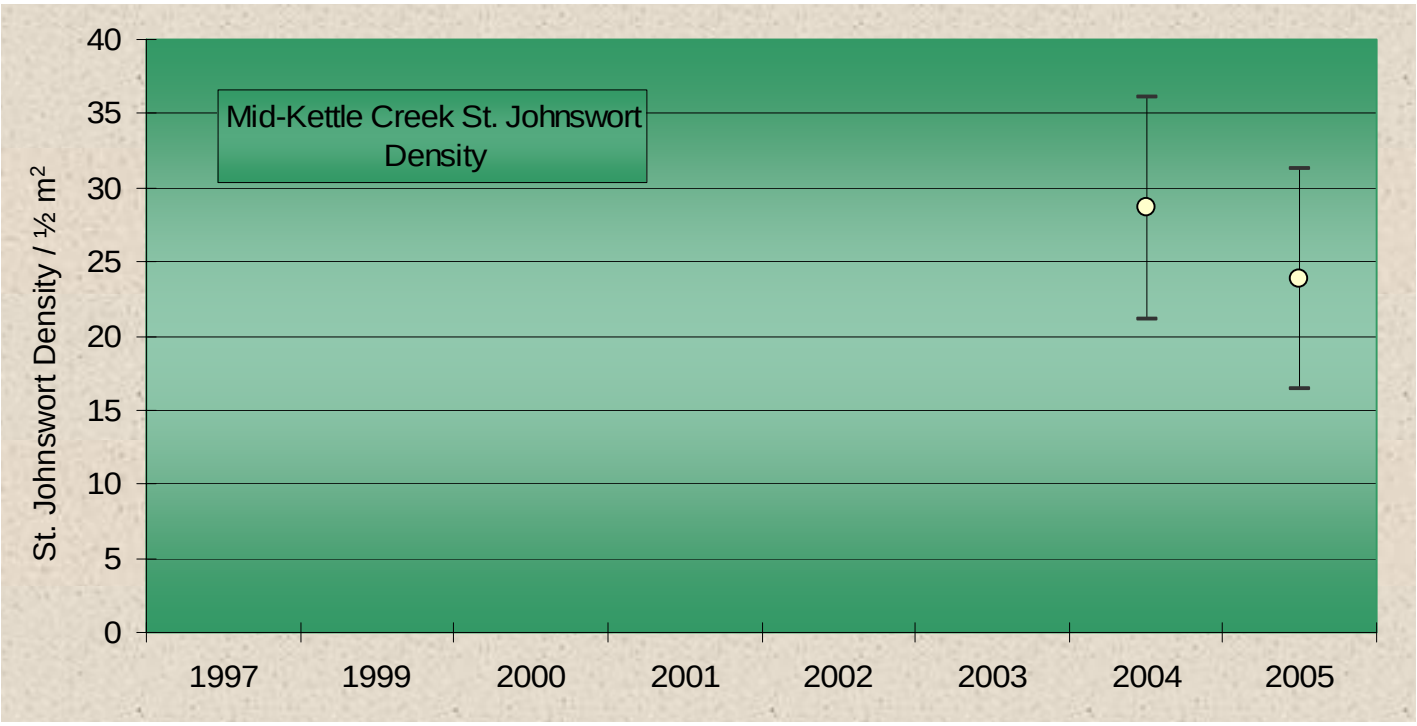


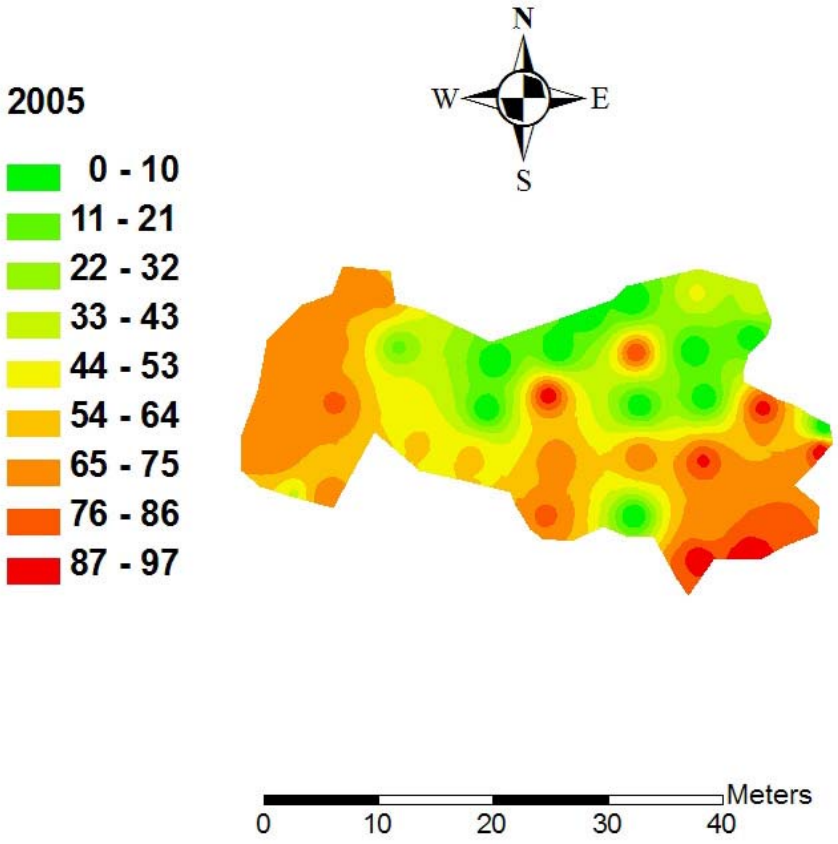


Midway Kettle Creek St. Johnswort perimeter in 2005.

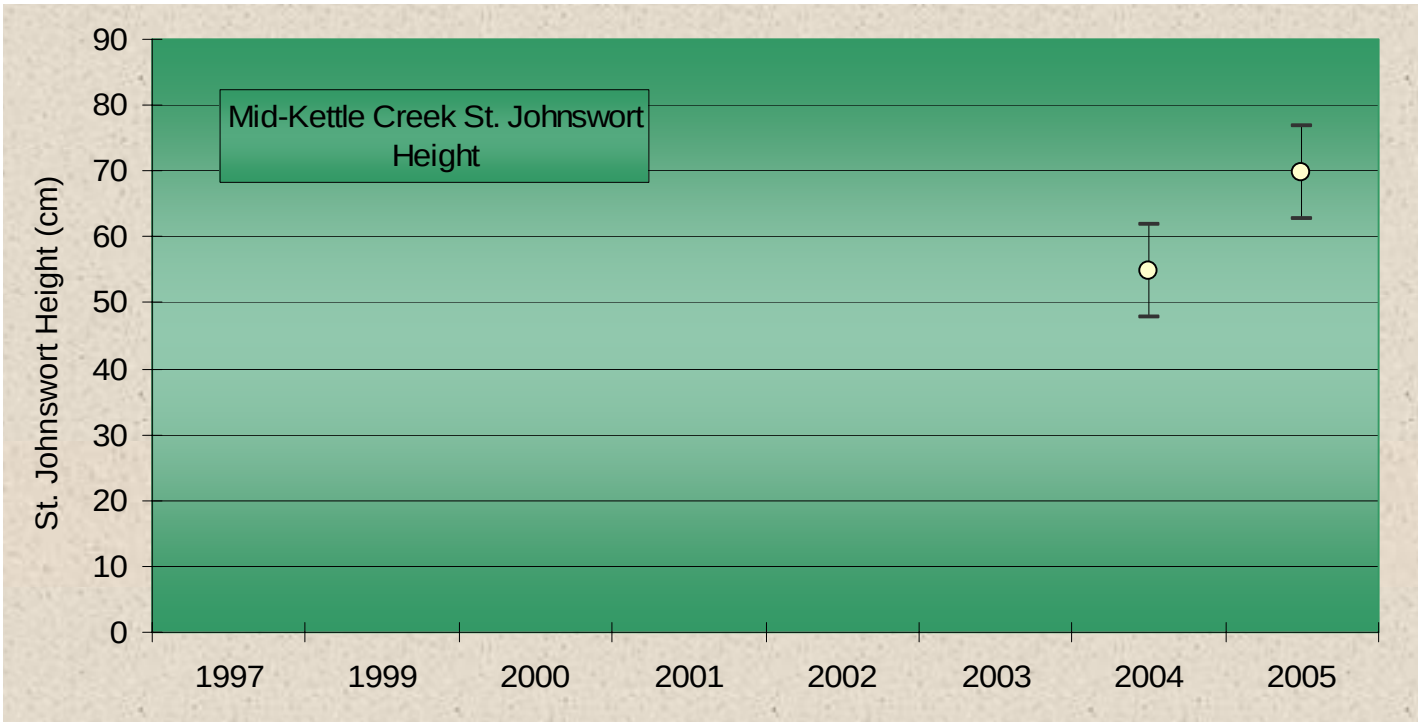


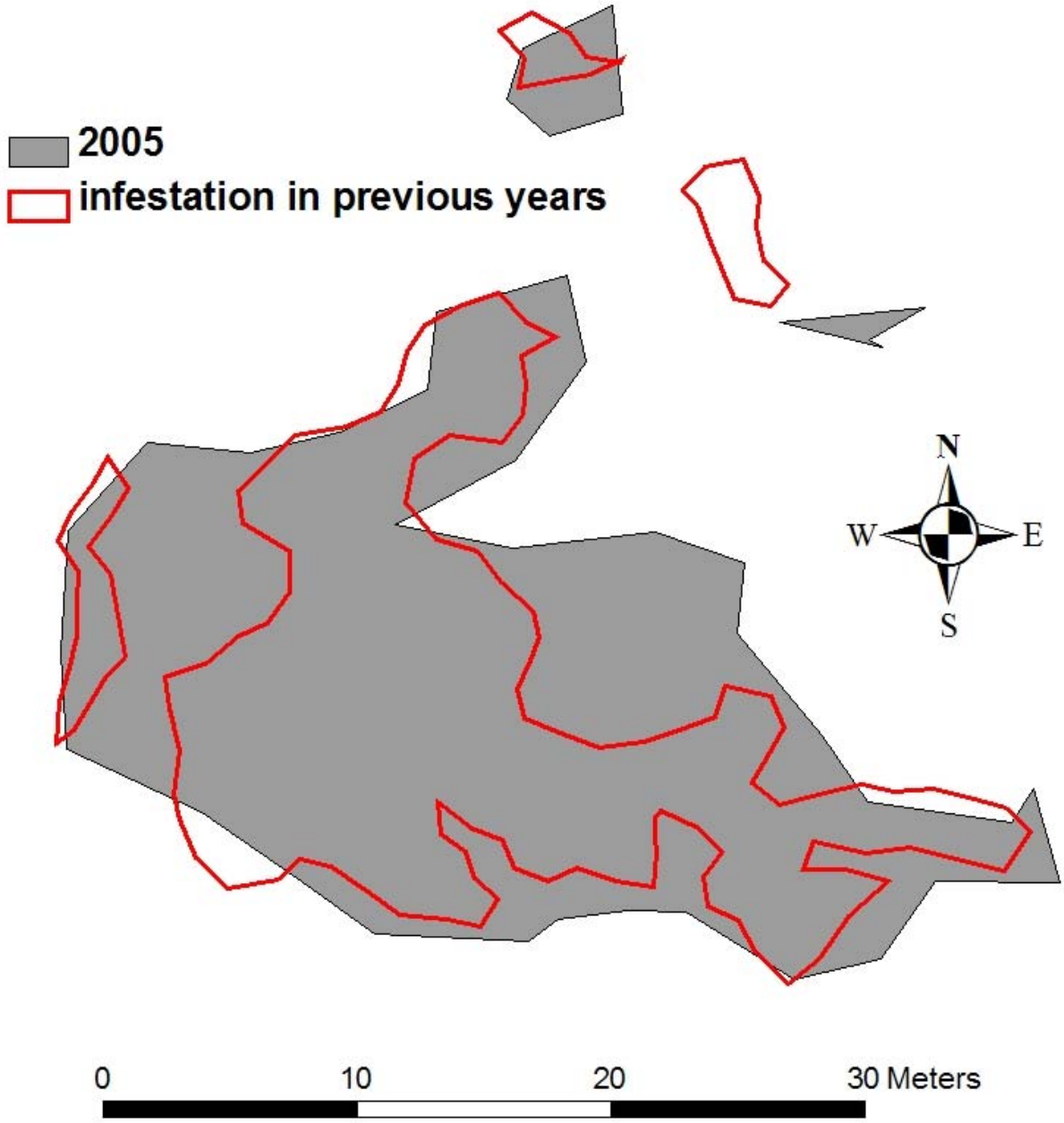
Midway Kettle Creek St. Johnswort density in 2005.



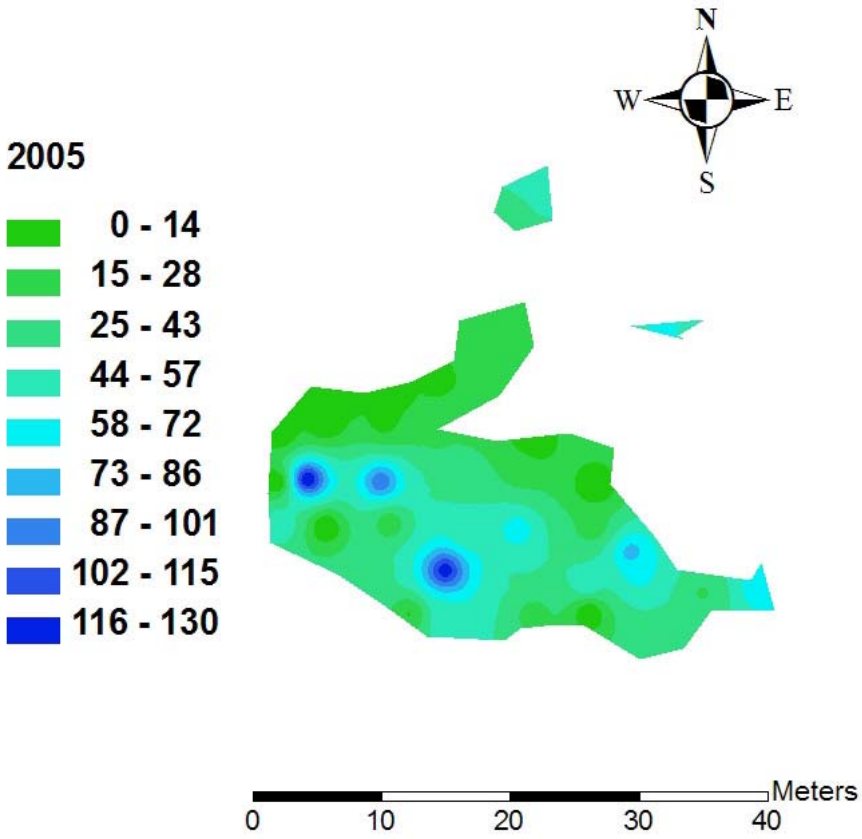


Midway Kettle Creek St. Johnswort height in 2005.

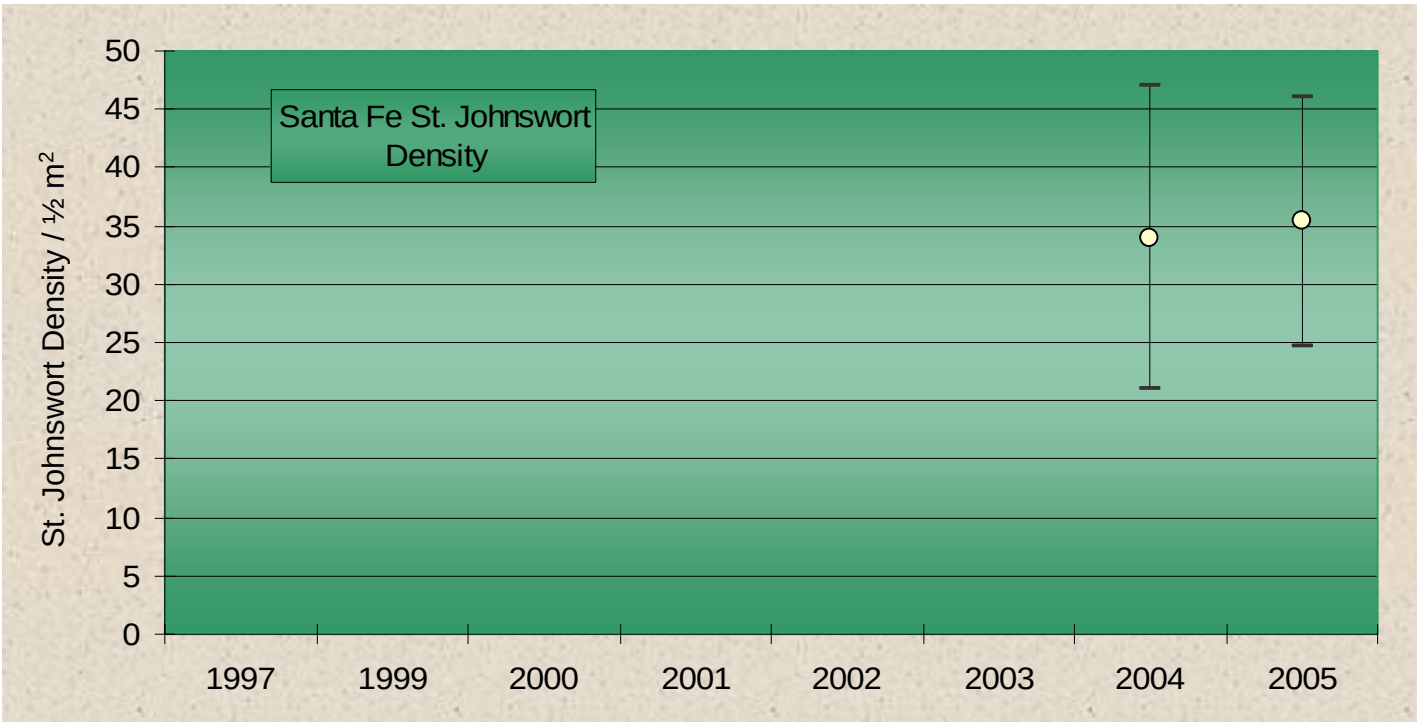


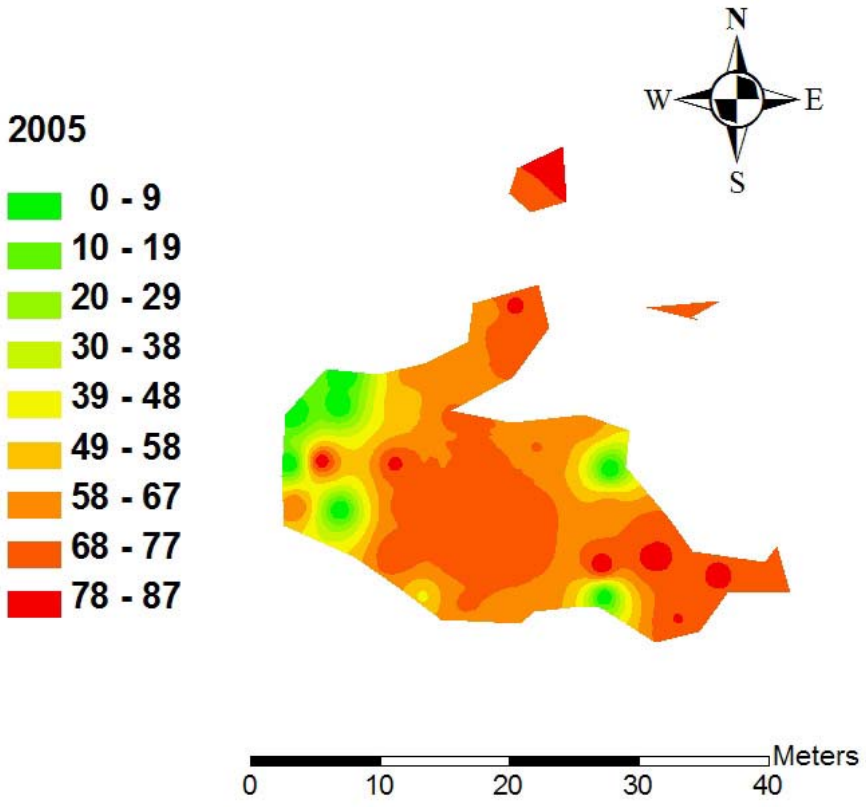


Santa Fe St. Johnswort perimeter in 2005.

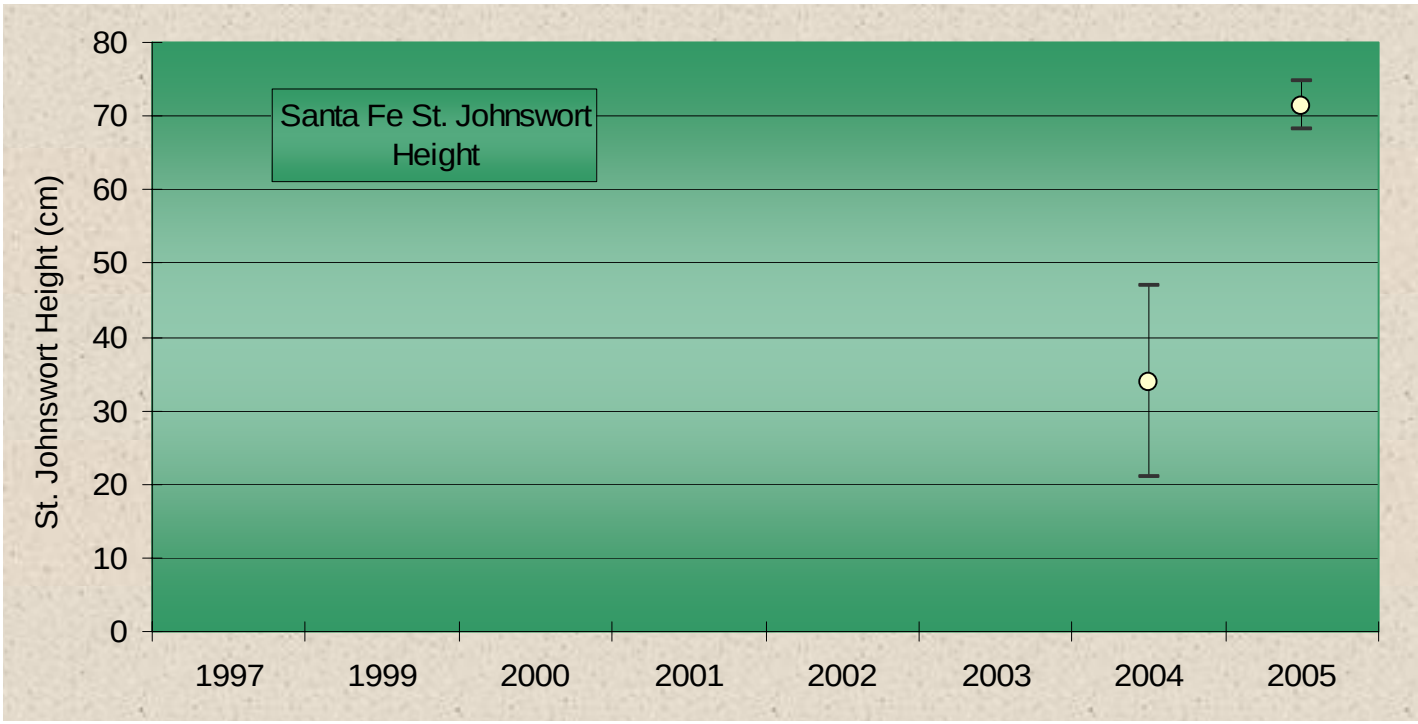


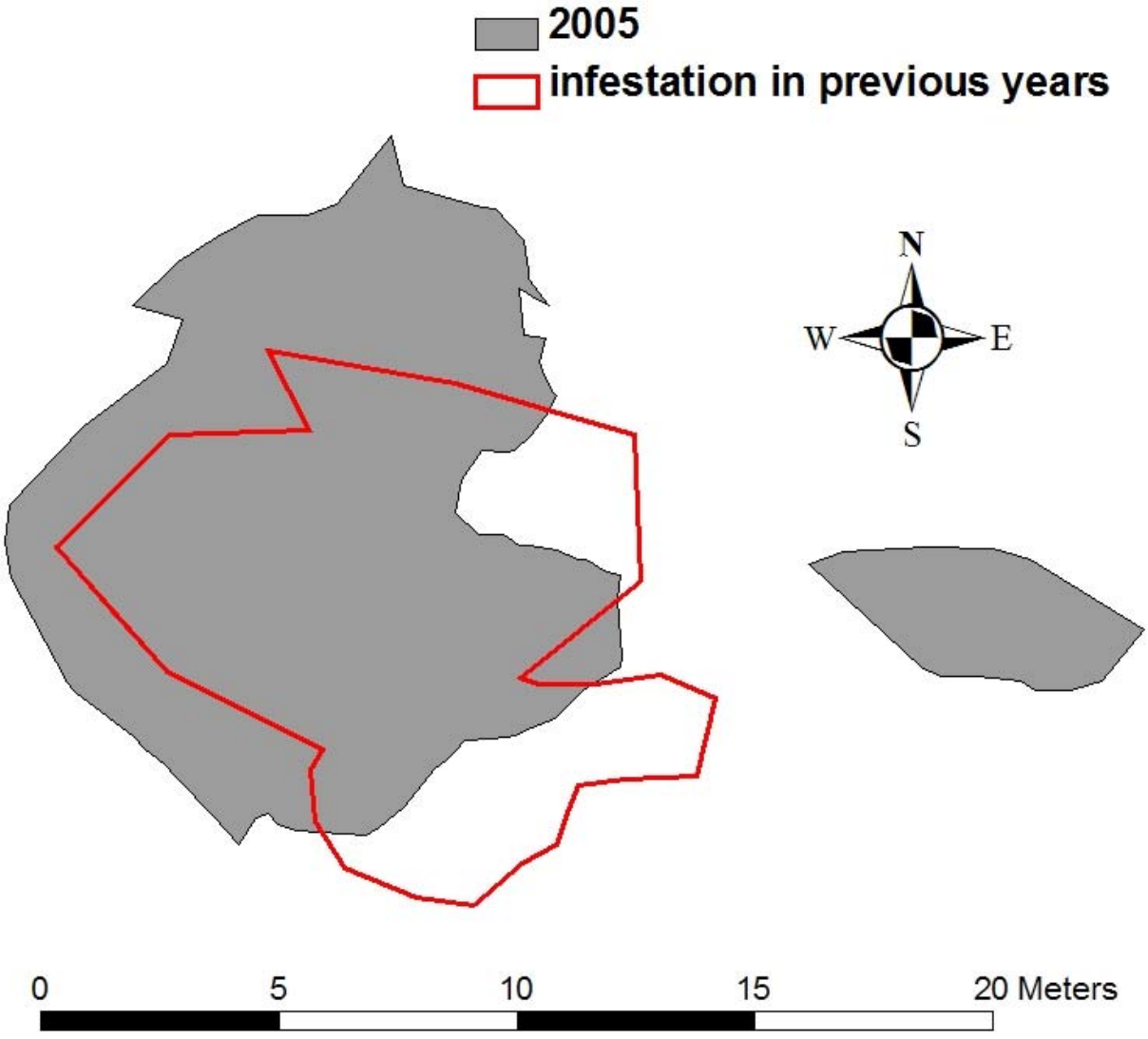
Santa Fe St. Johnswort density in 2005.



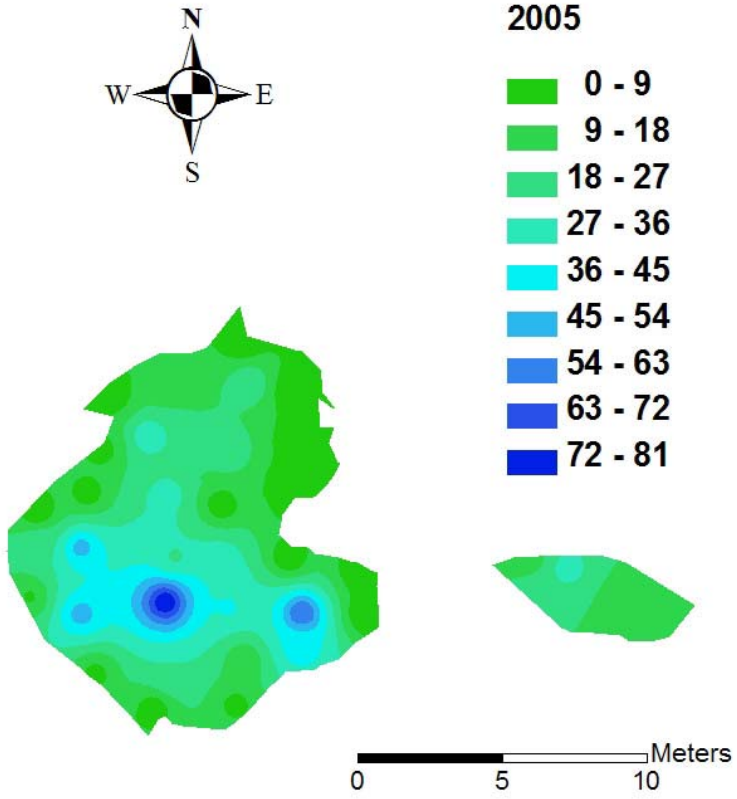


Santa Fe St. Johnswort height in 2005.





Community Center Drive I yellow toadflax perimeter in 2005.



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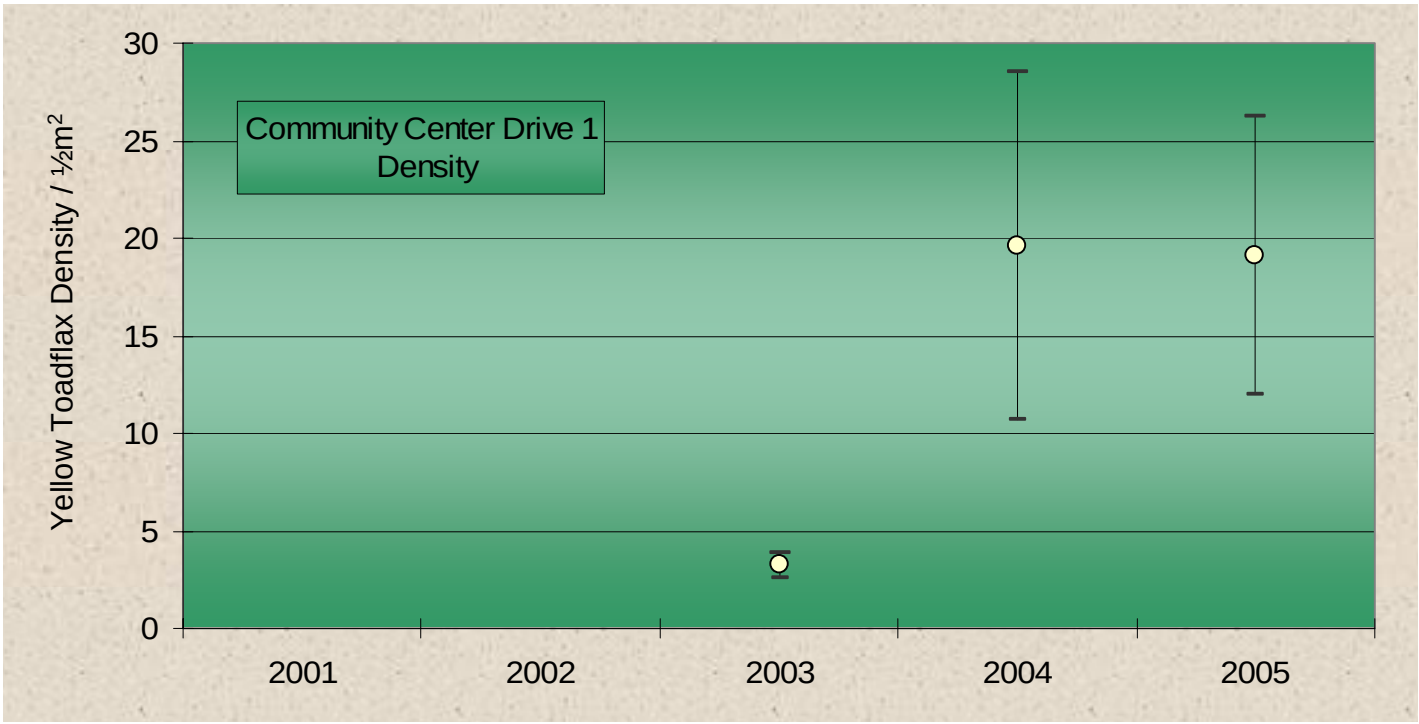
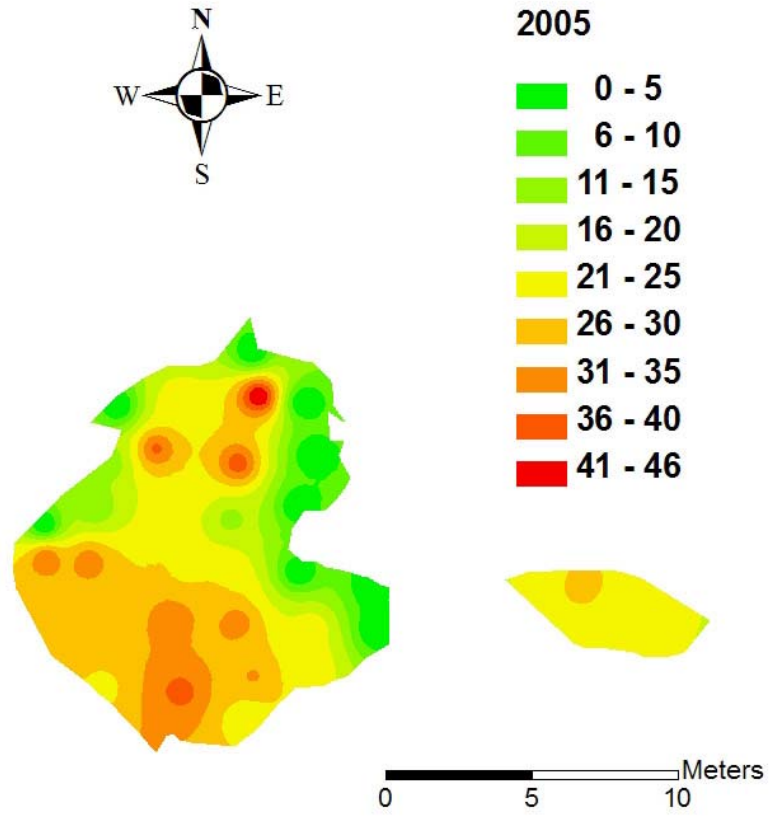
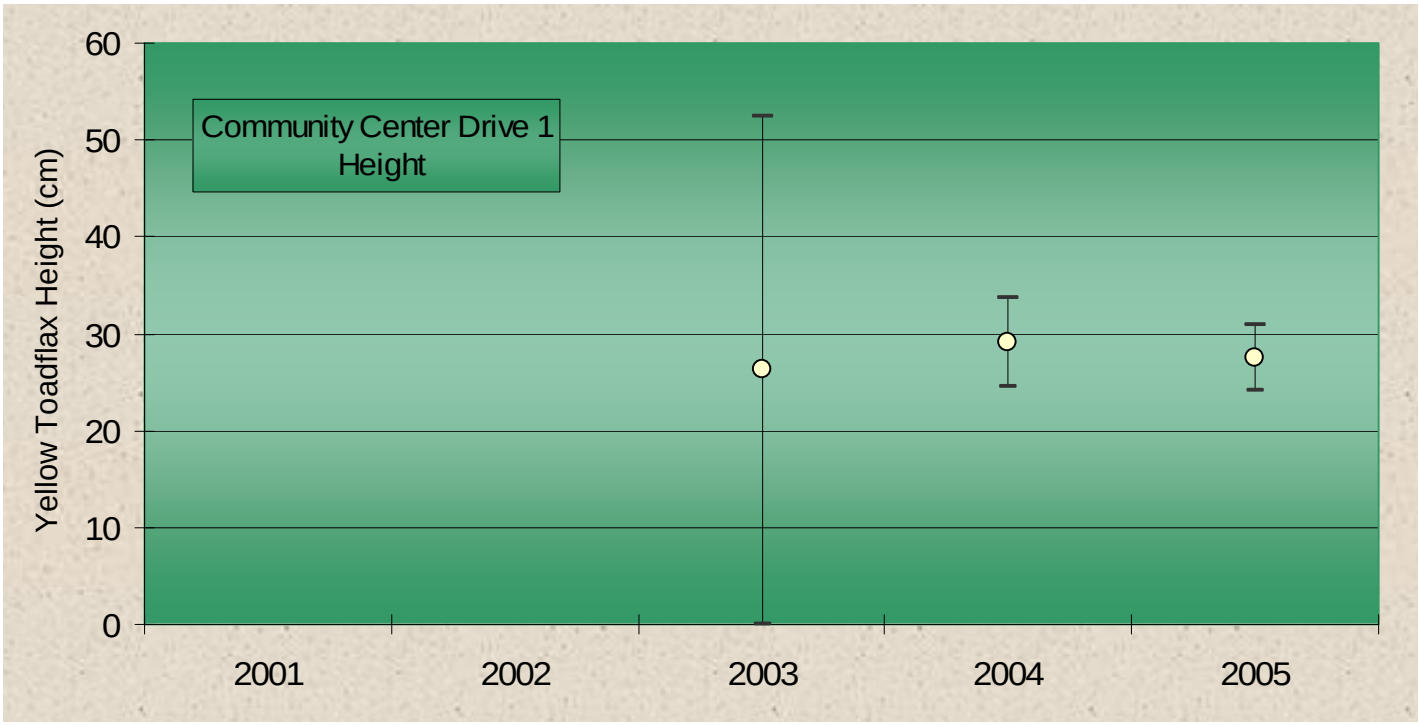
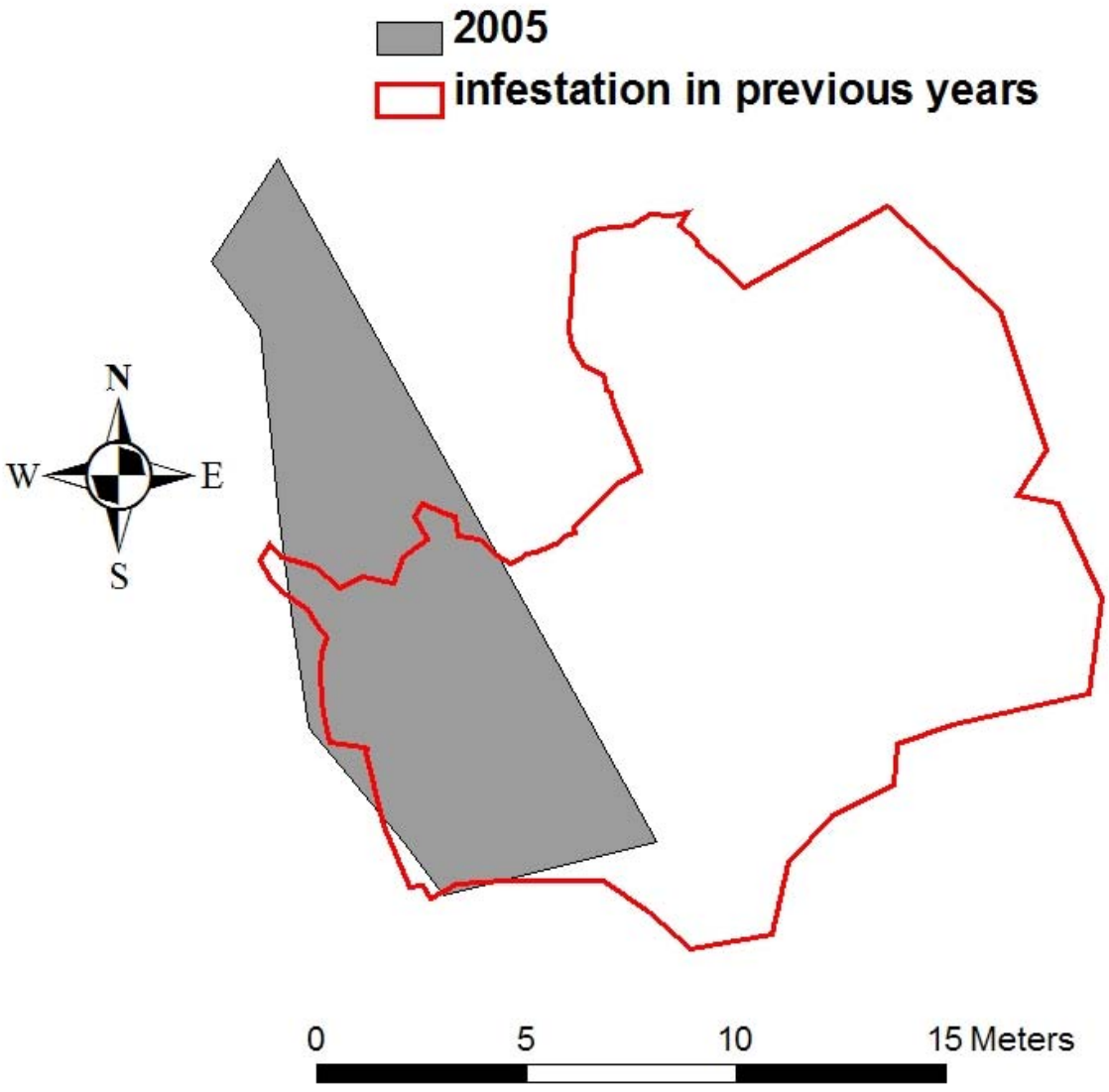


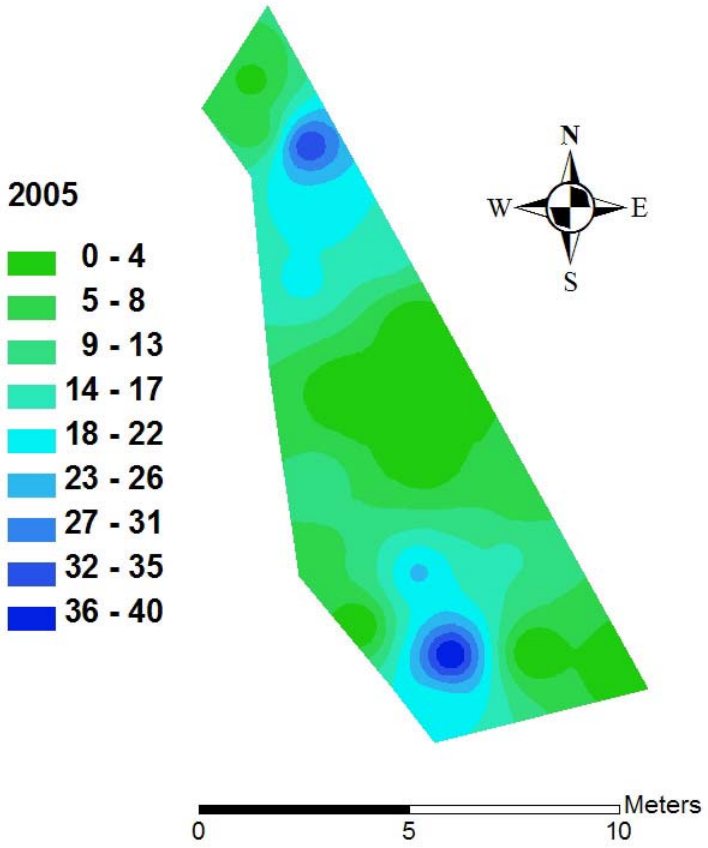


Community Center Drive I yellow toadflax height in 2005.





Community Center Drive II yellow toadflax perimeter in 2005.



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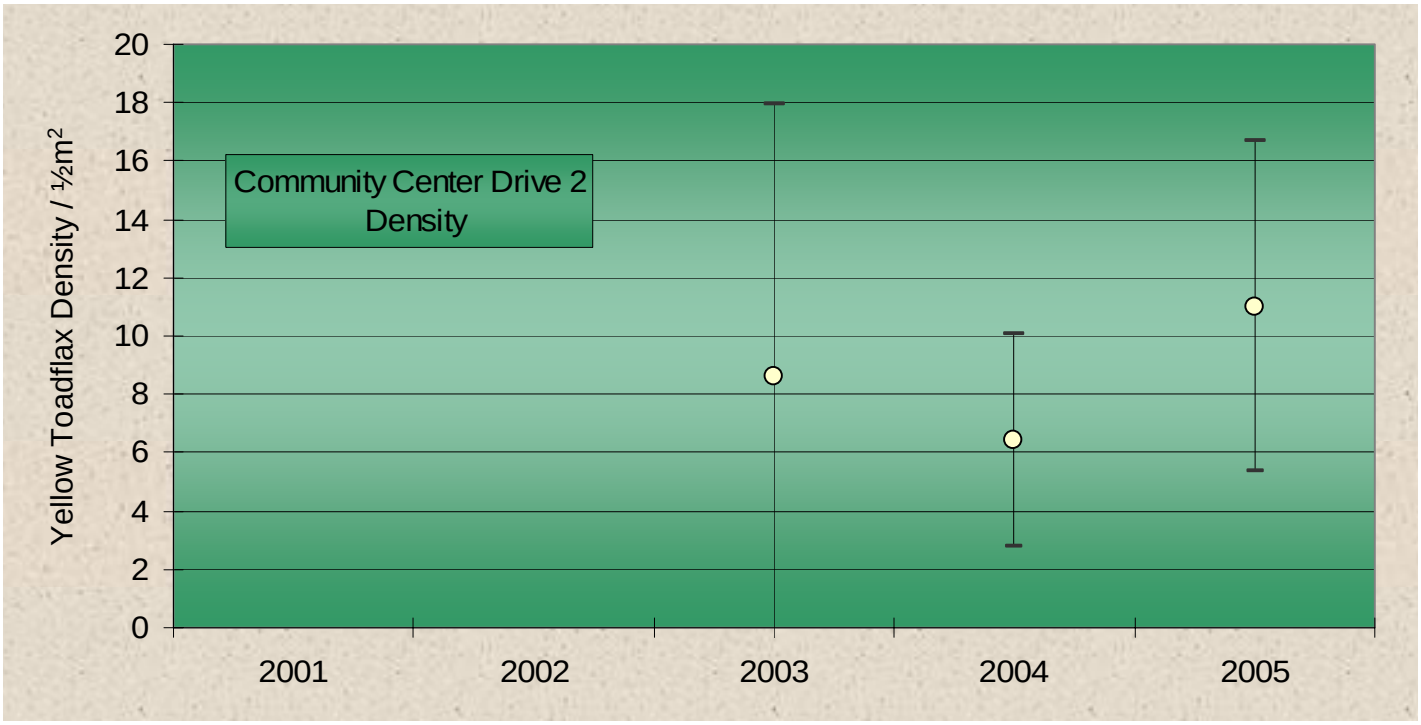
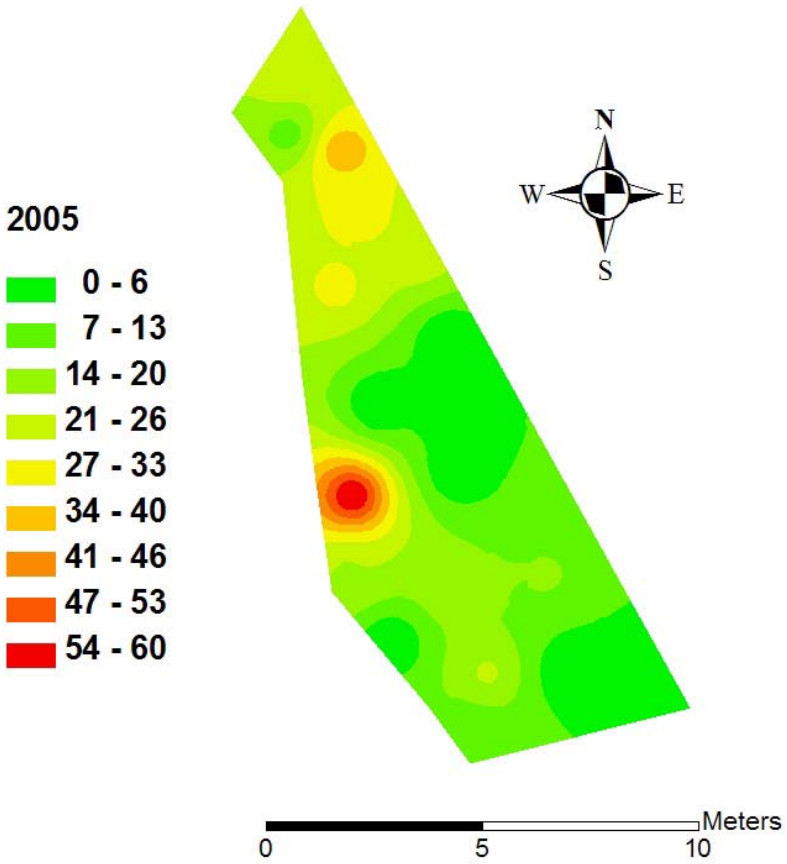
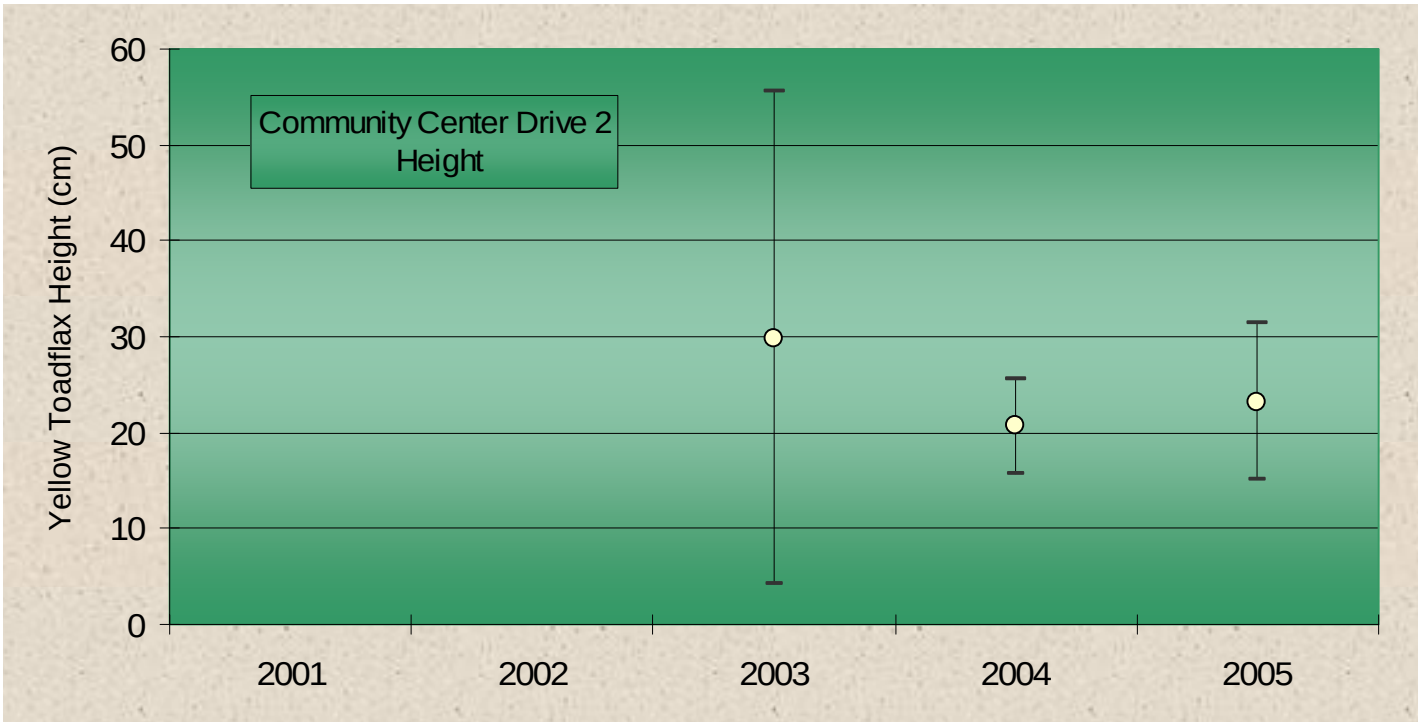
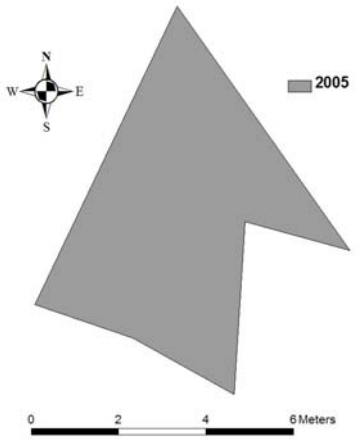


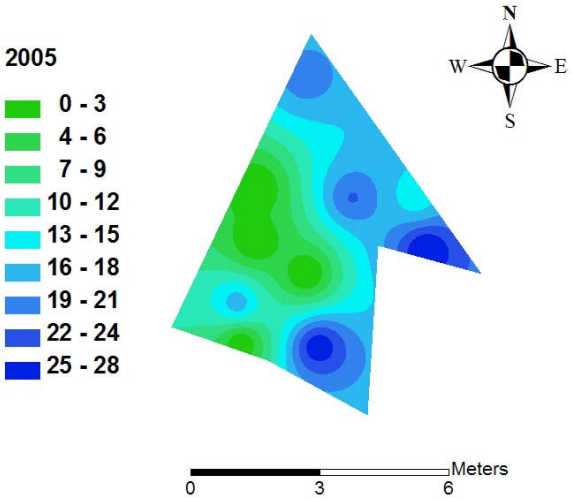


Community Center Drive II yellow toadflax height in 2005.

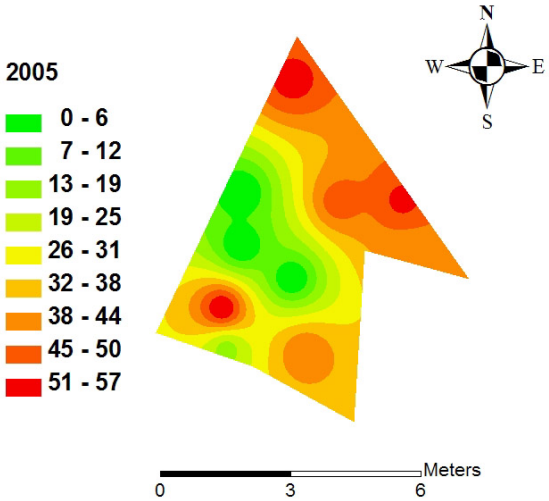




Community Center Drive III spotted knapweed perimeter in 2005.



Community Center Drive III spotted knapweed density in 2005.



Community Center Drive III spotted knapweed height in 2005.

Buckley Air Force Base

Seven weed patches from 2004 were again mapped at Buckley Air Force Base in 2005. In addition to the infestations monitored in 2004, we mapped a small, discrete patch of leafy spurge near the runway and identified it as the Interior site (Table 8). A total of 2.7 ha of weeds were mapped this year, including 0.20 ha of Canada thistle at Williams Lake, 0.44 ha of leafy spurge scattered across the base (4 sites) and 2.07 ha of Dalmatian toadflax, chiefly at the South Fence location (Figure 9). Despite much more favorable conditions for weed growth in 2004 and 2005, we have not seen a significant increase in the extent or abundance of either leafy spurge or Dalmatian toadflax at Buckley Air Force Base (Table 8). The area inhabited by Canada thistle at Williams Lake did spread from 2004 to 2005, however, weed density was reduced by almost 50%. In general, Canada thistle appeared more widespread in 2005 in various areas on base, as well as at nearby Rocky Flats Environmental Technology Site in Golden, CO.

Weed scouting efforts, with the assistance of Floyd Hatch and Kara Altvater, identified several other Canada thistle infestations near the Runway and SAW sites. Plans are underway to target these infestations with biological control agent releases and some monitoring in the future. Construction projects on base may also necessitate additional biological control efforts within disturbed areas in the coming years. The SAW Dalmatian toadflax site, for example, has dramatically increased in both density and height over a single season post-construction. High traffic areas near these sites should be carefully monitored for the spread and establishment of noxious weeds and bio-control agent release made accordingly.

Figure 9. Student workers, Sean Best (left) and Ed Raetz, map the extensive South Fence Dalmatian toadflax infestation near the 2004 point of *M. janthinus* release (orange marker, left).

In 2005, we revisited our initial biological control efforts on bindweed. By mid-summer, it became apparent at many areas both on and off base that dense monocultures of flowering bindweed had formed. Consequently, one of our main priorities on Buckley Airbase in 2005 was to strategically release more of the bio-control mite, *Aceria malherbae*, throughout the most highly impacted areas. Bindweed tissues, heavily populated by *A. malherbae* were dispersed from individual gallon Ziploc bags into four new sites (FW I, FW II, SAW I, SAW II). These sites were chosen on their likelihood of being mowed, as frequent mowing of bindweed after release of the mites greatly improves their dispersal and establishment. Each of these sites will be monitored in future years to ensure that healthy populations of *A. malherbae* are established.

A total of 8,680 *Aphthona* spp. flea beetles were released in 2005 onto four leafy spurge infestations (Runway site, established in 2004; the newly identified leafy spurge sites Interior, North Runway and South Fence). The different beetle species released at each site are listed in Table 9. As with the *Aphthona* spp. liberated at Air Force Academy in 2005, individual releases of 4,000 flea beetles each, composed of *A. cyparissiae*, *A. czwalinae*, *A. lacertosa*, and *A. nigriscutis*, were made at the Williams Lake and South Fence leafy spurge infestations. The releases were spread across shaded and open microhabitats to maximize establishment potential of the beetles.

A single release of 192 *Mecinus janthinus* was made in 2005 into the Dalmatian toadflax at the South Fence location to augment the population of insect agents previously released into this site. Evidence of *M. janthinus* attack (feeding and oviposition scars on collected stalks), combined with the observation of individual adults in stalks from the 2004 growing season, indicates that the weevil has successfully established at the South Fence site, albeit in low numbers. We are beginning to evaluate the influence of abiotic factors (primarily temperature and freezing) on weevil establishment and survival at the South Fence location, as well as at Rocky Flats Environmental Technology Site. Augmentative releases of *M. janthinus* are planned for 2006 at this and the South Aspen Way site.

In addition to the 8,862 insects released onto Buckley Air Force Base this summer, we had the opportunity to introduce a new insect agent against leafy spurge (Table 9). Spurge tip gall midge, *Spurgia esula*, was recovered from sites at F. E. Warren Air Force Base and transferred to the Williams Lake leafy spurge patch (Figure 10). Workers distributed 90-120 leafy spurge stems, each occupied by multiple *S. esula* larvae and pupae, throughout the spurge infestation. Capable of substantially deforming the tips of early spurge shoots before flowering and seed production can occur, this tiny midge offers the potential to improve biological control efforts on leafy spurge by acting augmentatively with *Aphthona* spp. defoliators. We are hopeful that a nursery site for this additional agent will be established at Williams Lake.

Figure 10. Leafy spurge (left) released at Williams Lake, inhabited by biological control agent *Spurgia esula*. The characteristic galling of the shoot tips is seen on the right.

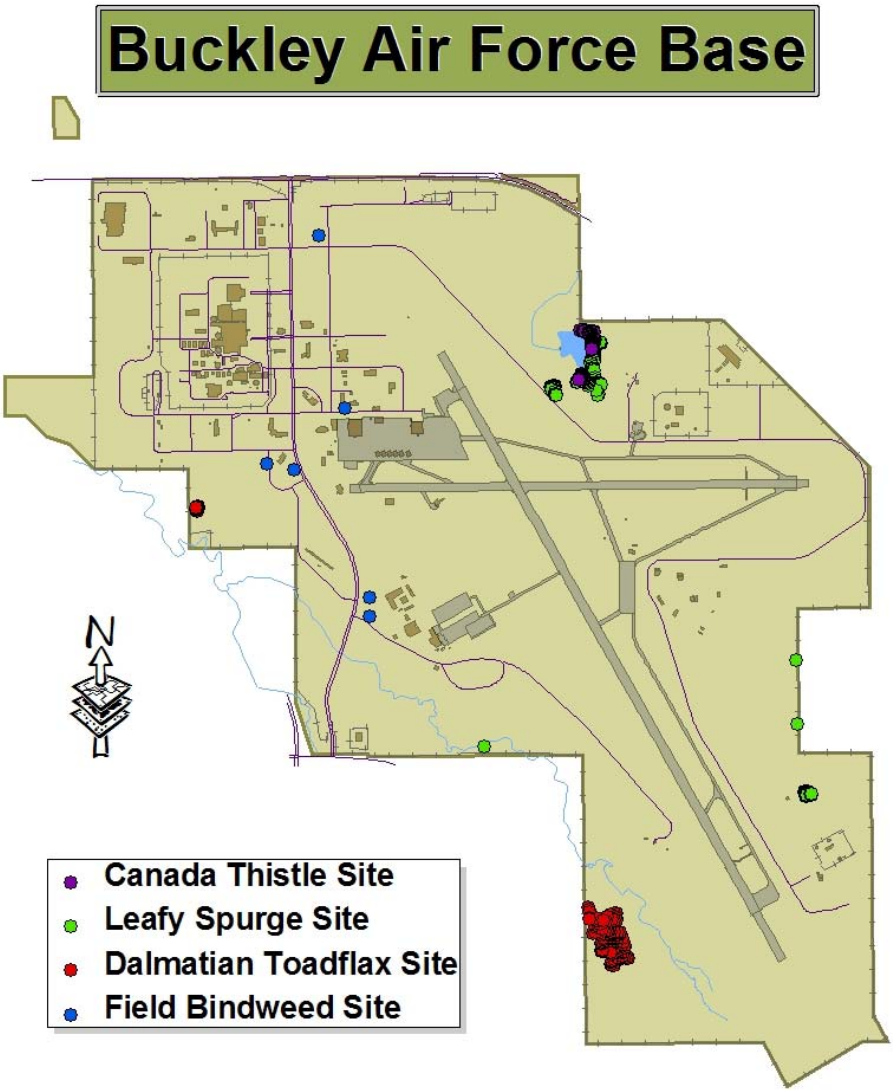


Figure 11. Schematic diagram of Buckley Air Force Base with weed biological control study areas superimposed.

Table 8. Historic noxious weed infestation parameters, Buckley Air Force Base, Colorado, 2003-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. Seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Canada Thistle – William's Lake												
2003	1,070	129	6.45	26	65.92	145	17.83	0.71				
2004	1,419	66	9.52	47	51.92	98	1.40	1.80	32.63	47.60	-21.24	
2005	2,004	40	5.26	18	74.31	105	18.97	0.88	41.23	-44.75	43.12	87.29
Leafy spurge - Interior												
2005	102	28	8.07	99	39.59	57			na	na	na	na
Leafy spurge - Runway												
2004	597	44	22.61	42	35.09	54						
2005	751	34	29.50	95	43.92	66			25.80	30.47	25.16	25.80
Leafy Spurge – Southwest William's Lake												
2004	530	24	8.92	26	25.13	52						
2005	646	40	16.62	77	29.64	54			21.89	86.32	17.95	21.89
Leafy Spurge – William's Lake												
2003	4,615	112	36.53	123	51.06	98						
2004	3,617	77	15.01	52	39.61	73			-21.63	-58.91	-22.42	
2005	2,890	33	27.52	97	39.69	63			-20.10	83.34	0.20	-37.38
Dalmatian Toadflax – South Aspen Way												
2003	3,185											
2004	300	20	0.95	7	11.40	38			-99.08			
2005	275	28	12.00	61	39.47	59	10.61		-8.33	1163.16	246.23	-91.37
Dalmatian Toadflax – South Fence												
2003	32,556	374	3.50	78	36.10	128						
2004	20,657	101	3.31	18	29.28	82			-36.55	-5.43	-18.89	
2005	20,443	68	18.70	56	56.76	78	20.71		-1.04	464.95	93.85	-37.21

n – number of samples or observations

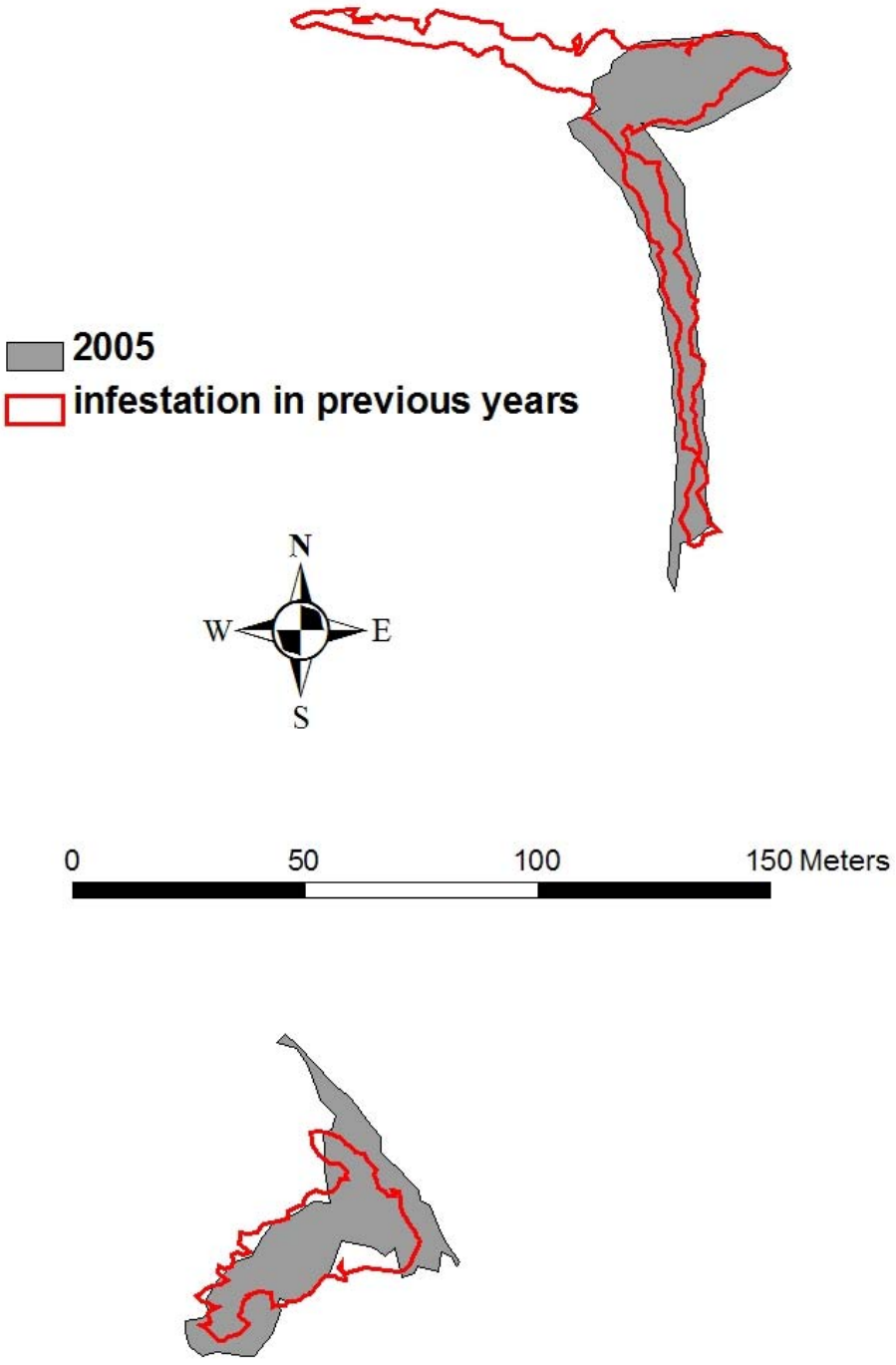
na – not applicable, data represent first year of sampling

Table 9. Noxious weed biological control sites, target weeds, species released and recoveries at Buckley Air Force Base, Colorado, 2005.

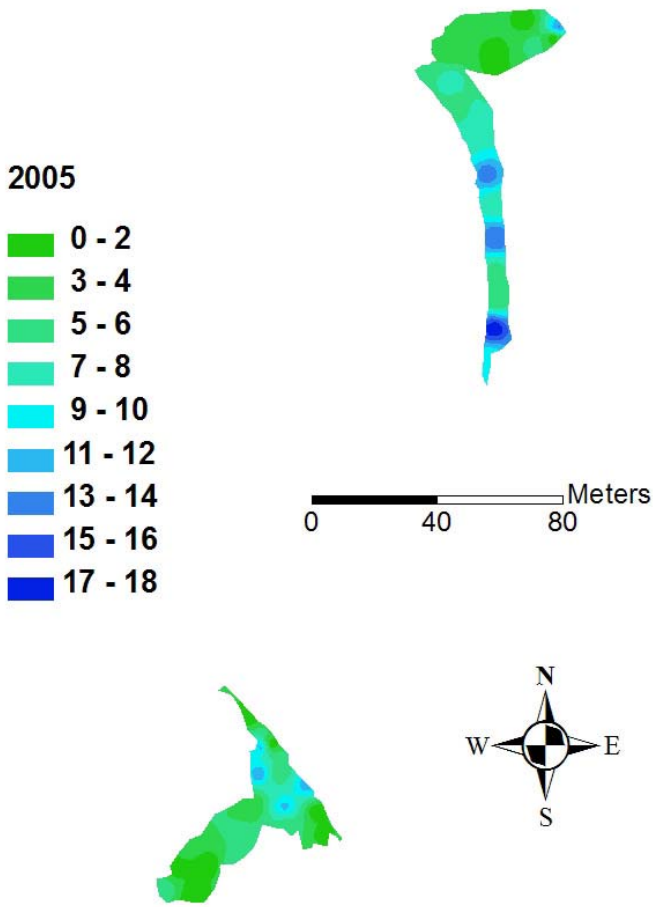
Release Location	Target Weed	Release Site	Species released	Species recovered	New releases	New site
Buckley Airbase	Canada thistle	Williams Lake	*Cassida rubiginosa*			
Buckley Airbase	Canada thistle	Williams Lake	*Trichosirocalus horridus*	X [1]		
Buckley Airbase	Canada thistle	Williams Lake	*Urophora cardui*			
Buckley Airbase	Field bindweed	Multiple sites	*Aceria malherbae*	X	X	
Buckley Airbase	Leafy spurge	Interior	*Aphthona flava*		X	
Buckley Airbase	Leafy spurge	Interior	*Aphthona nigriscutis*		X	
Buckley Airbase	Leafy spurge	Runway North	*Aphthona flava*		X	X [2]
Buckley Airbase	Leafy spurge	Runway North	*Aphthona nigriscutis*		X	X [2]
Buckley Airbase	Leafy spurge	Runway	*Aphthona flava*	X	X	
Buckley Airbase	Leafy spurge	Runway	*Aphthona nigriscutis*	X	X	
Buckley Airbase	Leafy spurge	South Fence	*Aphthona cyparissiae*		X	X [2]
Buckley Airbase	Leafy spurge	South Fence	*Aphthona czwalinae*		X	X [2]
Buckley Airbase	Leafy spurge	South Fence	*Aphthona lacertosa*		X	X [2]
Buckley Airbase	Leafy spurge	South Fence	*Aphthona nigriscutis*		X	X [2]
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona cyparissiae*		X	
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona czwalinae*		X	
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona flava*	X		
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona lacertosa*		X	
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona nigriscutis*	X	X	
Buckley Airbase	Leafy spurge	Williams Lake	*Spurgia esula*		X	
Buckley Airbase	Leafy spurge	Southwest Williams Lake				
Buckley Airbase	Dalmatian toadflax	South Aspen Way				
Buckley Airbase	Dalmatian toadflax	South Fence	*Mecinus janthinus*	X [3]	X	

[1] Adventitious recovery, none released at this site

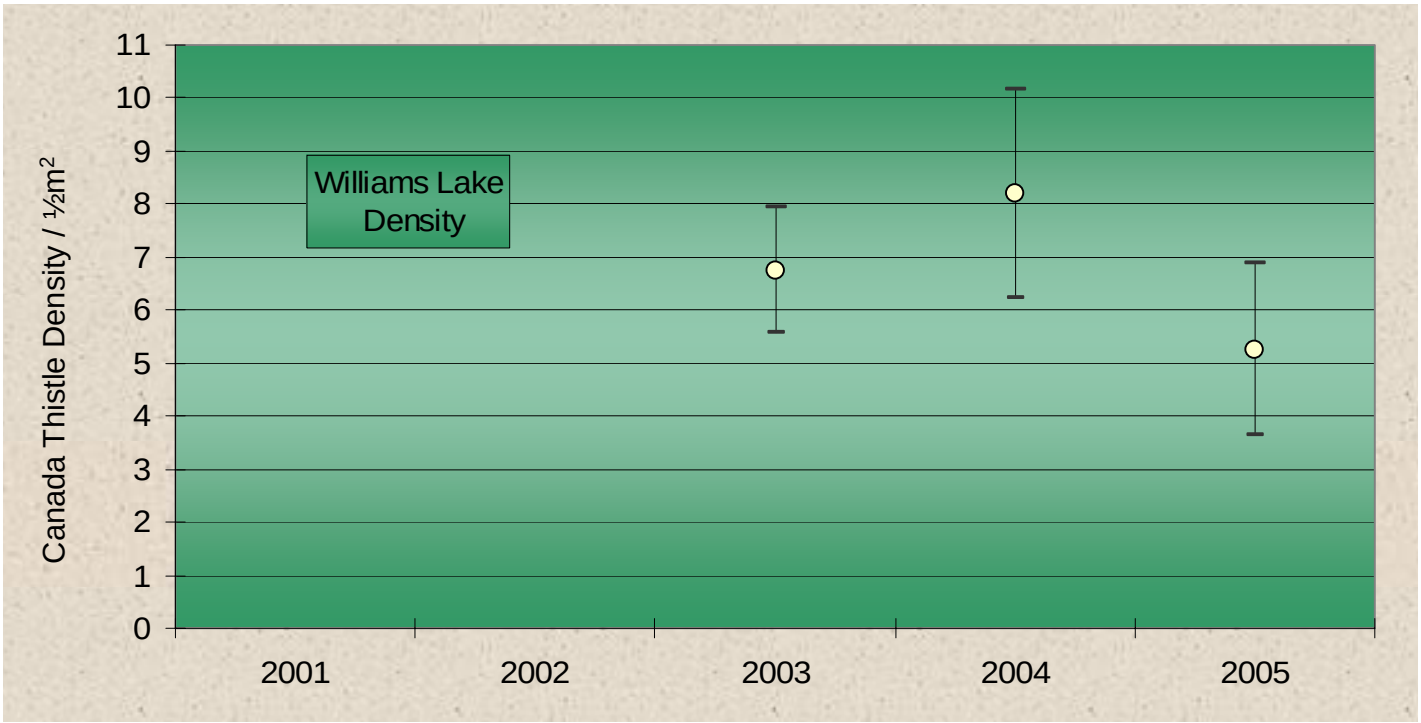
[3] New insect recovery in 2005

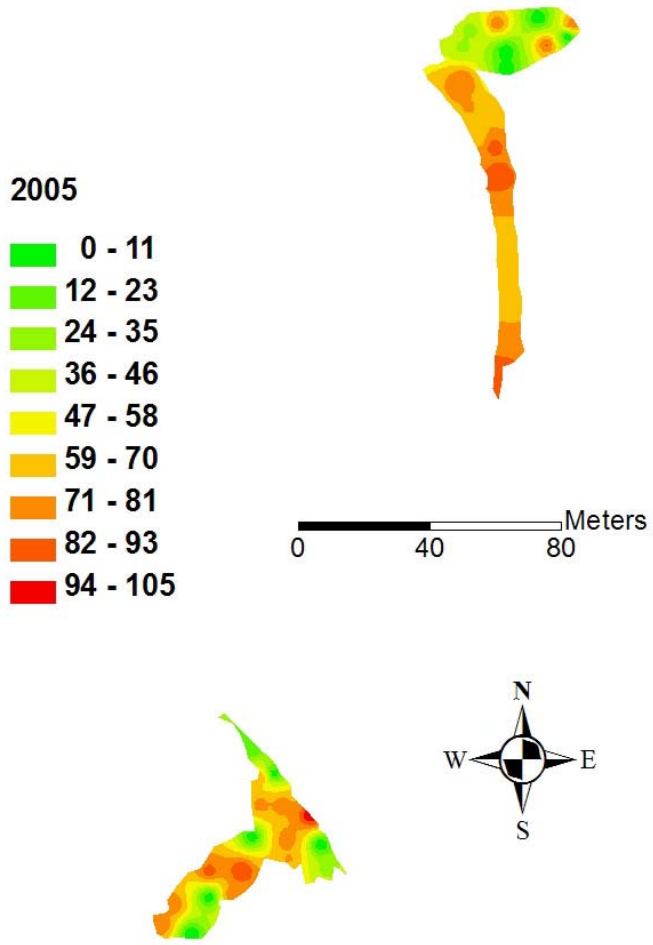


Williams Lake Canada thistle perimeter in 2005.

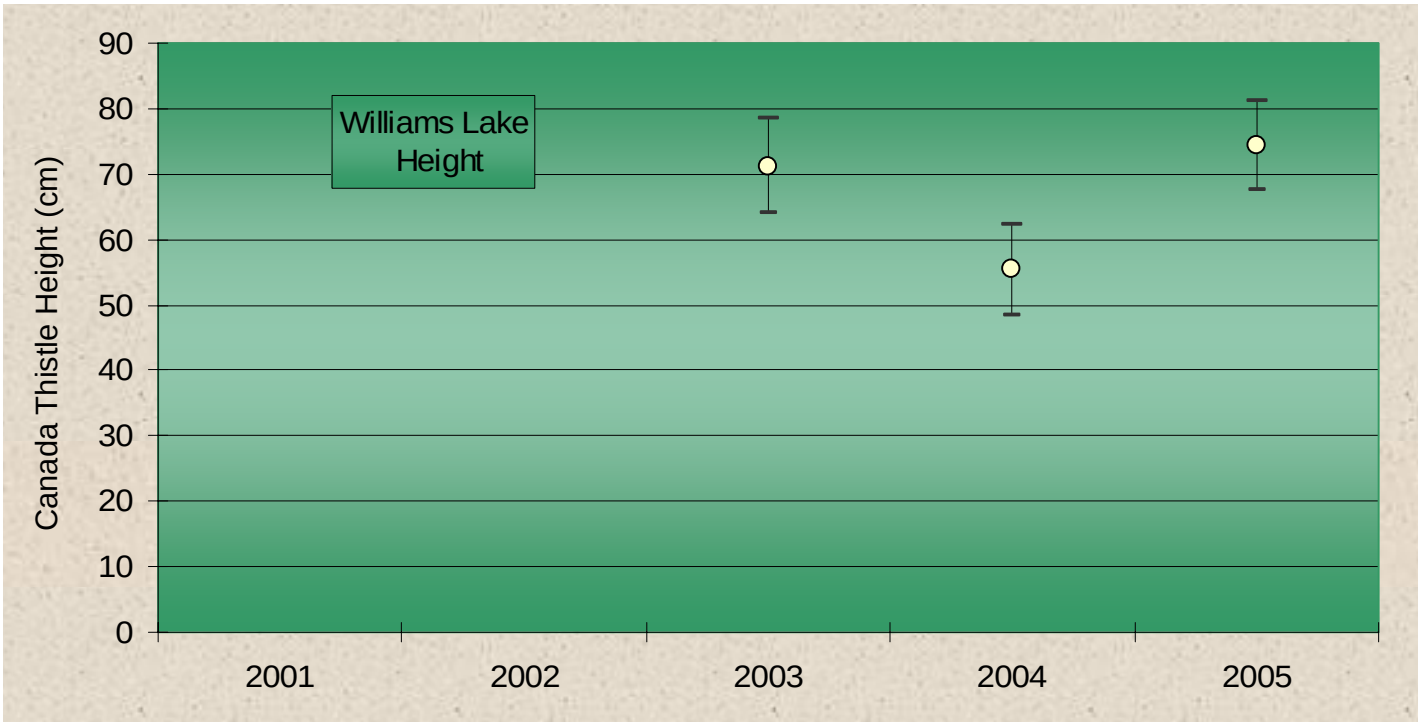


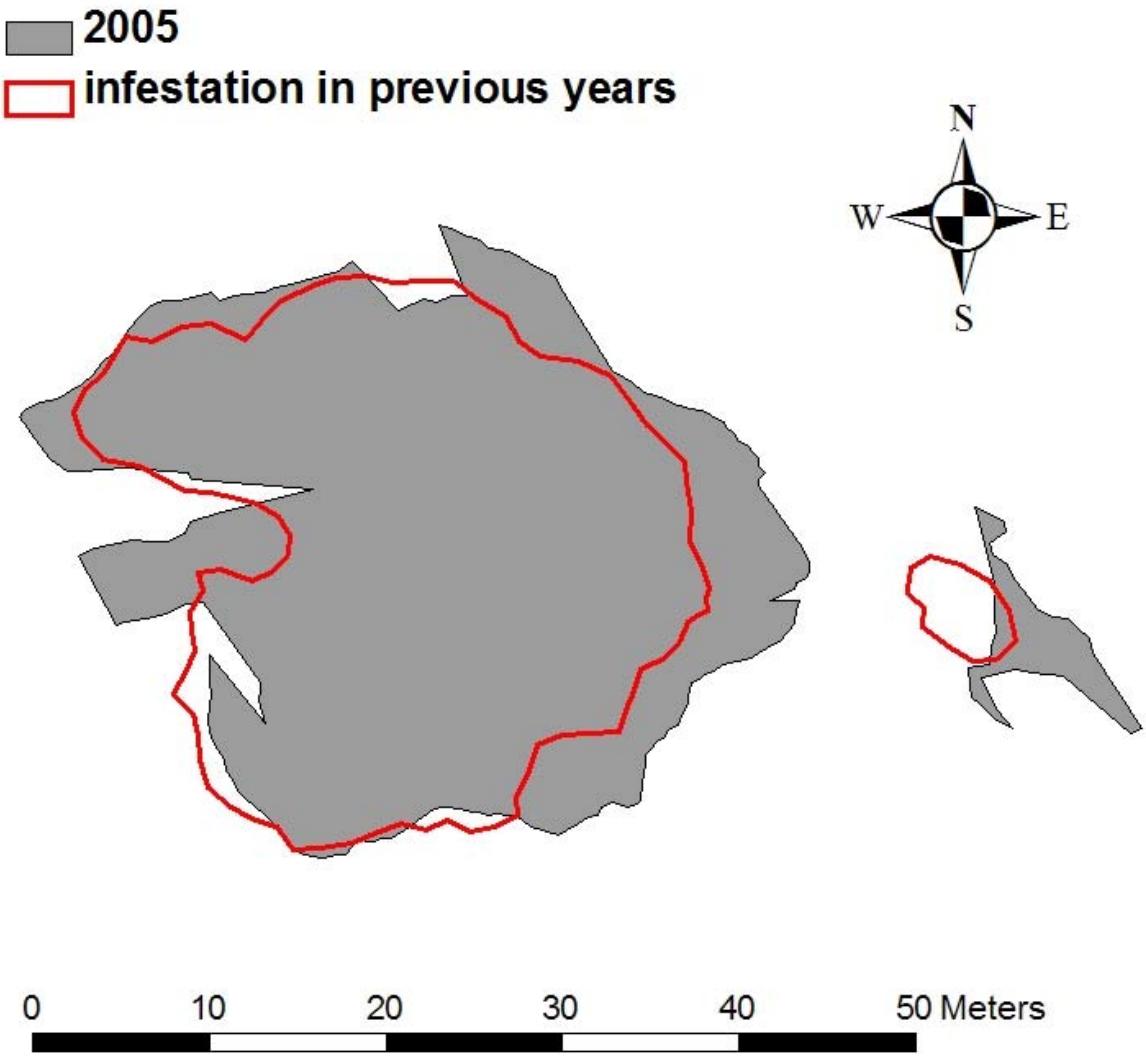
Williams Lake Canada thistle density in 2005.



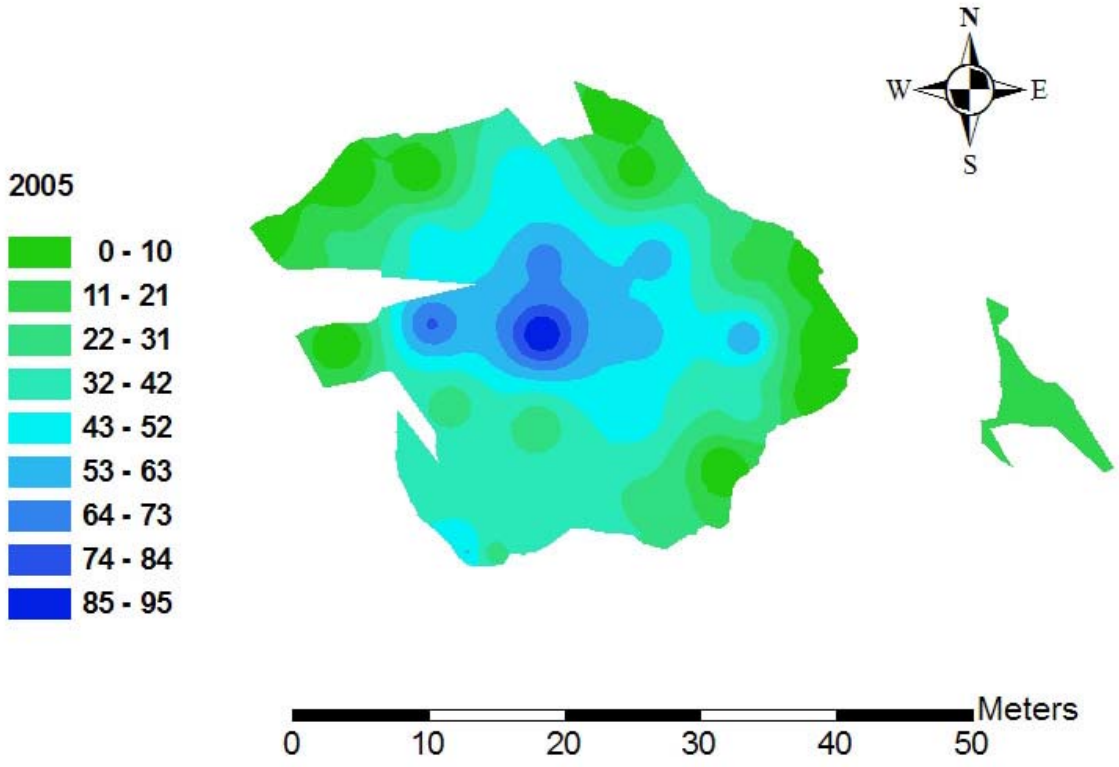


Williams Lake Canada thistle height in 2005.

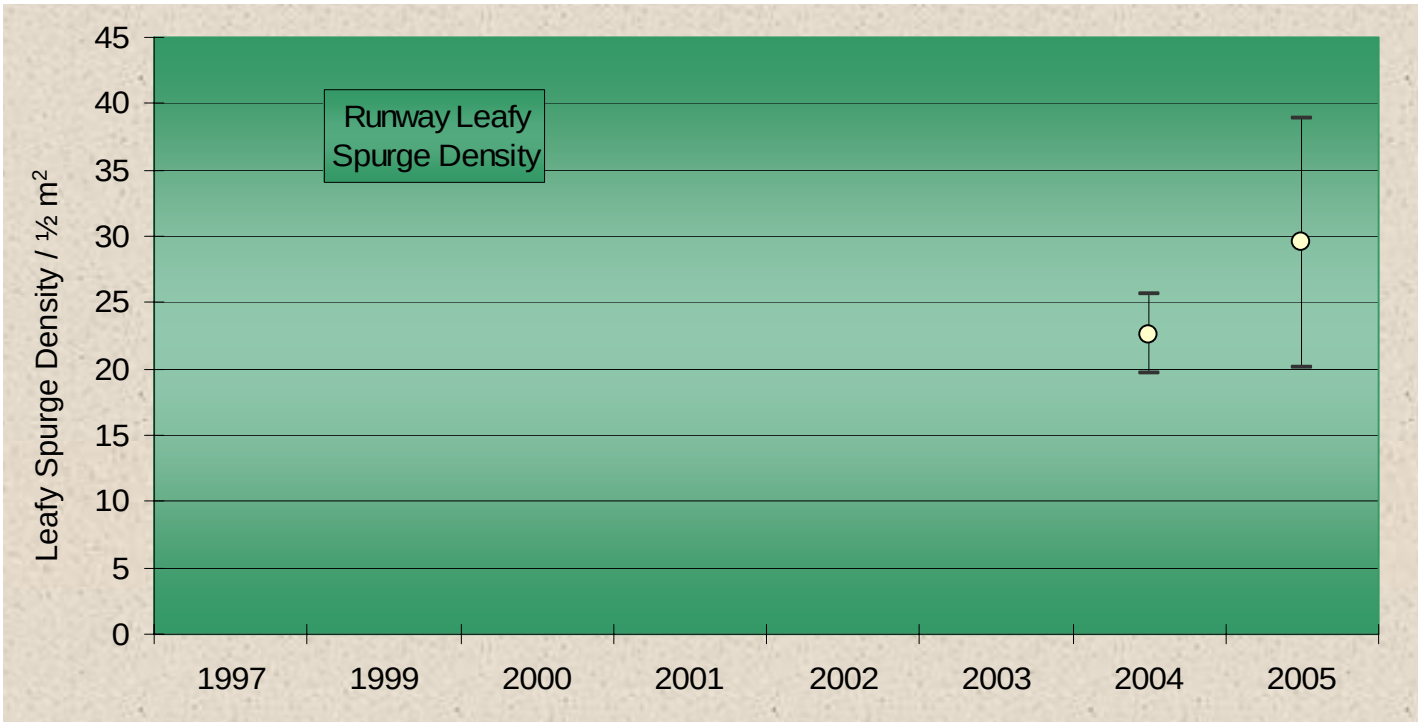


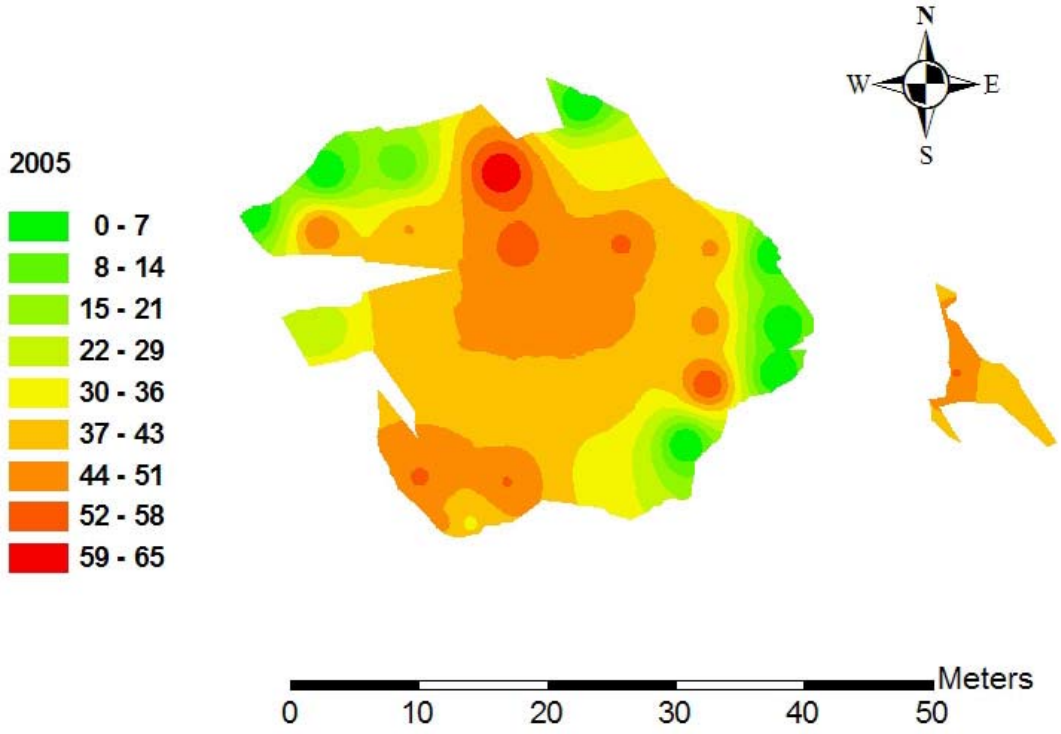


Runway leafy spurge perimeter in 2005.

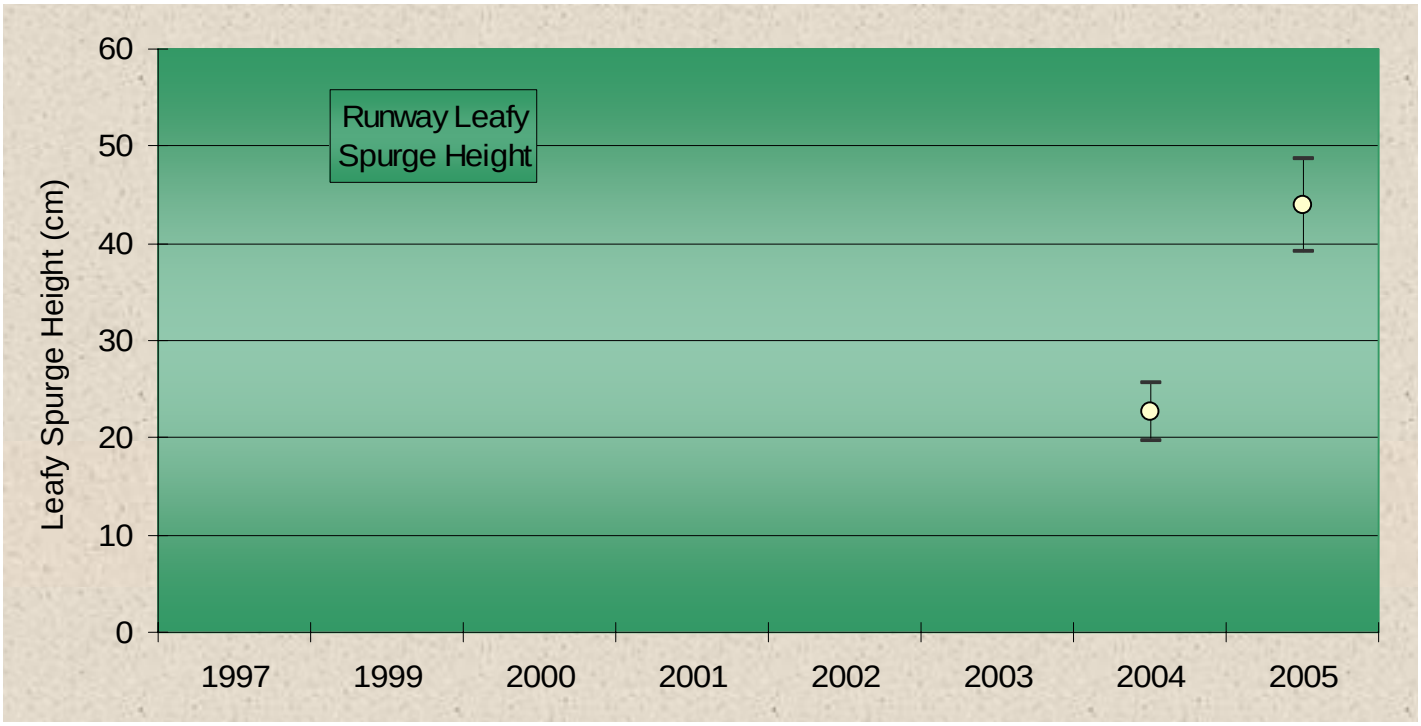


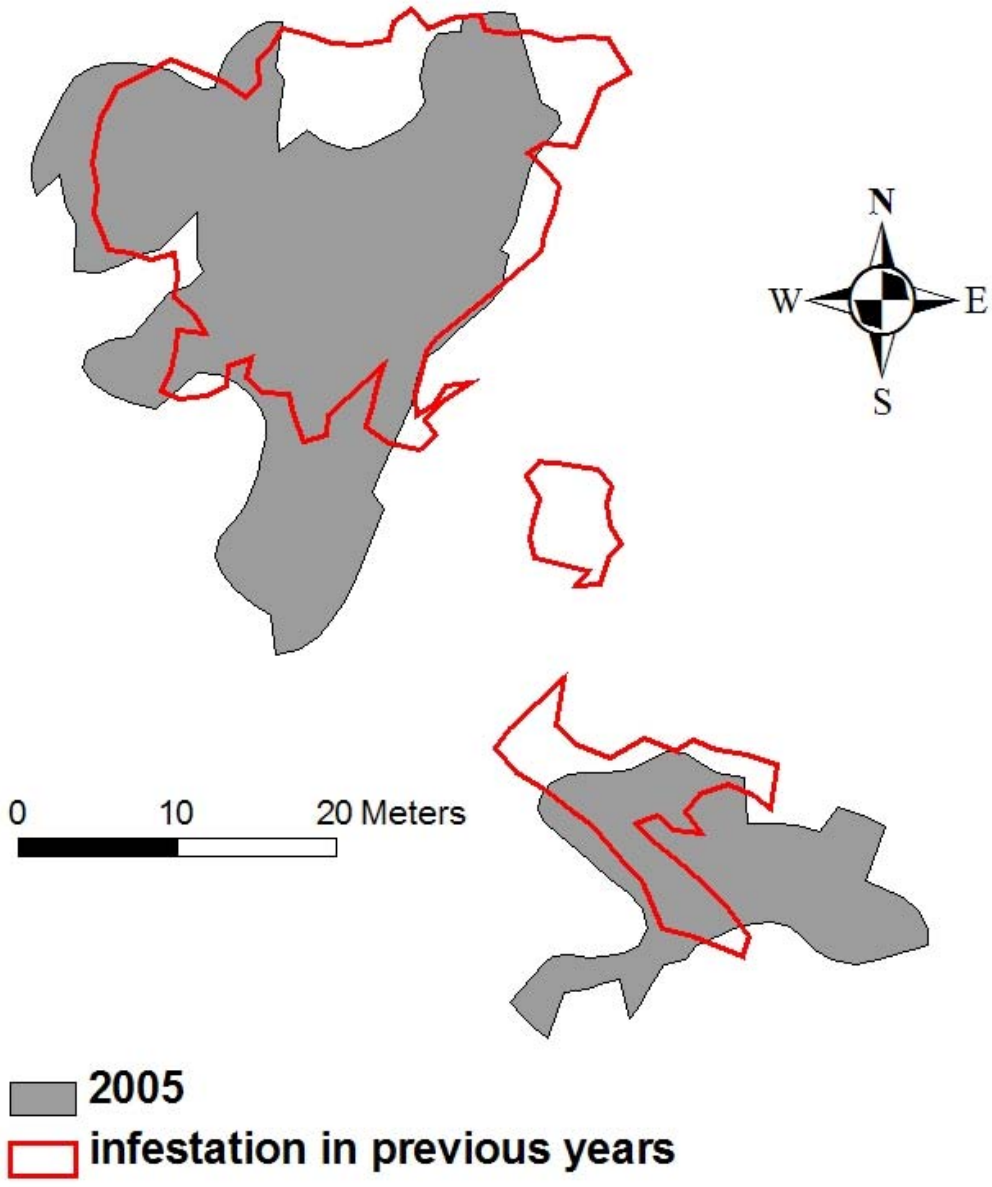
Runway leafy spurge density in 2005.



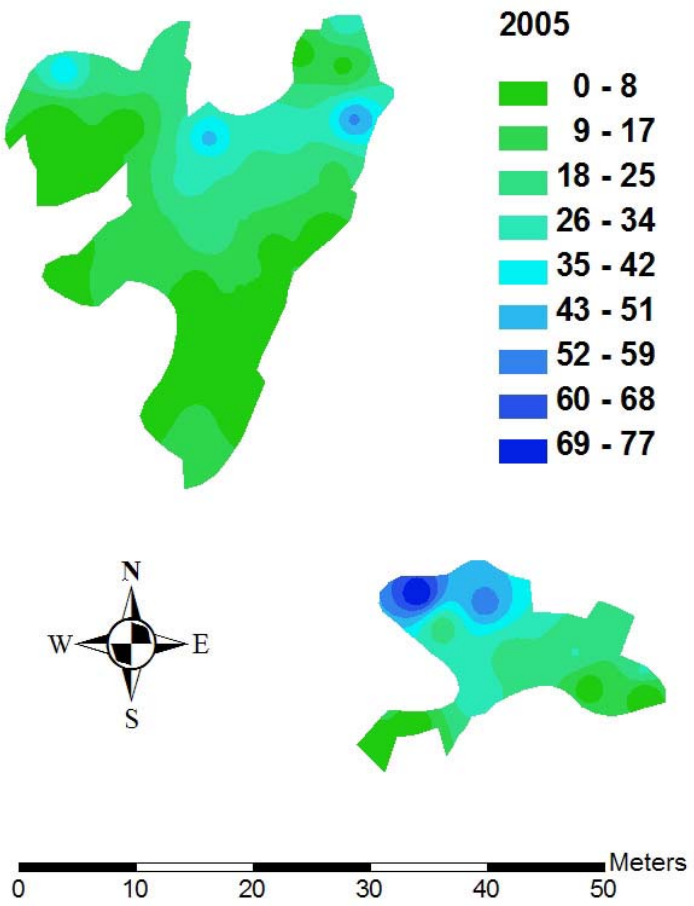


Runway leafy spurge height in 2005.

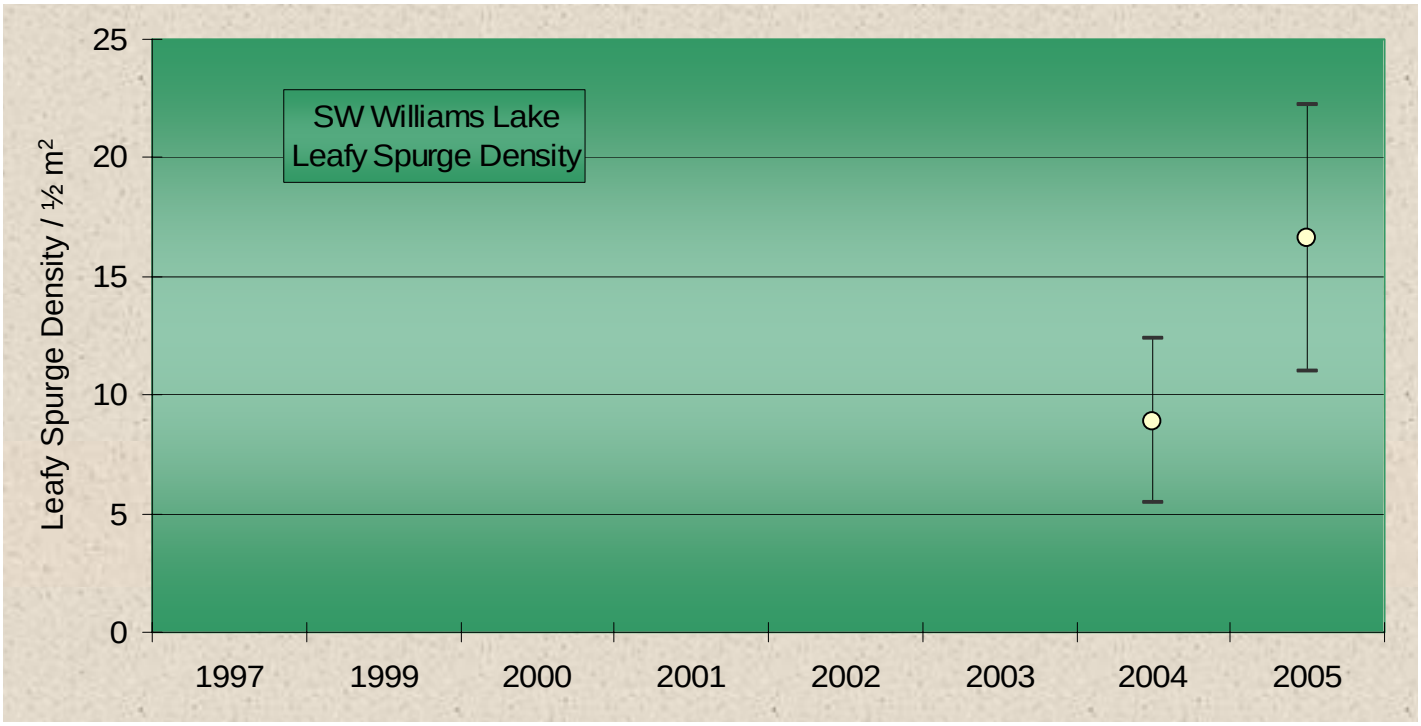


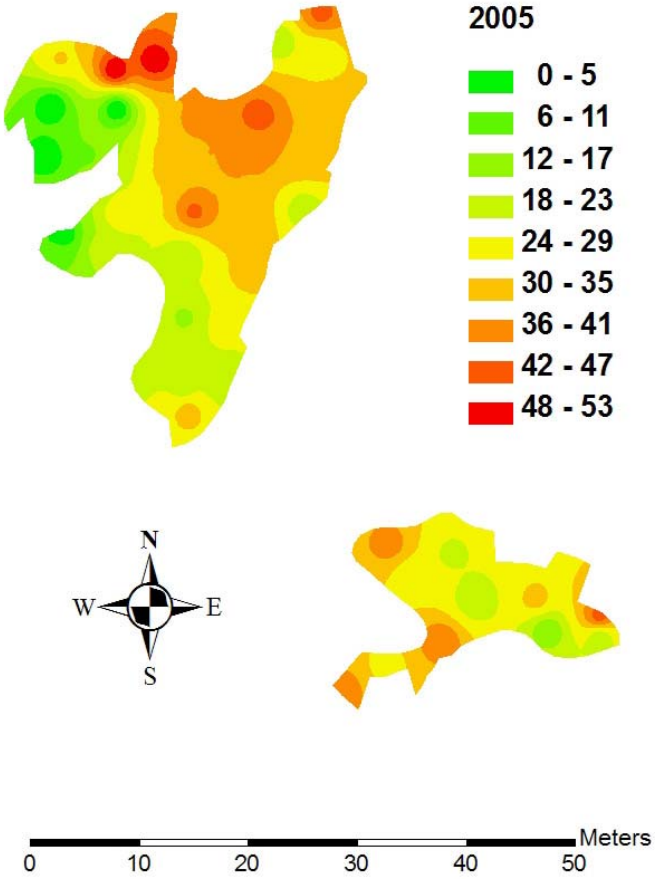


Southwest Williams Lake leafy spurge perimeter in 2005.

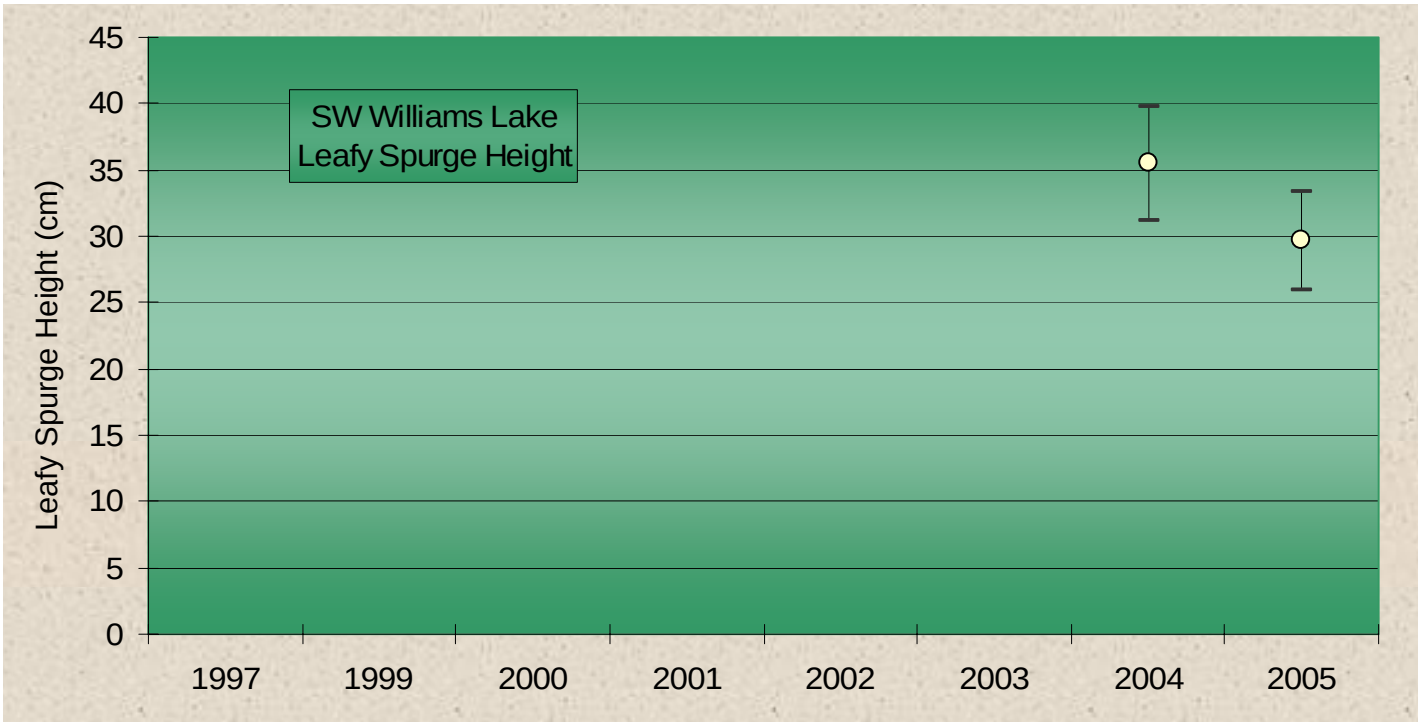


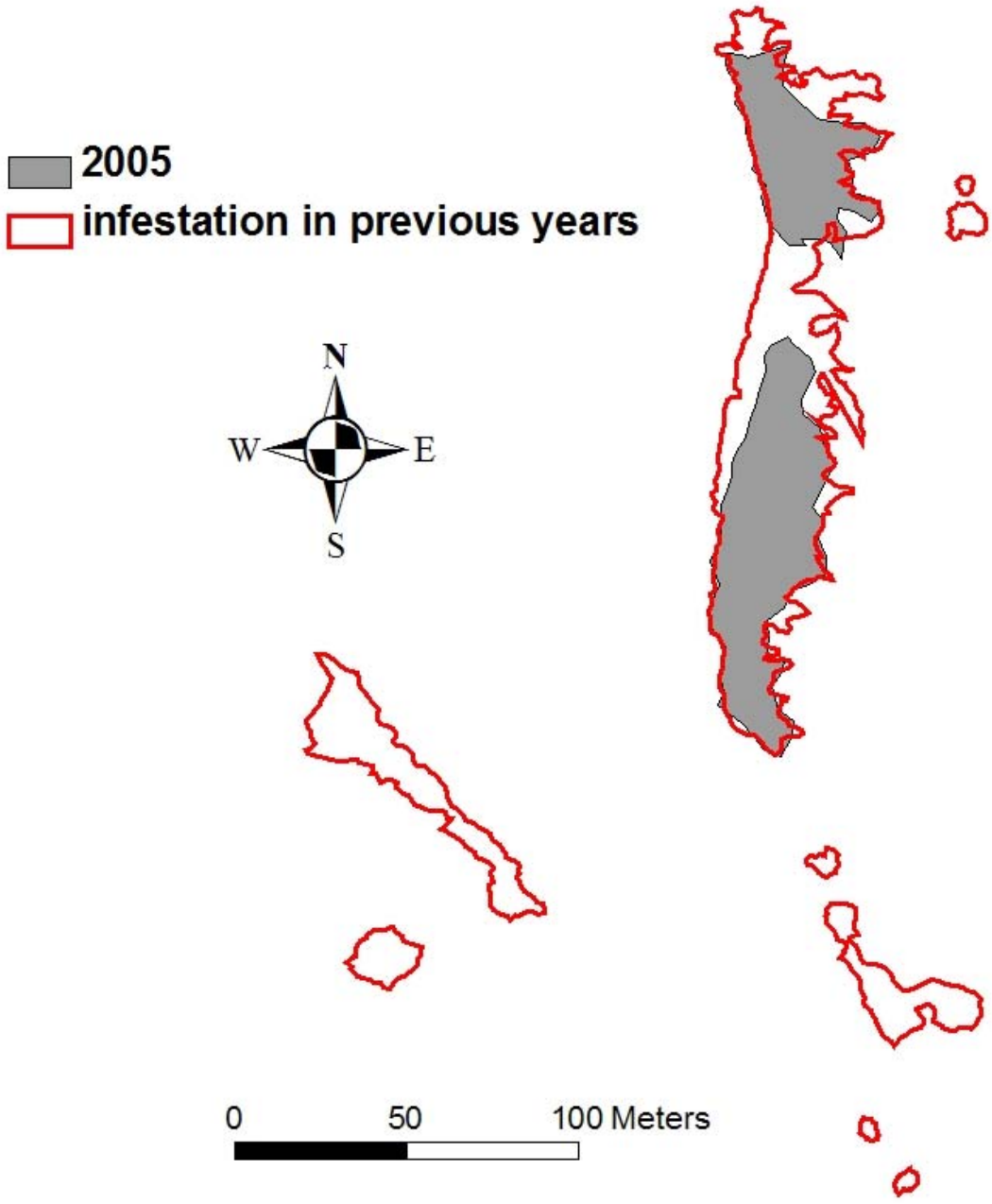
Southwest Williams Lake leafy spurge density in 2005.



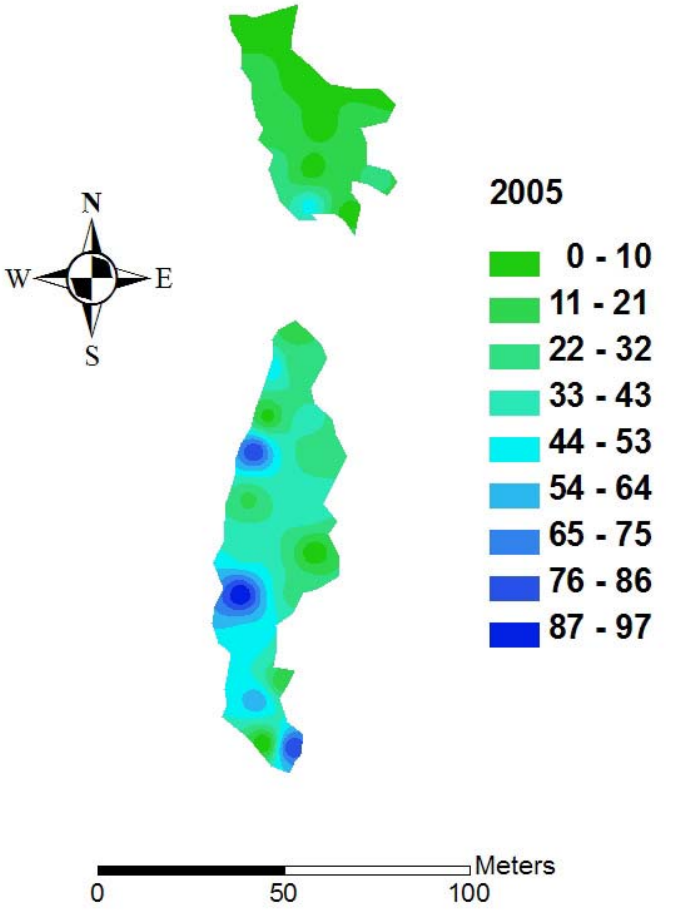


Southwest Williams Lake leafy spurge height in 2005.





Williams Lake leafy spurge perimeter in 2005.



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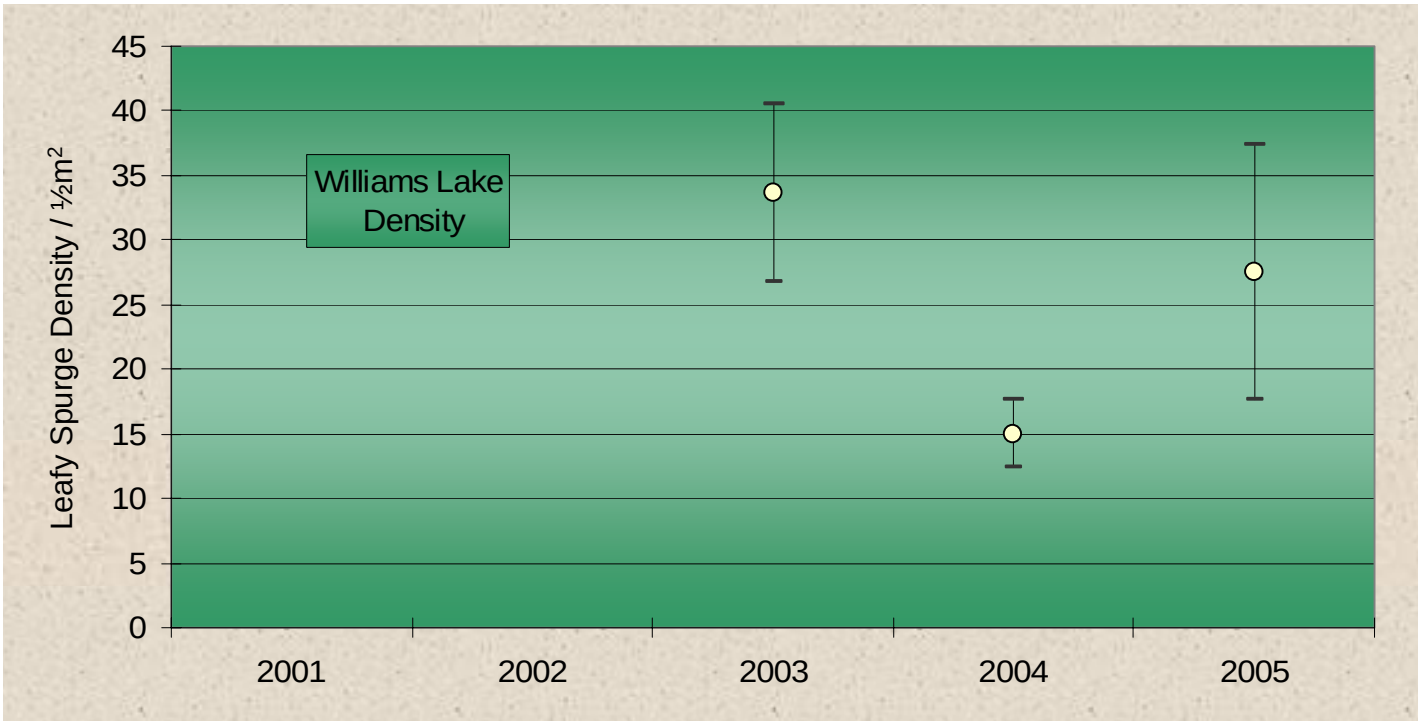
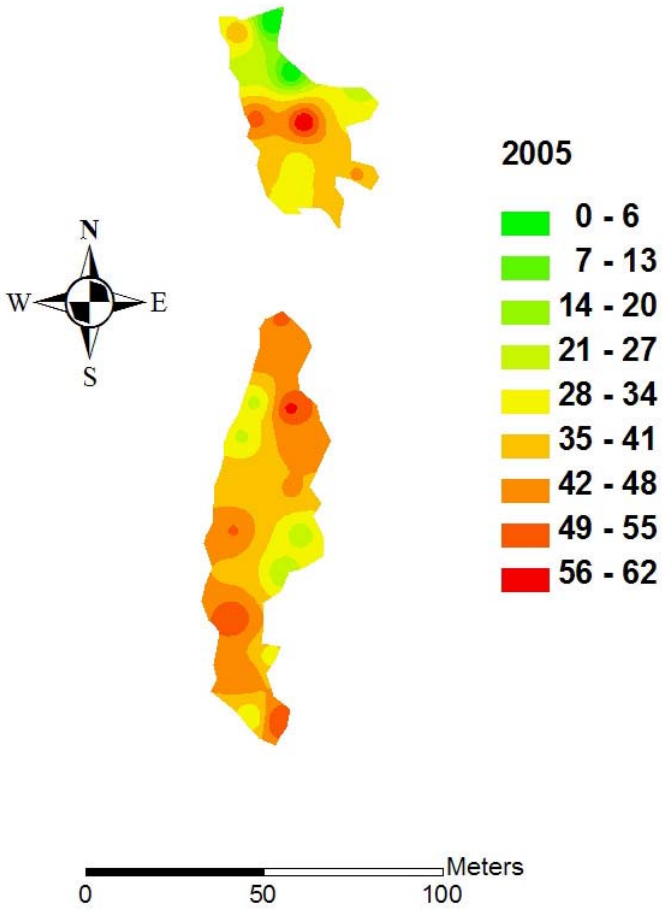
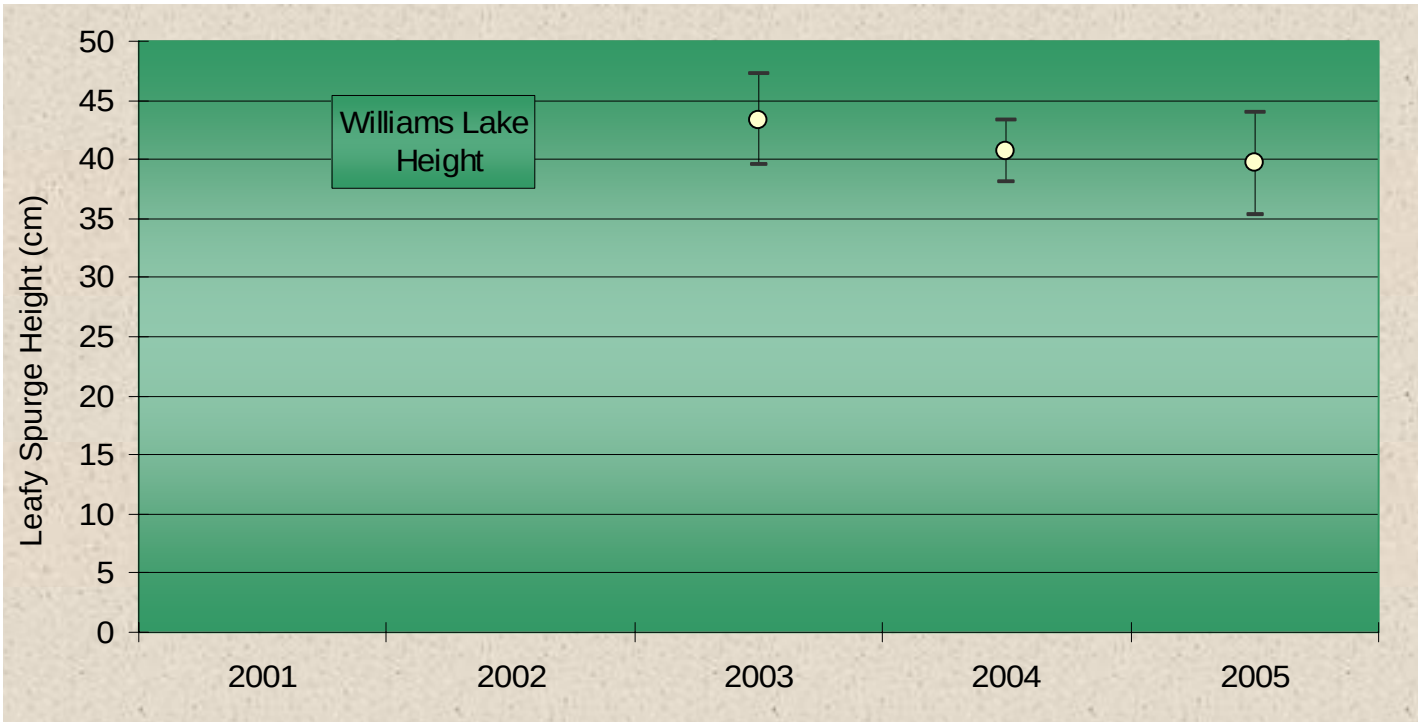
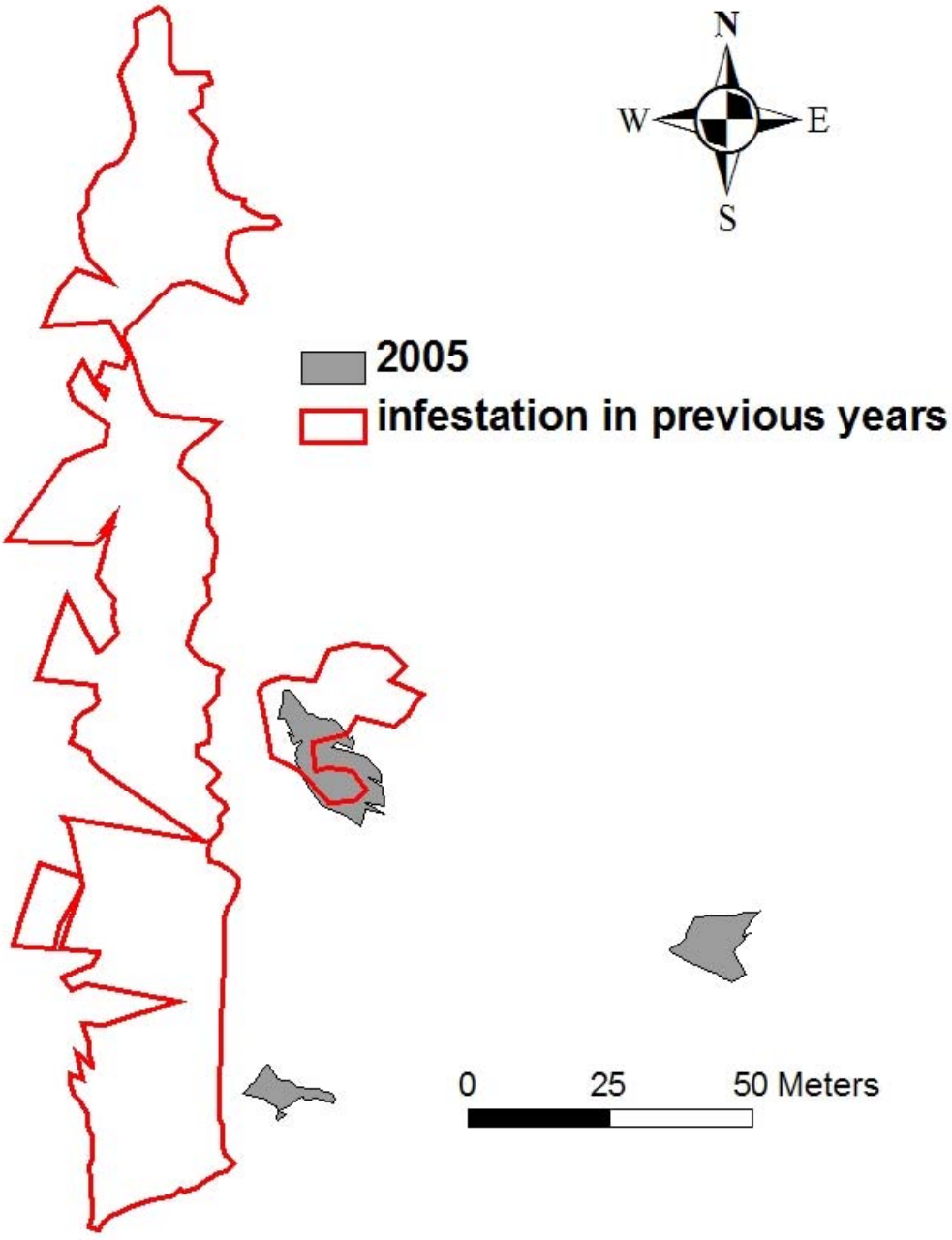


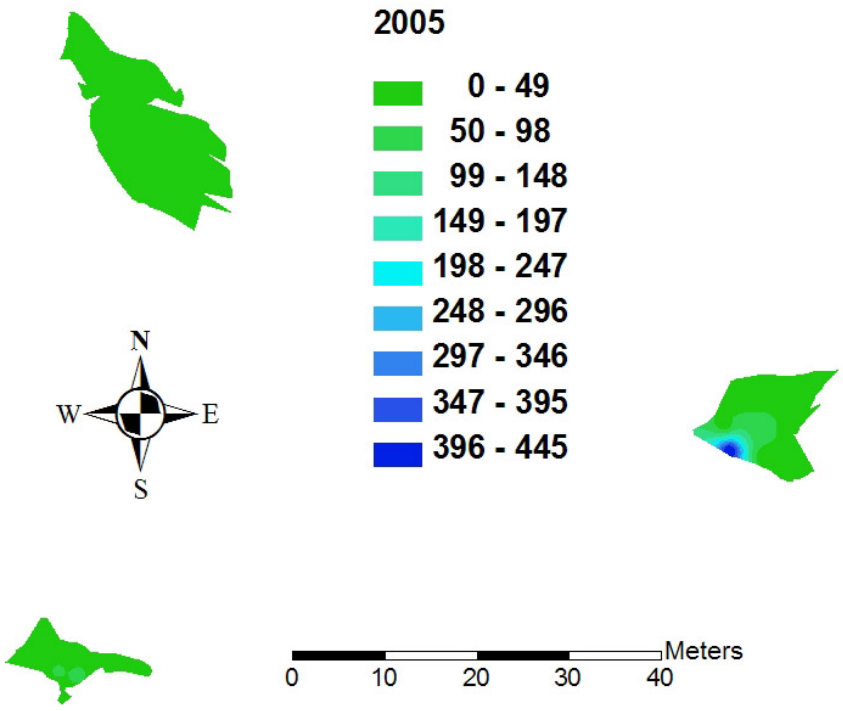


Williams Lake leafy spurge height in 2005.

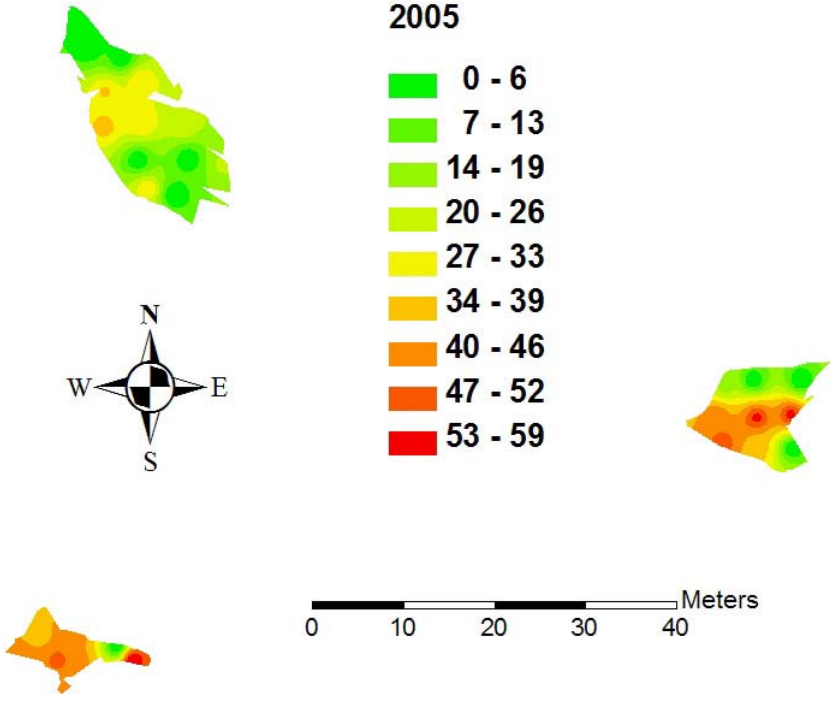




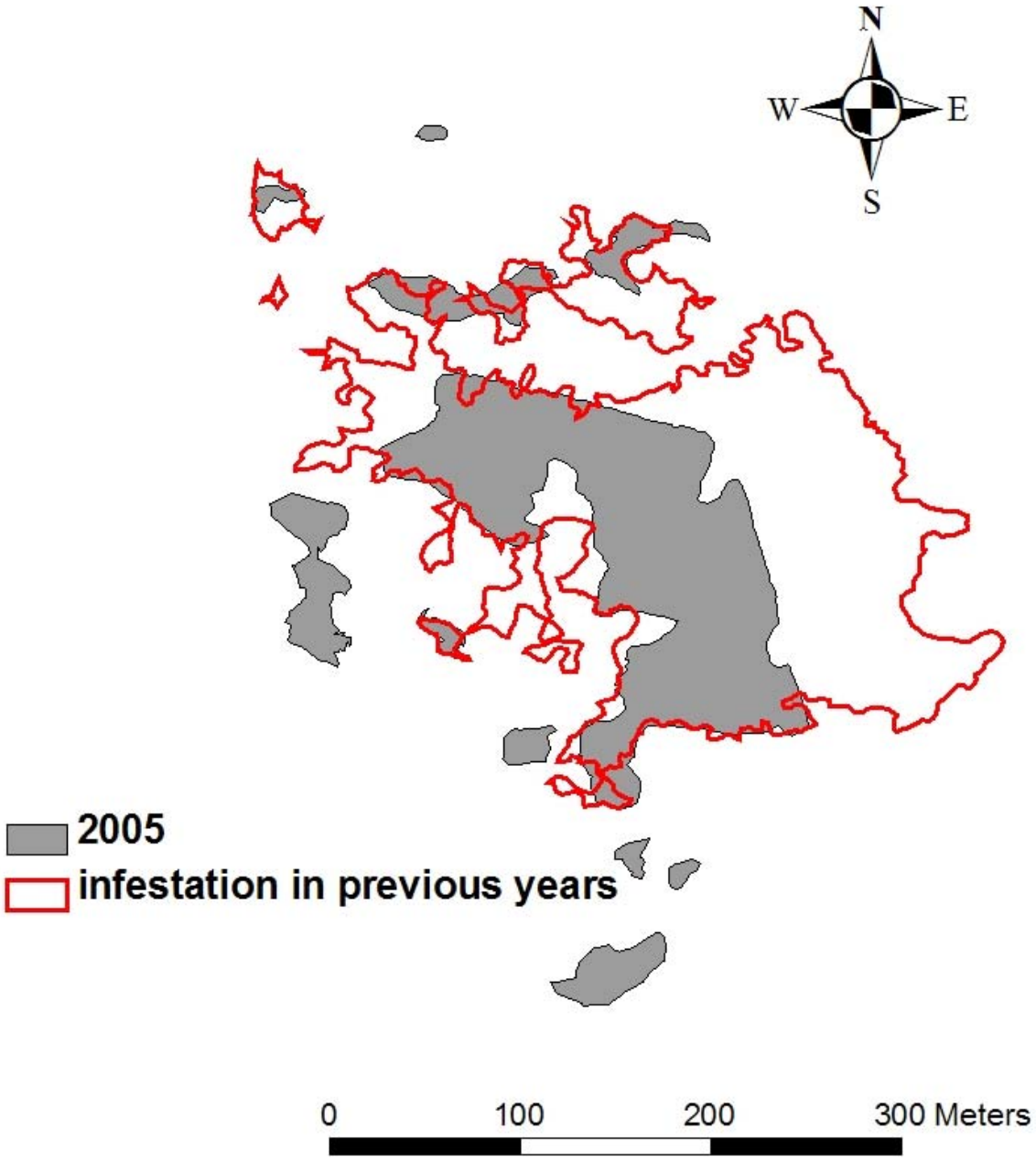
South Aspen Way Dalmatian toadflax perimeter in 2005.



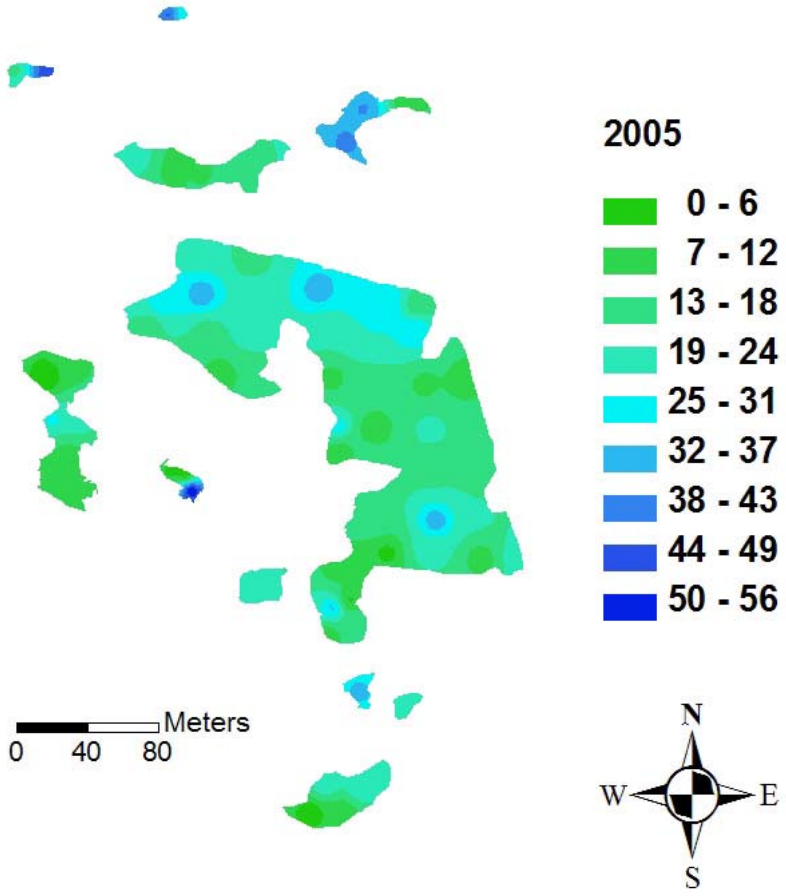
South Aspen Way Dalmatian toadflax density in 2005.



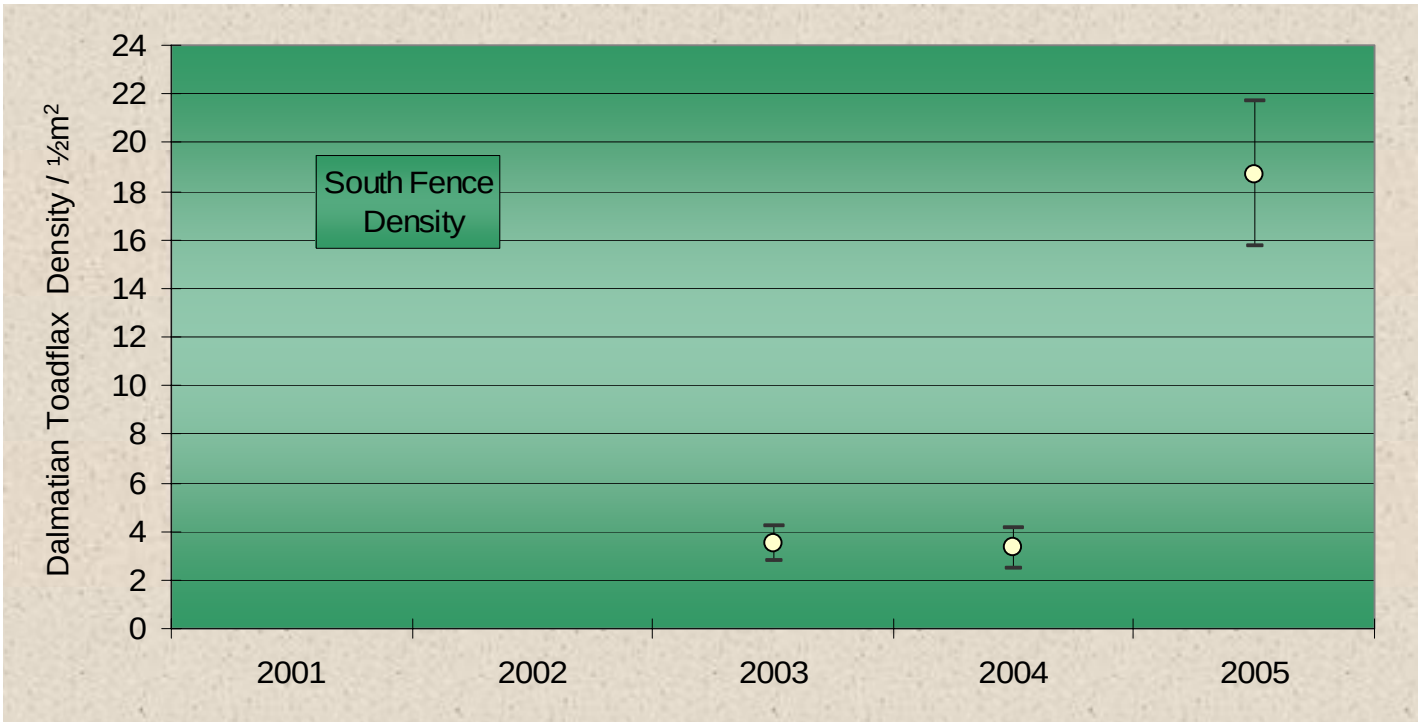
South Aspen Way Dalmatian toadflax height in 2005.

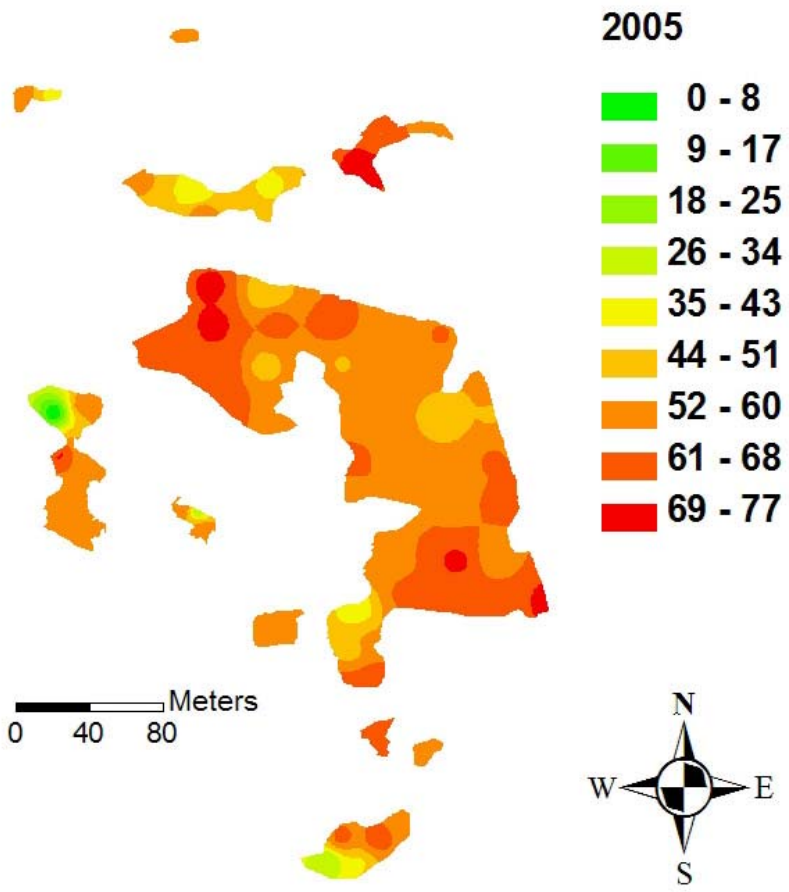


South Fence Dalmatian toadflax perimeter in 2005.

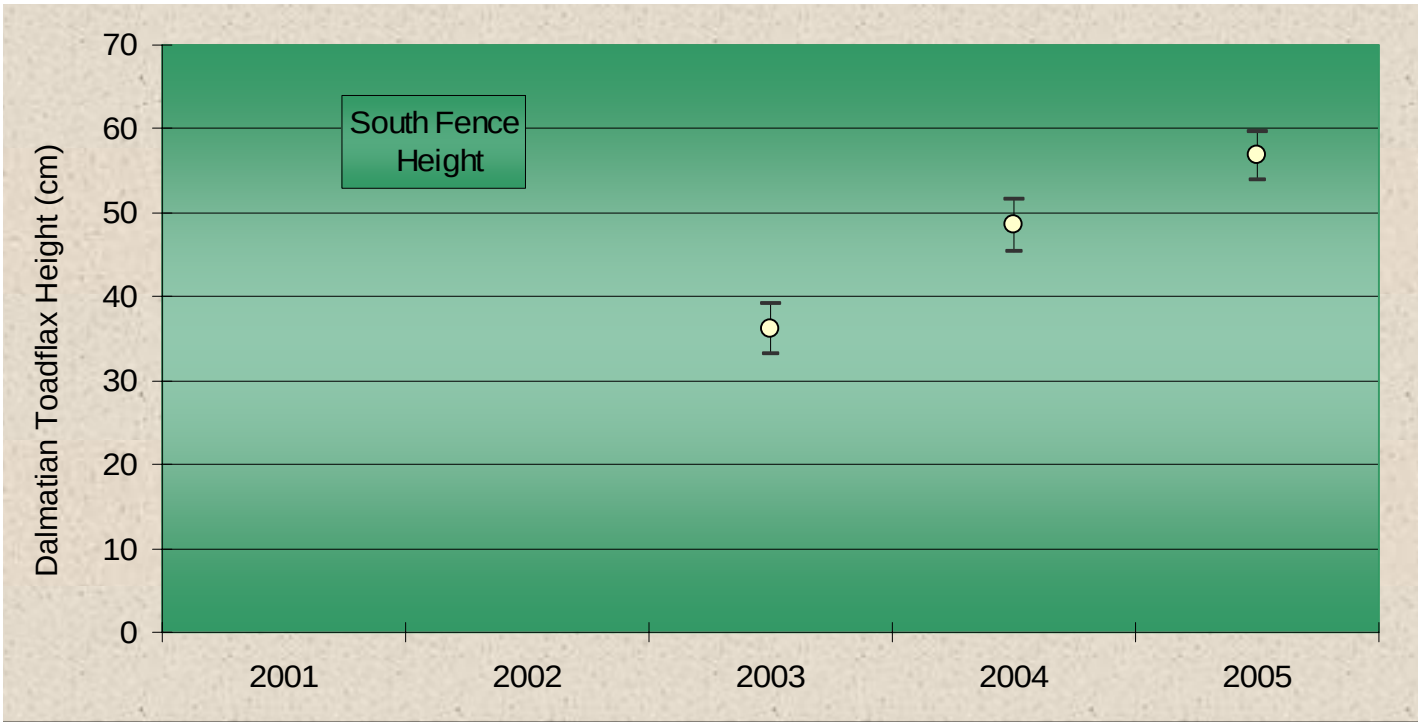


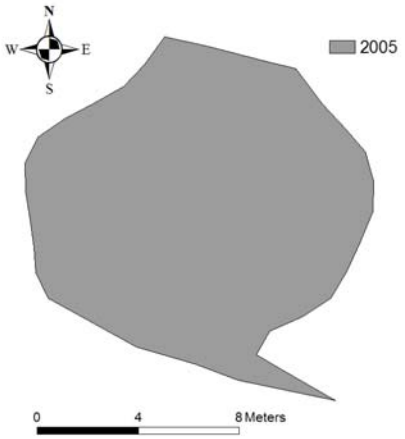
South Fence Dalmatian toadflax density in 2005.



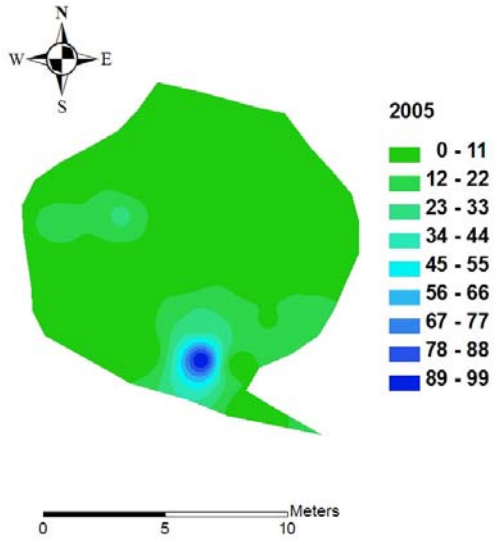


South Fence Dalmatian toadflax height in 2005.

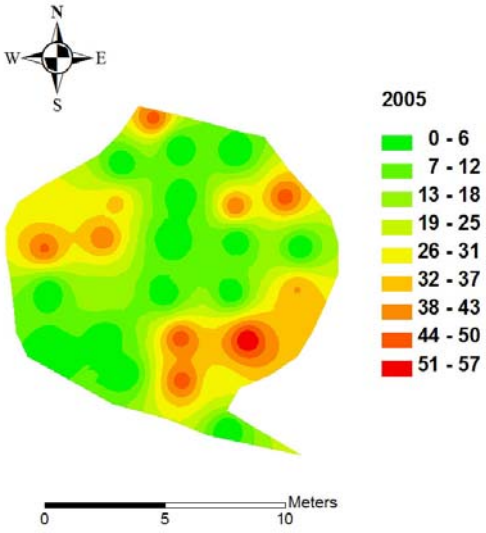




Interior leafy spurge perimeter in 2005.



Interior leafy spurge density in 2005.



Interior leafy spurge height in 2005.

Fort Carson Military Post

Eleven weed infestations at Fort Carson were surveyed in 2005 over a total of 33.1 ha (Table 10). Nine of these areas are long-term biological control management sites (established in 2000 or earlier) and are showing various stages of control. Biological control efforts on base continue to be focused on field bindweed by the redistribution of gall-mite, *Aceria malherbae*, and on targeting spotted knapweed (1.0 ha in 2005), Canada and musk thistle (30.7 and 0.4 ha mapped in 2005, respectively) using numerous biocontrol insect species. Newly established in 2004, the Gun Club diffuse knapweed infestation (1.0 ha) is already showing great promise in terms of insect agent population increase and impact (Table 2, Introduction). Both root-feeder, *Cyphocleonus achates*, and seedhead weevil, *Larinus minutus*, were recovered at Gun Club in 2005, one year after their initial release (Table 11), and both appear to be establishing well on diffuse knapweed (40% of sampled seedheads attacked). Additional biocontrol recoveries at this site include *Metzneria paucipunctella* and *Urophora affinis*, both self-dispersed (Figure 12).

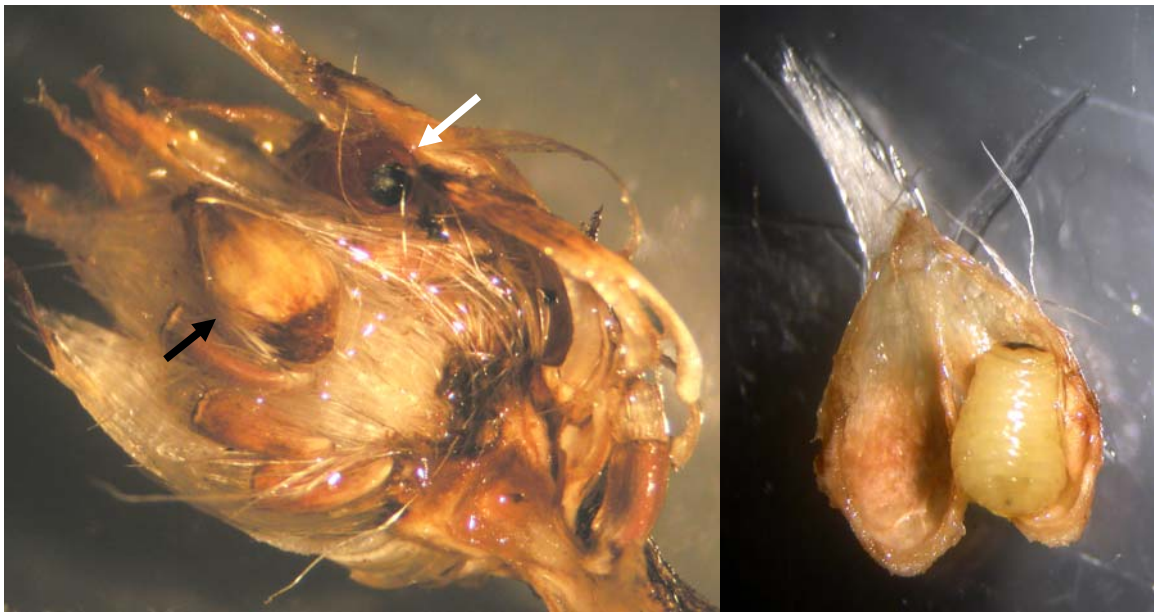


Figure 12. Spotted knapweed seedhead from Fort Carson on left, with galls made by *Urophora affinis* (black arrow) and *U. quadrifasciata* (white arrow). A close-up view of an *U. affinis* larva is shown on the right.

As the original monitored weed populations at Fort Carson began fragmenting and disappearing under intensive pressure from biological control agents, we determined that it was necessary to expand our control efforts to areas adjacent to the original weed patches. A good example of this can be observed at the original ARA Canada thistle infestation and nearby expansion site, ARA II. As the 2005 perimeter maps show, the area originally monitored for Canada thistle at ARA I no longer contains thistle plants. During the search in August 2005 for Canada thistle tissue containing *A. anthocoptes* mites, a lone Canada thistle plant, less than 20 cm in height, was found within that original ARA I weed perimeter. Monitoring efforts at ARA I have, therefore shifted to

adjacent areas where Canada thistle remains. ARA II is an extensive Canada thistle infestation approximately half a kilometer from the original ARA I site. The mapped area expanded dramatically this year (Table 10), as student workers diligently set out to determine the overall extent of this weed patch past a tree-line that had previously been selected as one of the artificial boundary extents to ARA I. Hence, the infestation areas reported in Table 10 for ARA I and II may be a bit misleading if the maps are not consulted, as the monitored areas are greatly expanded and shifted from what was originally mapped in 2003.

Similarly, spotted knapweed at Turkey Creek has declined steadily since 2001. In 2004 and 2005, an effort was made to document the entire weed-infested area mapped in previous years (Figure 13). As this year's Turkey Creek perimeter map shows, there is very little knapweed remaining in the area monitored since 1997. Table 10 shows correspondingly low plant densities in 2005 (1.7 plants/m^2 versus 16.0 plants/m^2 in 1997) in the remaining patches. We will continue to monitor and track these sites, even as weed populations disappear to prevent resurgence of the weeds in controlled or nearby areas.

Figure 13. Student worker, Taylor Mabry, acquiring a GPS signal in order to begin mapping the Turkey Creek spotted knapweed infestation.

An accurate assessment of the spotted knapweed infestations in the Cantonment (i.e. Fuel Site and Hazmat) could not be made in 2005. Despite best efforts with obvious signage requesting that the biological control area not be disturbed, annual mowing of both areas continues to occur. We have been fortunate enough in previous years to collect weed infestation and bio-agent establishment data prior to the sites being completely mowed off. However, as knapweed was late blooming this year, our weed monitoring efforts had to be made after a major mowing event in the Cantonment had taken place. Consequently, we were unable to collect and transfer biological control agents from these sites to Gun Club as planned and the data presented in Table 10 reflects only the few quadrats that we could still sample after mowing, rather than the full extent of the knapweed infestations. We were still able to collect some knapweed seedheads from

these two sites and are in the process of dissecting them to determine the level of colonization by the various biological control agents (Figure 14).

Several events occurring in 2005 on Fort Carson Canada thistle infestations are worth noting. A total of 400 *Ceutorhynchus litura* were released into the ARA II Canada thistle infestation in hopes of establishing a nursery site for these agents. Also noteworthy, we observed for the first time since release in 1999, *Urophora cardui* galls on Canada thistle at ARA I. Additionally, a patch of thistle within ARA II was presenting symptoms of yellowing and patchy coloring (chlorosis), stunting and excessive leaf tissue production (hypertrophy). Subsequent microscopic analysis of these plants showed extremely high densities of Eryophyid mites on leaf tissue, likely the highly Canada-thistle specific species *Aceria anthocoptes*. The visual appearance of these plants suggests that *A. anthocoptes* may have a dramatic effect on Canada thistle growth and vigor. We are awaiting confirmation of identification before redistributing any of the affected plant tissue to other areas within the ARA II patch and across federal installations. More work is planned for basic *A. anthocoptes* investigations in 2006.

Figure 14. Weak spotted knapweed plants, as pictured above, were typically those found at the Fuel Site, Hazmat and Turkey Creek sites in 2005. On the tips of the upper branches, *Larinus minutus*, seedhead-feeding weevil adults can be seen (inside red circle).

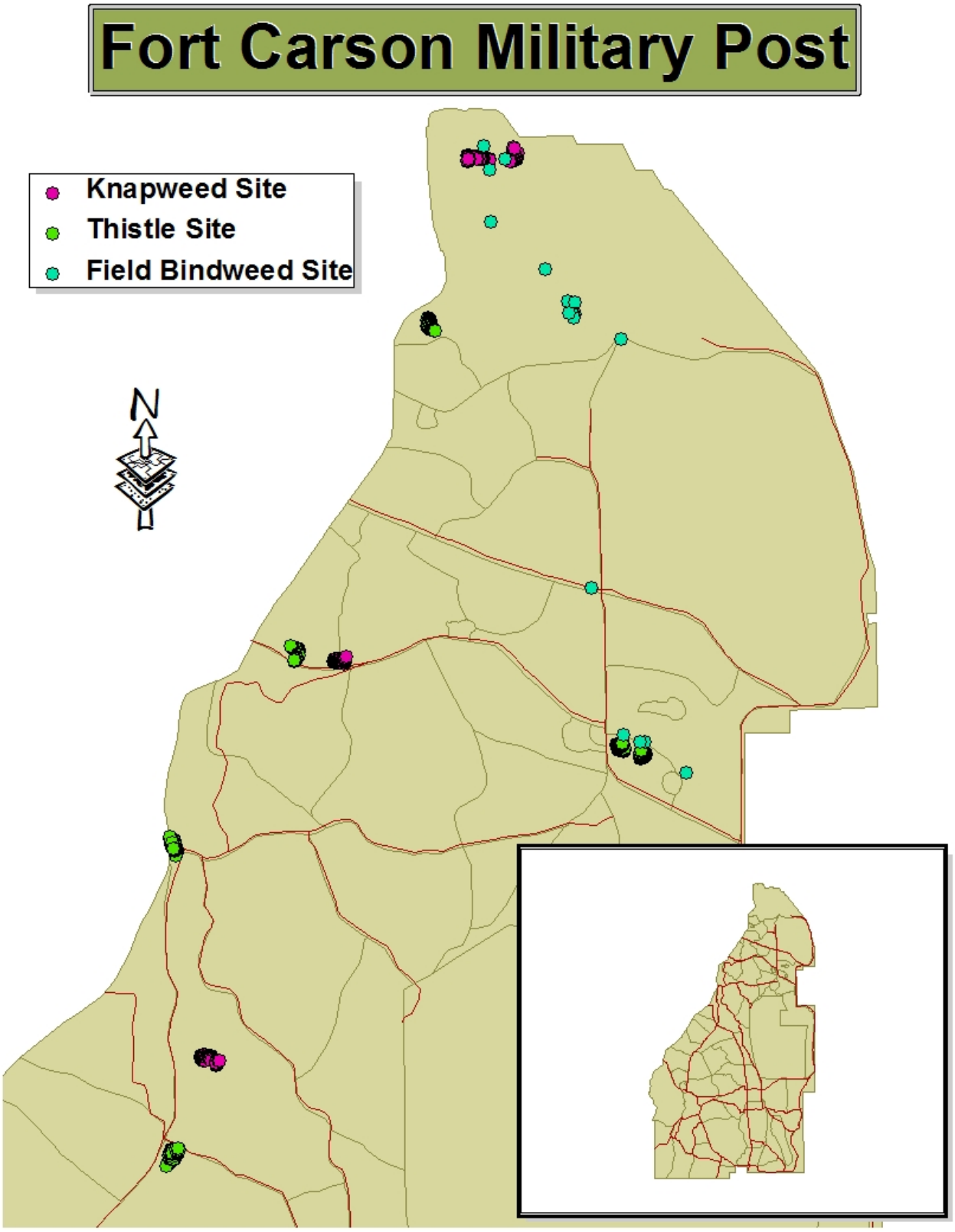


Figure 15. Schematic diagram of Fort Carson Military Post with weed biological control study areas superimposed.

Table 10. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2005.

Year	Area (m^2)	n	Density 1/2m^2)		Height (cm)		Seedheads per plant	Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Canada Thistle – ARA I												
1997		23	25.55	42								
1998												
1999		40			62.33	95						
2000	37,062	166	13.96	58	45.87	91					-26.41	
2001	37,061	299	12.94	64	52.98	122	18.95	0.57	0	-7.31	15.50	
2002	38,002	386	4.95	40	12.89	84	8.54	0.12	2.54	-61.75	-75.67	
2003	14,708	161	0.78	9	12.19	74	1.13	0.15	-61.30	-84.24	-5.43	
2004	4,919	75	2.53	19	10.83	37	0.24	0.26	-66.56	224.36	-11.16	
2005	10,528	34	3.59	14	42.79	62	10.58	0.74	114.03	41.90	295.11	-71.59
Canada Thistle – ARA II												
2003	6,284	63	6.48	24	61.21	125	1.28	0.07				
2004	13,845	64	13.20	38	50.14	98	1.48	2.50	120.33	103.70	-18.09	
2005	270,294	31	9.23	24	69.41	105	20.17	0.66	1852.29	-30.08	38.43	4201.30
Canada Thistle – Duckpond												
1997		19	35	82								
1998	27,769											
1999		33			70.82	114	34.88					
2000	28,788	267	9.33	58	76.76	193					8.38	
2001	39,409	26	16.23	70	66.73	136	18.12		36.90	73.95	-13.07	
2002	38,916	196	7.74	56	21.3	124	11.33	0.23	-1.25	-52.31	-68.08	
2003	29,486	147	5.25	29	38.9	143	3.08	0.22	-24.23	-32.17	82.63	
2004	20,724	65	14.17	116	26.03	90	1.18	6.20	-29.72	169.90	-33.08	
2005	21,130	35	9.43	28	61.46	115	25.61	0.74	1.96	-33.45	136.11	-23.91

Table 10. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. seedheads per plant	Head size avg. (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area(m^2)	Avg. density	Avg. height	
						Canada Thistle – HWY 115						
2000	1,445	82	12.47	40	53.49	80						
2001	4,239	54	10.22	48	57.87	147	14.51	0.64	193.36	-18.04	8.88	
2002	1,114	70	1.58	14	7.24	24	2.25	0.06	-73.72	-84.54	-87.49	
2003												
2004	1,287	69	6.29	23	38.33	96	7.95	0.47	15.53**	298.10**	429.62**	-10.93
2005	*(see Note)*											
						Musk Thistle – HWY 115						
2000	1,445	8	7.13	22								
2001	5,082	30	4.00	14	64.30	121	6.53	2.18	251.70	-43.90		
2002	827	53	2.13	13	6.26	35	0.63	0.43	-83.73	-46.75	-90.26	
2003	1,263	61	0.62	5	17.64	127	0.68		52.72	-70.89	181.79	
2004	9,918	55	1.85	25	24.88	100	3.47	0.97	685.27	198.39	41.04	
2005	735	44	1.05	7	42.31	90	1.56	1.51	-92.59	-43.24	70.06	-49.13
						Canada Thistle – Reservoir						
1997		22	20.82	30								
1998												
1999		26			73.12	109	19.12					
2000												
2001	9,517	143	7.25	31	39.53	84	13.55					
2002	5,268	101	8.16	32	24.26	65	6.36	0.30	-44.64	12.55	-38.63	
2003	3,635	165	6.09	38	41.48	123	6.02	0.38	-31.00	-25.37	70.98	
2004	4,549	68	6.13	28	23.22	57	0.52	0.74	25.13	0.66	-44.02	
2005	5,184	40	8.45	27	46.05	86	15.06	0.61	13.96	37.85	98.32	-45.53

Table 10. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Musk Thistle – Wildlife												
1999		59			110.92	175	7.53					
2000	5,035	114	1.76	14	43.14	138						
2001	2,844	68	3.84	21	72.22	174	6.07		-43.52	118.18	67.41	
2002	1,838	61	2.82	36	8.65	57	8.18	0.22	-35.39	-26.56	-88.02	
2003	10,219	77	0.27	3	14.39	124	1.17		456.14	-90.43	66.36	
2004	6,777	46	1.23	7	27.46	173	3.50	7.13	-33.68	355.56	90.83	
2005	3,453	36	1.37	9	98.31	187	8.69	2.75	-49.05	11.38	258.01	-31.42
Diffuse knapweed – Gun Club												
2004	14,941	46	1.59	8	21.87	65	36.04	1.43				
2005	9,685	35	3.40	22	41.36	57	42.48	0.45	-35.18	113.84	89.12	-35.18
Spotted knapweed – Fuel Site (Cantonment I)												
1997		22	55.27	82								
1998												
1999		50			71.68	104						
2000	2,072	154	16.71	50	46.69	91					-34.86	
2001	2,869	113	55.19	564	55.88	104	134.48	18.85	38.46	230.28	19.68	
2002	2,375	155	6.04	36	20.56	72	45.60	0.34	-17.22	-89.06	-63.21	
2003	2,093	92	5.98	35	64.35	150	52.26	1.92	-11.87	-0.99	212.99	
2004	6,830	42	4.64	21	46.64	100	9.39	5.00	226.41	-22.41	-27.52	
2005	2,567	41	5.16	26	42.52	74	13.25	0.52	-62.42	11.21	-8.83	23.89

Table 10. Historic noxious weed infestation parameters, Fort Carson Military Post, Colorado, 1997-2005.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Avg. seedheads per plant	Avg. Head size (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Spotted knapweed – 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				-46.57	
2001	9,094	143	20.66	140	60.48	100	72.35		7.47	96.02	41.11	
2002	3,429	92	12.24	58	22.69	81	31.16	0.35	-62.30	-40.46	-62.48	
2003	5,254	160	5.26	70	57.42	140	64.85	0.67	53.23	-57.03	153.06	
2004	5,779	57	5.37	18	43.07	97	9.41	4.62	10.00	2.09	-24.99	
2005	990	50	12.48	53	52.12	90	20.32	0.58	-82.87	132.40	21.01	-88.30
Spotted knapweed – Turkey Creek												
1997		22	16.00	18								
1998												
1999	11,818	25	12.72	20	109.67	132	19.36			-20.50		
2000	16,848	285	17.05	68	59.57	101			42.56	34.04	-45.68	
2001	30,681	375	8.83	65	54.66	125	44.3		82.10	48.21	-8.24	
2002	1,314	79	2.24	27	10.99	73	13.51	0.27	-95.72	-74.63	-79.89	
2003	328	48	5.33	43	46.83	118		0.34	-75.01	137.95	326.11	
2004	13,218	73	1.42	10	42.76	101	42.94		3929.79	-73.36	-8.69	
2005	5,937	40	1.70	15	52.47	89	17.67	0.43	-55.08	19.72	22.71	-49.76

n – number of samples or observations na – not applicable, data represent first year of sampling
**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 the few remaining plants at this site were scattered.

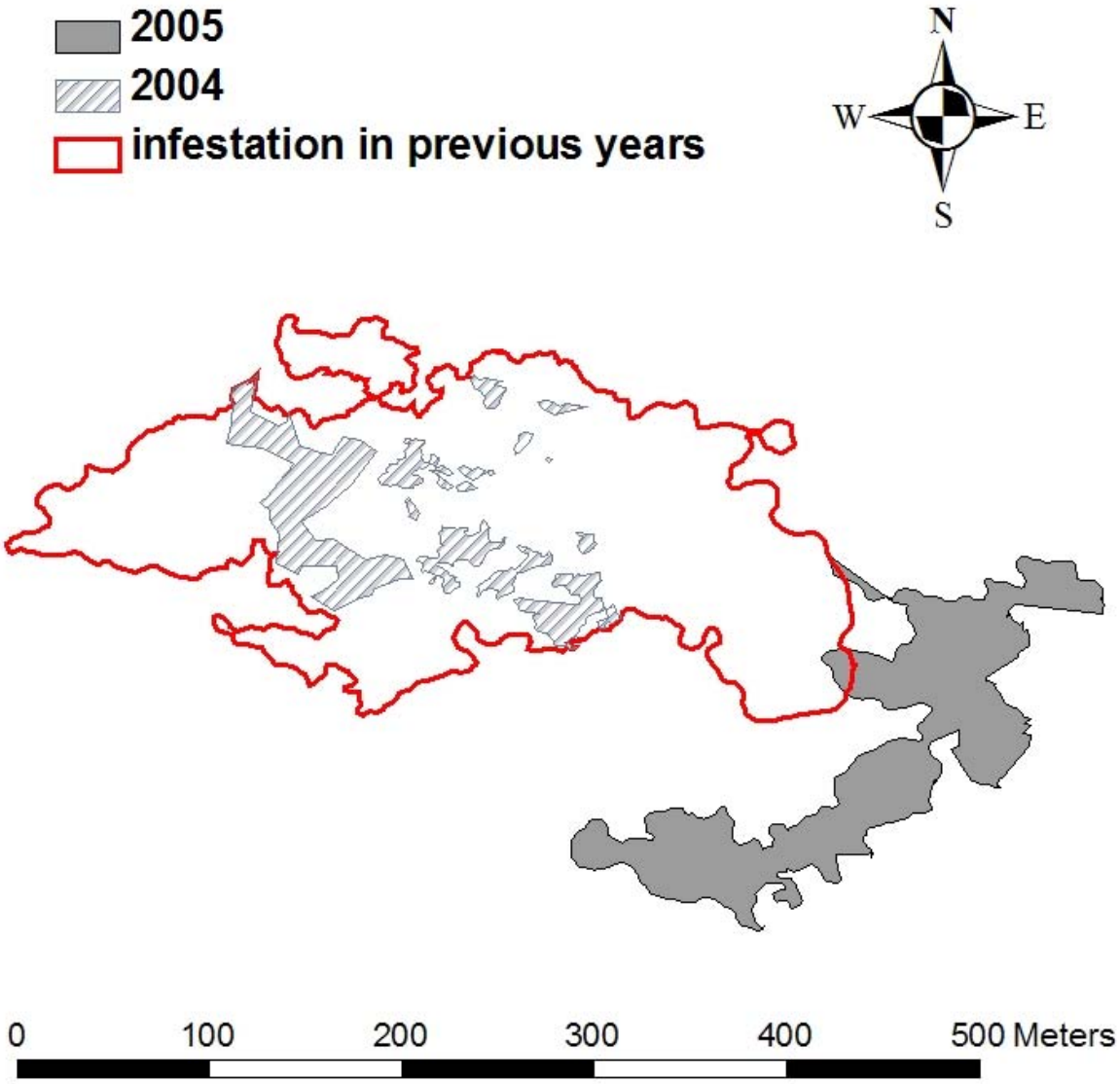
Table 11. Noxious weed biological control sites, target weeds, species released and recoveries at Fort Carson Military Post, 2005.

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

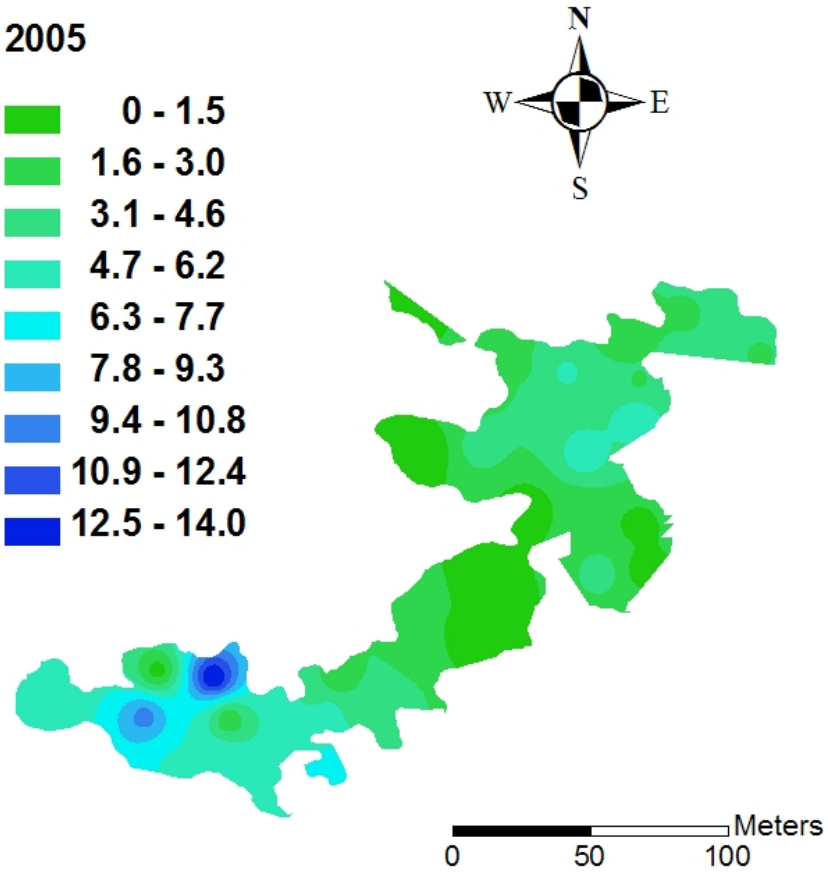
Table 11. Noxious weed biological control sites, target weeds, species released and recoveries at Fort Carson Military Post, 2005.

Location	Target weed	Site	Species released	Species recovered	New releases	New site
Ft. Carson	Spotted knapweed	Fuel Site	*Larinus minutus*	X		
Ft. Carson	Spotted knapweed	Fuel Site	*Larinus obtusus*			
Ft. Carson	Spotted knapweed	Fuel Site	*Metzneria paucipunctella*	X		
Ft. Carson	Spotted knapweed	Fuel Site	*Sphenoptera jugoslavica*	X		
Ft. Carson	Spotted knapweed	Fuel Site	*Urophora affinis*	X		
Ft. Carson	Spotted knapweed	HazMat	*Bangasternus fausti*			
Ft. Carson	Spotted knapweed	HazMat	*Cyphocleonus achates*	X		
Ft. Carson	Spotted knapweed	HazMat	*Larinus minutus*	X		
Ft. Carson	Spotted knapweed	HazMat	*Larinus obtusus*			
Ft. Carson	Spotted knapweed	HazMat	*Metzneria paucipunctella*	X		
Ft. Carson	Spotted knapweed	HazMat	*Sphenoptera jugoslavica*	X		
Ft. Carson	Spotted knapweed	HazMat	*Urophora affinis*	X		
Ft. Carson	Spotted knapweed	Turkey Creek	*Agapeta zoegana*			
Ft. Carson	Spotted knapweed	Turkey Creek	*Cyphocleonus achates*	X	X	
Ft. Carson	Spotted knapweed	Turkey Creek	*Larinus minutus*	X		
Ft. Carson	Spotted knapweed	Turkey Creek	*Metzneria paucipunctella*			
Ft. Carson	Spotted knapweed	Turkey Creek	*Sphenoptera jugoslavica*			
Ft. Carson	Spotted knapweed	Turkey Creek	*Urophora affinis*	X		

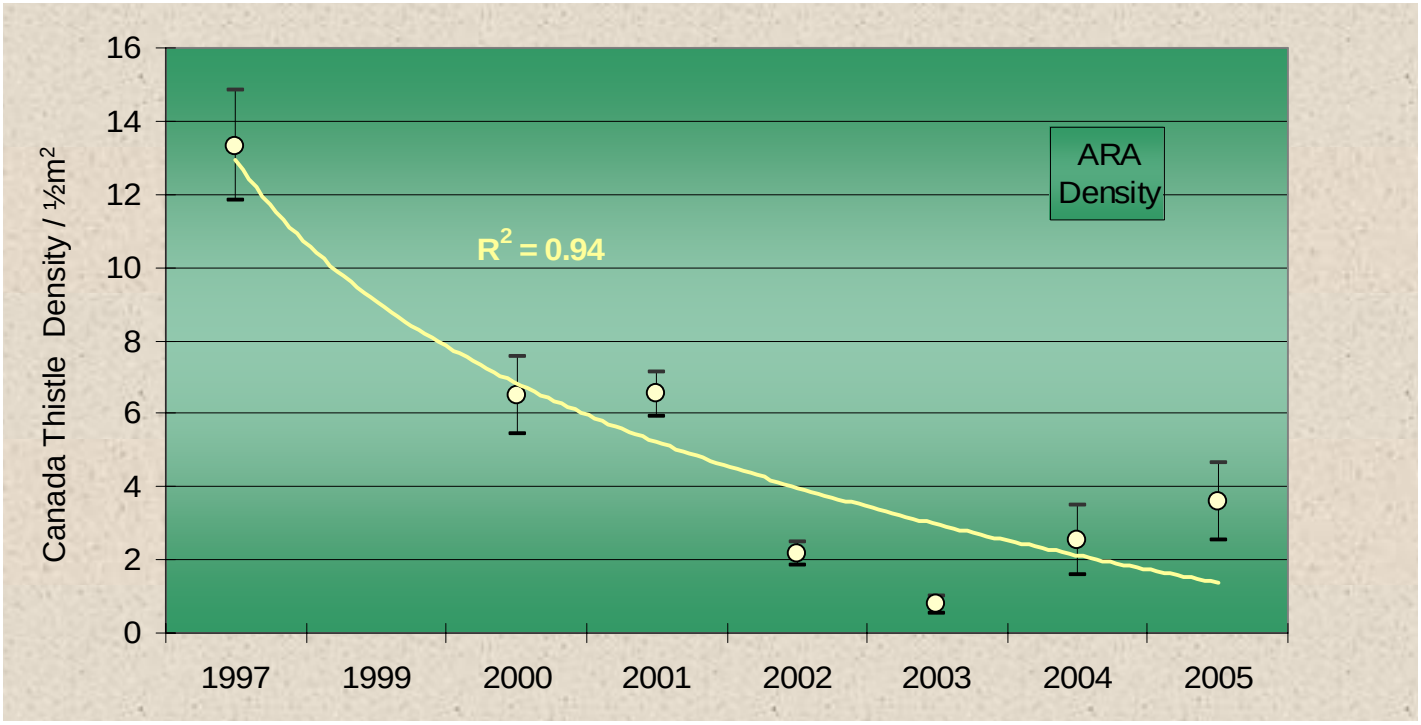
[1] New recovery in 2005
[2] Adventitious recovery, insects were not released at this location

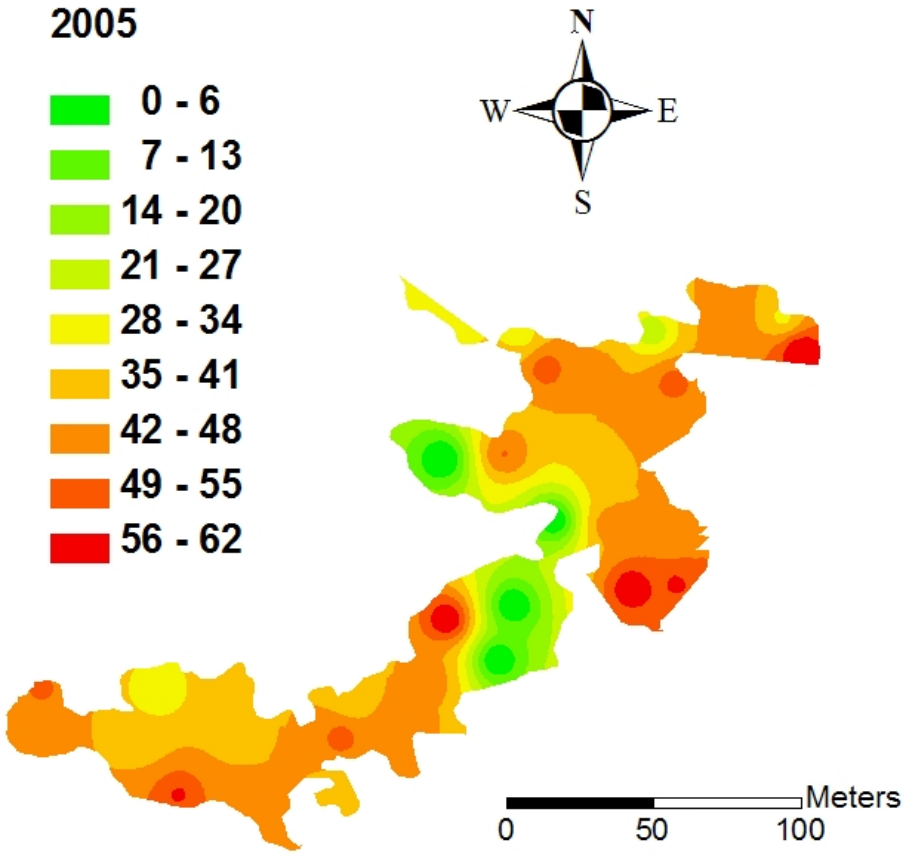


ARA I Canada thistle perimeter in 2005.

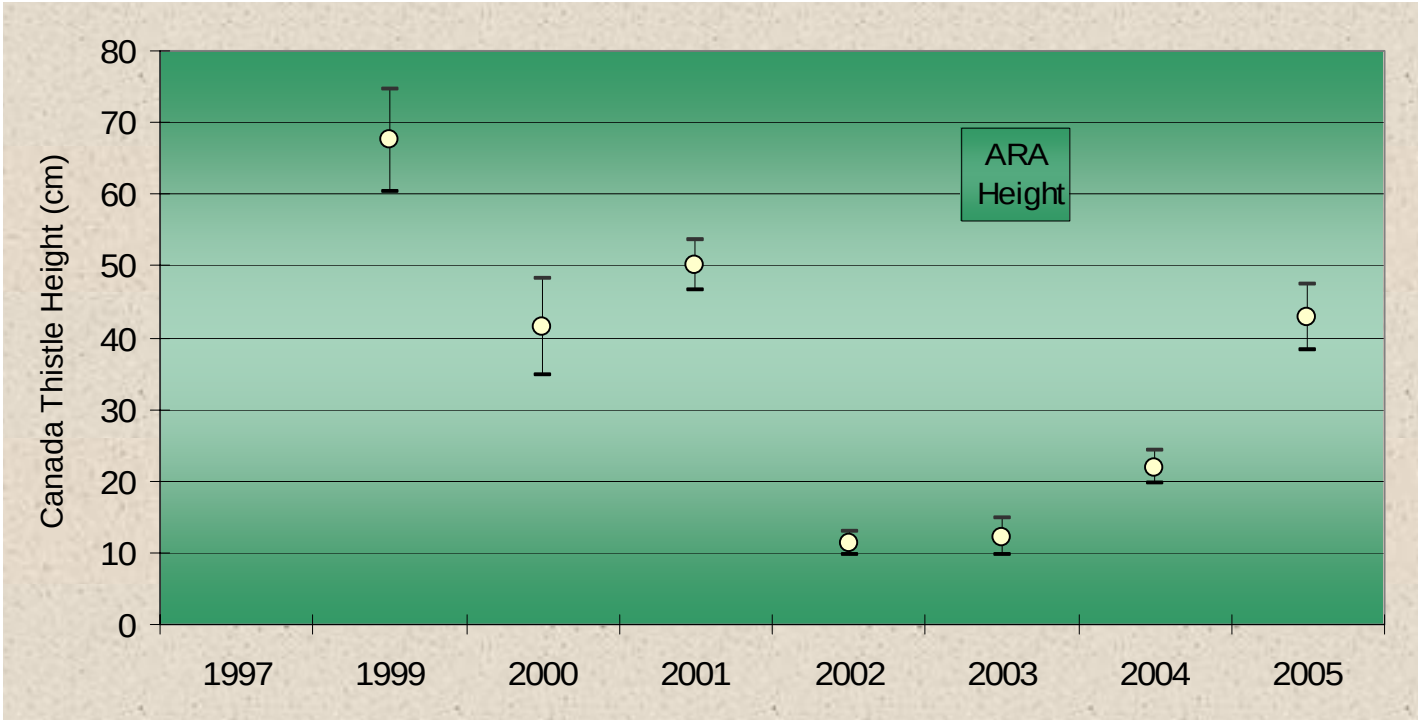


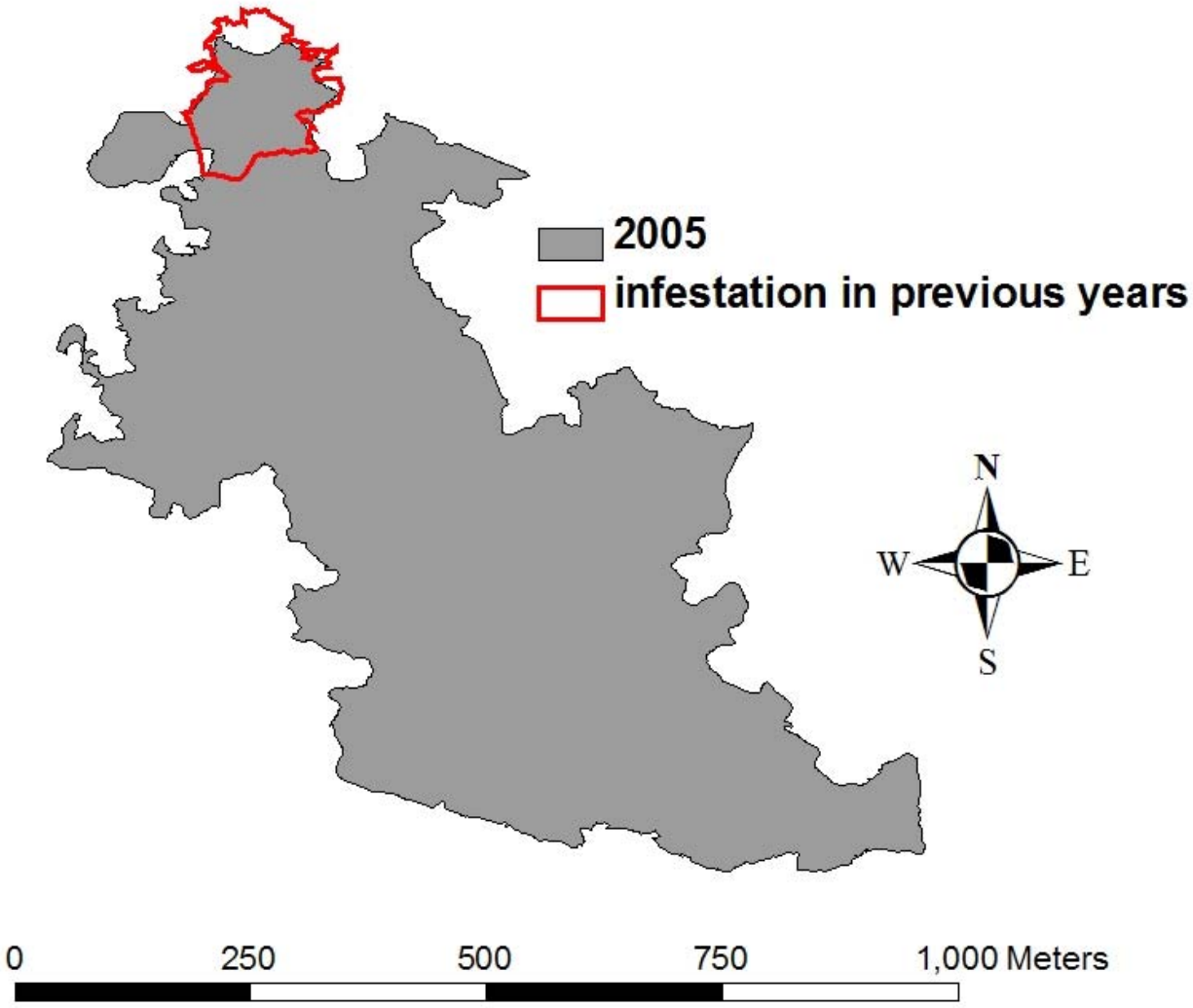
ARA I Canada thistle density in 2005.



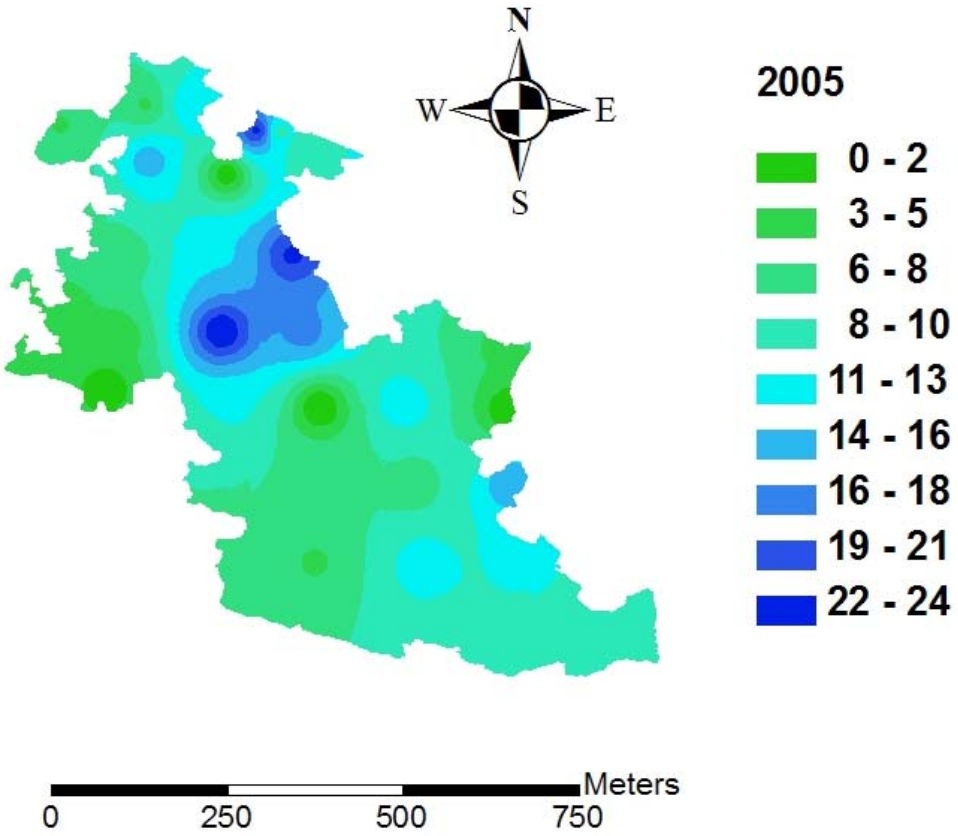


ARA I Canada thistle height in 2005.





ARA II Canada thistle perimeter in 2005.



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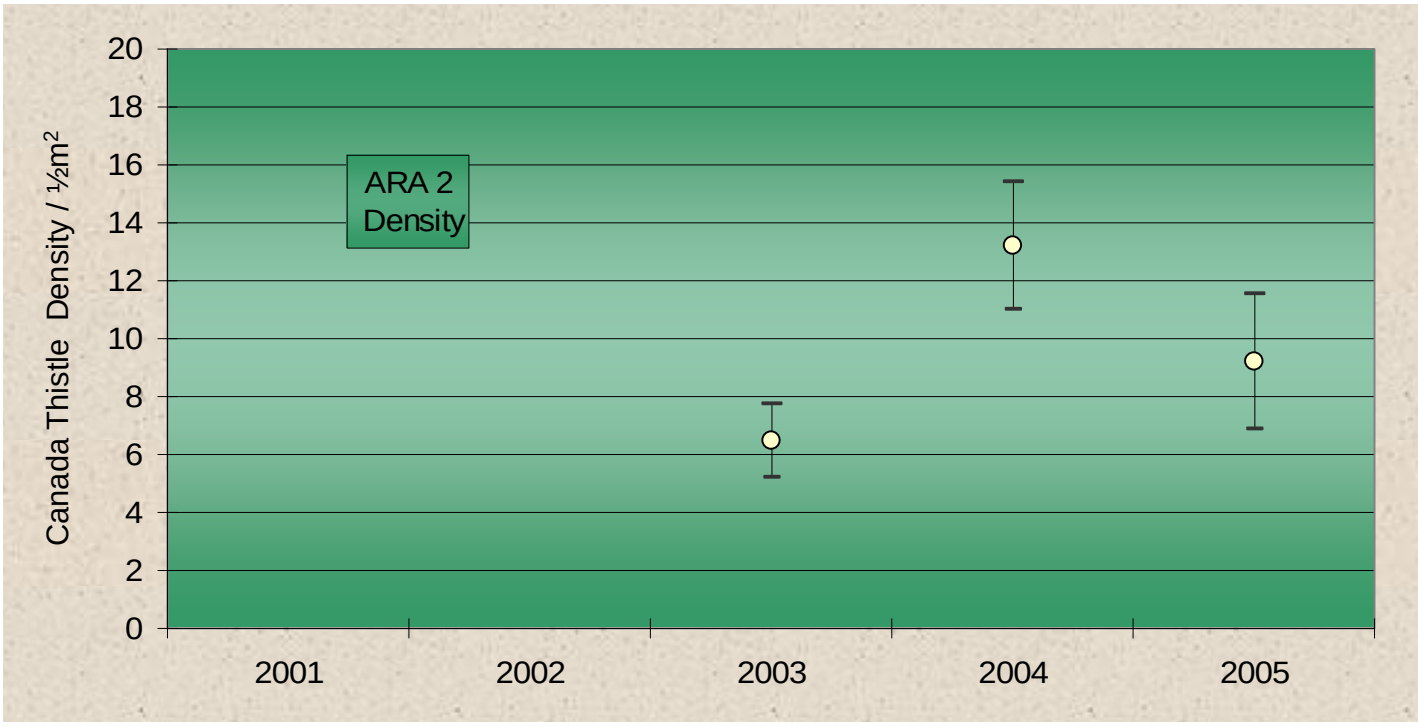
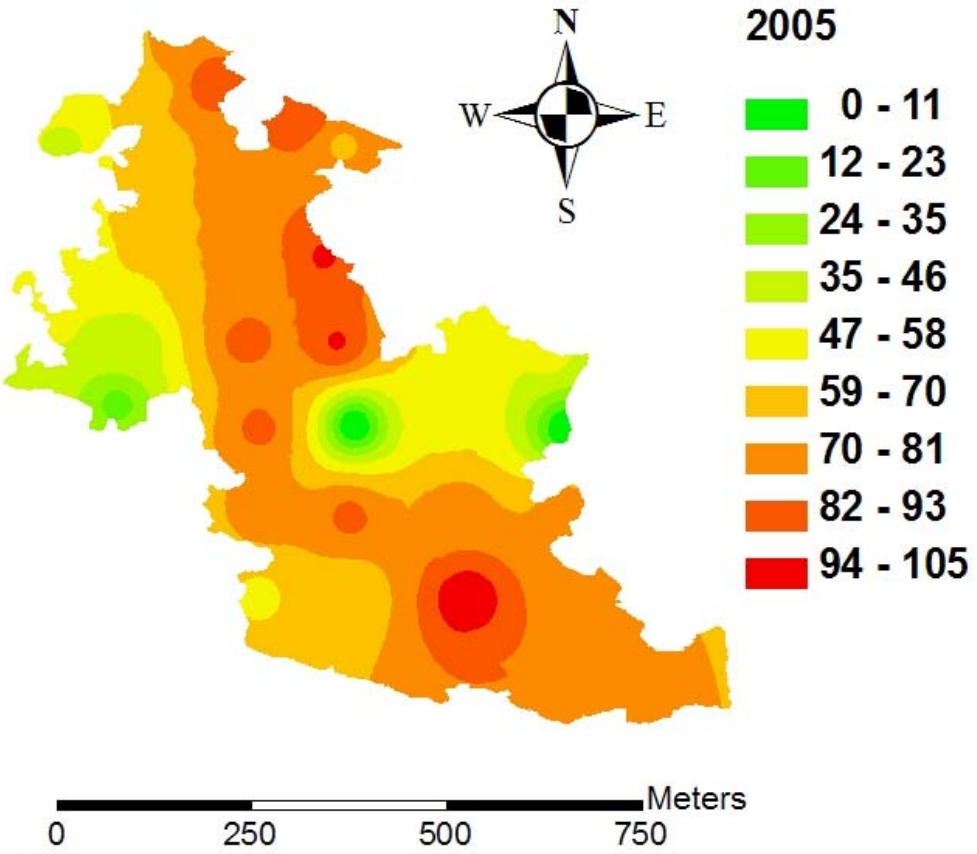
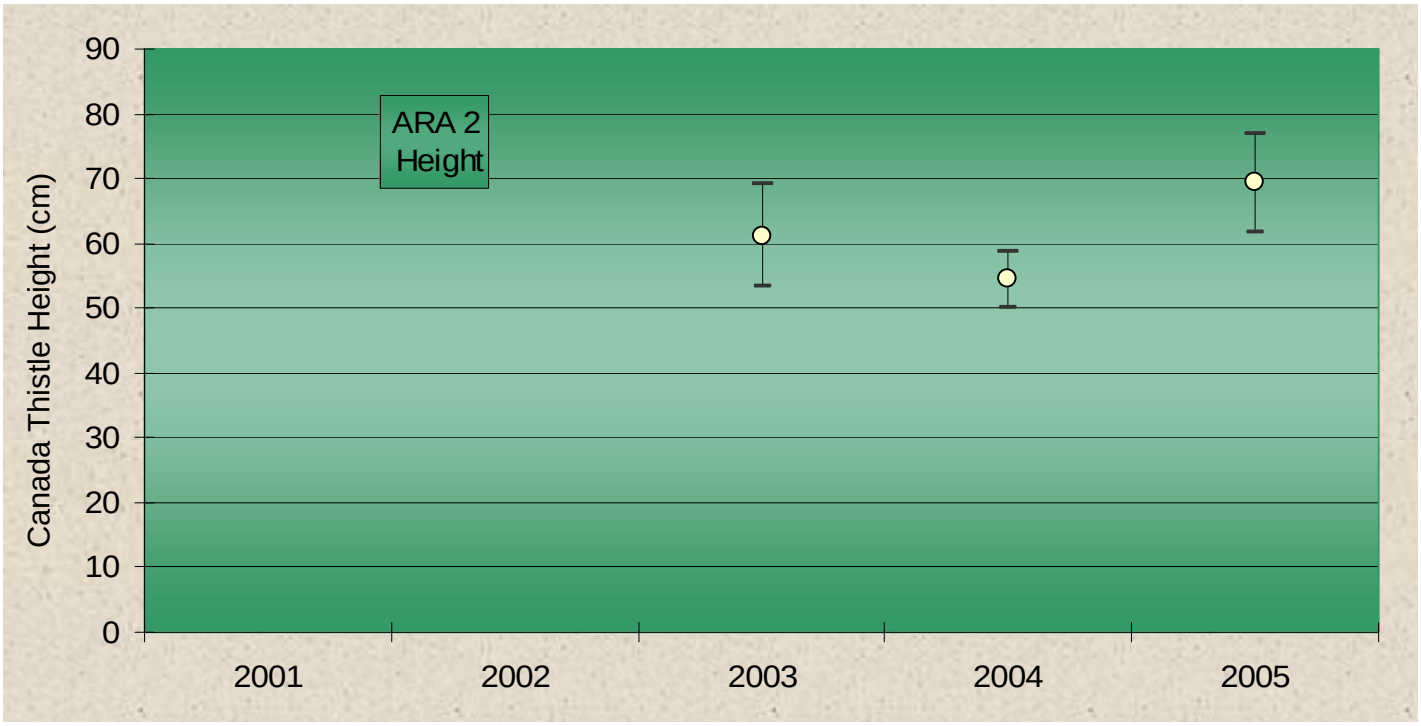
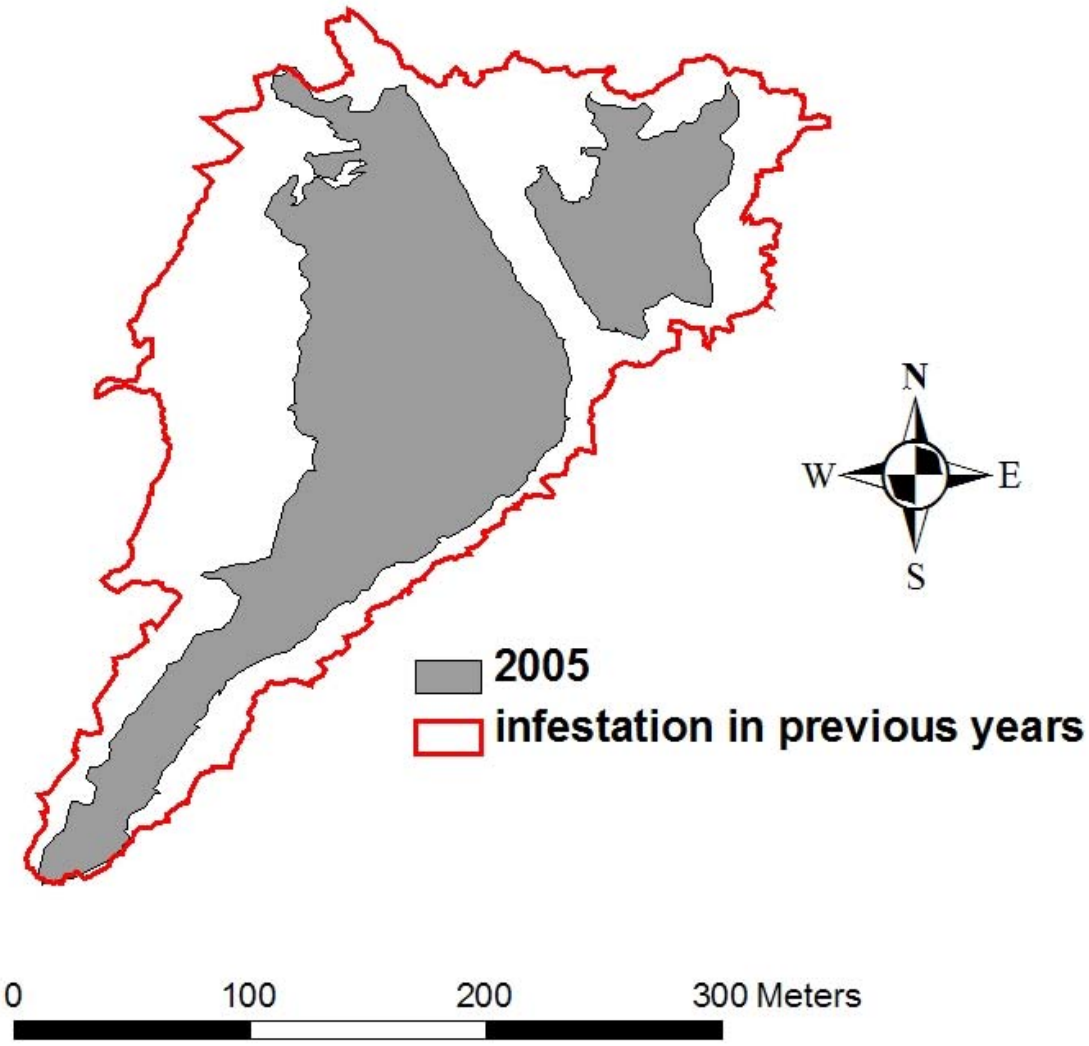


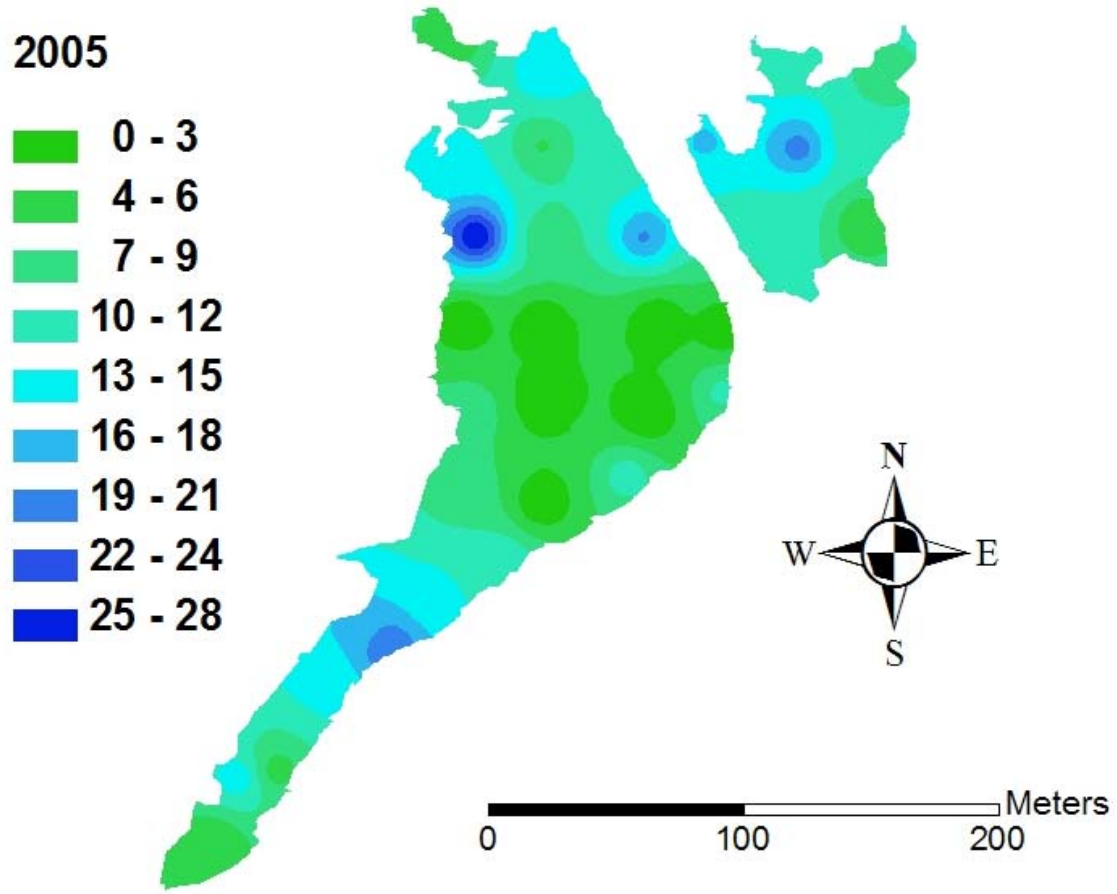


ARA II Canada thistle height in 2005.

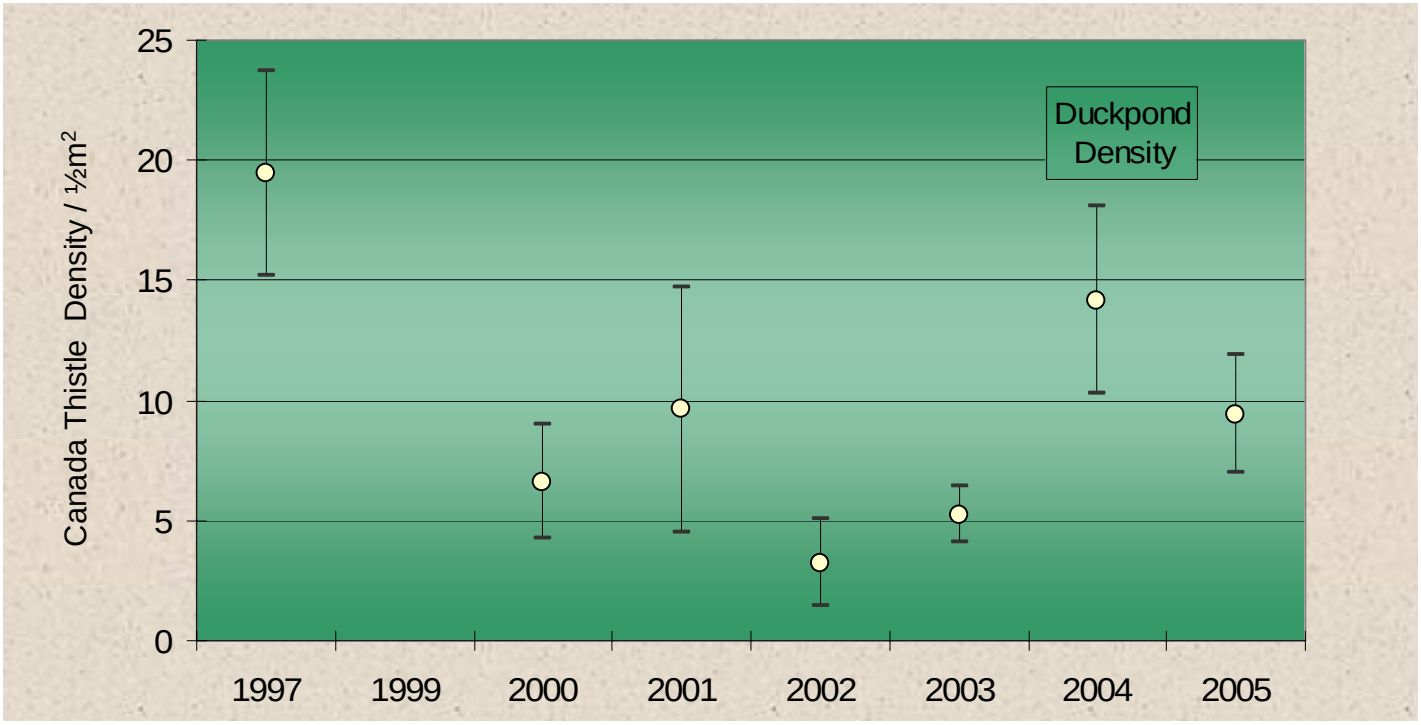


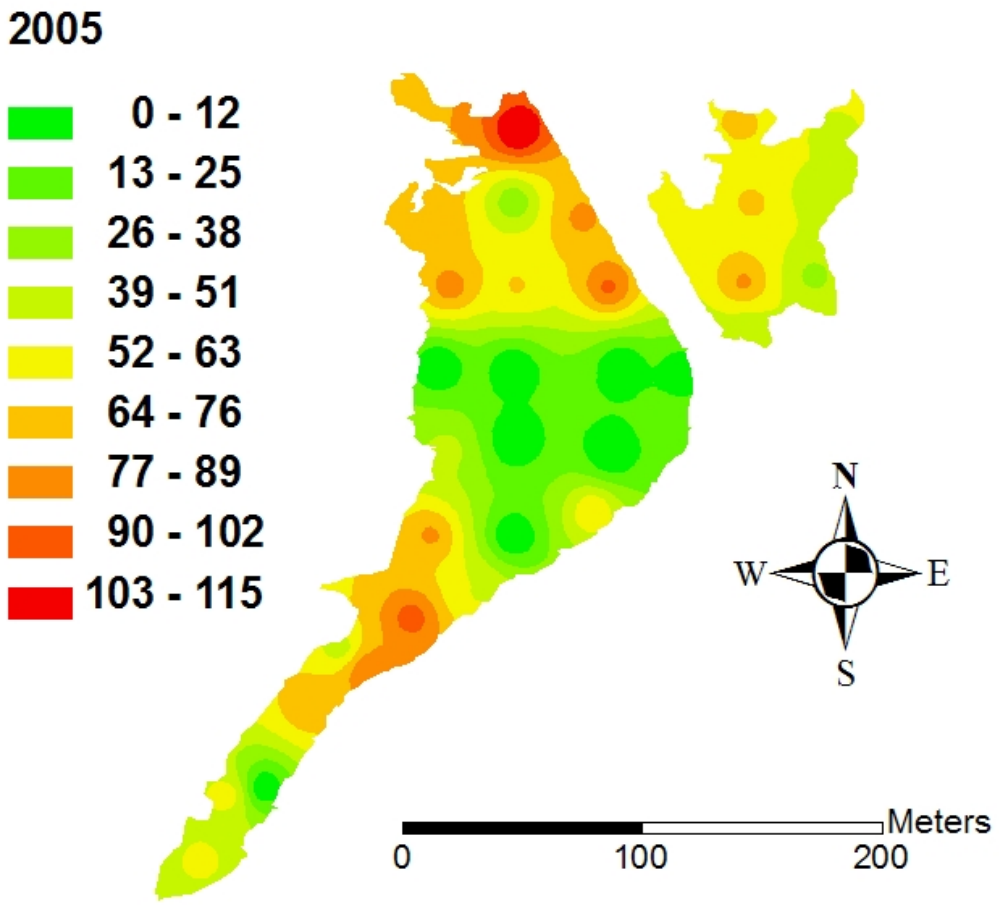


Duckpond Canada thistle perimeter in 2005.

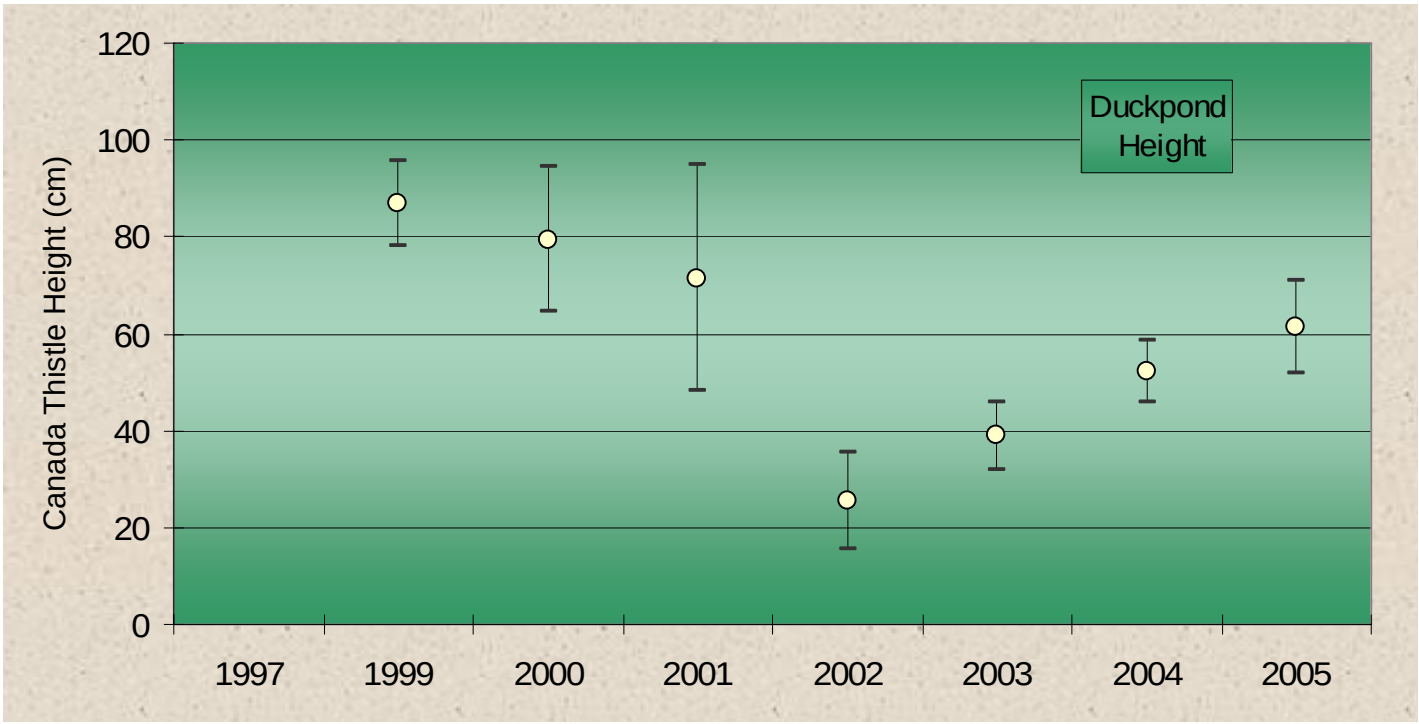


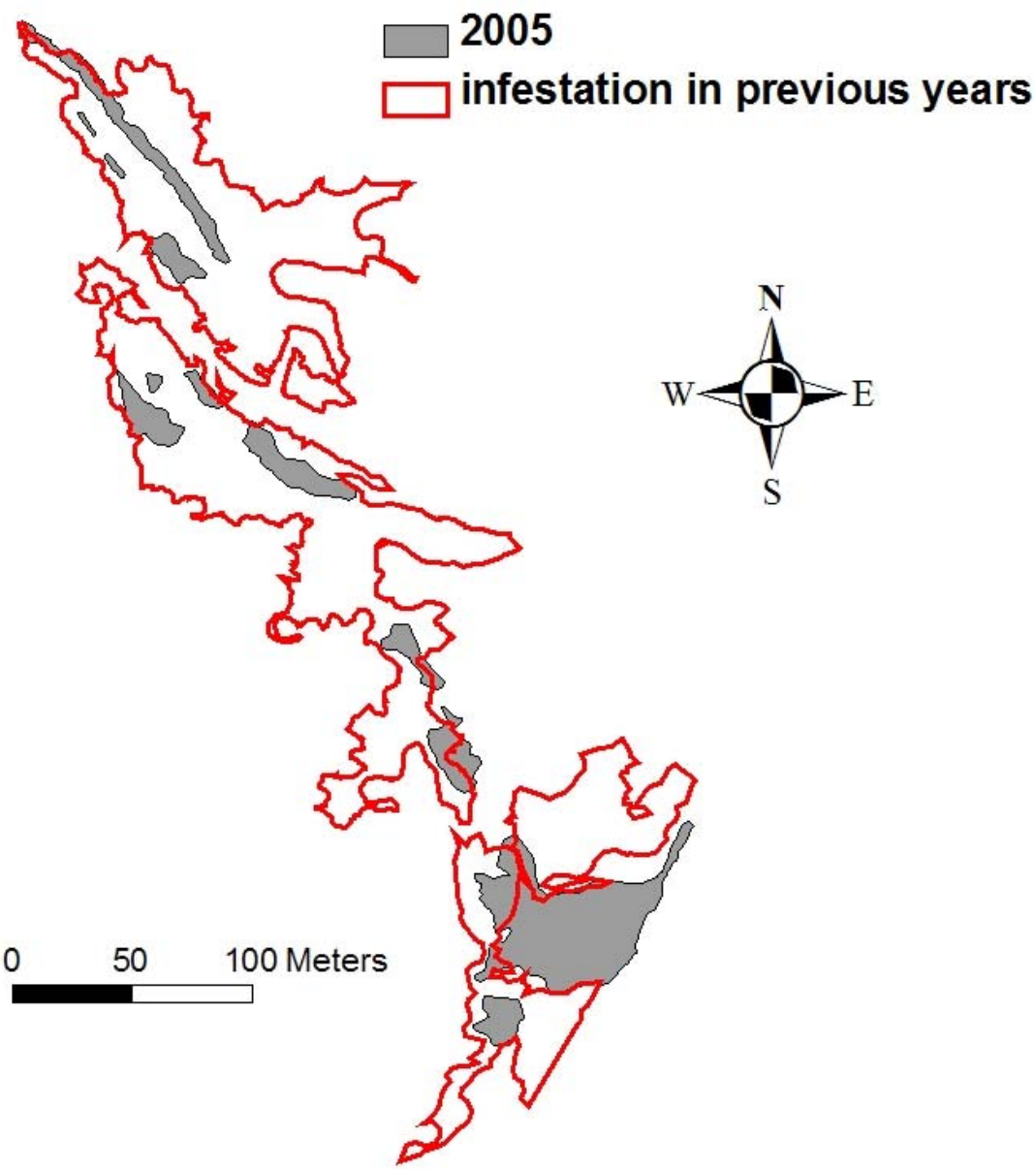
Duckpond Canada thistle density in 2005.



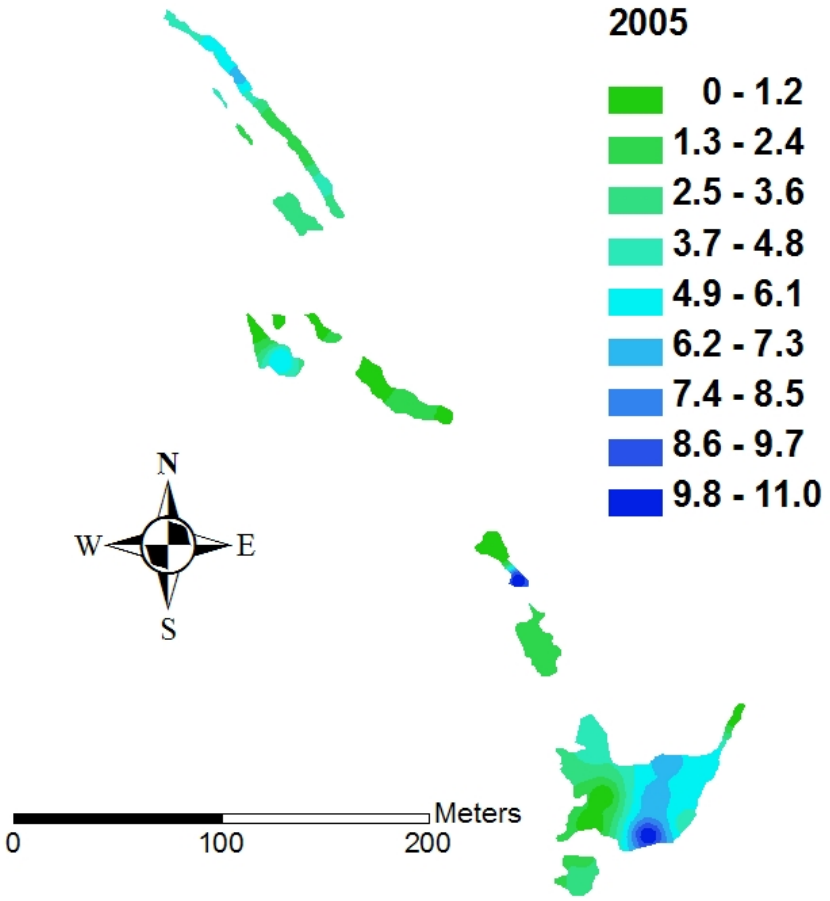


Duckpond Canada thistle height in 2005.

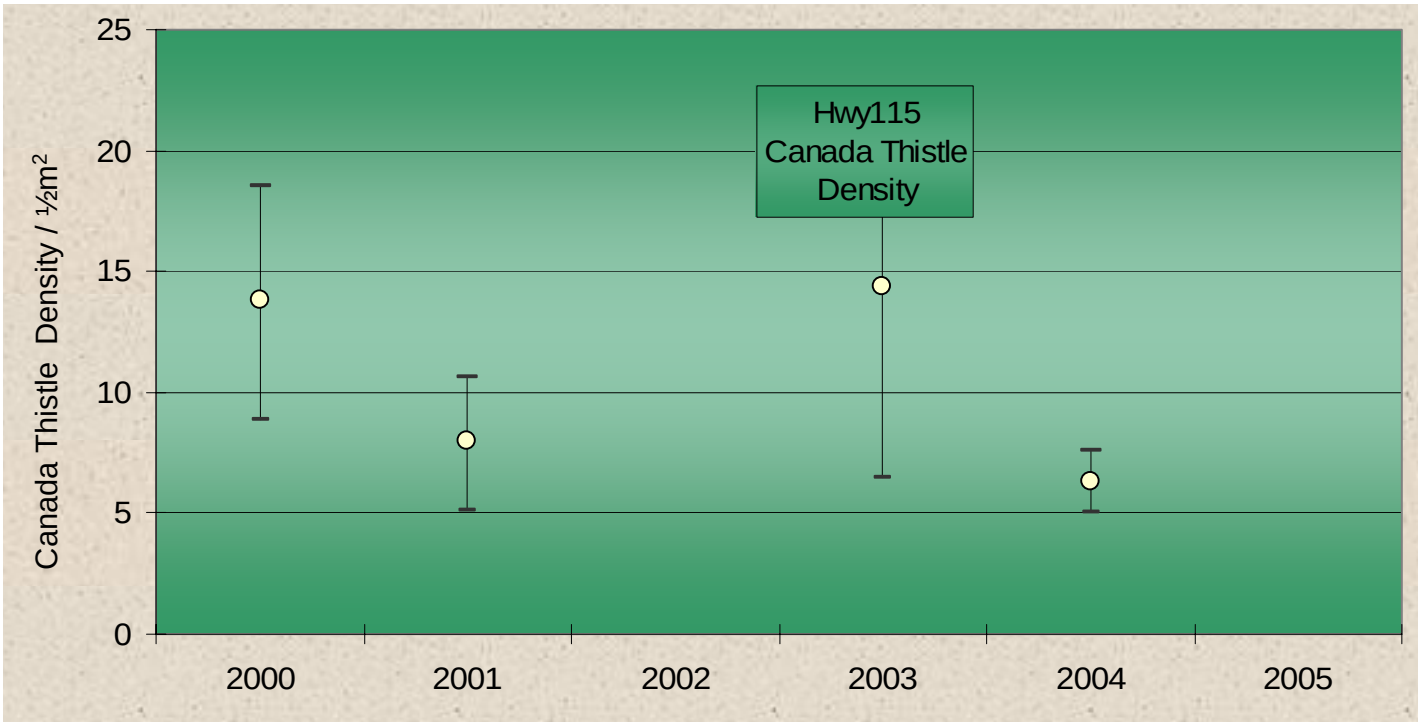


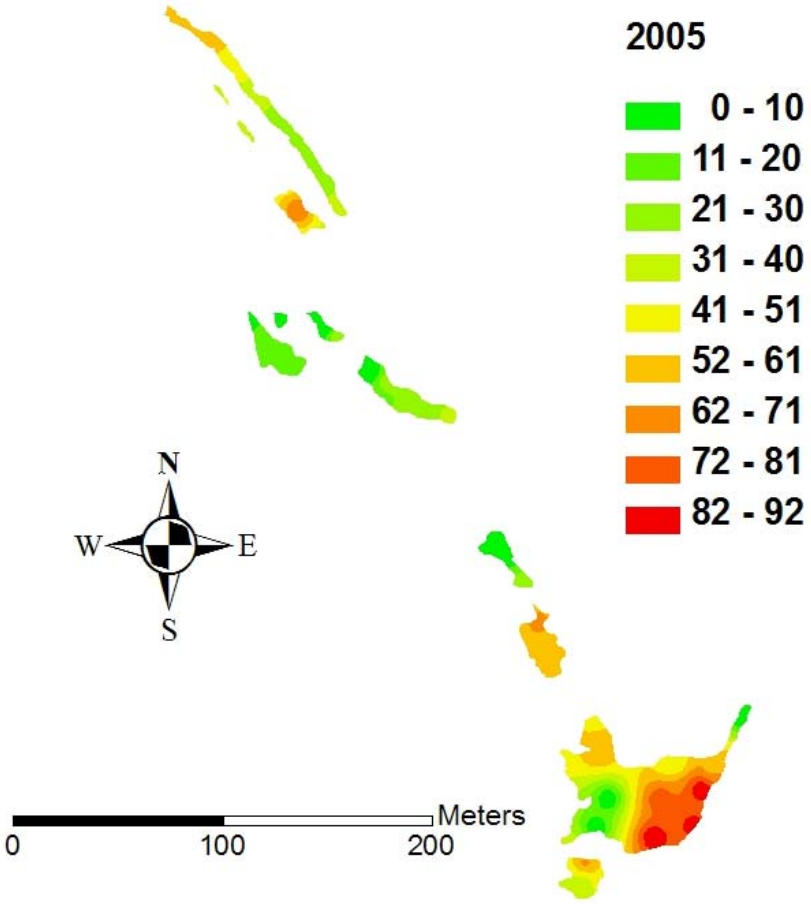


Highway 115 Canada & musk thistle perimeter in 2005.

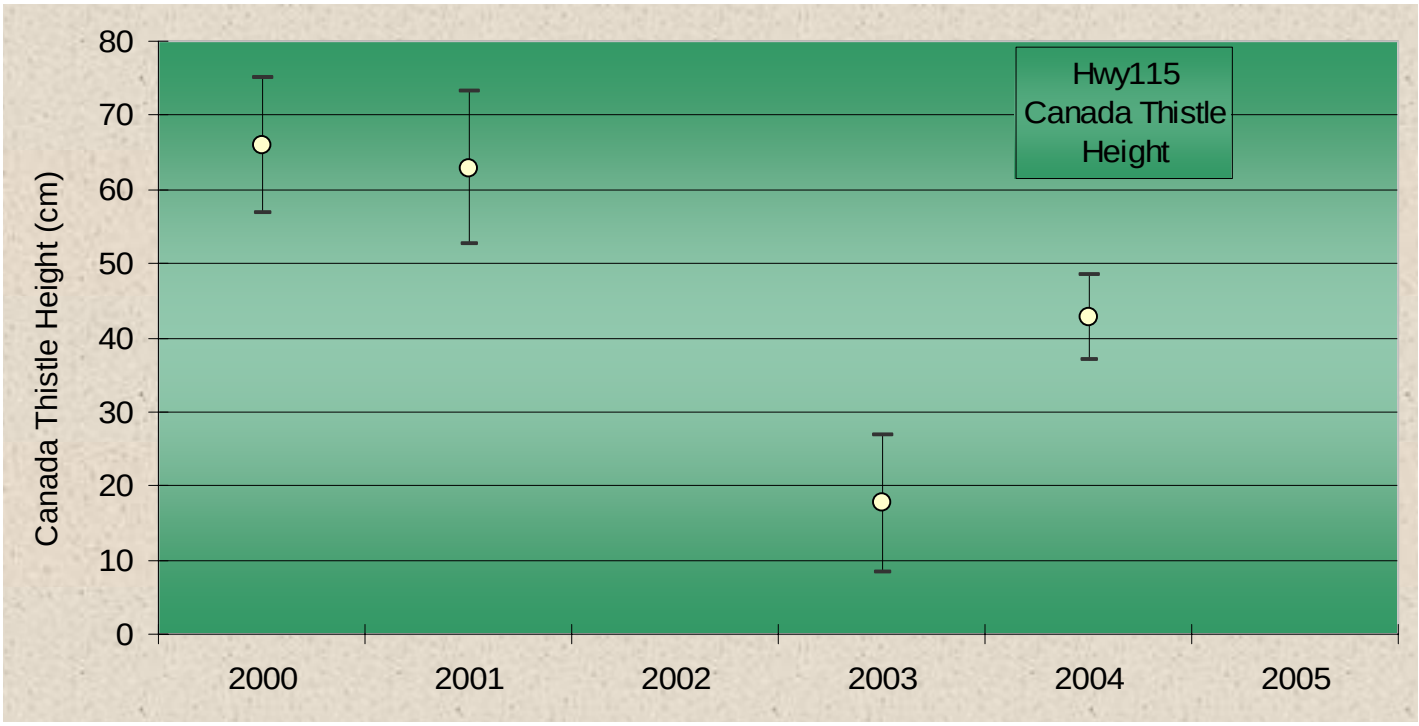


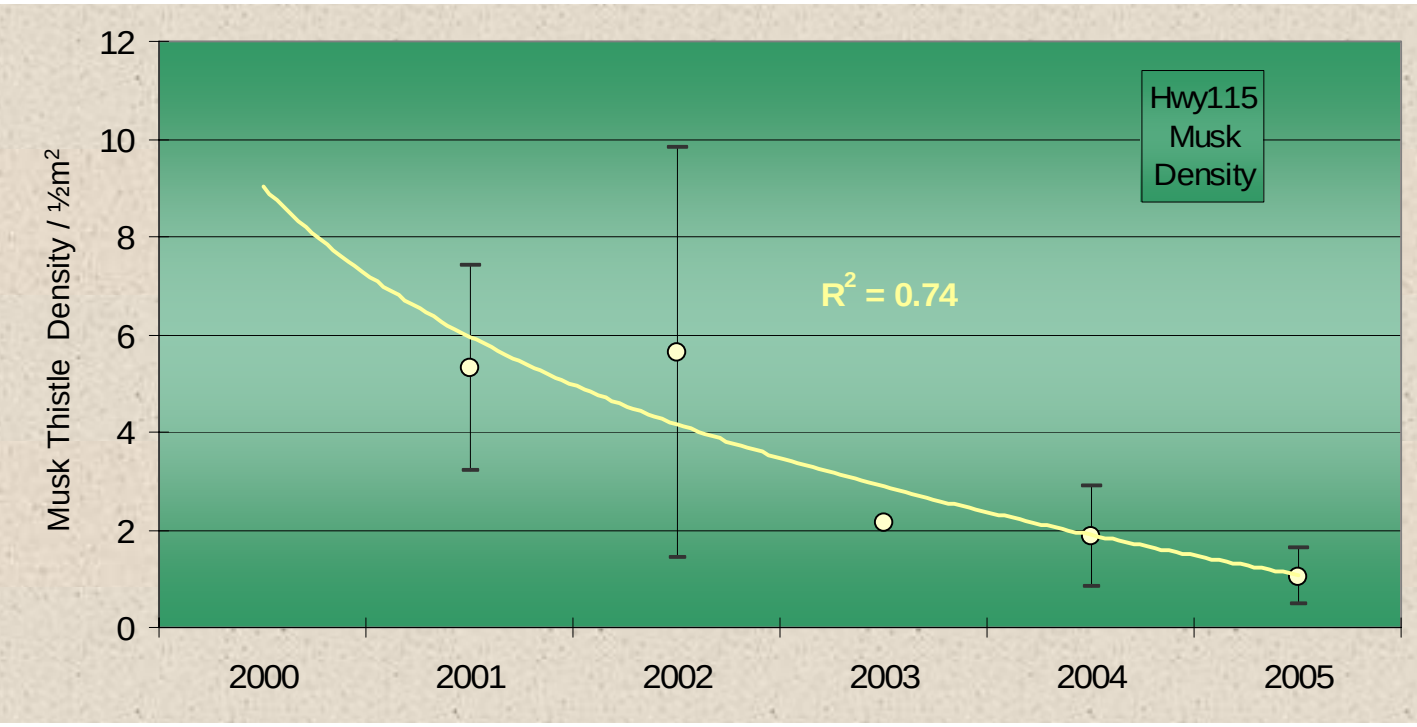
Highway 115 Canada thistle density in 2005.



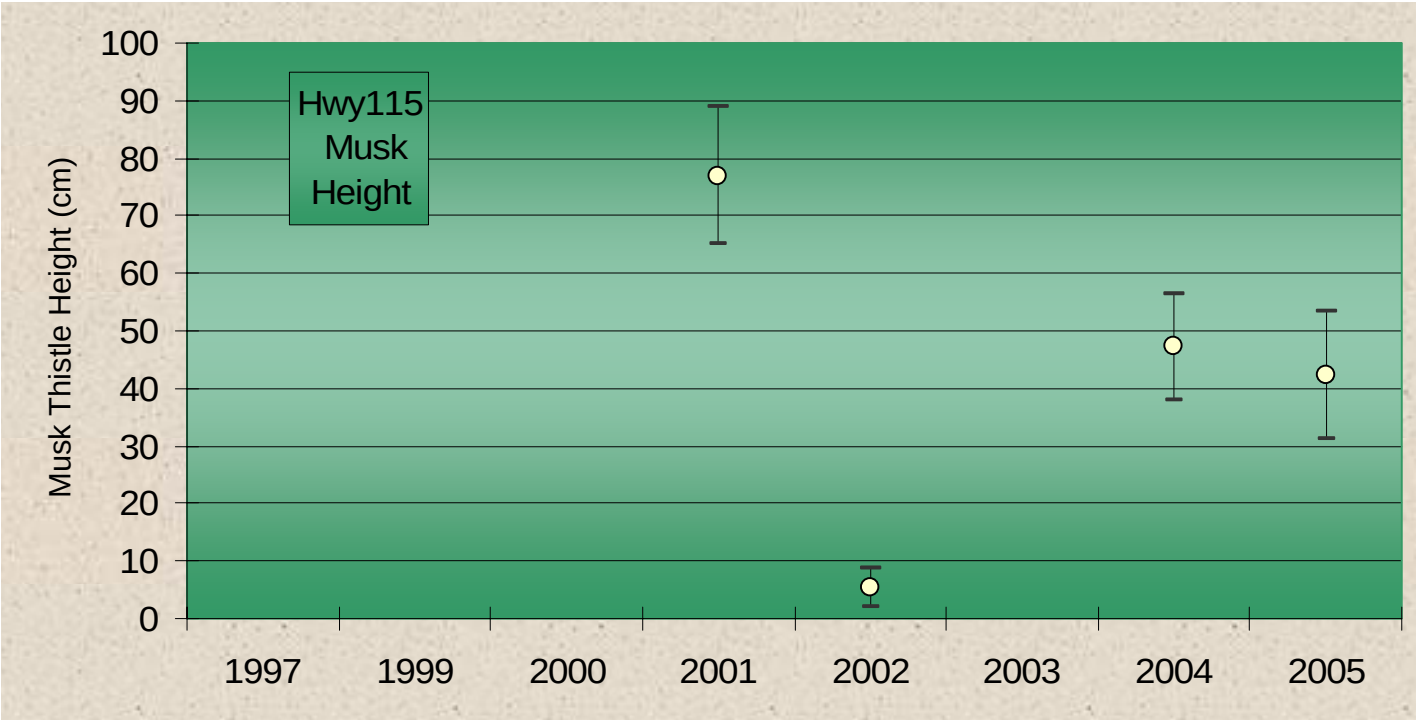


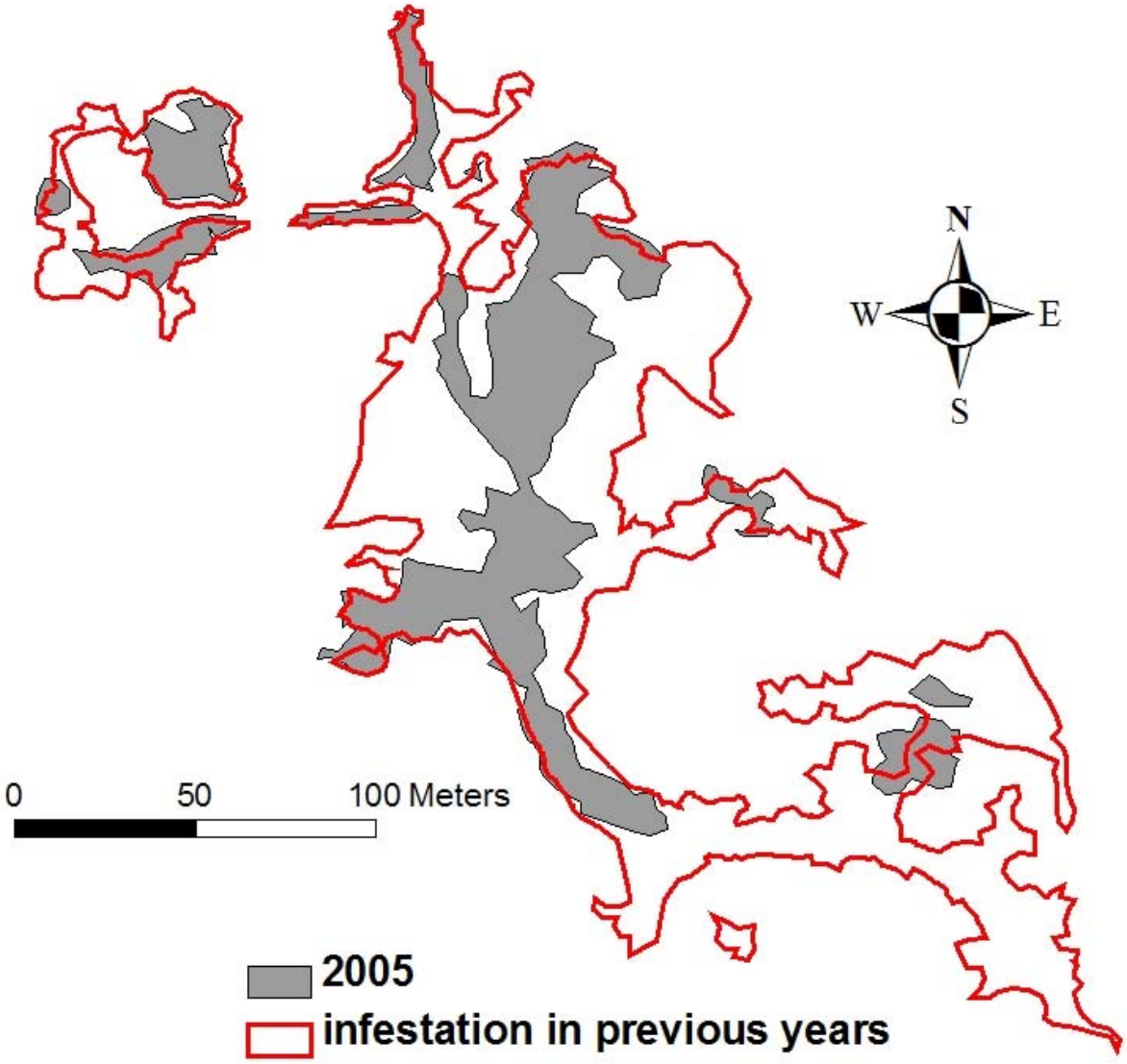
Highway 115 Canada thistle height in 2005.



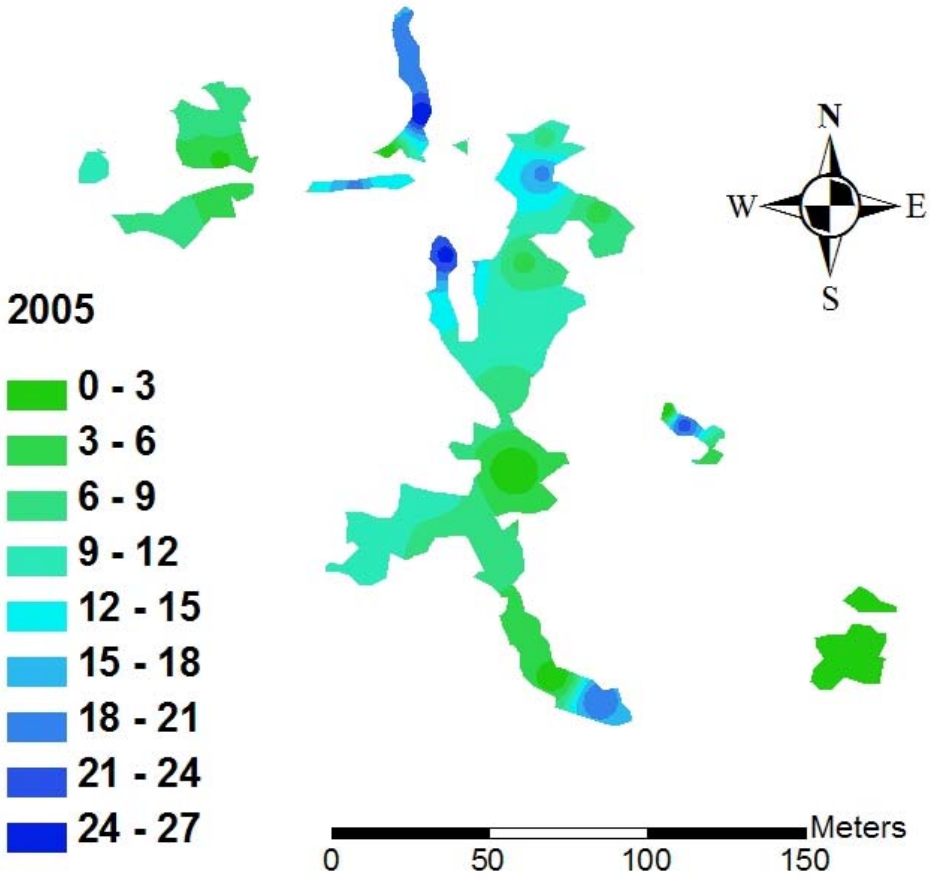


Highway 115 musk thistle density and height comparisons 2001-2005.

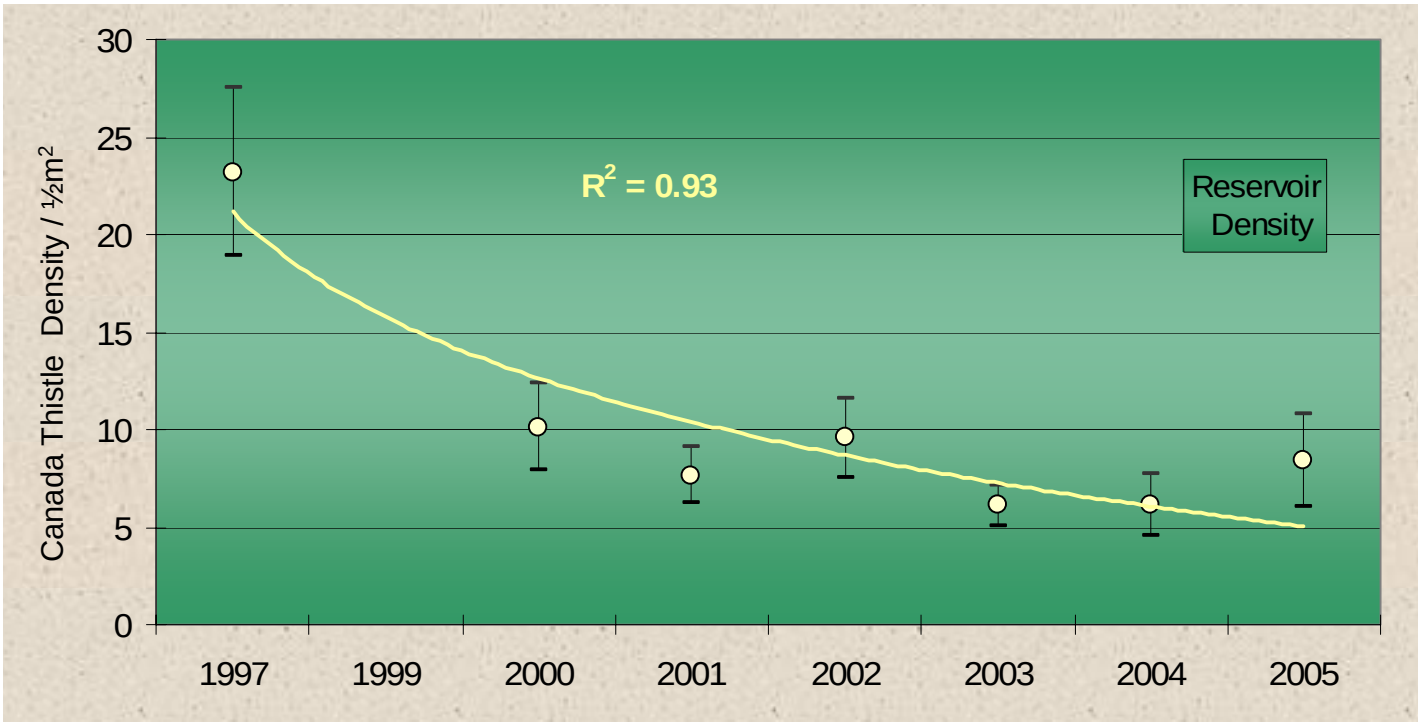


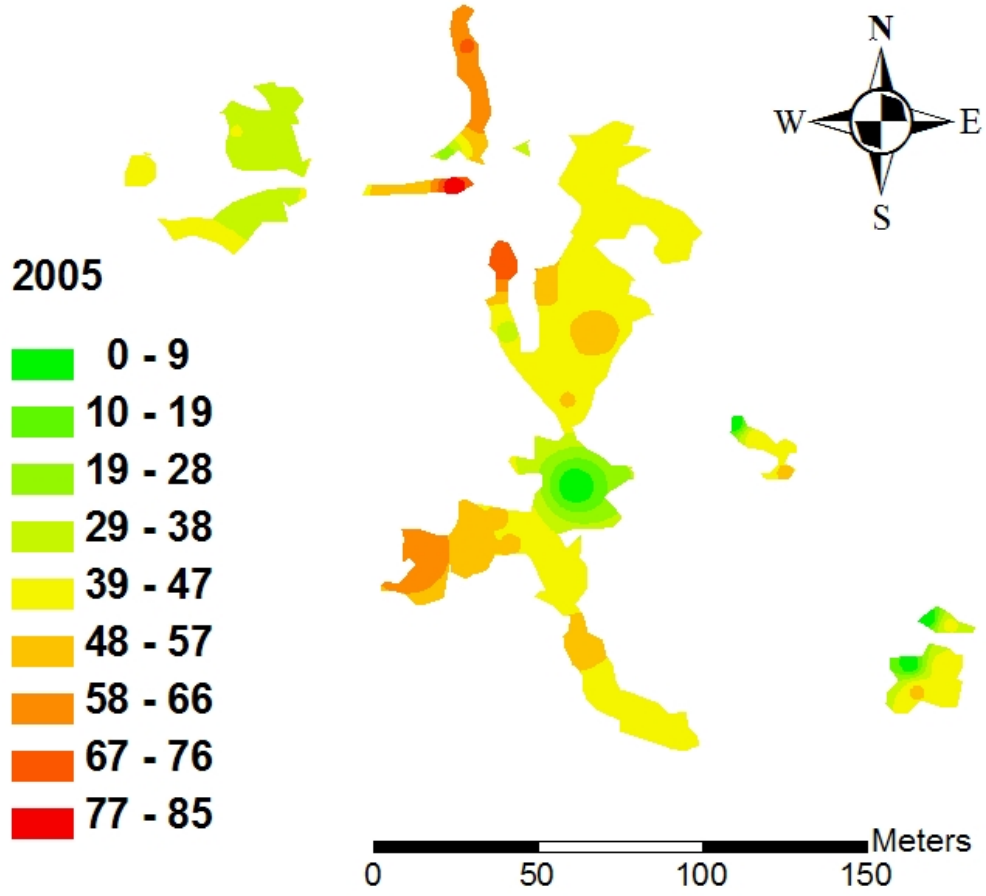


Reservoir Canada thistle perimeter in 2005.

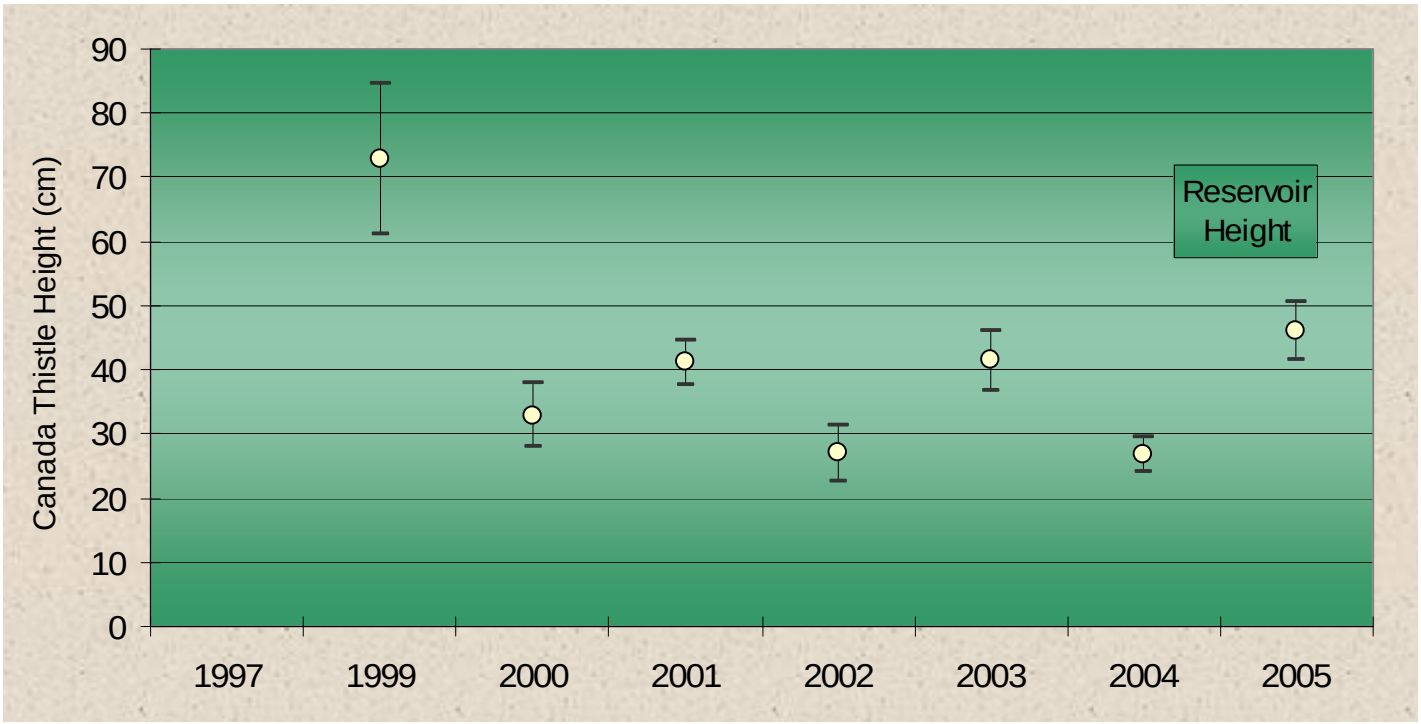


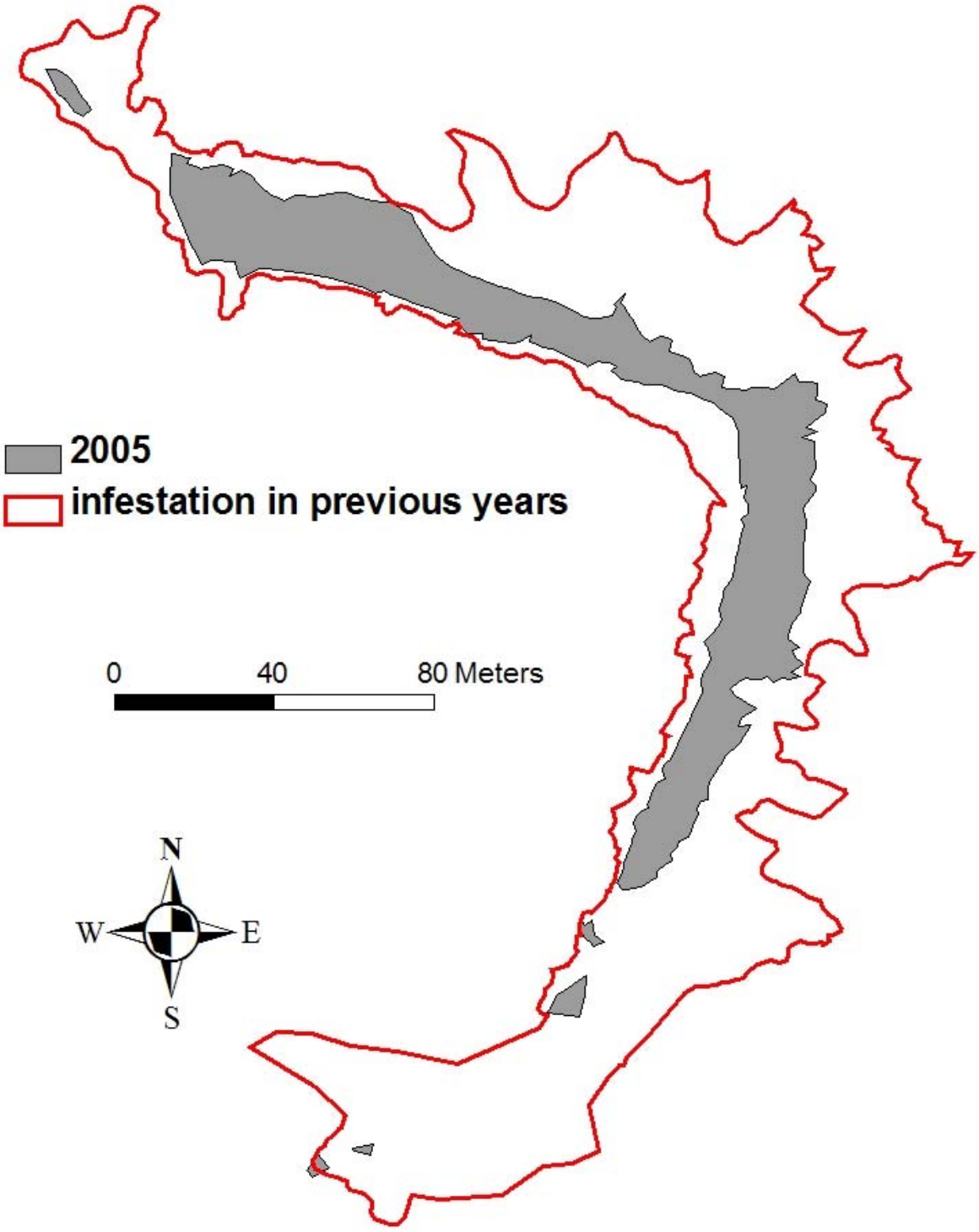
Reservoir Canada thistle density in 2005.



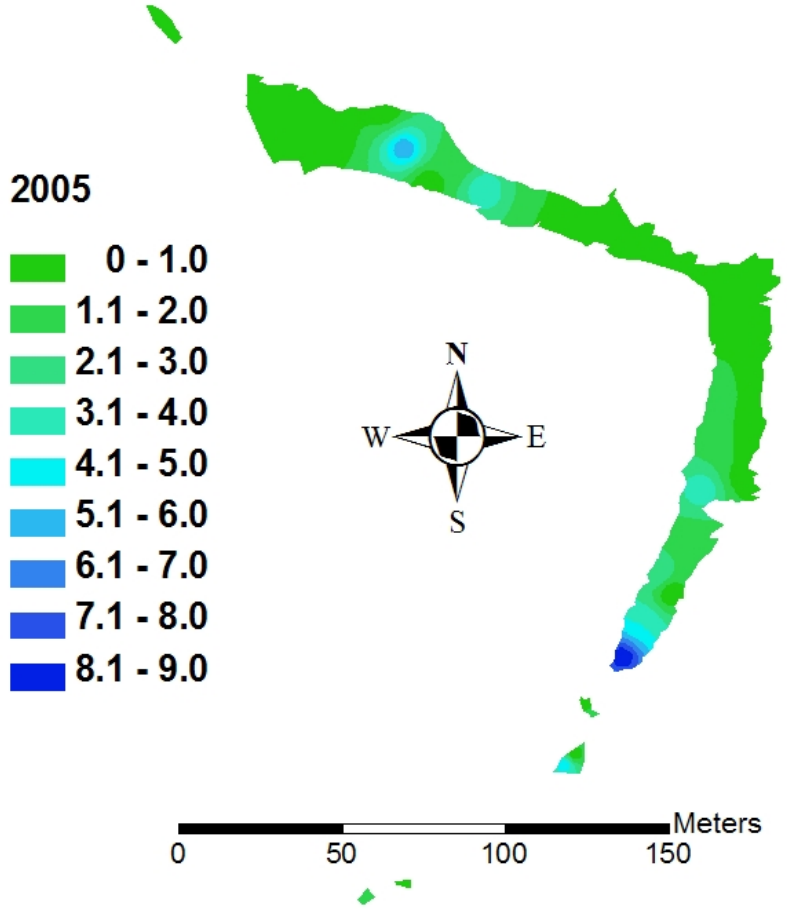


Reservoir Canada thistle height in 2005.

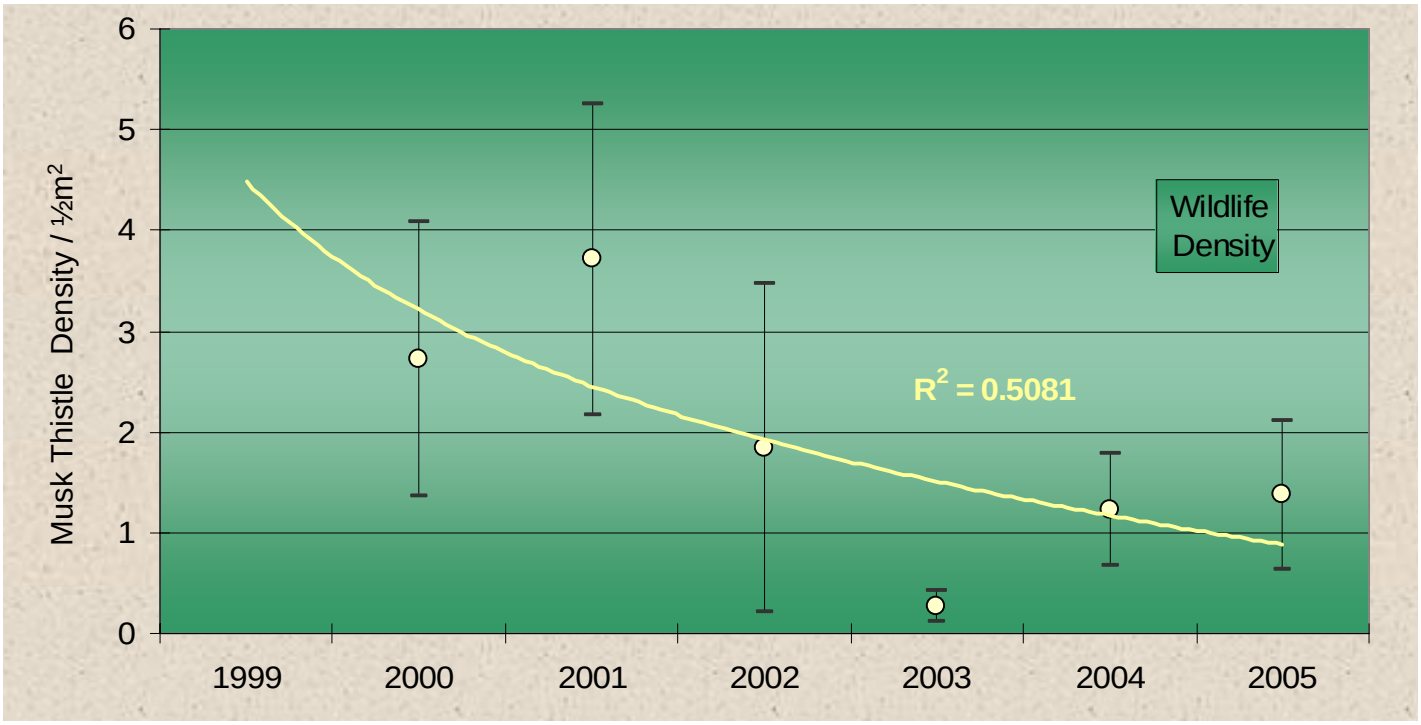


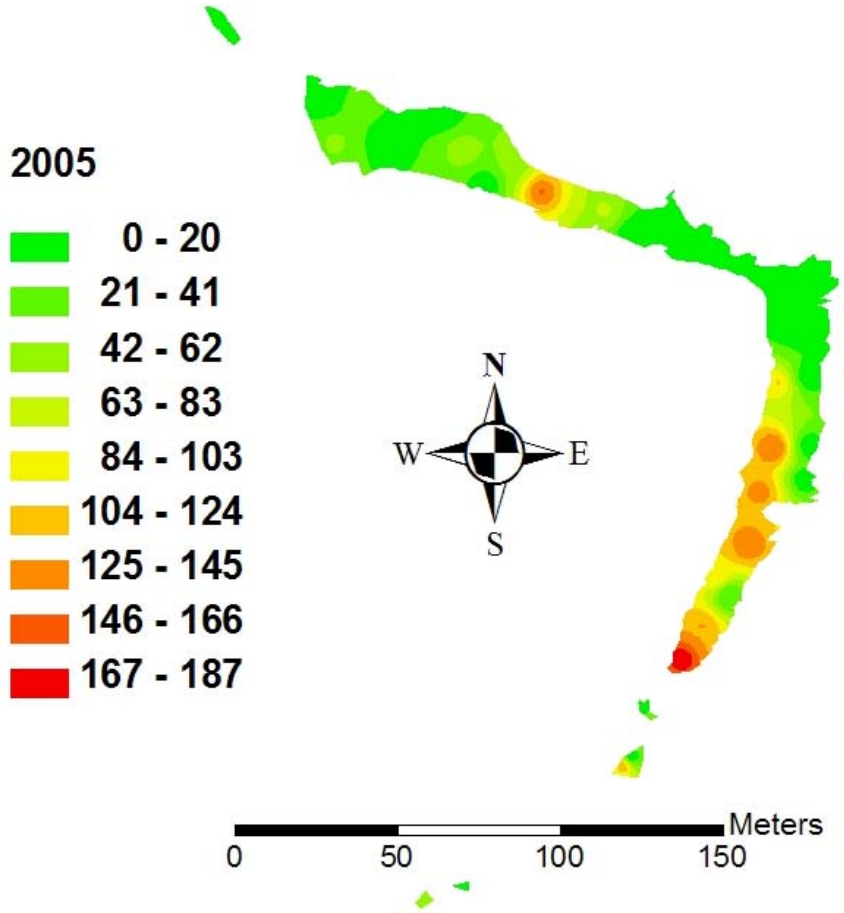


Wildlife Refuge musk thistle perimeter in 2005.

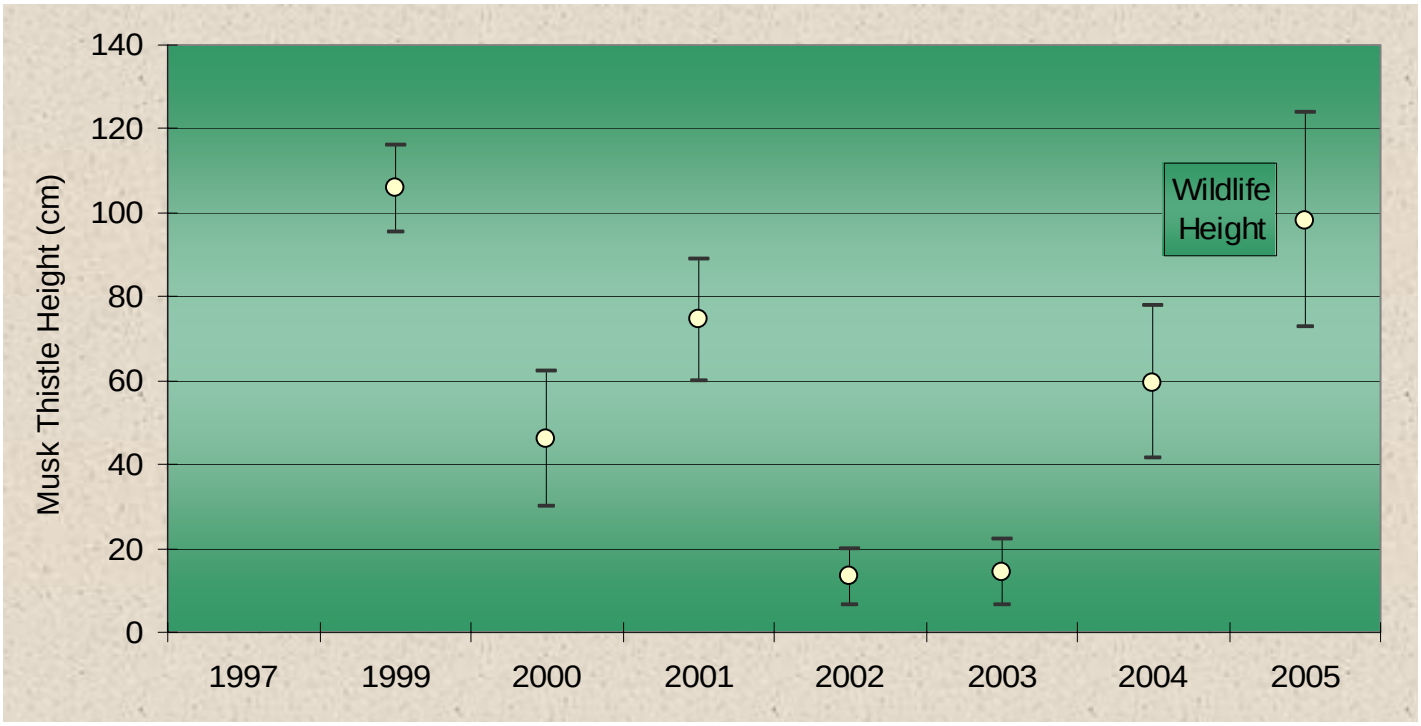


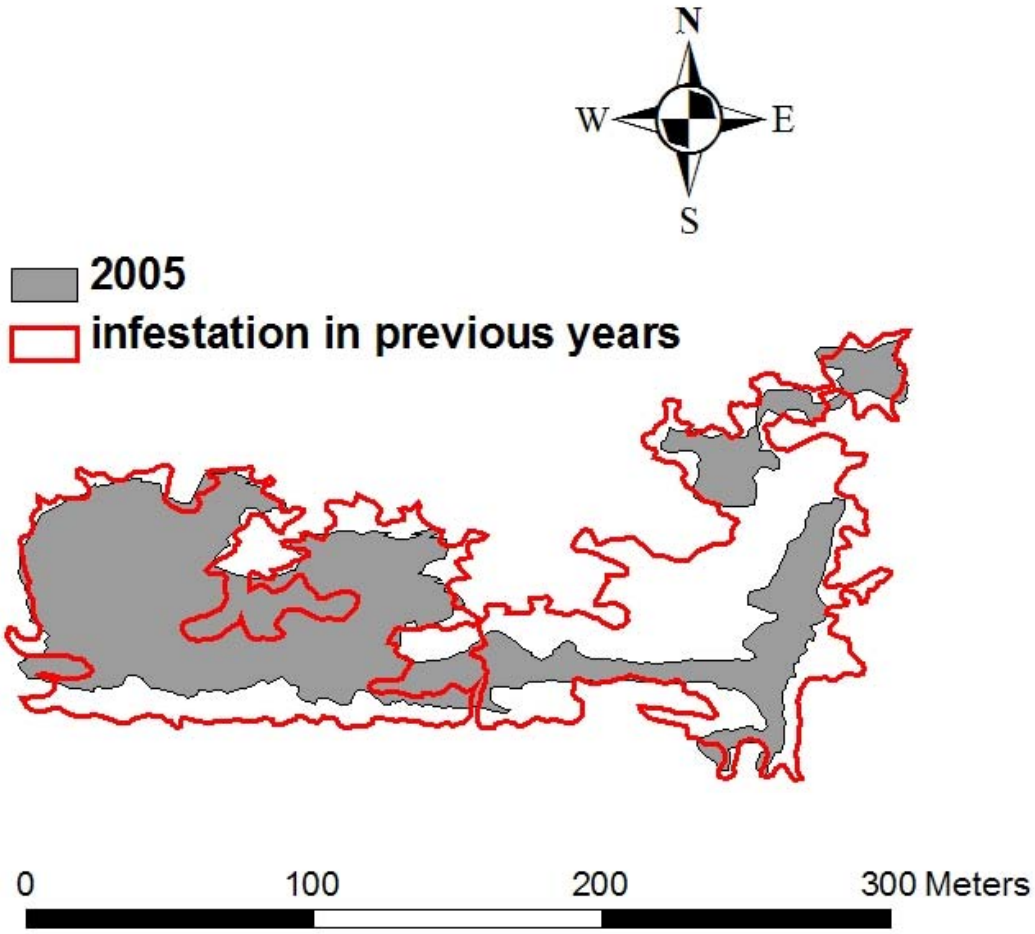
Wildlife Refuge musk thistle density in 2005.



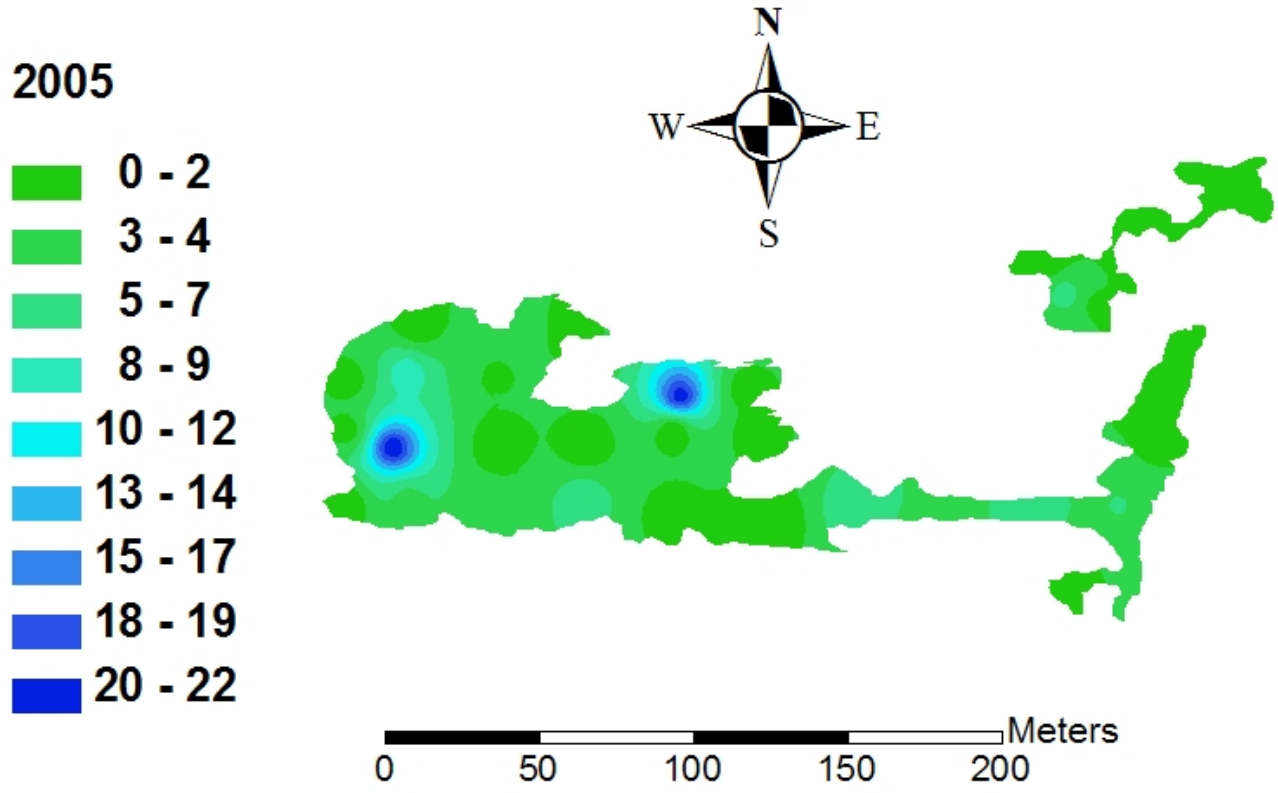


Wildlife Refuge musk thistle height in 2005.

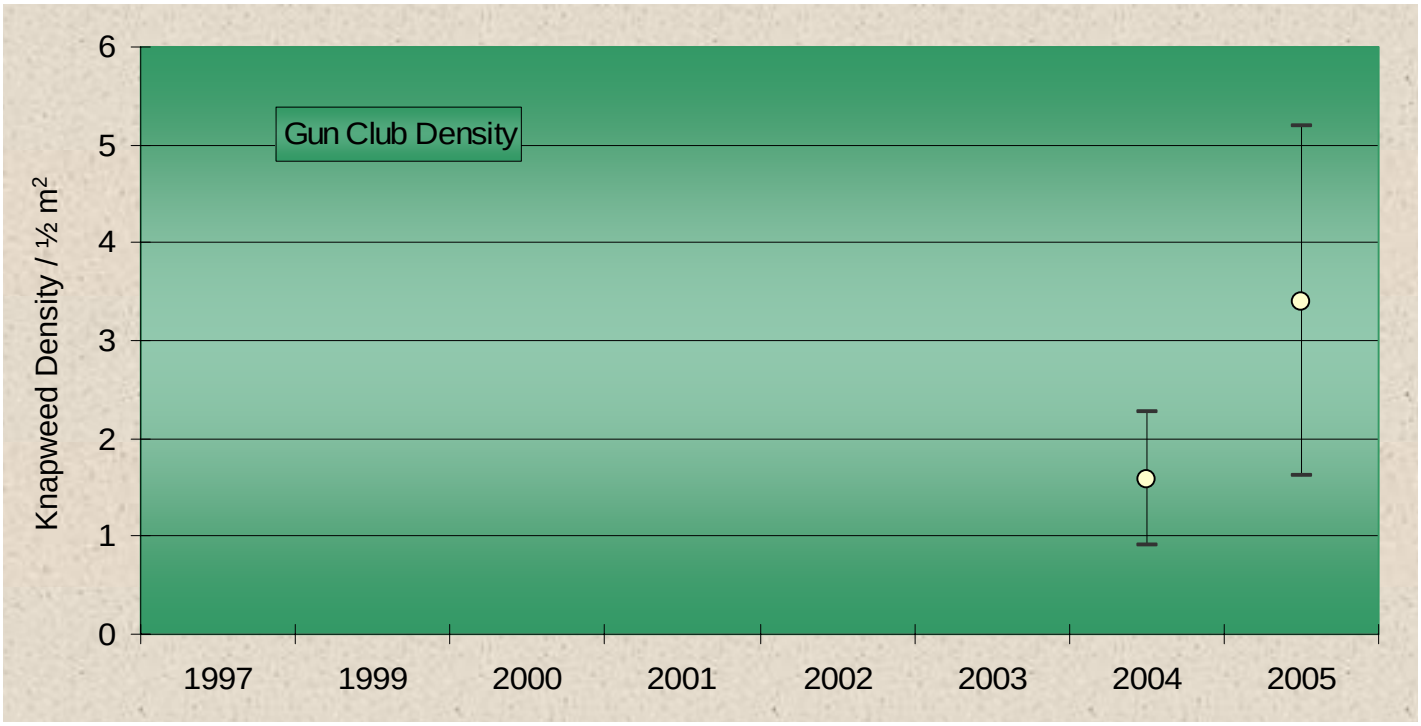


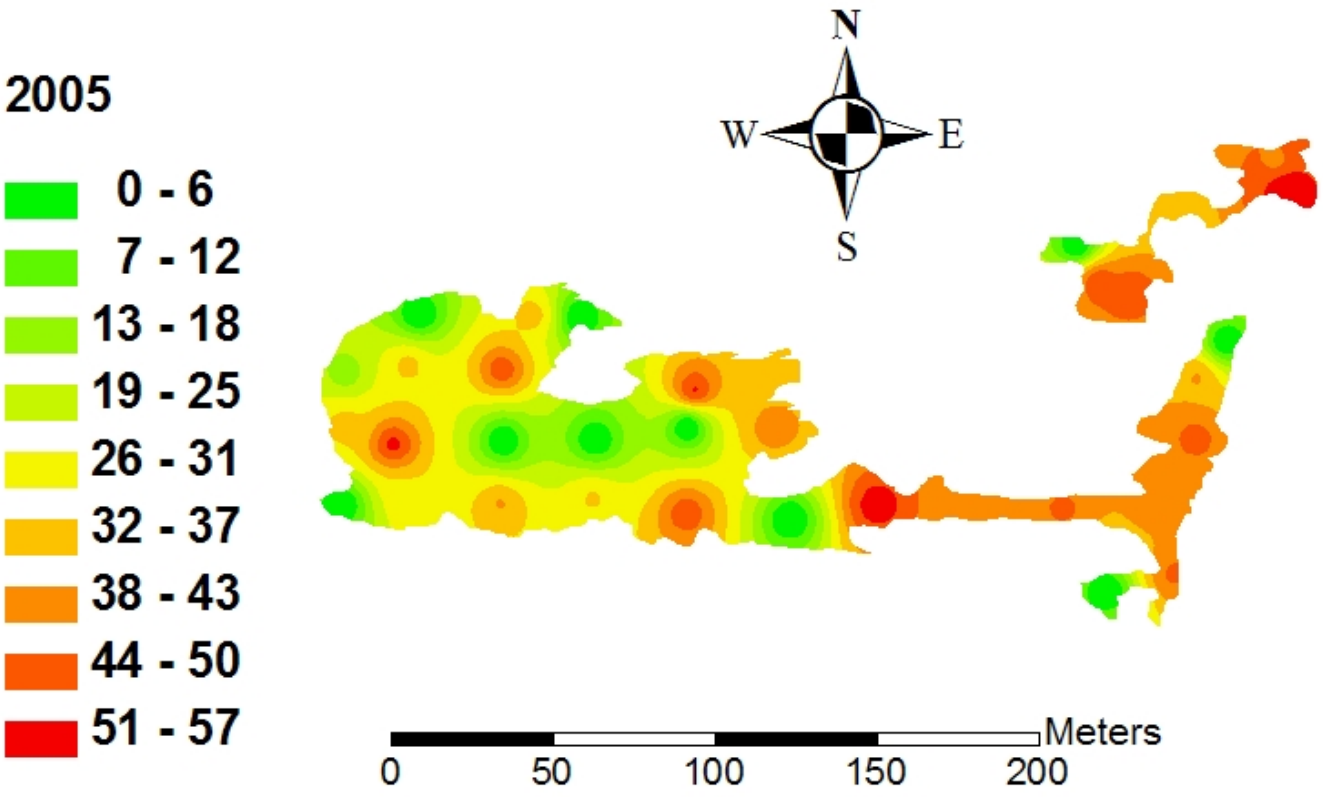


Gun Club diffuse knapweed perimeter in 2005.

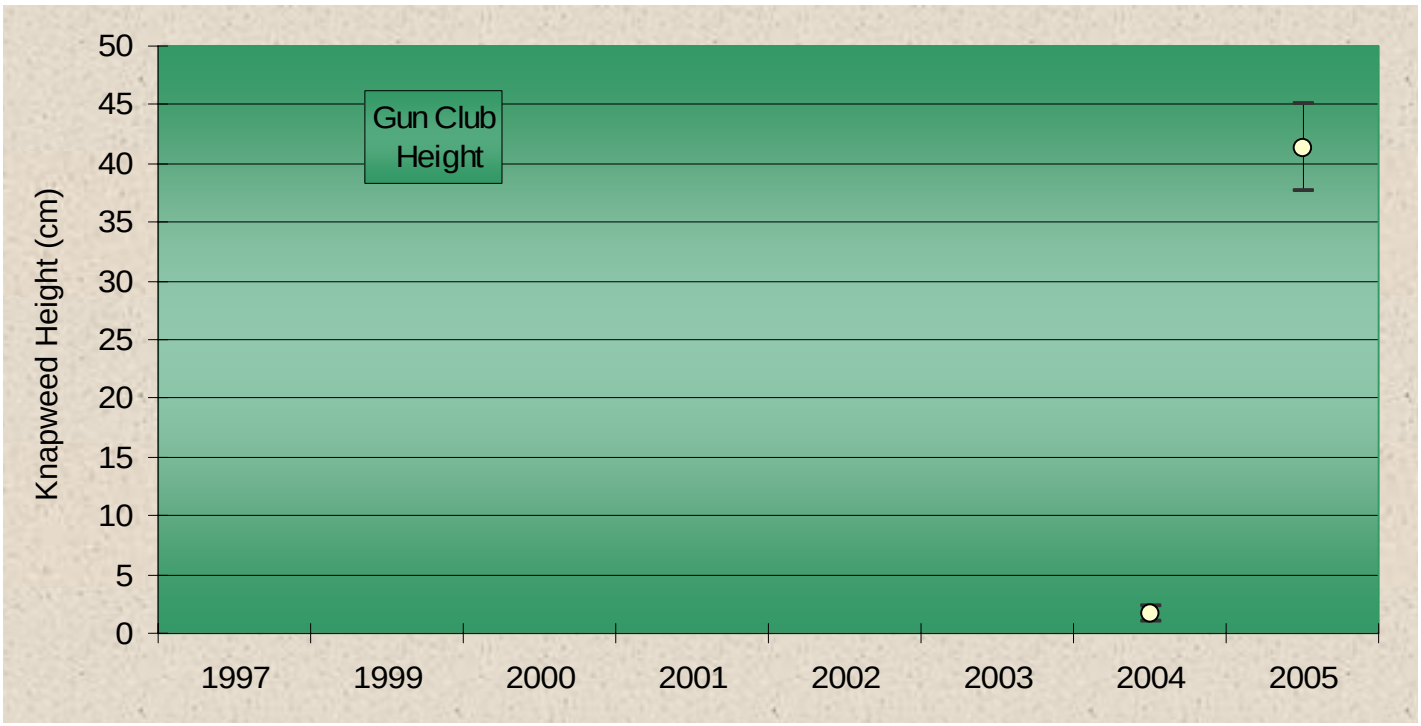


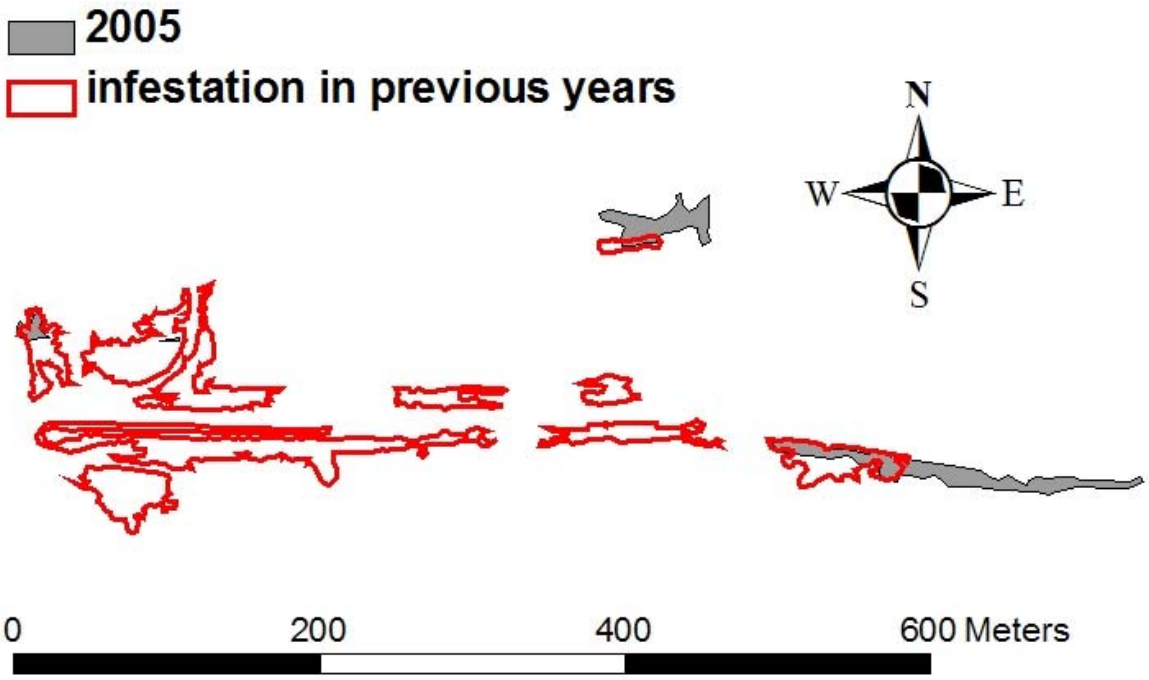
Gun Club diffuse knapweed density in 2005.



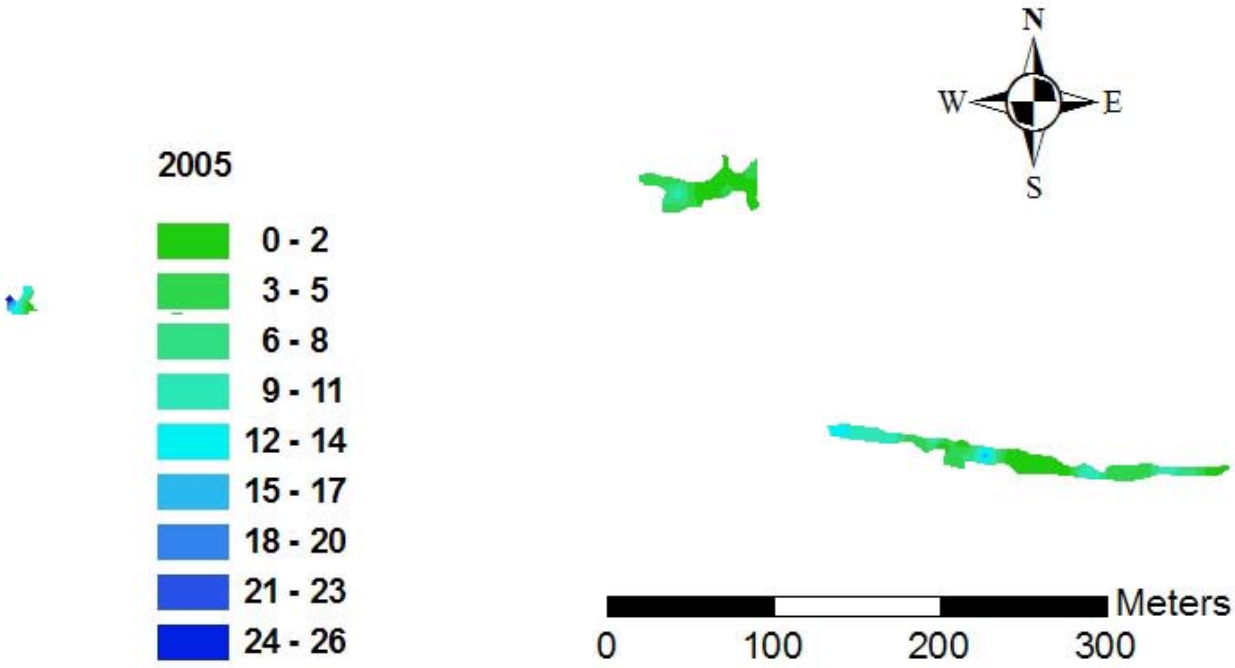


Gun Club diffuse knapweed height in 2005.

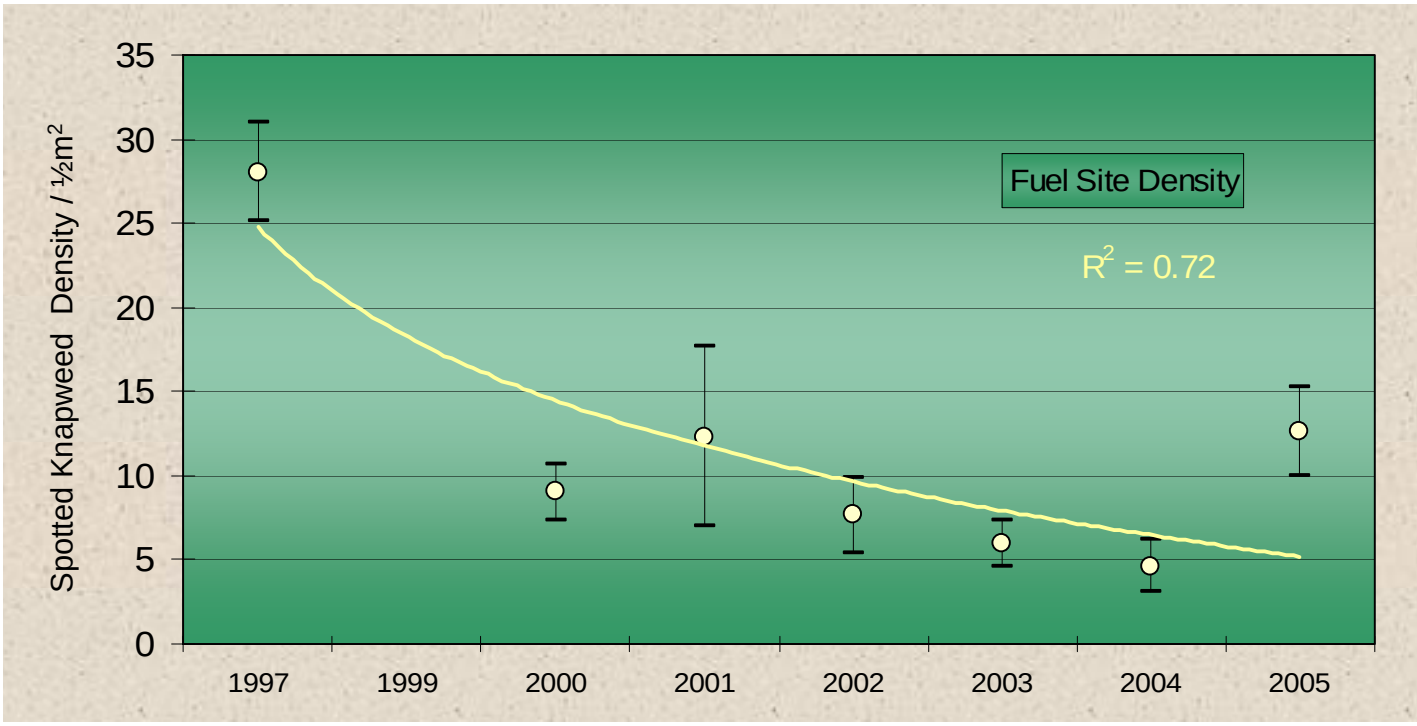


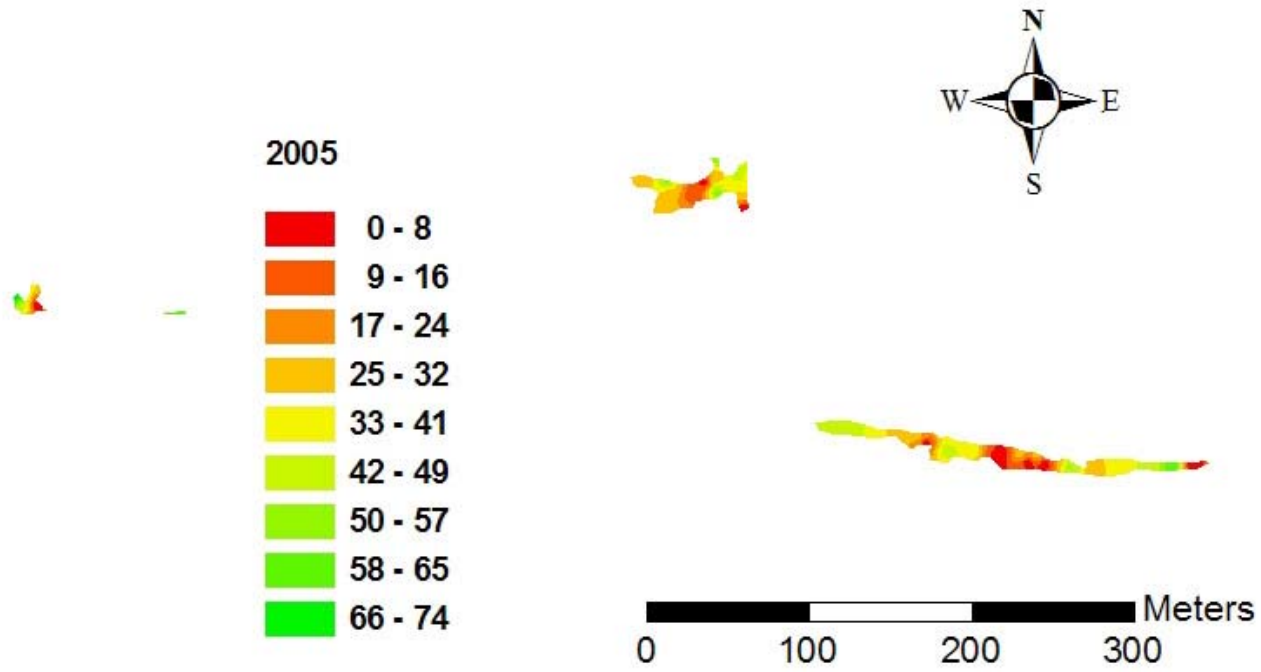


Fuel Site (Cantonment I) spotted knapweed perimeter in 2005.

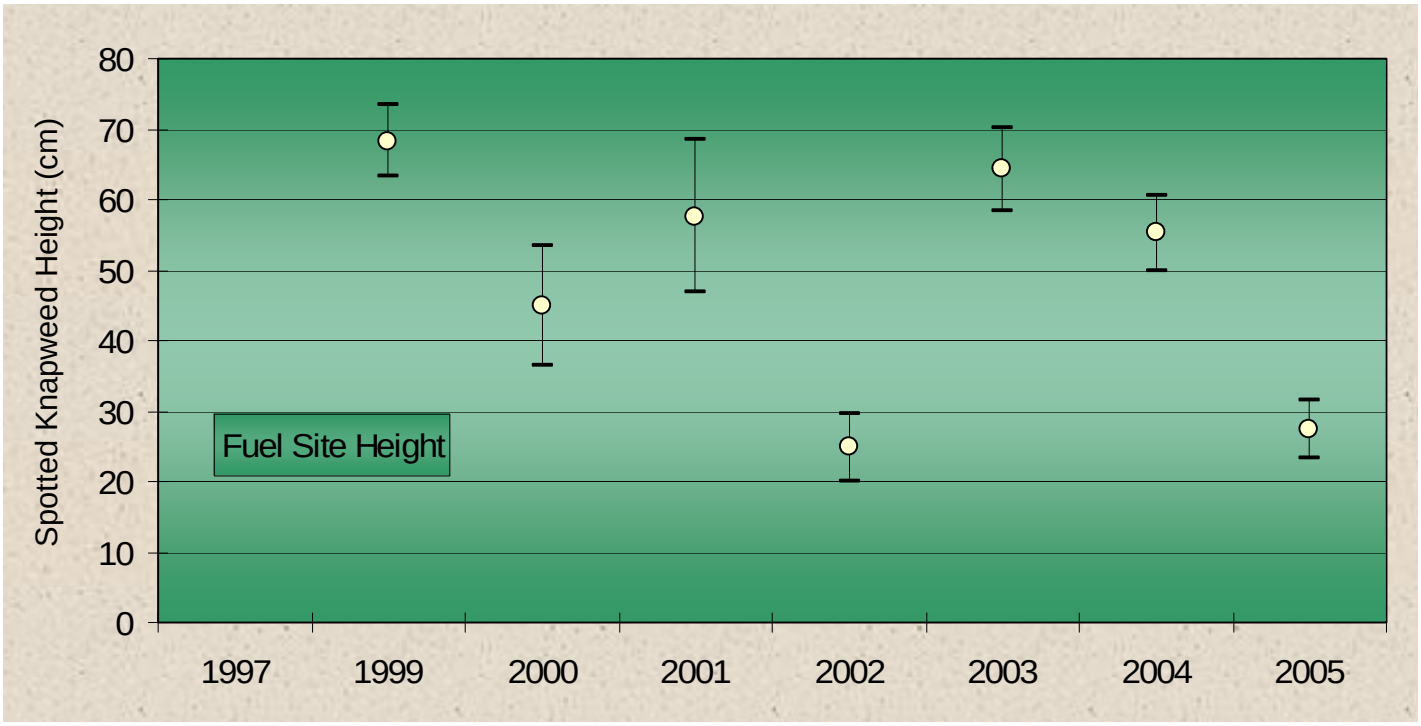


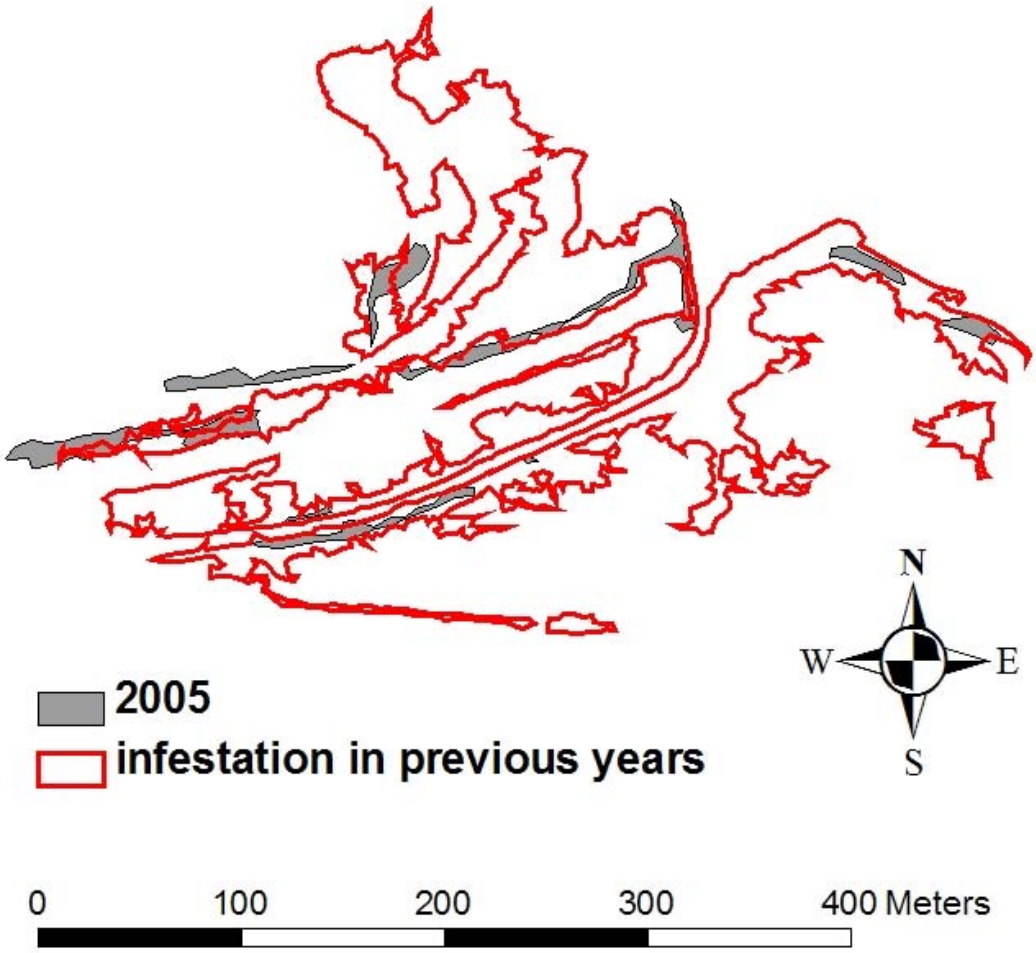
Fuel Site (Cantonment I) spotted knapweed density in 2005.



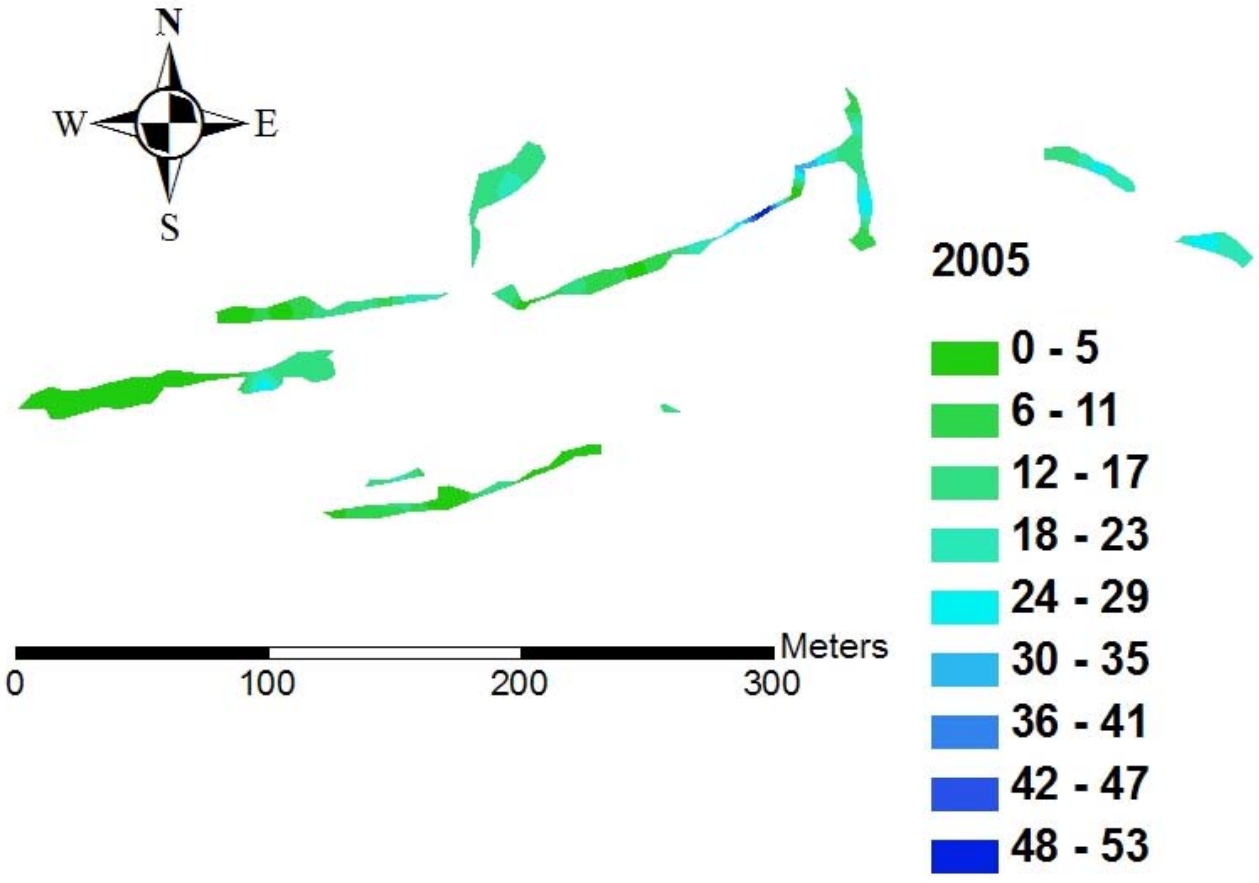


Fuel Site (Cantonment I) spotted knapweed height in 2005.

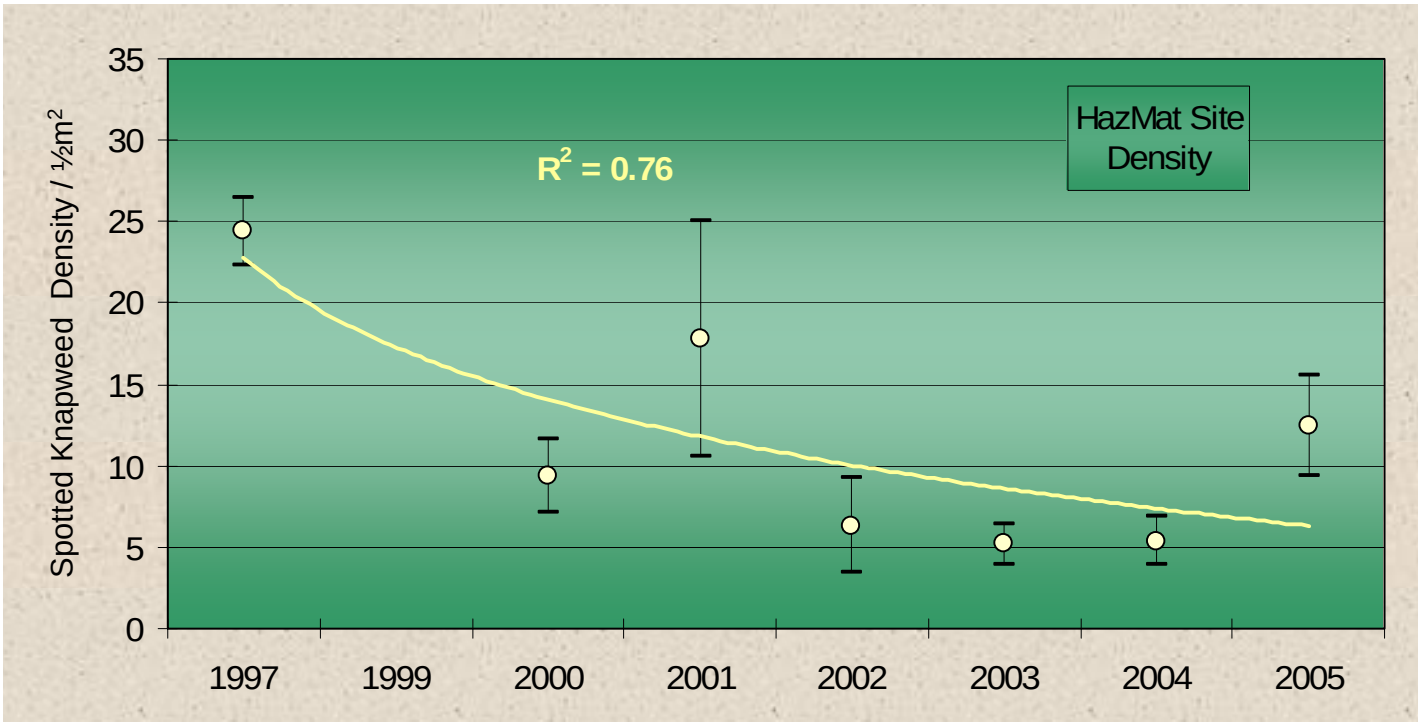


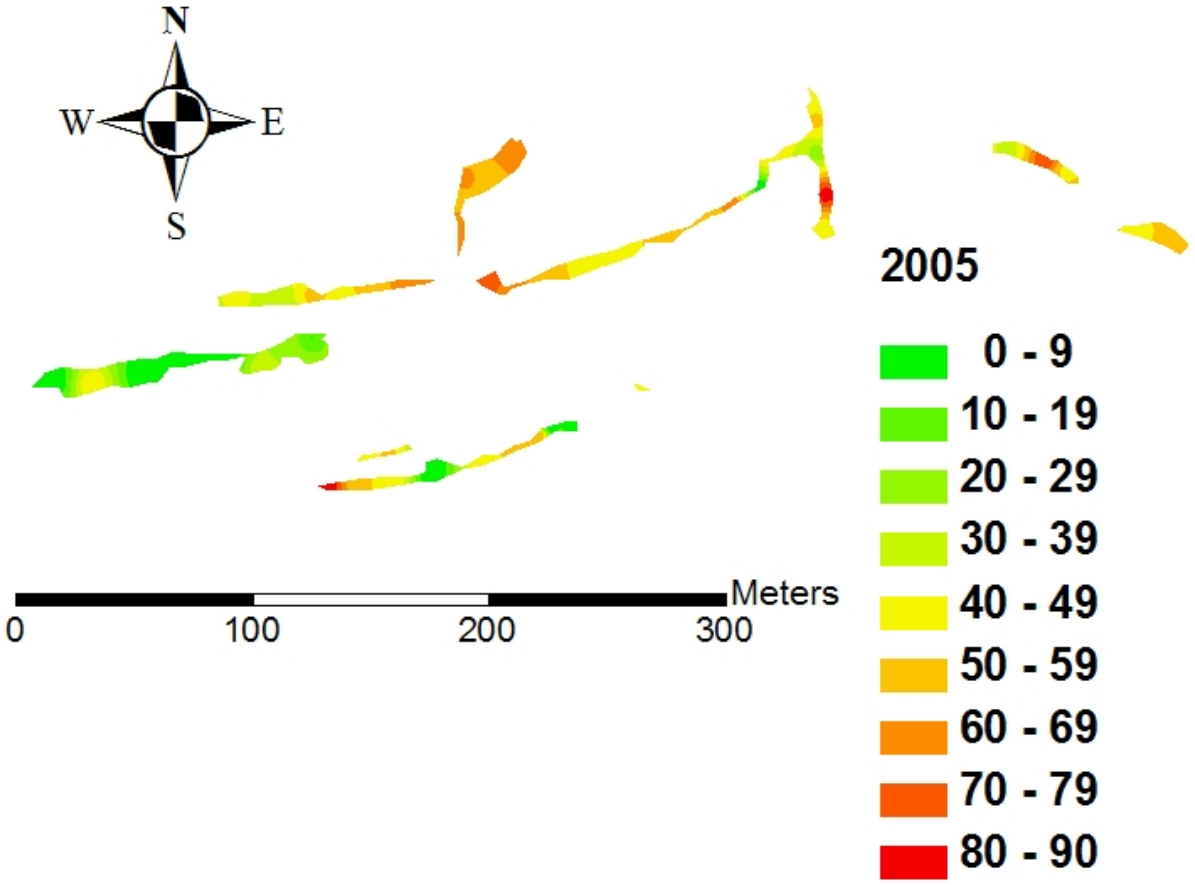


HazMat (Cantonment II) spotted knapweed perimeter in 2005.

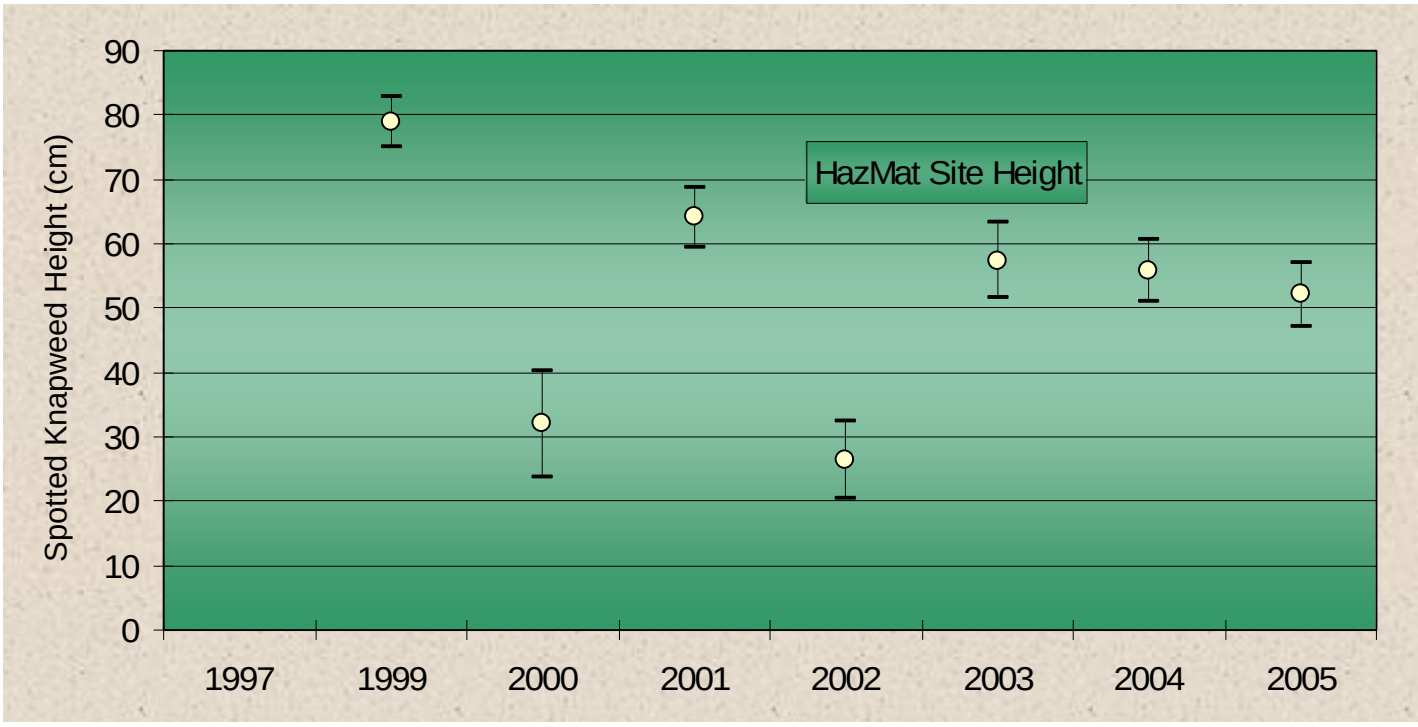


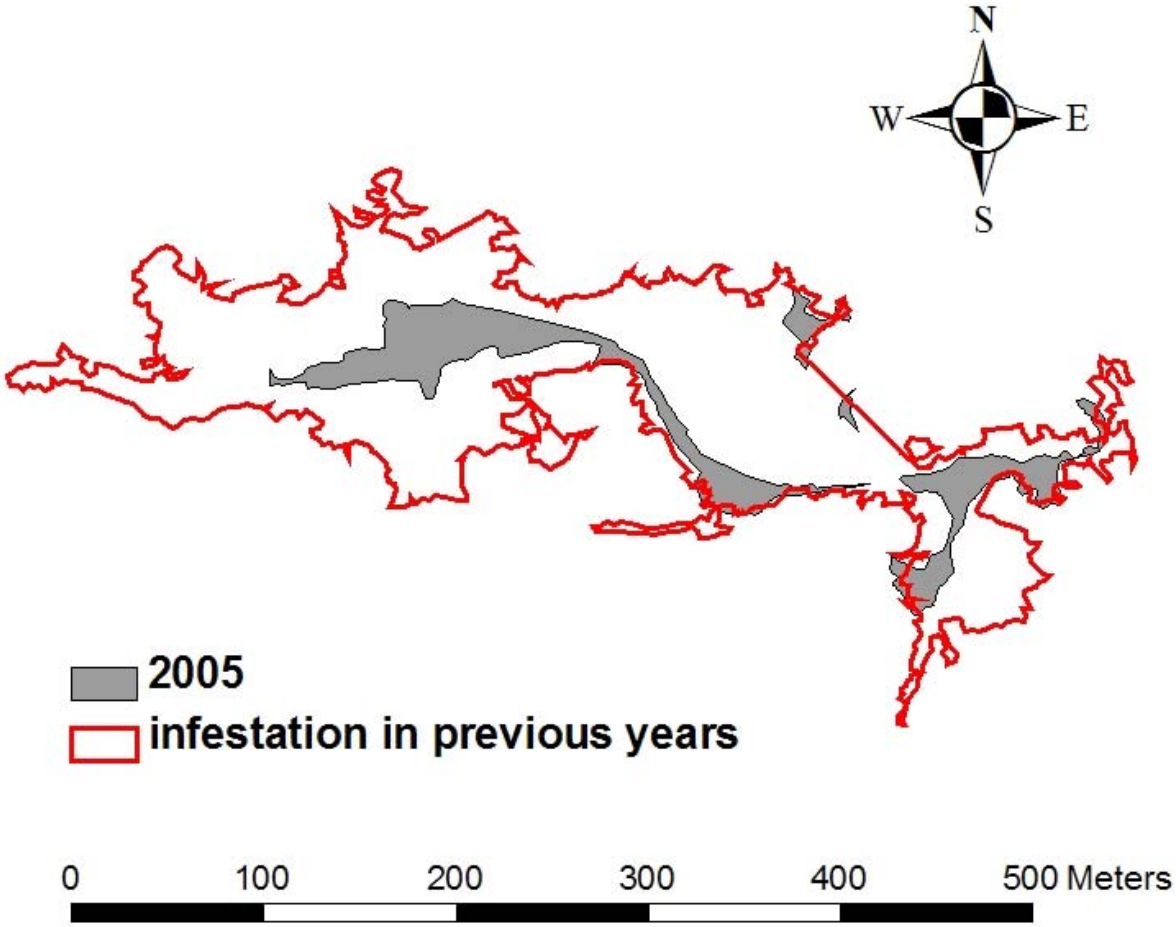
HazMat (Cantonment II) spotted knapweed density in 2005.



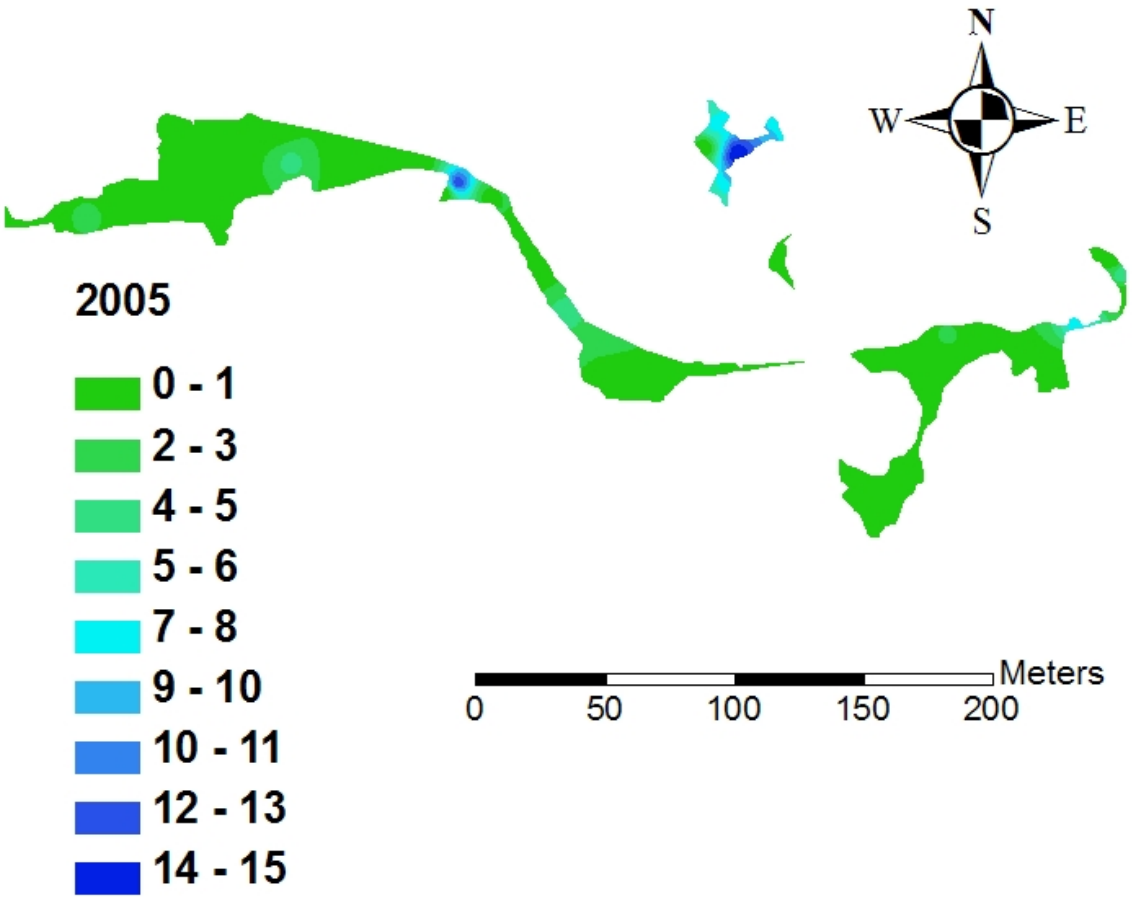


HazMat (Cantonment II) spotted knapweed height in 2005.

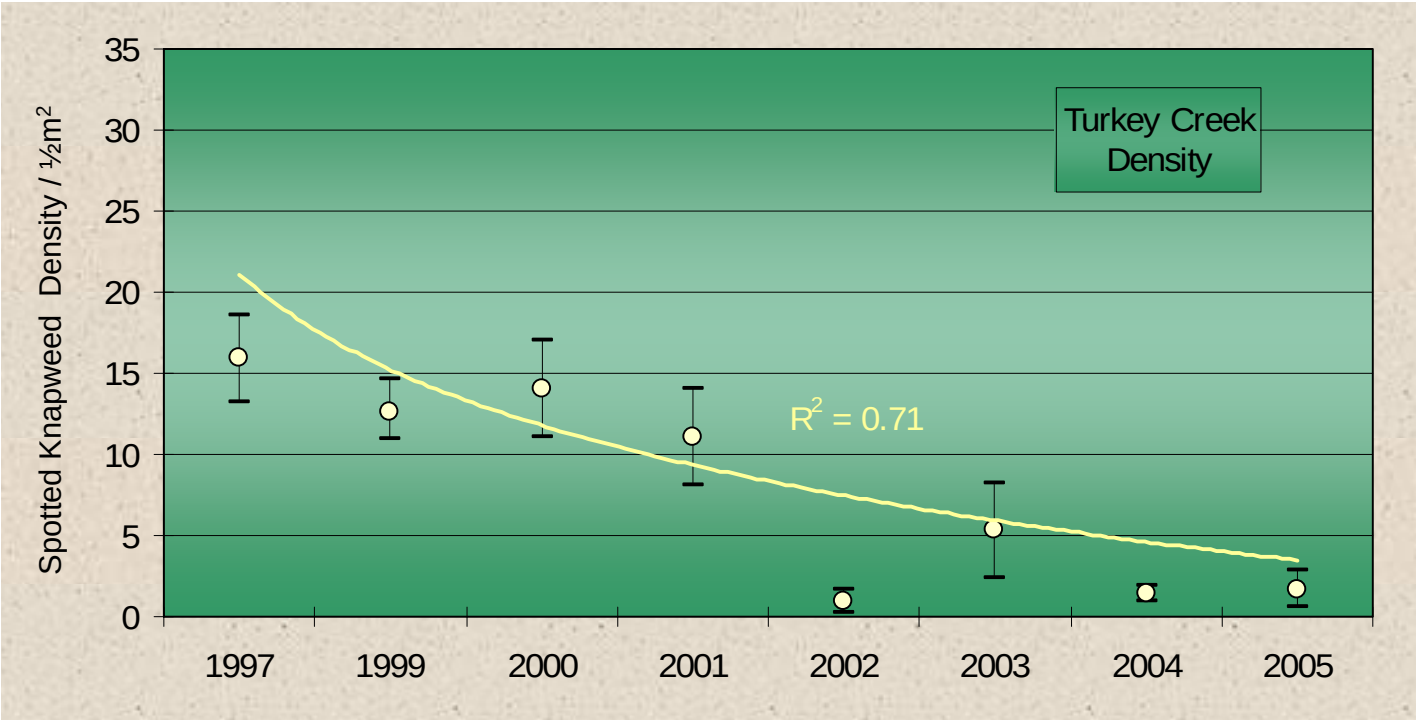


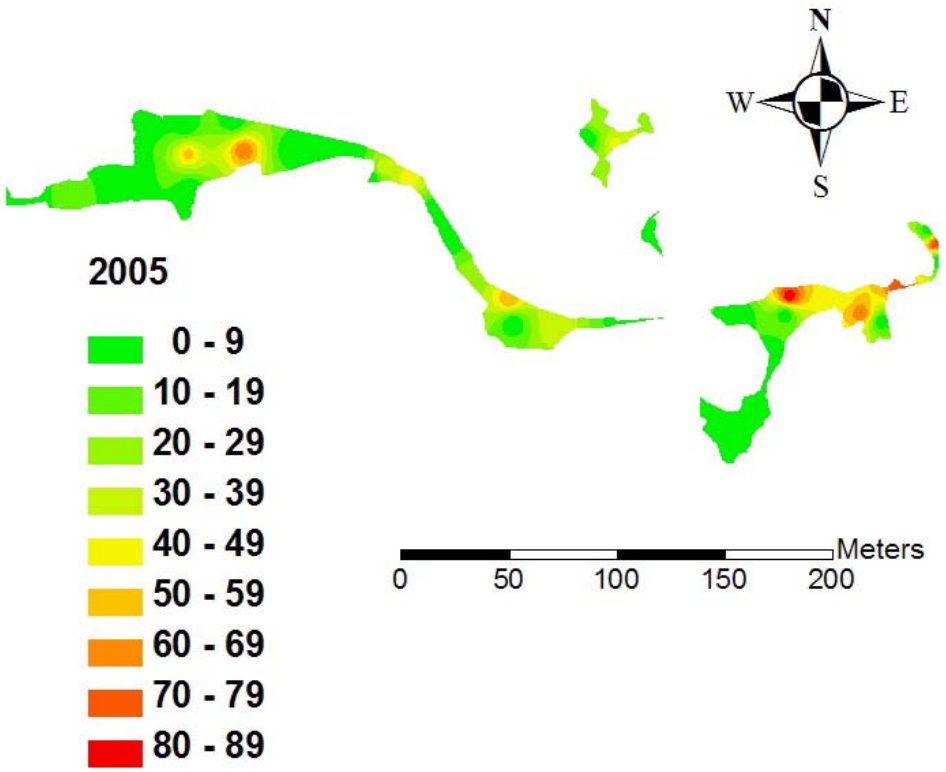


Turkey Creek spotted knapweed perimeter in 2005.

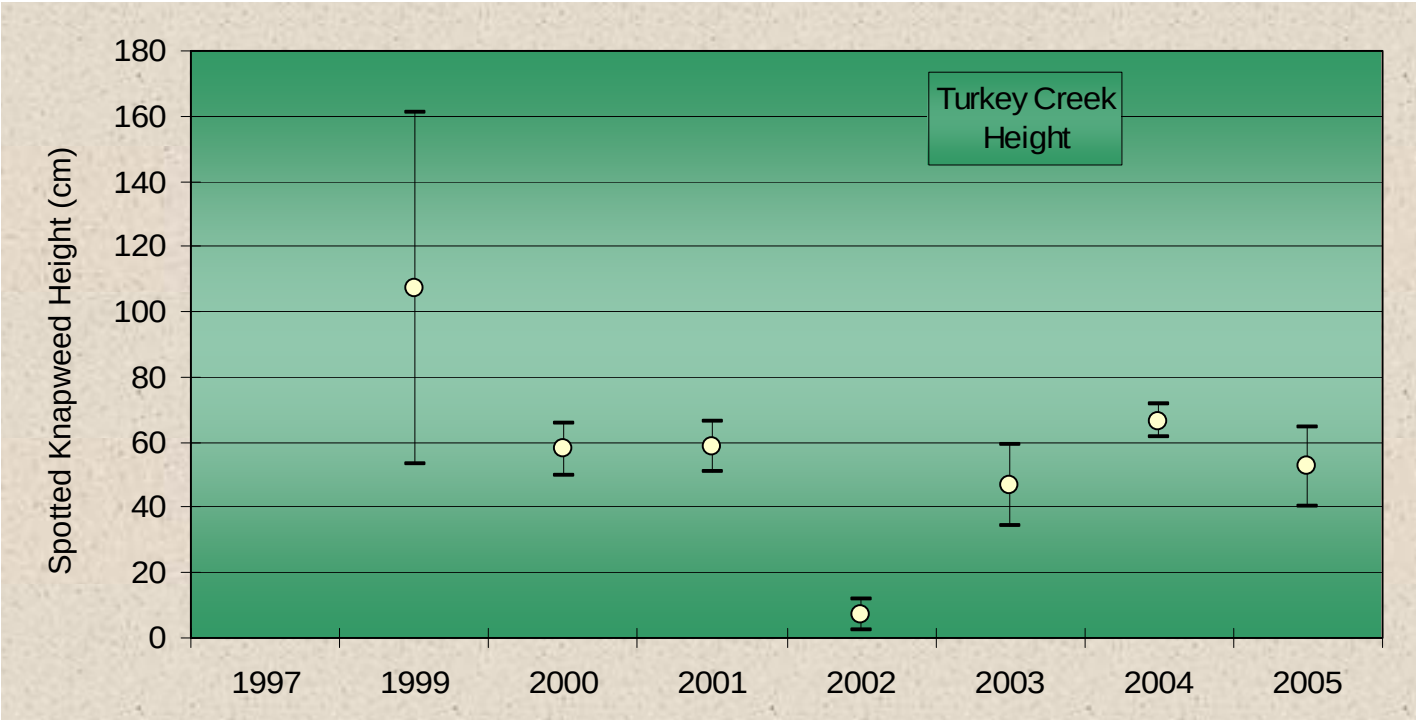


Turkey Creek spotted knapweed density in 2005.





Turkey Creek spotted knapweed height in 2005.



Rocky Flats Environmental Technology Site

Rocky Flats Environmental Technology Site has experienced some significant alterations in appearance and function within the last year. In response to the demolition and reclamation efforts being made on site, the scope of our biological control efforts against noxious weeds was modified accordingly. Several weed monitoring and bio-agent release sites were destroyed between the summers of 2004 and 2005, including the Dalmatian toadflax Sites III & IV, diffuse knapweed Sites I & II and the North Buffer musk thistle infestation. Consequently, in 2005, we concentrated our biological control monitoring efforts on three main areas of concern. These included 0.2 ha of Canada thistle at Lindsey Ranch increased over last year's 0.07 ha, 0.2 ha of Dalmatian toadflax mapped at the 2001 Original Dalmatian toadflax site, established in 2001 (Table 12). Additionally, 3.5 km of Dalmatian toadflax and 4.0 km of diffuse knapweed was surveyed using a linear transect method (Table 12) in the South and North Buffer areas, respectively.

As in 2004, we adopted a method of linear transect sampling (i.e. taking samples of weed density and plant vigor at regimented intervals along a straight line), as this technique lends itself much better to surveying and monitoring extensive, scattered weed infestations. Mapping a discrete weed perimeter in these cases is neither feasible nor informative. We repeated the transect sampling from 2004 for diffuse knapweed in the North Buffer area, performing four surveys at the same locations as the previous year, sampling knapweed every 20 m from a center point (in most cases, the area of release of a biocontrol agent) up to 200 m in each cardinal direction. In addition, three parallel 500 m linear transects were similarly sampled in 2005 within a heavily damaged knapweed stand.

Figure 16. Summer worker, Sean Best, releases *M. janthinus* on Dalmatian toadflax in the South Perimeter Fence area.

In 2005, three new transect surveys were undertaken along the south perimeter fence at Rocky Flats in order to establish baseline estimates of the level of Dalmatian toadflax infestation in that area. Within each of these transects, Dalmatian toadflax plants were surveyed within 0.5 m^2 quadrats every 50 m up to 500 m in each cardinal direction from a center point. At the center point, approximately 200 stem-mining *Mecinus janthinus* were subsequently released onto the toadflax (Figure 16; Table 13). Impact and dispersal of the weevils will be monitored in future years and augmentation to the biological control agent population will be made as necessary. Weather stations measuring temperature at various heights (underground, at ground level and 1 m above-ground) were also installed at these locations in order to monitor microclimatic conditions that may influence the overwintering and establishment success of *M. janthinus* along the Front Range.

In 2003 and 2004, maps of the Dalmatian toadflax infestation at the Original release site could not be constructed, as all that remained after the successful establishment of bio-agent, *M. janthinus*, was a few scattered, heavily damaged plants. In 2005, conditions were highly favorable for Dalmatian toadflax growth and small weed patches near the Original site were observed and monitored (Figure 17; Table 12). High numbers of *M. janthinus* were observed feeding and ovipositing into the toadflax within each new patch found.

Figure 17. Summer workers, Taylor Mabry (left) and Ed Raetz, map re-emerged Dalmatian toadflax at the Original Site.

In terms of biological control agent activity, we continue to find healthy populations of various biological control agents in the diffuse knapweed of the North Buffer area. Seedhead dissections and visual observation confirm the presence of seed feeders, *Larinus minutus*, *Metzneria paucipunctella*, *Urophora affinis* and *Urophora*

quadrifasciata, along with root-feeders *Cyphocleonus achates* and *Sphenoptera jugoslavica* (Table 2, Introduction; Table 13). Similarly, at Lindsey Ranch, defoliator, *Cassida rubiginosa*, was observed in high numbers feeding on and stunting Canada thistle plants (Table 13). We expanded our mapping of this patch of thistle in 2005, as the extent of the infestation increased dramatically since 2004. Seedhead-feeder *Rhinocyllus conicus* was found in abundance in Canada and musk thistle throughout the North Buffer zone. We continued to see extremely low numbers of defoliator/stem miner, *Trichosirocalus horridus*, although the weevil has been recovered at Rocky Flats. Plans are underway to augment populations of this biological control agent at field sites and to attempt to establish laboratory populations for release and redistribution.

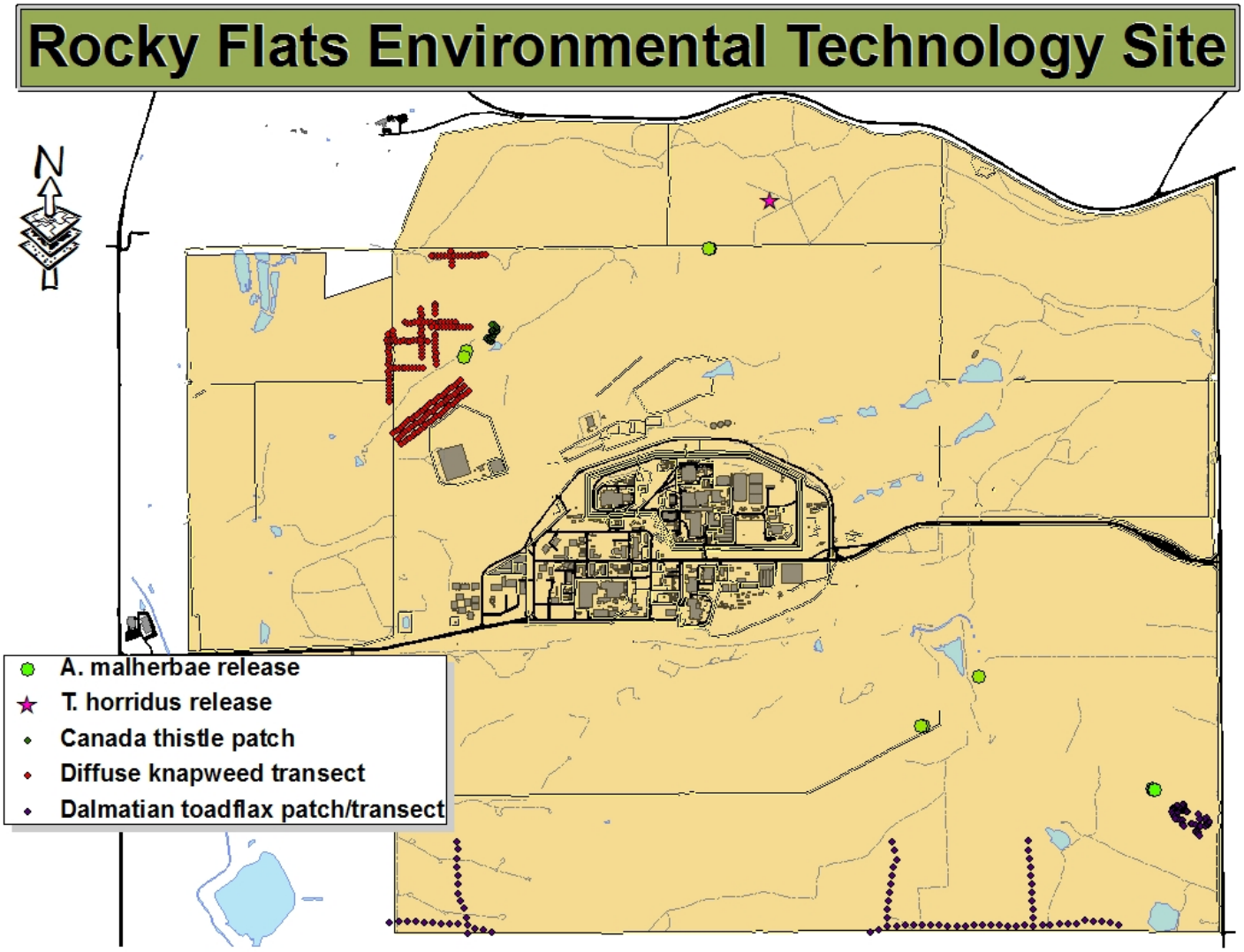


Figure 18. Schematic diagram of Rocky Flats Environmental Technology Site with weed biological control study areas superimposed.

Table 12. Historic noxious weed infestation parameters, Rocky Flats Environmental Technology Site, Colorado, 2001-2005.

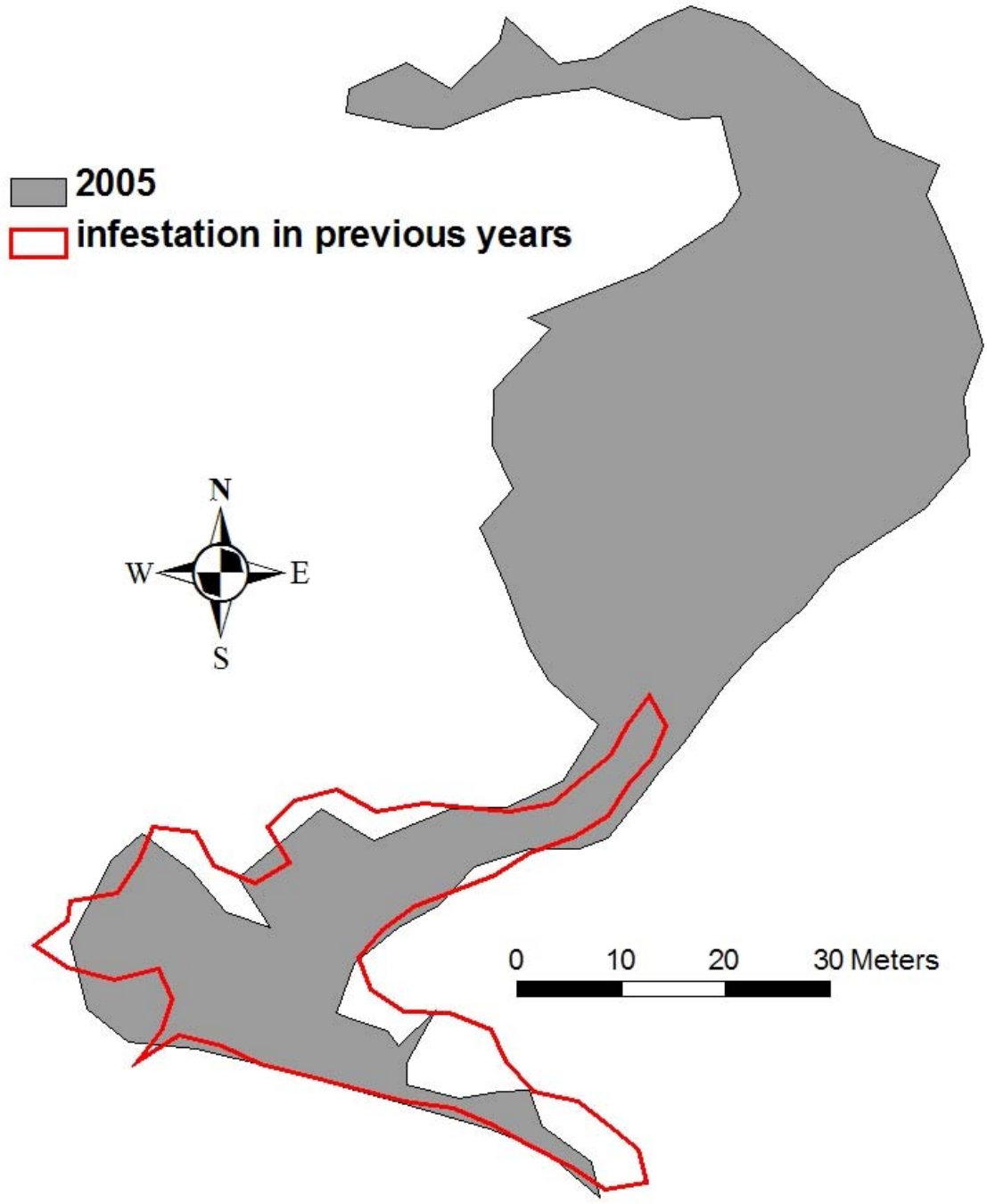
Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads per plant avg.	Head size avg. (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Canada thistle – Lindsey Ranch												
2004	692	43	7.84	34	56.05	104	1.64	0.30				
2005	2,205	30	5.93	16	94.23	165	18.14	0.72	218.64	-24.36	68.12	218.64
Dalmatian toadflax – Original Site												
2001	1,688	48	22.43	64	52.94	84						
2002	7,913	93	3.81	23	12.90	55			368.78	-83.01	-75.63	368.78
2003	*(see Note)*											
2004	*(see Note)*											
2005	2,216	69	8.21	26	43.40	66	16.81					31.28
Dalmatian toadflax – Sites III and IV *												
2003	13,479	88	3.24	16	68.92	130						
2004	692	179	4.97	46	25.16	86			-92.43	33.60	-57.99	-92.43
Dalmatian toadflax – South Perimeter Fence **												
2005		71	3.04	29	47.94	74	9.76	1.12	na	na	na	na
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	
Diffuse knapweed – Site I *												
2003	1,624	18	3.06	9	49.44	70						
Diffuse knapweed – Site II *												
2003	3,841	40	3.03	13	36.00	65						

n – number of samples or observations na – not applicable, data represent first year of sampling
* – sampling was discontinued in 2004, as site was destroyed in conjunction with building demolition
** - infestation was not mapped (a linear transect method was utilized to survey the weed population)
Note - site was not mapped, as toadflax infestation had been reduced to a few scattered plants.

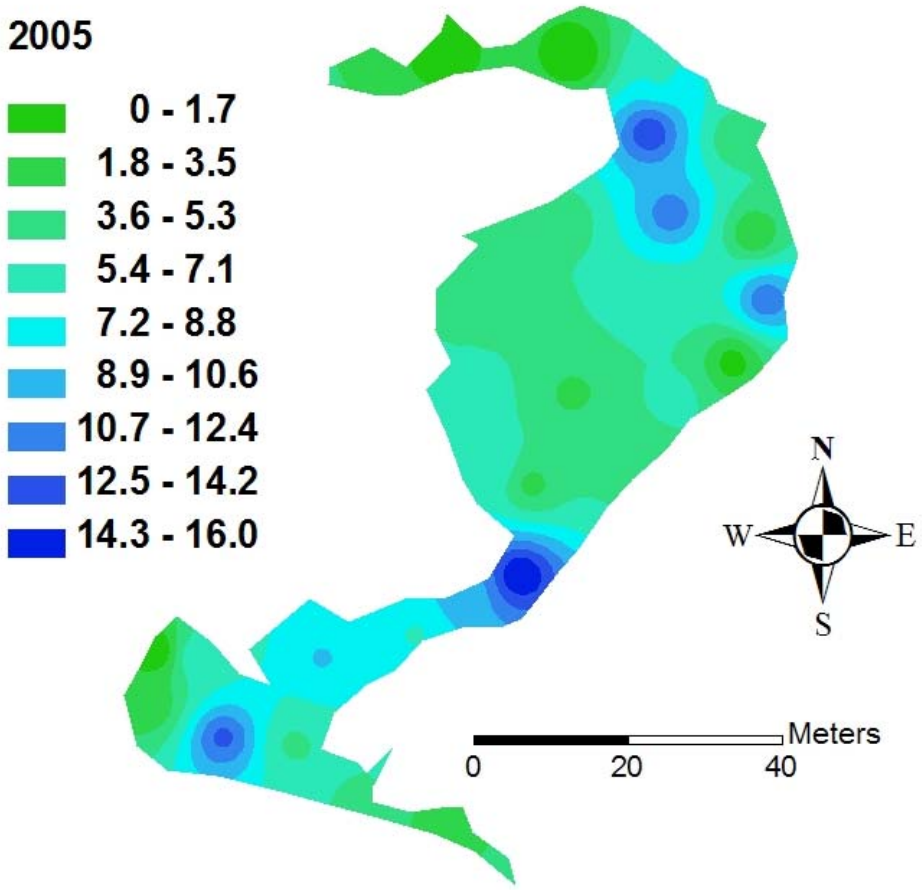
Table 13. Noxious weed biological control sites, target weeds, species released and recoveries at Rocky Flats, 2005.

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

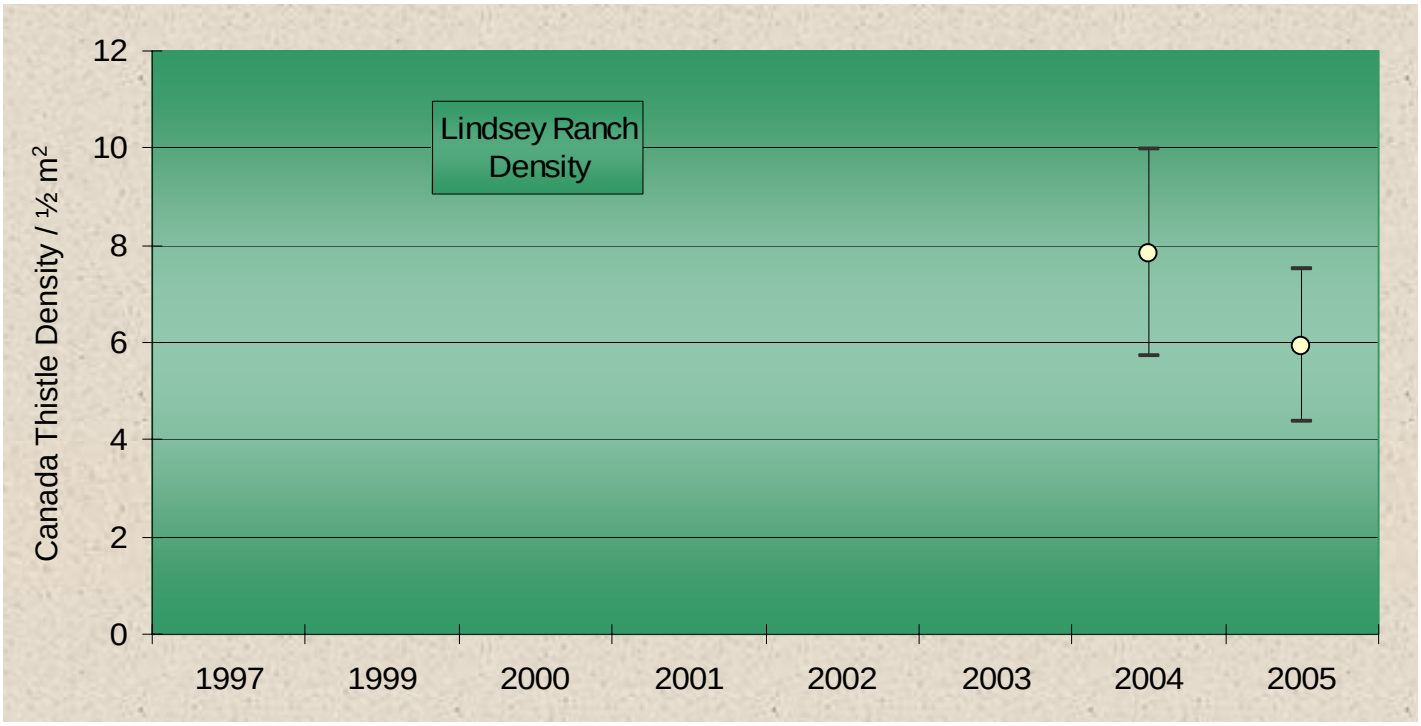
[1] Adventitious recovery, insects were not released at this location

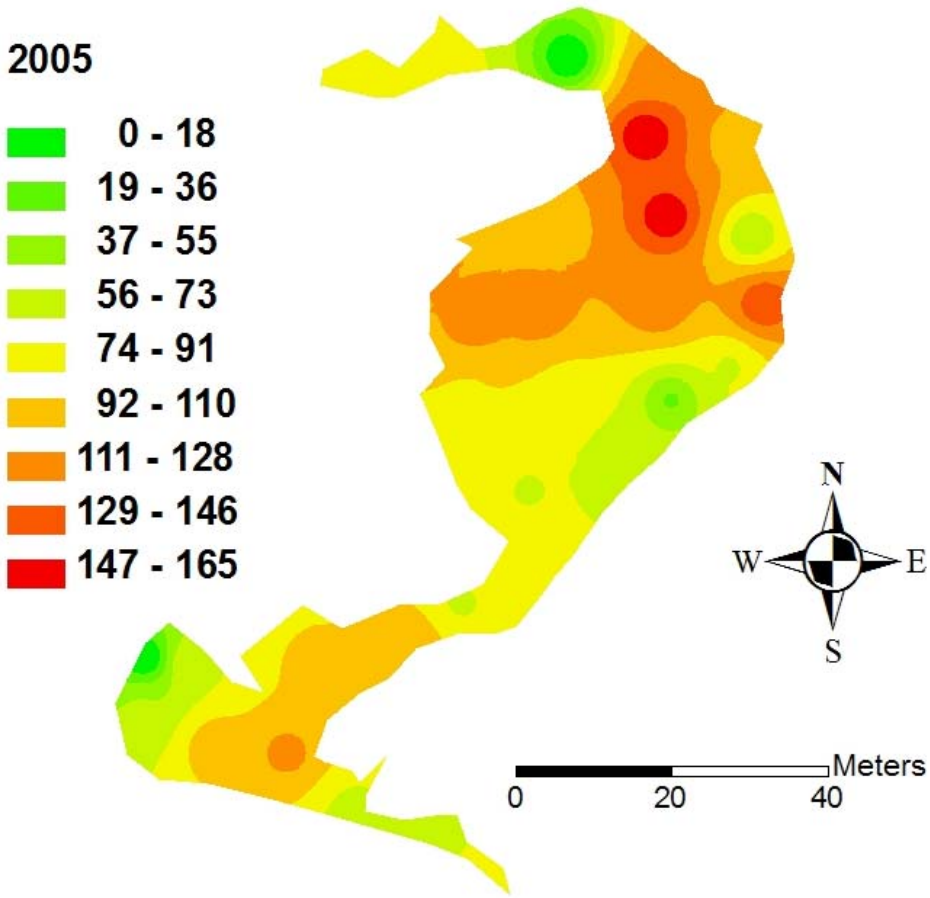


Lindsey Ranch Canada thistle perimeter in 2005.

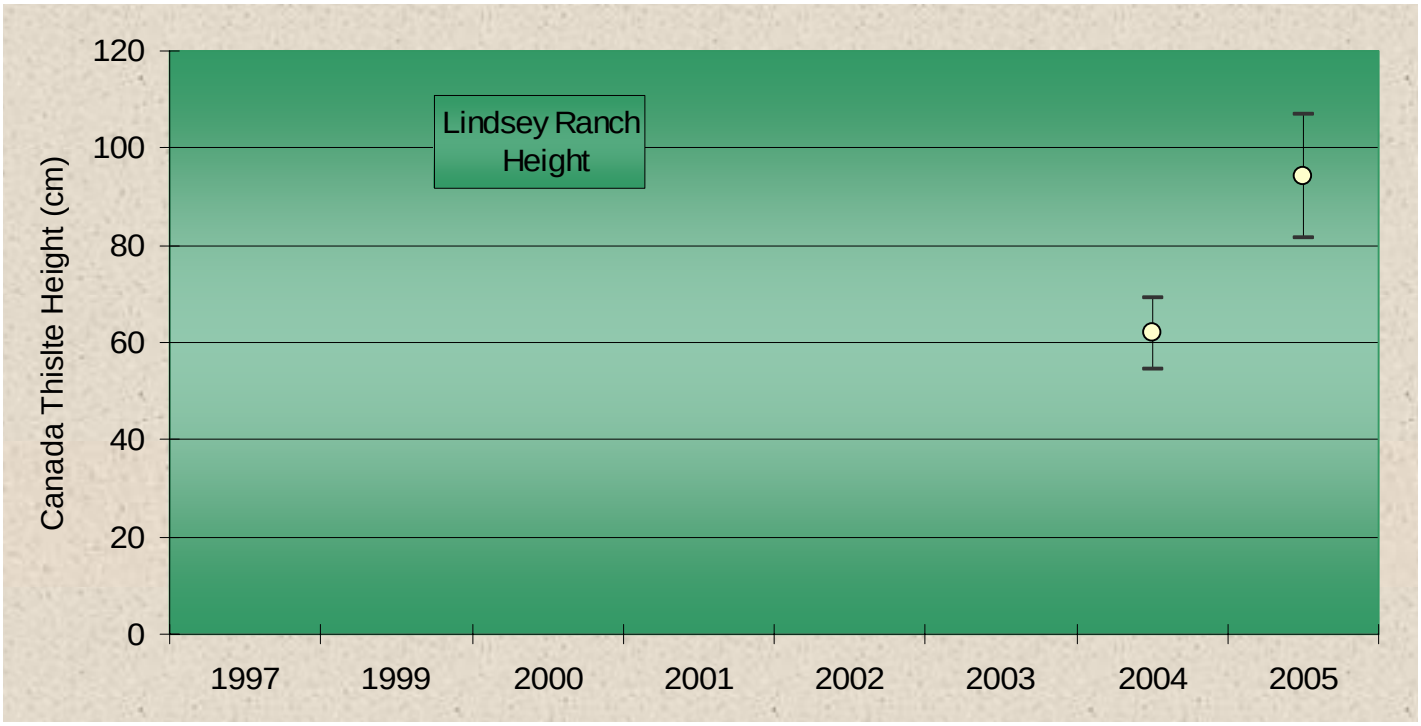


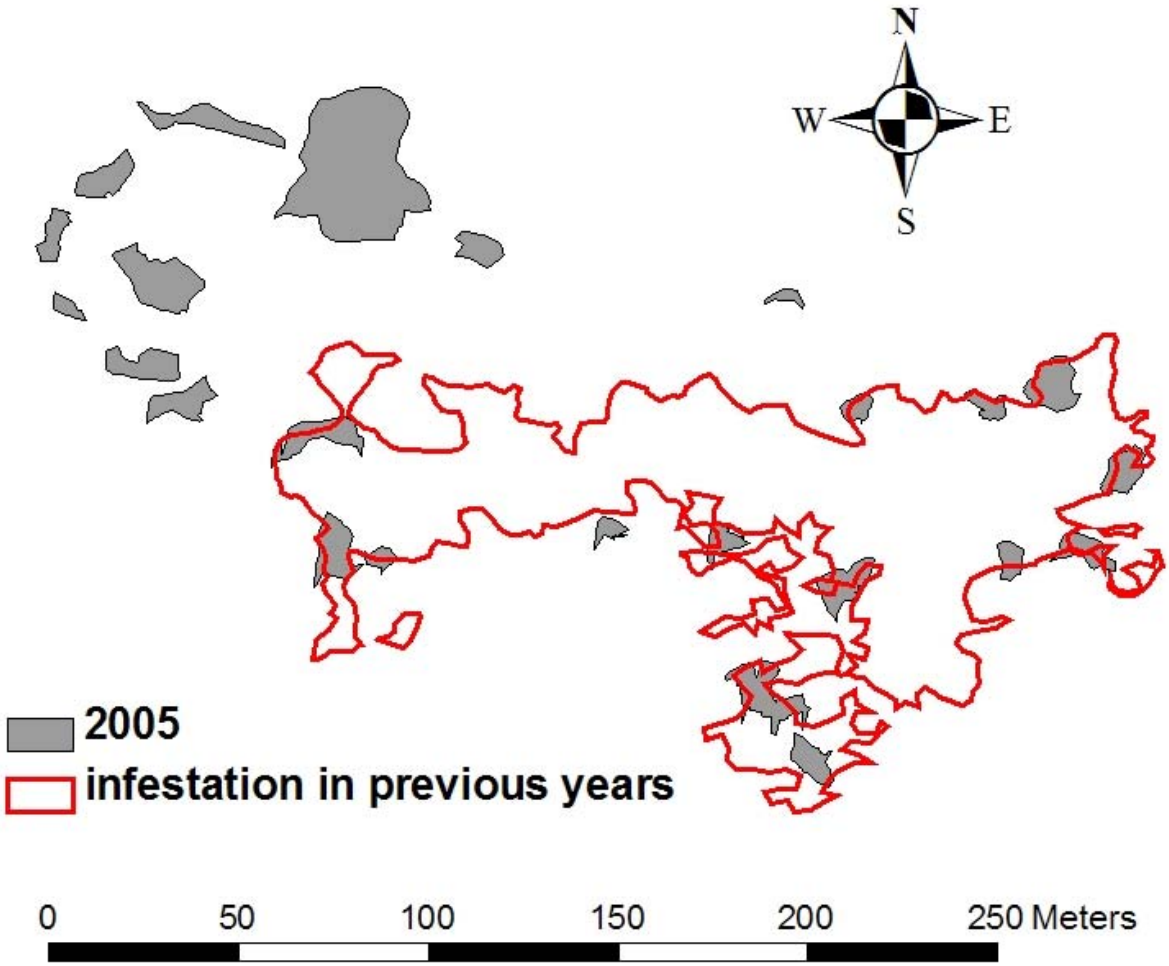
Lindsey Ranch Canada thistle density in 2005.



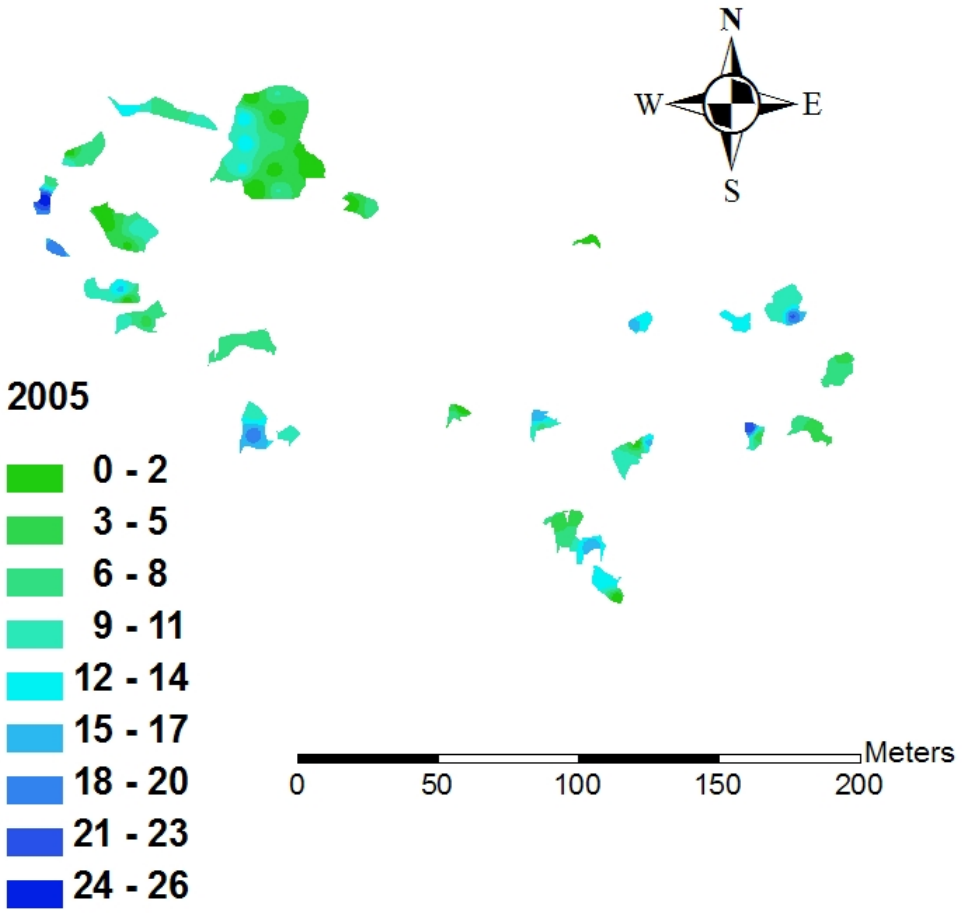


Lindsey Ranch Canada thistle height in 2005.

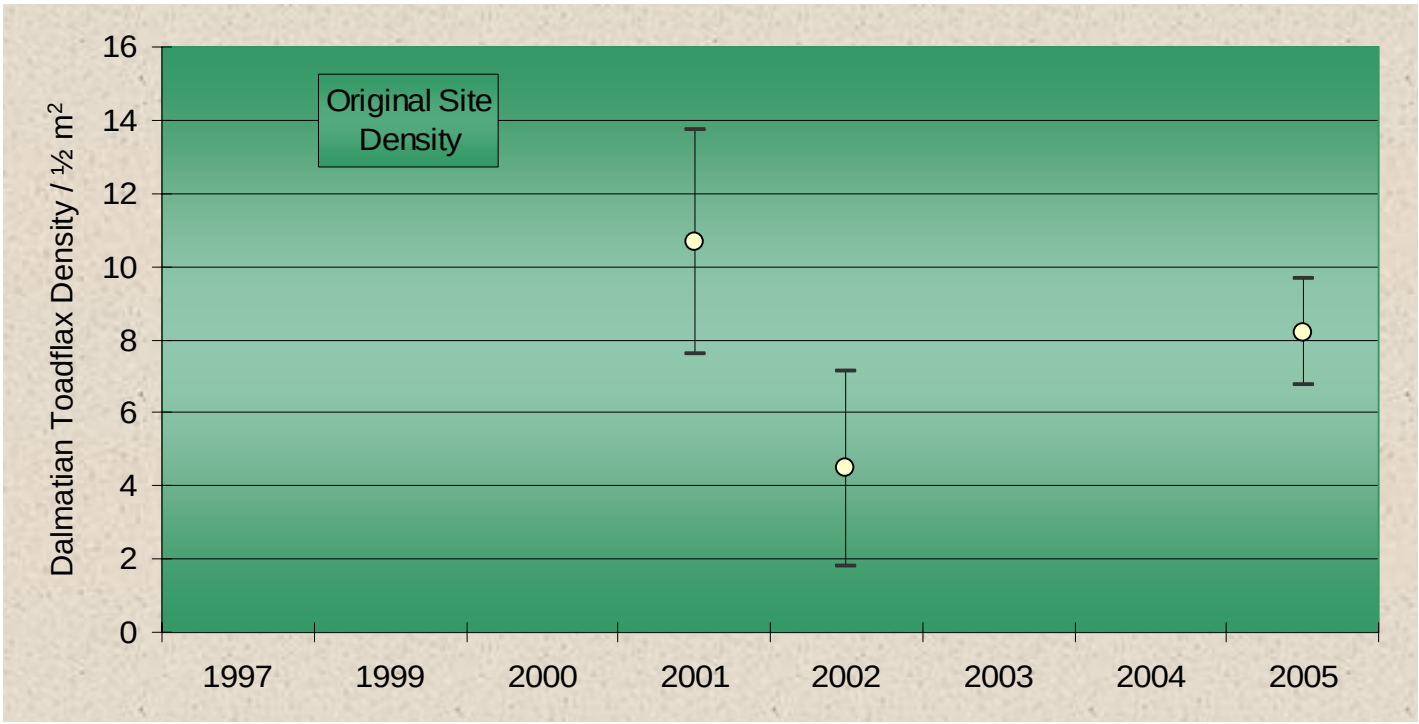


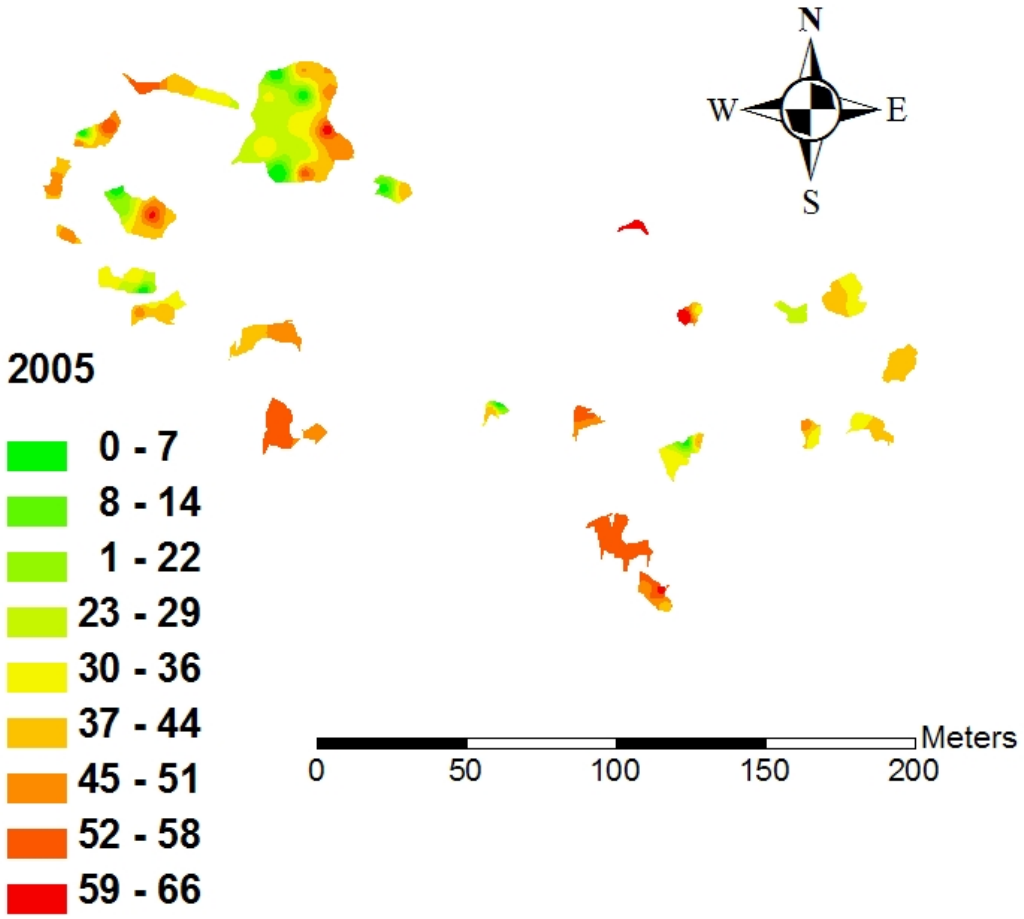


Original Dalmatian toadflax perimeter in 2005.

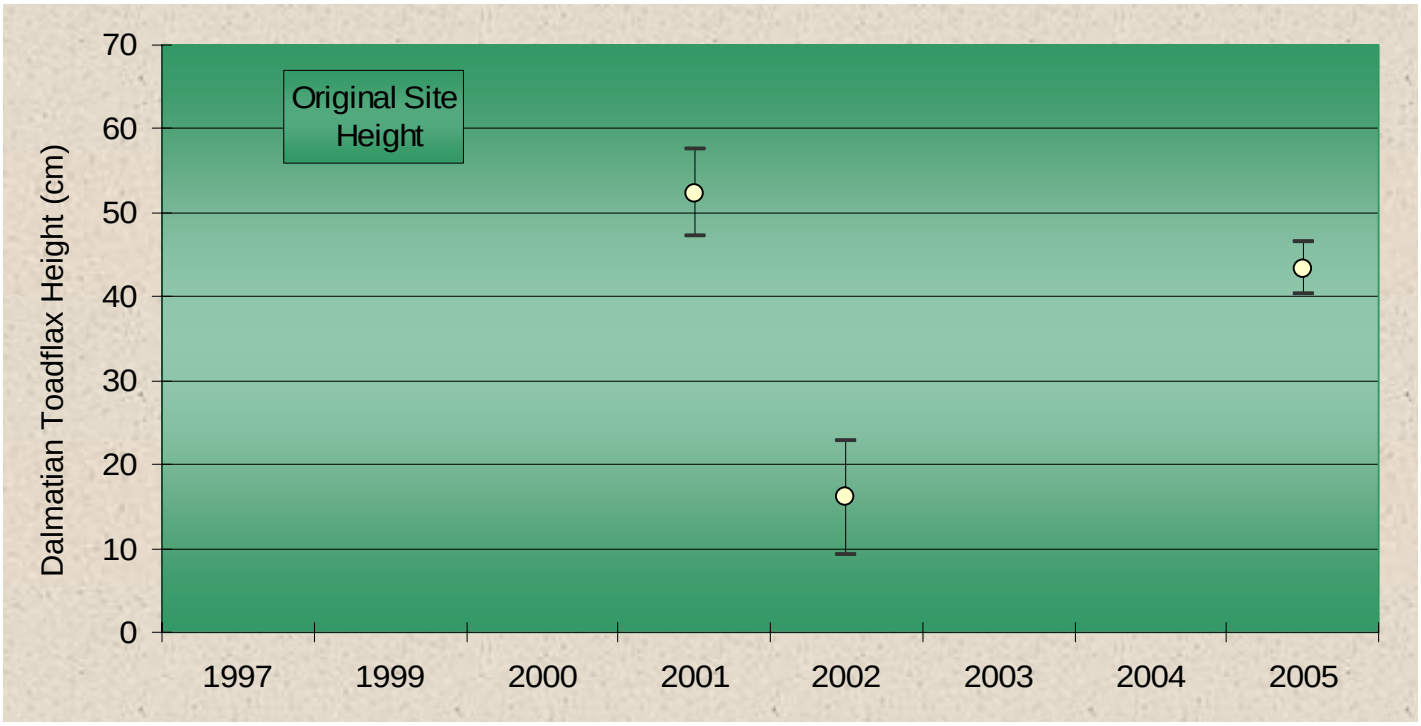


Original Dalmatian toadflax density in 2005.





Original Dalmatian toadflax height in 2005.



Diffuse Knapweed & Dalmatian Toadflax Transect Surveys

As large, discontinuous patches of diffuse knapweed and Dalmatian toadflax continue to be identified as primary targets for biological control, our survey techniques to evaluate the efficacy of control insects are evolving. Instead of trying to map an infestation in discrete chunks (which is often impossible), a more comprehensive transect method was adopted in 2004 within several diffuse knapweed patches. This method assesses the same weed patch attributes as mapping and quadrat subsampling within a mapped area. The advantage of transect sampling lies in being able to directly observe reductions in target weed density and vigor as biocontrol insect populations establish and spread from the point of release.

Presented in the following graphs are the densities of either diffuse knapweed or Dalmatian toadflax plants per ½ m^2 quadrat at regimented distances in each of the cardinal directions from the point of a biocontrol insect release (20m intervals for knapweed, 50m for toadflax). Additional graphs for the diffuse knapweed transects show the 2005 populations of each agent released in the area.

As mentioned above, transect surveys targeting diffuse knapweed were initiated in 2004, utilizing biocontrol insect releases from 2001-2002 as the point of origin for each. We present data from transects originating at two *Cyphocleonus achates* (Figure 19) and two *Larinus minutus* (Figure 20) release sites, along with a "control" or "no relase" area (Figure 21) nearby for comparison. Another root-boring agent, *Sphenoptera jugoslavica*, has been present in transect samples since 2004 and is presented along with the other two knapweed insects. Transect surveys revealed only a very slight increase in diffuse knapweed population density between 2004 and 2005 (Table 12). The vigor, however, as represented by height measurements, increased significantly in 2005 from the previous year's stunted plants (~18cm tall) to relatively robust bushes (~53cm tall). This coincided with a decline in the number of biological control agents observed on and within the surveyed knapweed plants. The graphs representing insect populations within knapweed plants may, however, underestimate the population of *Larinus minutus* at Rocky Flats Environmental Technology Site this year, as transect surveys were performed after the peak emergence of this insect.

The Dalmatian toadflax transect monitoring was initiated in 2005, in conjunction with three releases of stem-mining insect, *Mecinus janthinus*. Similar to the techniques used in diffuse knapweed transect surveying, we collected data on the density, height and seed production of Dalmatian toadflax at 50m intervals in each cardinal direction from the points of weevil release. We present only a graph of the densities of this weed in each of the *M. janthinus* release areas (Figure 22). There were no insects present at any distance from the origin of release, as would be expected from the small releases made concurrently with transect surveys. As Figure 22 indicates, patches of toadflax were not extremely dense 50m past the initial area of *M. janthinus* release. Nonetheless, these transects will be quite useful in future years to monitor the spread of both Dalmatian toadflax and *M. janthinus*, as the biocontrol agent begins to impact its target weed.

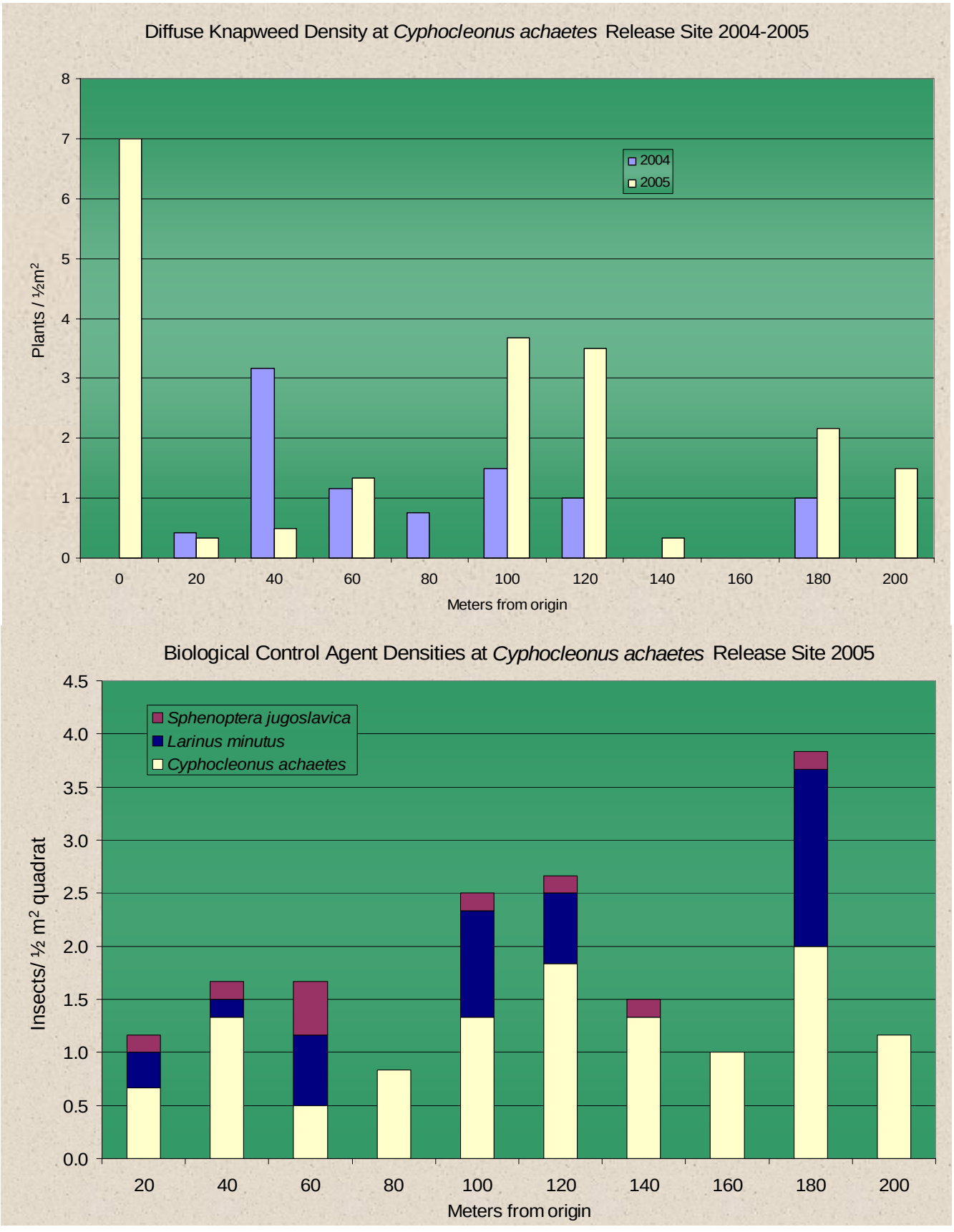


Figure 19. Diffuse knapweed (above) and insect bio-control agent (below) densities at various distances from *C. achates* release sites.

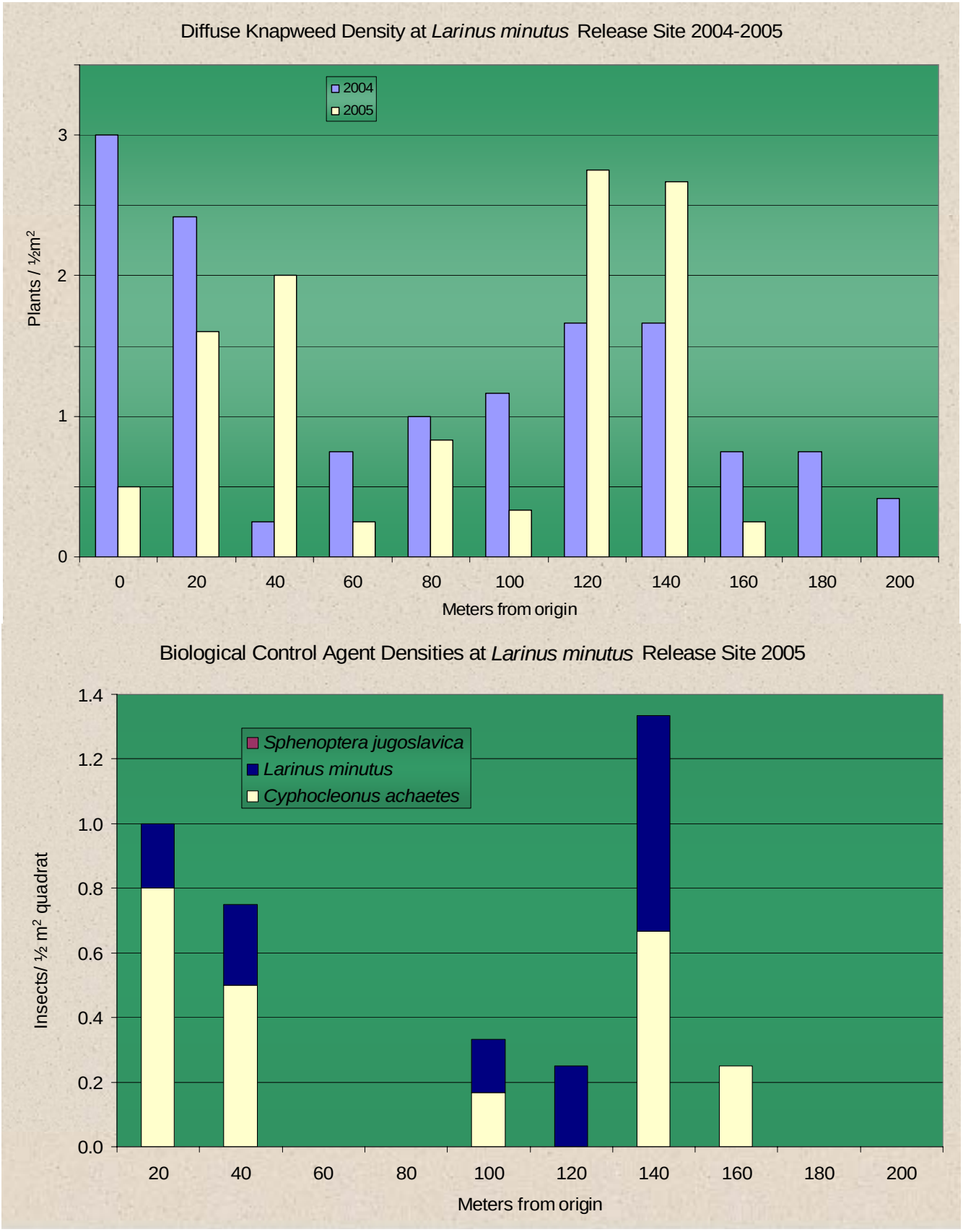


Figure 20. Diffuse knapweed (above) and insect bio-control agent (below) densities at various distances from *L. minutus* release sites.

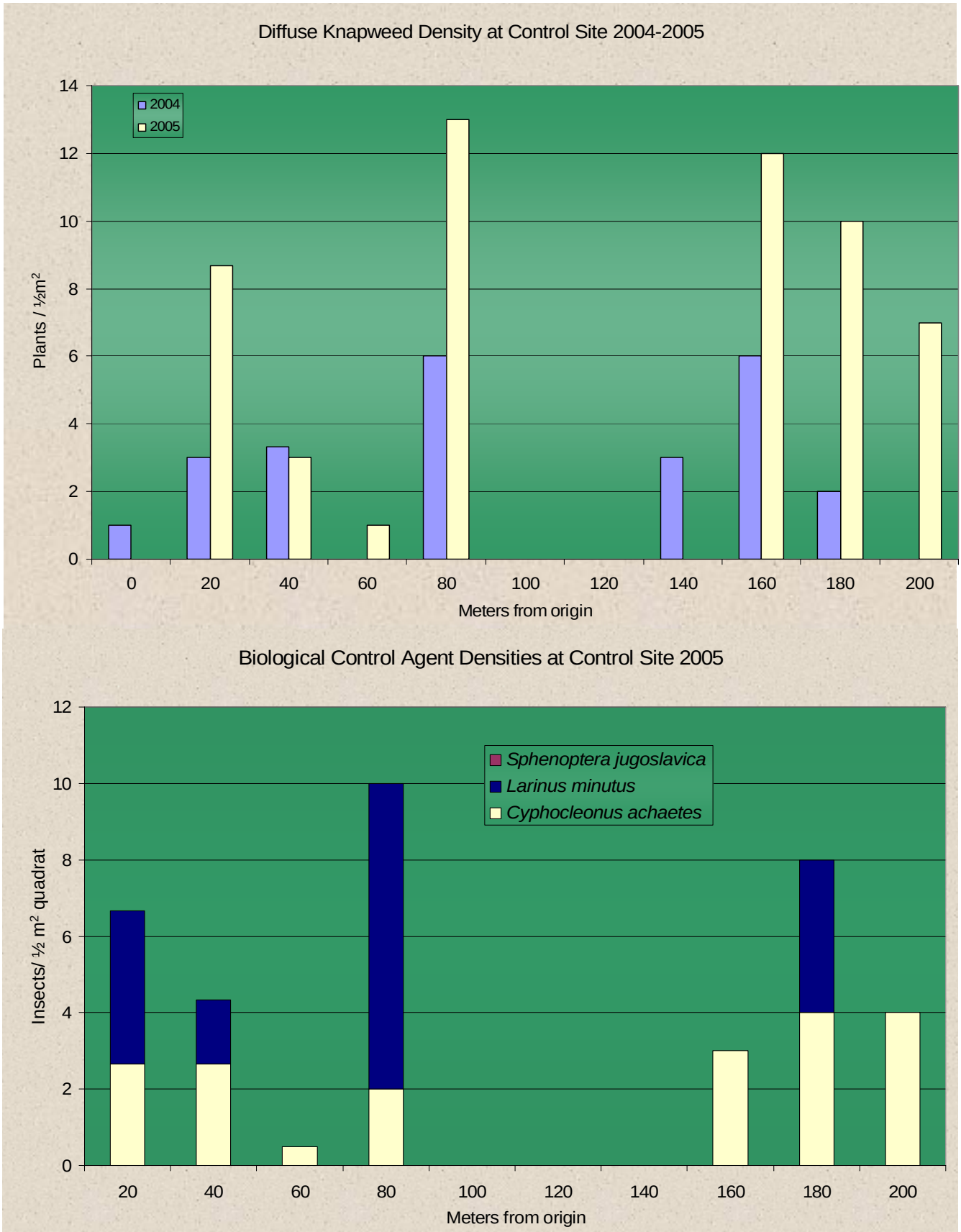


Figure 21. Diffuse knapweed (above) and insect bio-control agent (below) densities at various distances from “no release (aka Control) point.

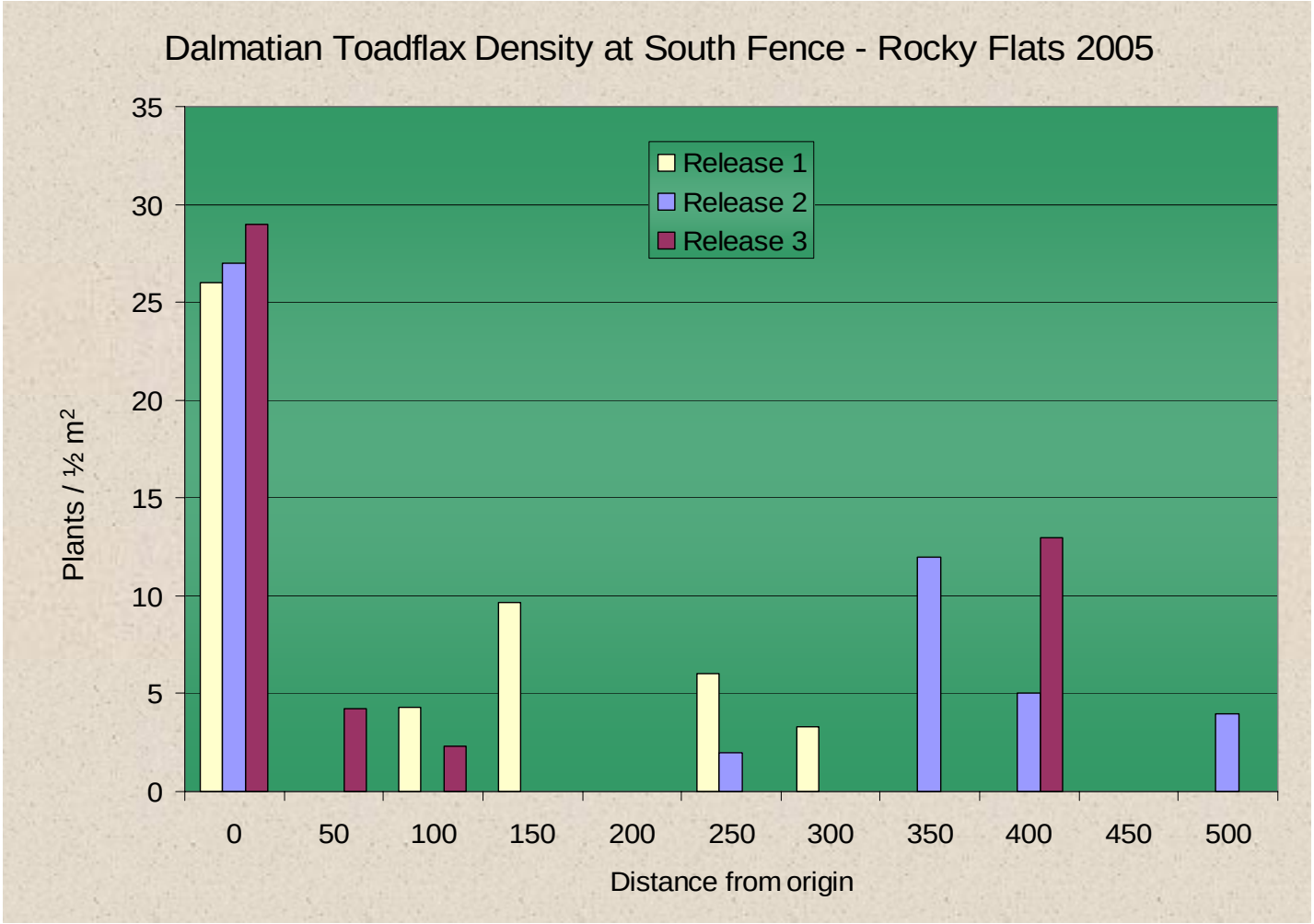


Figure 22. Dalmatian toadflax density within transects at each of the three *M. janthinus* release sites. The origin denotes the location at which weevils were released.

F. E. Warren Air Force Base

The most predominant weed at F. E. Warren Air Force Base in 2005 was, without a doubt, leafy spurge (Figure 23). Growing as a massive, continuous infestation base-wide, spurge became our main biological control priority this year, with 6.4 ha of infestation mapped and surveyed (Table 14). The area we managed to map is by no means representative of the total extent of this noxious weed across the installation, rather a continuation of the survey commenced in 2004, with the addition of a new leafy spurge site, Black Powder Road. Two of the leafy spurge patches mapped in 2004 (Nature I & II) remained relatively constant in size, although density and height of individual plants increased at all survey locations. This summer, we found the leafy spurge Control site, a discrete weed patch in 2004, at the center of one of the sweeping expansions of spurge base-wide. Consequently, the Control perimeter mapped in 2005 was bounded only by man-made barriers (fence line, bridge, etc.); the leafy spurge infestation extended well beyond the installation and the reaches of our mapping abilities.

Figure 23. Nature II site heavily infested with leafy spurge.

Biological control efforts were made across the installation in a total of 15 releases of 4,000 *Aphthona* sp. flea beetles each (Table 15). *Aphthona nigriscutis* beetles,

released at Nature I & II in 2004, were recovered this year from leafy spurge at both sites. Both *A. lacertosa*, previously discovered at the Control site in 2004 and *A. nigriscutis* were found at the Control site this season, the latter presumably having dispersed from one of the Nature releases (Figure 24). This year's insect releases focused on diversifying the habitats in which *Aphthona* spp. were liberated, thereby improving the chances of establishment of the beetle complex, composed of four different defoliating *Aphthona* species (Table 15). Plans are underway to obtain more leafy spurge agents for release at Warren Airbase in 2006.

Figure 24. Summer worker, Ed Raetz, inspecting leafy spurge plants (left) for biological control agents, *Aphthona* spp. flea beetles (right).

An interesting discovery was made at the Nature I and II spurge infestations in 2005. A stem-tip galling midge, *Spurgia esula*, previously released in Laramie County as a biological control agent against leafy spurge, was found in relatively high densities this year at the Nature Trail sites. A combined effect of preventing seed production by this agent, along with the impact of large numbers of *Aphthona* beetles feeding to reduce the vigor of plants, may provide much faster control than using either bio-agent alone.

Monitoring of Dalmatian toadflax infestations took place over a slightly larger area (10.0 ha) this year than in 2004. Dalmatian toadflax also appeared to have a better growing season in 2005 than 2004, with greater plant density and height (Table 14). No stem-mining weevils released in 2004 were recovered this year and additional releases of *M. janthinus* are planned for 2006. Two hundred *M. janthinus* were released into a sheltered location near the Nature I leafy spurge infestation this year in order to establish a nursery area for the beetles. This location differs from the 2004 releases, which were made in open fields, and may provide a more stable overwintering environment than either of the Nature or Missile sites. If this turns out to be the case, this nursery site will be used to redistribute acclimated beetles to the Nature and Missile sites on base in future years.

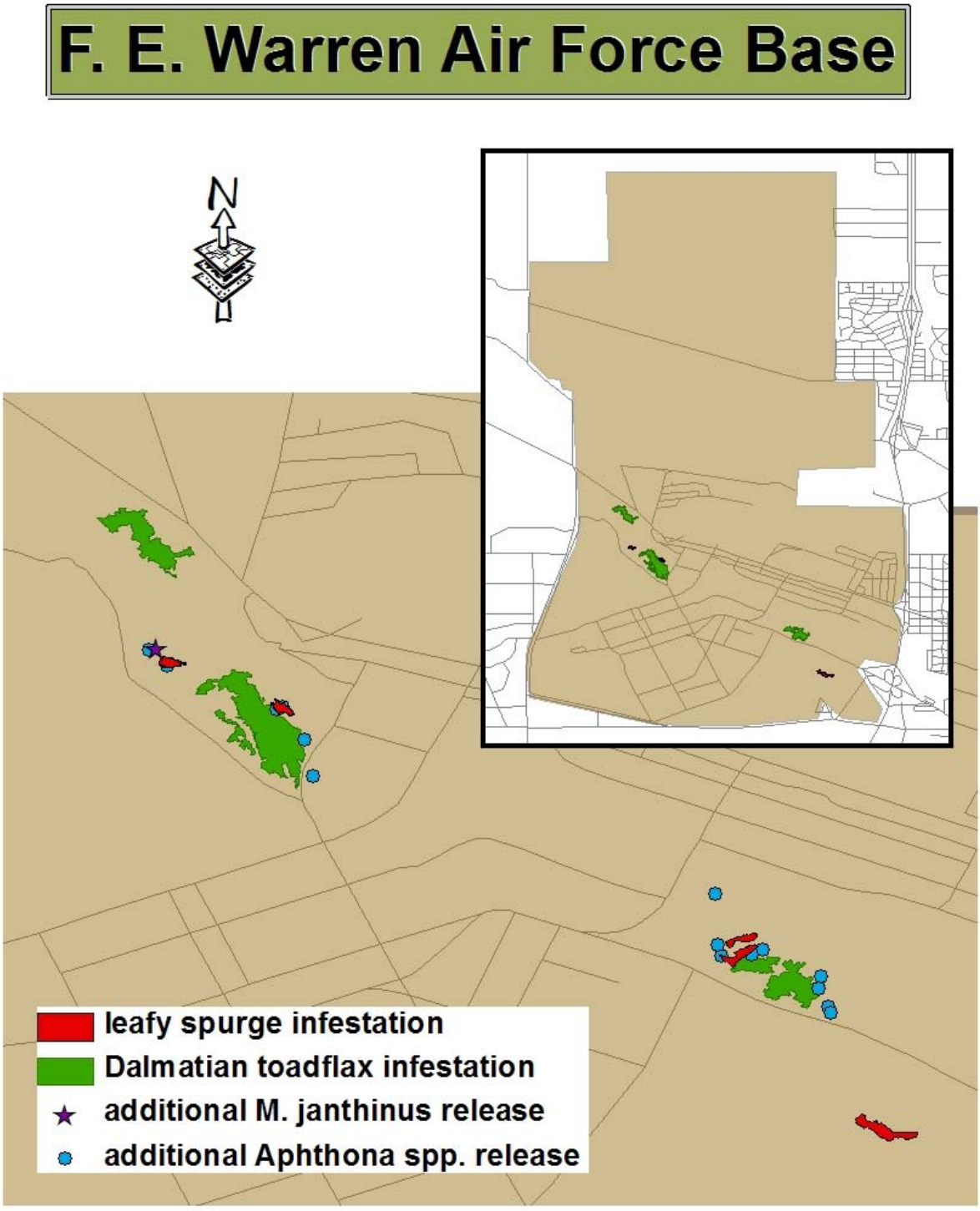


Figure 25. Schematic diagram of F. E. Warren Air Force Base with weed biological control study areas superimposed.

Table 14. Historic noxious weed infestation parameters, F. E. Warren Air Force Base, Wyoming, 2004-2005.

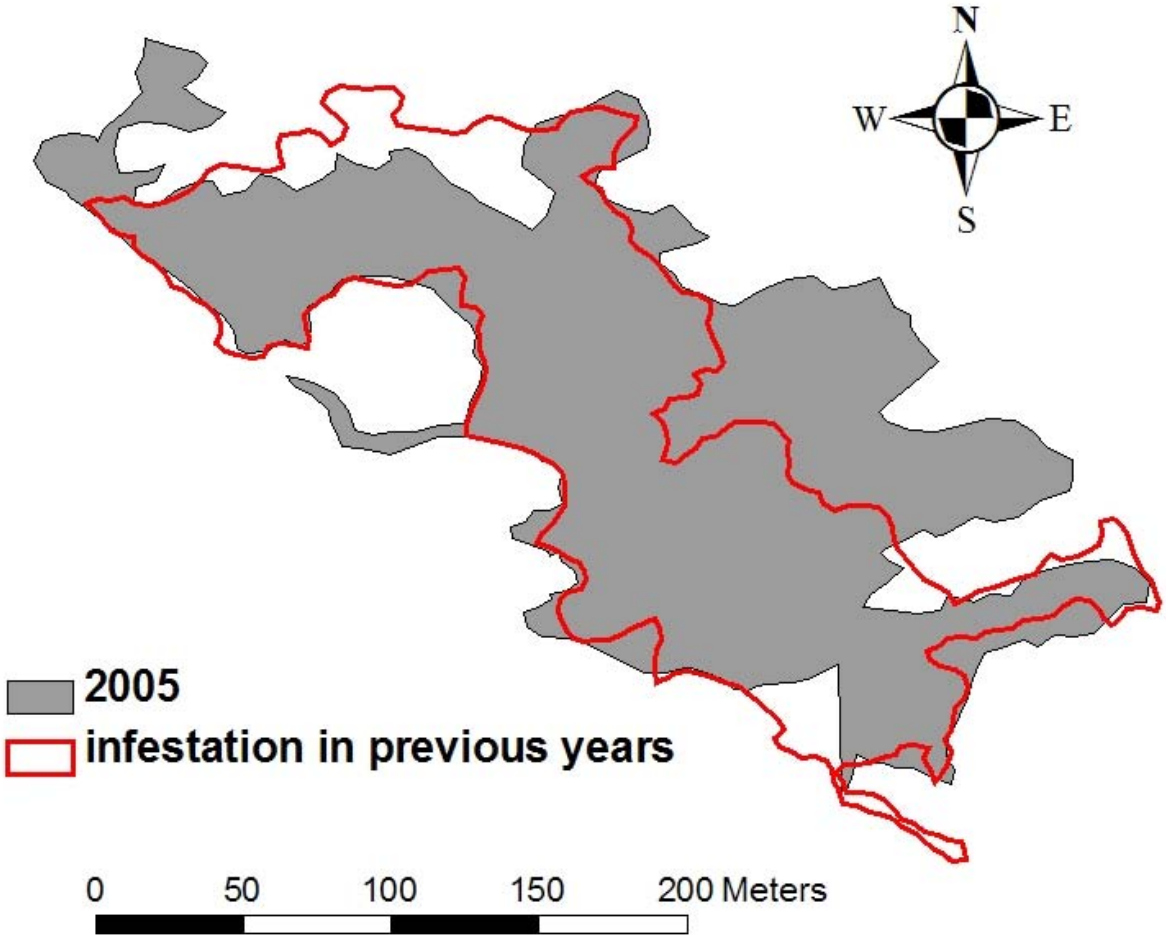
Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads per plant avg.	Head size avg. (mm)	Year to year % change			% Area change to date
			Avg.	Max	Avg.	Max			Area (m^2)	Avg. density	Avg. height	
Dalmatian toadflax - Control												
2004	18,424	45	2.67	21	32.73	91						
2005	23,234	44	3.66	25	49.36	74	13.57		26.11	37.08	50.81	26.11
Dalmatian toadflax - Missile												
2004	20,356	49	0.63	3	24.14	80						
2005	27,247	54	4.35	54	53.52	91	10.217		33.85	590.48	121.71	33.85
Dalmatian toadflax – Nature												
2004	45,471	80	1.16	8	25.01	84						
2005	49,471	63	4.61	29	55.15	98	14.26		8.80	297.41	120.51	8.80
Leafy spurge – Black Powder Road												
2005	2,797	28	48.82	127	64.93	91			na	na	na	na
Leafy spurge - Control												
2004	5,526	31	41.70	98	48.71	69						
2005	60,606	50	59.80	362	63.03	94			996.74	43.41	29.40	996.74
Leafy spurge – Nature I												
2004	1,849	44	36.95	88	67.14	95						
2005	1,547	35	45.77	250	68.35	97			-16.33	23.87	1.80	-16.33
Leafy spurge – Nature II												
2004	1,703	42	66.19	129	55.98	81						
2005	1,463	38	85.30	184	62.35	80			-14.09	28.87	11.38	-14.09

n – number of samples or observations
na – not applicable, data represent first year of sampling

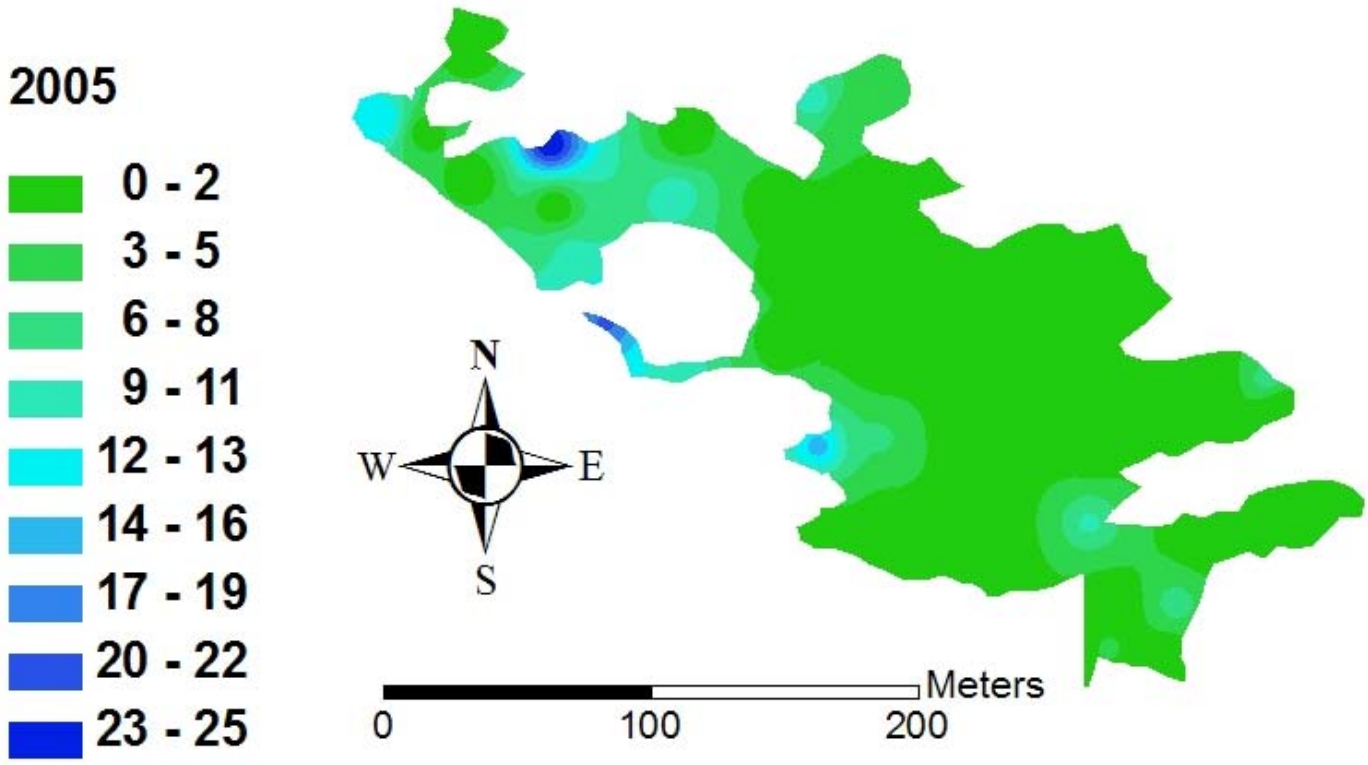
Table 15. Noxious weed biological control sites, target weeds, species released and recoveries at F. E. Warren Air Force Base, 2005.

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

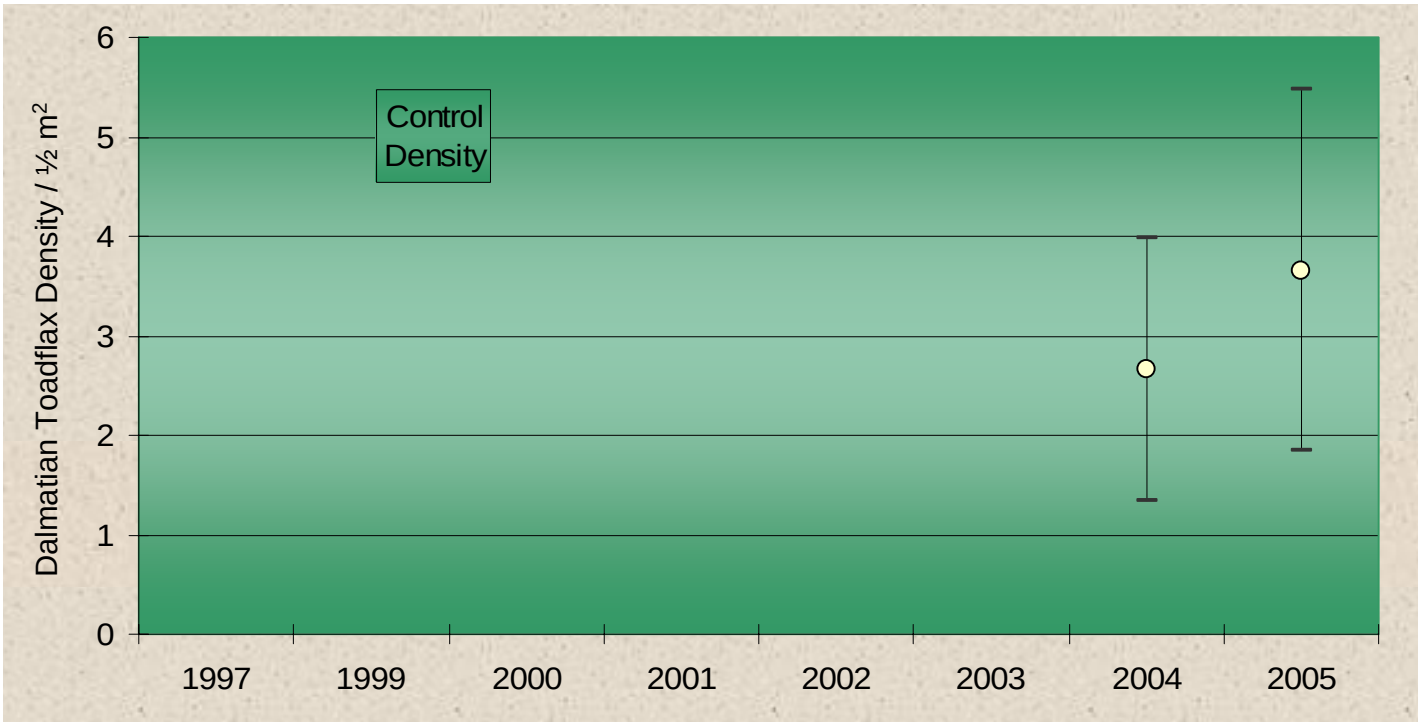
[1] *Aphthona sp*. complex is composed of varying proportions of *A. cyparissiae, A. czwalinae, A. lacertosa* and *A. nigriscutis*
[2] Adventitious recovery, no release made at this site
[3] Area not mapped, release only

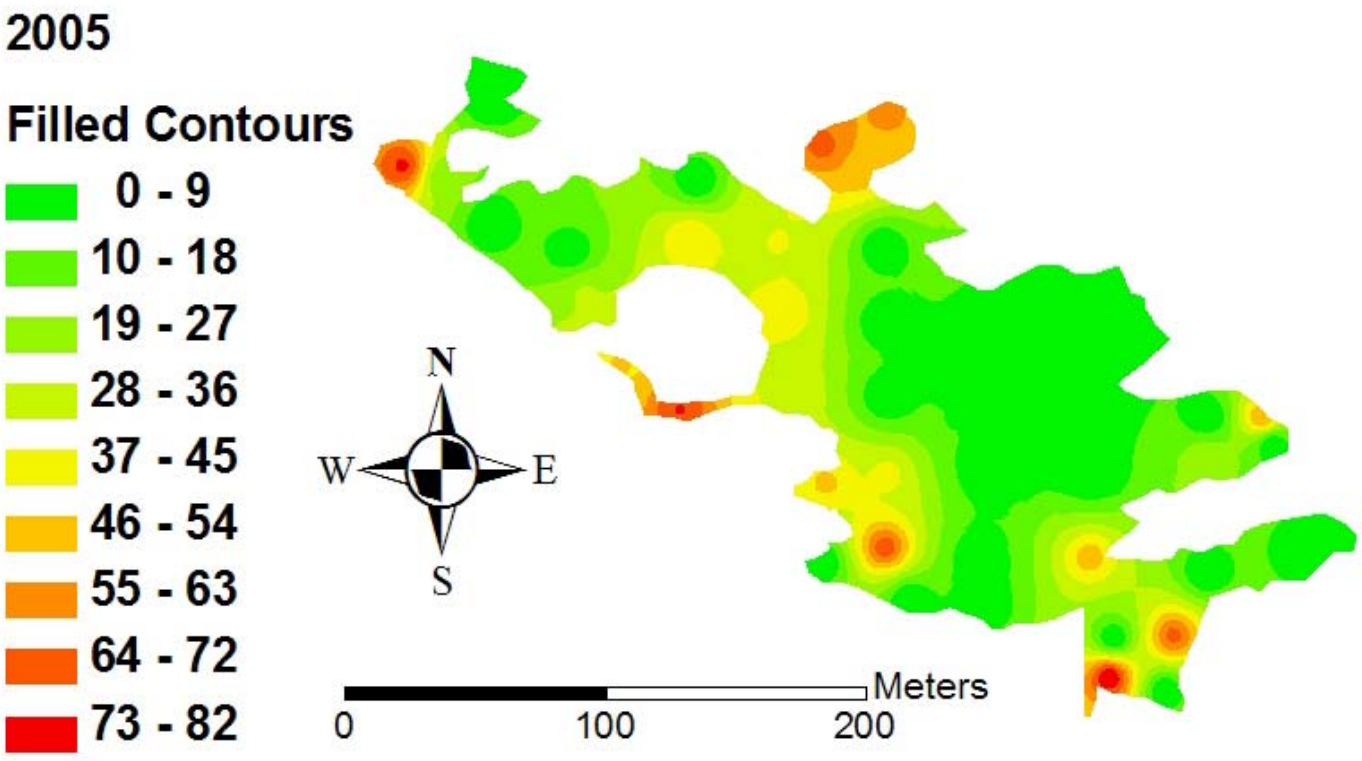


Control Dalmatian toadflax perimeter in 2005.

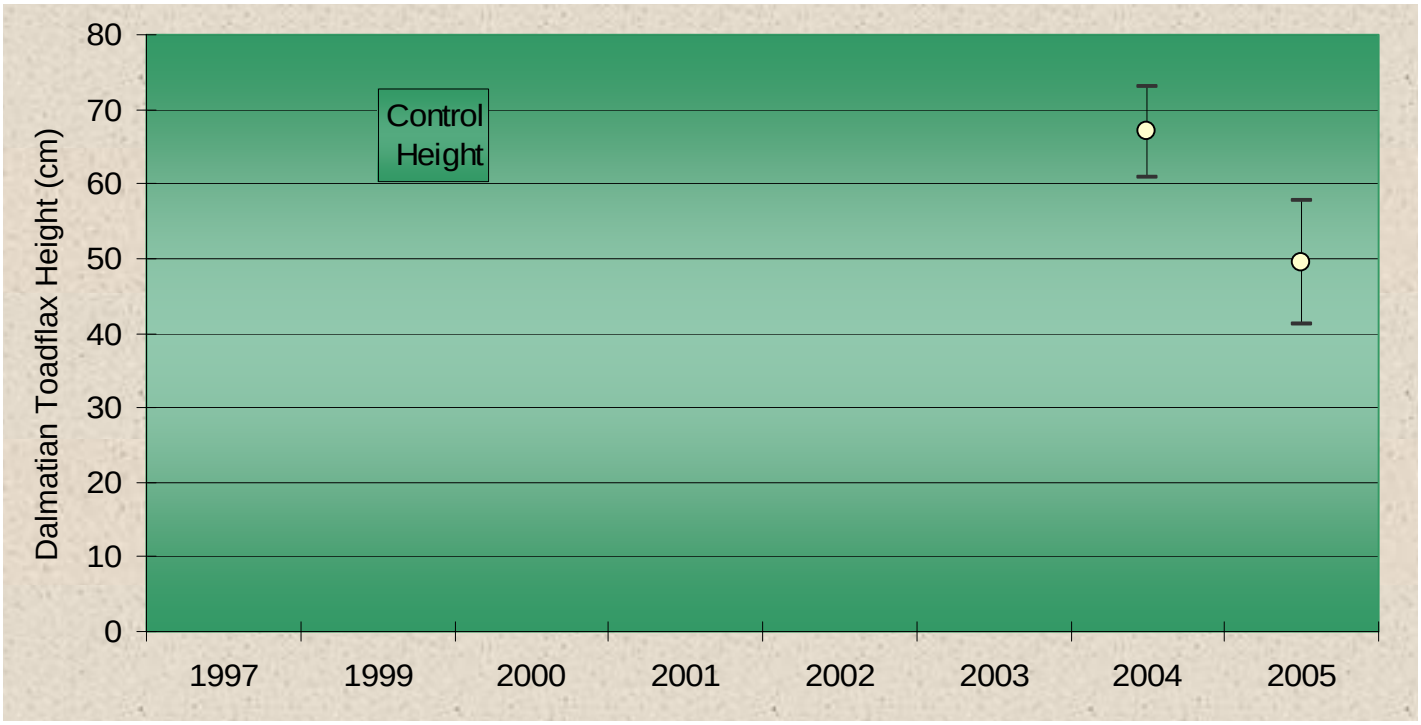


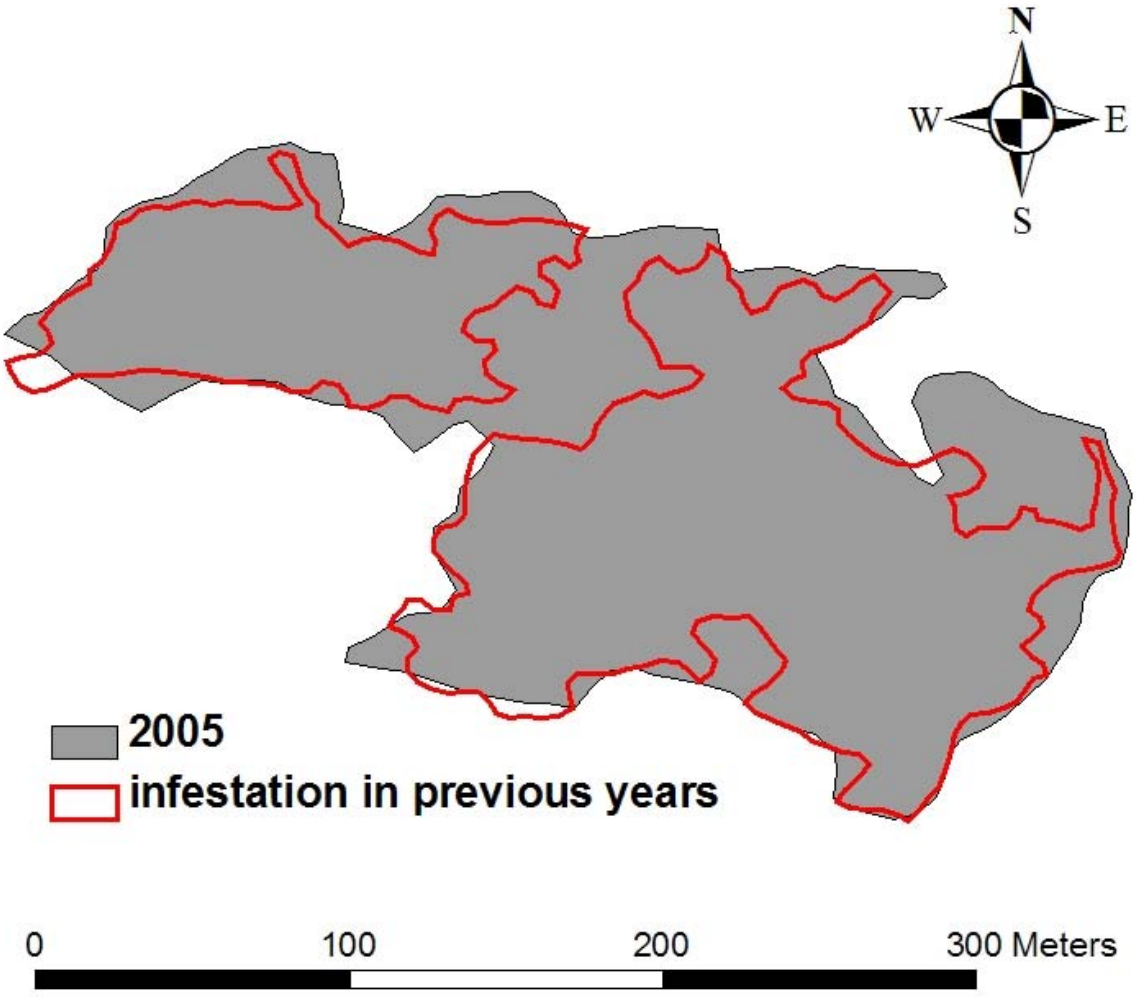
Control Dalmatian toadflax density in 2005.



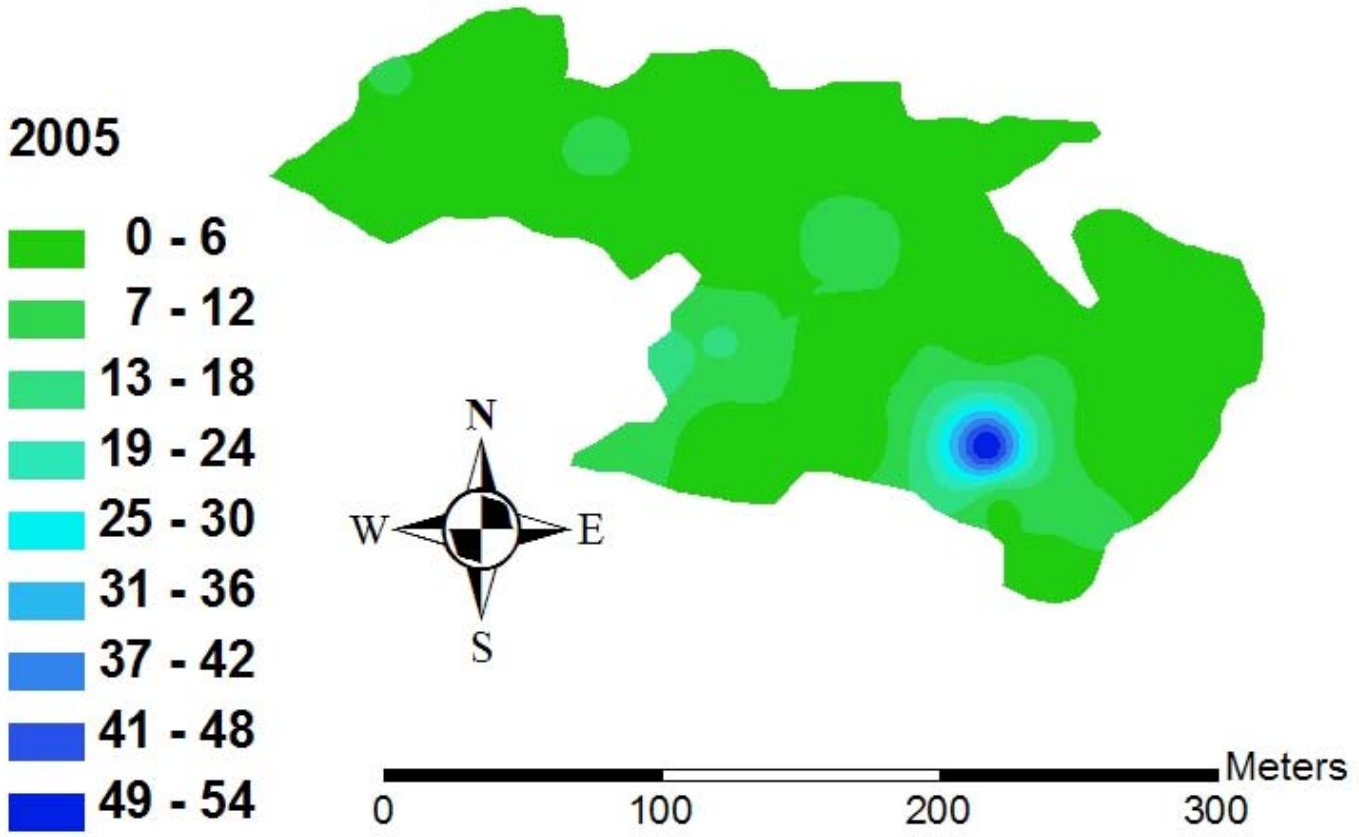


Control Dalmatian toadflax height in 2005.

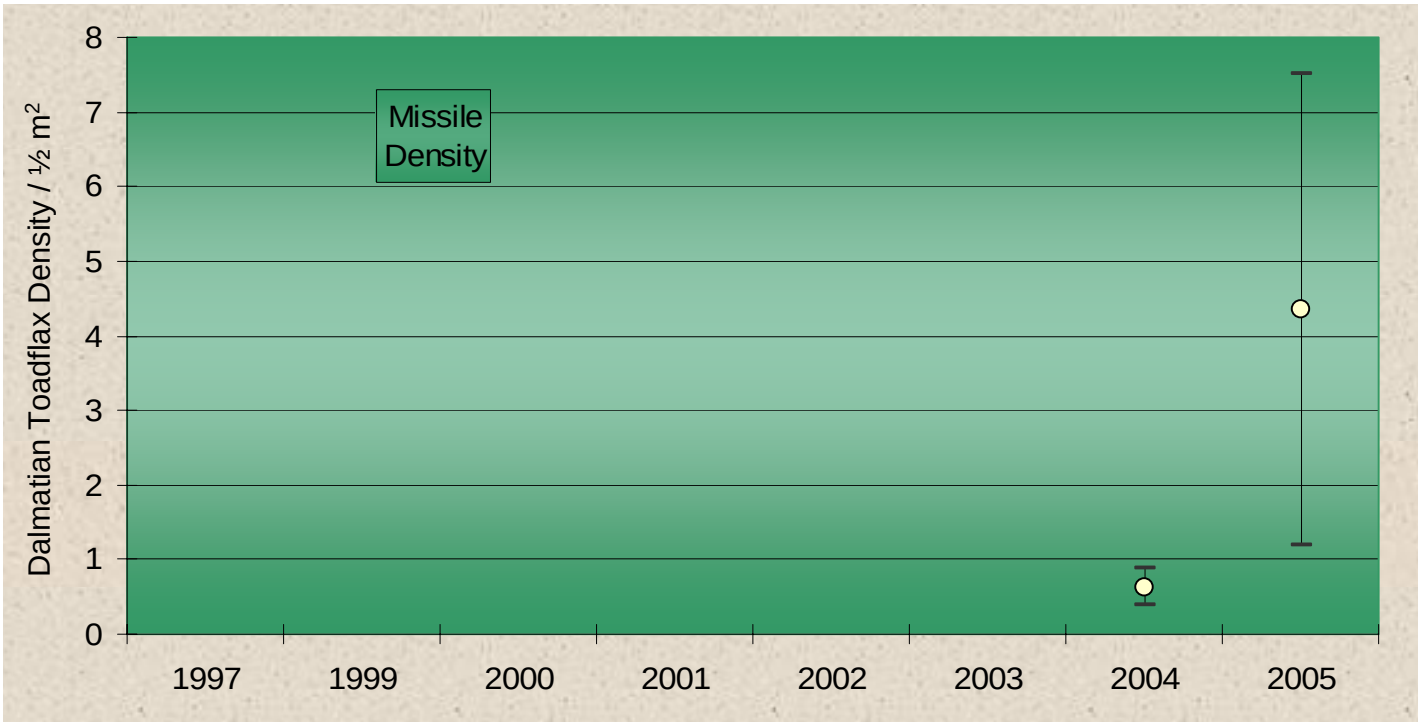


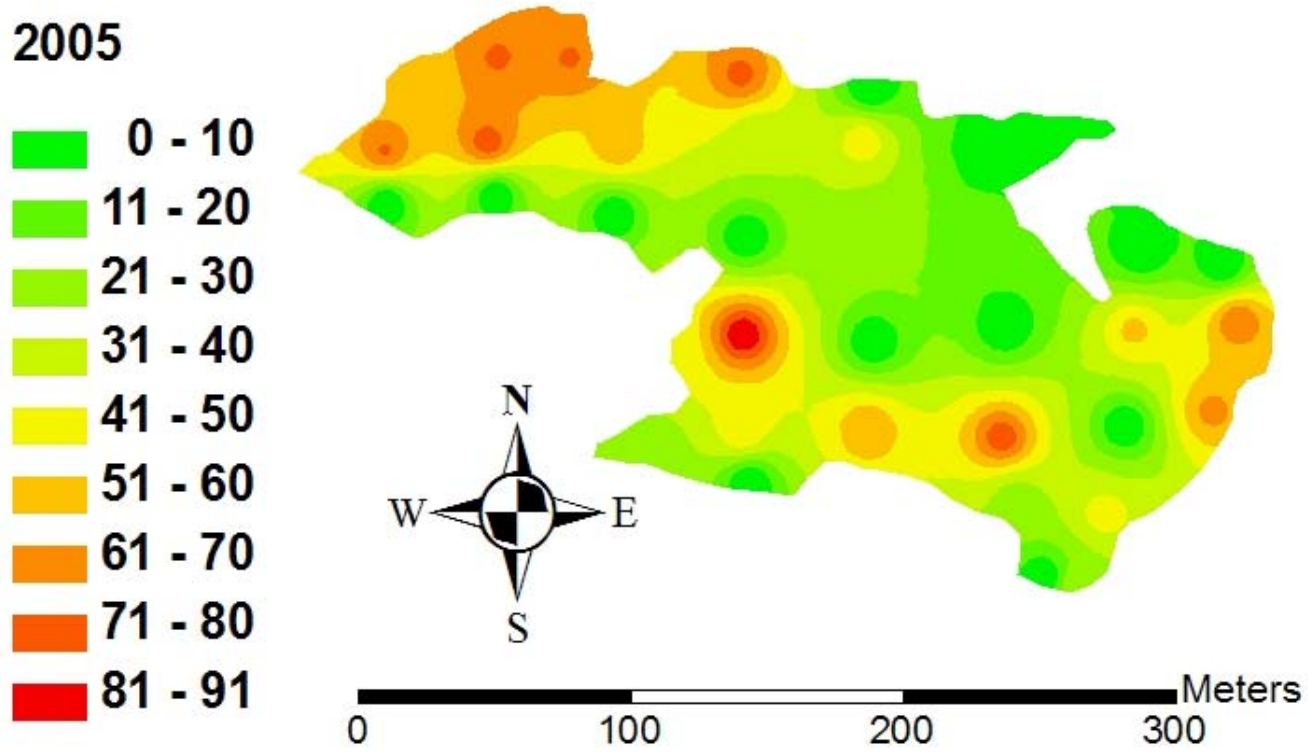


Missile Dalmatian toadflax perimeter in 2005.

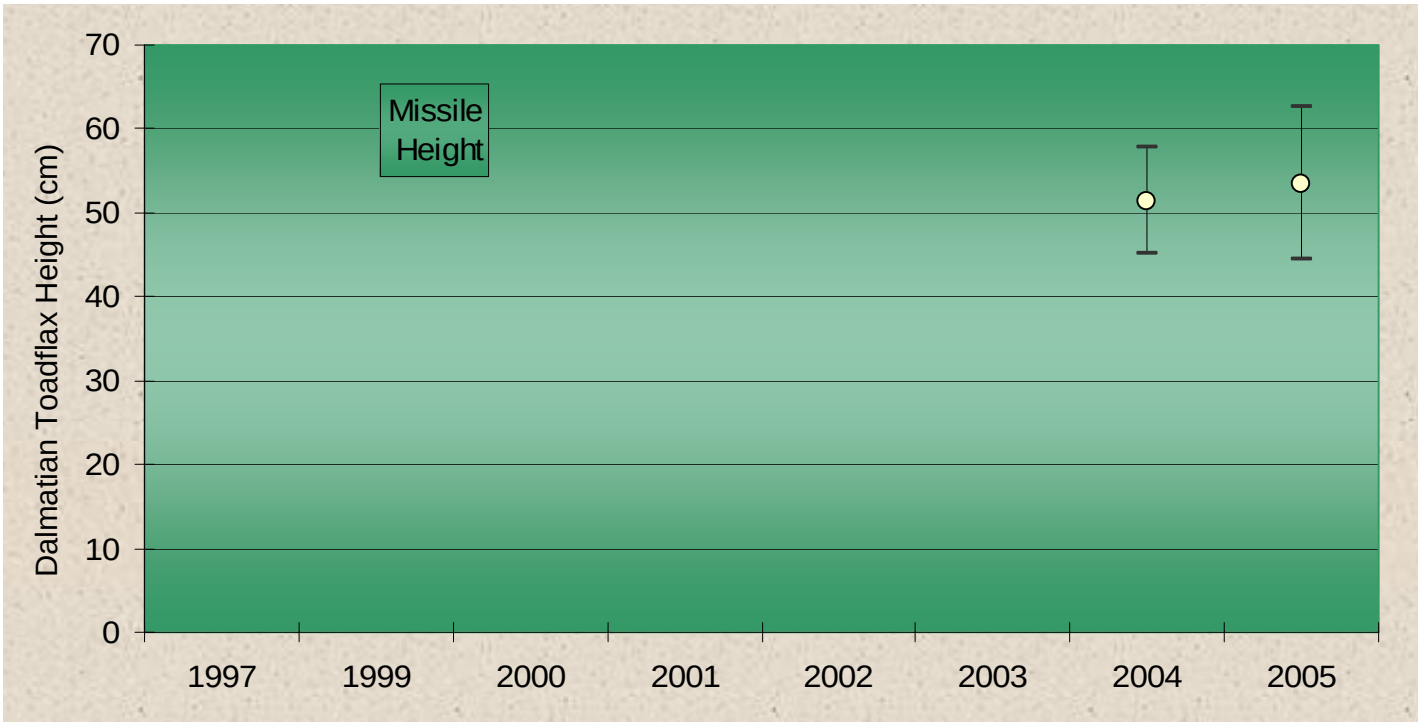


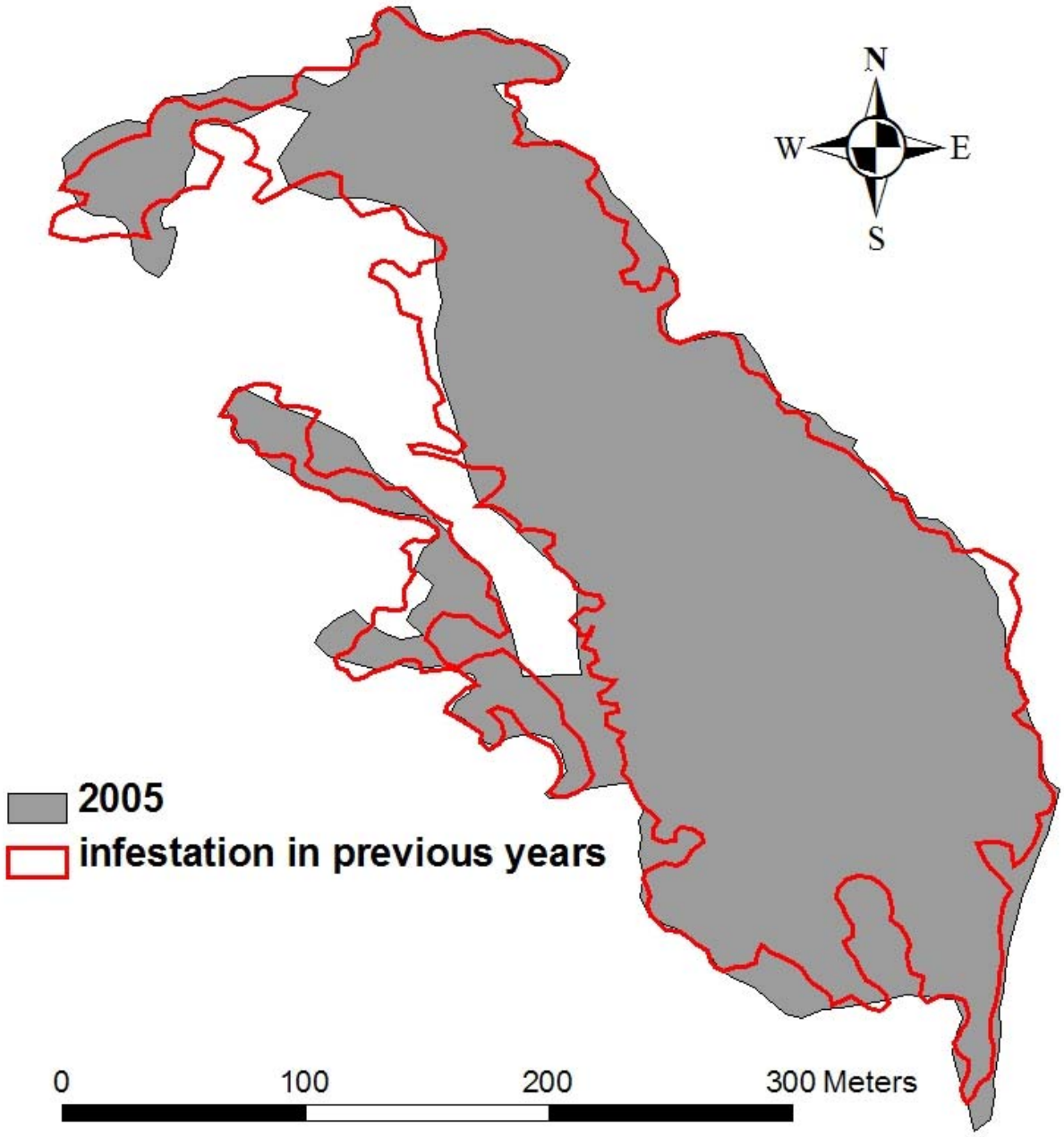
Missile Dalmatian toadflax density in 2005.



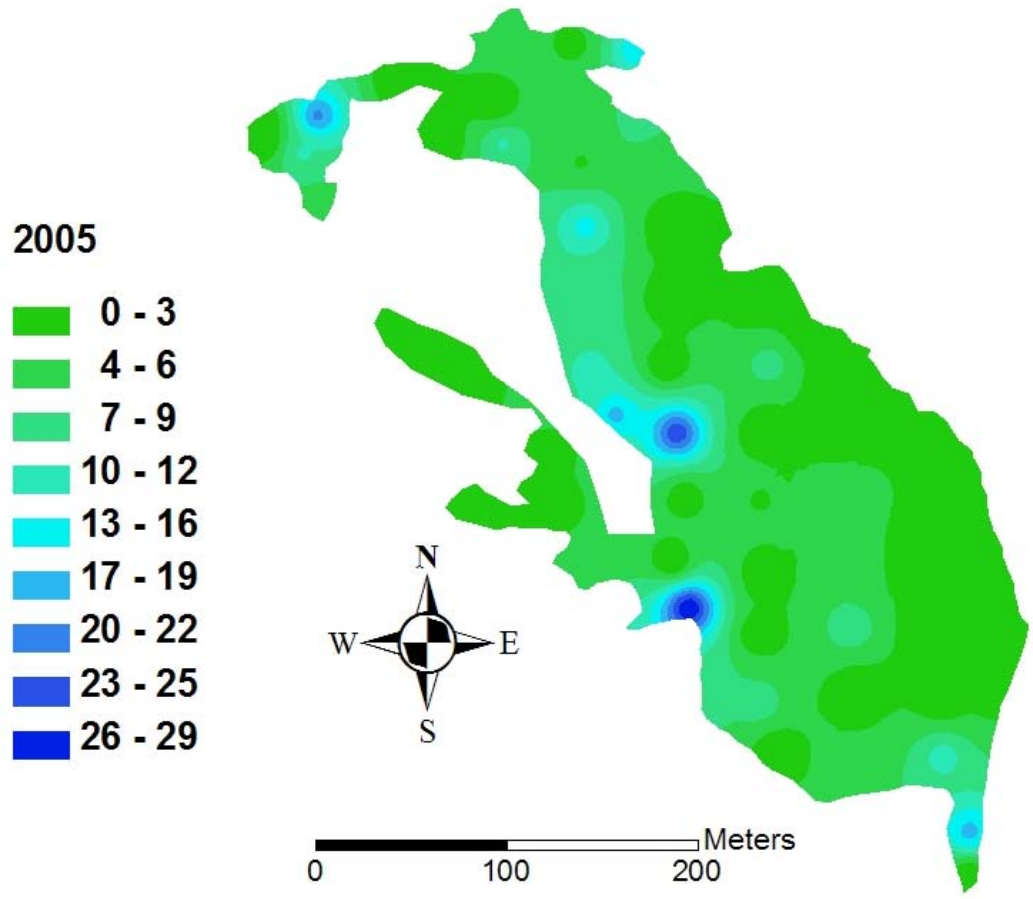


Missile Dalmatian toadflax height in 2005.

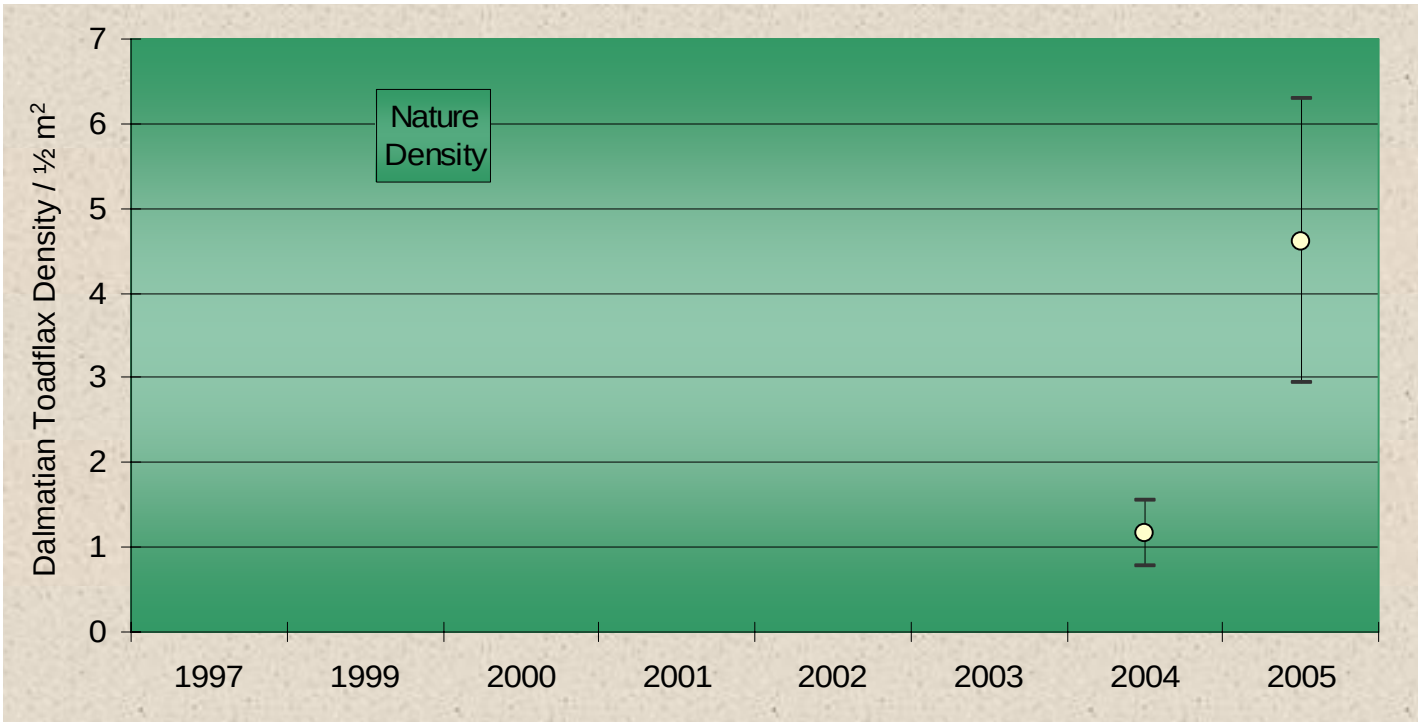


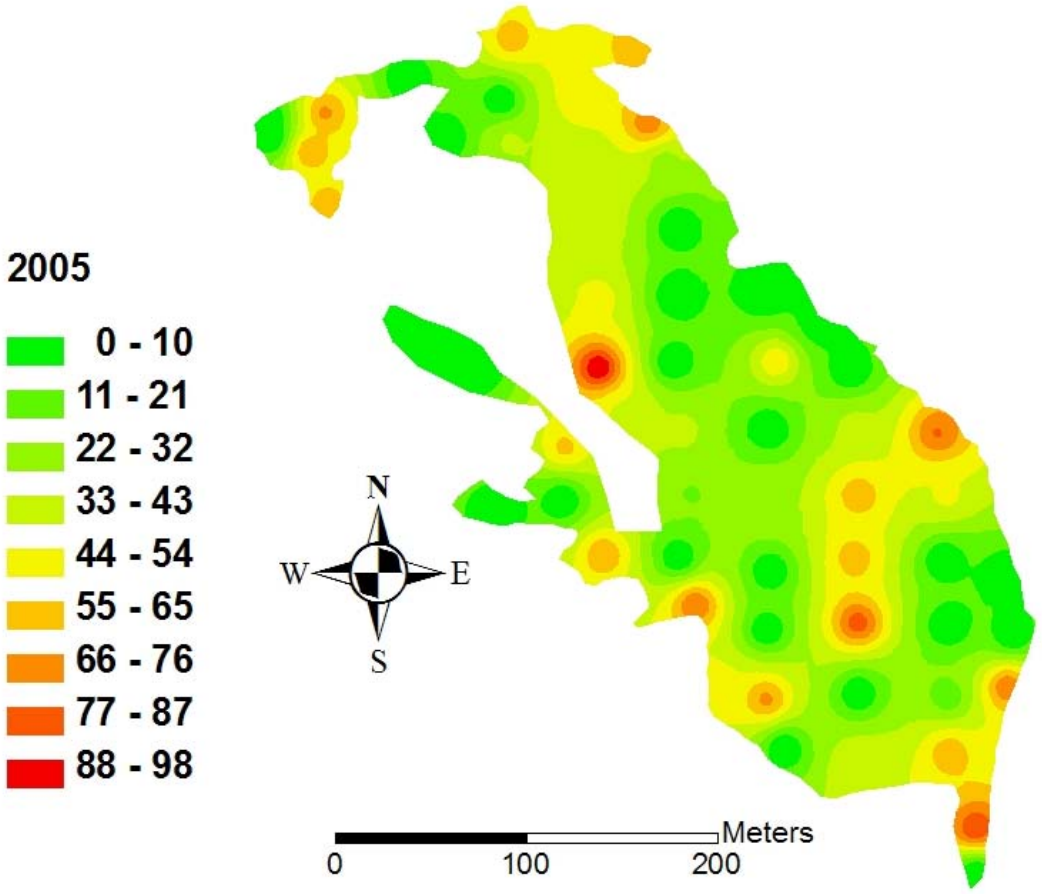


Nature Dalmatian toadflax perimeter in 2005.



Nature Dalmatian toadflax density in 2005.





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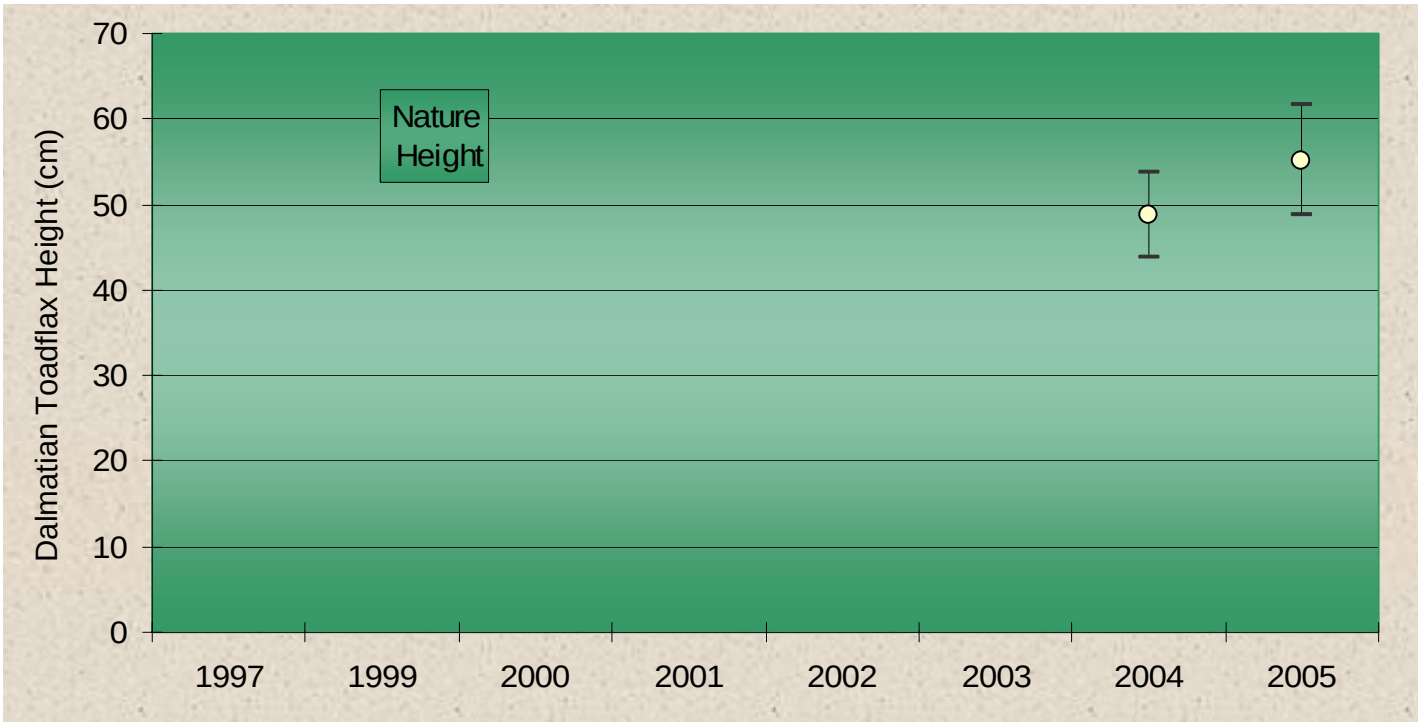
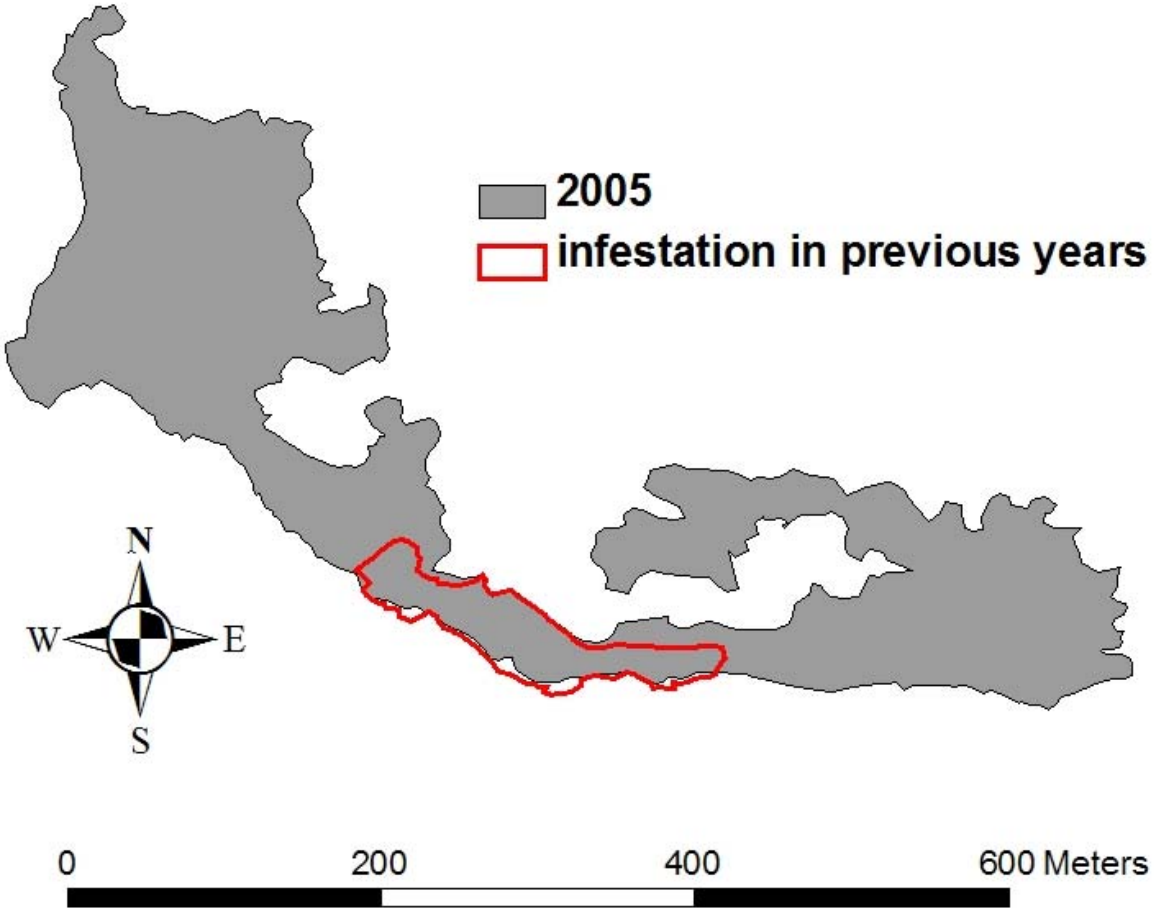
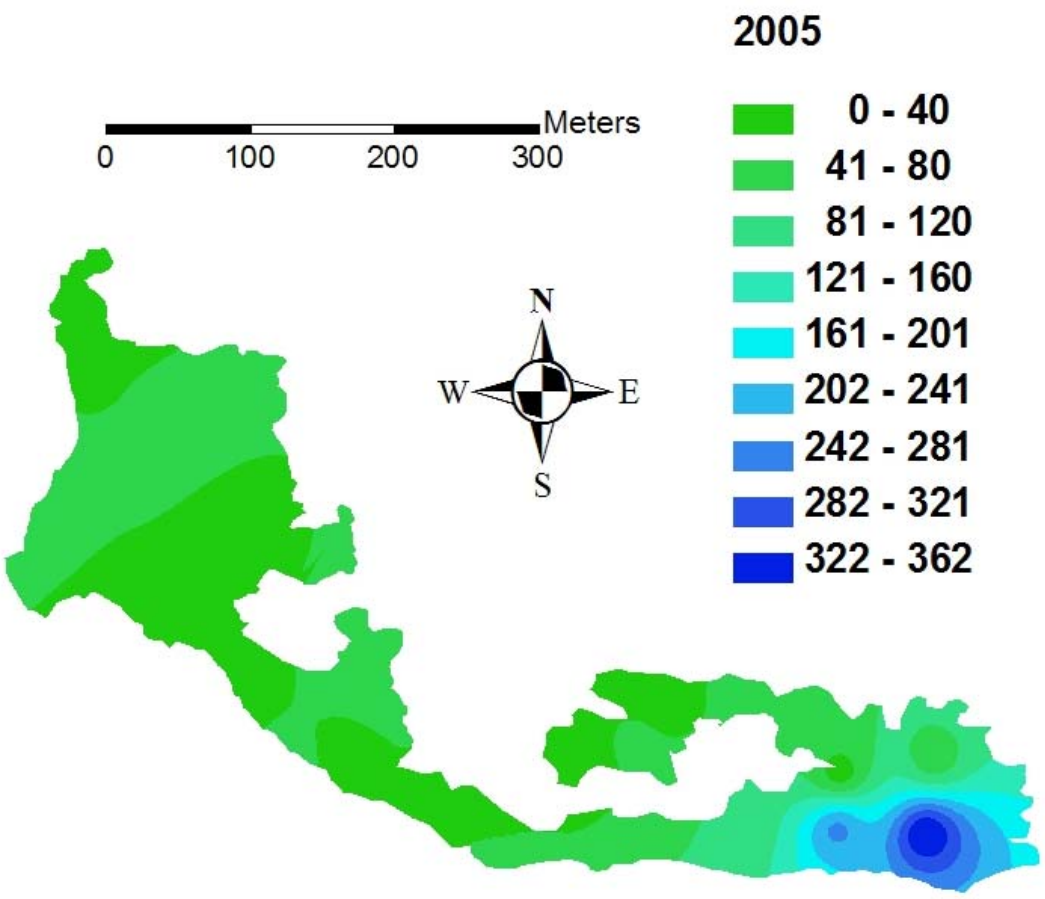




Control leafy spurge perimeter in 2005.



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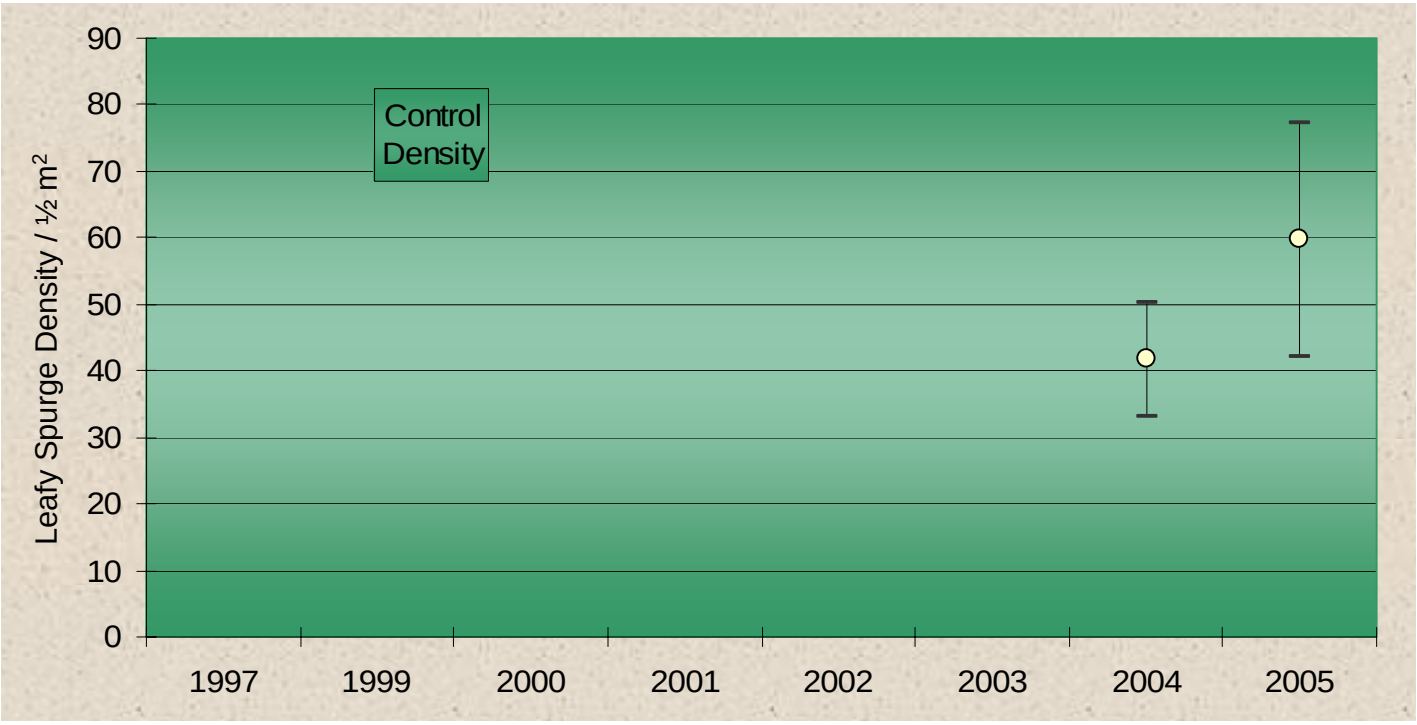

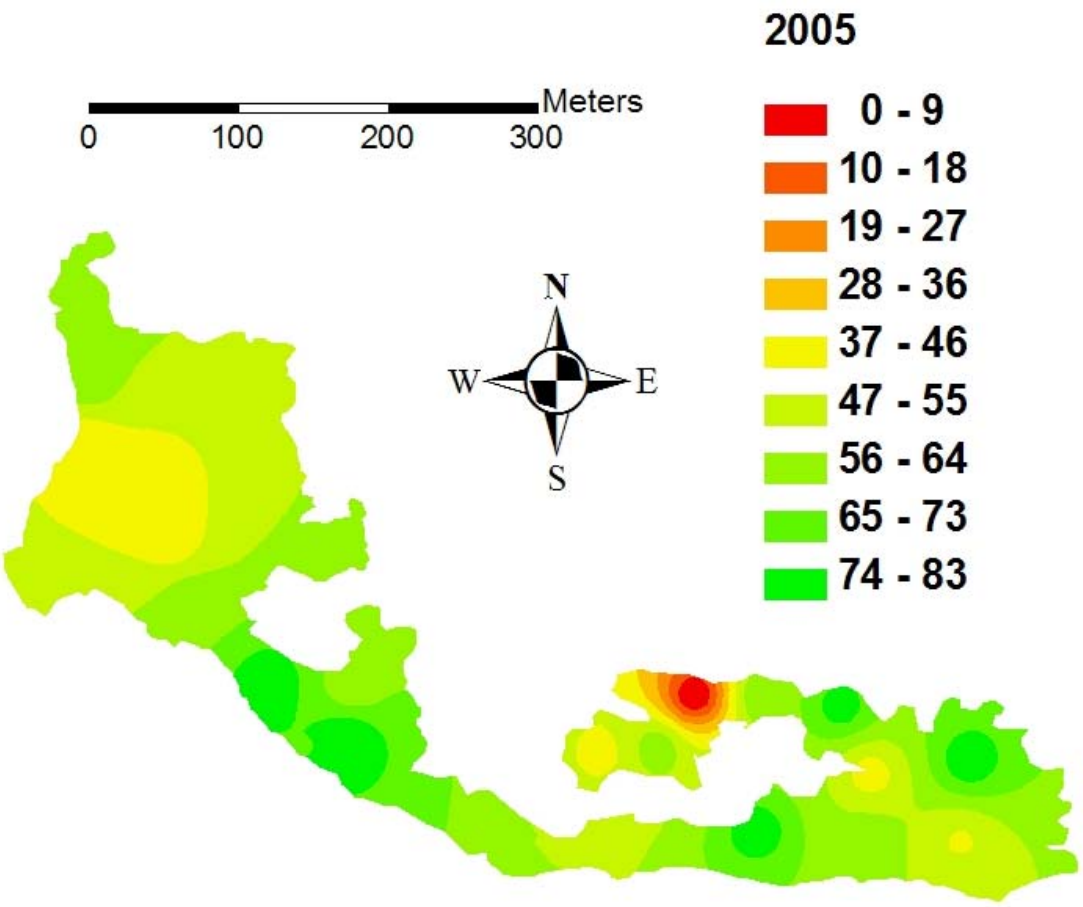

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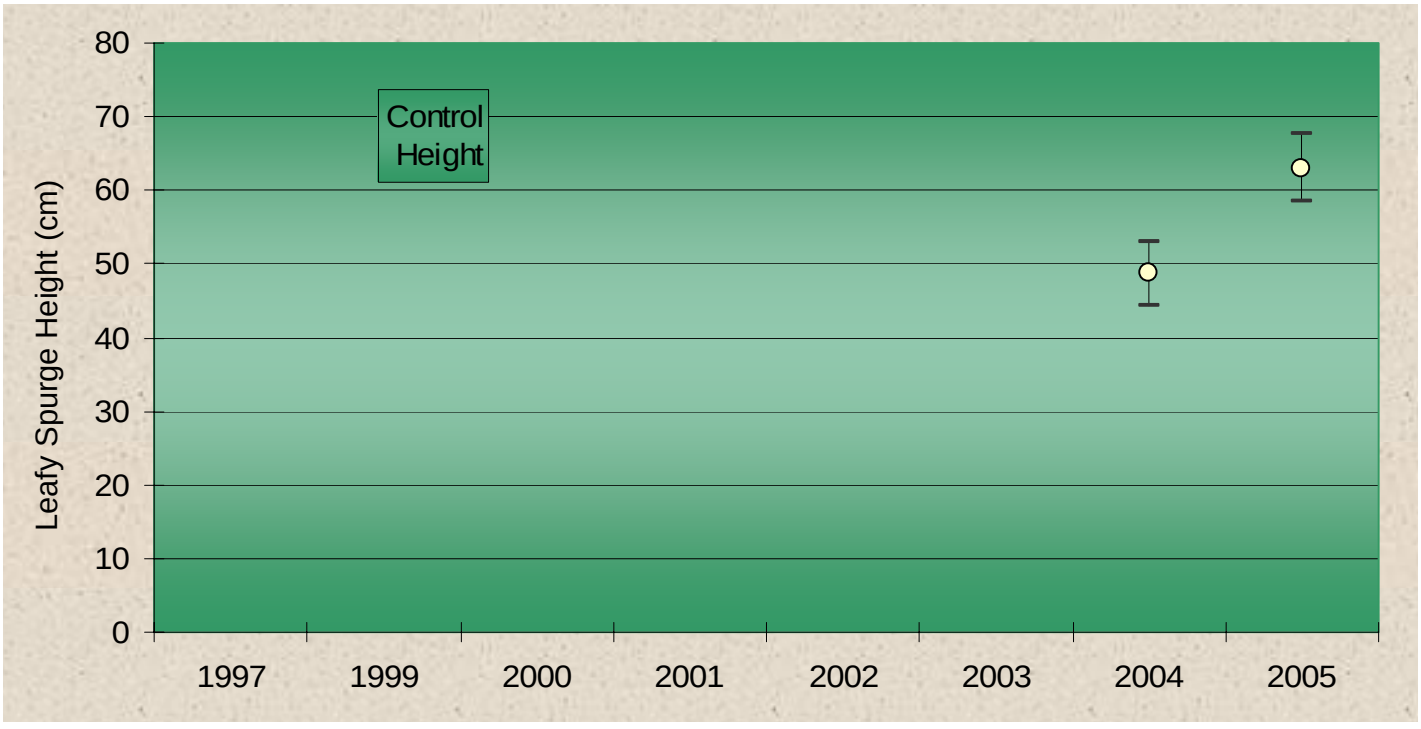

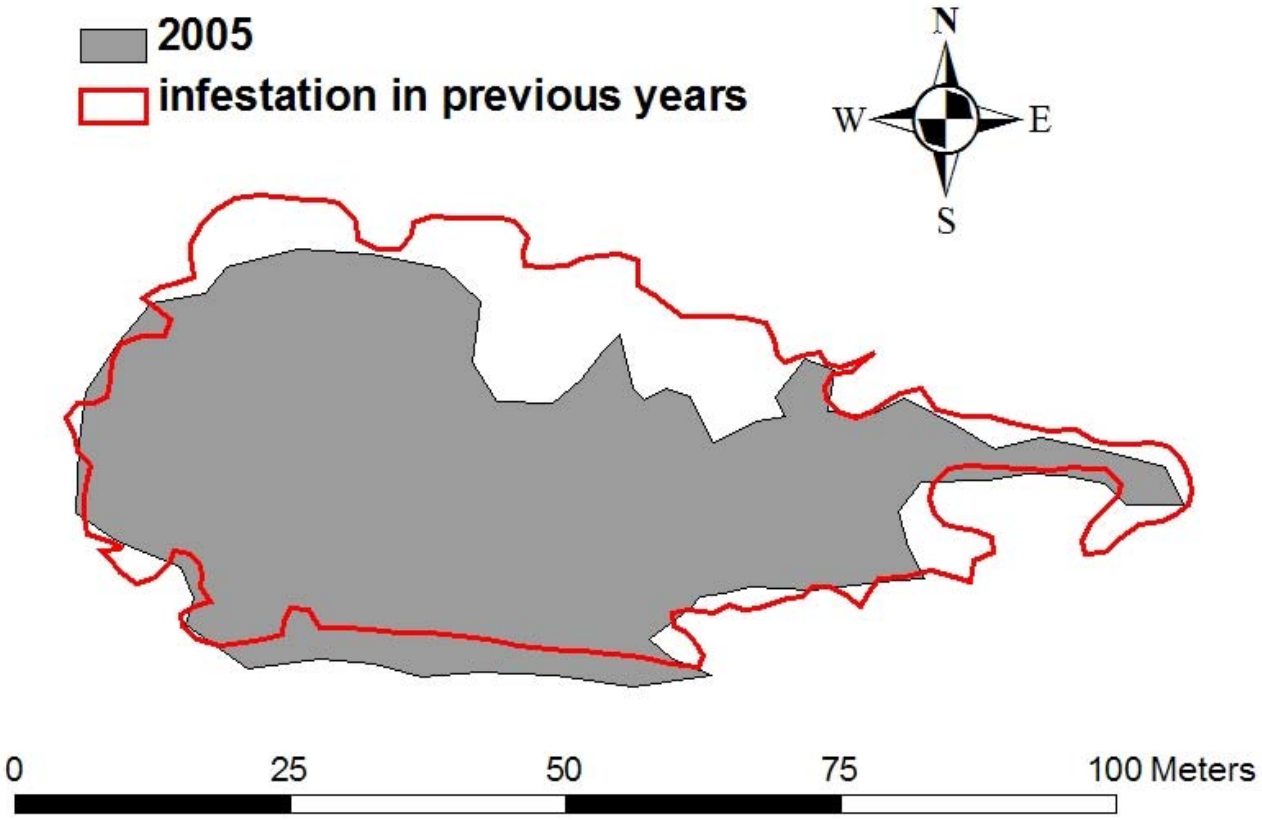

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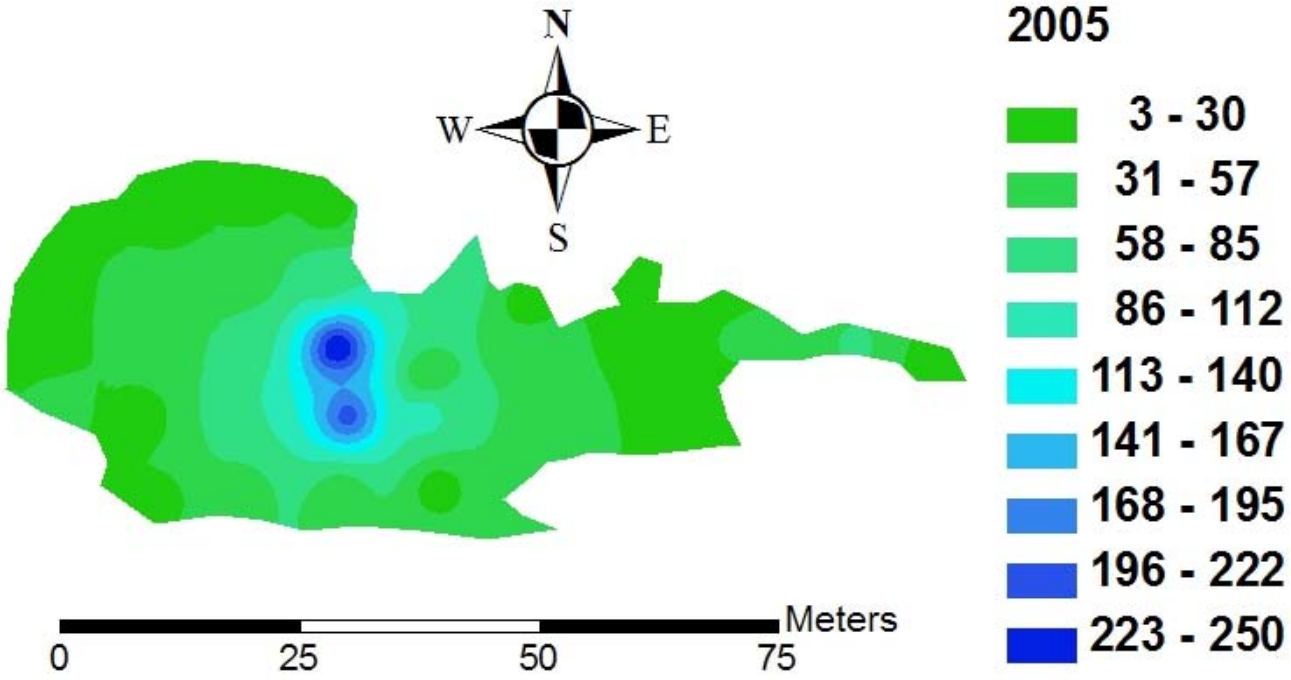

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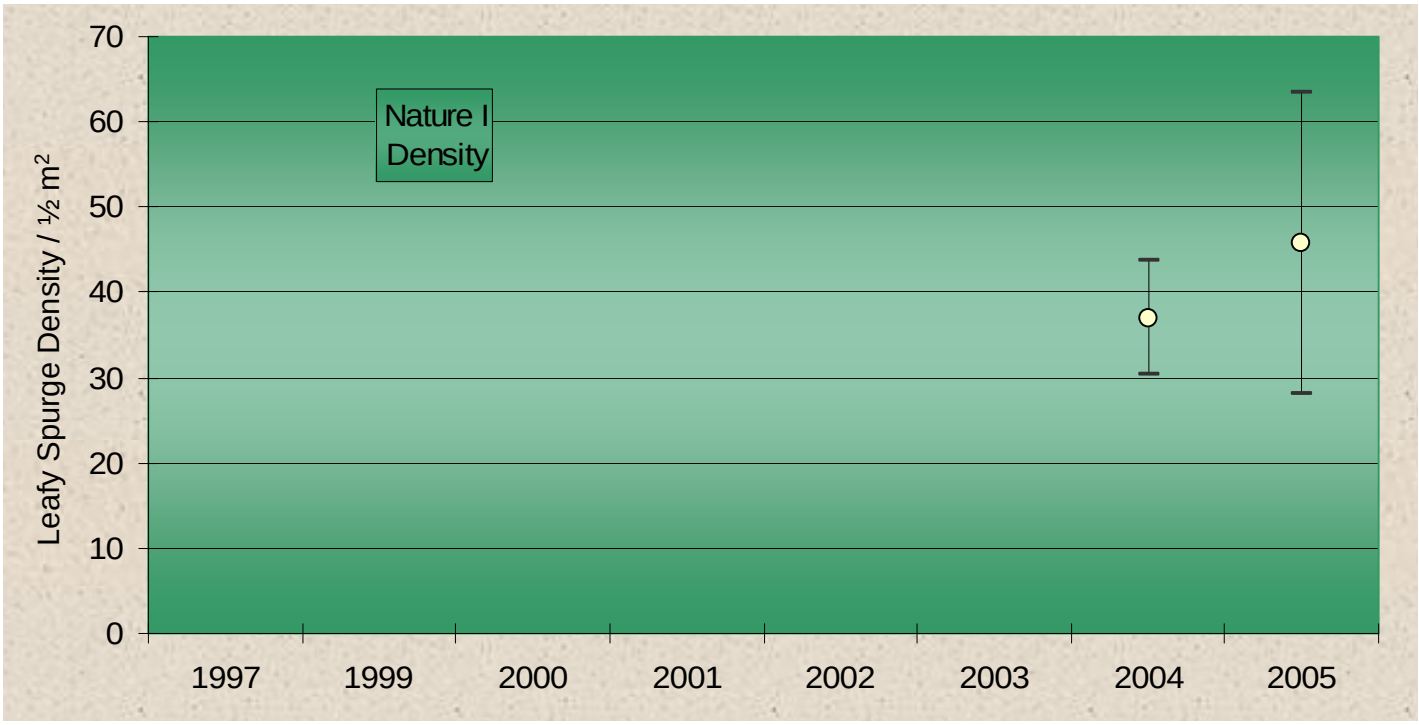

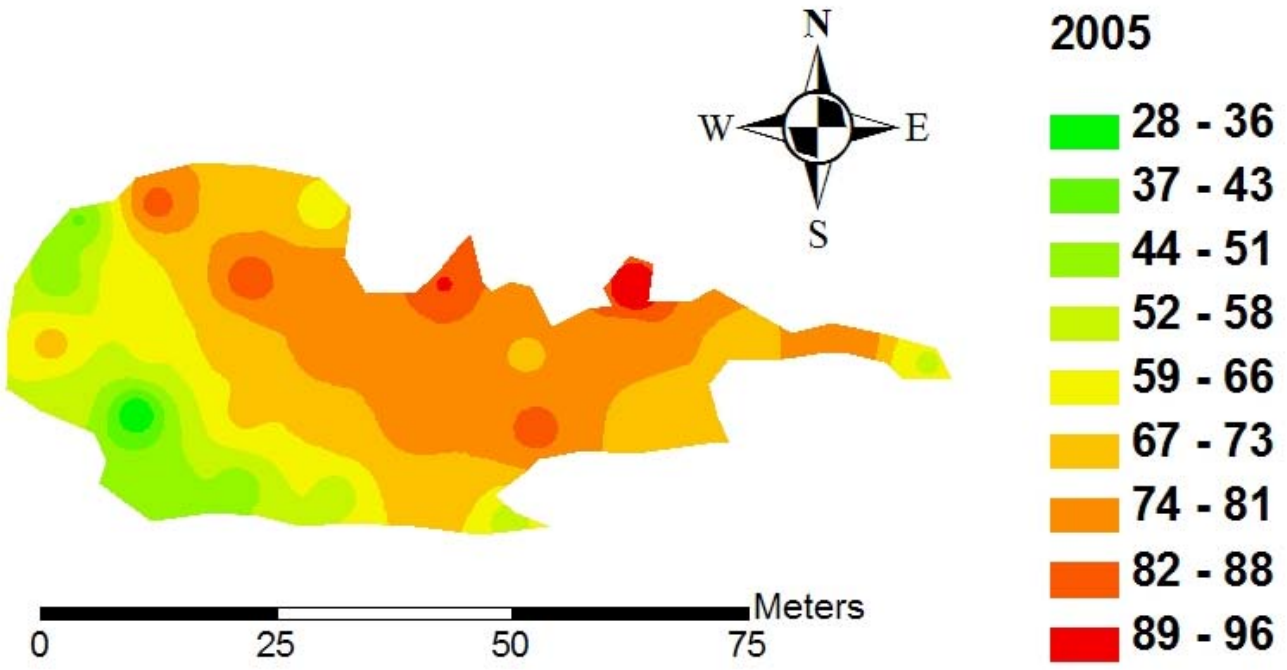

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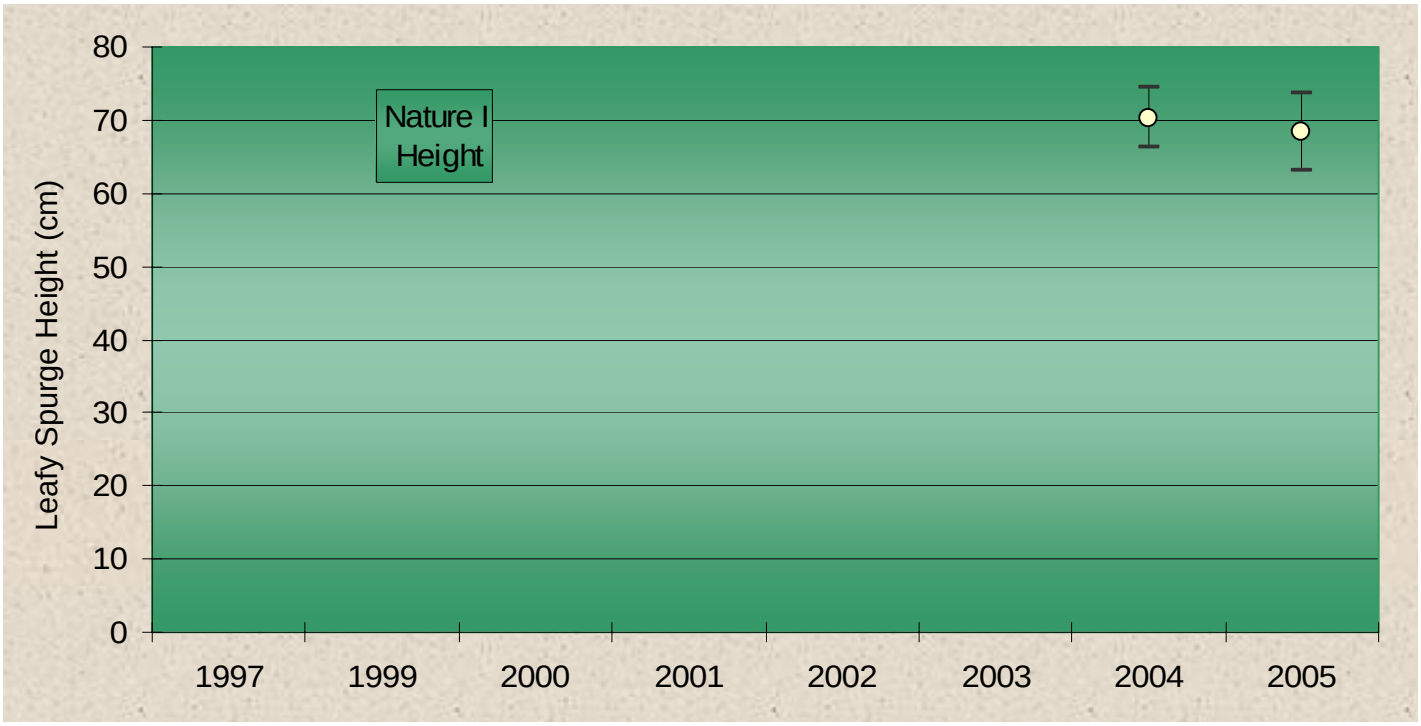

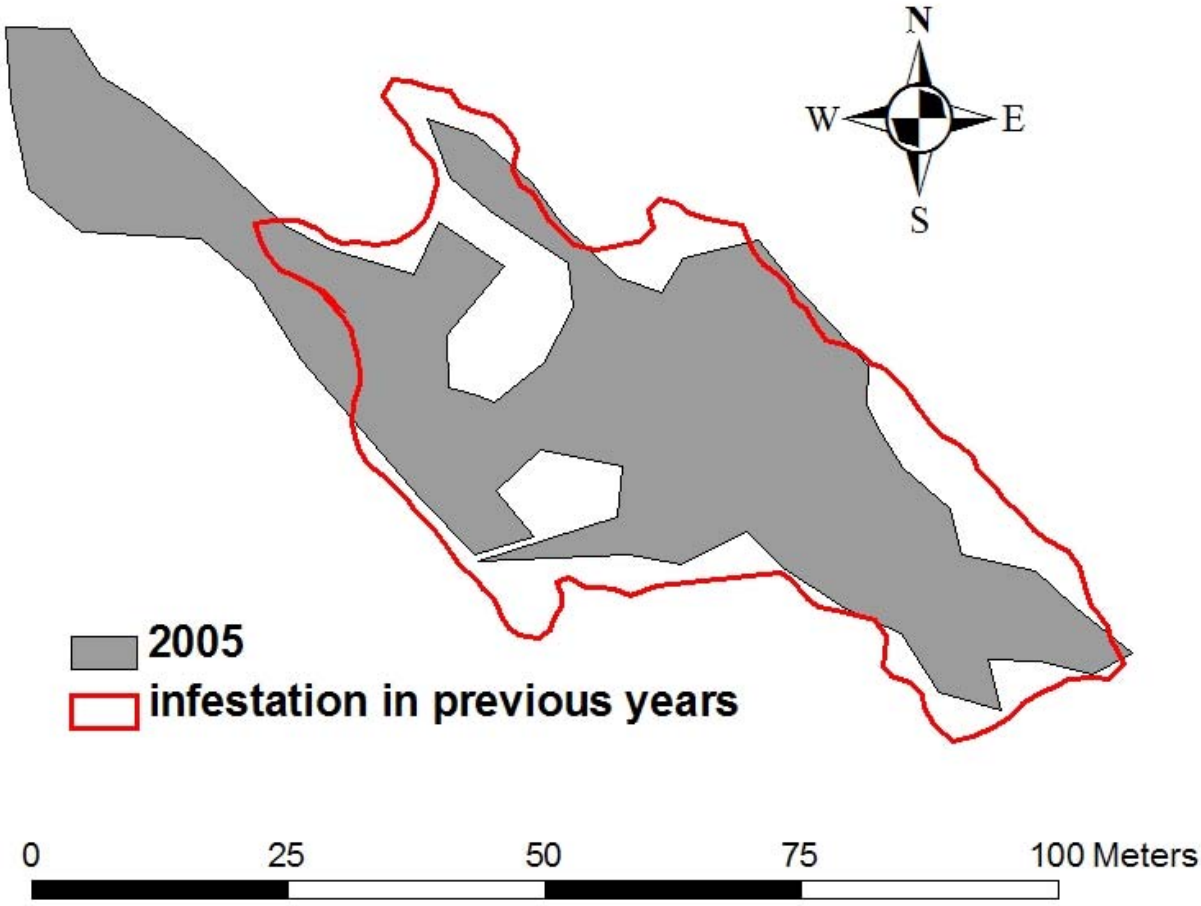

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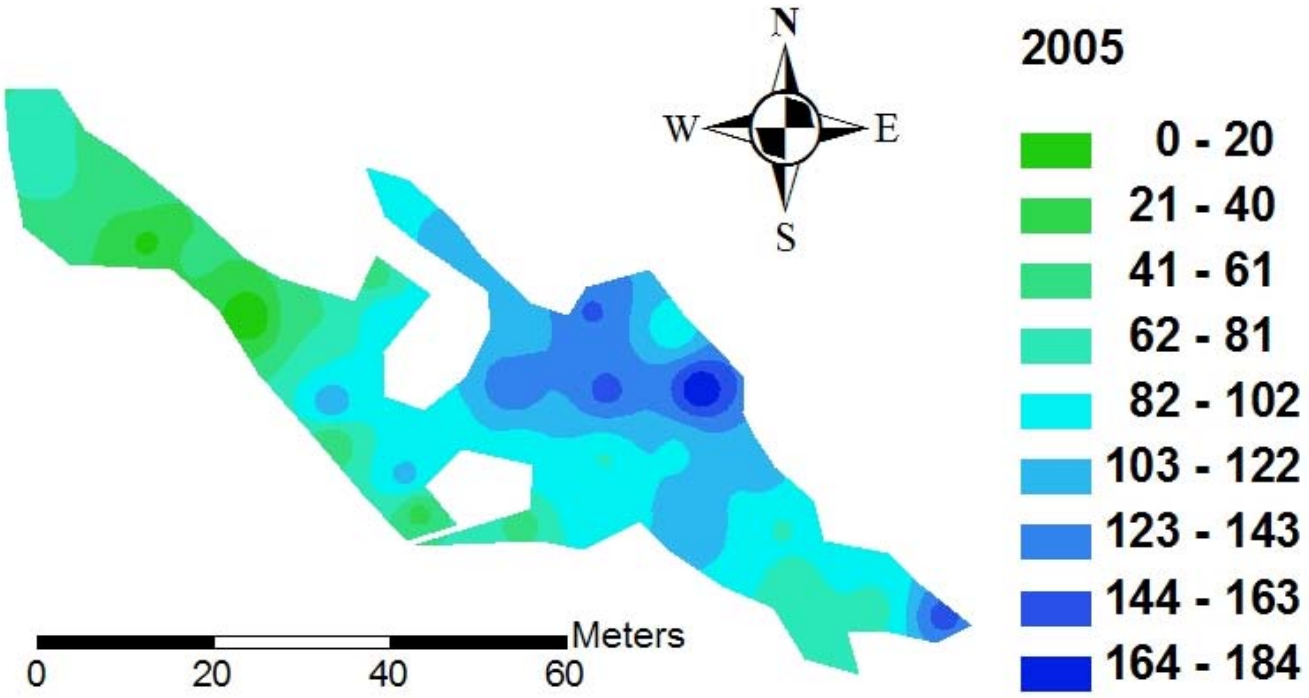
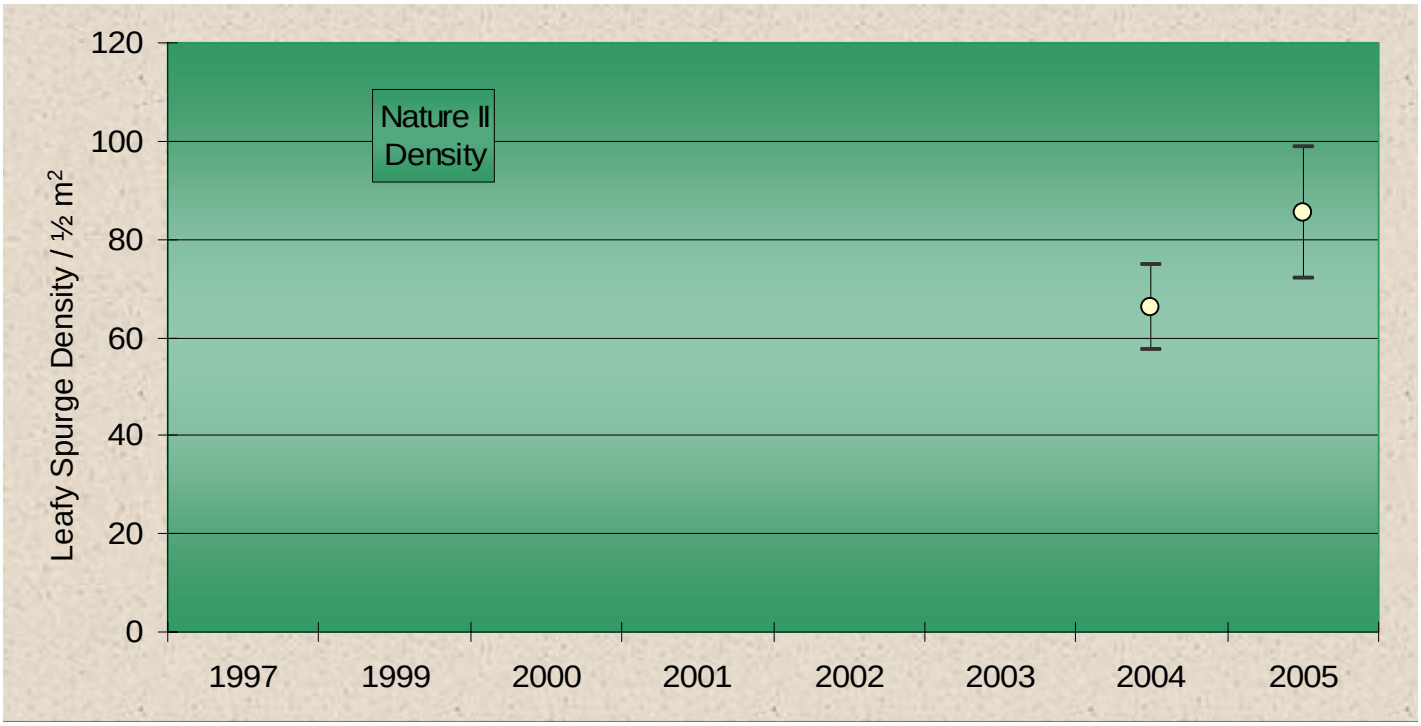
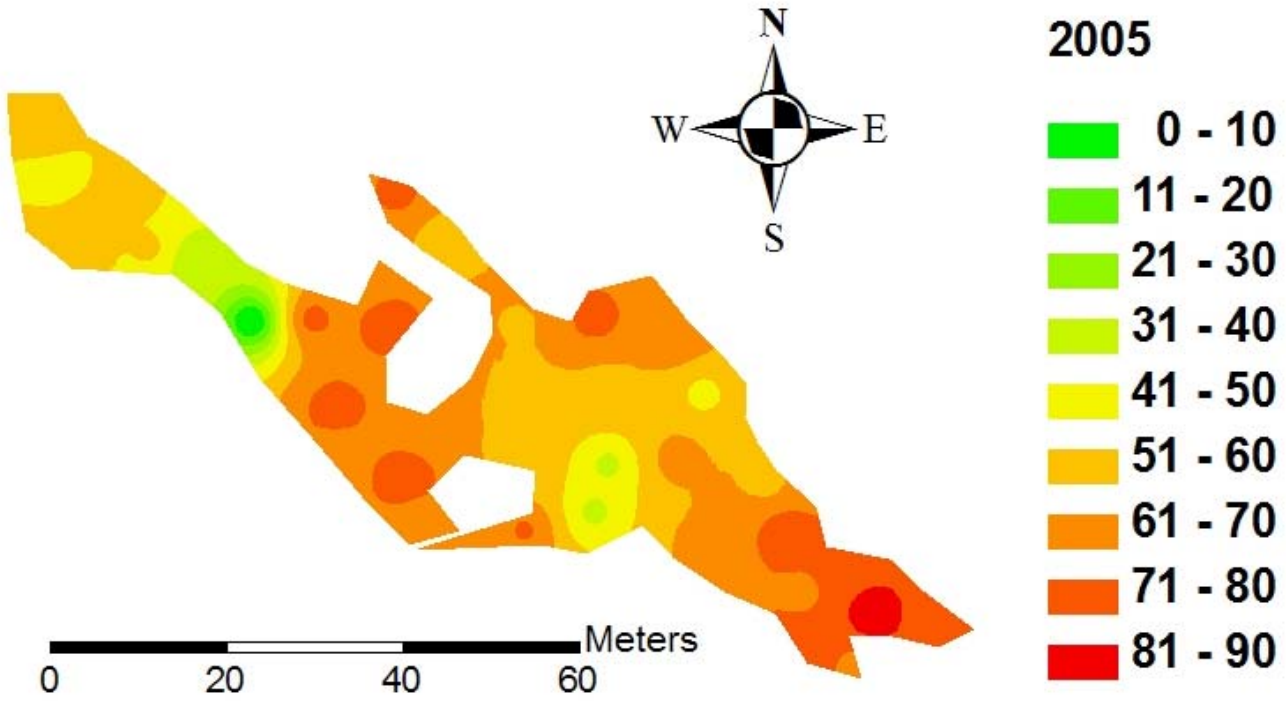


Nature II leafy spurge density in 2005.





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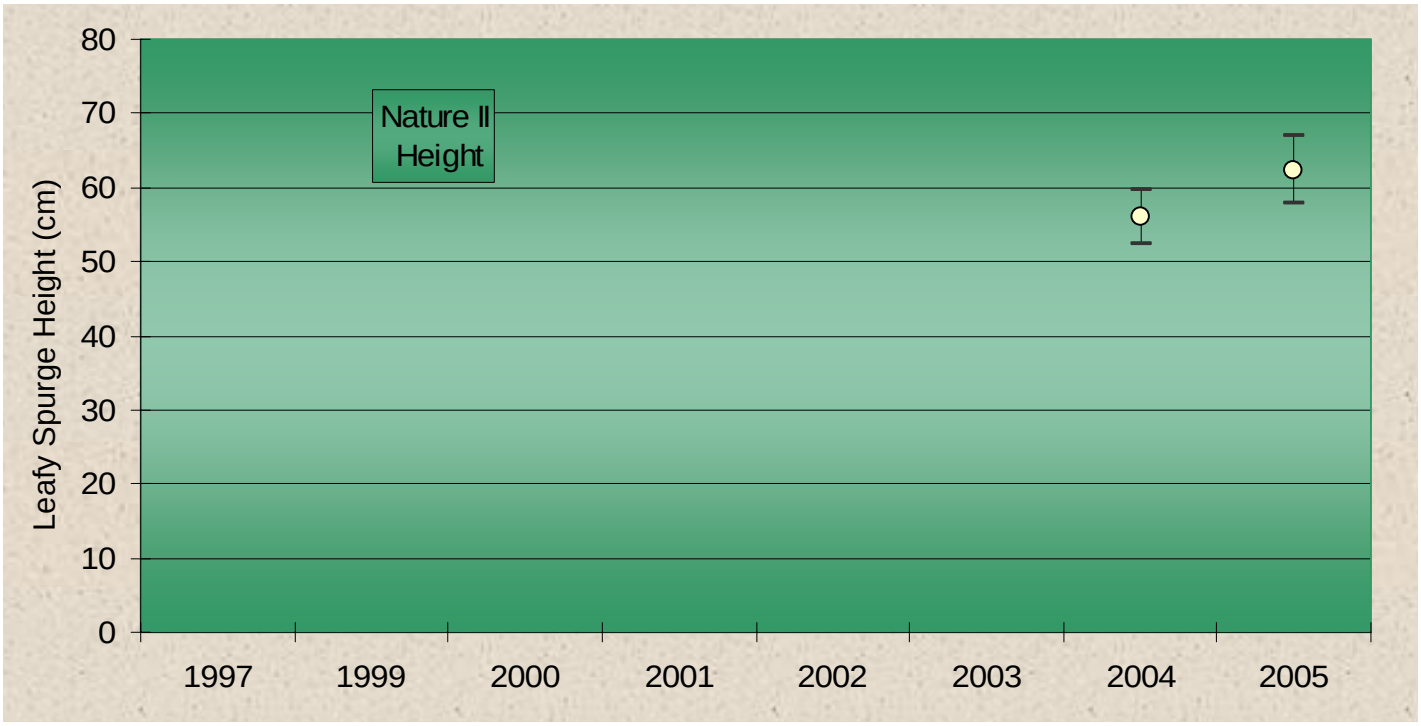
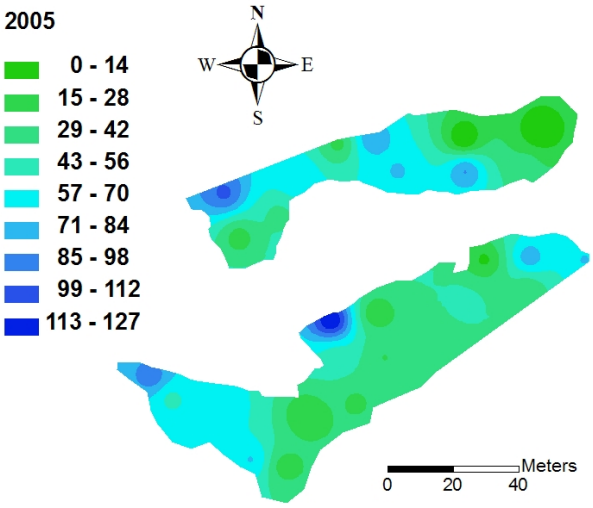
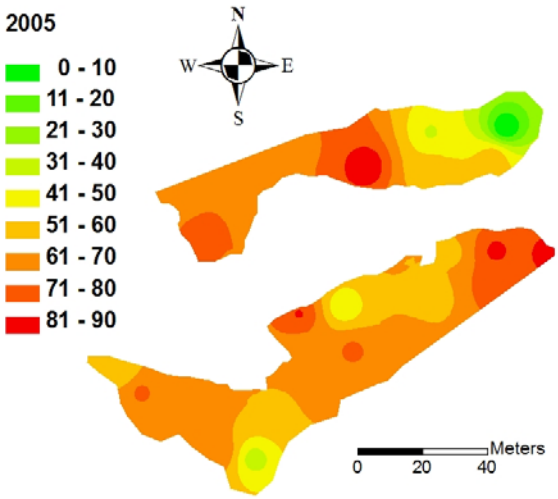


Black Powder Road leafy spurge perimeter in 2005.



Black Powder Road leafy spurge density in 2005.



Black Powder Road leafy spurge height in 2005.