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

Air Force Academy
Buckley Airbase
Ft. Carson Military Post
Monument Fire Center
Rocky Flats Environmental Technology Site
Warren Airbase

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Consolidated 2004 Report

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Introduction

The summer of 2004 marked the seventh year of the biological control program for noxious weeds at Fort Carson, the fifth year at the Air Force Academy and Monument Fire Center, third year at Rocky Flats Environmental Technology Site, second year at Buckley Airbase, and the first year of work at Warren Airbase in Cheyenne, Wyoming. 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, followed by a graph illustrating the historic extent of the infestation and the percentage change in the infestation over time. These figures are followed by maps illustrating the weed infestation density for 2004, an historic graph of weed density, a map of plant height followed by a graph indicating historic plant height at the site, and finally, for certain weeds, a graph of historic seedheads per plant.

For all tables, maps, and graphs, infestation perimeters are in m^2, plant densities are in plants per $1/2m^2$, and plant height is in cm. 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.

We welcome comments on this consolidated report, and look forward to continuing this valuable program.

General Notes for All Sites

In 2004, the drought that had plagued Colorado lessened to an extent (see Figure 1). As we commented in last year's report, there was some concern that these climatic conditions may have given false indications of the actual noxious weed control, especially where dramatic decreases in plant density in 2003 were observed when compared to the data from 2002. This seems to have been the case. In many sites, weed infestations appear to have rebounded in 2004. However, at most sites, there are indications that good weed control is underway, and biocontrol agents are present and causing damage. When results from 2004 are compared to those from the beginning of the program at a given location, there is an often significant drop in the weed parameters.

In this year's report, where appropriate, we also have included regression analyses on the individual graphs for a site. These are logarithmic regressions, and the R^2 value is included on the graph. These regression lines give a clearer indication of the reduction in weed density over the years that the program has been in effect, and corrects for year-to-year variations.

Assessing biological control taking place at a given site may seem confusing if one looks at just one or two parameters. For instance, the perimeter map for an infestation may show a significant increase in the area of the infestation, or plant height may have increased significantly from 2003 to 2004. However, all parameters need to be looked at in light of each other.

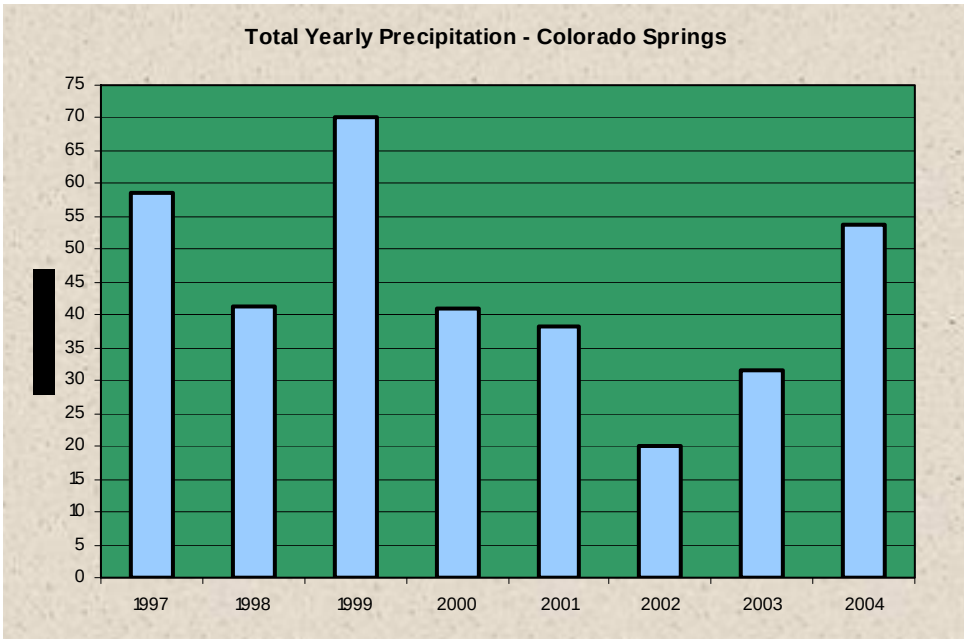

Figure 1. Total annual precipitation in Colorado, 1997 to present.

As the biocontrol agents do their job, the best indication of control is plant density per $1/2m^2$. As a weed infestation begins to break down into smaller and smaller pockets of weeds, it is obvious that height or seedheads per plant could increase because the weeds that remain have more resources available than when crowded together in a dense infestation. The infestation perimeter may increase as seeds spread or rhizomatous growth invades other areas. However, this is not an indication that the biocontrol agents will not attack these areas in the future. The seed bank, seeds already in the soil that have not yet germinated, also is a factor to consider. This phenomenon can result in an area that was devoid of a weed species in a previous year having new or higher weed densities in a subsequent year. However, where biocontrol agents are present, these new areas should be attacked and controlled over time.

One of the reasons for including the 95% confidence intervals in the graphs, in addition to tracking the year-to-year change at a site, is to give an indication of the plant population parameters not readily illustrated by single mean data points. Site parameters with narrow confidence intervals indicate a more uniform distribution; those with broad confidence intervals indicate a more variable weed distribution. Therefore, at a given site, a high plant density with a narrow confidence interval would indicate a uniform distribution while high density with a broad confidence interval would indicate that there is a wide range of densities observed in the infestation. It is expected that as a weed infestation begins to collapse, there would be a more clumped weed distribution, and sampling would encompass areas of high and low weed density. As the collapse continues, one would expect more consistently low plant density parameters across the site and a correspondingly narrow confidence interval. A good example of these types of results is found in the Air Force Academy leafy spurge site at Deadman's Trail (pp. 33-35). The plant density graph shows a wide confidence interval in 2000 and 2001, indicating a wide range of plant densities across the site in those years. In 2002, the plant density declined, but not significantly over the previous two years, however the confidence interval is contract. In 2003, leafy spurge density declined significantly and the confidence interval was quite narrow, indicating plant density per unit area becoming uniformly low. In 2004 density rebounded, but

the confidence interval, although not as tight as in 2003, did shrink when compared to 2000-2002. On the other hand, at this same site, plant height increased between 2002 and 2003, although not significantly, and then decreased in 2004. The increase in 2003 was probably due to the clumping effect as the density declines, and the remaining plants, although fewer in number, have more resources to draw upon. The site also needs to be looked at in light of the drought. An increase in plant height in 2004 may well be due to more available moisture.

Also, it should be kept in mind that we sample plant density, height and seed head numbers out of the remaining infestation. Therefore, the plant parameters are those observed in the existing infestation, not the density for the entire original area. If samples were taken from the entire original area of infestation, all density data would be significantly lower.

Examples of Long-Term Noxious Weed Reduction

In many instances, sites that have been established for some time show dramatic reductions in noxious weeds. We have selected five sites; three knapweed sites from Ft. Carson and leafy spurge sites from Air Force Academy and Monument Fire Center to demonstrate these reductions.

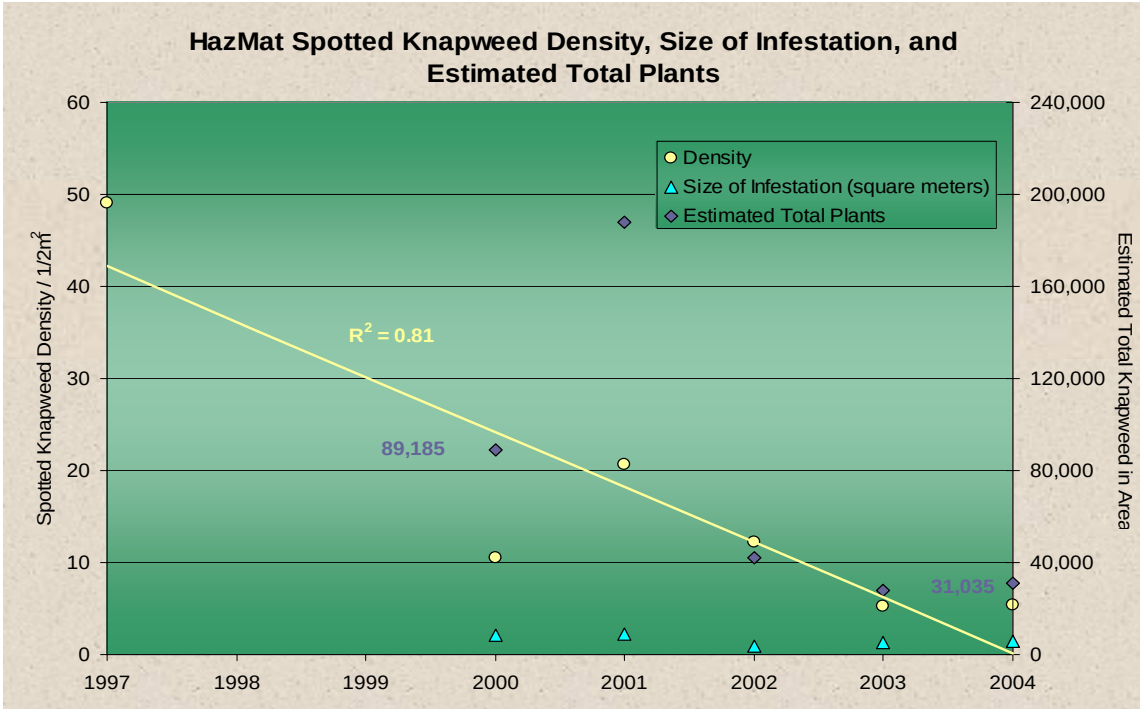

Figure 2. Measured and estimated plant parameters for spotted knapweed at the HazMat site, Ft. Carson.

The first example is from the Ft. Carson HazMat (Cantonment II) spotted knapweed site (Figure 2). *Cyphocleonus achaetes* and *Larinus minutus* have been established at this site since 1998. *Sphenoptera jugoslavica* and *Metzneria paucipunctella* were recovered in 2004. Density records indicate that density declined from approximately 50 plants/0.5 m^2 to less than 10 plants/0.5 m^2. Since 2000, when an accurate extent of the infestation was mapped with GPS, the estimated total knapweed plants in the area dropped from 89,185 to 31,035, a 65% reduction. If

the peak number of estimated plants is used (187,882 in 2001), the estimated total number of plants dropped by 83.5%.

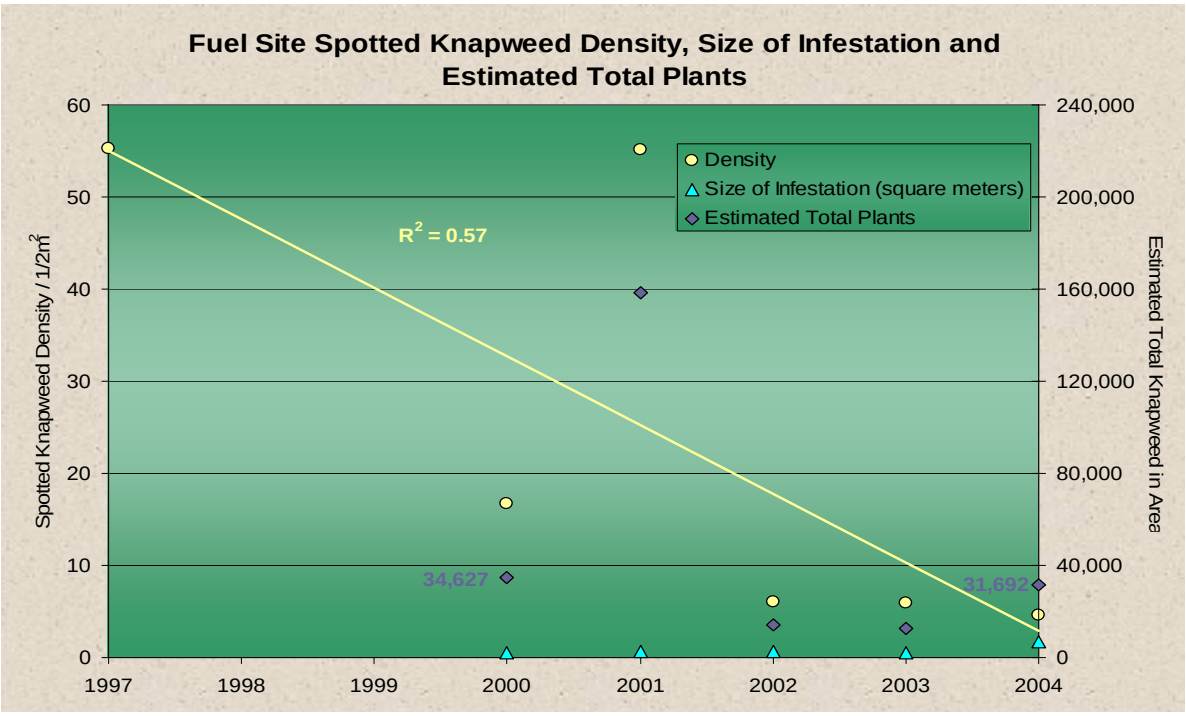

Figure 3. Measured and estimated plant parameters for spotted knapweed at Fuel Site, Ft. Carson.

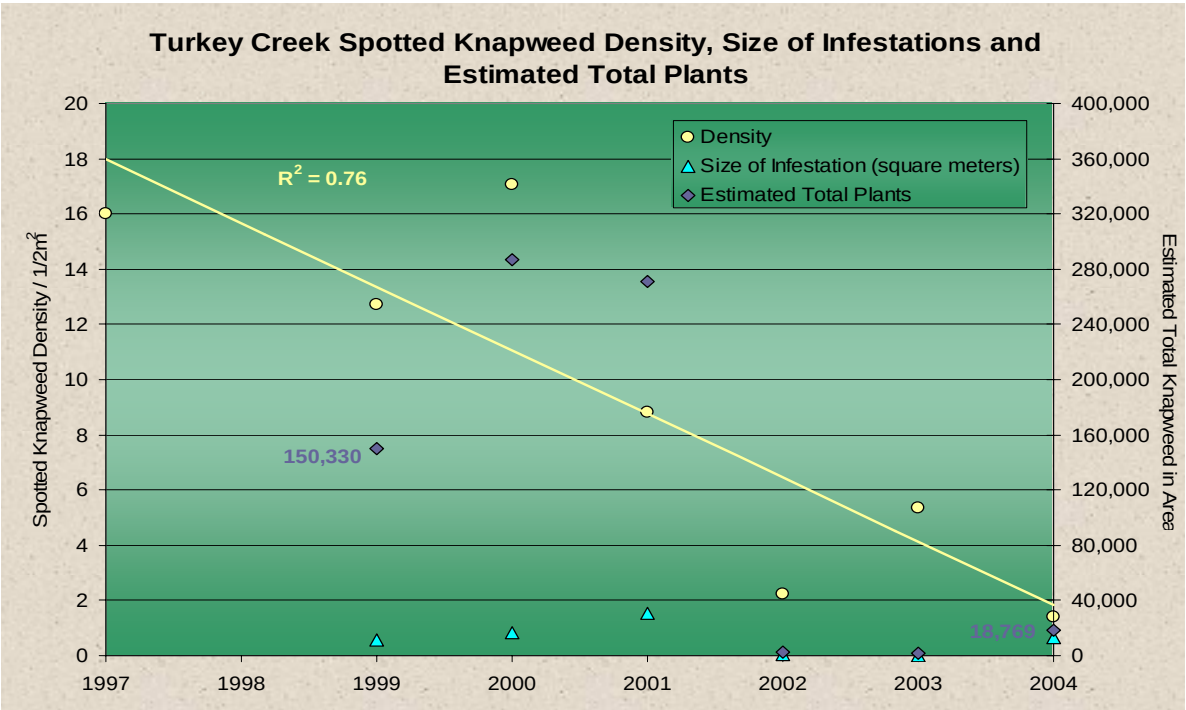

Figure 4. Measured and estimated plant parameters for spotted knapweed at the Turkey Creek site, Ft. Carson.

Similar results are found at the nearby Fuel Site spotted knapweed site (Figure 3). The same insects established at the HazMat site are found here. From a peak density of nearly 55 plants/0.5m^2 in 1997, the infestation has dropped to an average of less than 5 plants/0.5m^2 in 2004. The estimated total number of plants at the site has dropped from a high of 158,348 in 2001 to 31,692 in 2004, an 80% reduction in four years.

Perhaps the most striking results for spotted knapweed reduction at Ft. Carson come from the Turkey Creek site (Figure 4). At this site, plant density has dropped from 16/0.5m^2 in 1997, when insects were first released, to less than 2/0.5m^2 in 2004. Total estimated plants have fallen from a peak of 287,261 in 2000 to 18,769 in 2004, a 93% reduction. An R^2 of 0.76 is exceptionally strong for field data. The primary insects at this site are *Cyphocleonus achates*, *Larinus minutus*, and *Urophora affinis*. *Urophora quadrifasciata* was found at this site, and all other knapweed sites at Ft. Carson, in 1997, indicating that it had very little impact alone. We do not believe that *U. affinis* is a significant biocontrol agent at this site, at least relative to *C. achaetes* and *L. minutus*.

Although plant density at Turkey Creek always has been lower than at HazMat or Fuel Site, this infestation was more extensive than the other two sites. It is interesting to note at all three of these sites that the drought, if it had an impact on plant density, manifested itself more strongly in 2002 than any other year. Additionally, after the drought moderated, the knapweed infestation continued to decline.

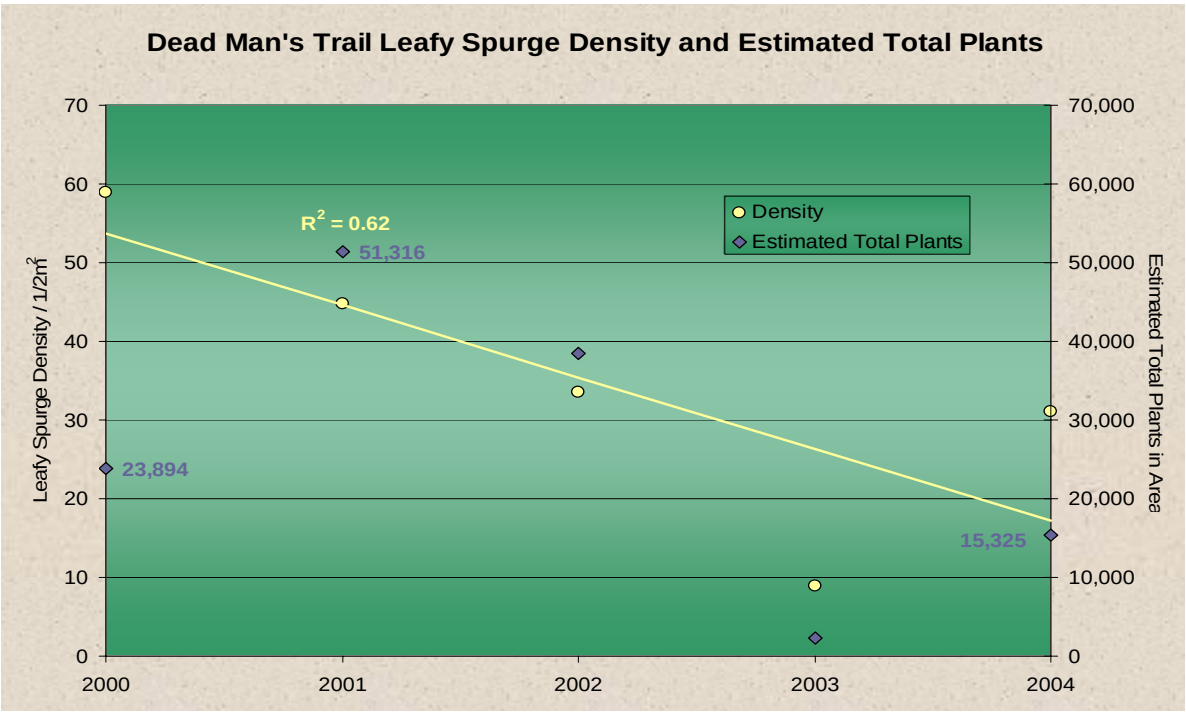

Figure 5. Leafy spurge density and estimated plant population at Deadman's Trail, Air Force Academy.

Similar to the spotted knapweed examples from Ft. Carson, leafy spurge data from Air Force Academy and Monument Fire Center sites point to significant reduction in this noxious weed. At both sites, the biocontrol agents are *Apthona czwalinae*, *A. lacertosa*, and *A. nigriscutis*. All three species have been recovered at these sites. These are aggressive Chrysomelid beetles that are well known for their ability to reduce leafy spurge infestations. Once established, these insects seem to be tenacious. According to published literature, the three

species have different edaphic requirements and may sort themselves out at a give site according to the factors, such as moisture and exposure, that best suite them.

At the Deadman's Trail site at Air Force Academy, density has decreased from nearly 60 plants/0.5m^2 in 2000 to slightly over 30 plants/0.5m^2 in 2004 (Figure 5). From a peak estimate of 51,316 plants in 2001, there has been a 70% reduction to 15,325 in 2004. At this site there seems to have been a significant impact from the drought in 2003, that may have resulted in a rebound of plants in 2004. However, the regression indicates a continuous decline in the density of this infestation, and the total estimated number of plants follows a similar trajectory.

At the Monument Fire Center leafy spurge site, density has declined from 52 plants/0.5m^2 in 2001, to approximately 12/0.5m^2 in 2004 (Figure 6). The estimated total number of plants in the infestation has declined 92%, from a high of 214,753 plants in 2001 to 17,303 in 2004. The regression analysis of plant density at this site resulted in a very robust R^2 of 0.87.

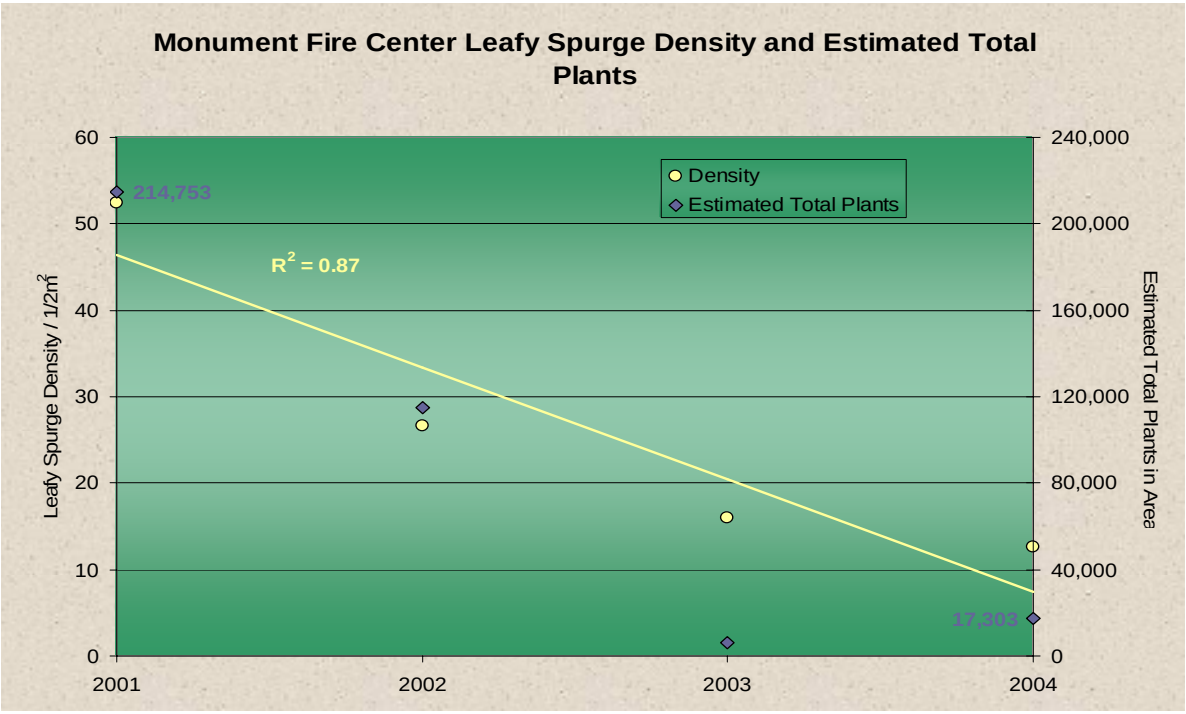

Figure 6. Leafy spurge density and estimated plant population at Monument Fire Center.

As the results from these five sites indicate, biological control of noxious weeds can be a reality if time is allowed for the biocontrol agents to work. The results presented here also indicate, although perhaps a bit prematurely, that the insects can survive a severe drought and continue to have an impact during and after a drought. Data collected in subsequent years may more fully solidify this conclusion.

Similar reductions in diffuse knapweed have been noted at Rocky Flats, although the massive size of that infestation has not allow for similar types of data to be collected as with the smaller spotted knapweed and leafy spurge infestations at Ft. Carson. Results from the Rocky Flats site are presented in that section.

Aceria anthocoptes – A potential Canada thistle agent

Since 2002, we have had an interest in Aceria *anthocoptes*, a gall-forming eriophyiid mite that is know to attack Canada thistle in Europe. Ft. Carson has supported efforts by CABI Bioscience Switzerland Centre to conduct host preference tests and exploration for this mite. The portion of CABI's annual report on their progress with *A. anthocoptes* is reprinted below. There seems to be a growing amount of evidence that *A. anthocoptes* is very host specific to Canada thistle.

However, Drs. Ron Ochoa, Eric Erbe and John Lydon reported *A. anthocoptes* to be already in the United States as a accidental introduction in the east and mid-western USA. This mite appears to be host specific to Canada thistle. The mites have been found in Maryland, it surrounding states, and as far west as Minnesota and North Dakota. Since this mite could be a great benefit to Canada thistle control, if found to already exist in Colorado or Wyoming, we conducted a survey in August of 2004 of Canada thistle in western Nebraska and Kansas and eastern Wyoming and Colorado. Samples were sent overnight to Dr. John Lydon with the USDA in Beltsville, MD for analysis (see http://www.ars.usda.gov/is/AR/archive/oct00/mites1000.htm for information on Drs. Lydon and Ochoa's program).

Eriophyiid mites were found in 18 of the 19 samples sent to Beltsville. Of these, six had abundant mites. In addition, we sampled five Canada thistle sites at Ft. Carson for eriophyiid mites on 8/18/04. Four of the samples had mites present and 1 had abundant mites. At the present time, we are awaiting results of DNA analyses to confirm the mites as *A. anthocoptes*. These analyses are being done by Dr. Ron Ochoa, at the USDA Beltsville facility, for DNA identification. Table 1 summarizes our surveys in 2004. There were many more samples actually taken than appear in the table, but tight time budgets for the cooperators in Beltsville did not allow all samples to be processed, and some "pre-selecting" of potential mite-harboring samples was made in Beltsville.

CABI Report

CANADA THISTLE (*CIRSIUM ARVENSE*)
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Aceria anthocoptes (Acari, Eryiophyiidae)

Several surveys were carried out in August-September to collect additional information on the field host range of Aceria anthocoptes. The study included three populations of *Leontodon autumnali*s which has been thought to be associated with the mite in Europe. No evidence has been found to support the hypothesis that *L. autumnalis* is a field host plant of *A. anthocoptes*. Between August 20 and September 23, additional host specificity tests have been carried out with another *A. anthocoptes* population (SAB-01) identified at Sabac in Serbia. A minimum of 15 protogyne females were transferred onto 10 plant species in 5 to 6 replicates: *Cirsium arvense*, *C. vulgare*, *C. heterophyllum*, *C. monspessulanum*, *C. creticum*, *C. pannonicum*, *Carduus acanthoides*, *C. crispus*, *Leontodon autumnalis* and *Cynara scolymus*. Population growth was recorded on all replicates on *C. arvense* only, while no mite survival was recorded on *C. vulgare*, *C. heterophyllum* and *L. autumnalis* which have all been mentioned as alternate host plants of the mite in the literature. Thus, in contrast to the results obtained in 2003 with another mite population (BG1), no mites survived in any of the five replicates of *Cirsium vulgare*. A host specificity test with deutogyne females will be set up in early October.

Table 1. Canada thistle sampling for *Aceria anthocoptes* in Colorado, Wyoming and Nebraska. 2004.

Date	Location	Latitude		Longitude		Elevation	Mites
8/10/04	Warren Airbase	41	9.42	104	52.38	6083	P
8/10/04	Chugwater, WY	41	46.27	104	47.99	5570	P
8/10/04	Torrington, WY	42	1.43	104	12.78	4201	NP
8/10/04	Torrington, WY	42	1.35	104	12.97	4186	P
8/10/04	Veteran, WY	41	56.60	104	22.93	4235	P
8/10/04	Stegall, NE	41	52.29	103	57.58	4145	P
8/10/04	Gering, NE	41	45.76	103	40.48	3991	P
8/10/04	Kimball, NE	41	14.15	103	36.61	4672	A
8/11/04	Lodgepole, NE	41	9.33	102	42.11	3874	P
8/11/04	Lodgepole, NE	41	9.33	102	42.11	3874	A
8/11/04	Chappell, NE	41	3.08	102	24.82	3640	A
8/11/04	Sutherland, NE	41	8.64	101	13.46	3017	A
8/11/04	Potter, NE	41	12.55	103	14.66	4347	A
8/11/04	Albin, WY	41	25.11	104	7.57	5377	P
8/11/04	Burns, WY	41	13.45	104	20.95	5398	A
8/11/04	Hereford, CO	40	58.41	104	18.65	5366	A
8/11/04	S. of Hereford, CO	40	48.08	104	20.08	5004	P
8/11/04	Briggsdale, CO	40	38.61	104	20.09	4851	P
8/11/04	Near Cornish, CO	40	28.73	104	31.31	4691	P
8/18/04	Ft. Carson	ARA1					P
8/18/04	Ft. Carson	ARA2					A
8/18/04	Ft. Carson	Duckpond					NP
8/18/04	Ft. Carson	Hwy 115					P
8/18/04	Ft. Carson	Reservoir					P

A - abundant, P - present, NP - not present.

Air Force Academy

A total of 21 weed infestations were mapped in 2004, including 16 that had been identified and mapped in previous sample years (2000-2003) (Table 2). In total, 0.96 ha of diffuse and spotted knapweed were mapped and sampled in 2004. Likewise, there were 0.17 ha of Canada and musk thistle, 0.22 ha of leafy spurge, and a small infestation of yellow toadflax (0.01 ha) monitored in 2004.

New monitoring has begun on 0.15 ha of the weed St. Johnswort, *Hypericum perforatum*, concurrent with releases of its natural enemy, *Chrysolina sp*., a leaf and flower-feeding beetle previously released at Air Force Academy (Table 3). The three new infestations of St. Johnswort (Kettle Creek, Midway Kettle Creek, Santa Fe) will be monitored in coming years to assess the efficacy of released beetles (Figure 7). Additionally, a new spotted knapweed biological control site has been established along Monument Creek, 700 meters from the original Monument Creek point of release for the knapweed seed head feeders, *Larinus minutus* and *Metzneria paucipunctella*. The original knapweed infestation along Monument Creek, first mapped in 2000, has been successfully reduced to a few scattered plants and is no longer being mapped or sampled. Upon initial examination of the nearby New Monument Creek site in 2004, a population of *L. minutus* was discovered, presumable migrants from the original release almost a kilometer away. An augmentative release of *L. minutus* and a new release of root-weevil, *Cyphocleonus achates*, were made this past year at the New Monument Creek site.

Figure 7. Several releases of *Chrysolina sp*. beetles were made at Air Force Academy in 2004 to augment existing populations.

Not included in Table 2 are data that are currently being collected on biocontrol agent establishment within yellow toadflax, diffuse and spotted knapweed patches at Air Force Academy. Extensive destructive sampling of collected knapweed seed heads and roots, as well as toadflax stalks, are being performed in order to determine the population levels of the following biocontrol agents at their release sites: *Cyphocleonus achates*, *Larinus minutus*, *Mecinus janthinus*, and *Metzneria paucipunctella, Urophora affinis, U. quadrifasciata*.

Figure 8. Biocontrol agent *Cyphocleonus achates* was recovered from the Water Treatment Plant diffuse and spotted knapweed infestation for the first time this year.

A total of 1356 insects were introduced to Air Force Academy this year in 12 separate release events. Details of specific releases are described below and in Table 3 (including records of insect biological control agent recoveries). New agent establishment in 2004 included the detection of stem-boring weevil, *Mecinus janthinus*, on yellow toadflax at Community Center Drive 1 and the identification of *Cyphocleonus achates*, a root-feeding weevil, on knapweed at Water Treatment Plant (Figure 8). There were not extensive populations of either weevil found this year, but recovery of these species one year post-release is encouraging, as these insects have demonstrated the ability to overwinter within their new habitats at Air Force Academy.

Insect Agent Released in 2004	# Insects Released	Target Weed
Apthona lacertosa	250	Leafy spurge
Cassida rubiginosa	500	Canada thistle
Chrysolina sp.	150	St. Johnswort
Cyphocleonus achates	247	knapweeds
Larinus minutus	209	knapweeds

Each weed infestation mapped in 2004 has had at least one biological control agent release during the course of the biocontrol project, with the exception of the Parade Loop spotted knapweed sites. Parade Loop 1, as designated in this report, is an amalgamation of two sites mapped separately in 2003, labeled in the previous report as Parade Loops 1 and 2. Changes were made in the labeling of these sites to simplify mapping based on the proximity of one weed patch to another. There are plans to make biocontrol insect releases into each of these Parade Loop sites in 2005.

A new site to receive insects this year was the diffuse knapweed infestation mapped in 2003 along Highway 83. An abundance of *C. achates* in 2004 at established release sites made it possible to redistribute some weevils to this patch of knapweed.

A new release of *Larinus minutus*, made along Deadman's Creek, is listed in Table 3. This release is unaccompanied by mapping of the infestation of spotted knapweed, as the weed patch was far too extensive and scattered to accurately map.

Other weed infestations potentially benefiting from biological control efforts continue to be identified on Air Force Academy property, including diffuse knapweed located near the North Gate, spotted knapweed at each of North Kettle Lake, Deadman's Creek and the compost yard. These sites may be mapped and monitored in 2005 as time and biological control agent redistribution resources allow.

Figure 9. Leafy spurge biological control agent *Aphthona lacertosa*, as seen in this photo, were released on a spurge infestation at the Douglass School site. A close relative, *A. nigriscutis*, were found in large enough number this year at Deadman's Trail to be used for redistribution to other leafy spurge infestations.

Table 2. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2004.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads	Head size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
Canada thistle - Ice Lake Road 1												
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	-74.99
Canada thistle - Ice Lake Road 2												
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	-62.98	-75.02	
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	-57.42
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	1.07
Canada thistle - Parade Loop												
2003	6	1	0.82	10	24.09	70		0.00				
2004	36	10	4.30	13	62.29	87	6.00	2.40	483.36	424.39	158.57	483.36
Musk thistle - Ice Lake Road 1												
2000	1,016	129	7.76	82	58.87	171						
2001	976	39	1.13	6	23.82	158	2.57	0.90	-3.95	-85.44	-59.54	
2002	449	7	2.00	6	63.66	111	9.00	2.18	-54.00	76.99	167.25	
2003												
2004	98	30	1.26	8	31.93	131	1.11	10.40				-90.33

Table 2. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2004 (cont.).

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads	Head size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
Leafy spurge - Deadman's Trail												
2000	406	28	63.50	195	44.33	76						
2001	1,148	66	59.78	214	50.25	97			182.94	-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	21.73
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			30.94	-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	-72.42
Leafy spurge-FERL												
2000	1,139		5.21		19.54							
2001	1,528	24	4.26	194	24.59	67			34.15			
2002	796	66	11.29	66	19.85	49			-47.89	-65.92	-56.56	
2003	329	28	11.54	51	40.54	85			-58.71	2.21	104.23	
2004	2,145	103	7.31	88	31.85	54			551.95	-36.66	-21.44	88.32
Yellow toadflax - Community Center Drive 1												
2003	52	4	3.24	15	26.25	40						
2004	30	18	19.61	57	29.08	44			-42.21	505.25	10.78	-42.21
Yellow toadflax - Community Center Drive 2												
2003	96	8	8.63	34	29.88	95						
2004	112	34	6.44	47	20.67	44			16.82	-25.38	-30.82	16.82

Table 1. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2004 (cont.).

Table 2. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2004 (cont.).

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads	Head size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
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	329.06
Diffuse/Spotted knapweed - New Monument Creek												
2004	700	44	3.36	23	28.96	90	35.07	1.70	na	na	na	na
Diffuse/Spotted knapweed - Old Monument Creek												
2000	622	35	9.00	25	37.30	80						
2001	948	45	9.52	68	39.70	98	133.15		52.36	5.78	6.43	
2002	746	41	2.19	26	8.40	73	2.62	0.26	-21.32	-77.00	-78.84	
2003	236	44	1.50	9	27.09	93	23.02	0.28	-68.37	-31.51	222.50	-62.08
2004												
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	32.47
Spotted knapweed - Monument Trail Road												
2003	484	20	1.50	7	27.09	115	23.02					
2004	1,937	32	3.00	17	68.57	112	48.24	4.00	300.26	100.00	153.12	300.26
Spotted knapweed - Non-potable Water Reservoir												
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	295.03
Spotted knapweed - Parade Loop I (previously Parade Loop I & II)												
2003	1,437	65	0.80	4	34.18	130	7.10	0.39				
2004	921	43	3.58	13	45.07	97	7.51	3.00	-35.91	347.50	31.86	-35.91
Spotted knapweed - Parade Loop II												
2004	578	33	0.79	3	34.15	118	118.11	2.90	na	na	na	na

Table 2. Historic noxious weed infestation parameters, Air Force Academy, Colorado, 2000-2004 (cont.).

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads	Head size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
Spotted knapweed - Parade Loop III												
2004	1,412	41	1.53	11	21.37	73	11.68	2.60	na	na	na	na
St. Johnswort - Kettle Creek												
2004	1,254	90	30.94	85	53.92	85			na	na	na	na
St. Johnswort - Santa Fe												
2004	266	24	33.96	96	46.75	73			na	na	na	na

n - number of samples or observations.

na - not applicable, data represent first year of sampling.

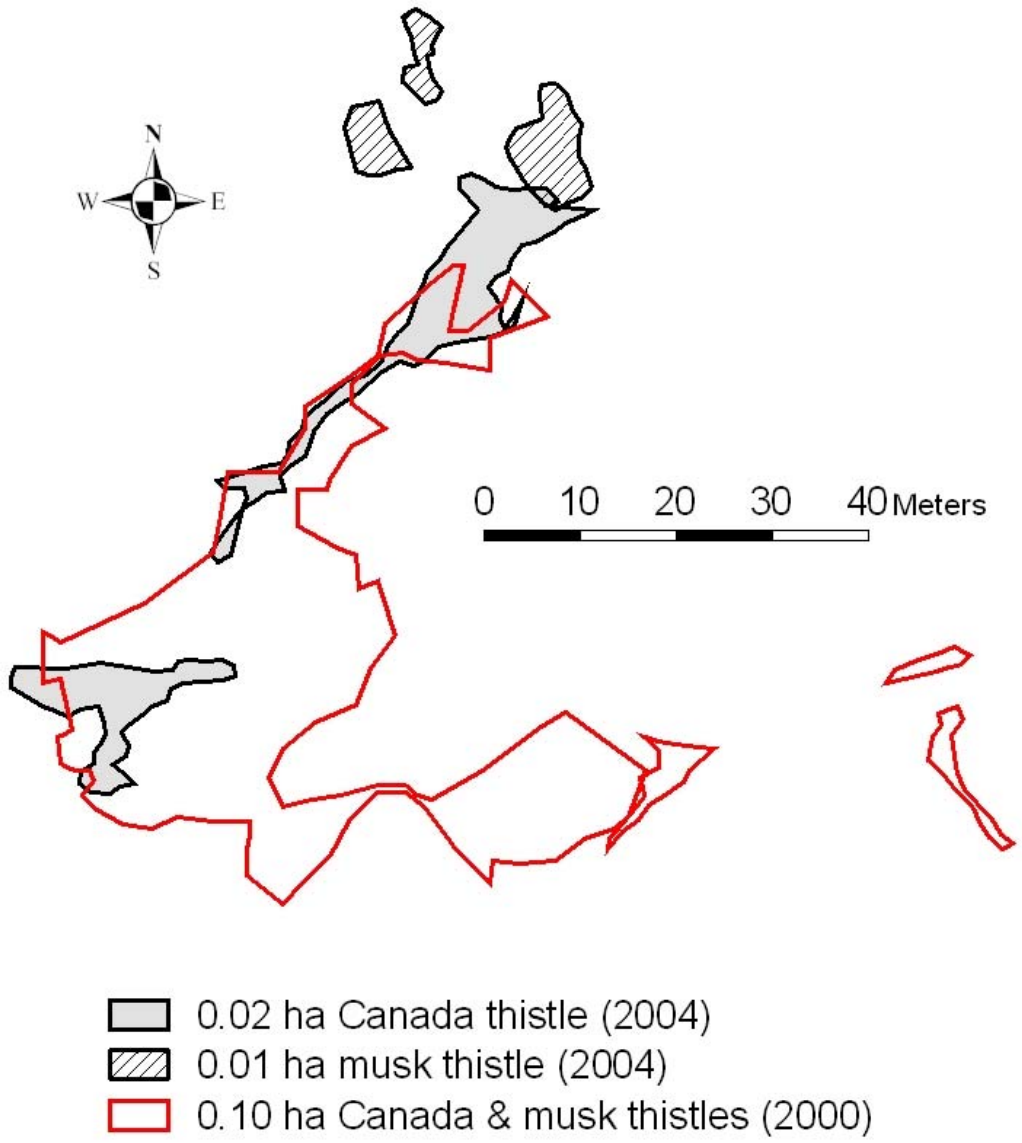
Table 3. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, 2004.

Location	Target weed	Site	Species released	Species recovered	New releases	New site
Air Force Academy	Canada & musk thistle	Ice Lake Road 1	*Trichosirocalus horridus*	X		
Air Force Academy	Canada thistle	Ice Lake Road 1	*Urophora cardui*			
Air Force Academy	Canada thistle	Ice Lake Road 2	*Cassida rubiginosa*	X		
Air Force Academy	Canada thistle	Ice Lake Road 2	*Larinus planus*	X		
Air Force Academy	Canada thistle	Ice Lake Road 2	*Urophora cardui*			
Air Force Academy	Canada thistle	Kettle Lake	*Cassida rubiginosa*			
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	*Apthona czwalinae*	X		
Air Force Academy	Leafy spurge	Deadman's Trail	*Apthona lacertosa*	X		
Air Force Academy	Leafy spurge	Deadman's Trail	*Apthona nigriscutis*	X		
Air Force Academy	Leafy spurge	Douglas School	*Apthona czwalinae*	X		
Air Force Academy	Leafy spurge	Douglas School	*Apthona lacertosa*	X		
Air Force Academy	Leafy spurge	Douglas School	*Apthona nigriscutis*	X		
Air Force Academy	Leafy spurge	FERL	*Apthona czwalinae*	X		
Air Force Academy	Leafy spurge	FERL	*Apthona lacertosa*	X		
Air Force Academy	Leafy spurge	FERL	*Apthona nigriscutis*	X		
Air Force Academy	Diffuse knapweed	Highway 83	*Cyphocleonus achates*		X	
Air Force Academy	Spotted knapweed	Deadman's Creek	*Larinus minutus*		X [1]	X
Air Force Academy	Spotted knapweed	Monument Trail Road	*Cyphocleonus achates*		X	
Air Force Academy	Spotted knapweed	Monument Trail Road	*Larinus minutus*			
Air Force Academy	Spotted knapweed	New Monument Creek	*Cyphocleonus achates*		X	X
Air Force Academy	Spotted knapweed	New Monument Creek	*Larinus minutus*	X [2]	X	X
Air Force Academy	Spotted knapweed	NPWR	*Larinus minutus*			
Air Force Academy	Spotted knapweed	NPWR	*Urophora affinis*	X [2]		

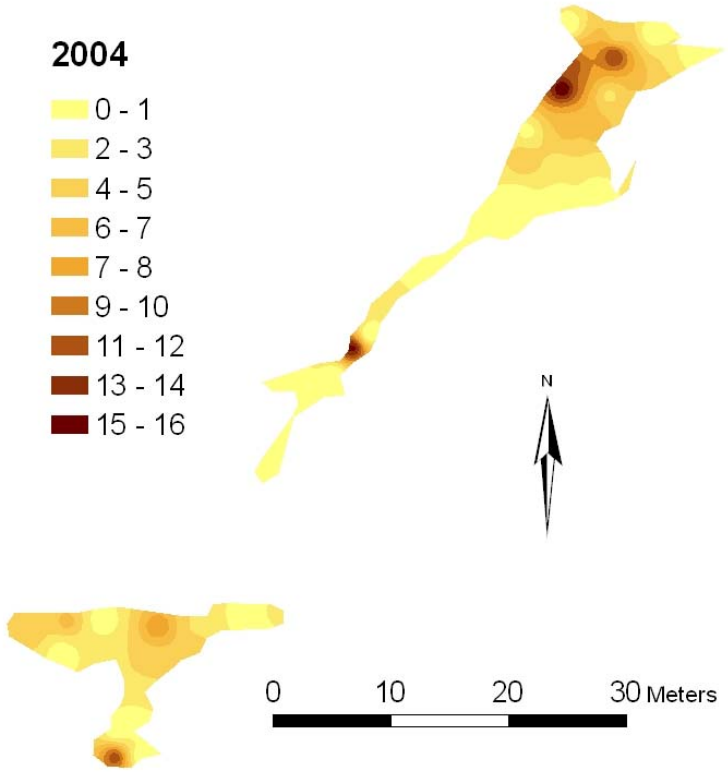
Table 3. Noxious weed biological control sites, target weeds, species released and recoveries at Air Force Academy, 2004.

Location	Target weed	Site	Species released	Species recovered	New releases	New site
Air Force Academy	Spotted knapweed	Old Monument Creek	*Cyphocleonus achates*			
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 1				
Air Force Academy	Spotted knapweed	Parade Loop 2				X
Air Force Academy	Spotted knapweed	Parade Loop 3				X
Air Force Academy	Diffuse & spotted knapweed	Water Treatment Plant	*Cyphocleonus achates*	X [3]	X	
Air Force Academy	Diffuse & spotted knapweed	Water Treatment Plant	*Larinus minutus*			
Air Force Academy	St. Johnswort	Kettle Creek	*Chrysolina sp.*	X [4]	X	X
Air Force Academy	St. Johnswort	Midway Kettle Creek	*Chrysolina sp.*	X [4]	X	X
Air Force Academy	St. Johnswort	Santa Fe	*Chrysolina sp.*	X [4]	X	X
Air Force Academy	Yellow toadflax	Comm Center Drive 1	*Mecinus janthinus*	X [3]		
Air Force Academy	Yellow toadflax	Comm Center Drive 2	*Mecinus janthinus*			

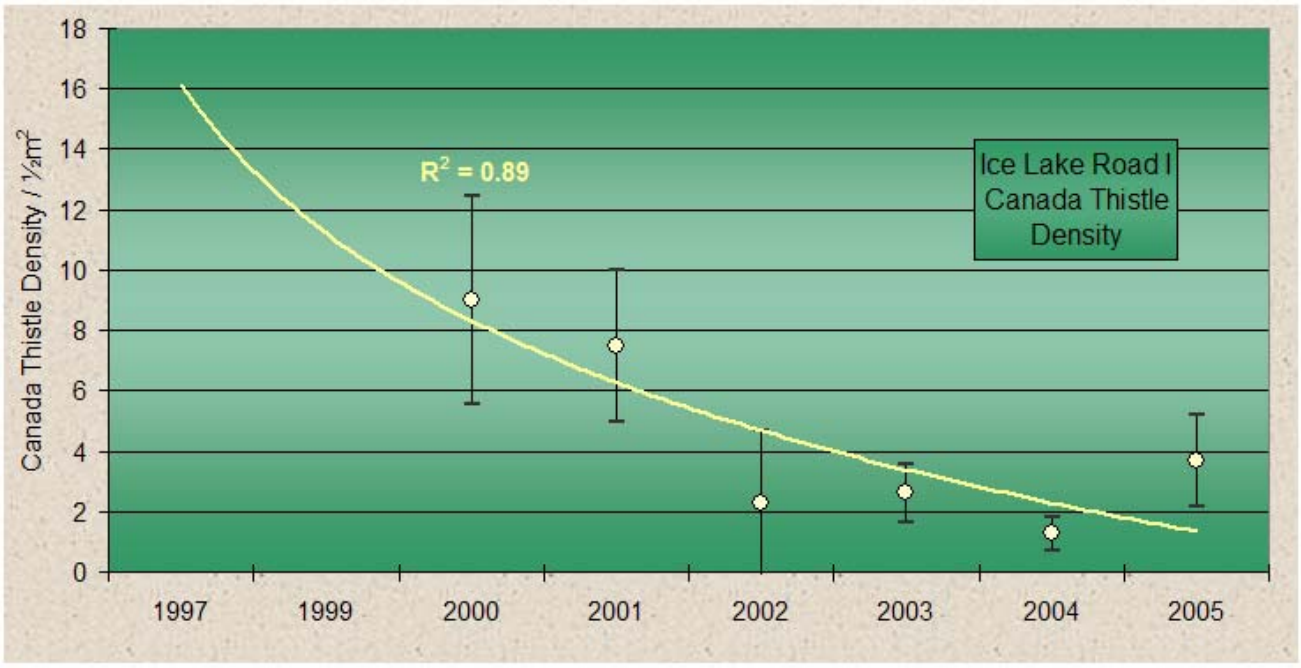
[1] Area not mapped, release only
[2] Adventitious recovery, no release made at this site
[3] New recovery in 2004
[4] Releases made on St. Johnswort nearby in previous years, area newly mapped in 2004

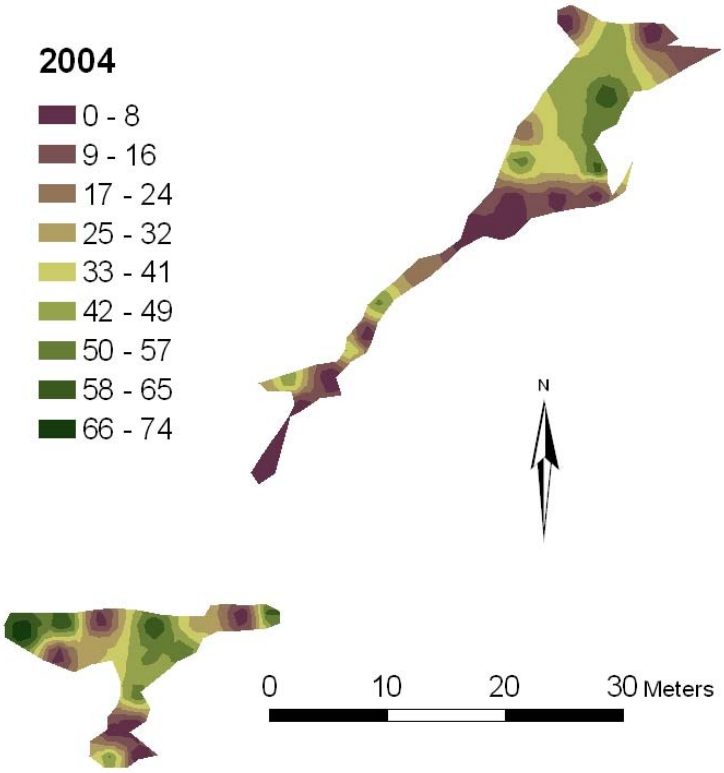


Ice Lake I Canada and musk thistle perimeters in 2004.

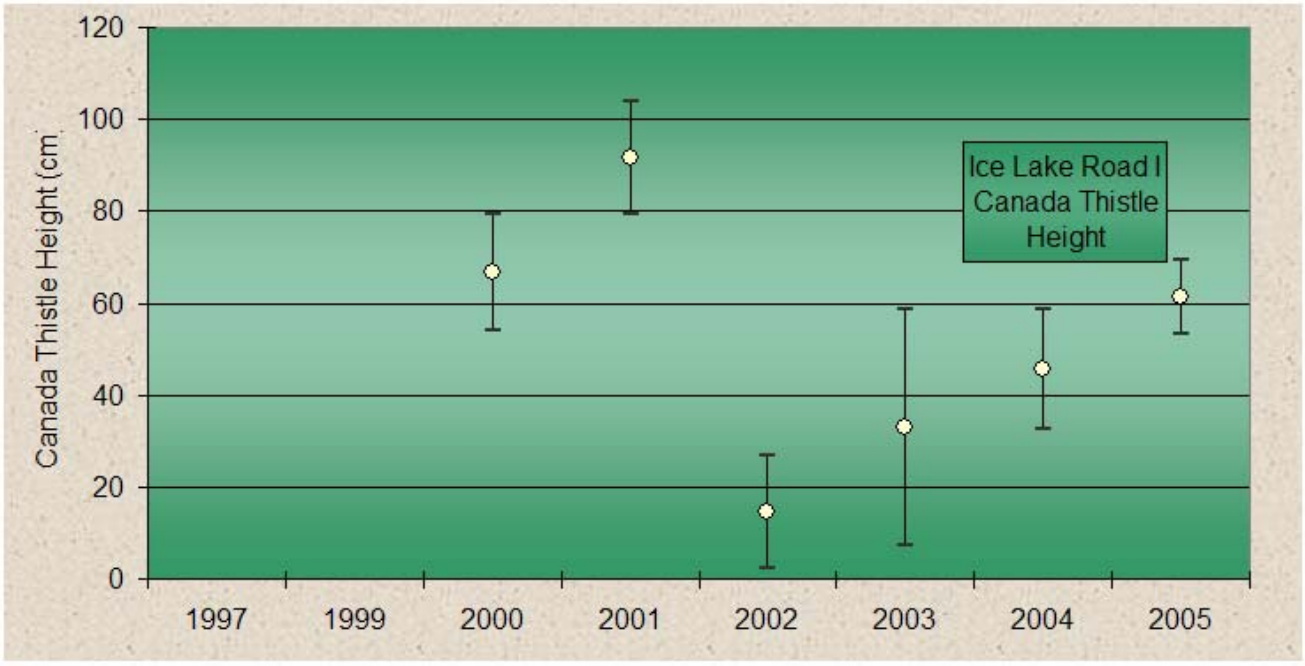


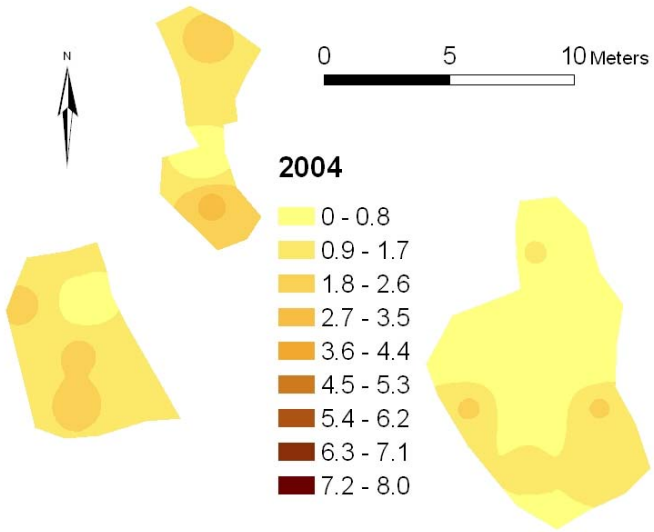
Ice Lake I Canada thistle density in 2004.



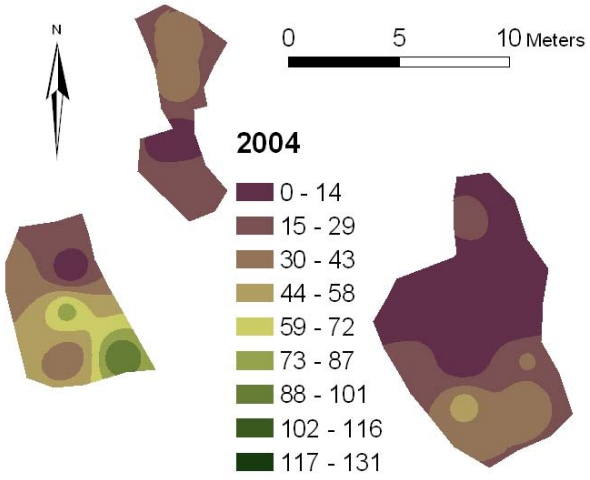


Ice Lake I Canada thistle height in 2004.

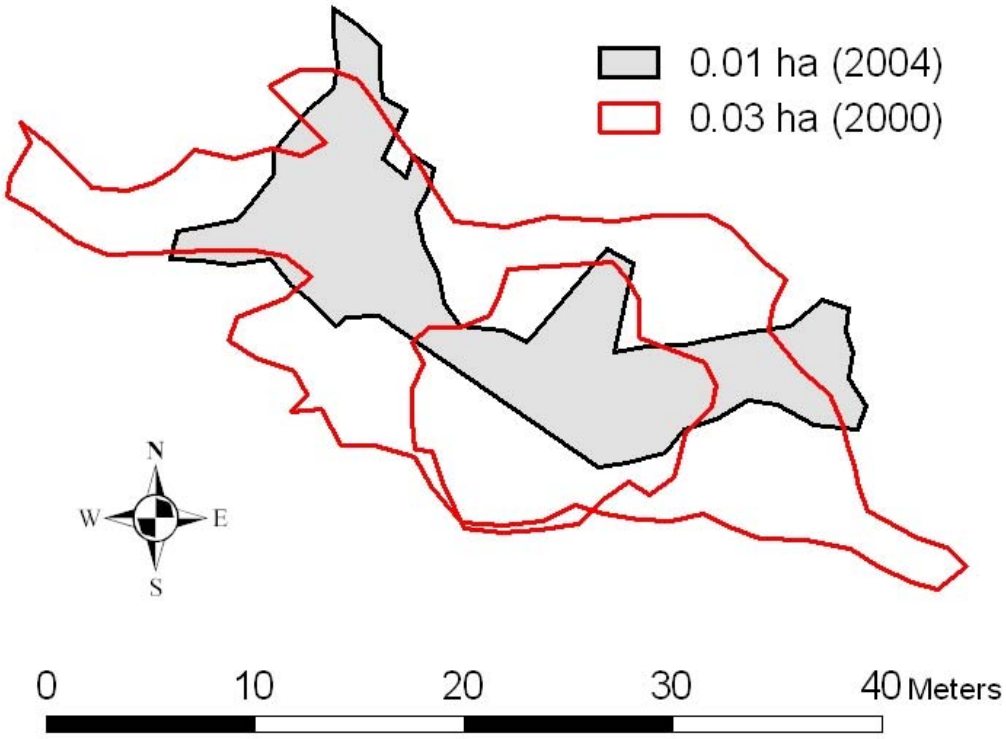




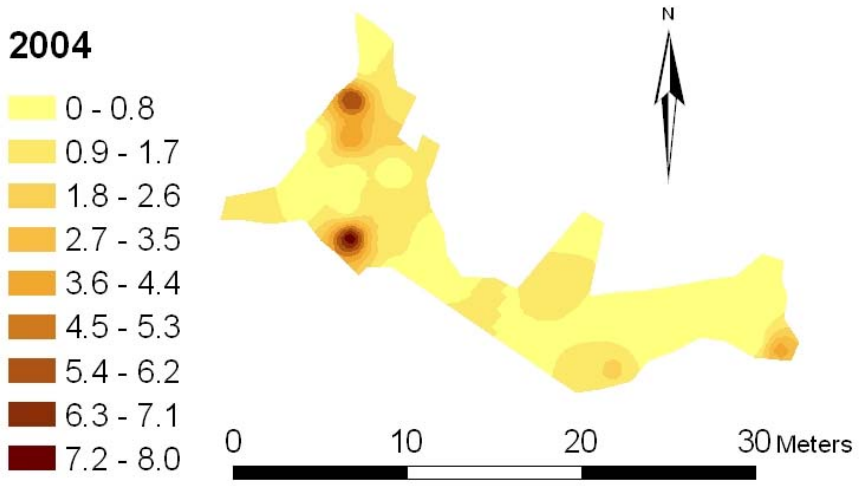
Ice Lake I musk thistle density in 2004.



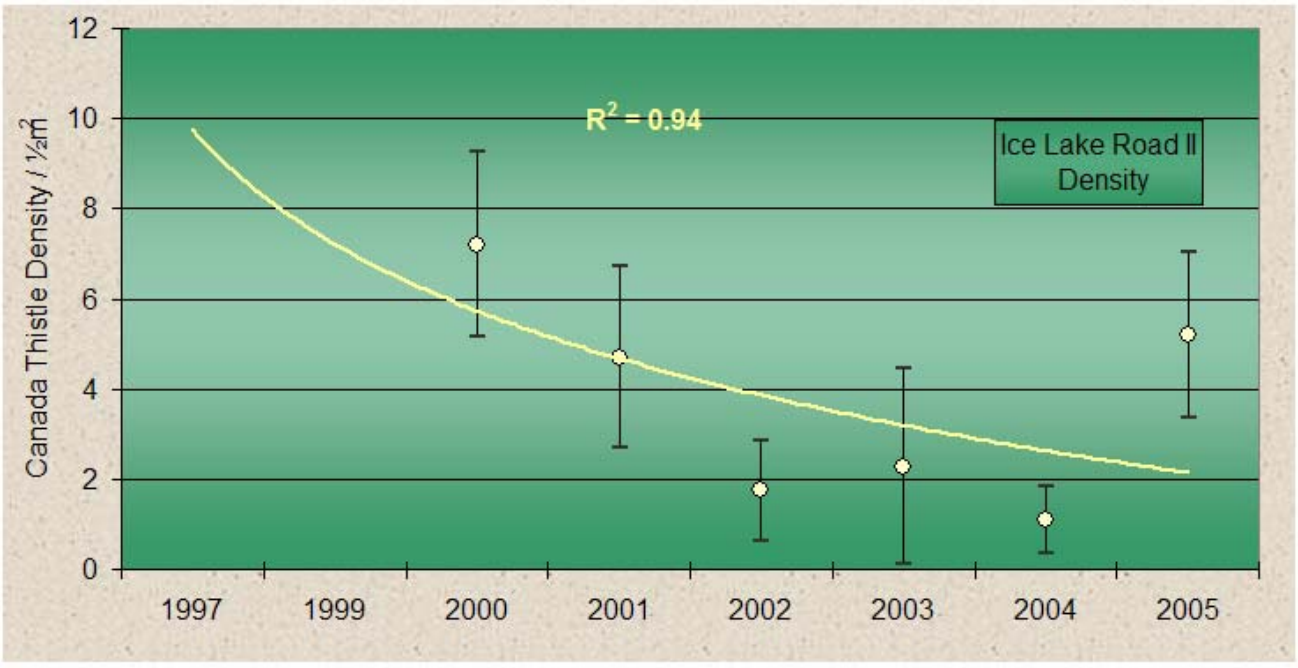
Ice Lake I musk thistle height in 2004.

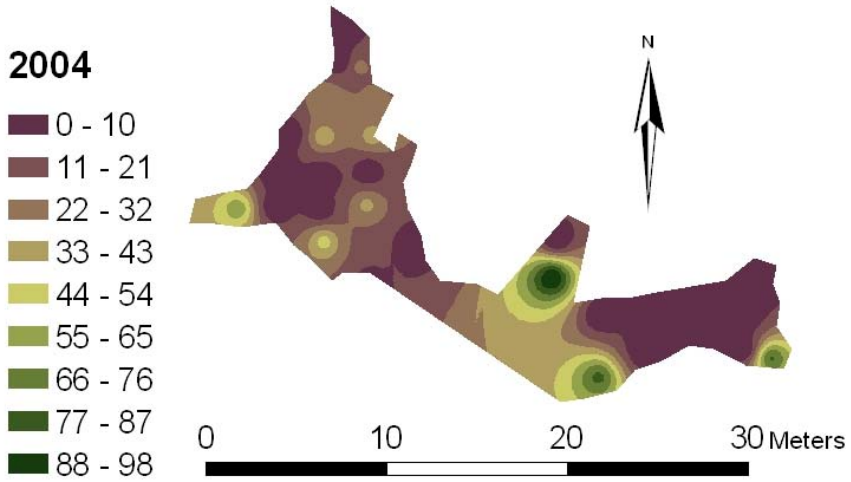


Ice Lake II Canada thistle perimeter in 2004.

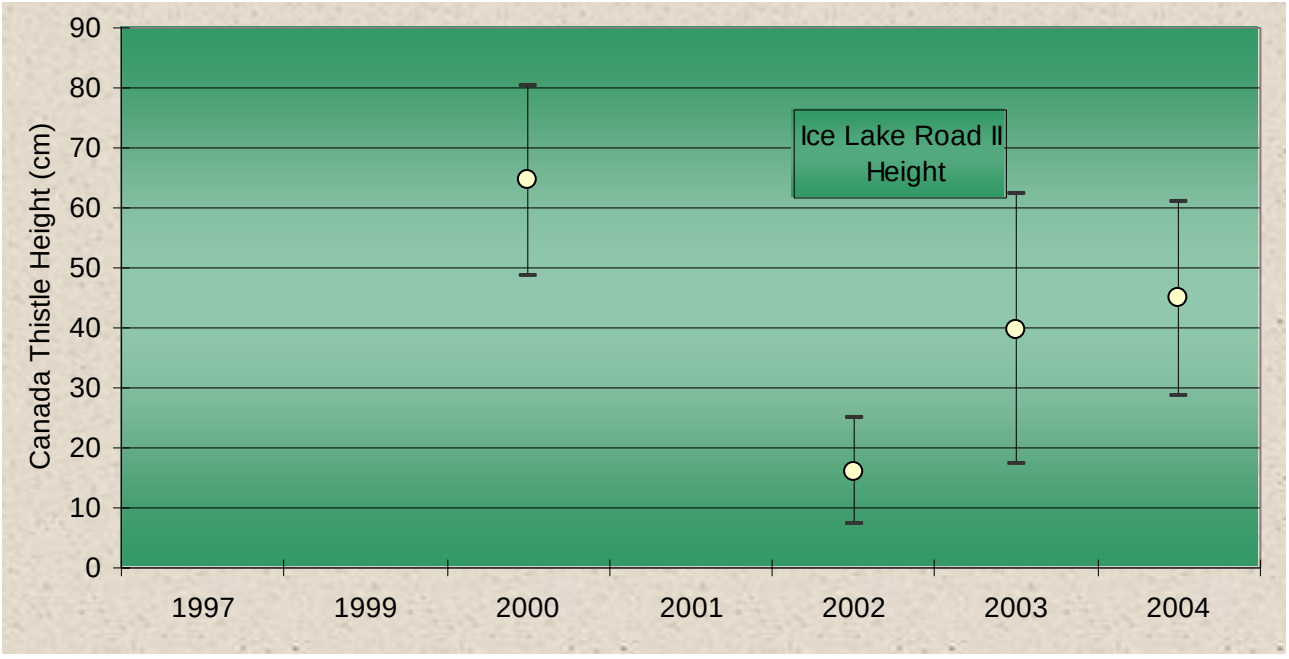


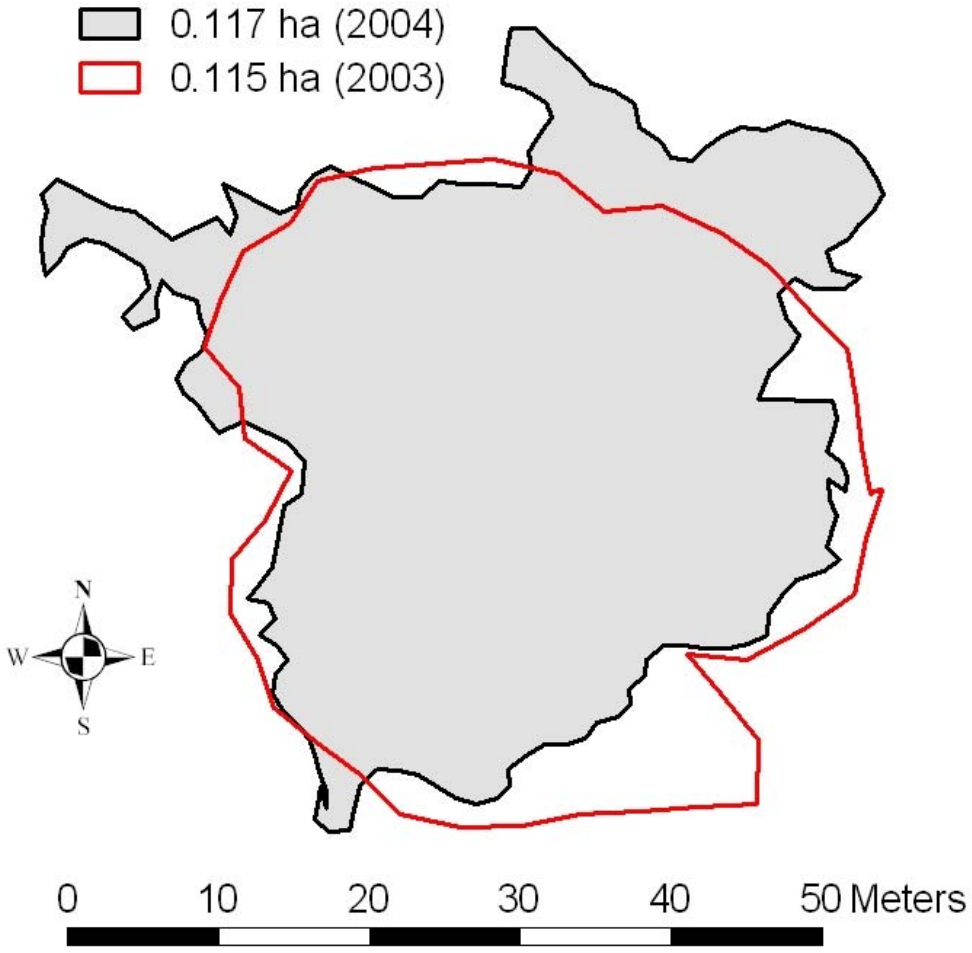
Ice Lake II Canada thistle density in 2004.



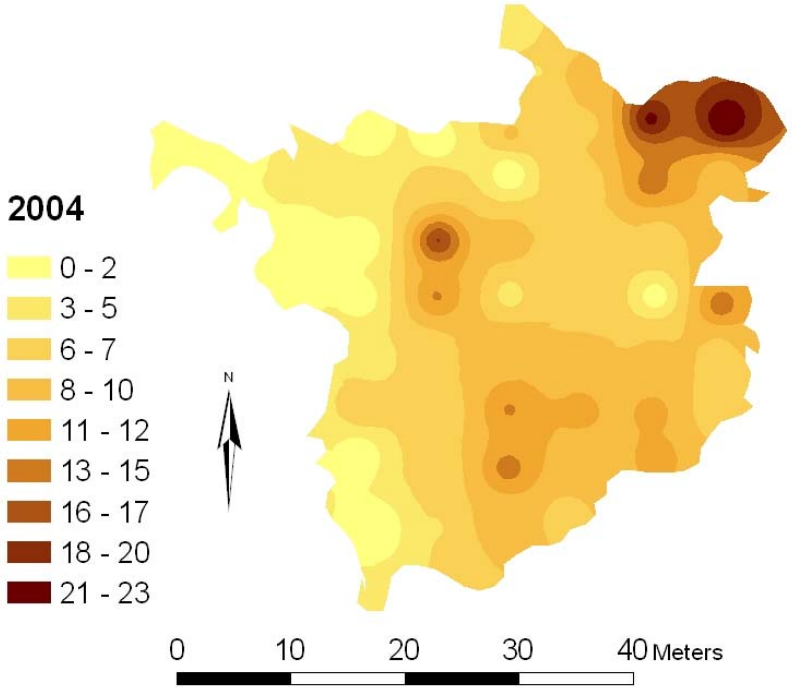


Ice Lake II Canada thistle height in 2004.

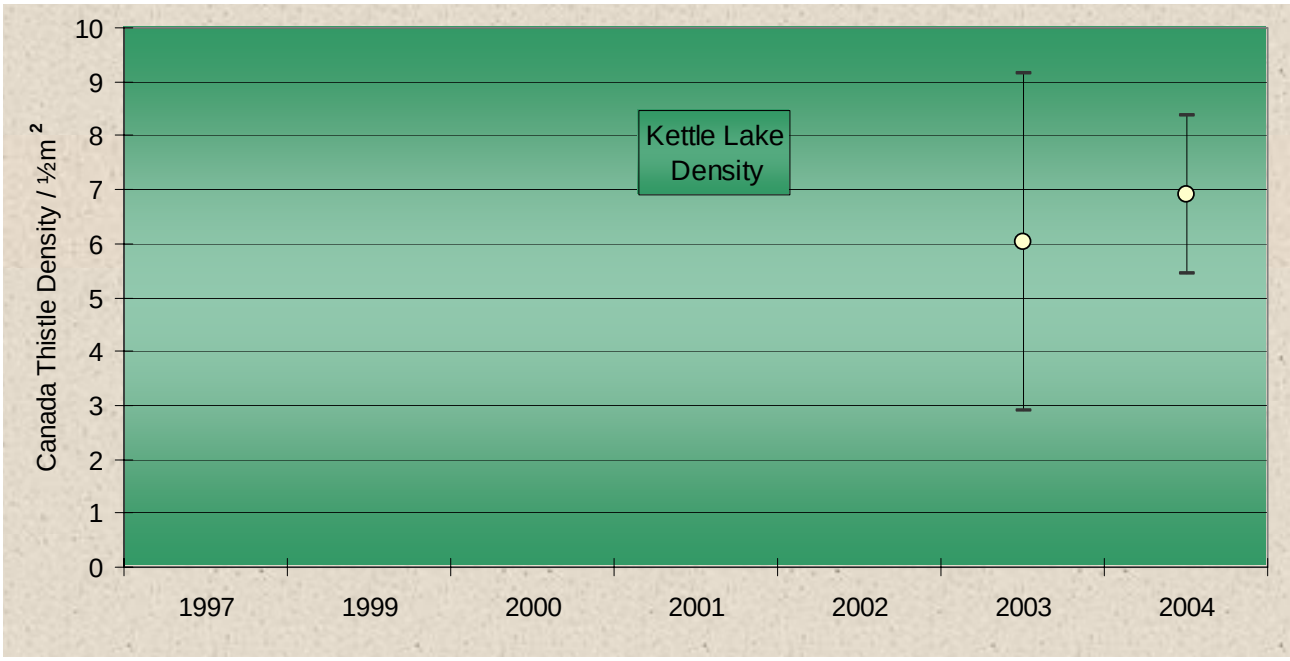


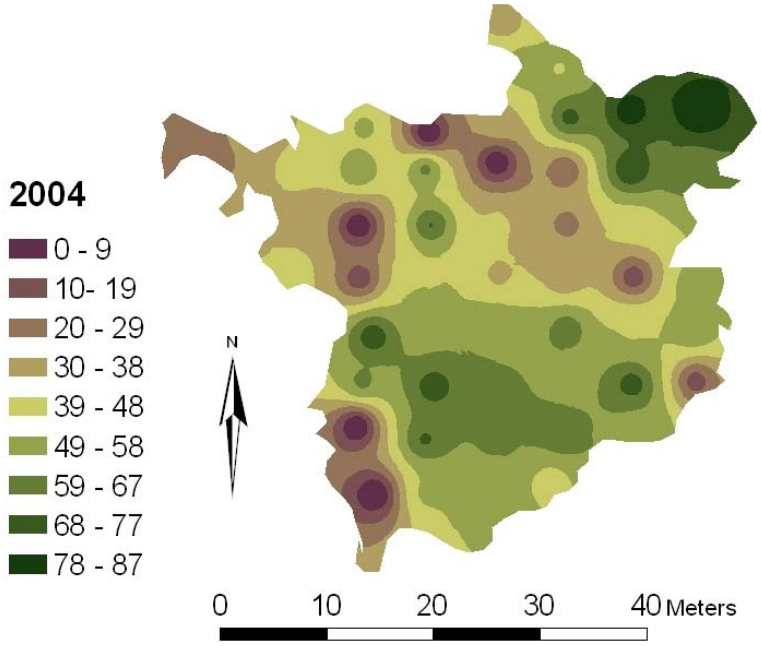


Kettle Lake Canada thistle perimeter in 2004.

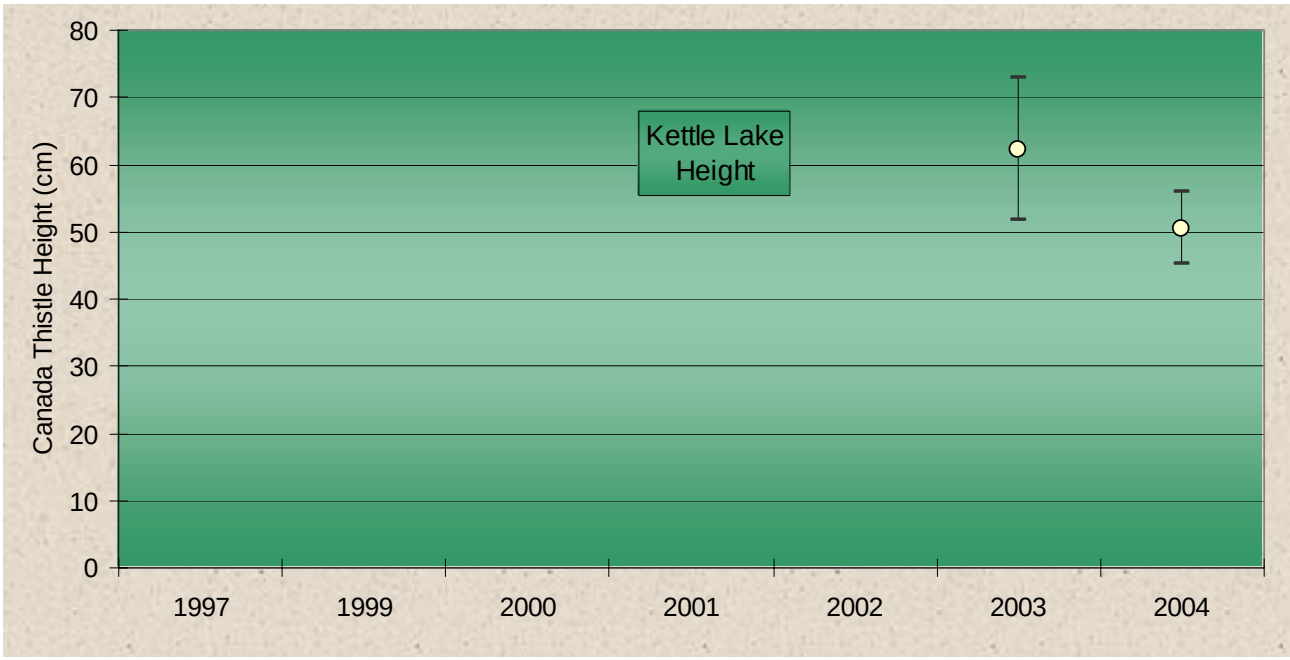


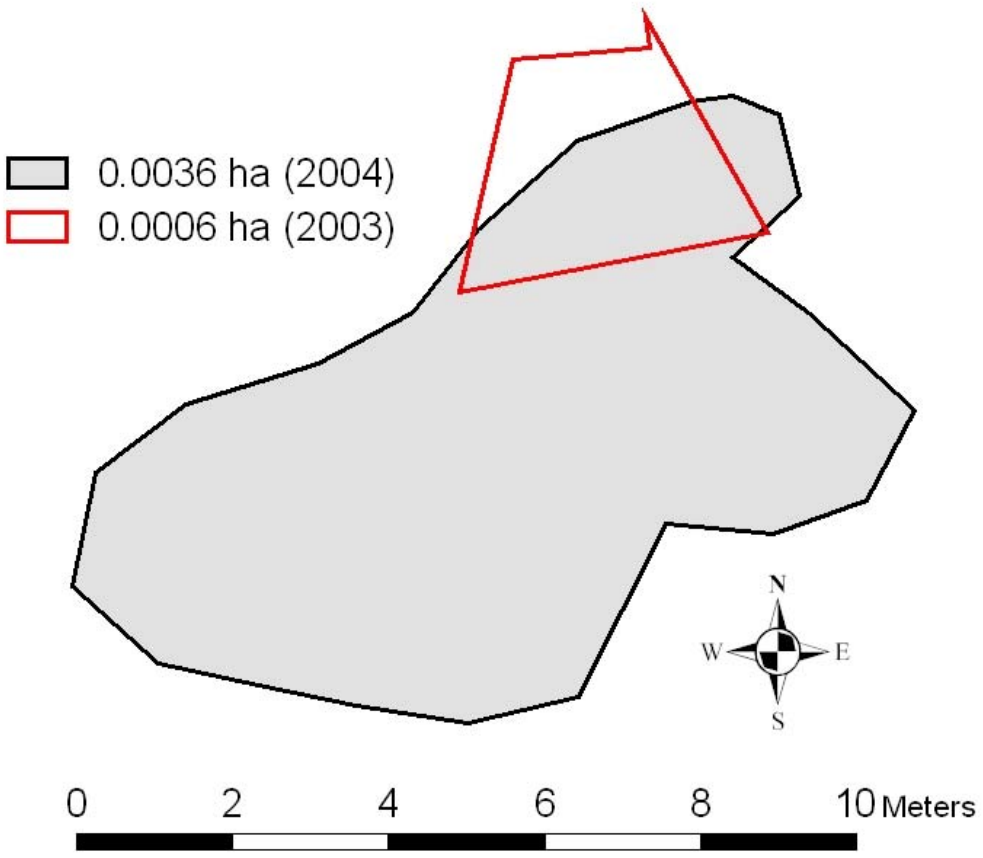
Kettle Lake Canada thistle density in 2004.



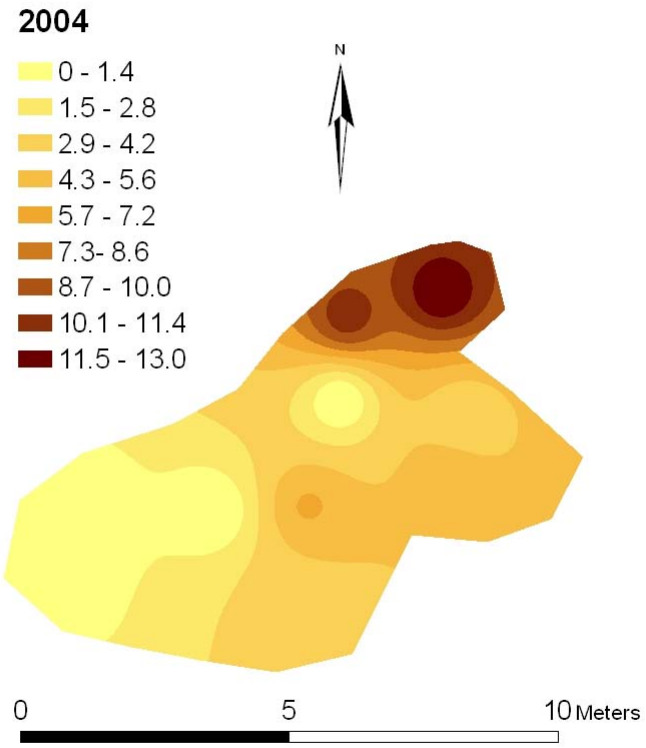


Kettle Lake Canada thistle height in 2004.

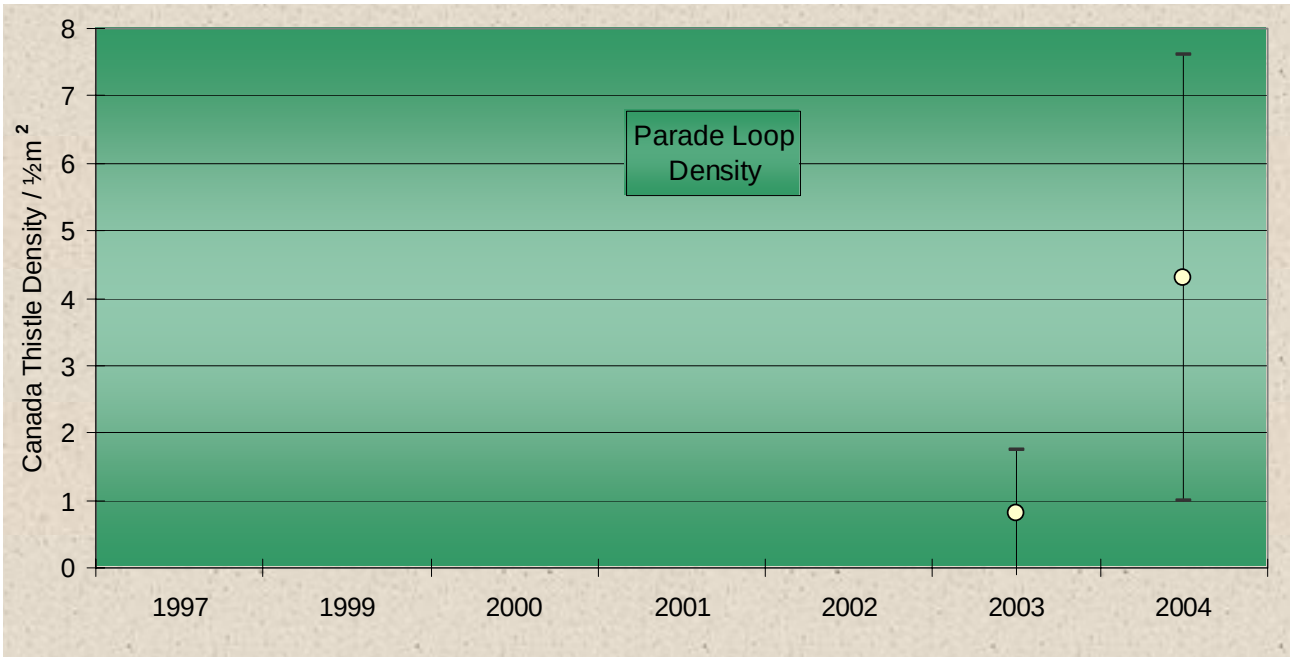


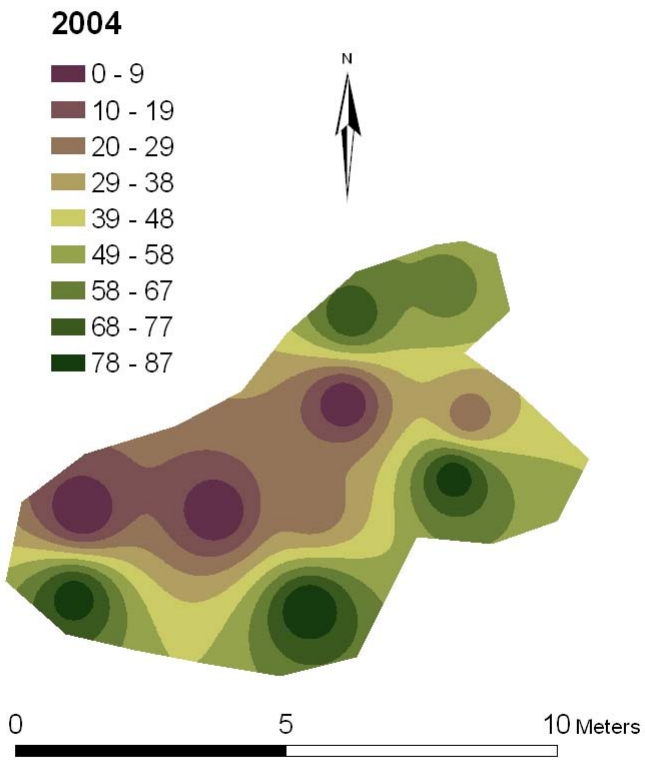


Parade Loop Canada thistle perimeter in 2004.

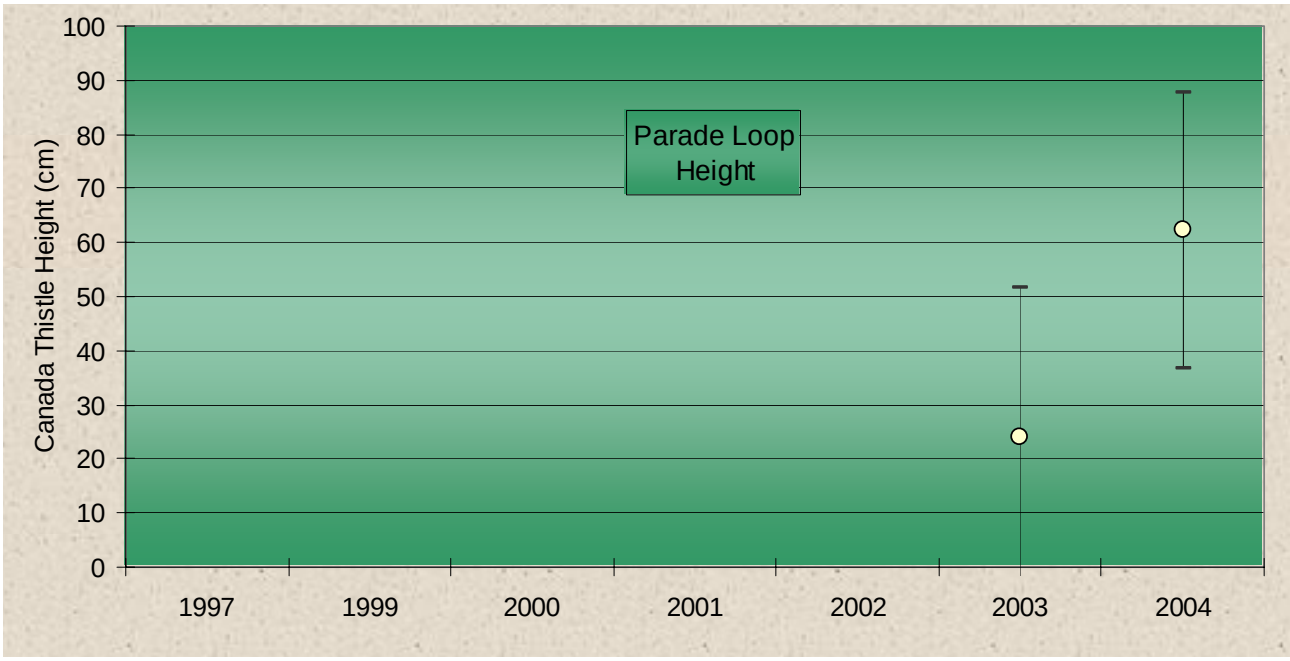


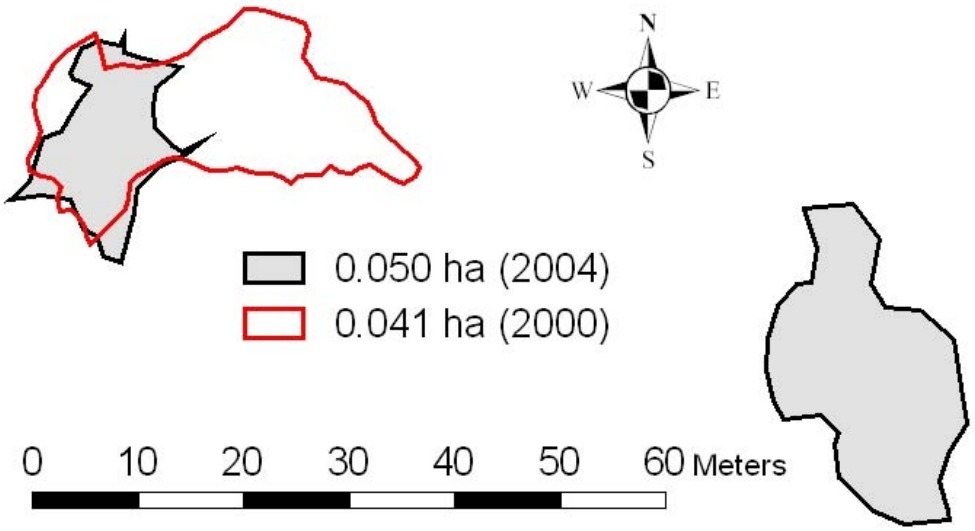
Parade Loop Canada thistle density in 2004.



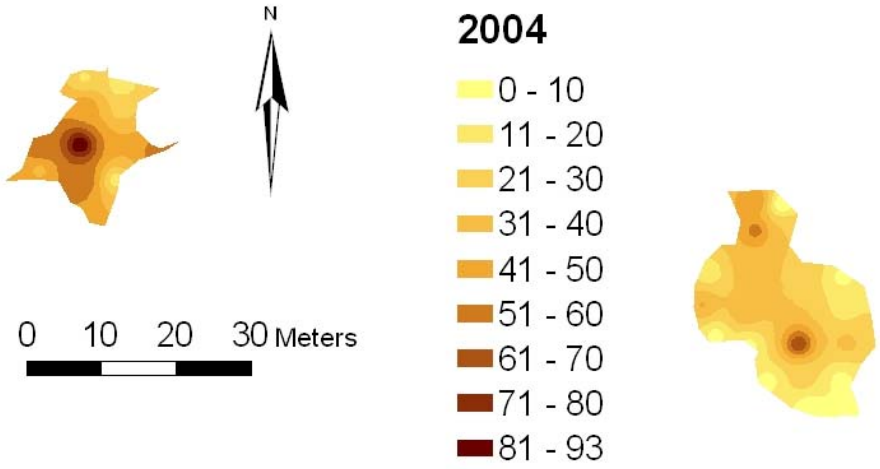


Parade Loop Canada thistle height in 2004.

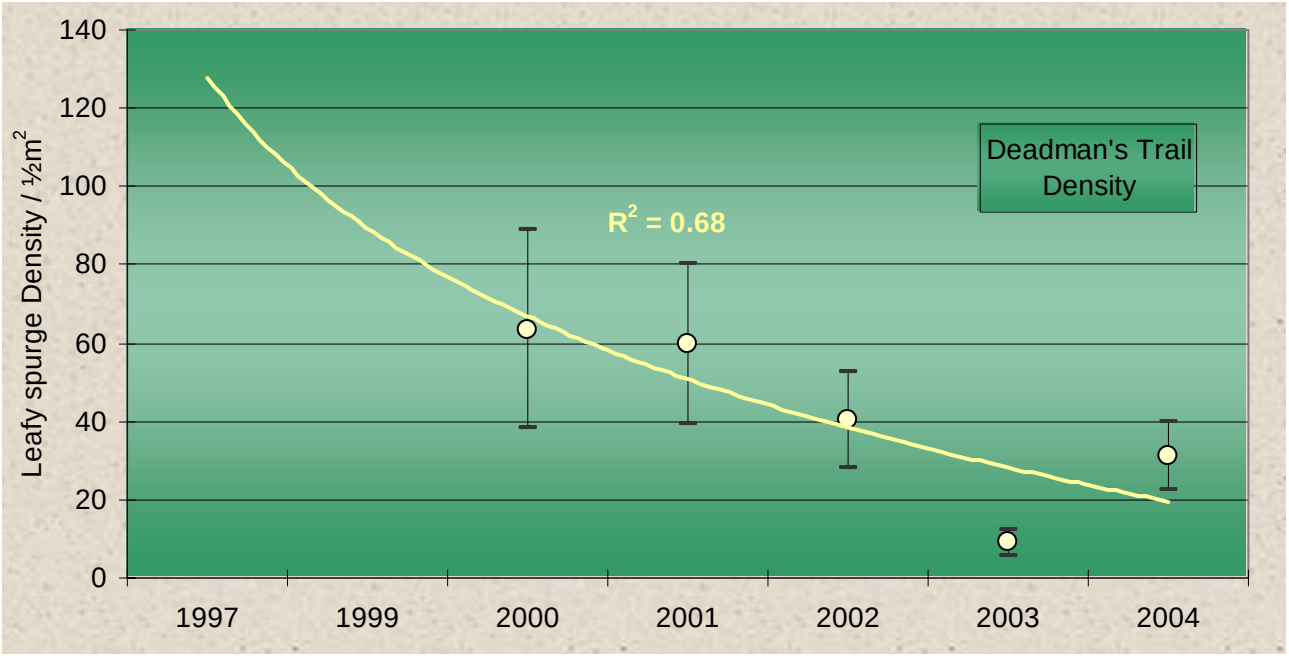


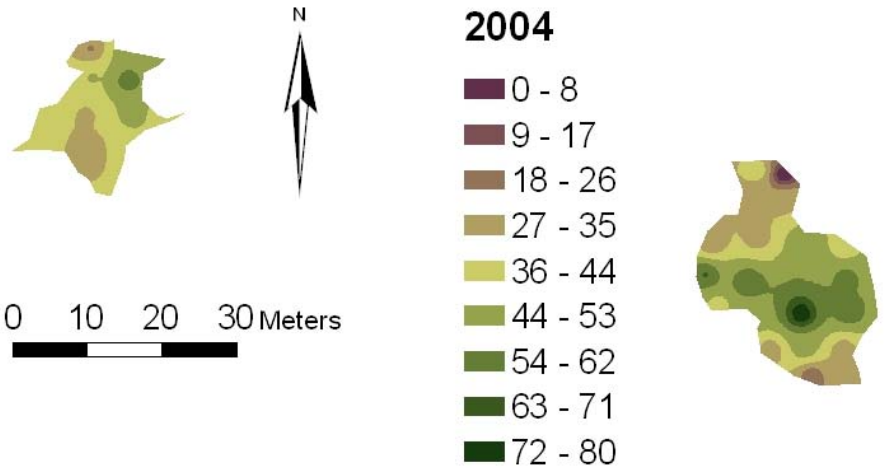


Deadman's Trail leafy spurge perimeter in 2004.

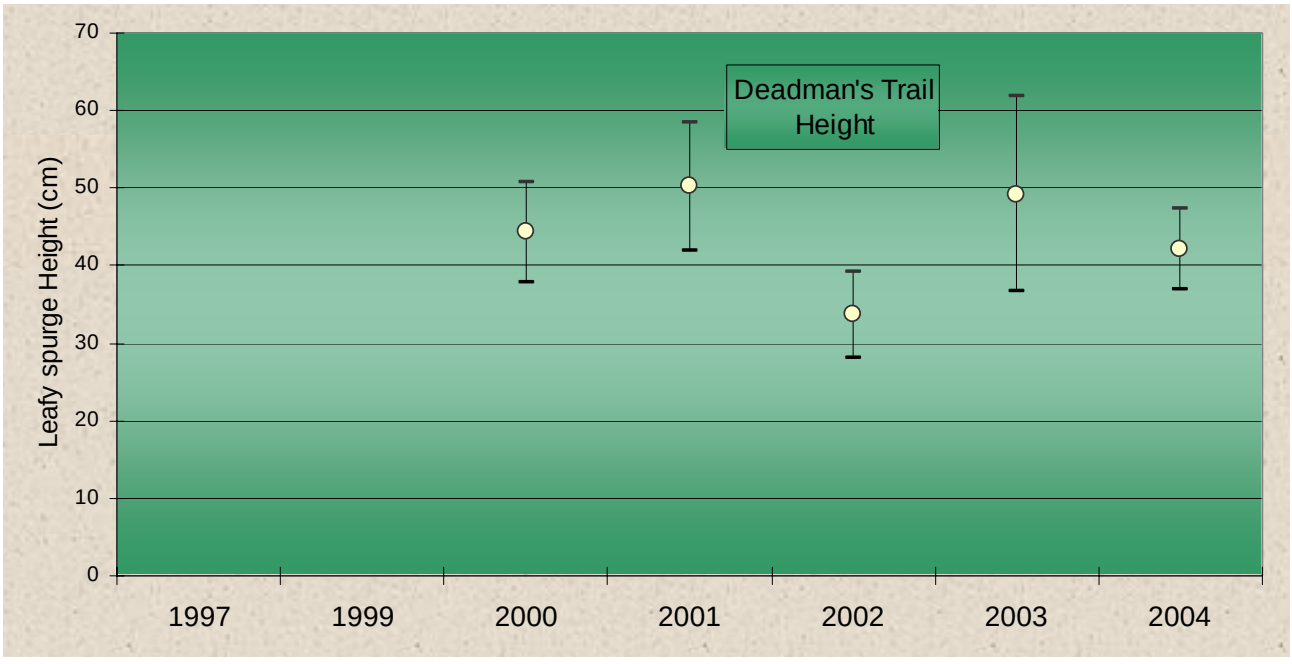


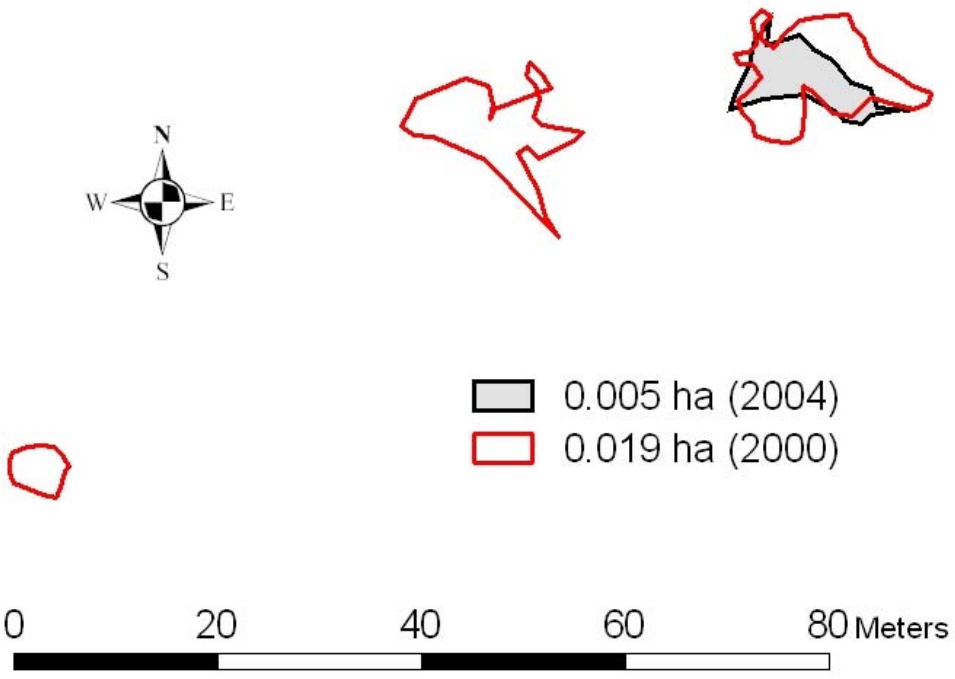
Deadman's Trail leafy spurge density in 2004.



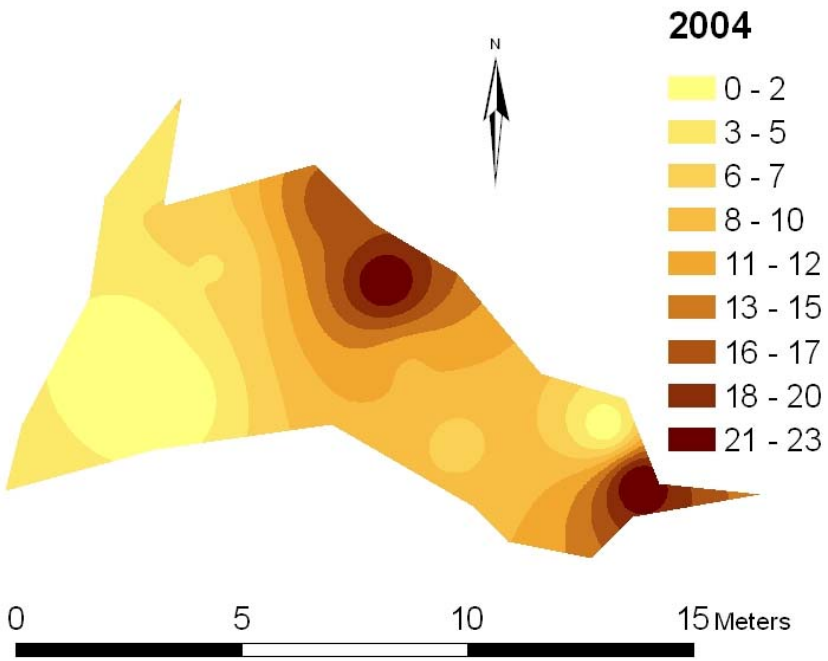


Deadman's Trail leafy spurge height in 2004.

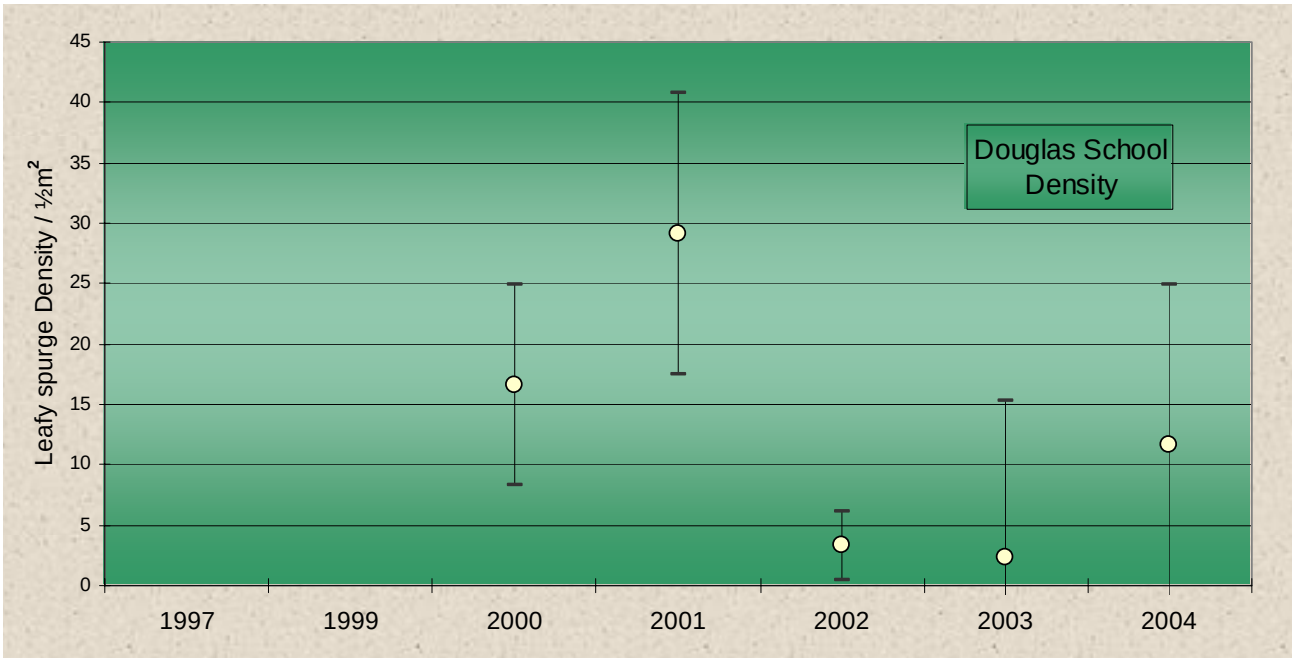


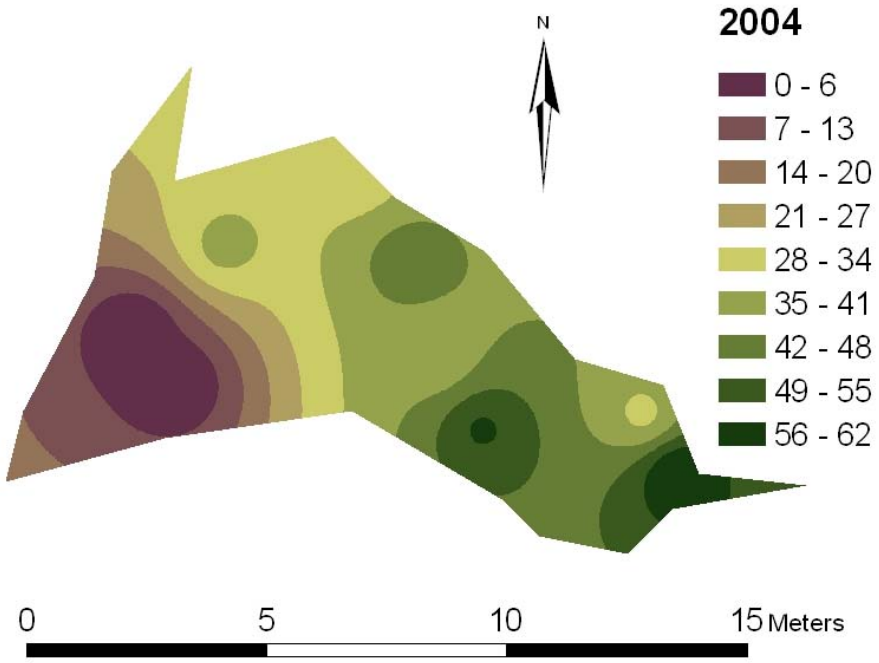


Douglass School leafy spurge perimeter in 2004.

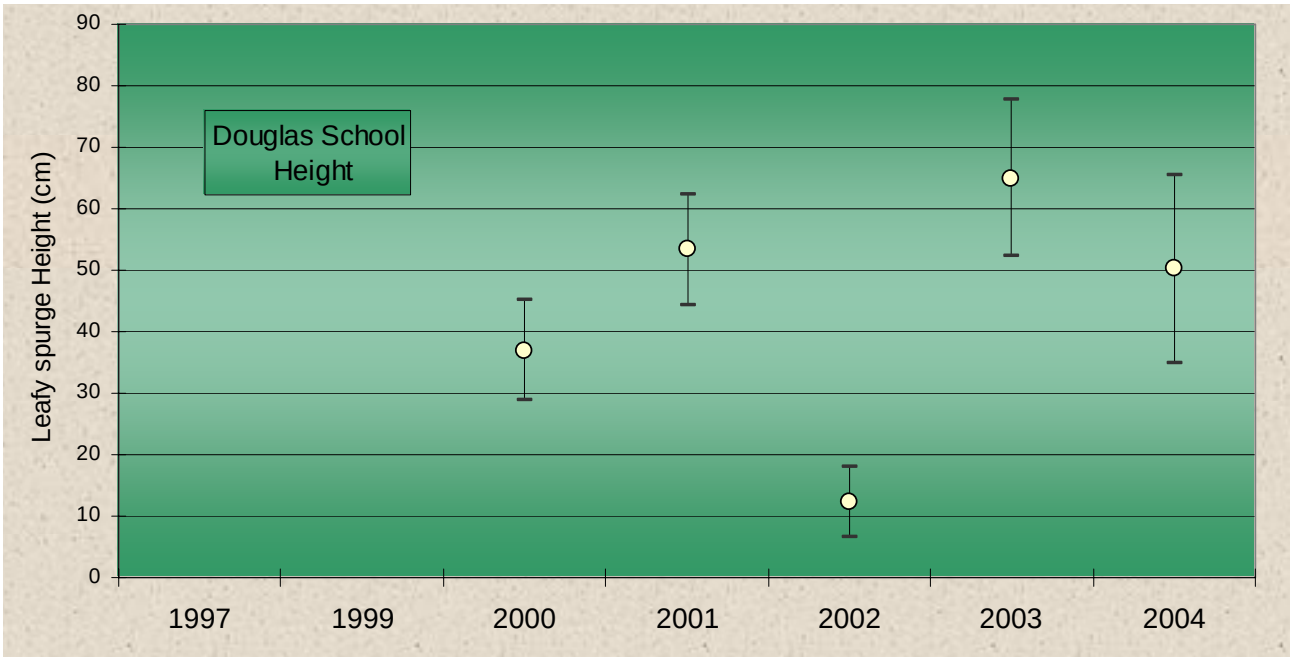


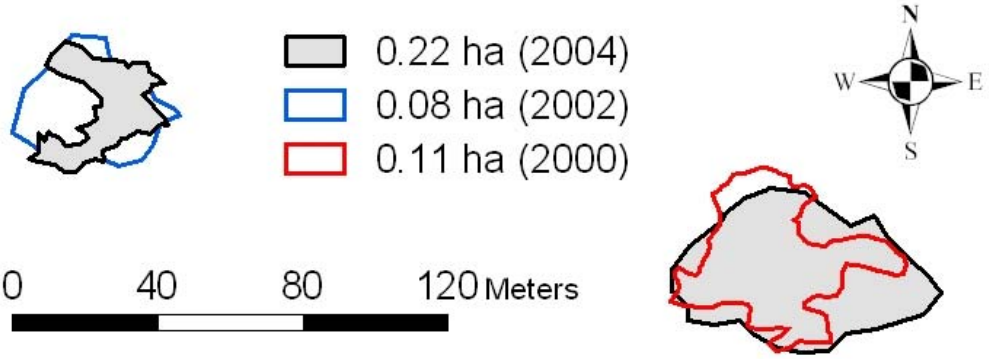
Douglass School leafy spurge density in 2004.



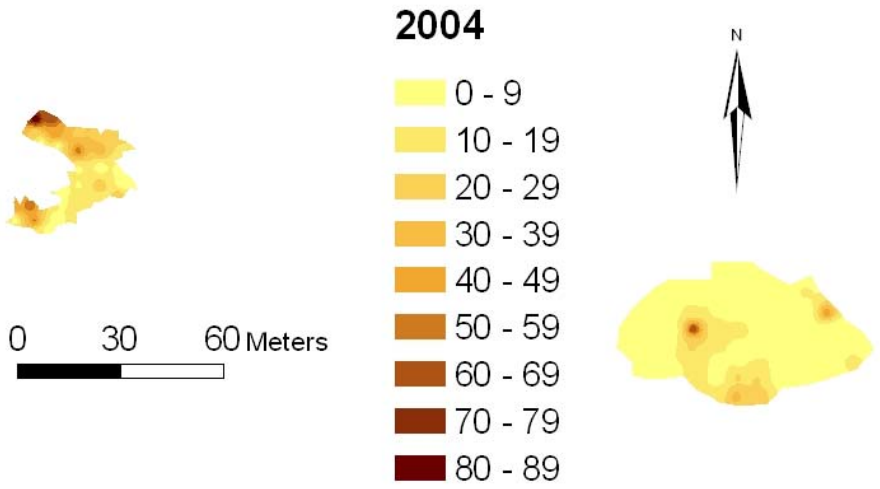


Douglass School leafy spurge height in 2004.

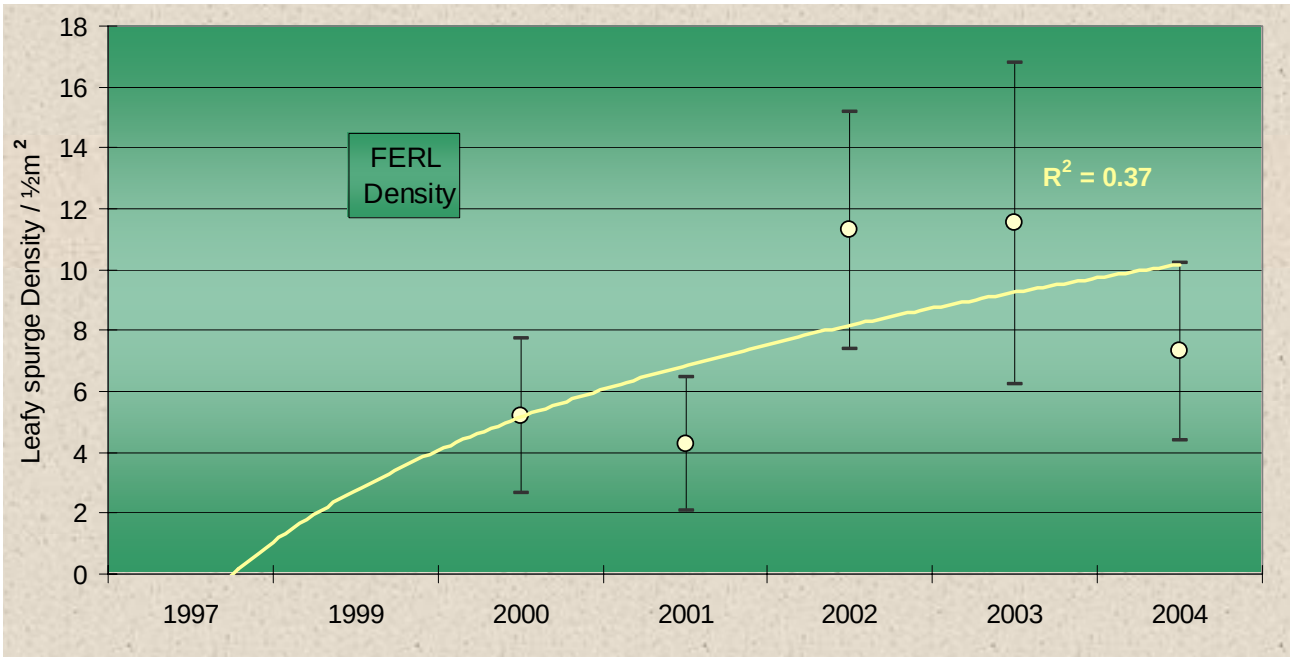


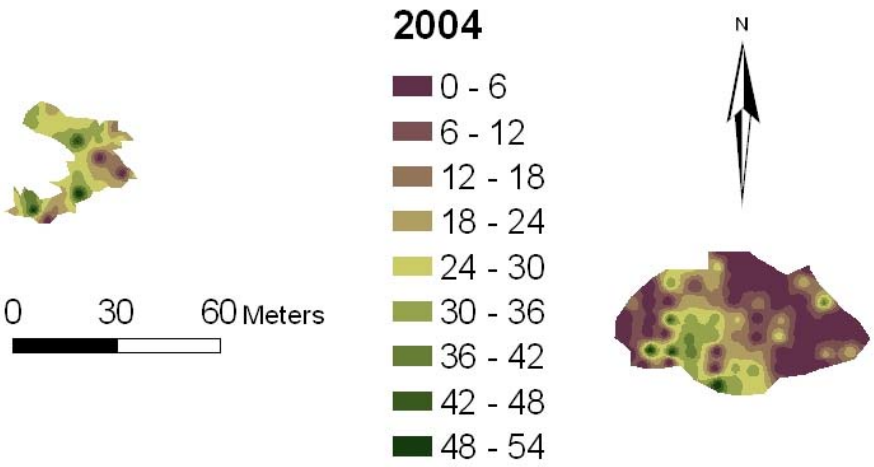


FERL leafy spurge perimeter in 2004.

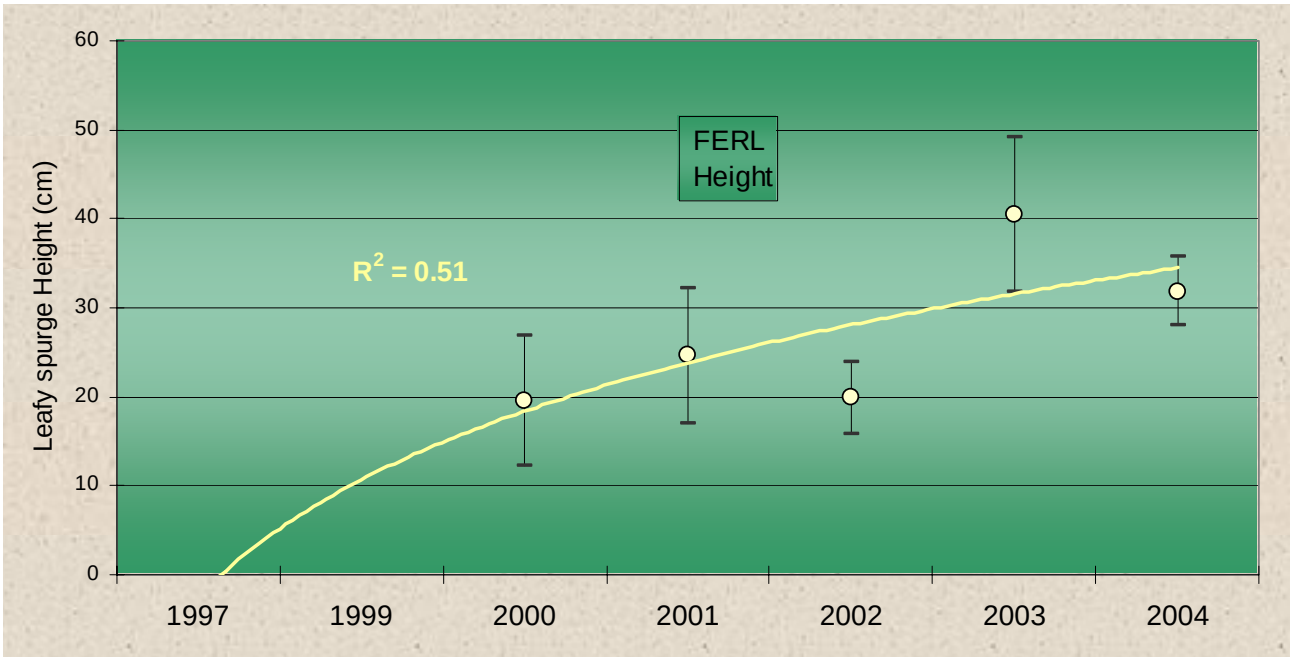


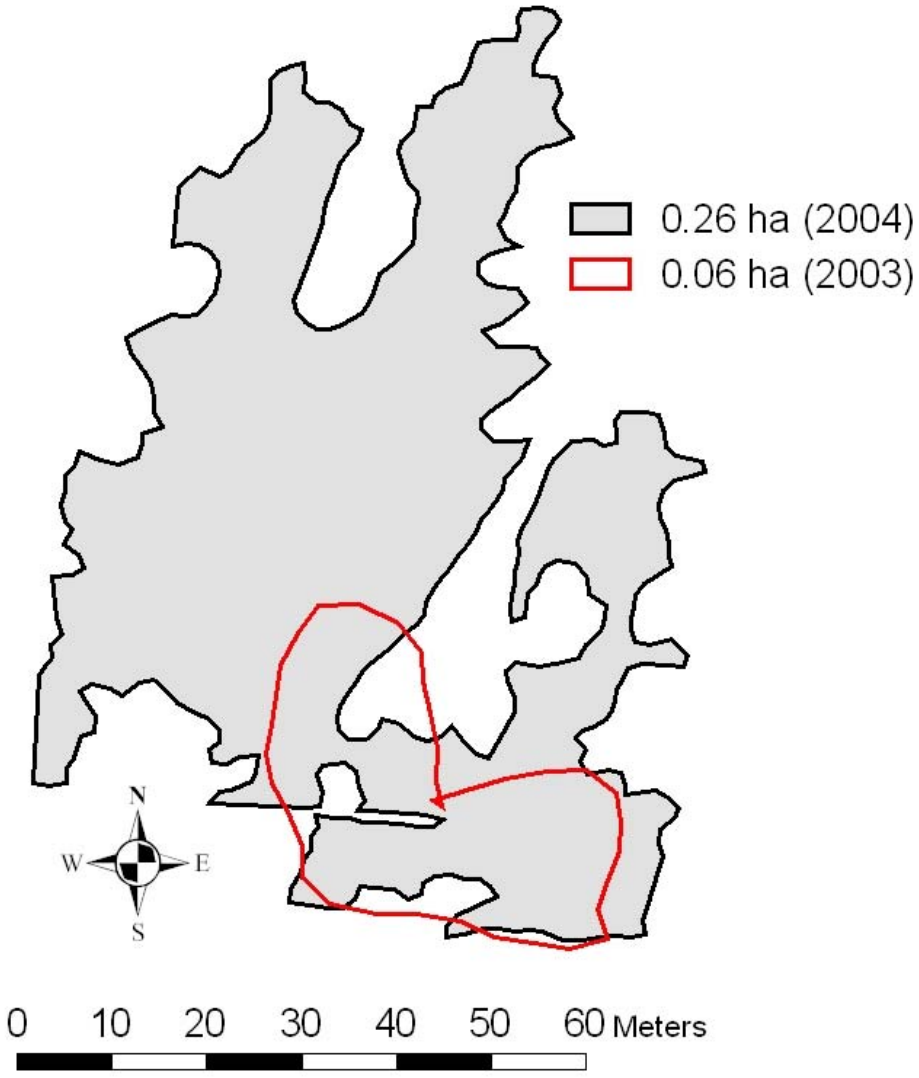
FERL leafy spurge density in 2004.



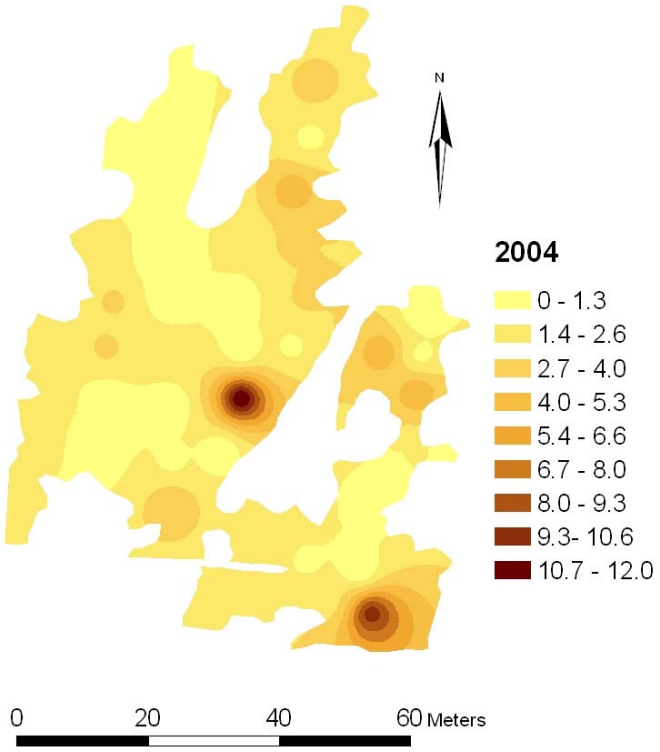


FERL leafy spurge height in 2004.

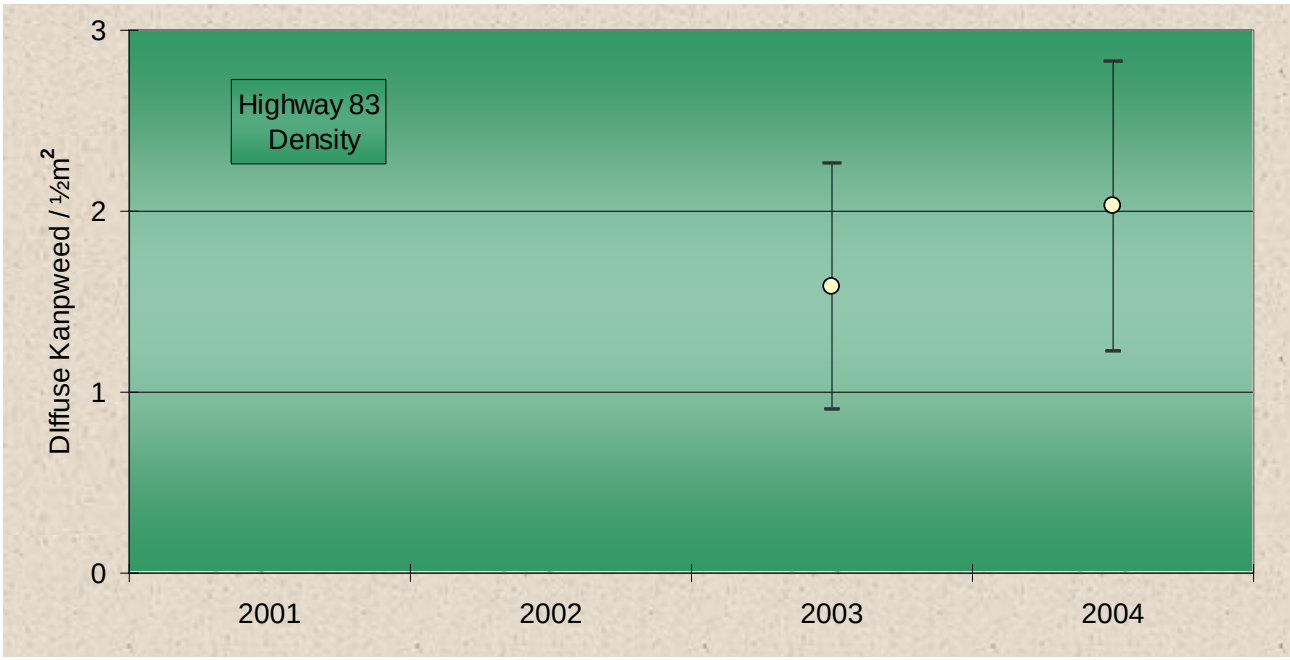


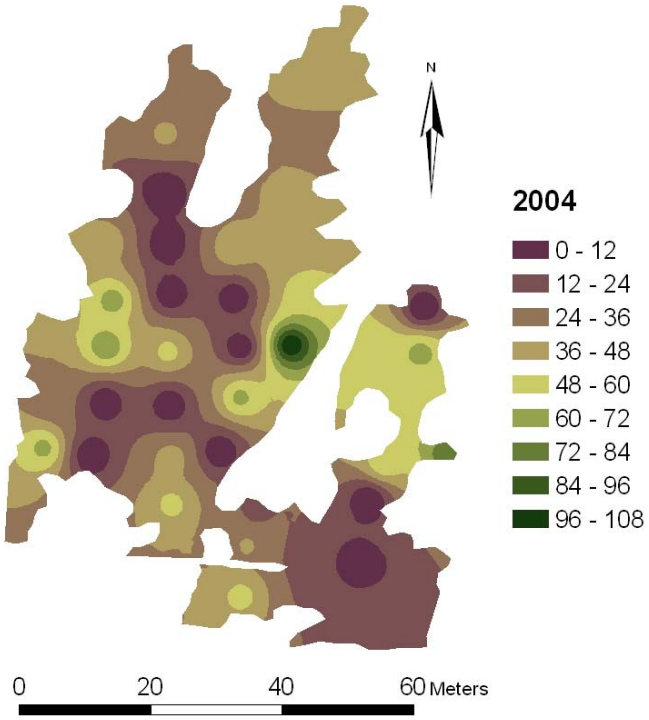


Highway 83 diffuse knapweed perimeter in 2004.

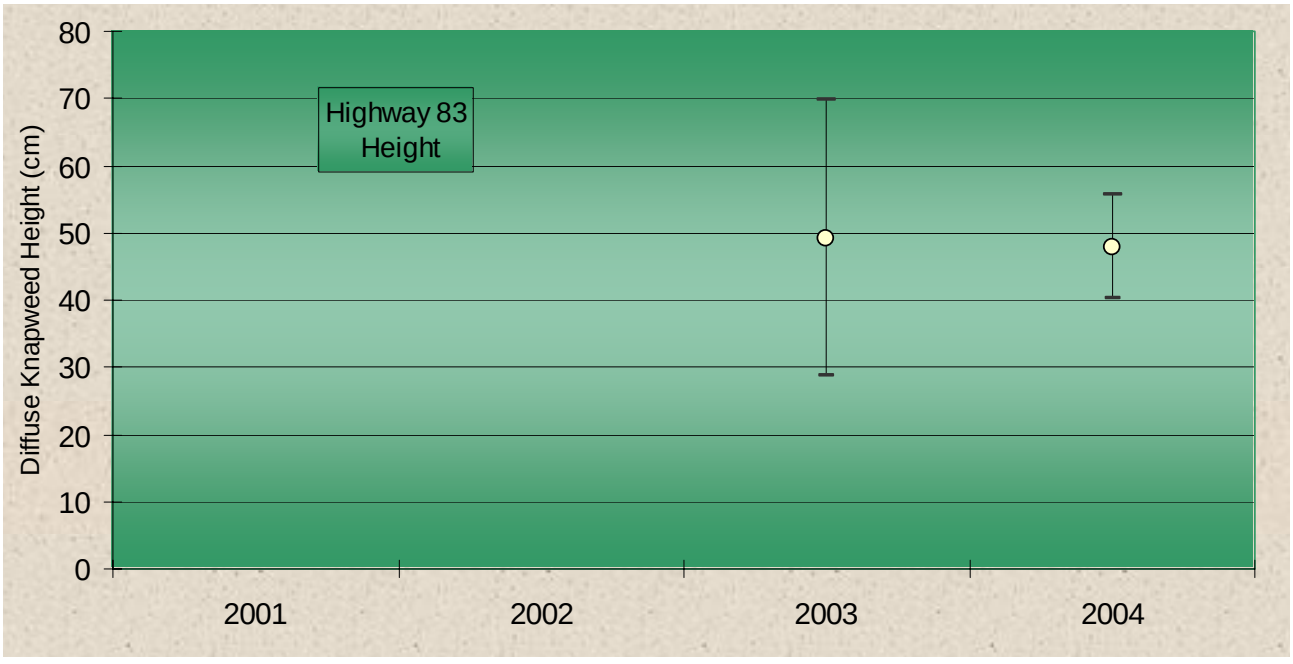


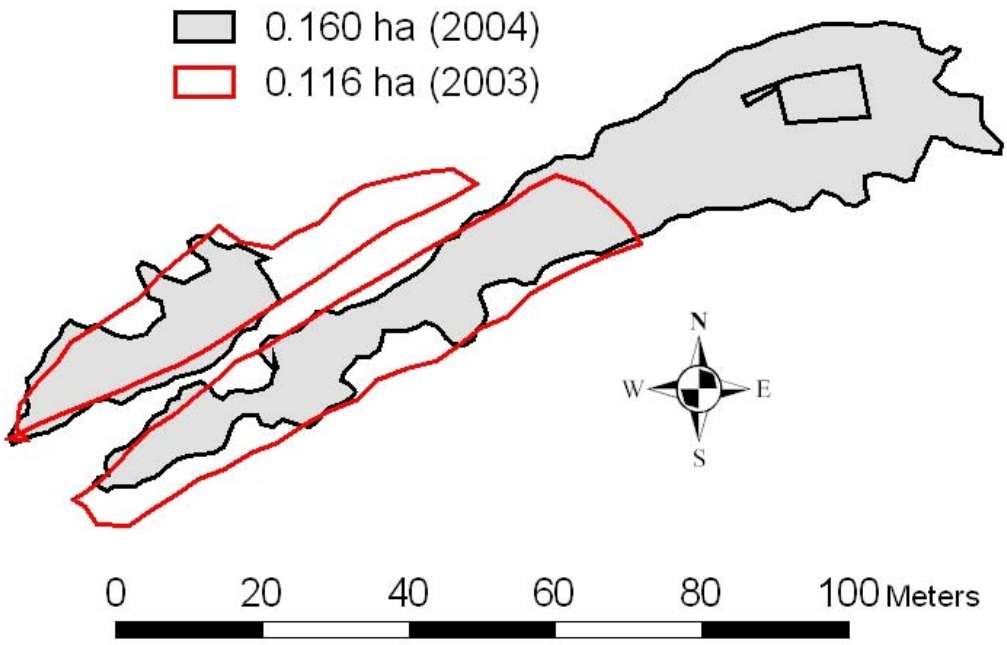
Highway 83 diffuse knapweed density in 2004.



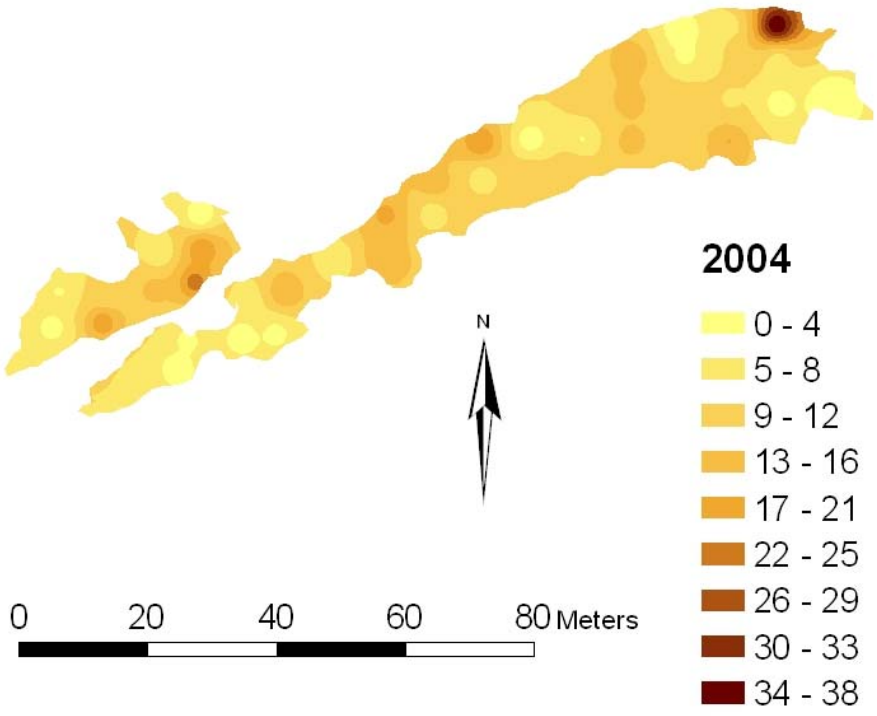


Highway 83 diffuse knapweed height in 2004.

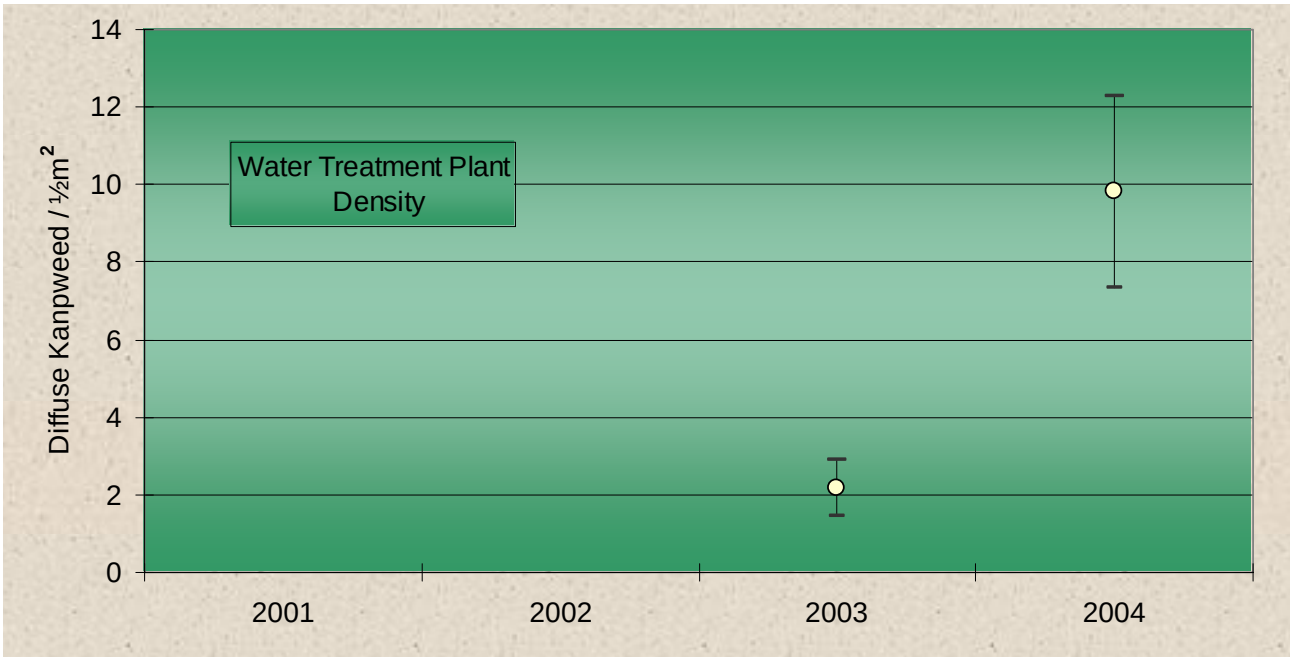


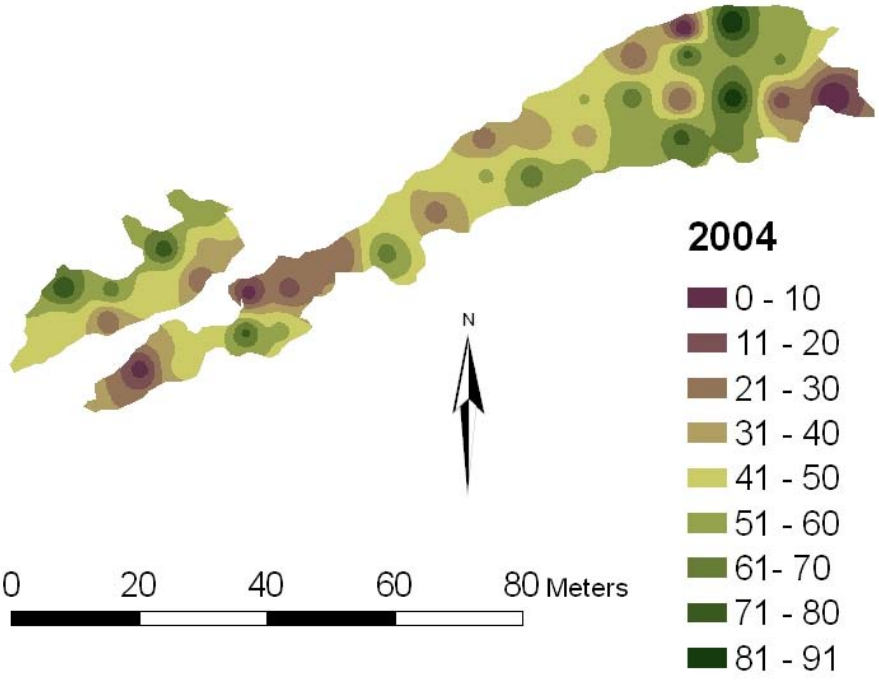


Water Treatment Plant diffuse knapweed perimeter in 2004.

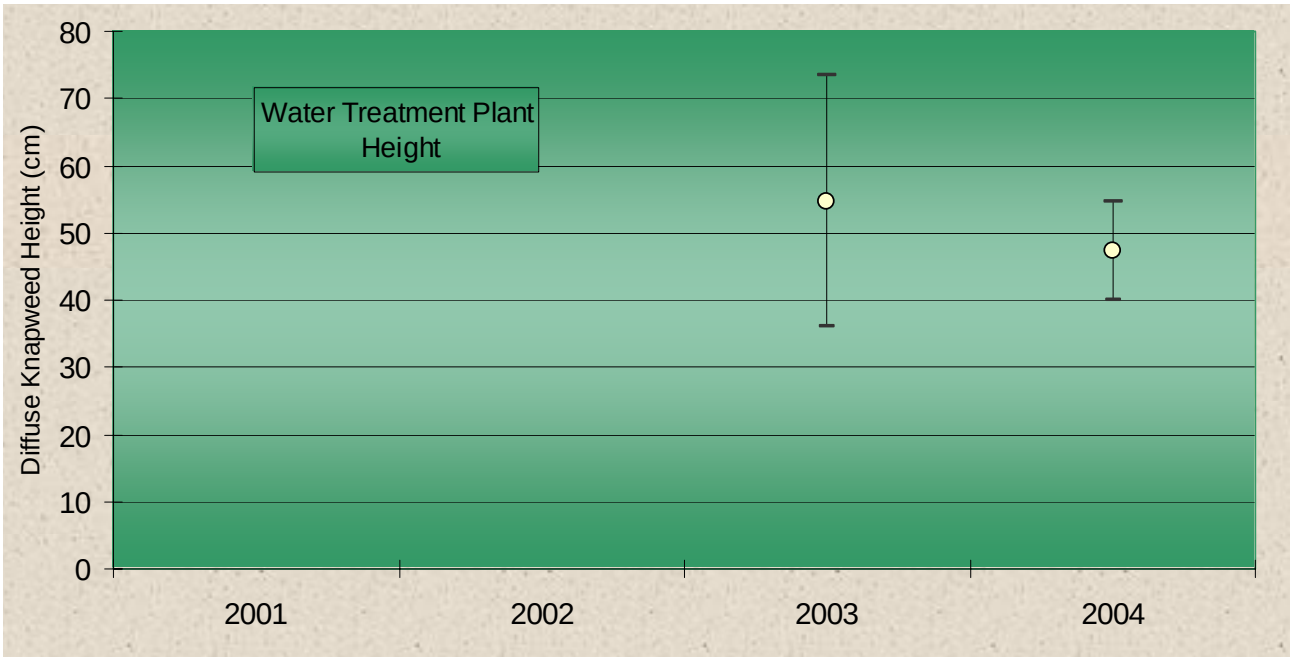


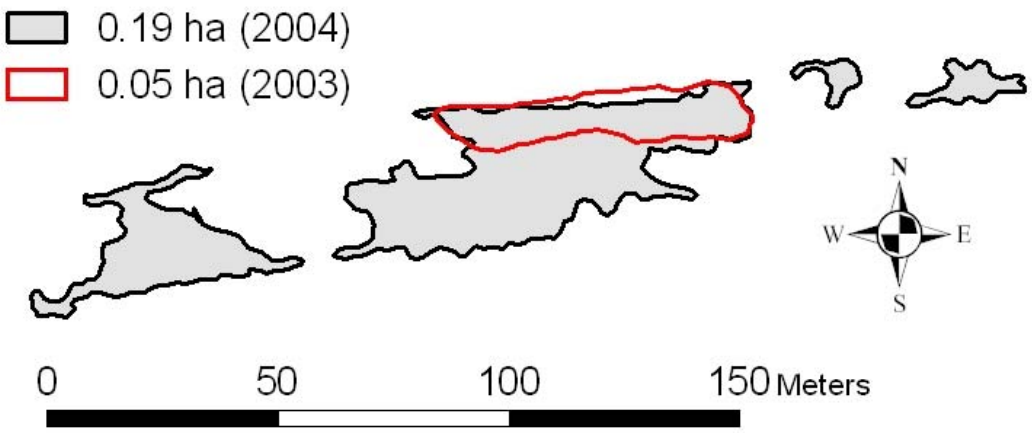
Water Treatment Plant diffuse knapweed density in 2004.



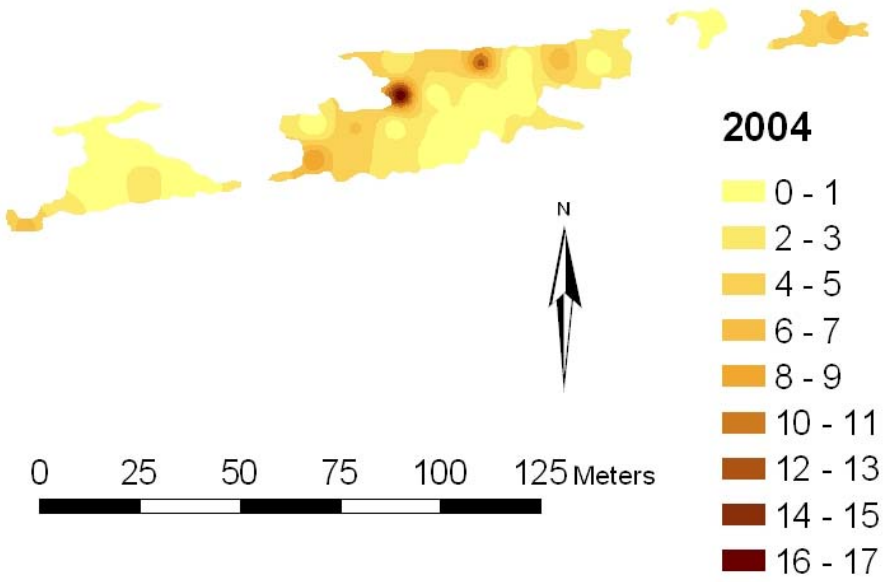


Water Treatment Plant diffuse knapweed height in 2004.

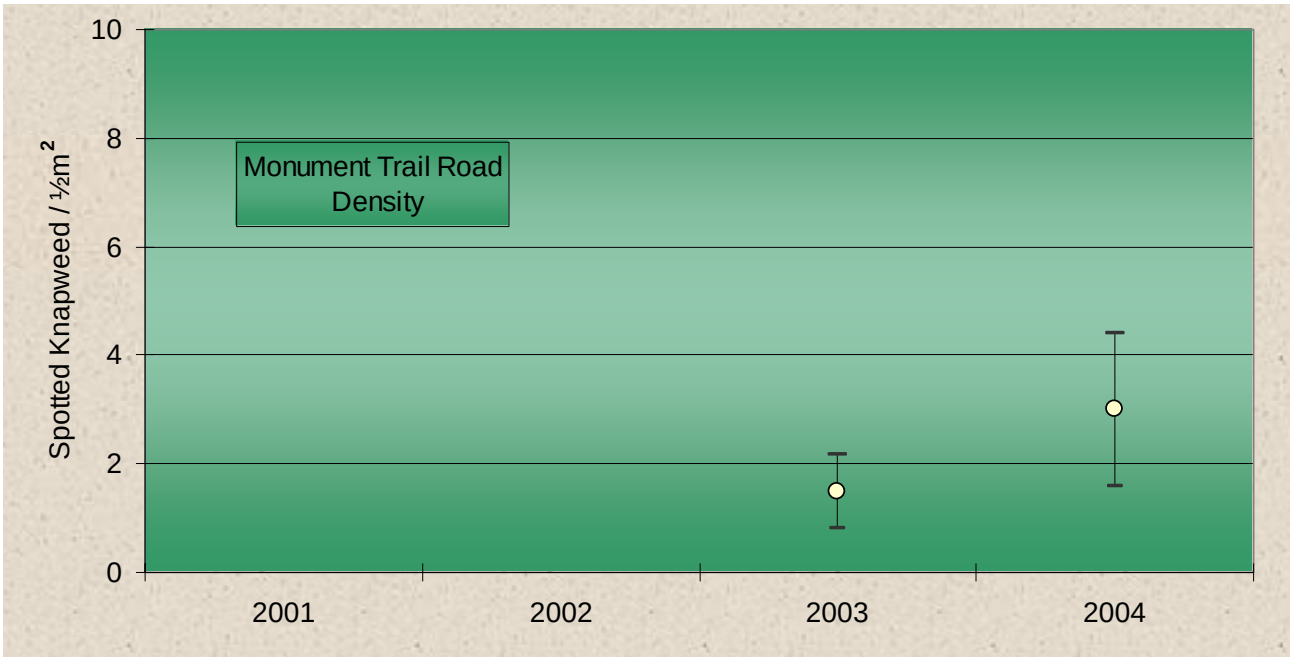


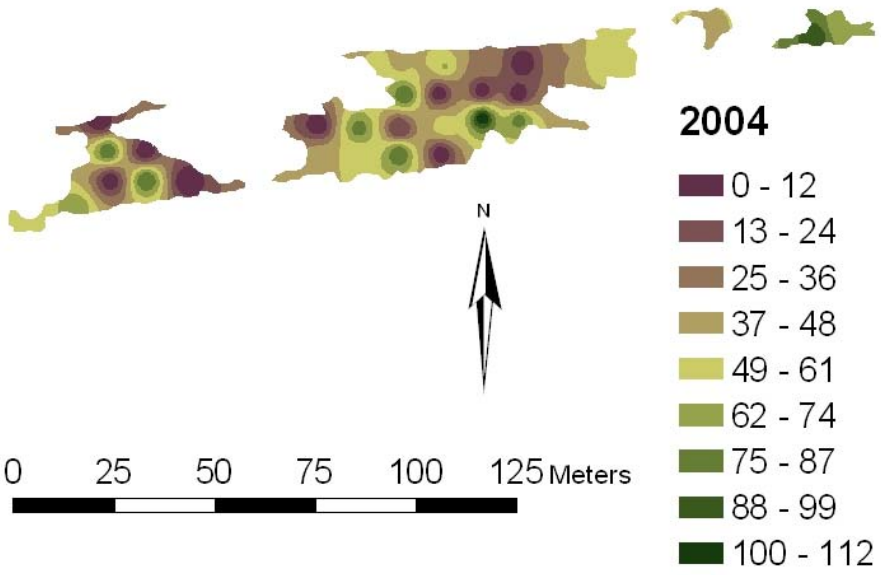


Monument Trail Road spotted knapweed perimeter in 2004.

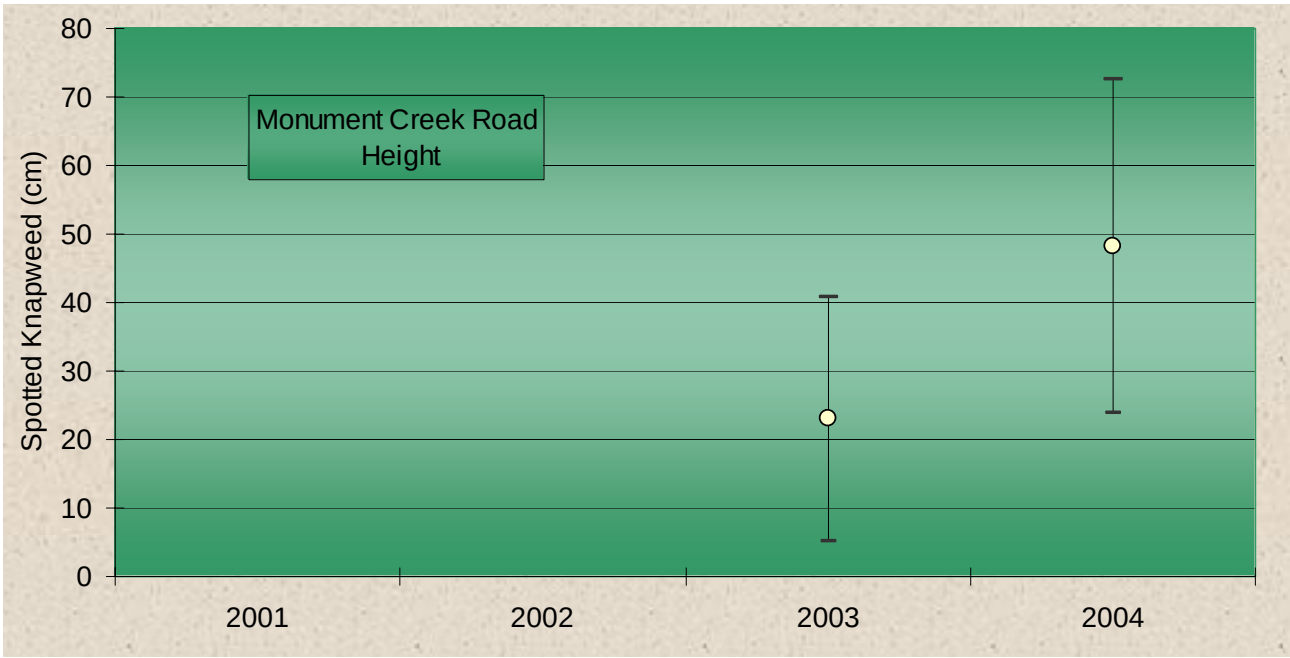


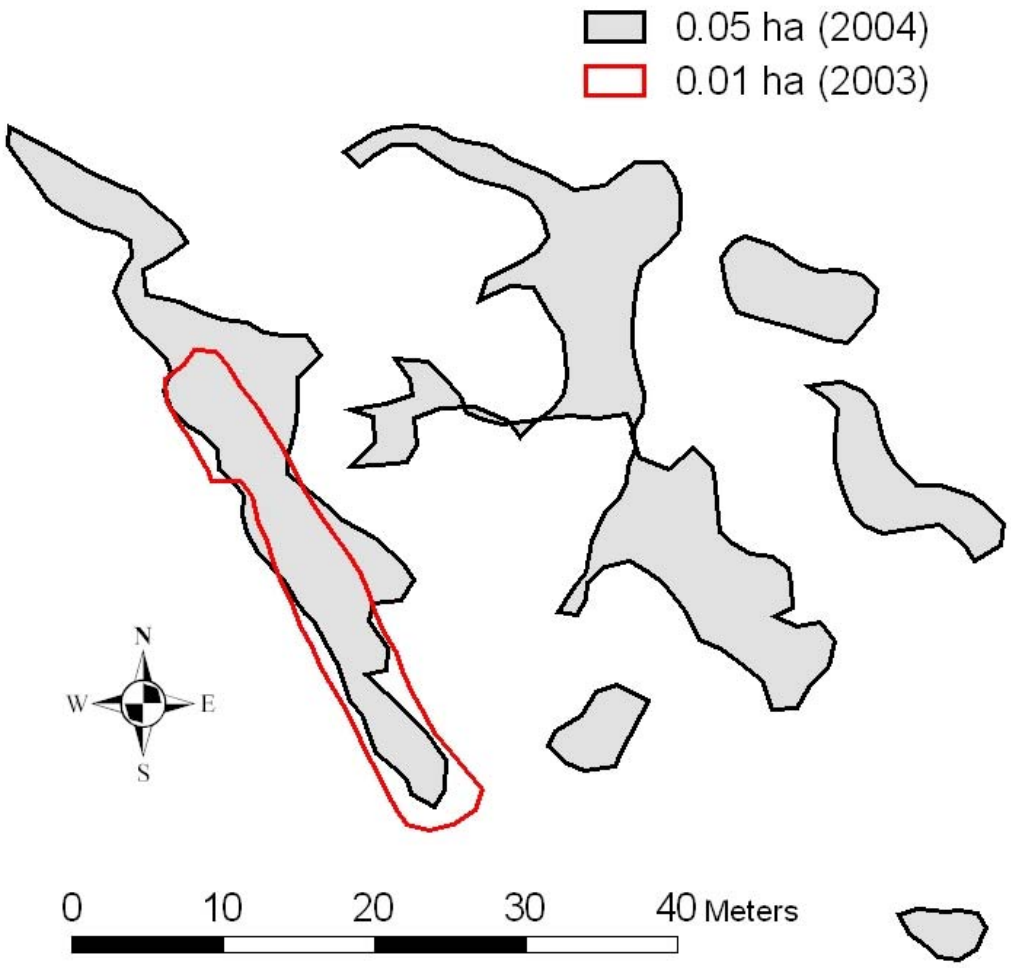
Monument Trail Road spotted knapweed density in 2004.



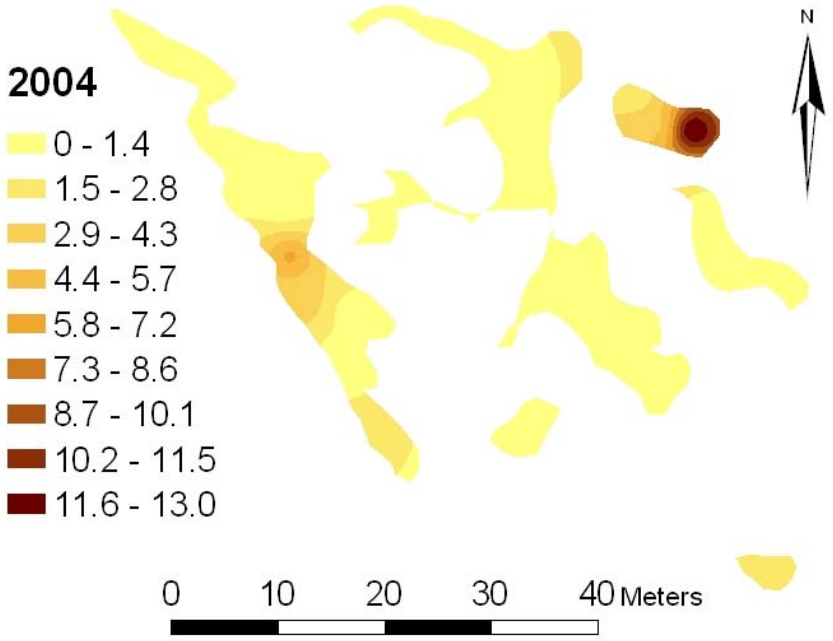


Monument Trail Road spotted knapweed height in 2004.

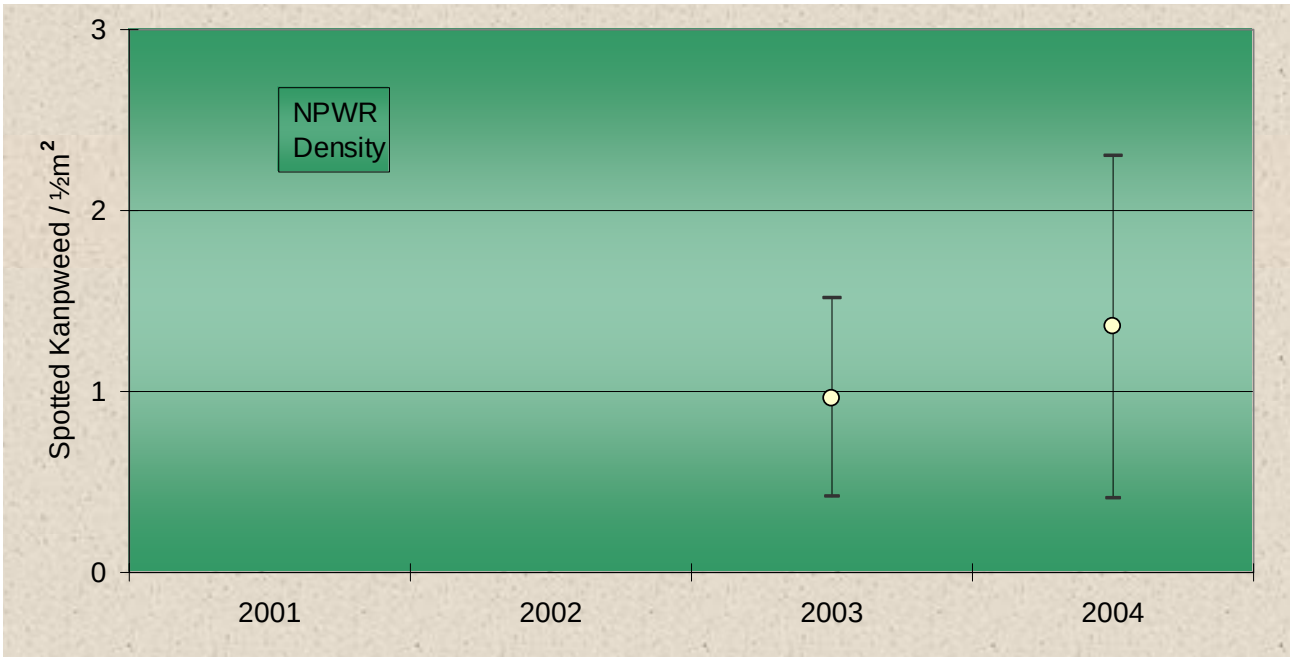


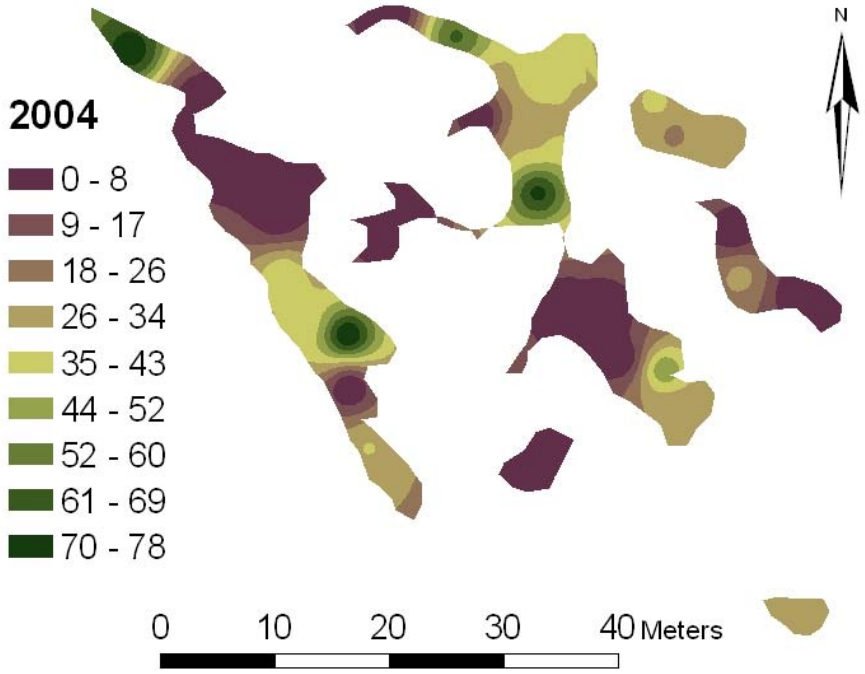


Non-potable Water Reservoir (NPWR) spotted knapweed perimeter in 2004.

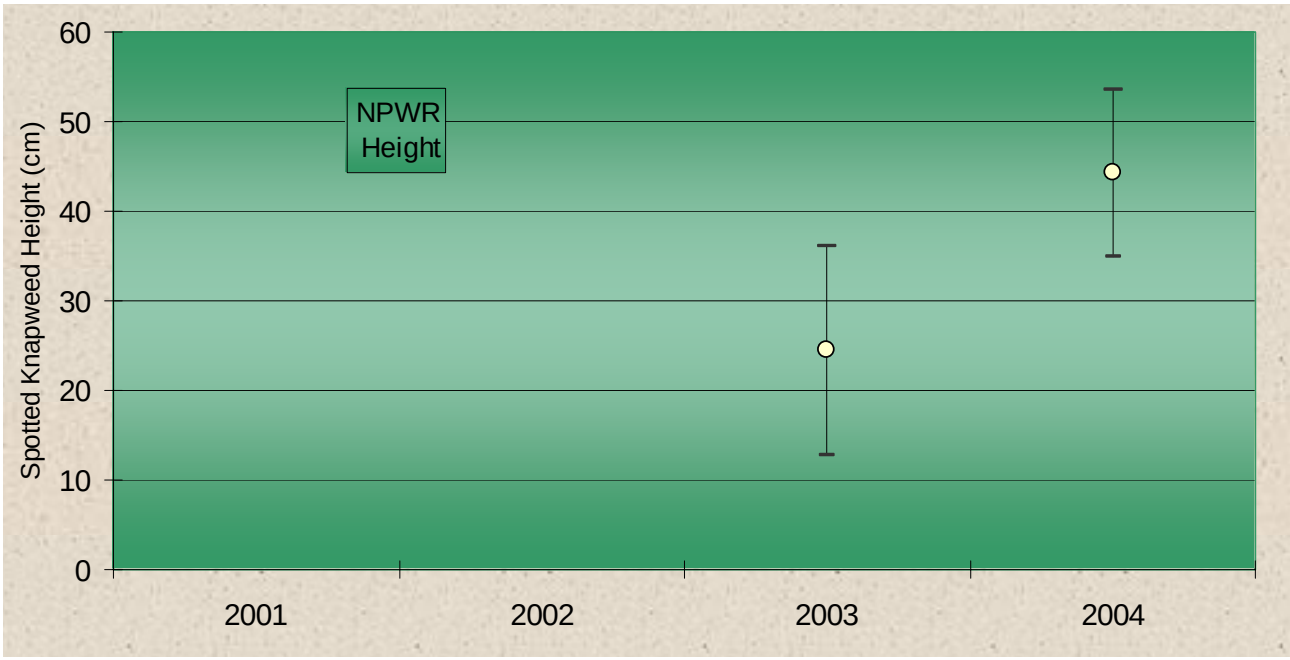


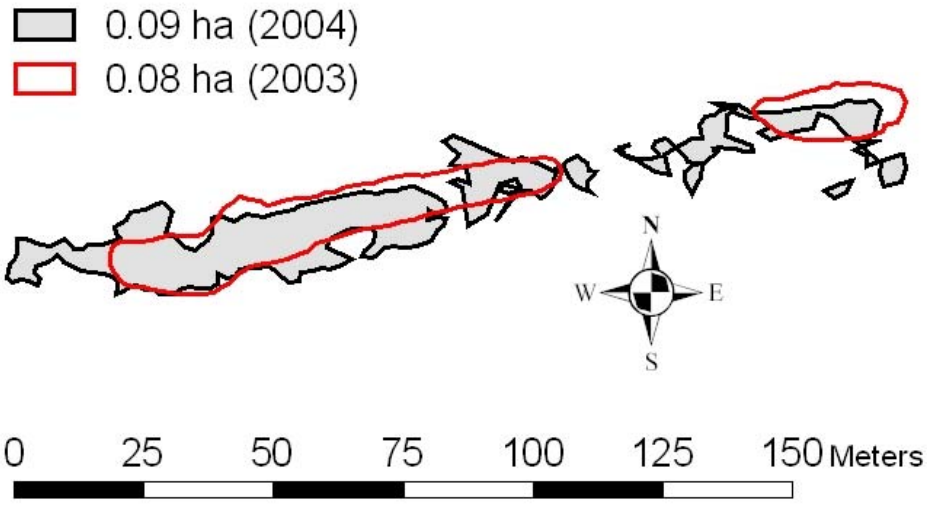
Non-potable Water Reservoir (NPWR) spotted knapweed density in 2004.



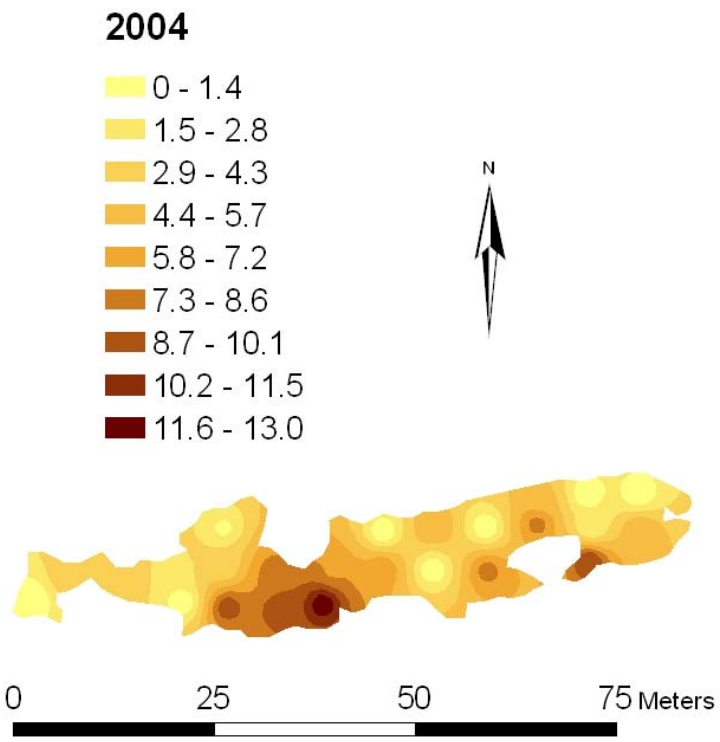


Non-potable Water Reservoir (NPWR) spotted knapweed height in 2004.

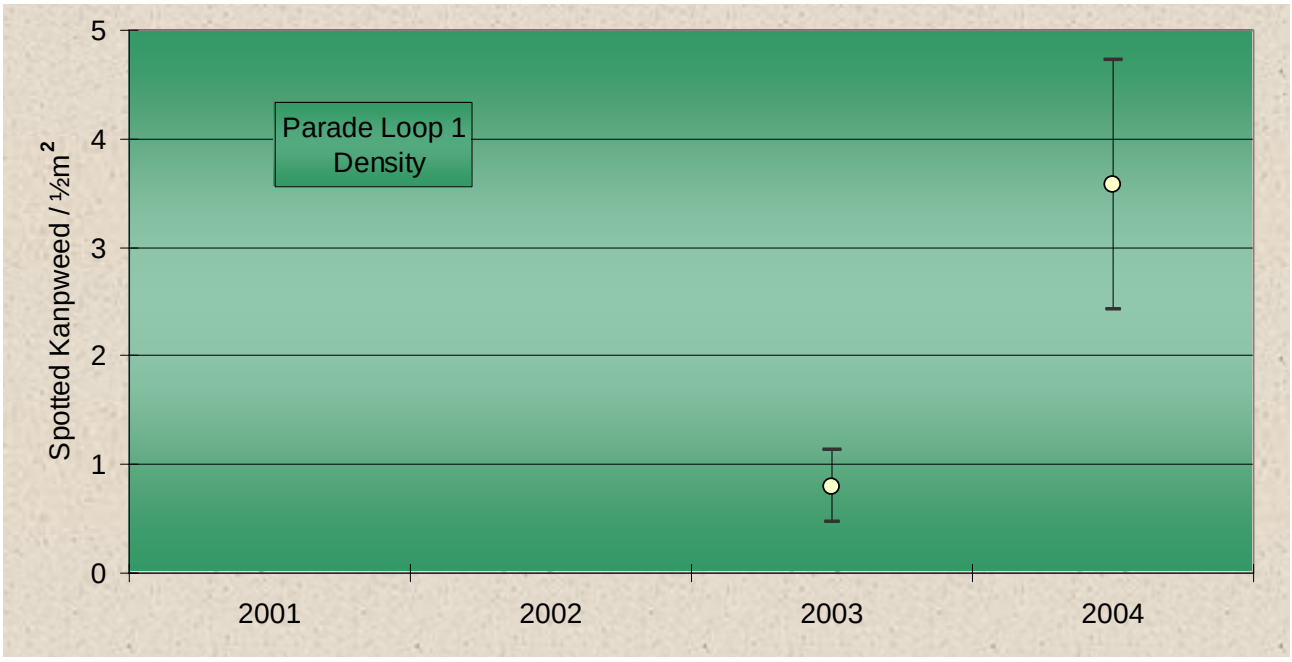


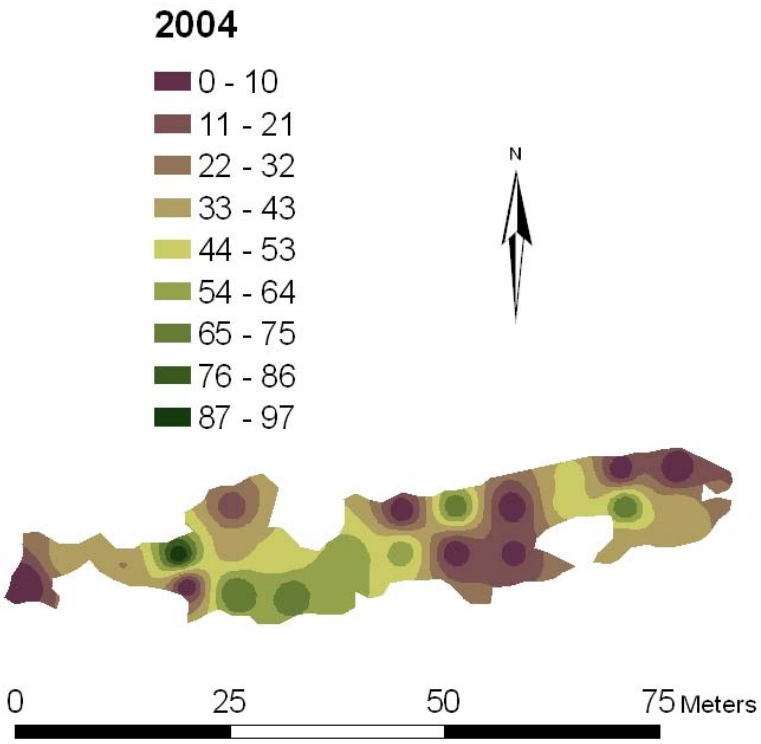


Parade Loop I spotted knapweed perimeter in 2004.

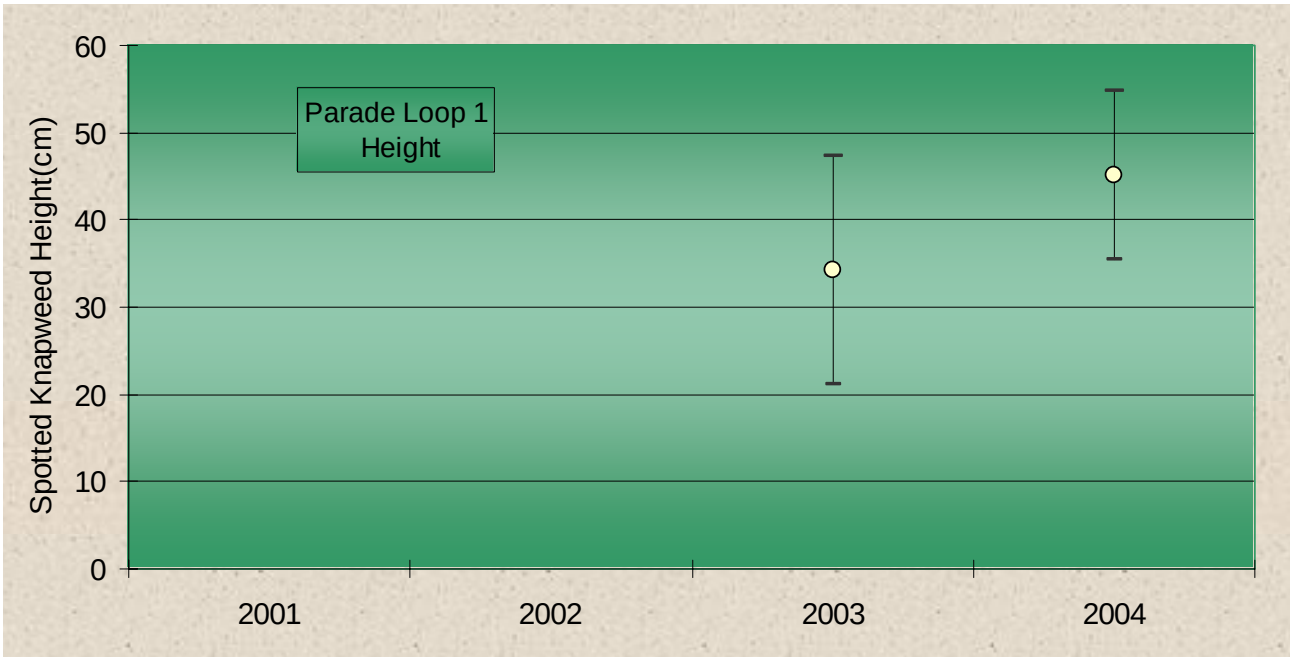


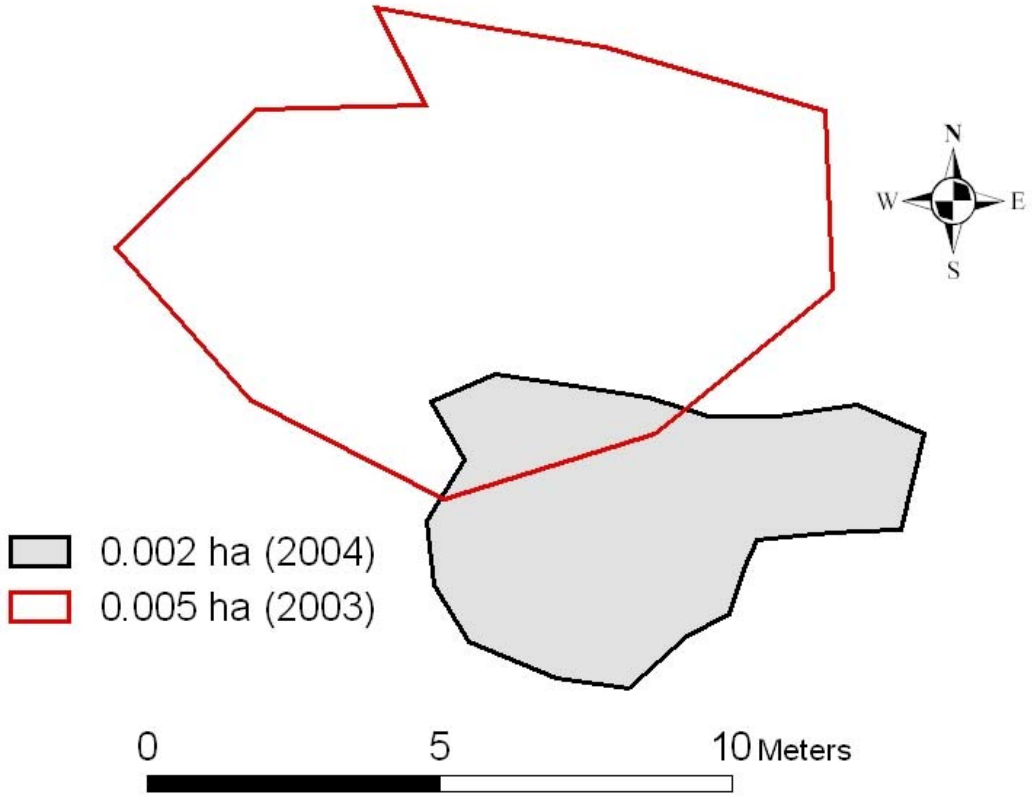
Parade Loop I spotted knapweed density in 2004.



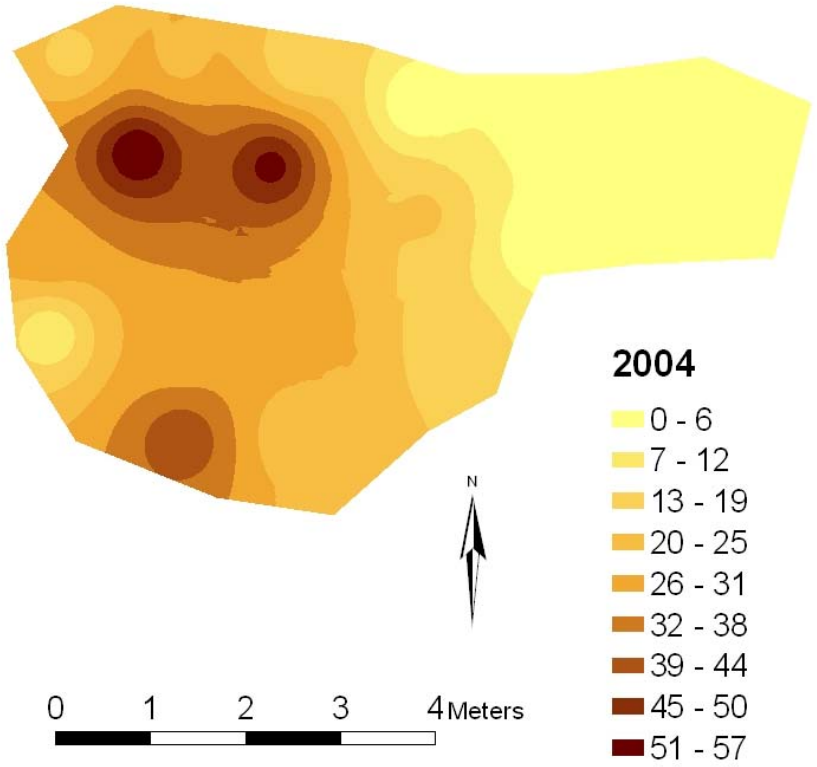


Parade Loop I spotted knapweed height in 2004.

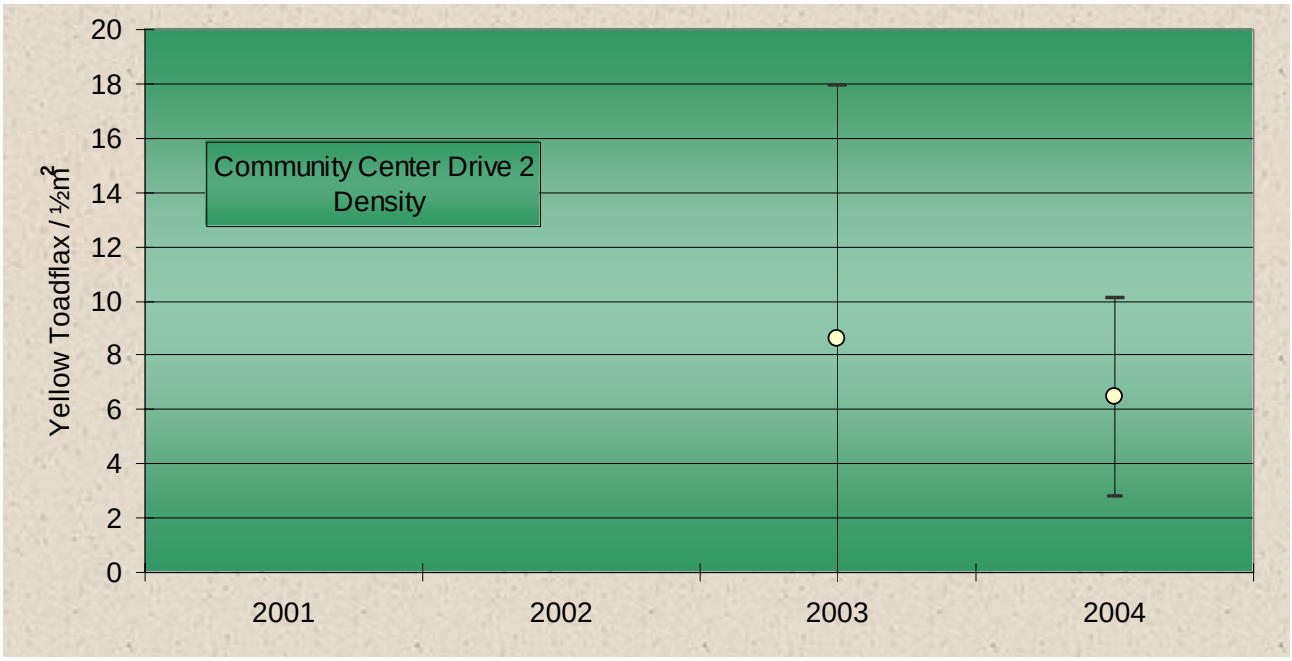


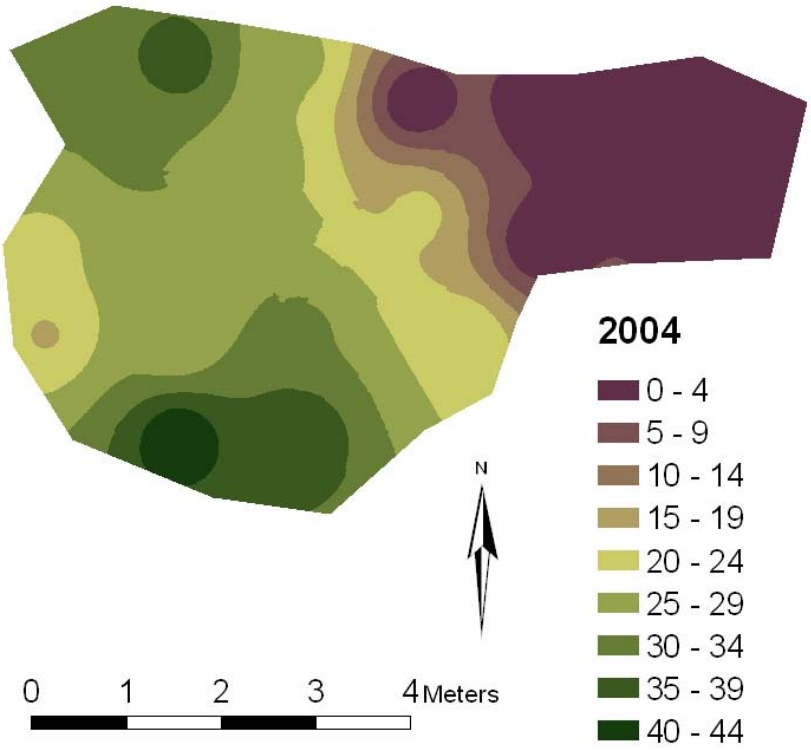


Community Center Drive I yellow toadflax perimeter in 2004.

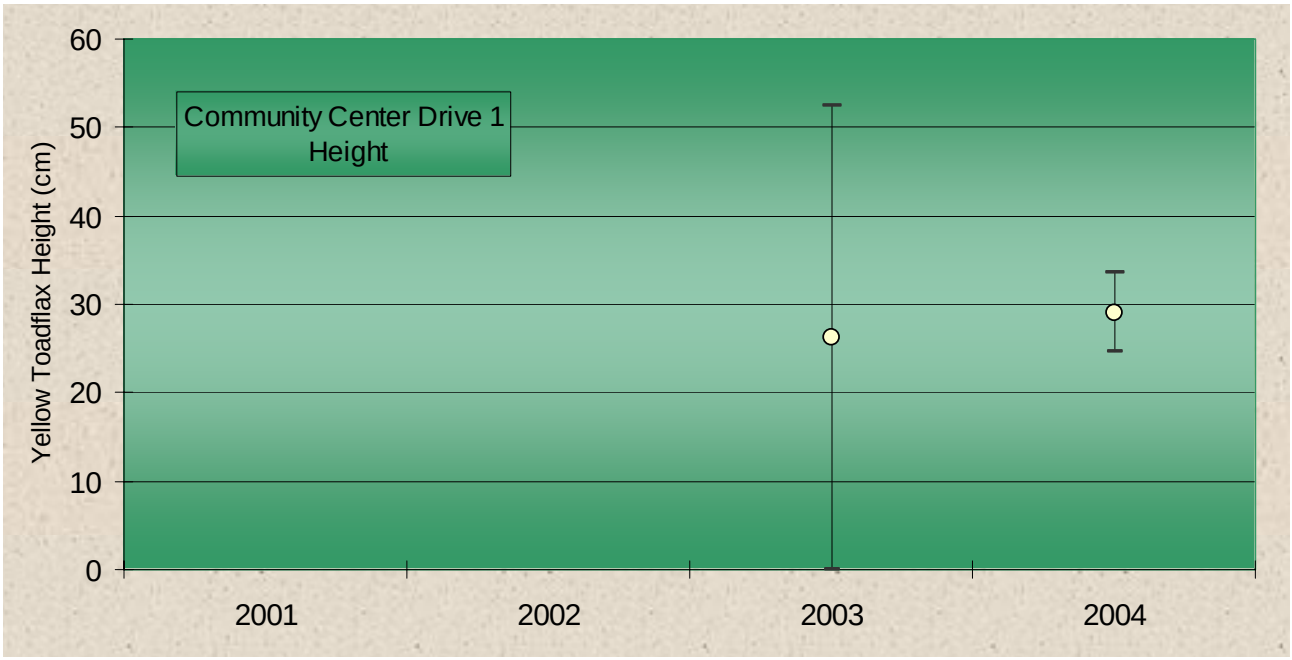


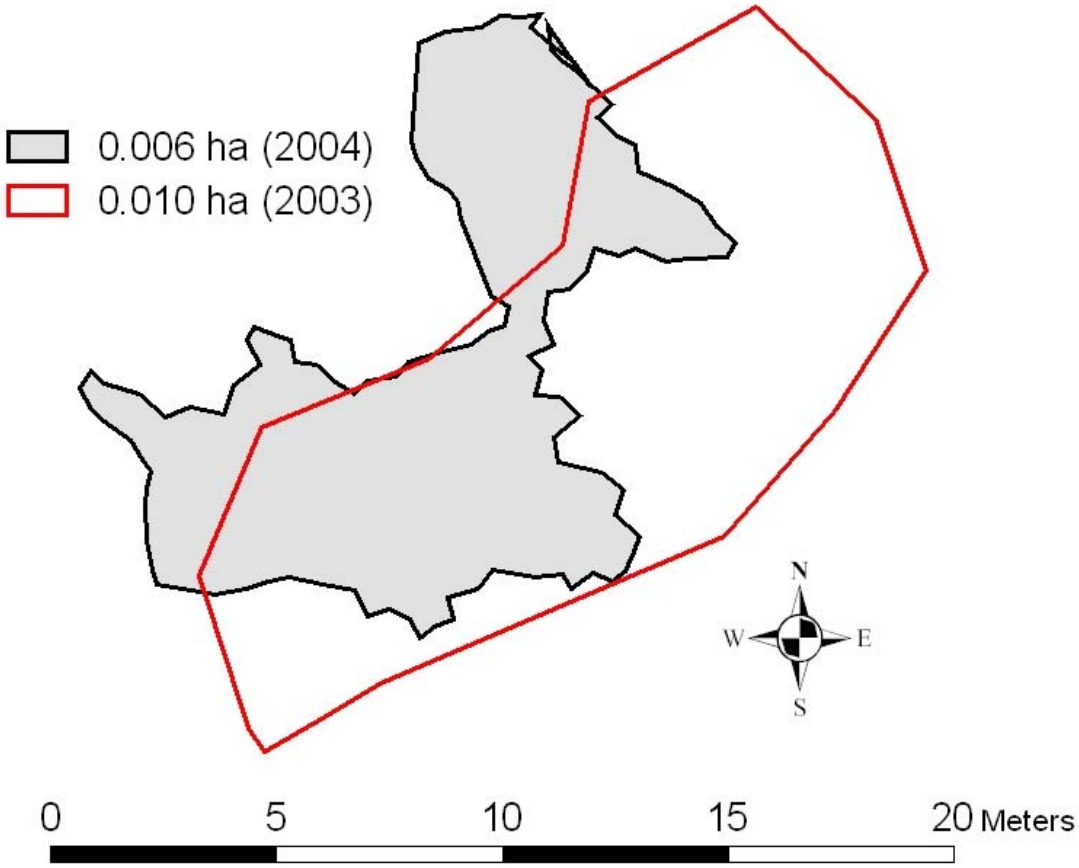
Community Center Drive I yellow toadflax density in 2004.



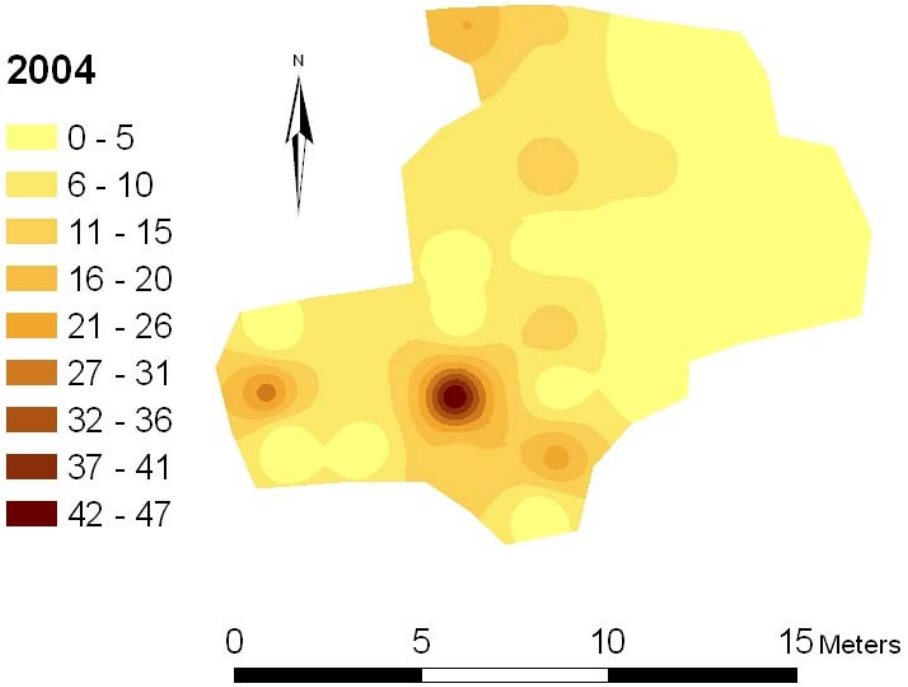


Community Center Drive I yellow toadflax height in 2004.

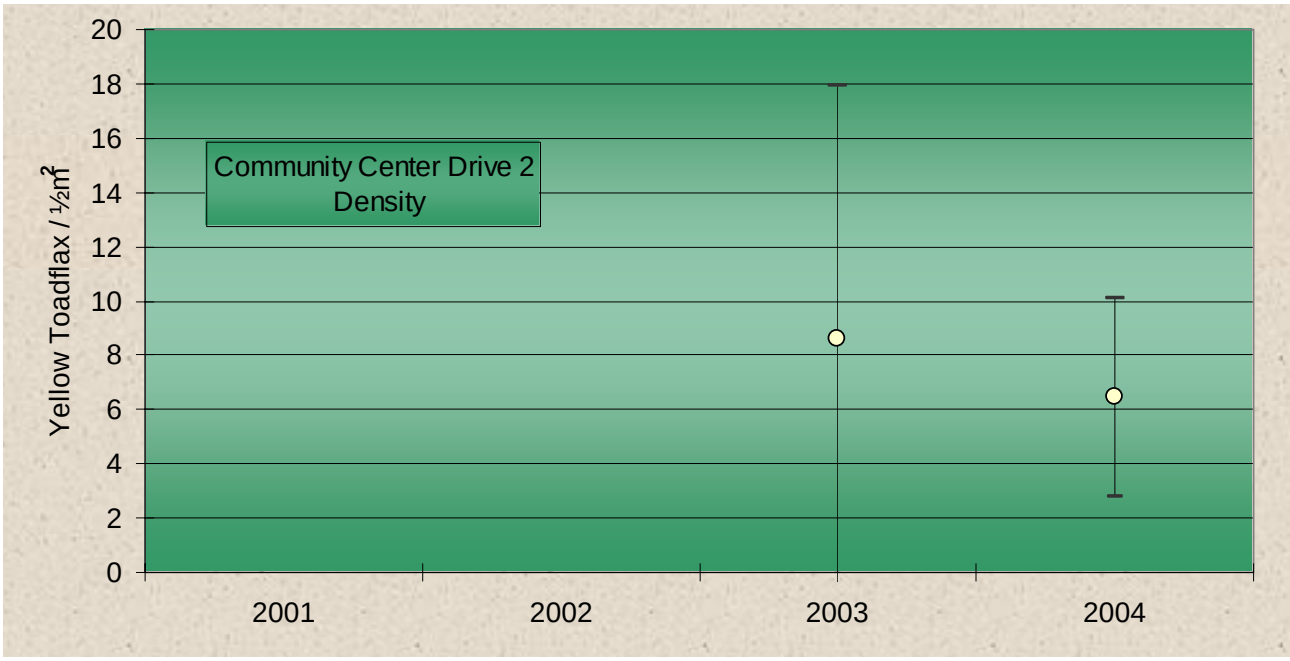


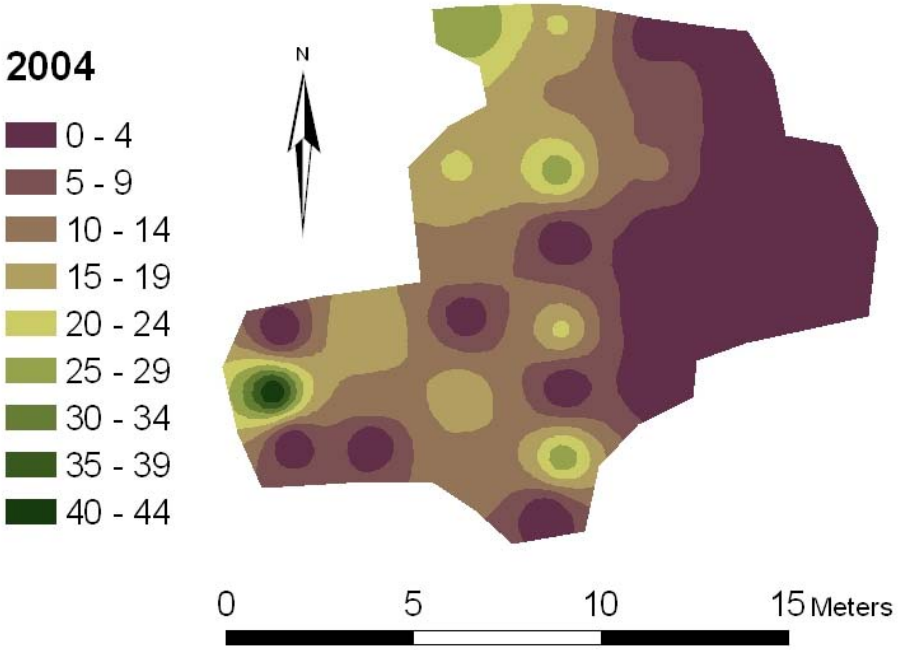


Community Center Drive II yellow toadflax perimeter in 2004.

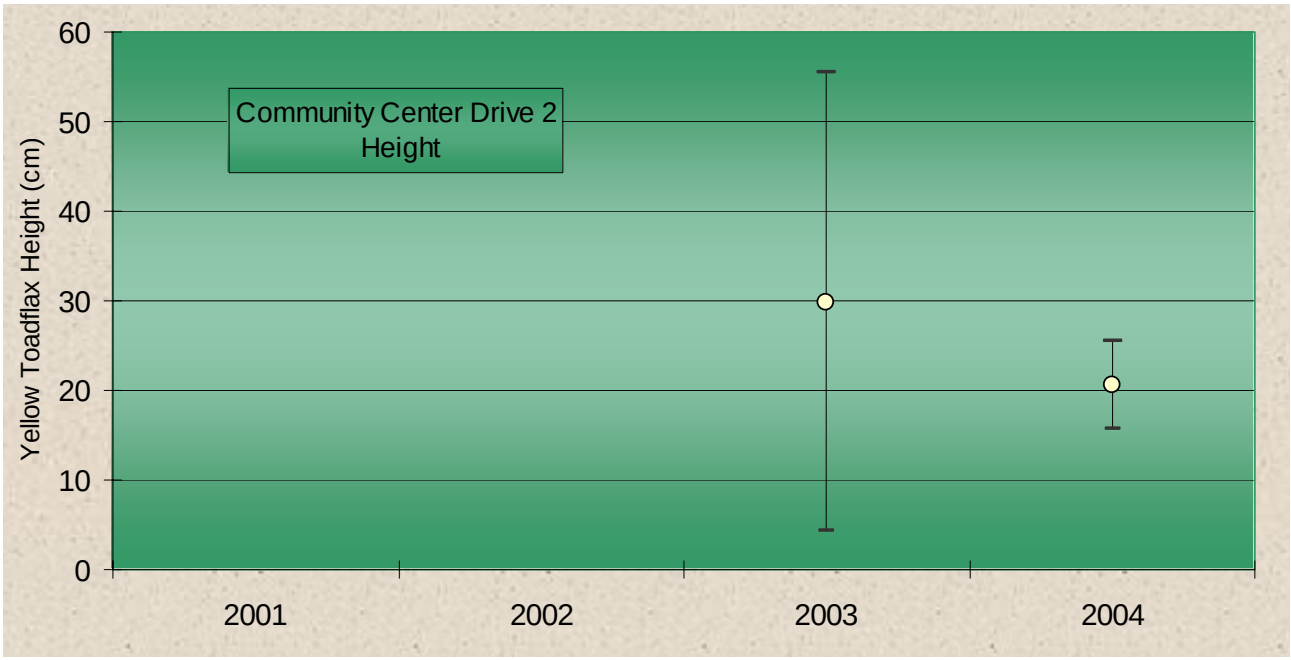


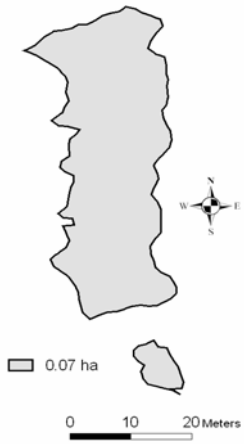
Community Center Drive II yellow toadflax density in 2004.



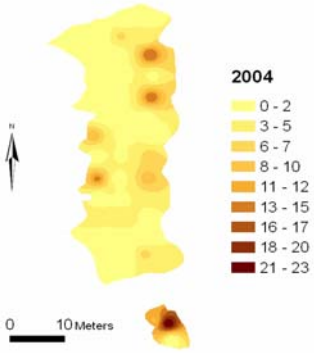


Community Center Drive II yellow toadflax height in 2004.

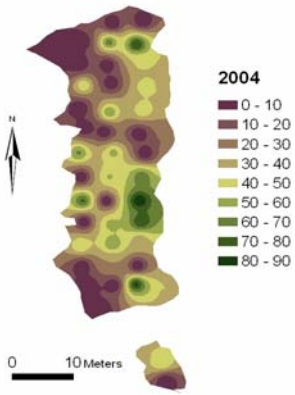




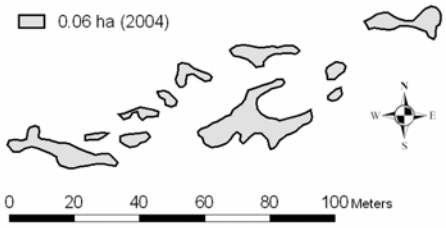
New Monument Creek spotted knapweed perimeter in 2004.



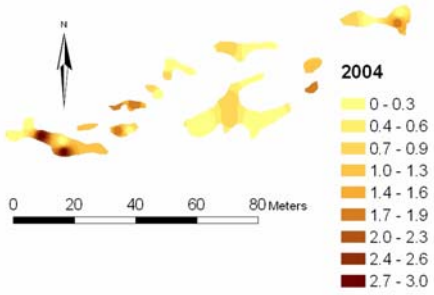
New Monument Creek spotted knapweed density in 2004.



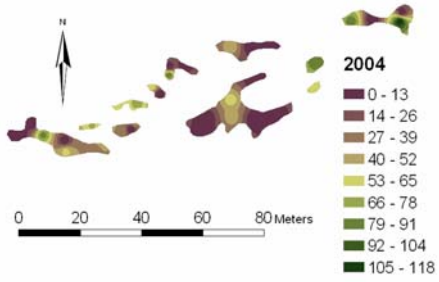
New Monument Creek spotted knapweed height in 2004.



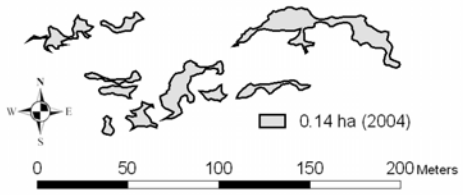
Parade Loop II spotted knapweed perimeter in 2004.



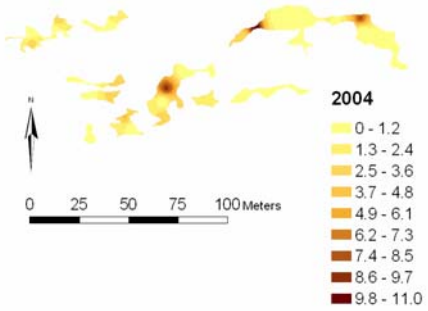
Parade Loop II spotted knapweed density in 2004.



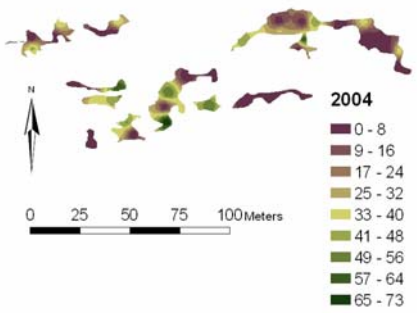
Parade Loop II spotted knapweed height in 2004.



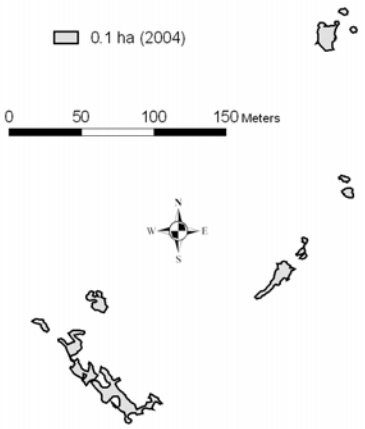
Parade Loop III spotted knapweed perimeter in 2004.



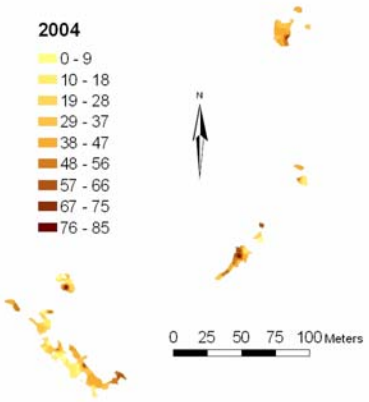
Parade Loop III spotted knapweed density in 2004.



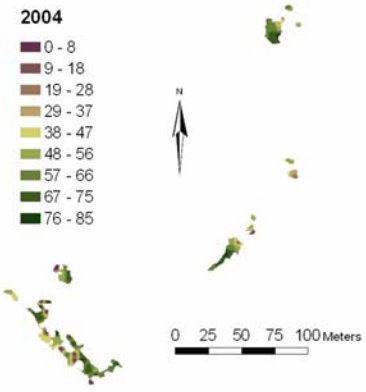
Parade Loop III spotted knapweed height in 2004.



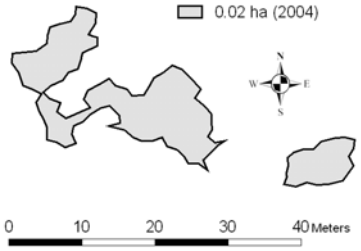
Kettle Creek St. Johnswort perimeter in 2004.



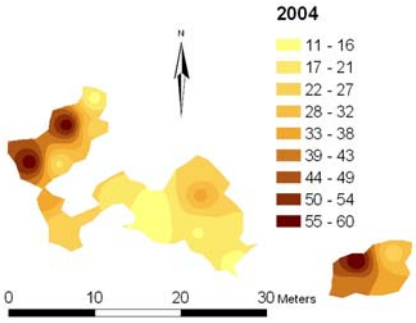
Kettle Creek St. Johnswort density in 2004.



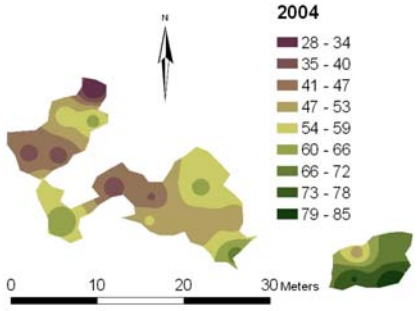
Kettle Creek St. Johnswort height in 2004.



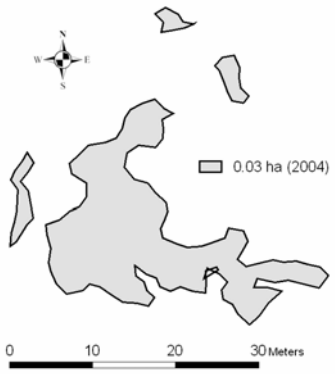
Midway Kettle Creek St. Johnswort perimeter in 2004.



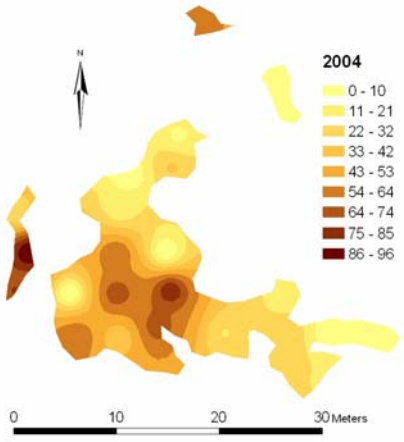
Midway Kettle Creek St. Johnswort density in 2004.



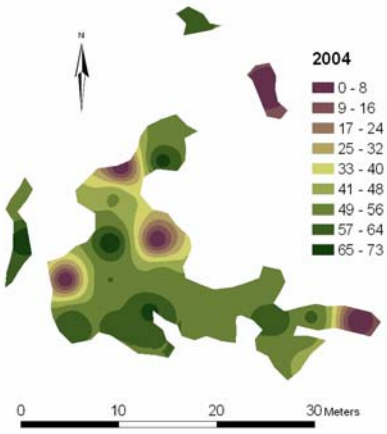
Midway Kettle Creek St. Johnswort height in 2004.



Santa Fe St. Johnswort perimeter in 2004.



Santa Fe St. Johnswort density in 2004.



Santa Fe St. Johnswort height in 2004.

Buckley Airbase

In 2004, eight weed populations comprising four different plant species were monitored during year two of the biological control program at Buckley Airbase. The main biocontrol targets for this installation are Canada thistle (0.14 ha mapped in 2004), field bindweed, leafy spurge (0.5 ha in 2004) and Dalmatian toadflax (2.1 ha monitored in 2004). Six of the eight weed infestations were identified and mapped in the first year of the program (2003), including Williams Lake Canada thistle and leafy spurge patches, South Aspen Way and South Fence Dalmatian toadflax infestations and field bindweed between the base entrance and RV storage lot and along South Aspen Way. Two new leafy spurge infestations (Runway, Southwest Williams Lake) were identified and mapped in 2004. The list of biological control agents released onto each weed patch can be found in Table 4, along with a record of insects recovered and new releases in 2004. Table 5 contains weed infestation monitoring data and illustrates the change in weed quantity and quality (i.e. density of infestation and height of plants).

Over one year, the area of the leafy spurge infestation was reduced at Williams Lake by 21%, density by 59% and the height of sampled plants by 22%. Similarly, the Dalmatian toadflax infestation at the South Fence site declined by 37% in area, 5% density and 19% height (Table 5). Construction and tree planting on the South Aspen Way toadflax site artificially reduced the area to sample for this weed in 2004. We will continue to monitor this area in subsequent years, however, and evaluate its suitability for biological control using the stem-boring weevil, *Mecinus janthinus*, as the spread of this weed is likely along the disturbed ground of a newly established tree row.

Figure 10. The Runway site, a new leafy spurge infestation, was mapped in 2004. One hundred forty-nine *Aphthona spp*. beetles were redistributed here from Williams Lake.

A total of 2149 insects were released onto weeds at 5 biocontrol sites at Buckley Airbase in 2004. Visual inspection of toadflax plants at the South Fence site did not show enough evidence that the *M. janthinus* released in 2003 successfully established, thus a supplementary release of 1500 weevils was made in late spring 2004. Toadflax stems collected during the 2004 growing season are being dissected to determine what level of biocontrol agent establishment occurred in the first year since weevil release.

Augmentative releases of the bindweed mite, *Aceria malherbae*, were made on both the RV storage lot bindweed site and along the South Aspen Way bindweed infestation (Figure 11). Populations of the mite were detected at both sites prior to release, however additional releases were made to boost mite populations and their potential for bindweed suppression, as climatic conditions made this an ideal year for field bindweed growth. Both releases are located in areas that are frequently mowed, greatly enhancing the dispersal capabilities of these biocontrol agents to nearby bindweed infestations. Reduction of the amount of field bindweed on Buckley Airbase continues to be a primary biocontrol objective and further releases of *A. malherbae* will be made in 2005 at sites identified this year as bindweed problem areas.

Figure 11. Photo, taken in 2003, of a healthy bindweed infestation at Buckley Airbase prior to impact by the biological control agent, *Aceria malherbae*. Damage caused by the mite can be seen in the inset photo.

Two species of defoliating flea beetle, *Aphthona nigriscutis* and *A. flava*, were recovered at the Williams Lake leafy spurge site in sufficient numbers to enable their redistribution to a new spurge infestation (Runway). This site is a relatively small (Figure 10), isolated patch of leafy spurge, making it an ideal biocontrol target. We will continue to monitor both the weed and biocontrol agent populations at this and other leafy spurge sites in coming years. The two original Williams Lake infestations quantified in 2003 (listed in the previous report as Leafy Spurge Site 1 and Williams Lake Dam) were amalgamated for simplification in 2004 due to their close proximity. No biological control agent release has been scheduled for the new Southwest Williams Lake site, as established populations of the highly mobile *Aphthona* beetles are anticipated to disperse from the original Williams Lake sites onto this area. We will continue to monitor the weed infestation, however, and redistribute into this site as necessary.

No biocontrol insects have been recovered on Canada thistle, and consequently, another 500 *Cassida rubiginosa* beetles were released into the Williams Lake thistle infestation this summer (see Figure 12). Monitoring thistle biological control agents, along with quantification of the weed infestation parameters, will continue in 2005.

Figure 12. Typical feeding damage of *Cassida rubiginosa* (center of photo) on Canada thistle.

Table 4. Noxious weed biological control sites, target weeds, species released and recoveries at Buckley Airbase, 2004.

Location	Target weed	Site	Species released	Species recovered	New releases	New site
Buckley Airbase	Canada thistle	Williams Lake	*Cassida rubiginosa*		X	
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	Runway	*Aphthona flava*	X	X	X
Buckley Airbase	Leafy spurge	Runway	*Aphthona nigriscutis*	X	X	X
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona czwalinae*			
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona flava*	X [2]		
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona lacertosa*			
Buckley Airbase	Leafy spurge	Williams Lake	*Aphthona nigriscutis*	X [2]		
Buckley Airbase	Leafy spurge	Southwest Williams Lake				
Buckley Airbase	Dalmatian toadflax	South Aspen Way				
Buckley Airbase	Dalmatian toadflax	South Fence	*Mecinus janthinus*		X	

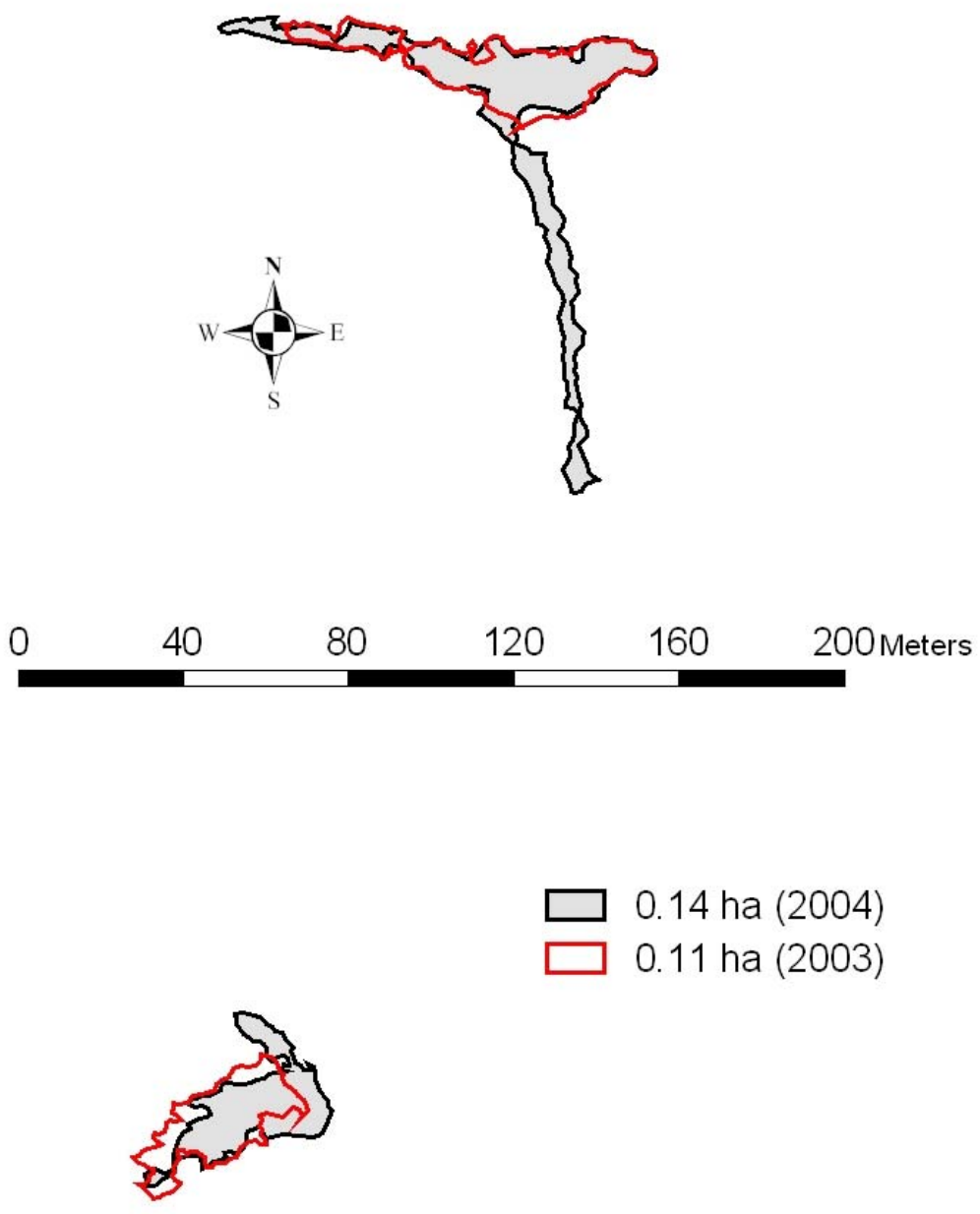
[1] Adventitious recovery, none released at this site
[2] New recovery in 2004

Table 5. Historic noxious weed infestation parameters, Buckley Airbase, Colorado, 2003.

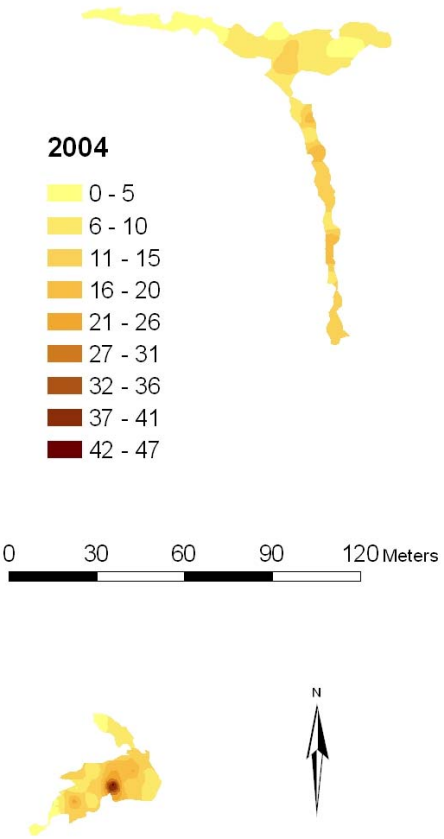
Year	Area (m^2)	n	(1/2m^2)		Height (cm)		Seedheads	Head size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
Canada thistle - William's Lake												
2003	1,070	129	6.74	26	71.20	145	17.83	0.71				
2004	1,419	66	8.21	47	55.41	98	1.40	1.80	32.63	21.81	-22.18	32.63
Leafy spurge - Runway												
2004	597	44	22.61	42	35.09	54			na	na	na	na
Leafy spurge - Southwest William's Lake												
2004	530	24	8.92	26	25.13	52			na	na	na	na
Leafy spurge - William's Lake												
2003	4,615	112	33.65	123	43.32	98						
2004	3,617	77.00	15.01	52	40.67	73			-21.63	-55.39	-6.12	-21.63
Dalmatian toadflax - South Aspen Way												
2003	3,185											
2004	300	20	0.95	7	11.40	38			na	na	na	na
Dalmatian toadflax - South Fence												
2003	32,556	374	3.50	78	36.10	128						
2004	20,657	101	3.31	18	48.48	82			-36.55	-5.43	34.29	-36.55

n - number of samples or observations.

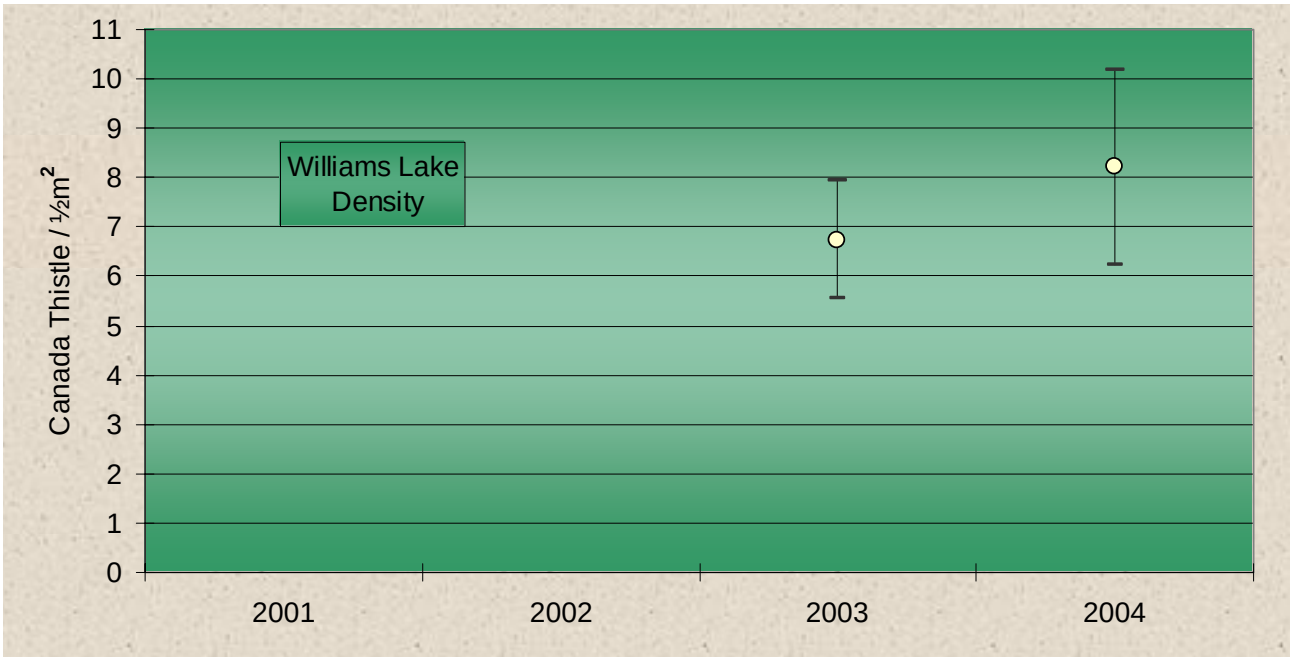
na - not applicable, data represent first year of sampling.

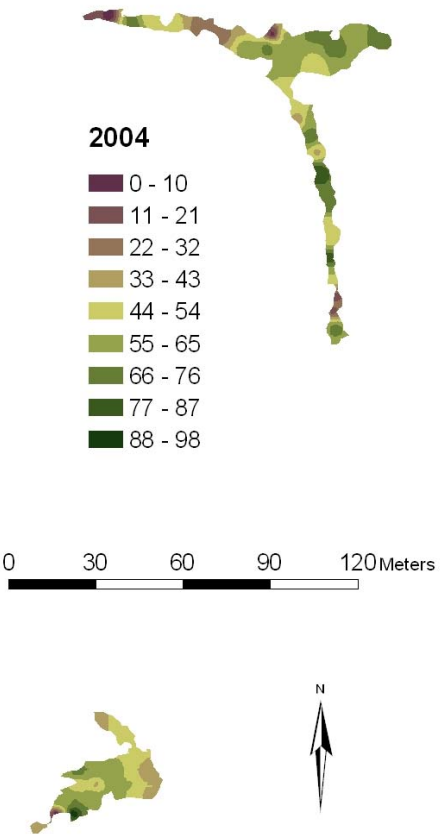


Williams Lake Canada thistle perimeter in 2004.

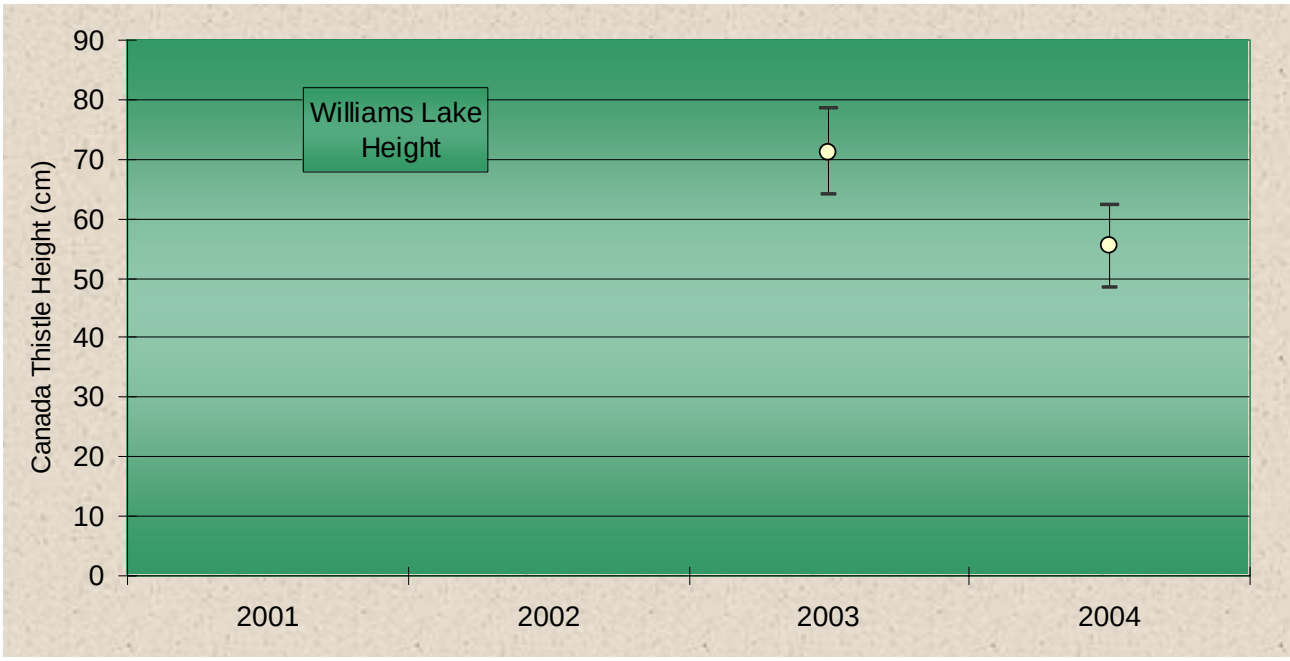


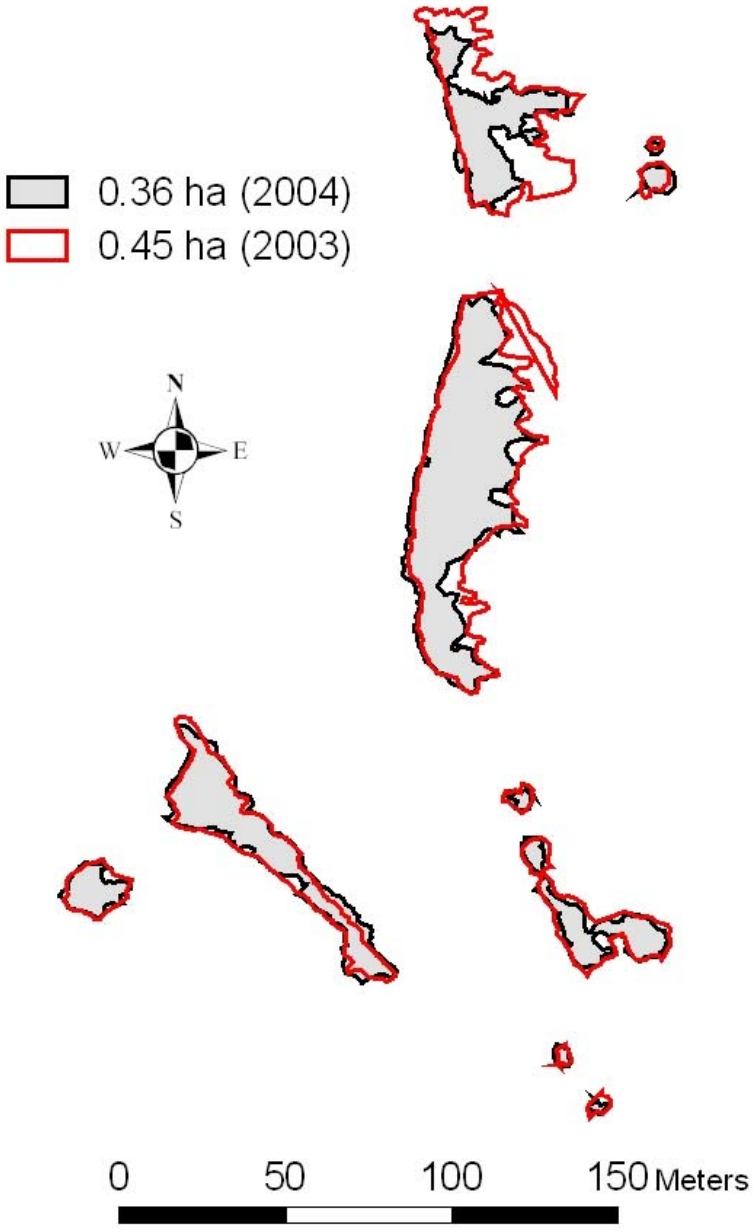
Williams Lake Canada thistle density in 2004.



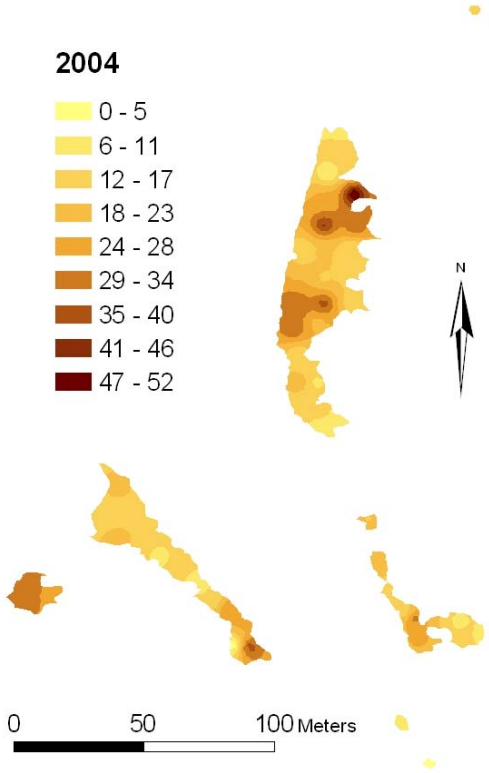


Williams Lake Canada thistle height in 2004.

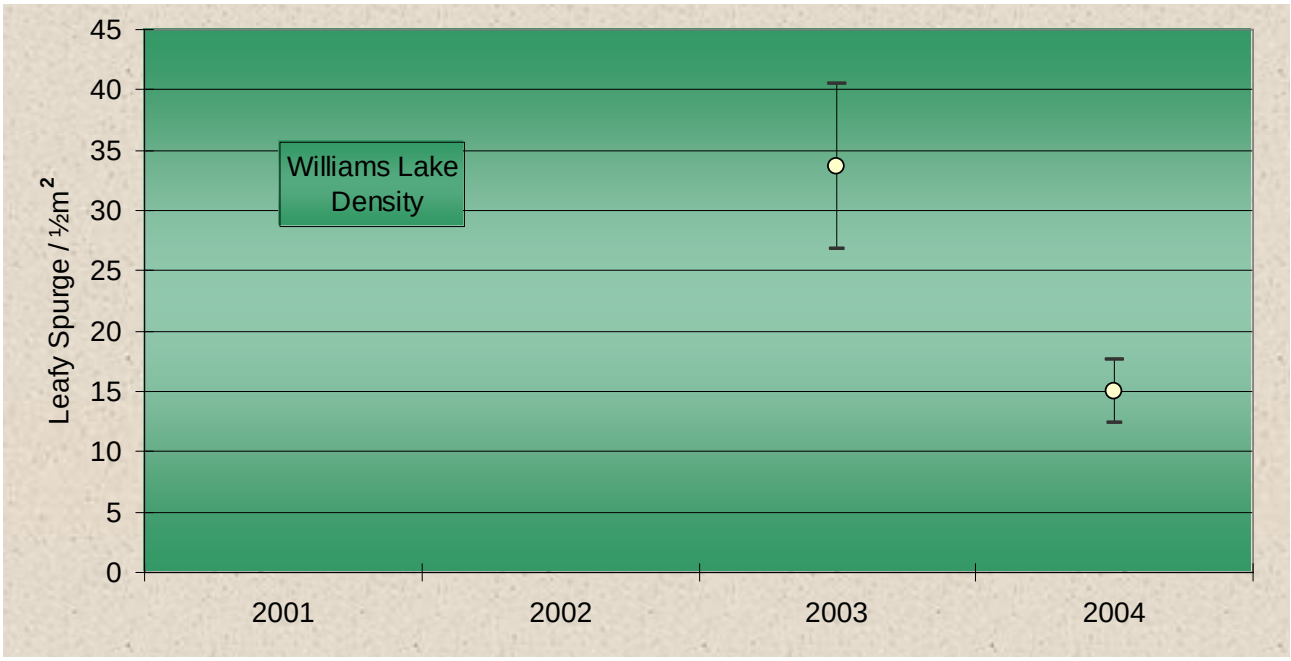


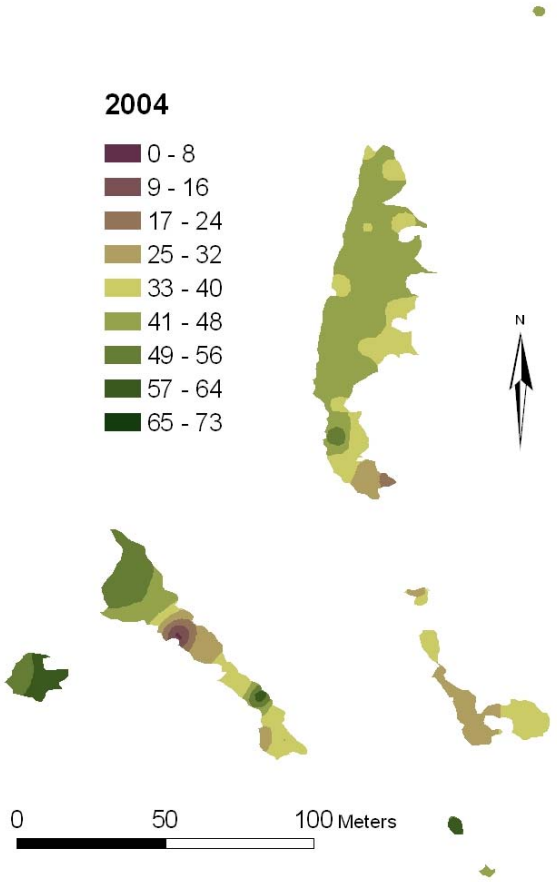


Williams Lake leafy spurge perimeter in 2004.



Williams Lake leafy spurge density in 2004.





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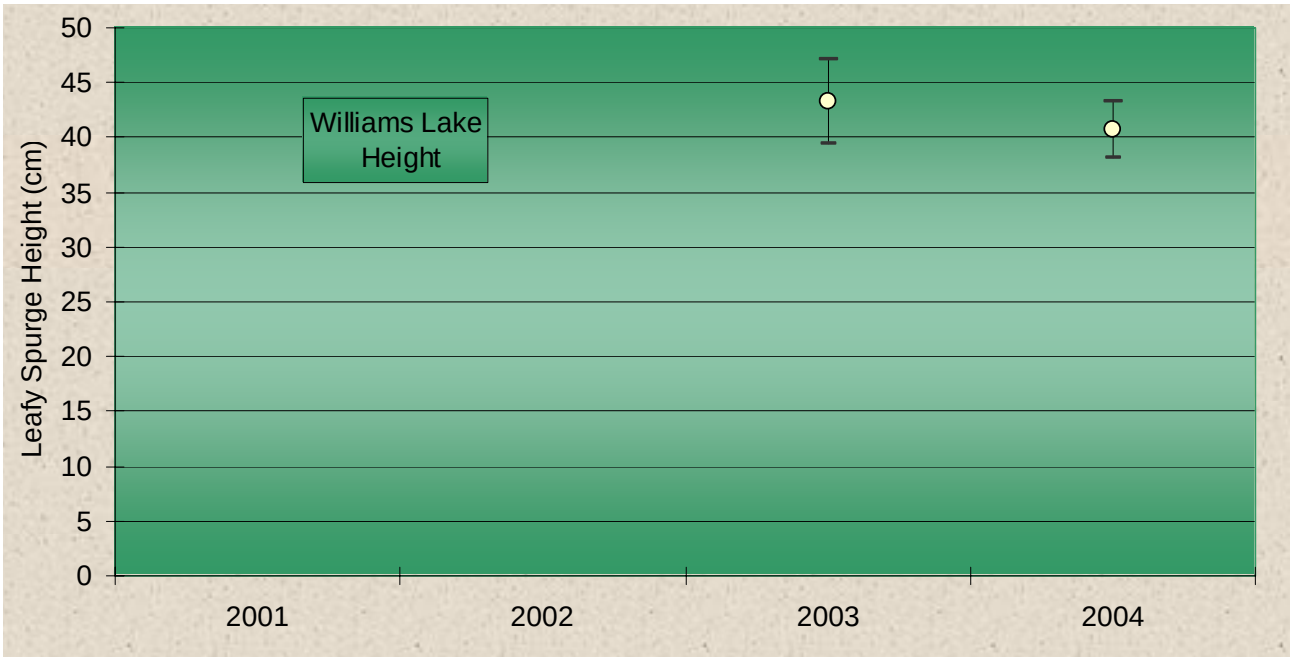
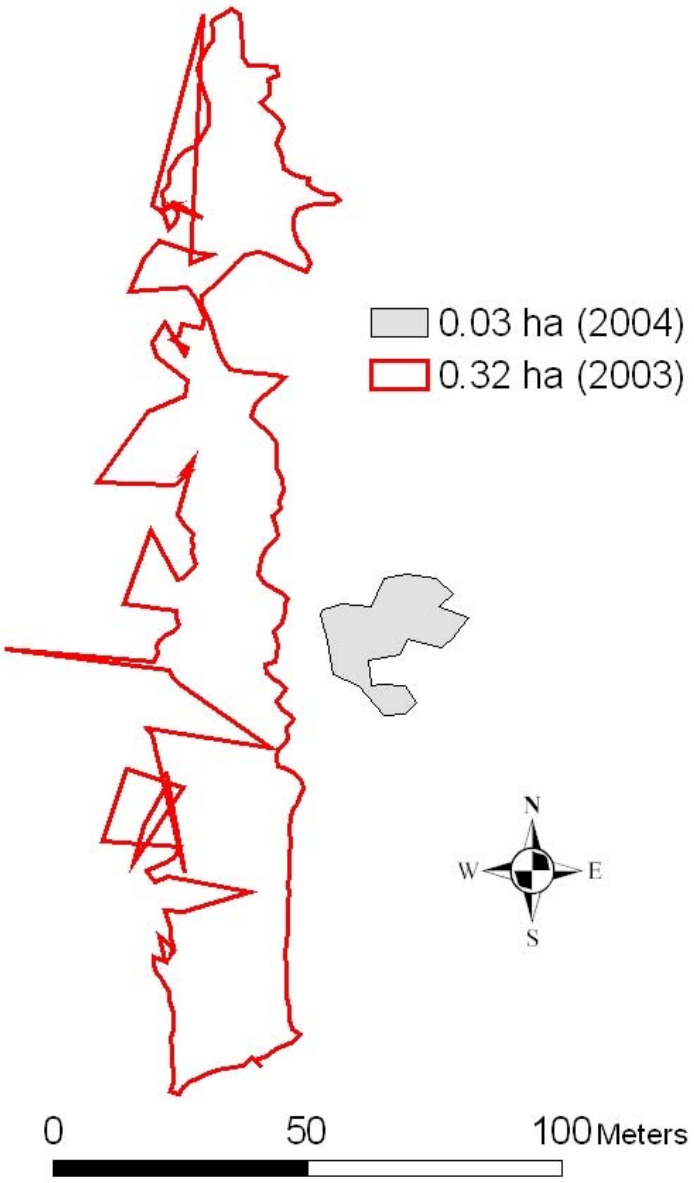
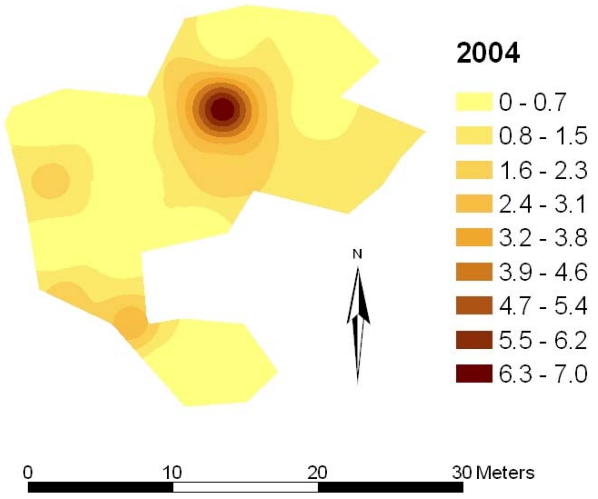
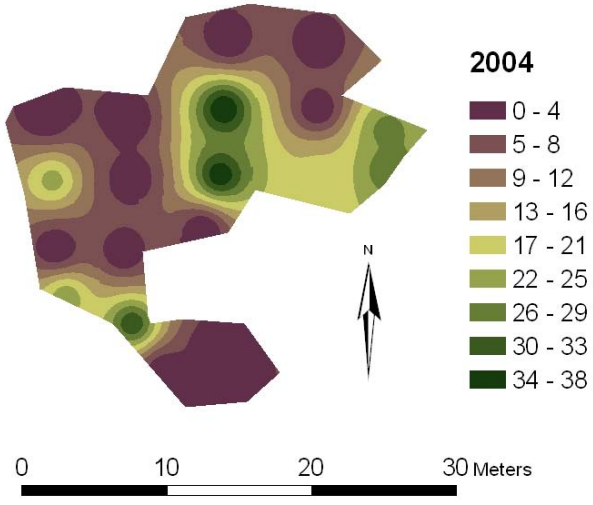




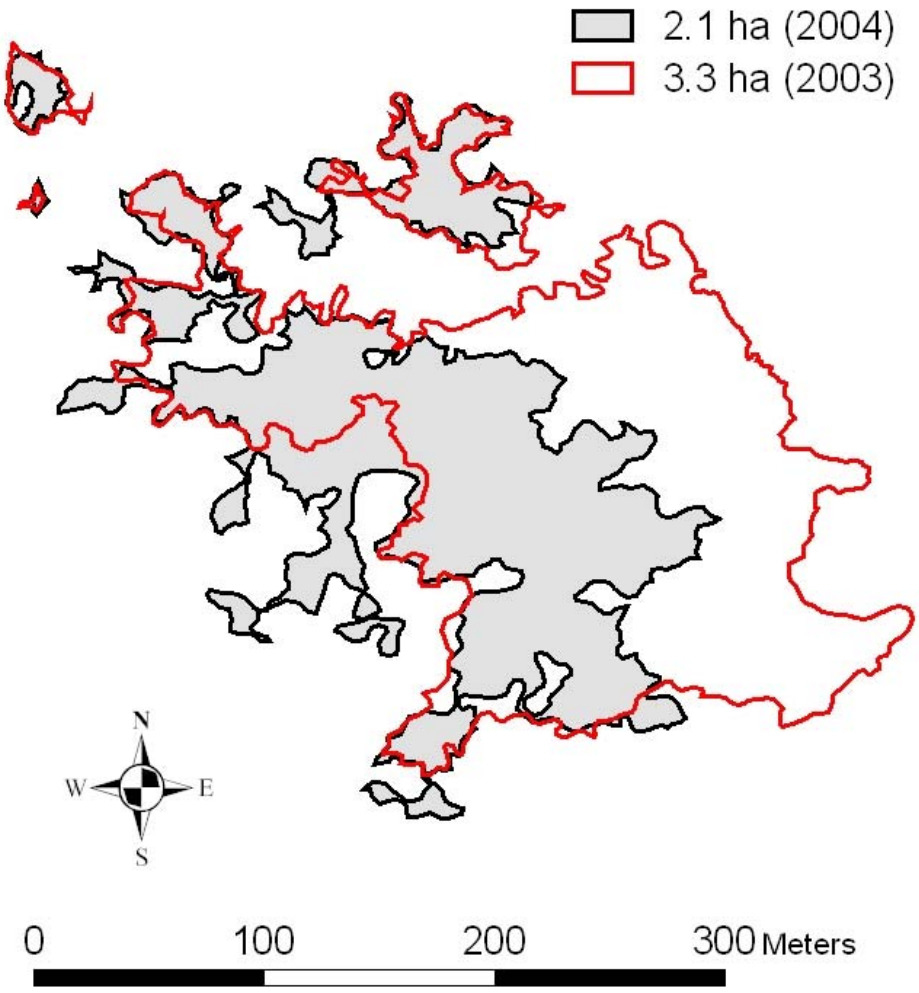
South Aspen Way Dalmatian toadflax perimeter in 2004.



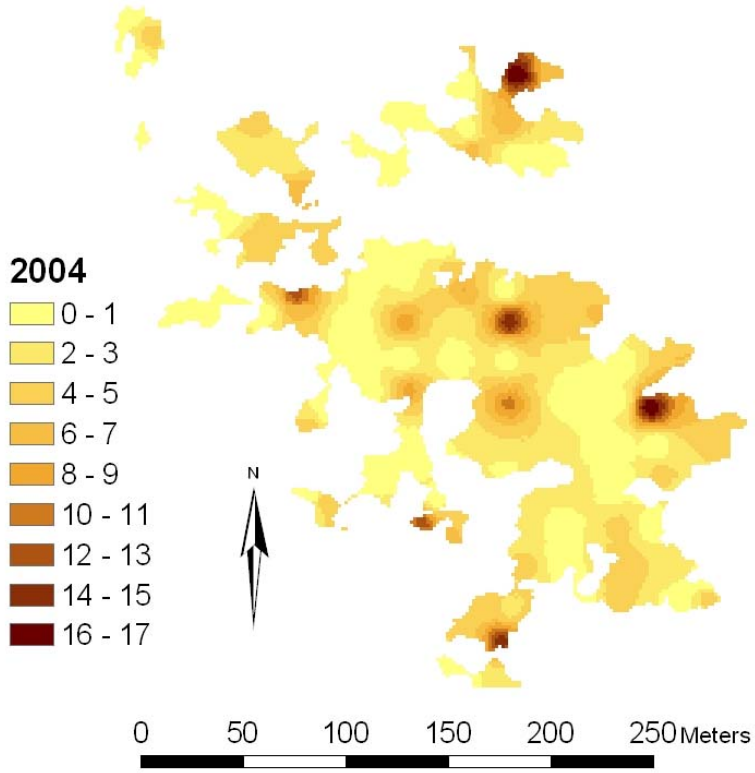
South Aspen Way Dalmatian toadflax density in 2004.



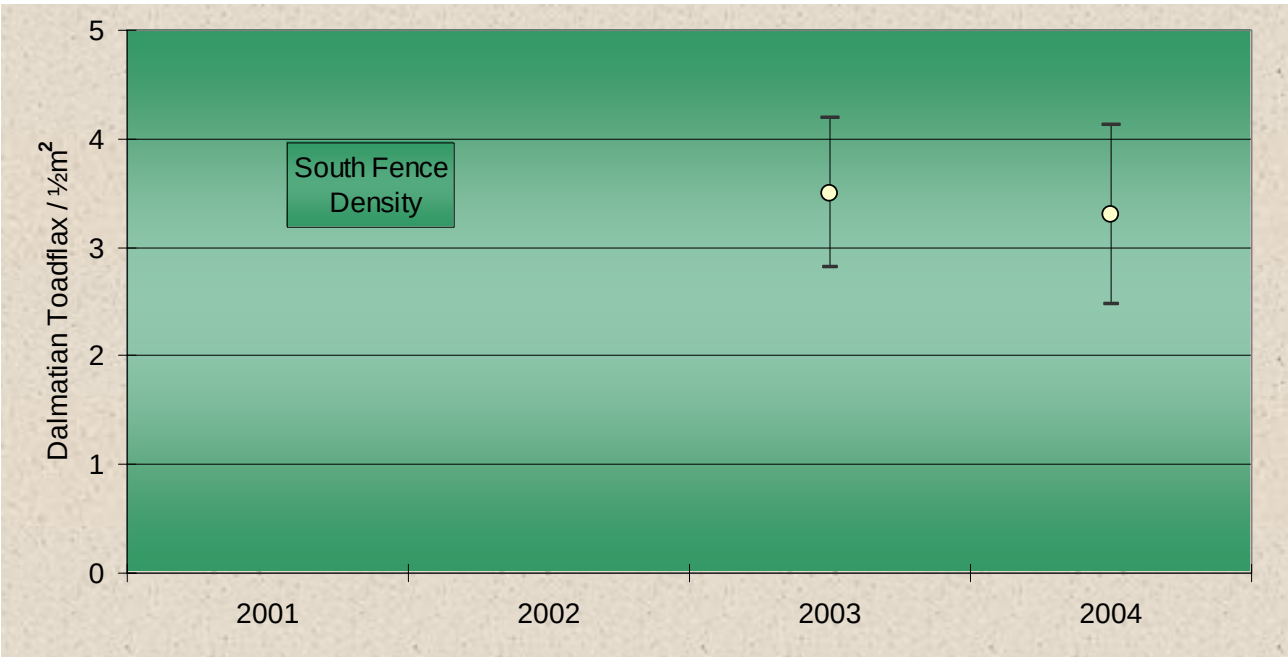
South Aspen Way Dalmatian toadflax height in 2004.

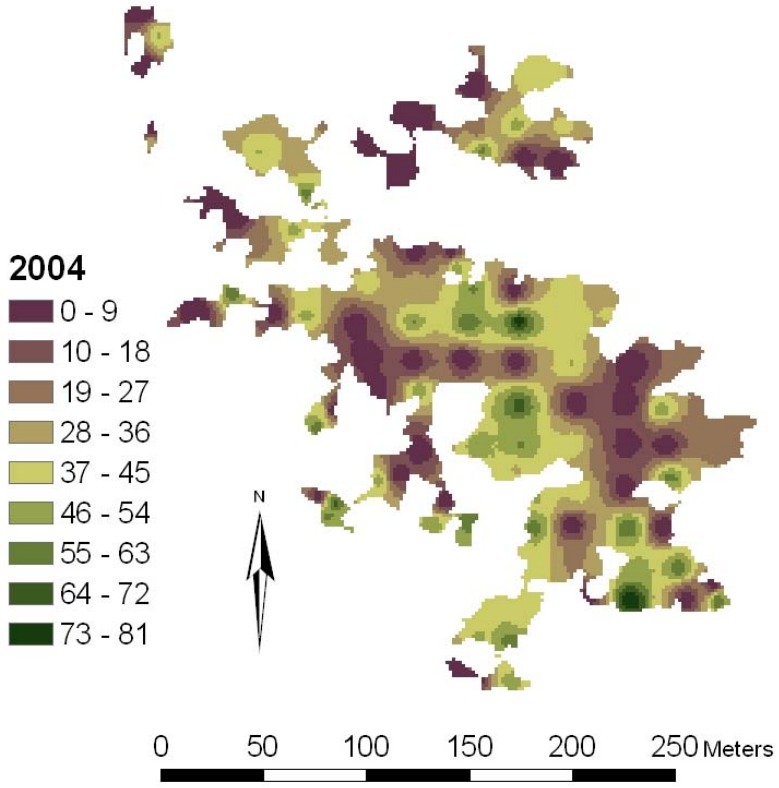


South Fence Dalmatian toadflax perimeter in 2004.

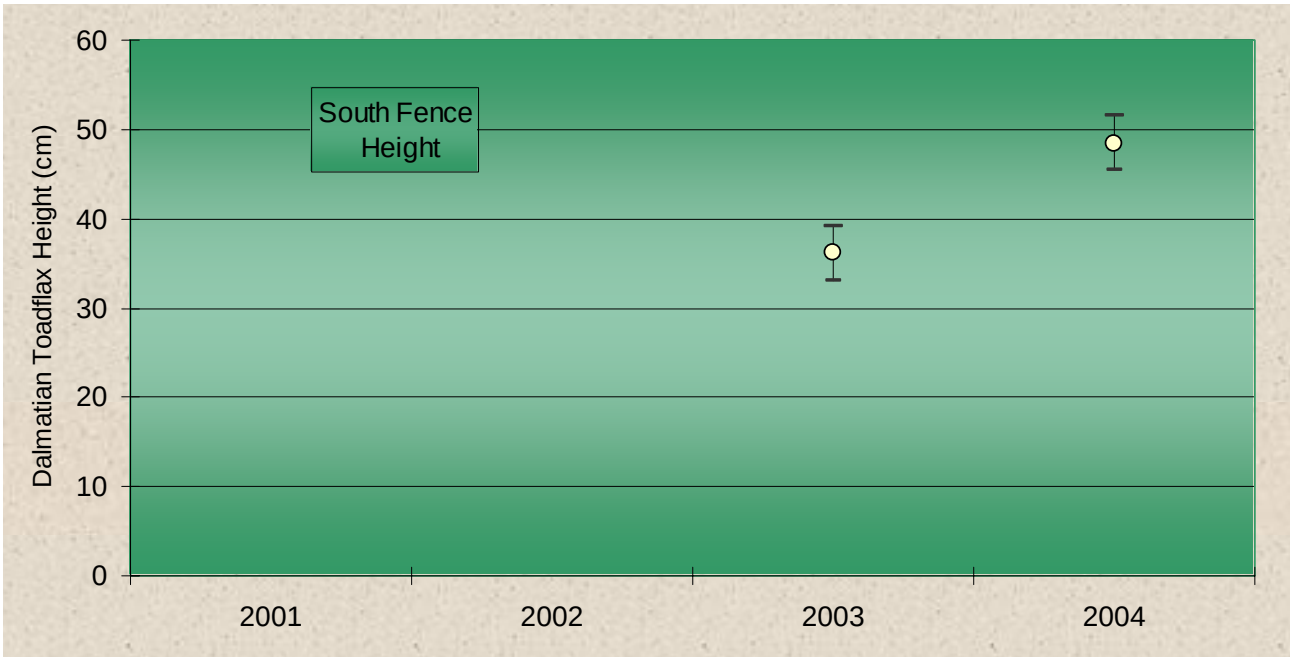


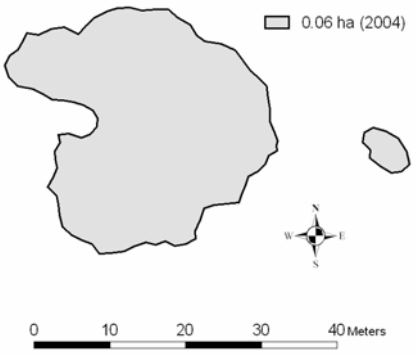
South Fence Dalmatian toadflax density in 2004.



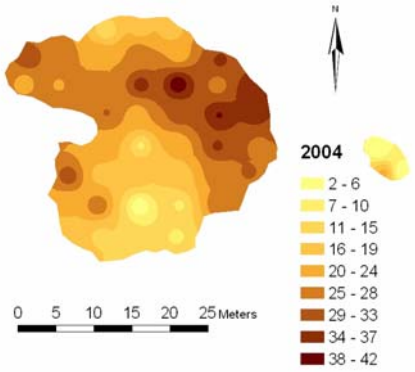


South Fence Dalmatian toadflax height in 2004.

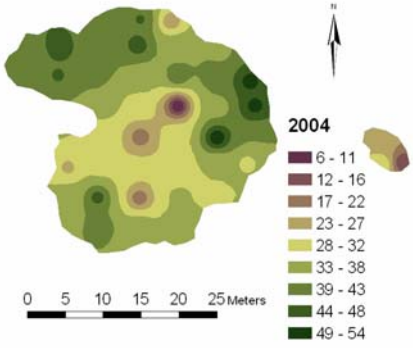




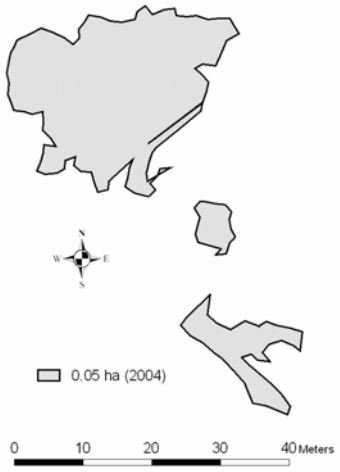
Runway leafy spurge perimeter in 2004.



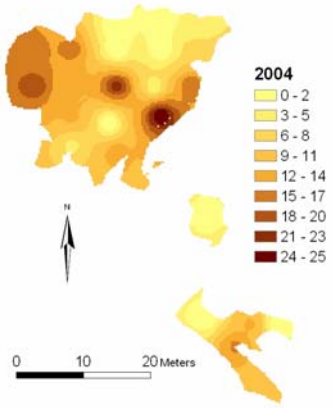
Runway leafy spurge density in 2004.



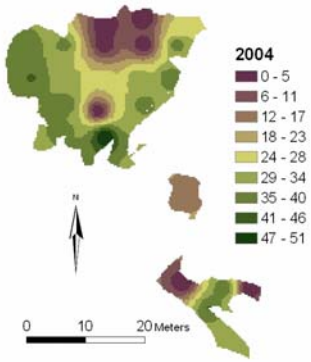
Runway leafy spurge height in 2004.



South Williams Lake leafy spurge perimeter in 2004.



South Williams Lake leafy spurge density in 2004.



South Williams Lake leafy spurge height in 2004.

Fort Carson Military Post

Eleven weed infestations were mapped and plant parameters evaluated at each in 2004 at Fort Carson. Nine of these sites have been monitored for numerous years (since either 2000 or 1997), thus weed population trends and reductions in the vigor and quantity of these plants has been well documented (Table 6). A total of 4.5 ha of Canada thistle, 1.7 ha musk thistle, 1.5 ha diffuse and 2.6 ha spotted knapweed were mapped and weed infestation parameters taken in 2004.

In 2003, mapping of one of the Canada thistle infestations expanded (ARA) and the additional weed perimeter is included in this report as ARA 2 to distinguish it from the original site first mapped in 1997. The biological control agents *Ceutorhynchus litura*, *Cassida rubiginosa*, *Larinus planus*, *Trichosirocalus horridus* and *Urophora cardui* were all introduced into the original ARA 1 site (Table 7), while ARA 2 received one release this year of *C. rubiginosa*. Insects established at ARA 1 are expected to migrate to the nearby ARA 2 site as the quality and quantity of their target host declines. This original ARA Canada thistle infestation area has been reduced by over 86% in the 8 years it has been monitored. The density of plants within this perimeter is merely 9% of the population surveyed in 1997 and plants are notably stunted (83% shorter in 2004). New monitoring began in 2004 on a large expanse (15,000 m^2) of diffuse knapweed, referred to in this report as the Gun Club site. The only weed not mapped and sampled this year is musk thistle at the Reservoir site, although we are still closely monitoring the reduction of Canada thistle at this site.

Figure 13. Spotted knapweed seed heads are completely destroyed by a single *Larinus minutus* weevil (as shown here). Destructive sampling of seed heads from Fuel Site and HazMat will allow us to confirm visual estimates that a substantial proportion of seed heads are infested by this biocontrol agent.

Generally, it was observed in 2004 that, despite the precipitation received at Fort Carson over the last year and ideal plant growing conditions, populations of Canada thistle and spotted knapweed continue to decline from their original extents. Spotted knapweed has been reduced by 32% and 70% at the HazMat (Cantonment 2) and Fuel Site (Cantonment 1) sites, respectively. The increase in weed coverage area at Turkey Creek is likely the result of a more extensive mapping effort in areas along and near the tank trail that runs through that site. The density of plants within this mapped area shows that the population of spotted knapweed has significantly declined (73%) at Turkey Creek (Table 6).

Biological control agents released at Fort Carson in 2004 include a redistribution of approximately 850 seed head weevils (*Larinus minutus*) from Fuel Site (Cantonment 1) to the new Gun Club site (see Figure 13). Additionally, 117 root-boring weevils, *Cyphocleonus achates*, were released at Gun Club. Both of these insects have been observed at Fort Carson (Fuel Site, HazMat, Turkey Creek) to establish well and achieve high population levels on knapweed, causing substantial damage to their hosts in the process. A supplementary release of 110 *C. achates* was made into Turkey Creek this past field season. Leaf-feeding beetles, *Cassida rubiginosa* (Figure 14), were released at the following Canada thistle infestations: ARA 1 (200), ARA 2 (300), Duckpond (500), and Reservoir (500).

Figure 14. The few remaining Canada thistle plants at ARA 1 resemble the stunted, heavily damaged specimen in the photo. The dark spots seen on the foliage are leaf-feeding beetle (*Cassida rubiginosa*) pupae.

In addition to the 11 weed infestations monitored in 2004 (Table 6), there were 9 releases of the mite, *Aceria malherbae*, to control field bindweed. Past releases of this mite on Fort Carson have been concentrated near or within the downrange area. Supplemental releases were made in 2004 in this area, as well as new releases into 6 locations around the Cantonment.

An extensive sampling of knapweed seed heads and roots is currently being undertaken on plant material collected in September 2004, in order to determine the population levels of several of the insect biological control agent released. The agents being surveyed include *Agapeta zoegana*, *Bangasternus fausti*, *C. achates*, *L. minutus*, *L. obtusus*, *Metzneria paucipunctella*, *Sphenoptera jugoslavica*, and *Urophora affinis*. Although results have not yet been fully collected, several new biological control agent recoveries have been discovered both on site and through the dissections. These include the seed head moth *M. paucipunctella* and root-boring beetle *S. jugoslavica* at both Fuel Site and HazMat (see Figure 15), and recovery of *M. paucipunctella* at the new Gun Club site, indicating that biocontrol agents are dispersing well and redistributing themselves to new weed patches on base.

Figure 15. Knapweed seed head-feeder, *Metznaria paucipunctella* (left), and root-borer, *Sphenoptera jugoslavica* (right), were recovered in 2004 at the Fuel Site and HazMat.

Table 6. Historic noxious weed infestation parameters at Ft. Carson, Colorado 1997-2004.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads	Head size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
Canada thistle - ARA1												
1997		23	13.36	42								
1999		40			67.59	95	27.14					
2000	37,062	166	6.50	58	41.51	91						
2001	37,061	299	6.53	64	50.03	122	14.94	0.57	0.00	0.46	20.53	
2002	38,002	386	2.15	40	11.32	83.5	2.75	0.12	2.54	-67.08	-77.37	
2003	14,708	161	0.79	9	12.19	74	2.98	0.15	-61.30	-63.26	7.69	
2004	4,919	75	2.53	19	21.95	37	0.60	0.26	-66.56	220.25	80.07	-86.73
Canada thistle - ARA2 (included as ARA in 2003)												
2003	6,284	63	6.48	24	61.21	125	1.28	0.07				
2004	13,845	64	13.20	38	54.39	98	1.48	2.50	120.33	103.70	-11.14	120.33
Canada Thistle - Duckpond												
1997		19	19.46	82								
1998	27,769											
1999		33			86.92	114	34.88					
2000	28,788	267	6.60	58	79.53	193						
2001	39,409	26	9.61	70	71.55	136	24.64		36.90	45.61	-10.03	
2002	38,916	196	3.24	56	25.52	124	10.86	0.23	-1.25	-66.29	-64.33	
2003	29,486	147	5.25	29	38.90	143	3.08	0.22	-24.23	62.04	52.43	
2004	20,724	65	14.17	116	52.35	90	20.15	6.20	-29.72	169.90	34.58	-25.37
Canada thistle - HWY 115												
2000			13.84		65.91							
2001			7.95		62.91					-42.56	-4.55	
2002												
2003			14.39		17.64					81.01	-71.96	
2004			6.29		42.66					-56.29	141.84	

Table 6. Historic noxious weed infestation parameters at Ft. Carson, Colorado 1997-2004 (cont.).

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads	size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
						Canada thistle - Reservoir						
1997		22	23.19	30								
1998												
1999		26			72.93	109	18.36					
2000	8,178	201	10.13	40	32.95	71					-54.82	
2001	9,517	143	7.66	31	41.13	84	13.14		16.38	-24.38	24.83	
2002	5,268	101	9.57	32	27.05	65	6.35	0.30	-44.64	24.93	-34.23	
2003	3,635	165	6.09	38	41.48	123	6.02	0.38	-31.00	-36.36	53.35	
2004	4,549	68	6.13	28	26.76	57	0.60	0.74	25.13	100.66	-35.49	-44.38
						Musk thistle - HWY 115						
2000	1,445	81	12.48	40		80						
2001	5,098	82	5.31	24	77.00	147				-57.45		
2002	1,998	70	5.64	14	5.45	29	2.25	0.03		6.21		
2003	1,263	61	2.13	5		127	0.68			-62.23		-12.59
2004			1.85		47.19							
						Musk Thistle - Reservoir						
1997		22	0.18	4								
1998												
1999												
2000		201	0.23	4								
2001	154	10	5.40	14	56.10	84	8.30			2247.83		
2002												
2003												
2004												
						Musk thistle - Wildlife						
1999		59			105.82	175	6.00					
2000	5,035	114	2.71	14	45.93	138					-56.60	
2001	2,844	68	3.71	21	74.52	174	6.83		-43.52	36.90	62.25	
2002	1,838	61	1.84	36	13.24	57.3	4.47	0.22	-35.39	-50.40	-82.23	
2003	10,219	77	0.27	3	14.39	124	1.17		456.14	-85.33	8.69	
2004	6,777	39	1.23	7	59.50	173	11.20	7.13	-33.68	355.56	313.48	34.59

Table 6. Historic noxious weed infestation parameters at Ft. Carson, Colorado 1997-2004 (cont.).

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads	Head size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
Diffuse knapweed - Gun Club												
2004	14,941	46	1.59	8	21.87	65	36.04	1.43	na	na	na	na
Spotted knapweed - Fuel Site (Cantonment 1)												
1997		22	20.08	82								
1999		50			68.30	104	20.52					
2000	2,072	154	9.02	50	44.95	91					-34.19	
2001	2,869	113	12.30	564	57.65	104	114.36		38.46	36.36	28.25	
2002	2,375	155	7.68	36	24.83	71.5	25.53	0.34	-17.22	-37.56	-56.93	
2003	2,093	92	5.98	35	64.35	150	52.26	1.92	-11.87	-22.14	159.16	
2004	6,830	42	4.64	21	55.22	100	49.51	5.00	226.33	-22.41	-100.00	-69.66
Spotted knapweed - HazMat (Cantonment 2)												
1997		21	24.40	62								
1999		100			78.99	116	45.48					
2000	8,462	361	9.39	52	31.97	127					-59.53	
2001	9,094	143	17.83	140	64.13	100	72.30		7.47	89.88	100.59	
2002	3,429	92	6.32	58	26.45	81	21.56	0.35	-62.30	-64.55	-58.76	
2003	5,254	160	5.16	70	57.42	140	64.85	0.67	53.23	-18.35	117.09	
2004	5,779	57	5.37	18	43.07	97	65.45	4.62	10.00	4.07	-24.99	-31.70
Spotted knapweed - Turkey Creek												
1997		22	15.90	18								
1999	11,818	25	12.62	20	107.33	132	36.11			-20.63		
2000	16,848	285	14.07	68	57.76	101			42.56	11.49	-46.18	
2001	30,681	375	11.09	65	58.78	125	60.93		82.10	-21.18	1.77	
2002	1,314	79	0.96	27	7.25	73.2	1.59	0.27	-95.72	-91.34	-87.67	
2003	328	48	5.33	43	46.83	118	0.34	0.34	-75.01	137.95	326.11	
2004	13,218	73	1.42	10	66.43	101	95.02	4.00	3929.79	-73.36	41.85	11.84

n - number of samples or observations.

na - not applicable, data represent first year of sampling.

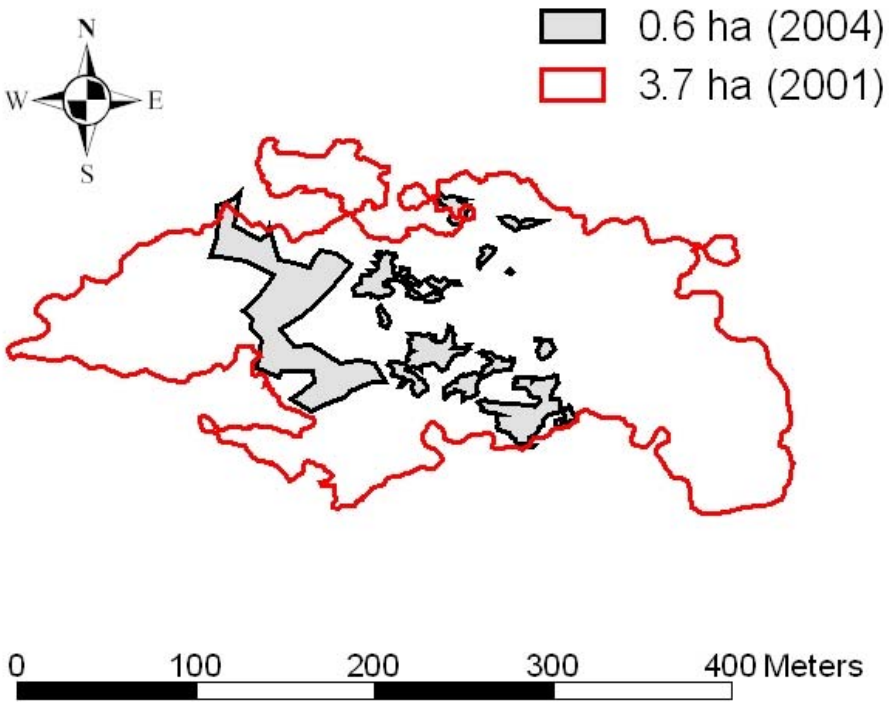
Table 7. Noxious weed biological control sites, target weeds, species released and recoveries at Ft. Carson, 2004.

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

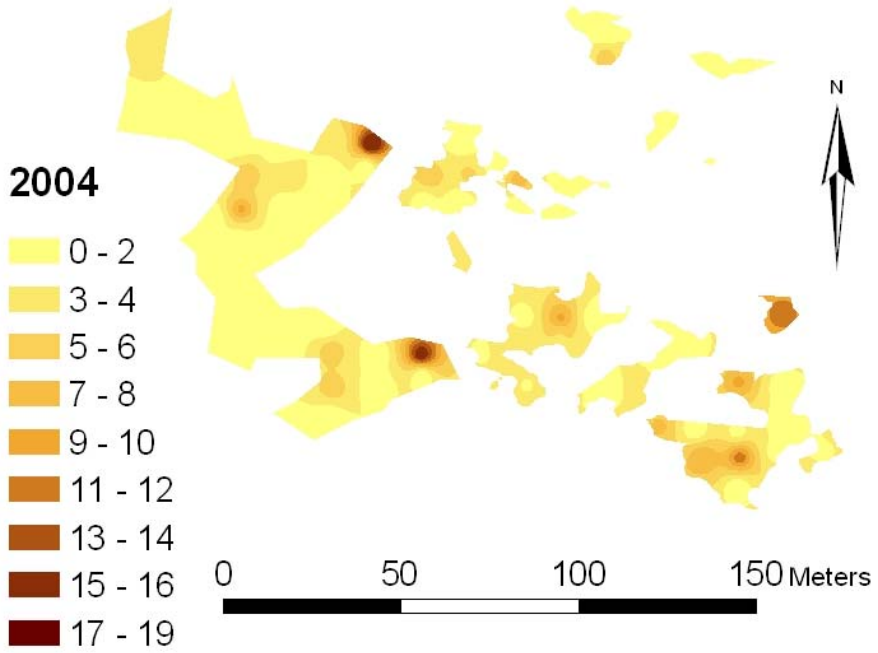
Table 7. Noxious weed biological control sites, target weeds, species released and recoveries at Ft. Carson, 2004.

Location	Target weed	Site	Species released	Species recovered	New releases	New site
Ft. Carson	Spotted knapweed	Fuel Site	*Metzneria paucipunctella*	X [2]		
Ft. Carson	Spotted knapweed	Fuel Site	*Sphenoptera jugoslavica*	X [2]		
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 [2]		
Ft. Carson	Spotted knapweed	HazMat	*Sphenoptera jugoslavica*	X [2]		
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		

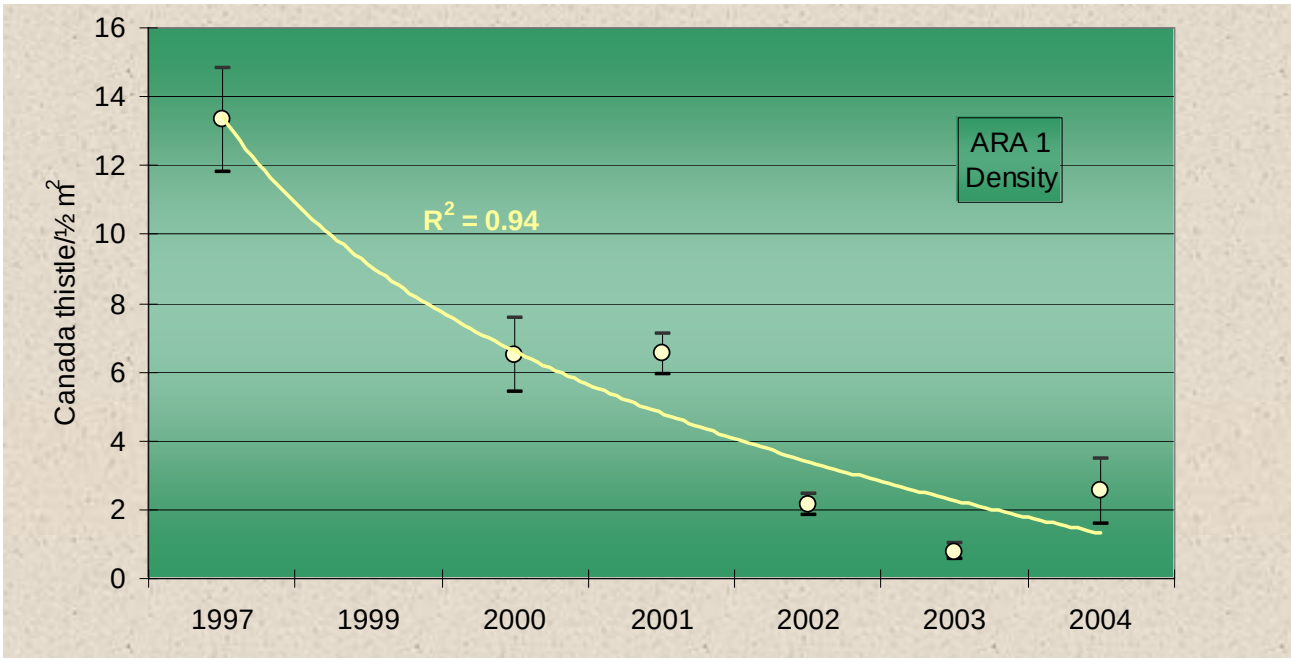
[1] Adventitious recovery, insects were not released at this location
[2] New recovery in 2004

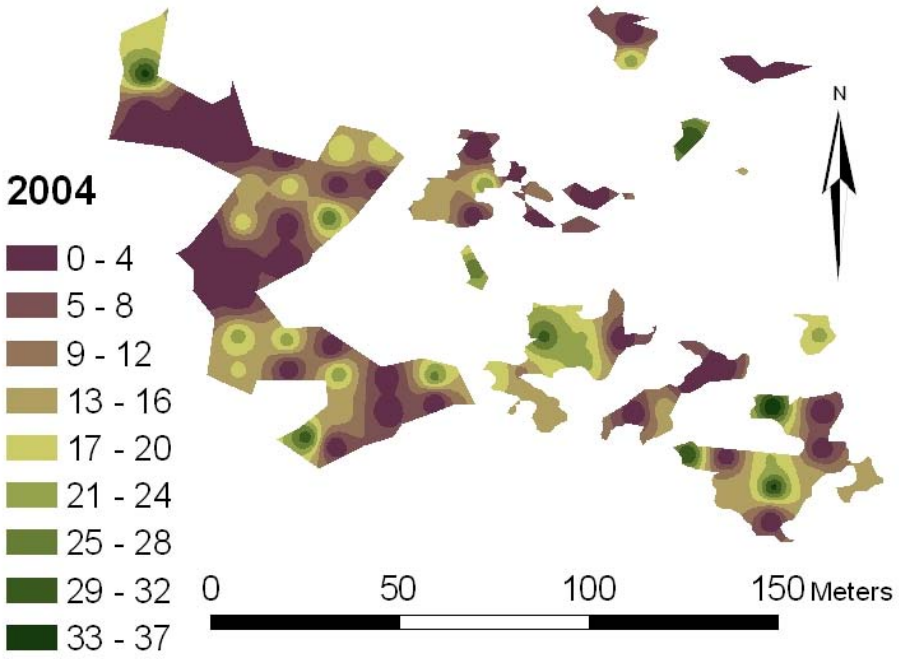


ARA I Canada thistle perimeter in 2004.

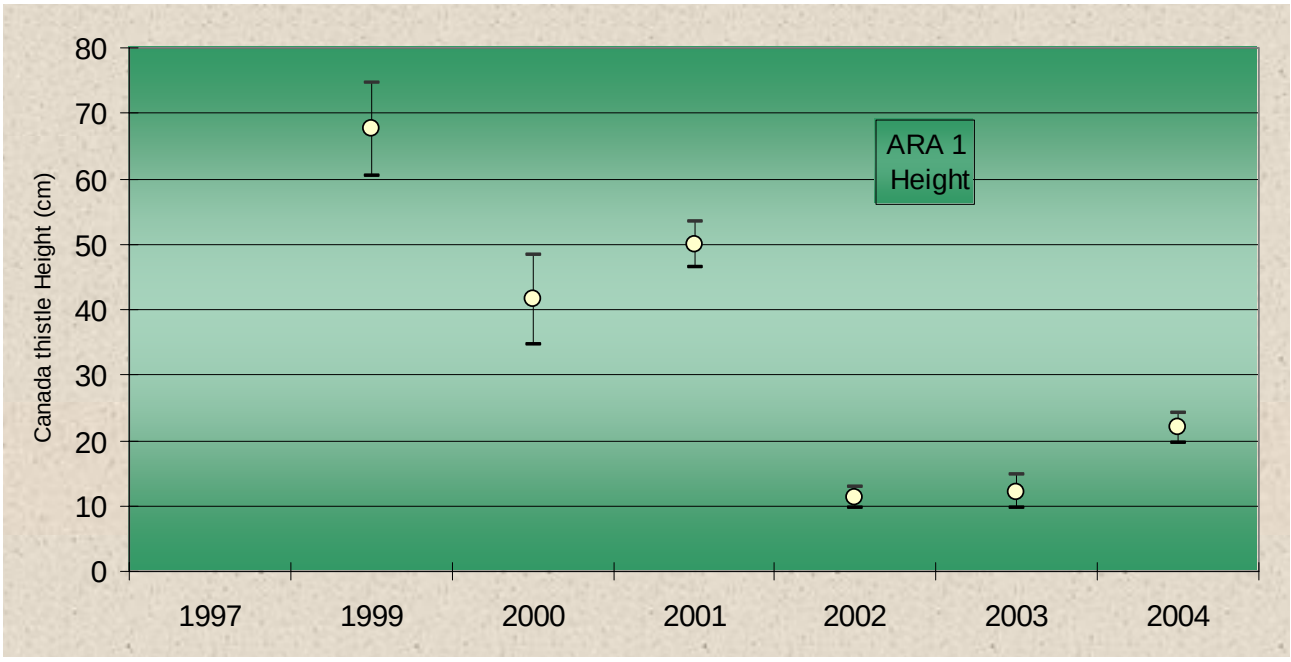


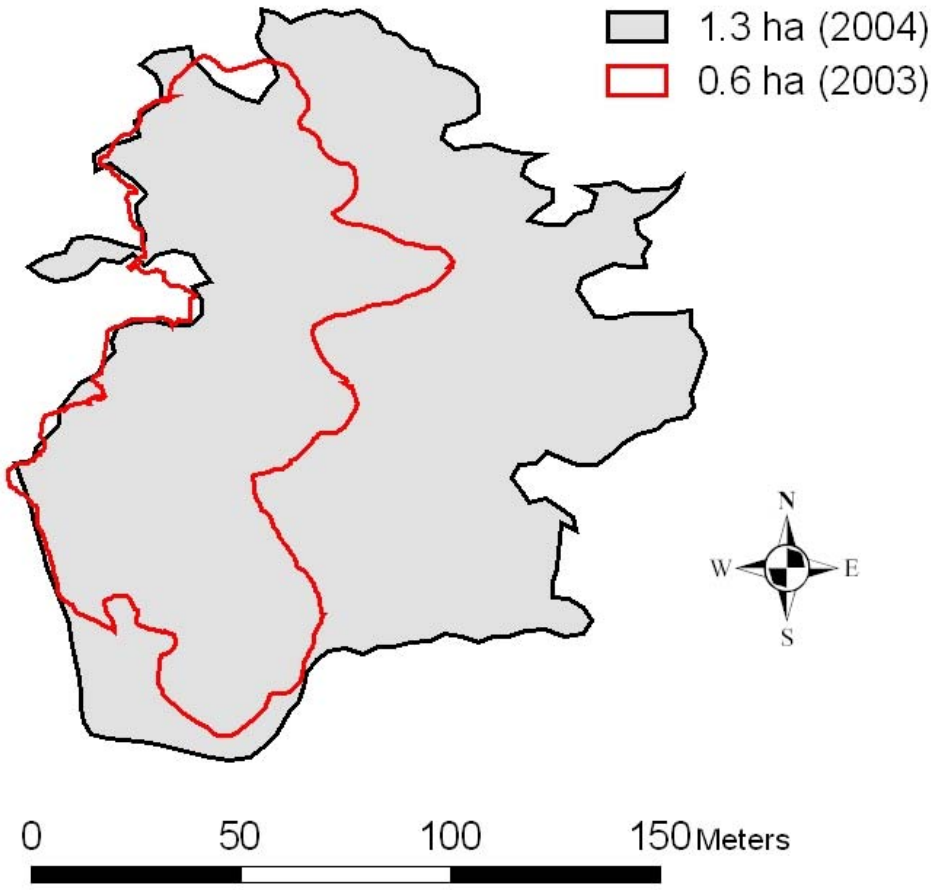
ARA I Canada thistle density in 2004.



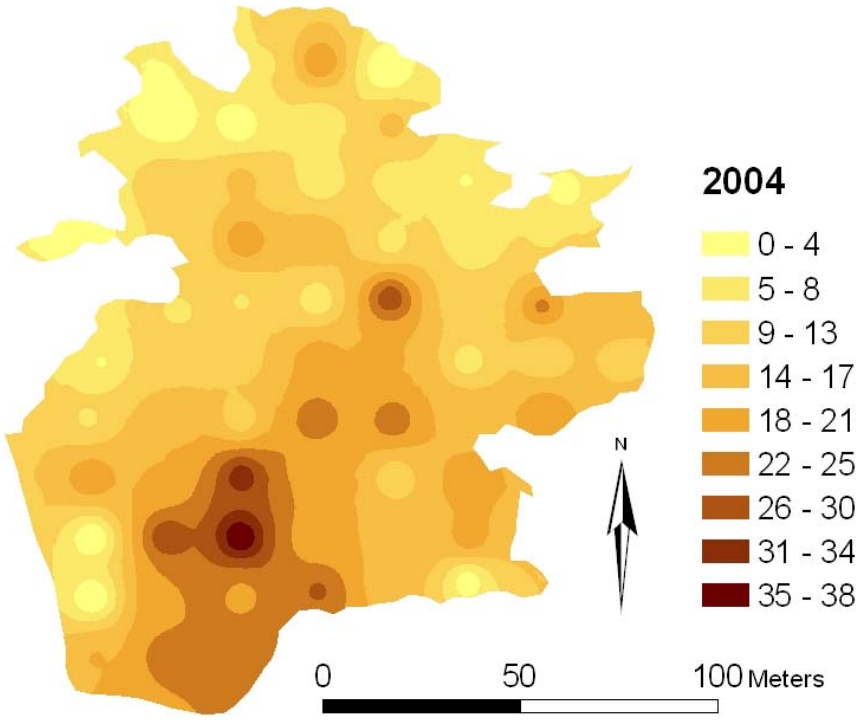


ARA I Canada thistle height in 2004.

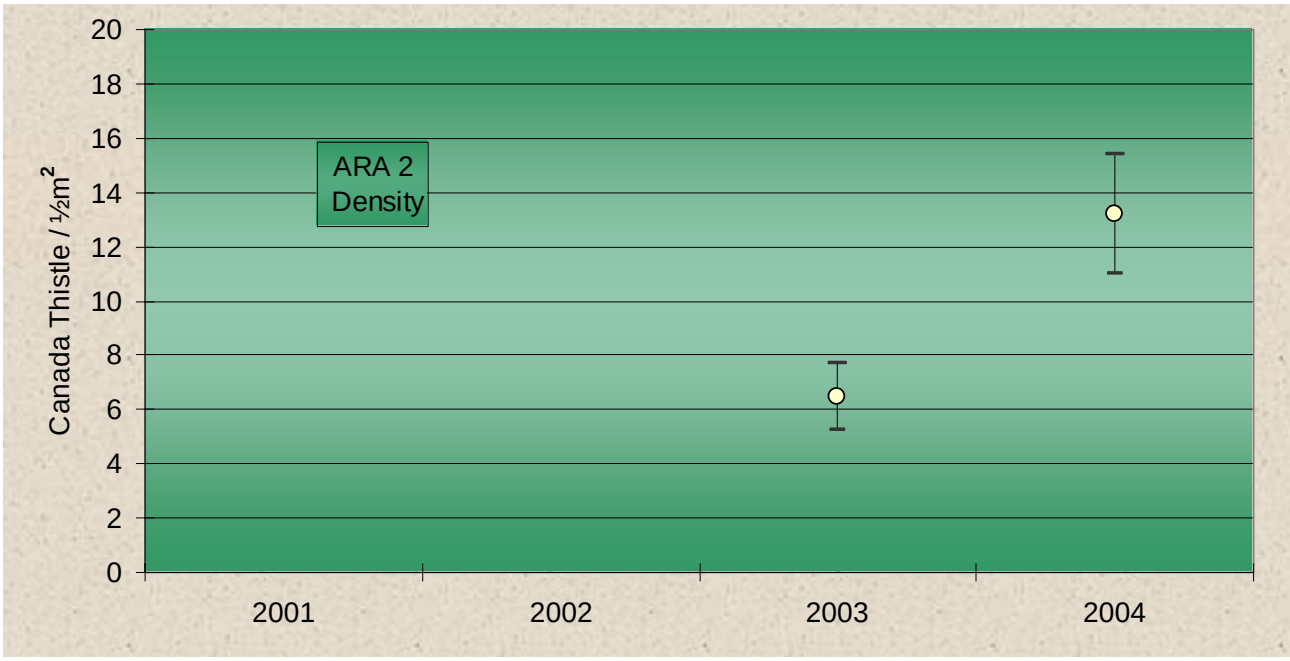


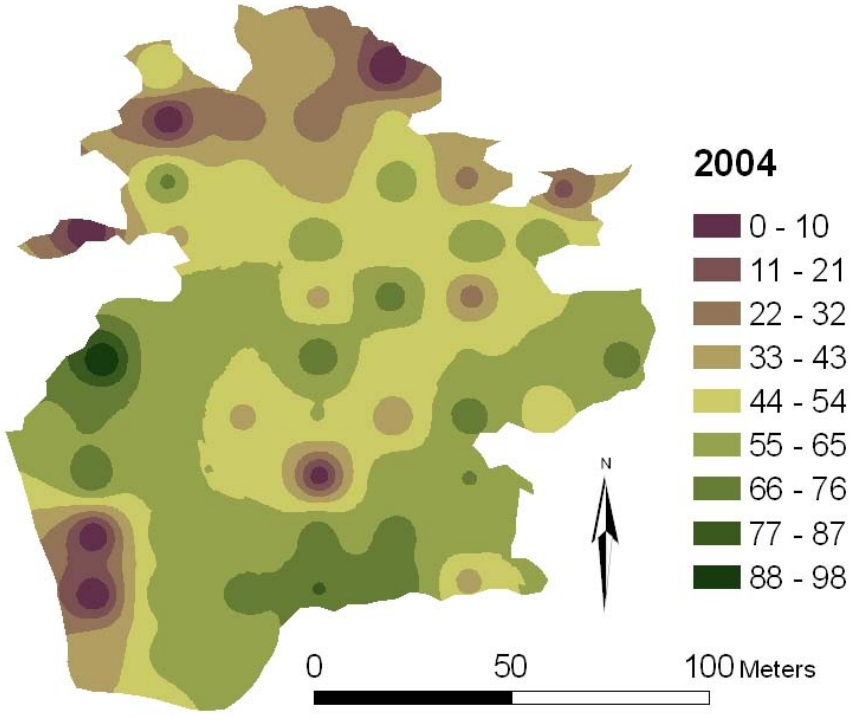


ARA II Canada thistle perimeter in 2004.

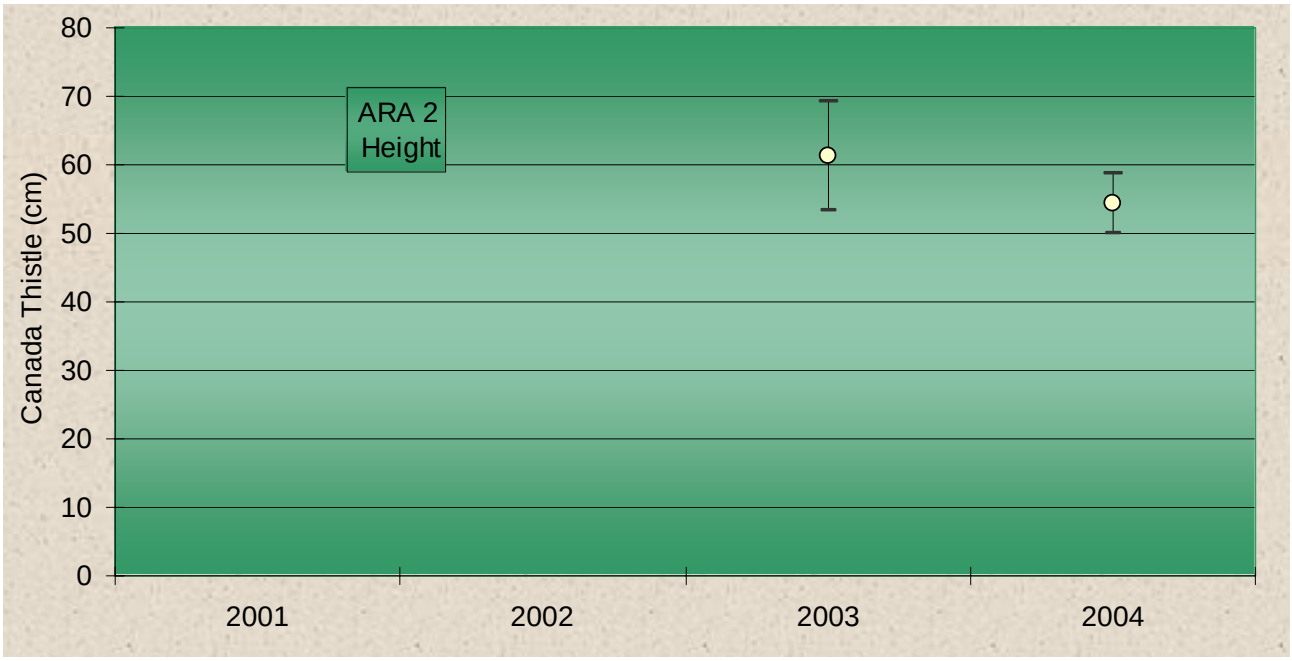


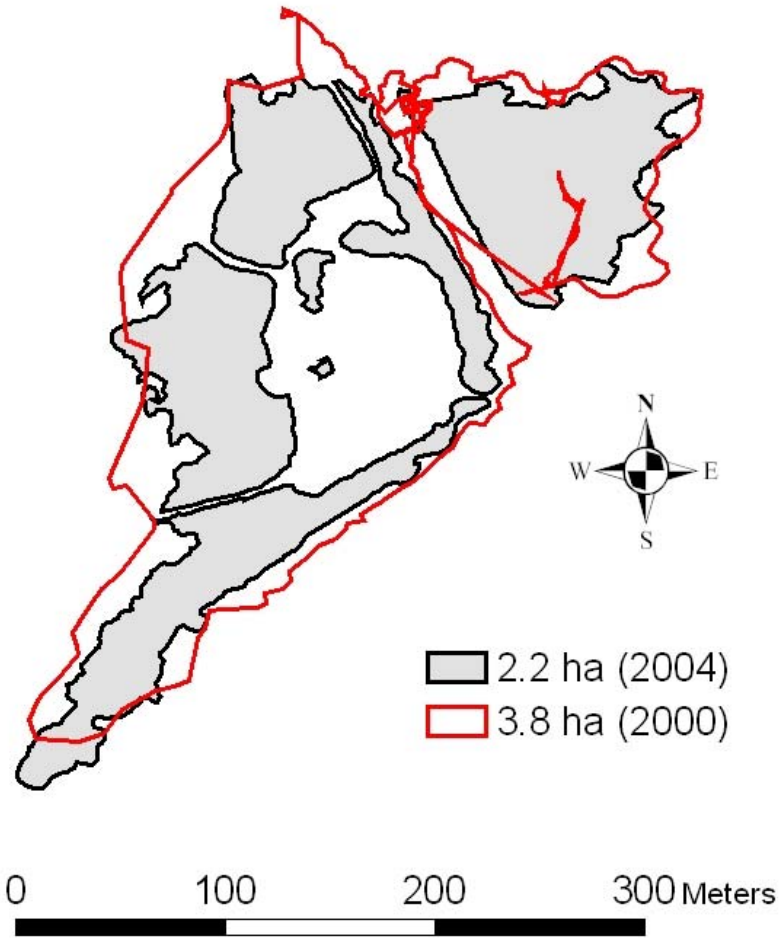
ARA II Canada thistle density in 2004.



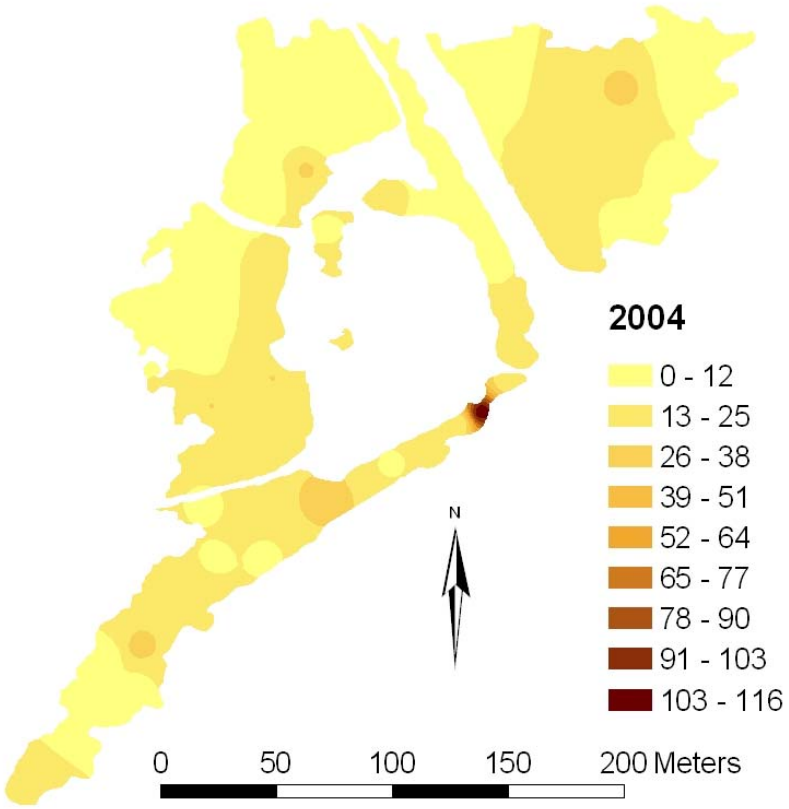


ARA II Canada thistle height in 2004.

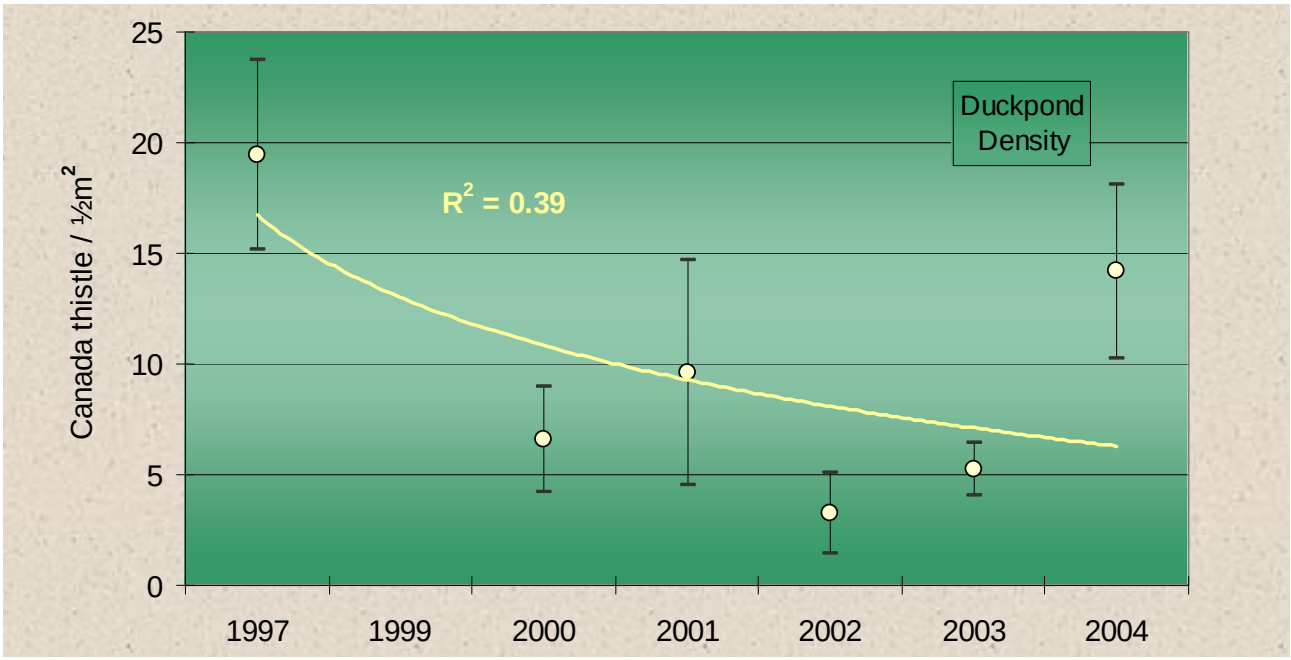


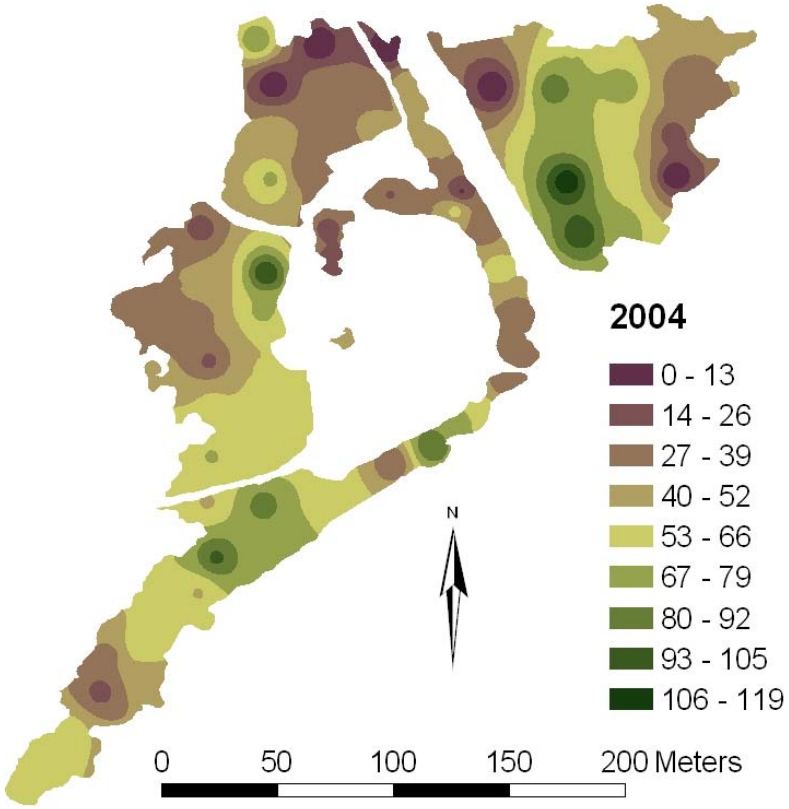


Duckpond Canada thistle perimeter in 2004.

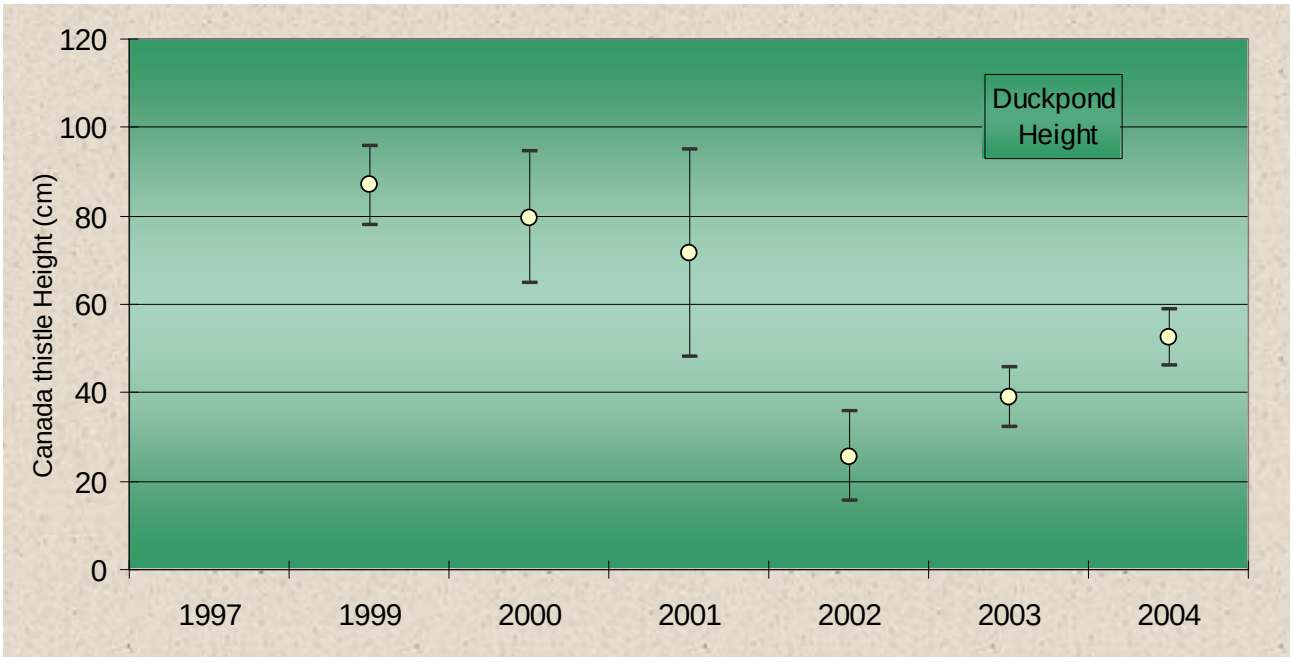


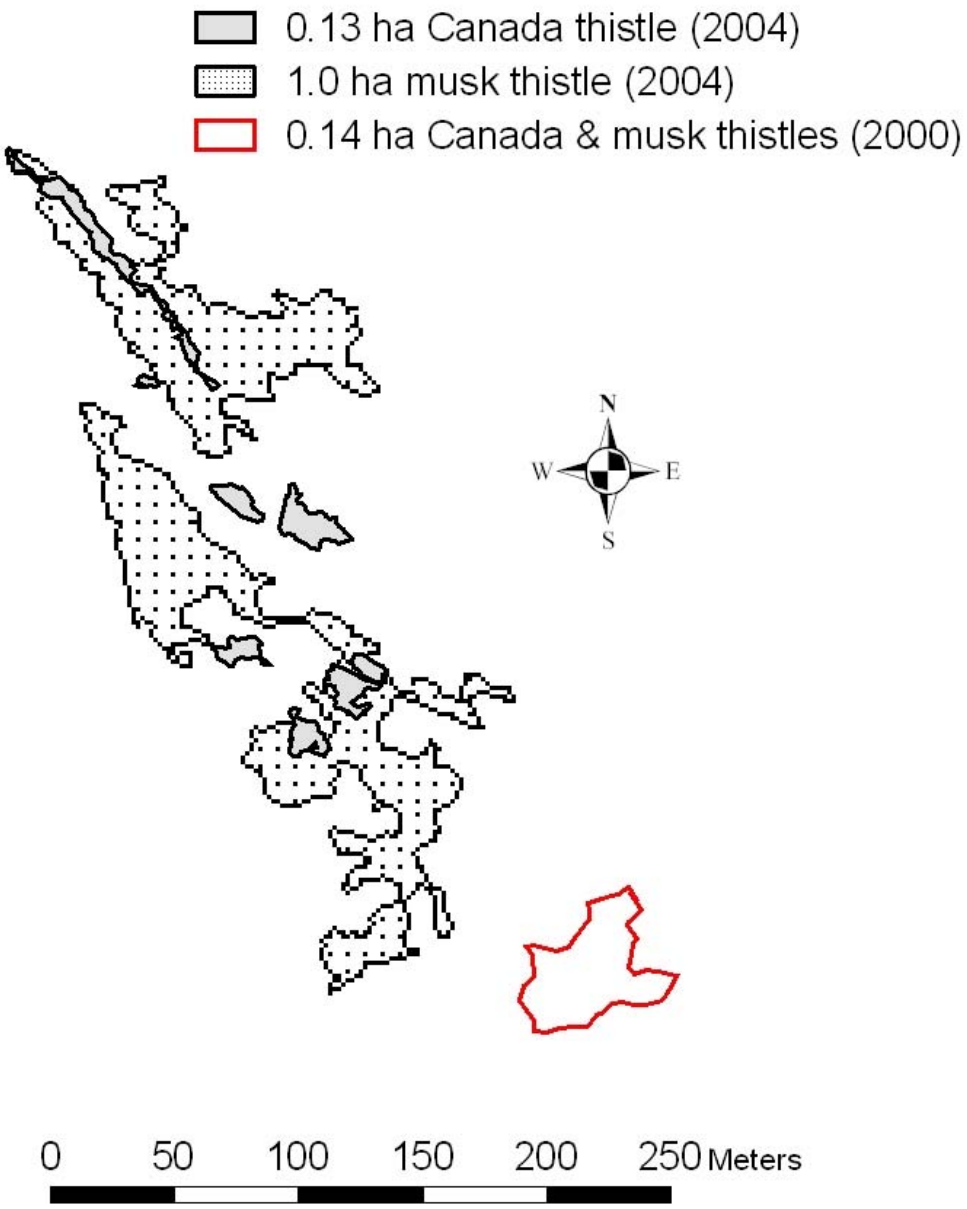
Duckpond Canada thistle density in 2004.



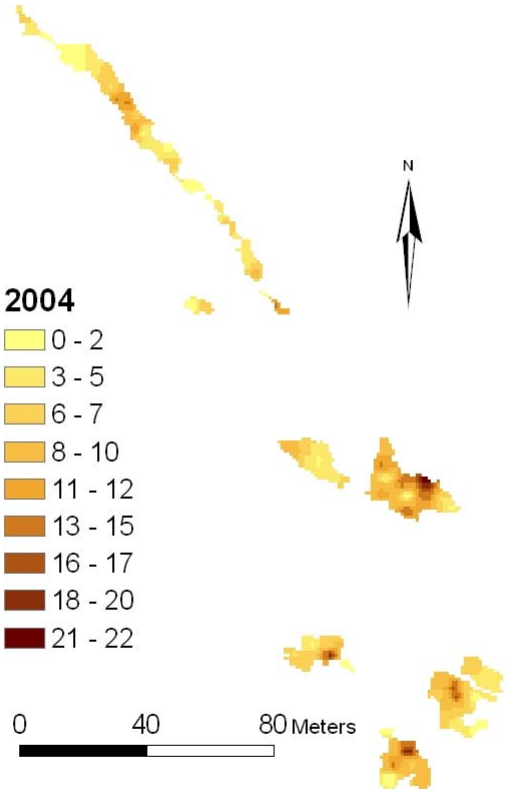


Duckpond Canada thistle height in 2004.

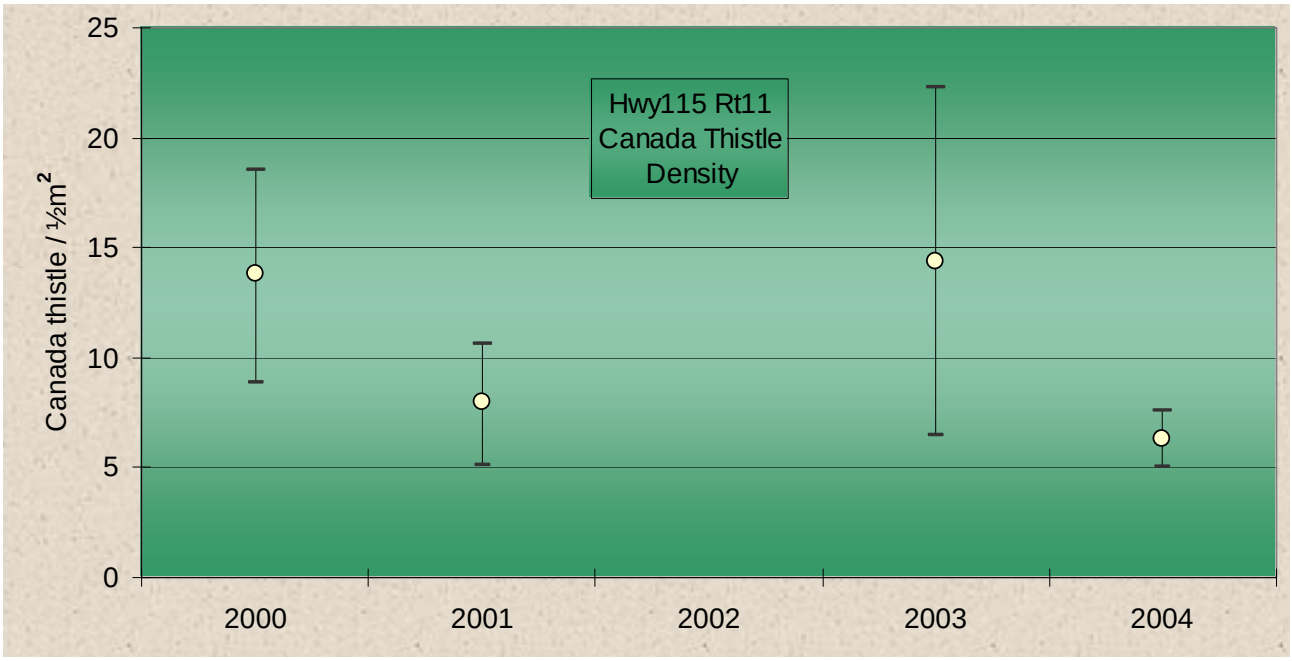


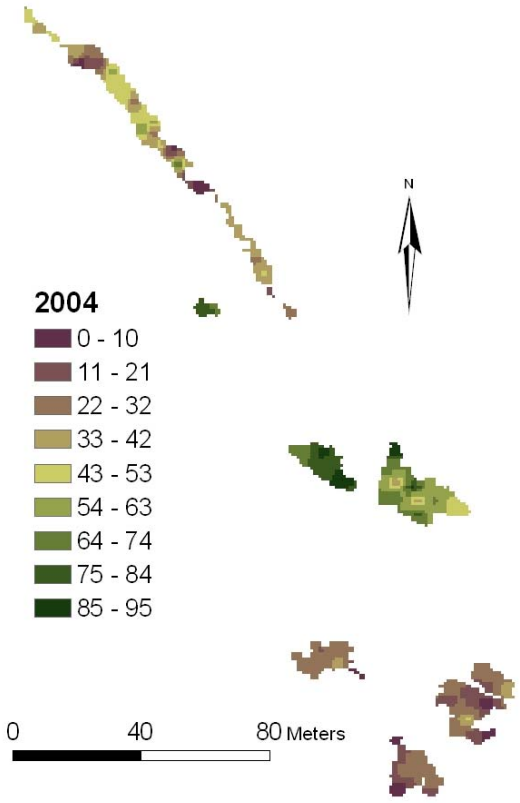


Highway 115 Canada & musk thistle perimeters in 2004.

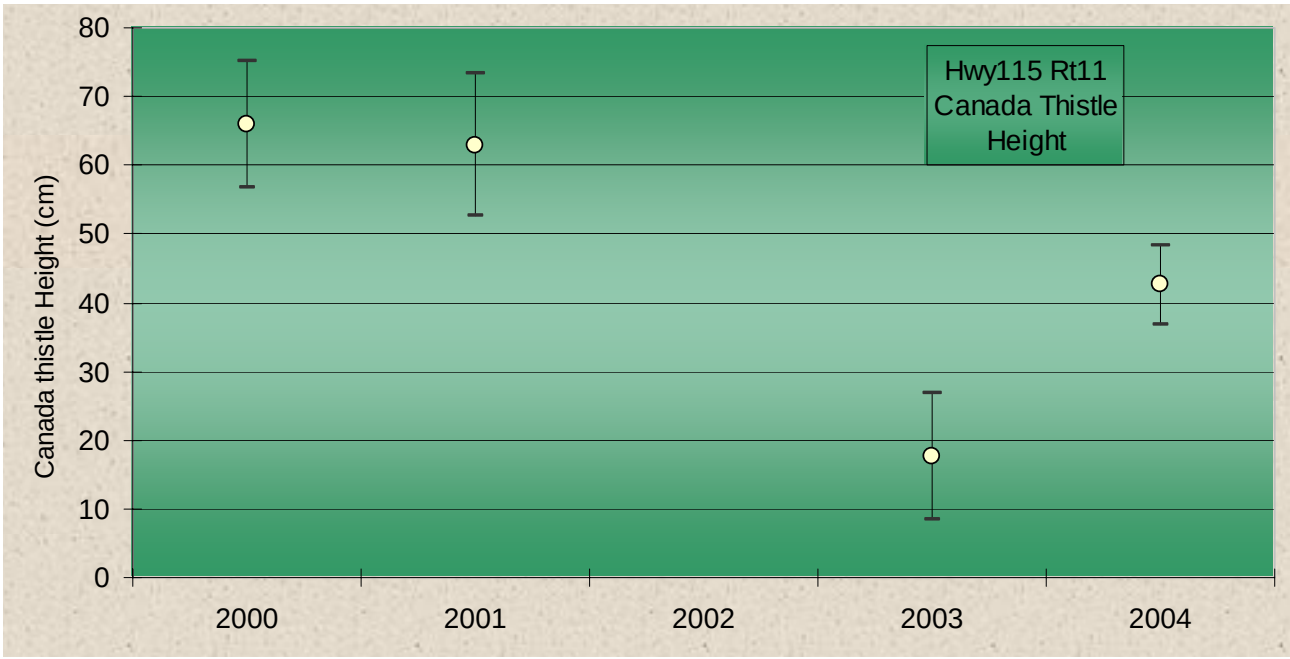


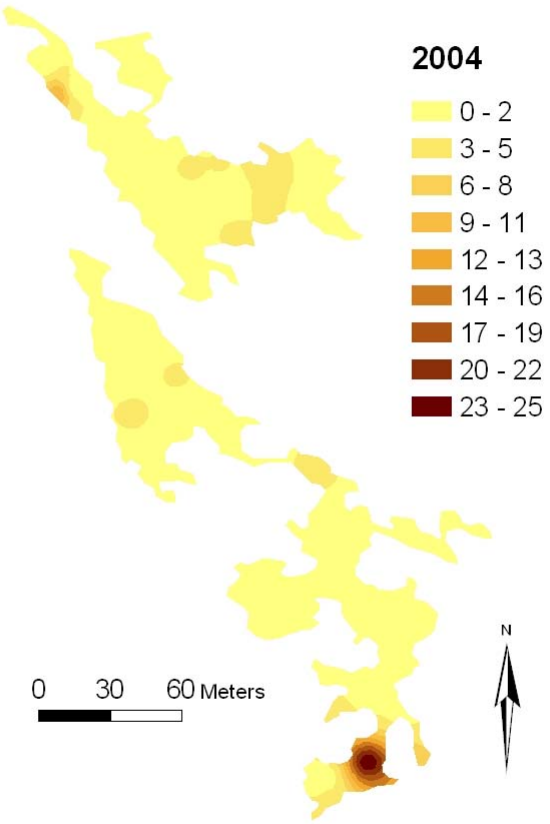
Highway 115 Canada thistle density in 2004.



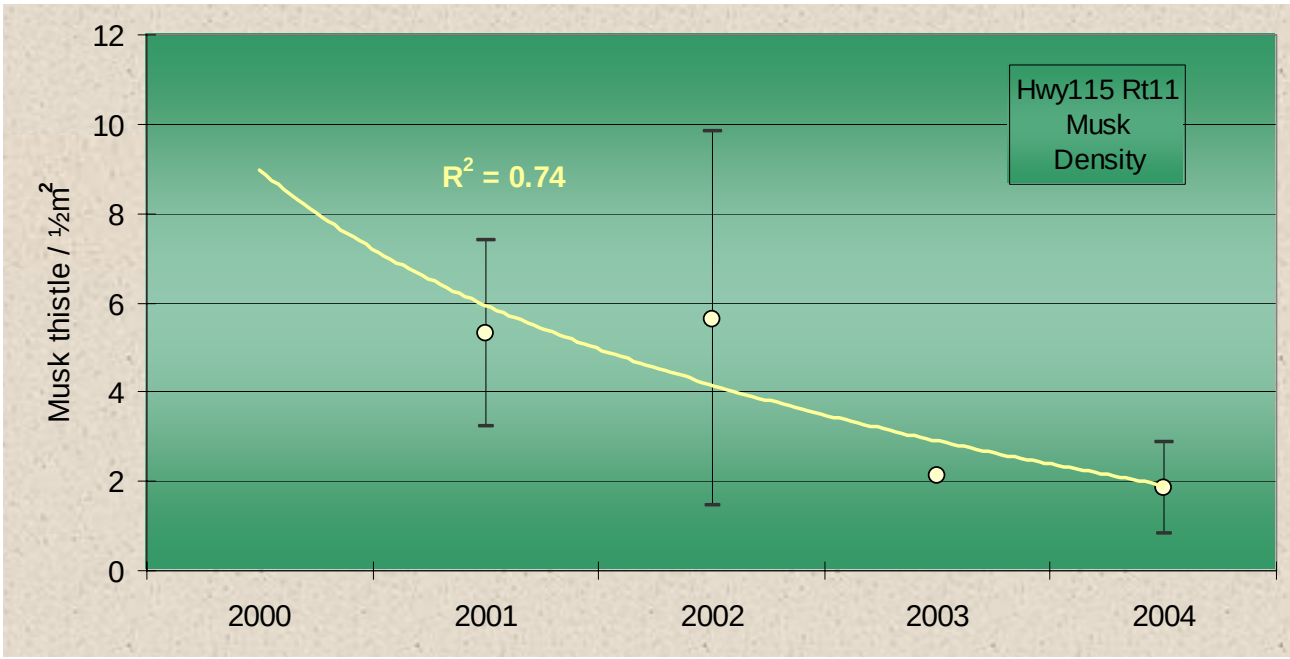


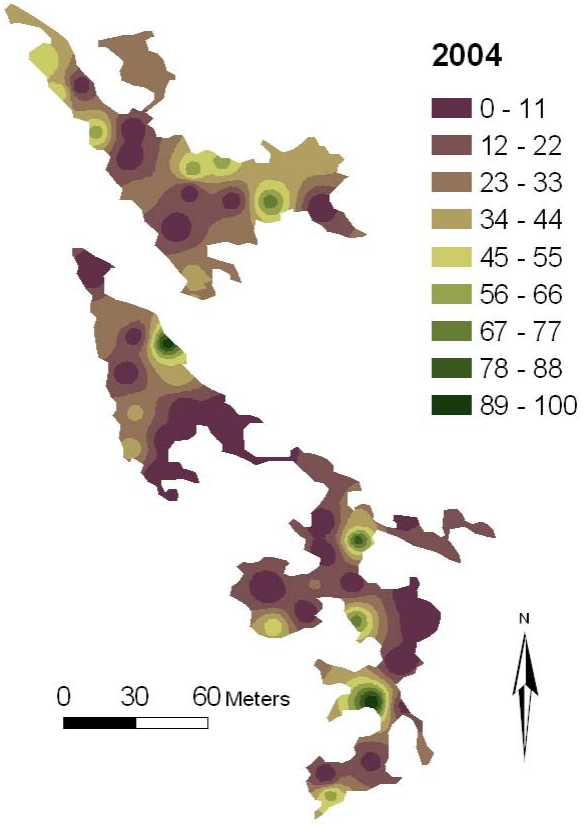
Highway 115 Canada thistle height in 2004.



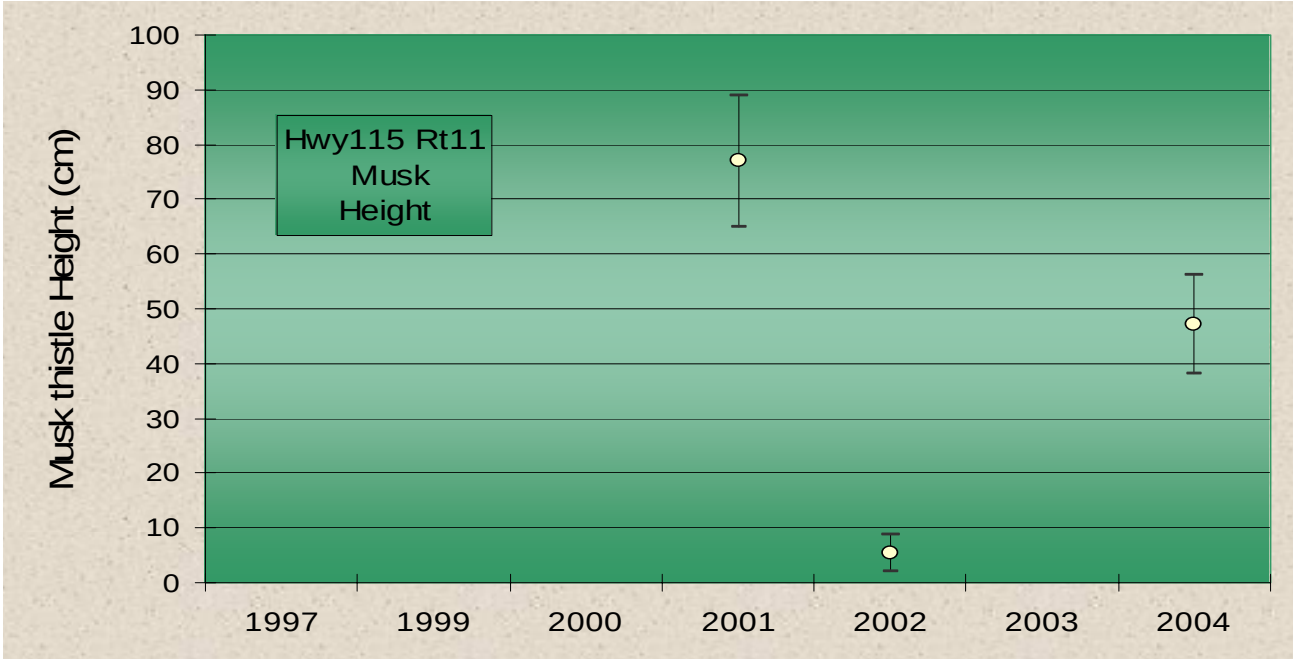


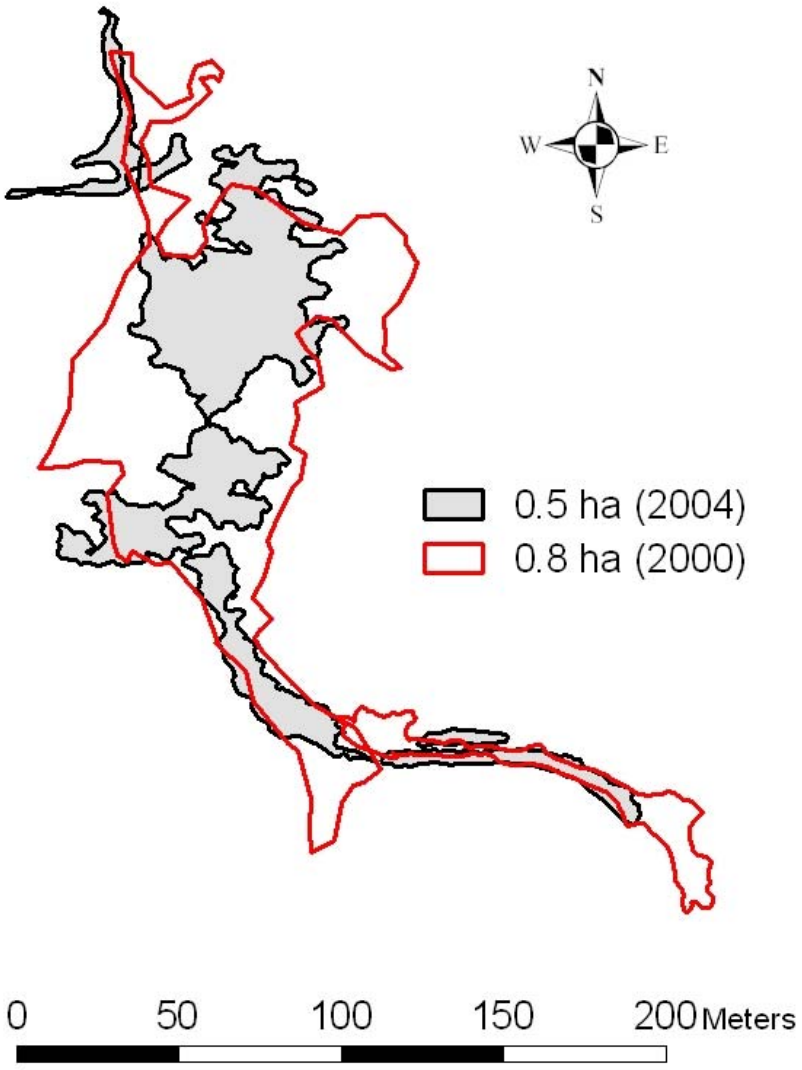
Highway 115 musk thistle density in 2004.



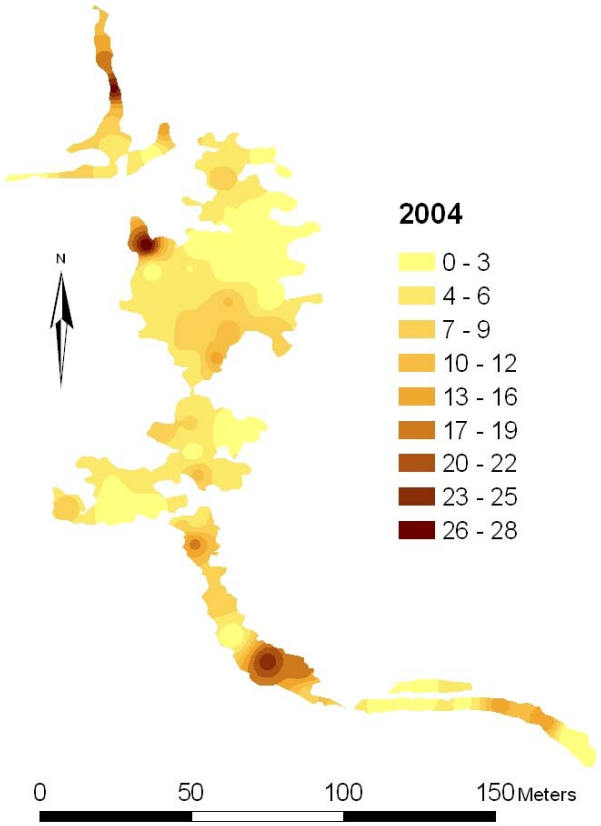


Highway 115 musk thistle height in 2004.

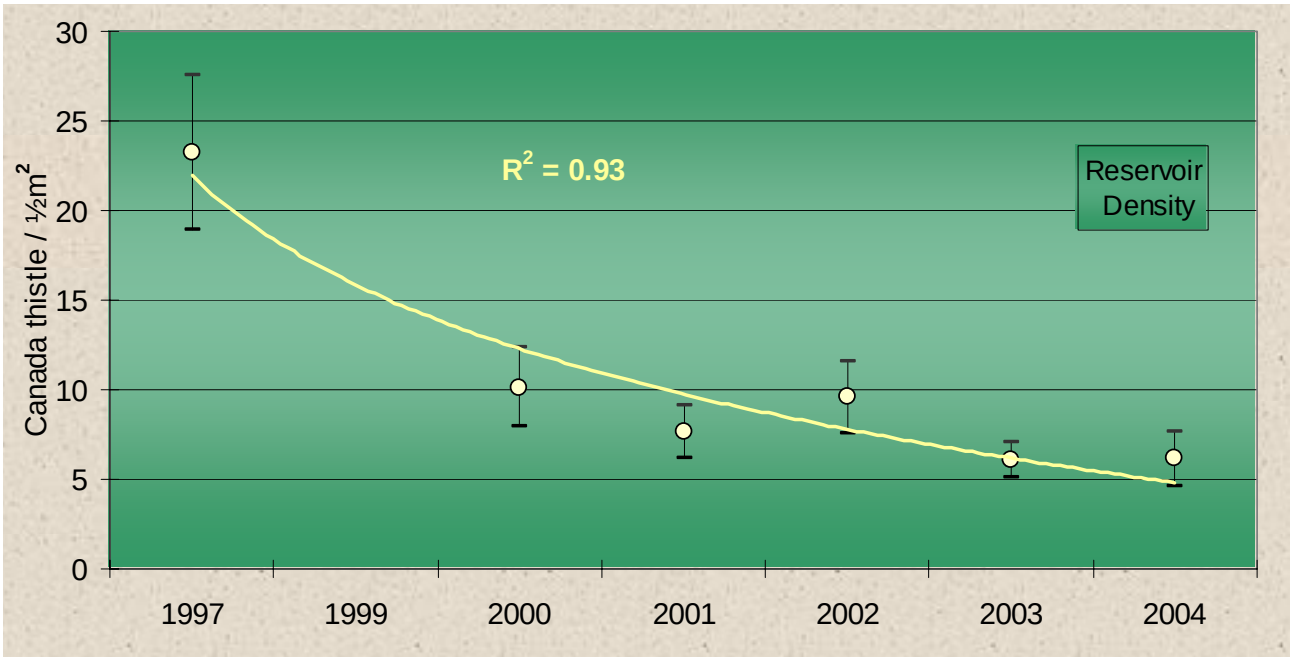


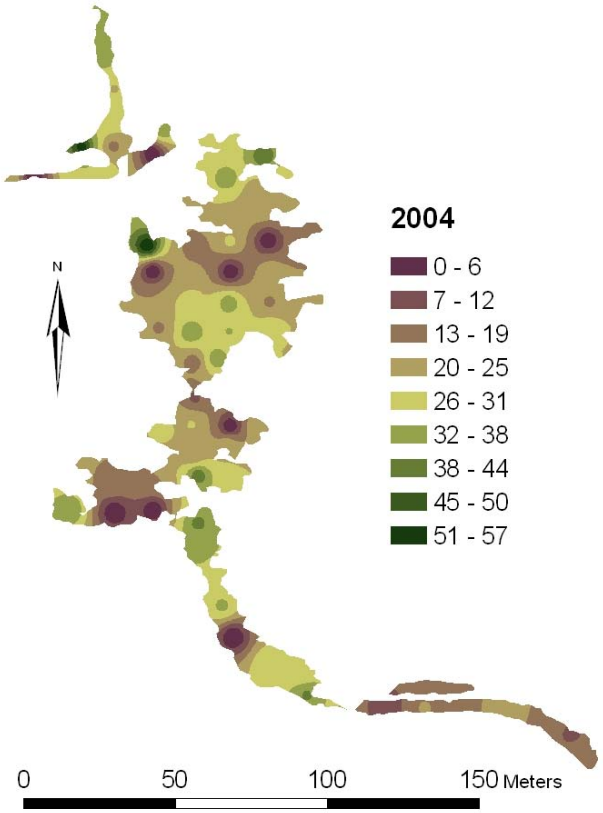


Reservoir Canada thistle perimeter in 2004.

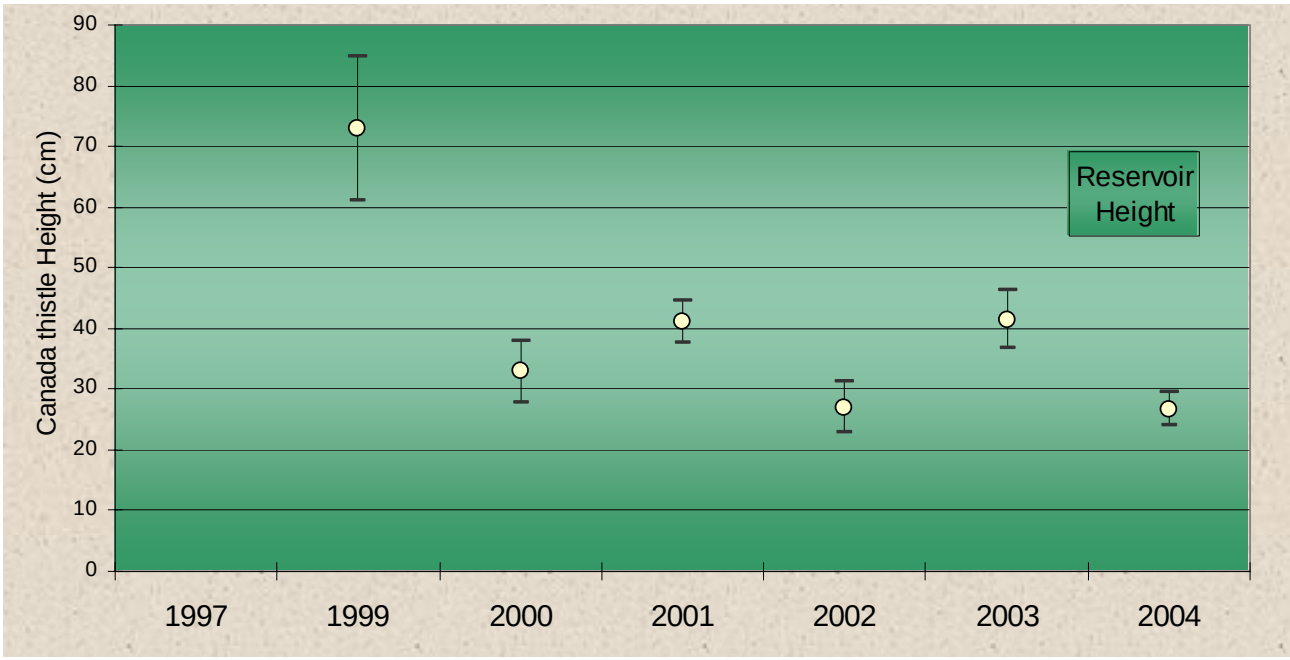


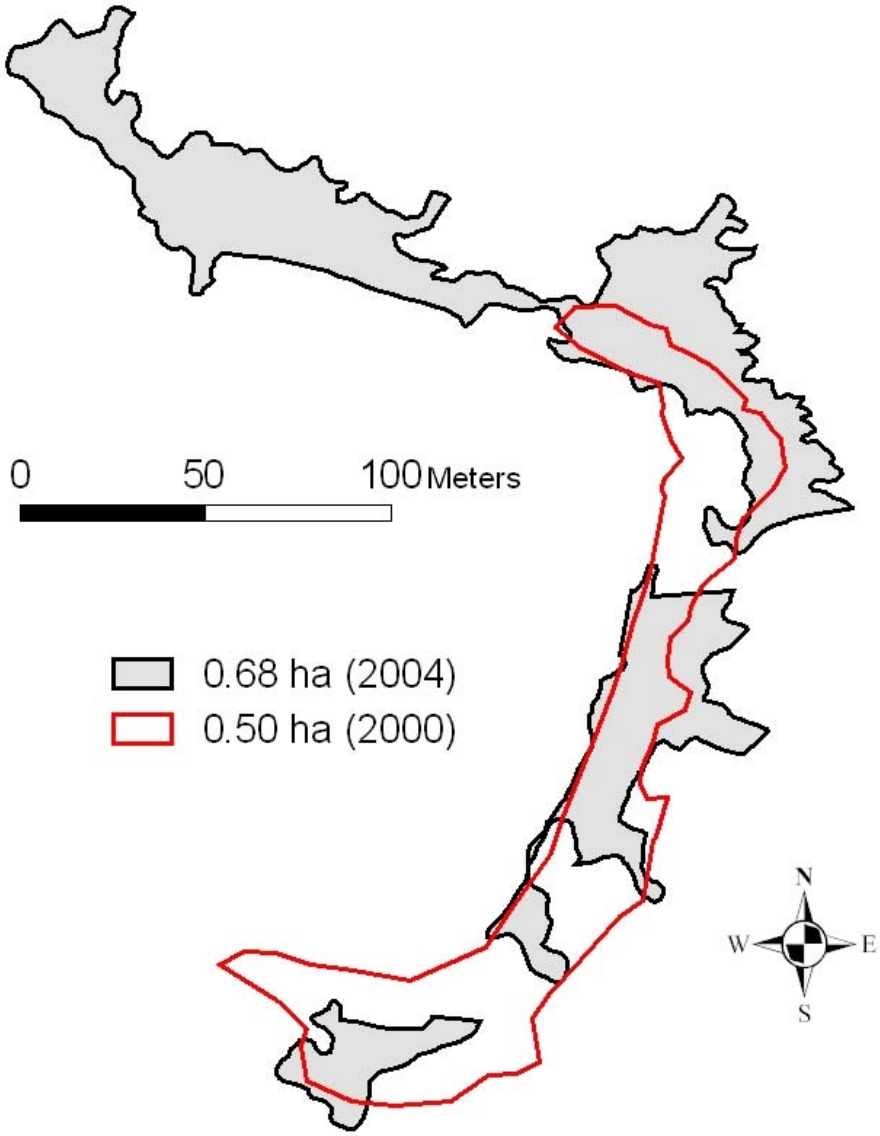
Reservoir Canada thistle density in 2004.



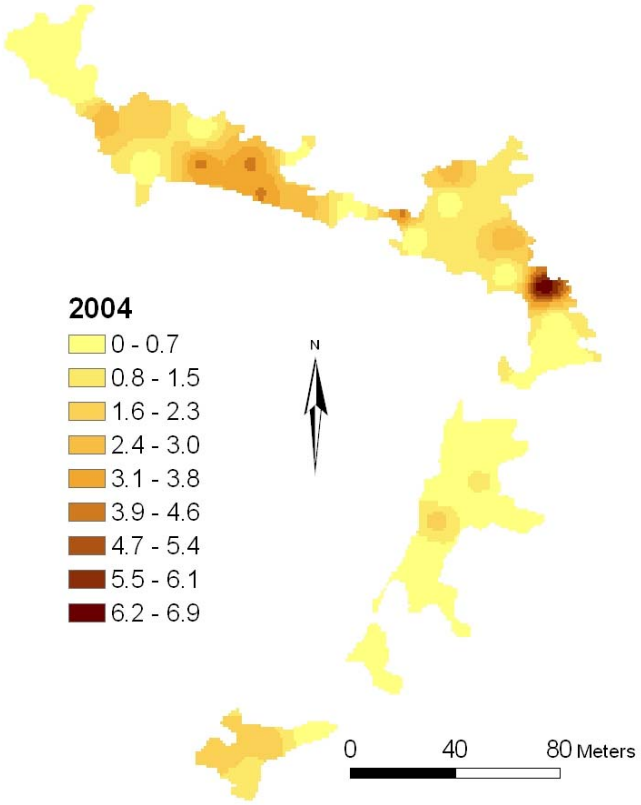


Reservoir Canada thistle height in 2004.

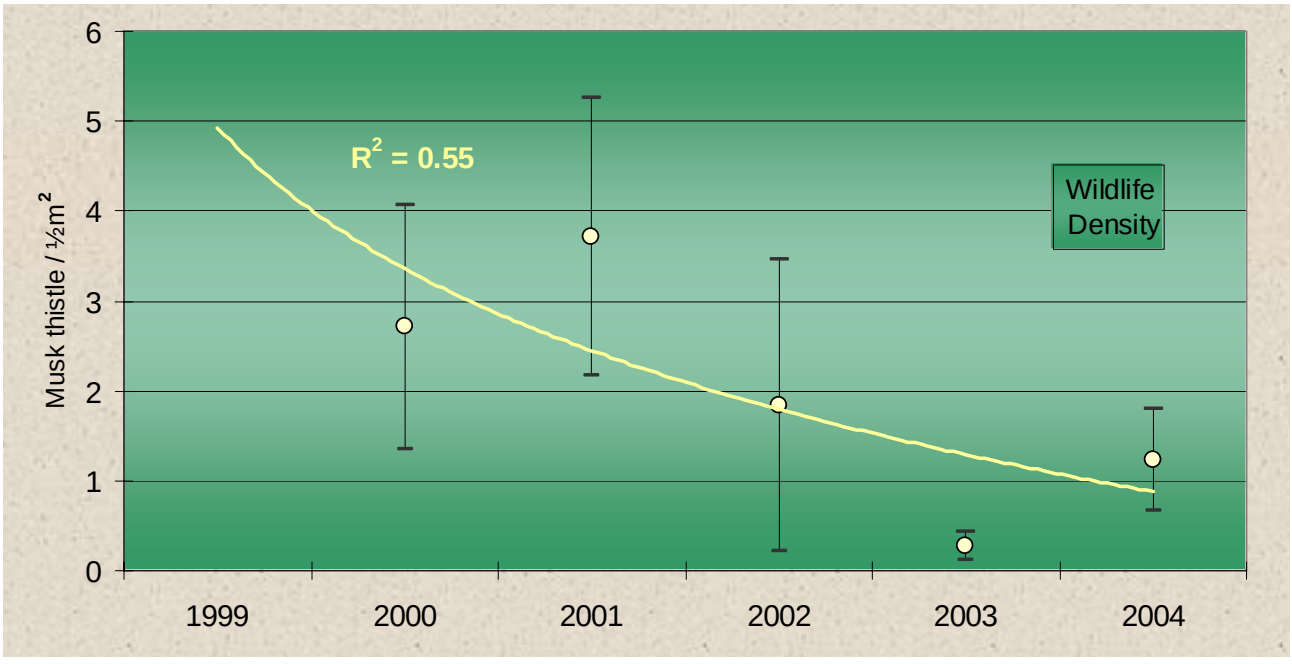


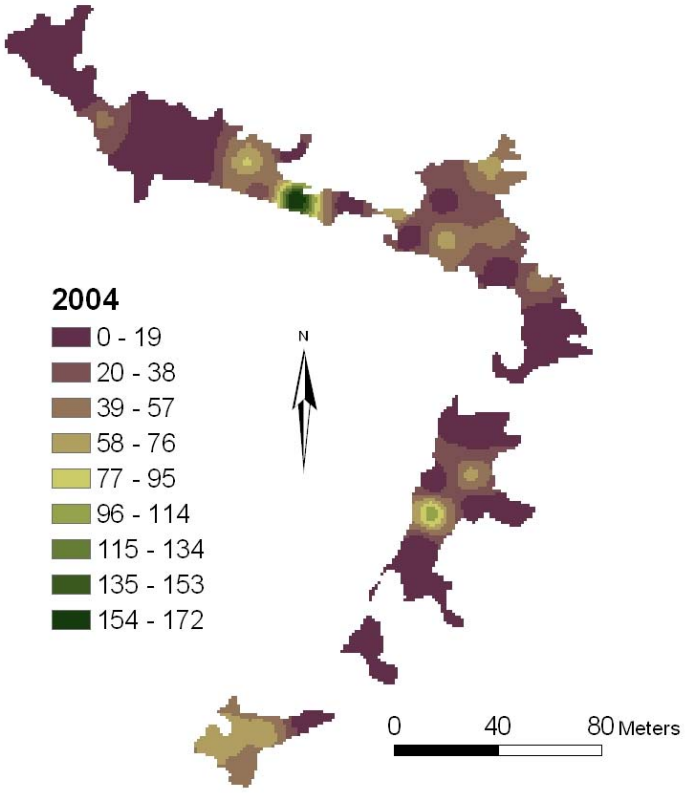


Wildlife Refuge musk thistle perimeter in 2004.

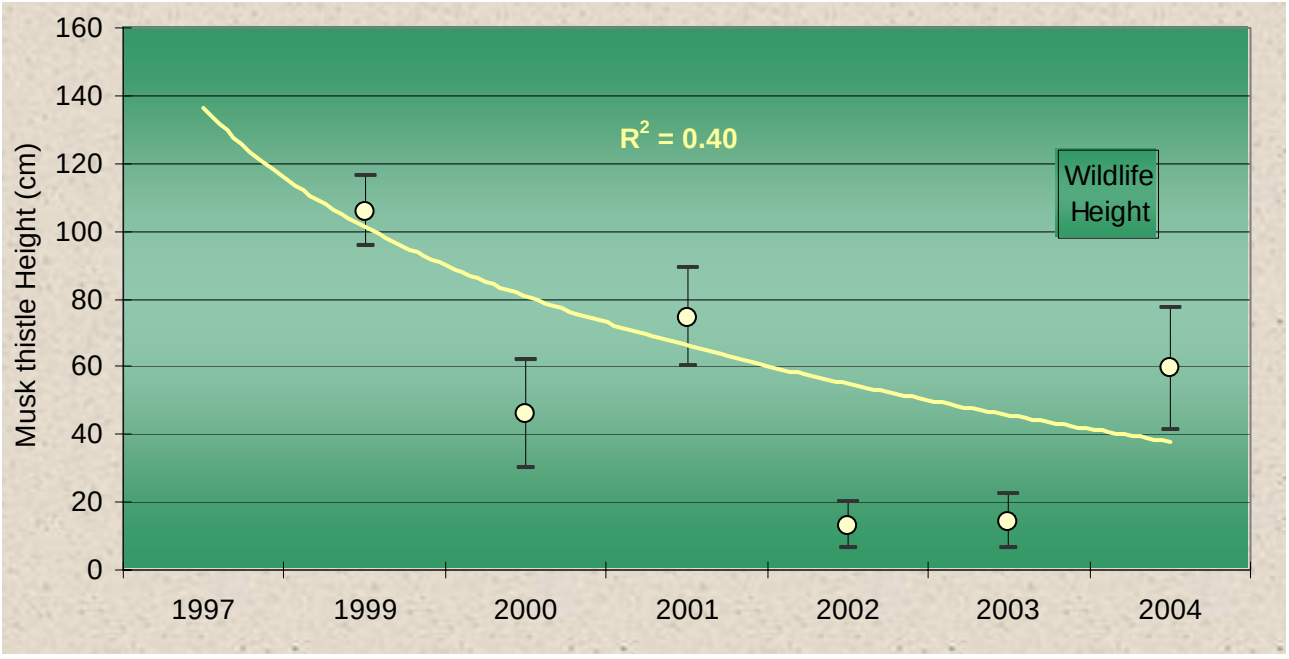


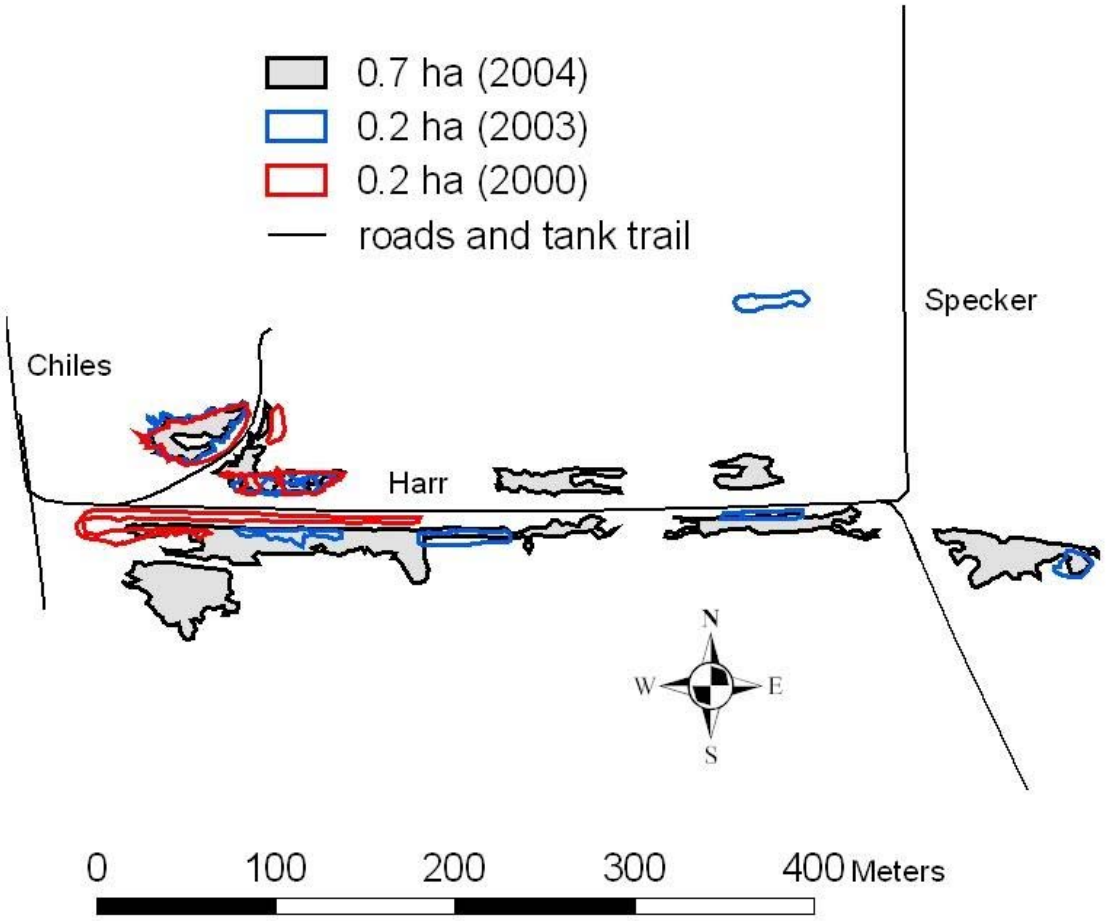
Wildlife Refuge musk thistle density in 2004.



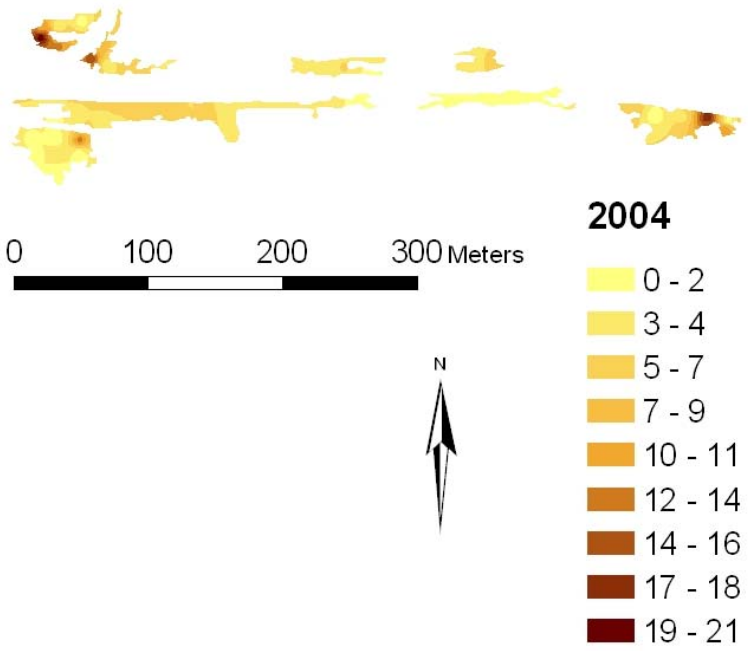


Wildlife Refuge musk thistle height in 2004.

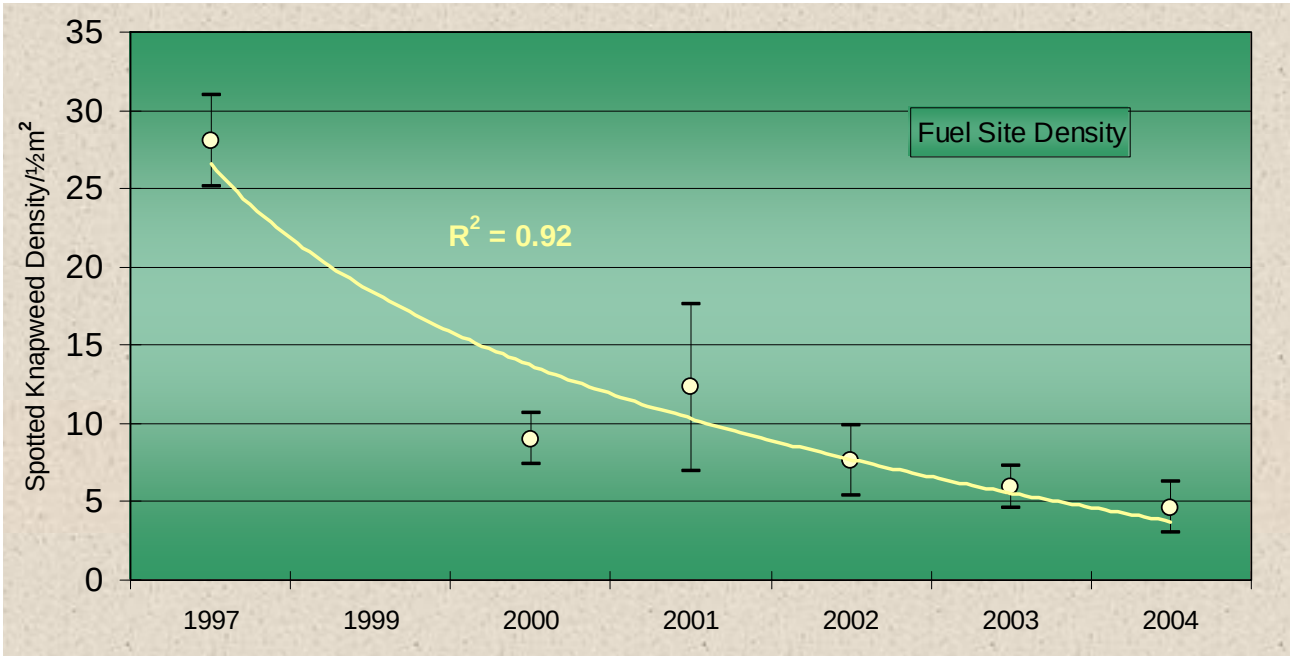


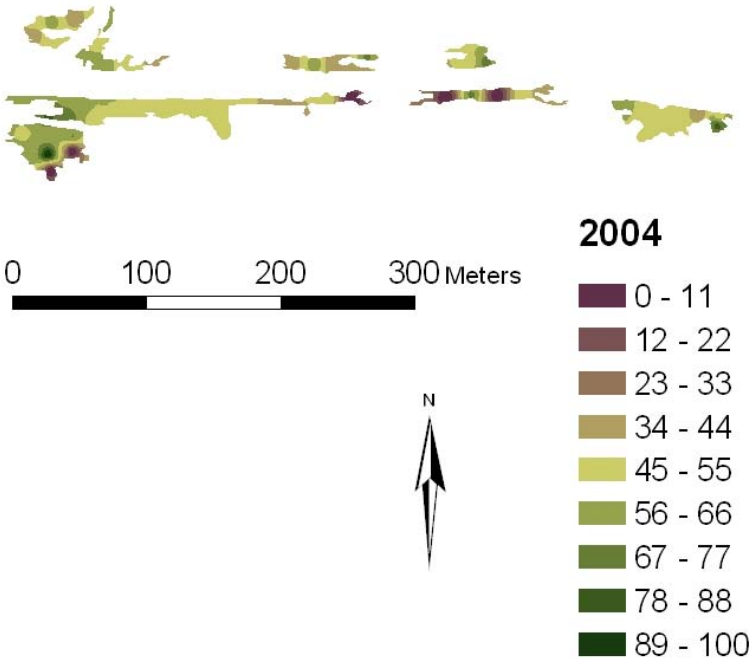


Fuel Site (Cantonment I) spotted knapweed perimeter in 2004.

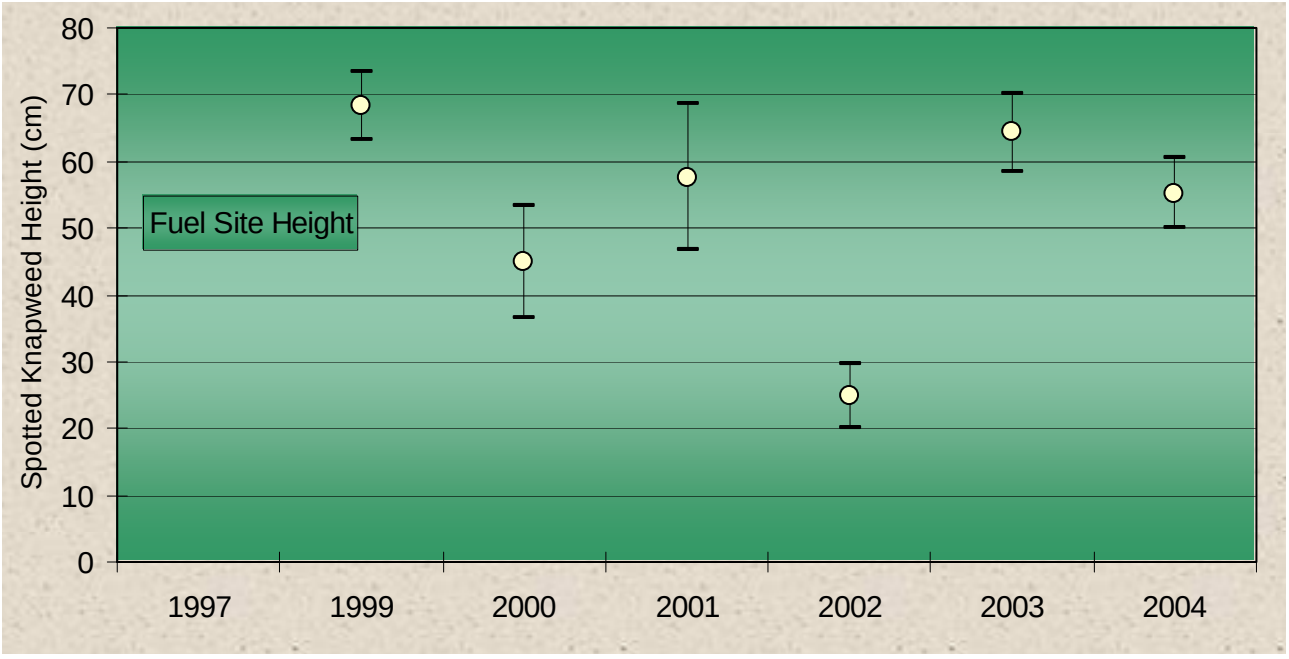


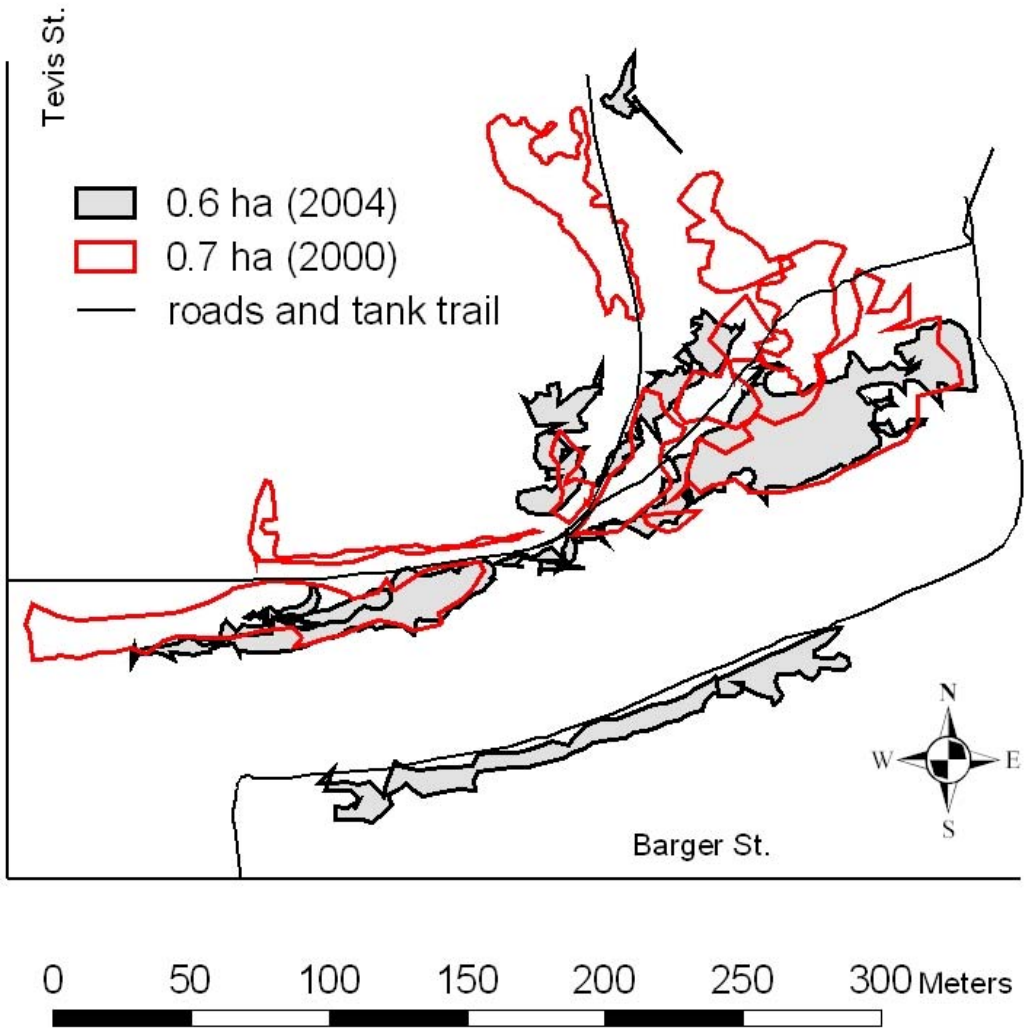
Fuel Site (Cantonment I) spotted knapweed density in 2004.



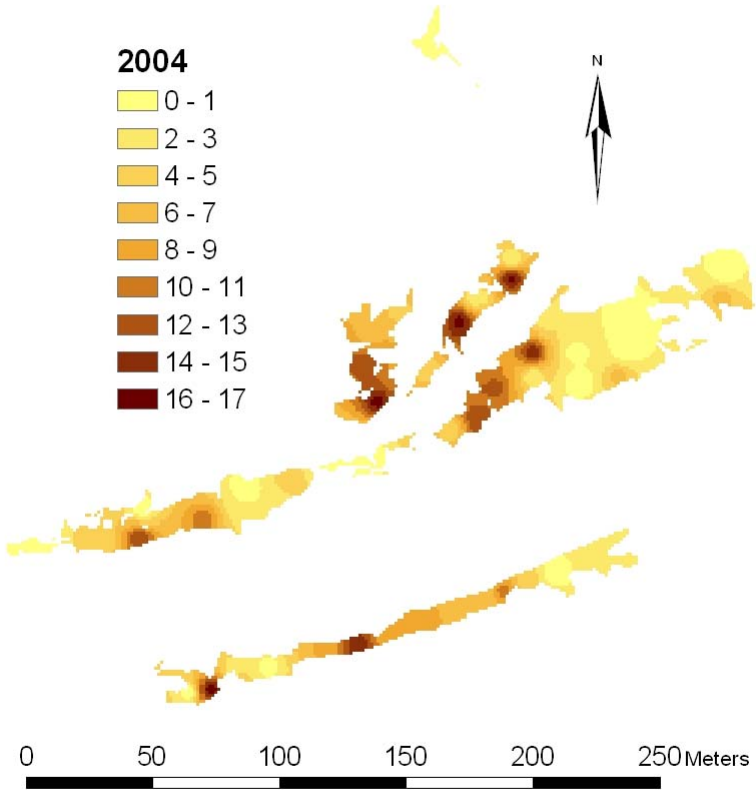


Fuel Site (Cantonment I) spotted knapweed height in 2004.

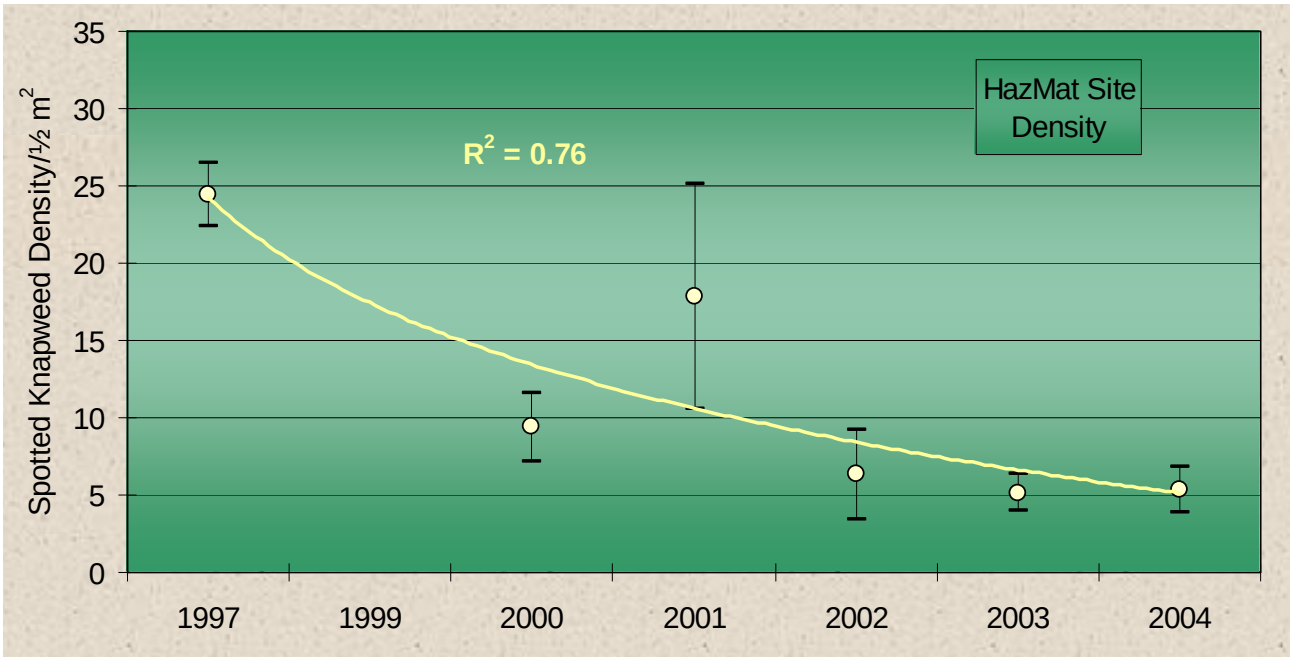


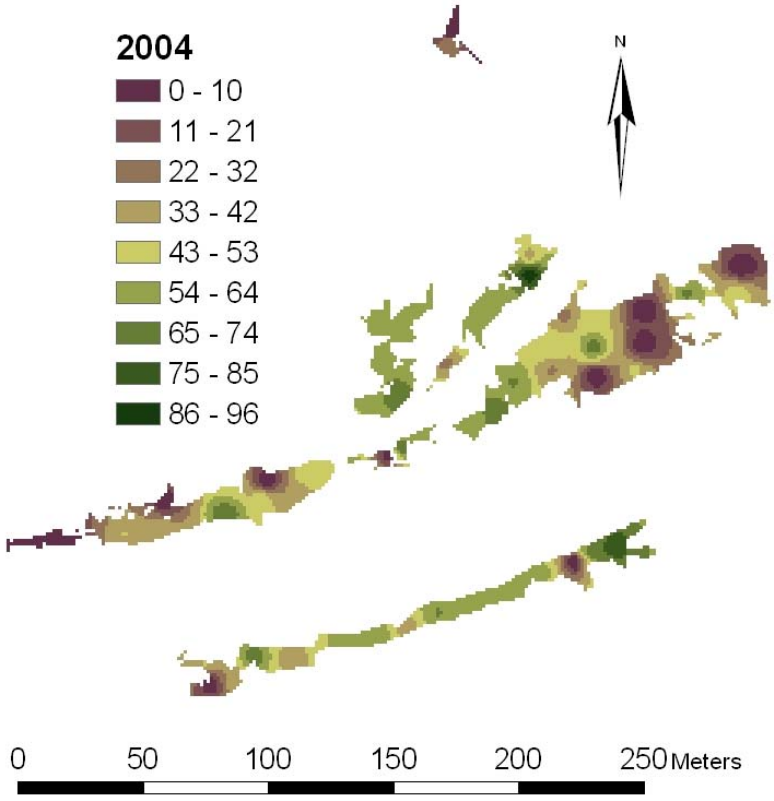


HazMat (Cantonment II) spotted knapweed perimeter in 2004.

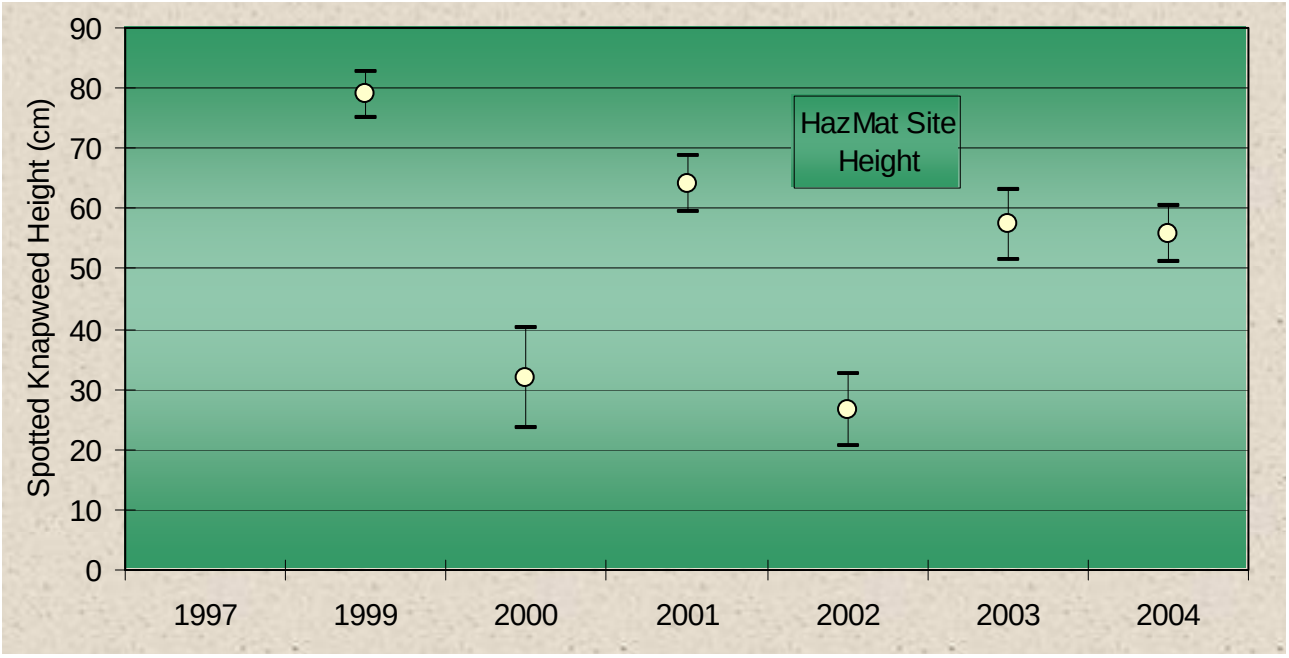


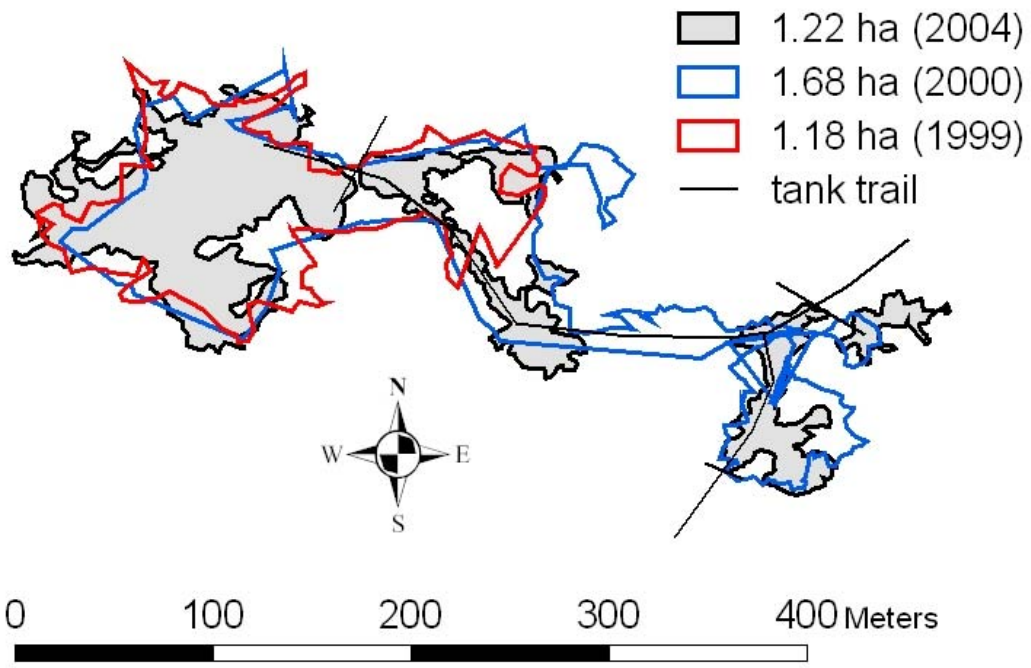
HazMat (Cantonment II) spotted knapweed density in 2004.



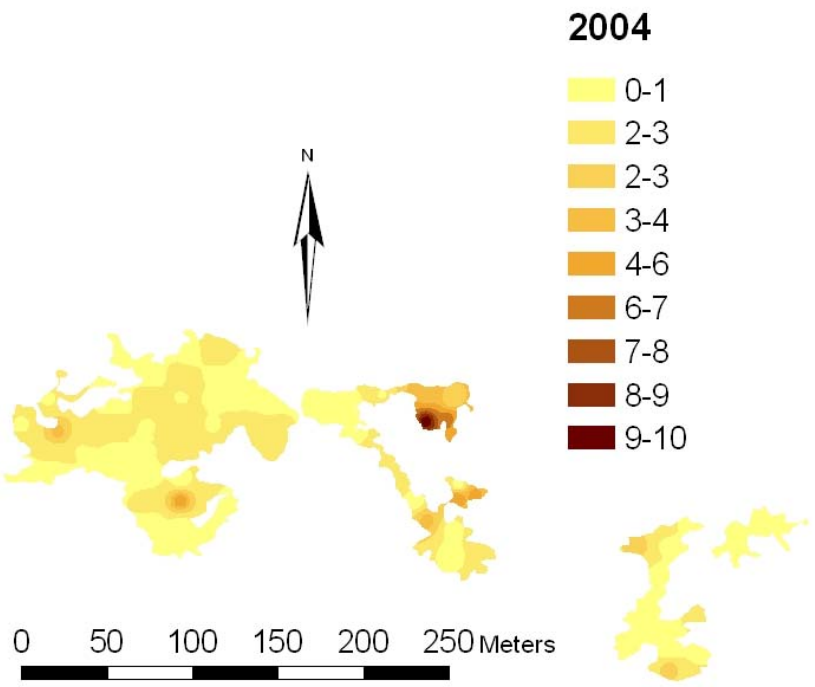


HazMat (Cantonment II) spotted knapweed height in 2004.

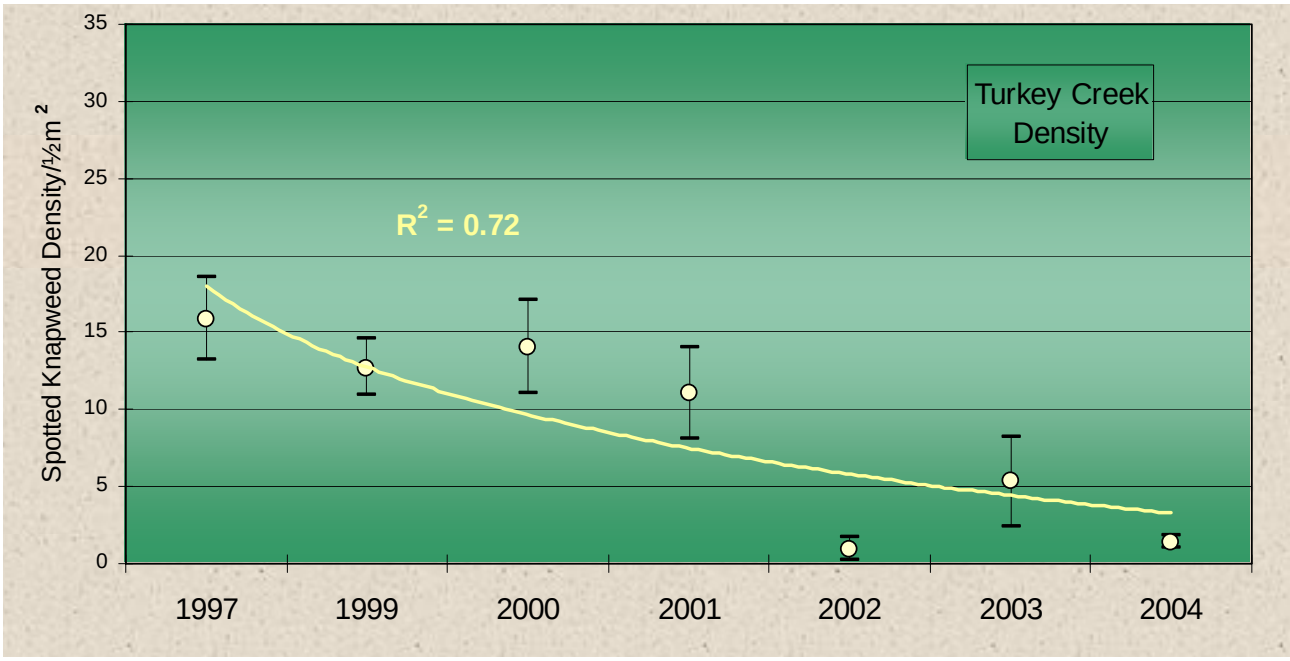


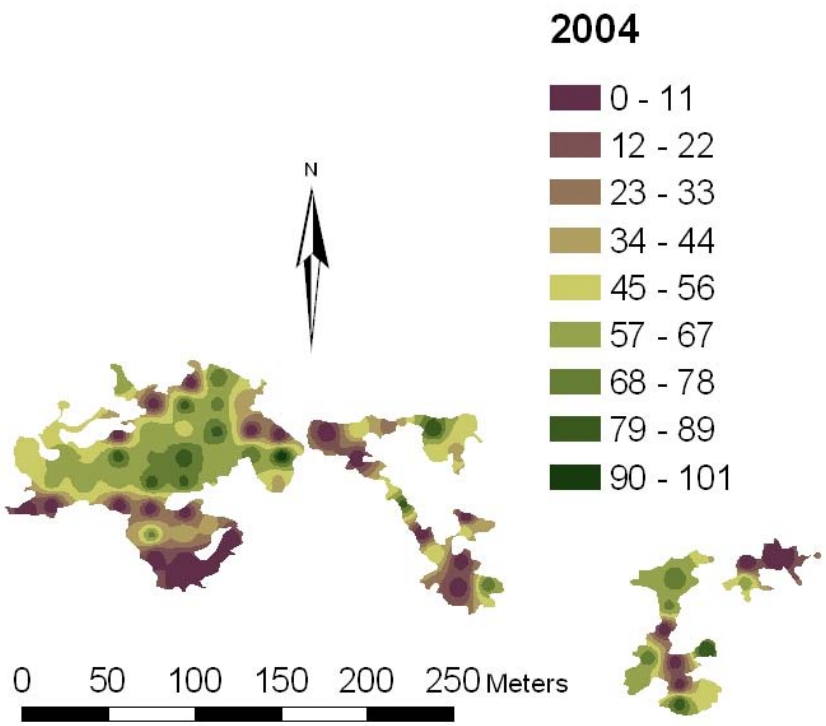


Turkey Creek spotted knapweed perimeter in 2004.

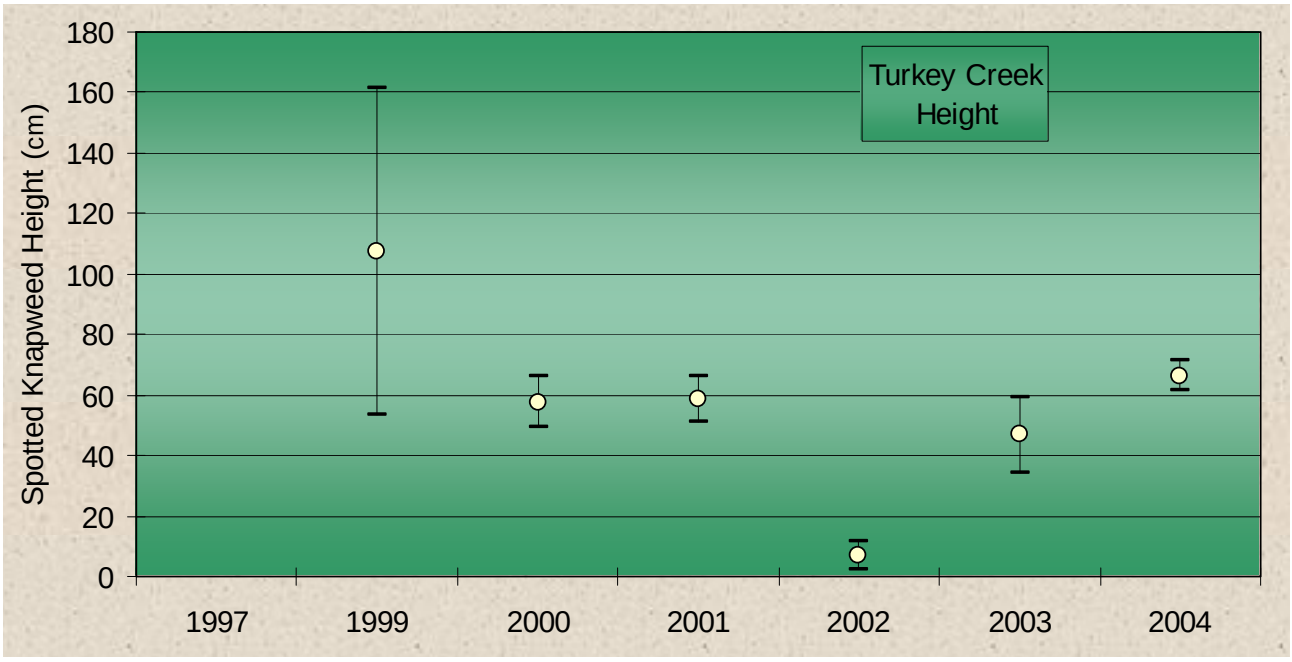


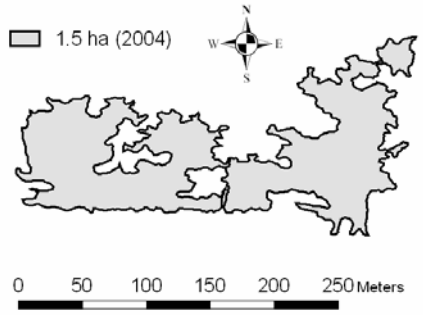
Turkey Creek spotted knapweed density in 2004.



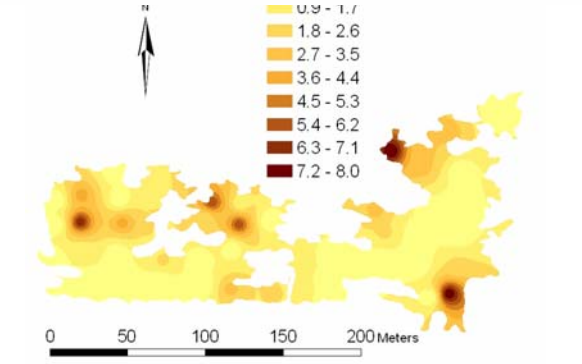


Turkey Creek spotted knapweed height in 2004.

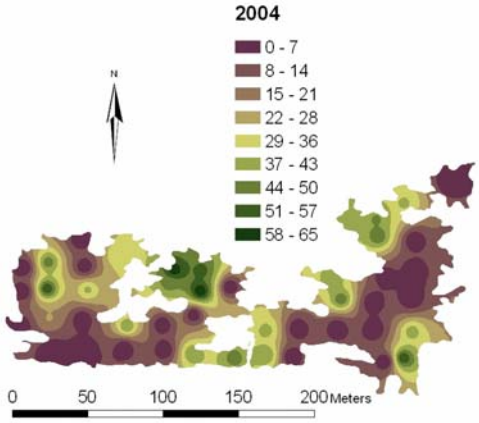




Gun Club diffuse knapweed perimeter in 2004.



Gun Club diffuse knapweed density in 2004.



Gun Club diffuse knapweed height in 2004.

Monument Fire Center

Leafy spurge was mapped (0.14 ha) and weed infestation parameters (i.e. density and height of target plants, area of infestation) were evaluated at Sites 1 & 2, as designated by the 2003 report. The overall spurge infestation area has been reduced by 66% since we began initial monitoring in 2001 (Table 8). Similarly, the quantity of leafy spurge, as indicated by the density of individual plants in a patch, continues to decline annually in the presence of the biocontrol insects. Samples taken in 2004 indicate that the leafy spurge population is now less than 25% of the original plant density measured in 2001, and the size of plants has steadily declined over the past 3 years (plants are 28% shorter in 2004 than originally measured). We continue to monitor our releases of *Aphthona sp*. flea beetles (Table 9) and their target host, however, no new activity is planned for this site.

Table 8. Historic noxious weed infestation parameters, Monument Fire Center, Colorado, 2001-2004.

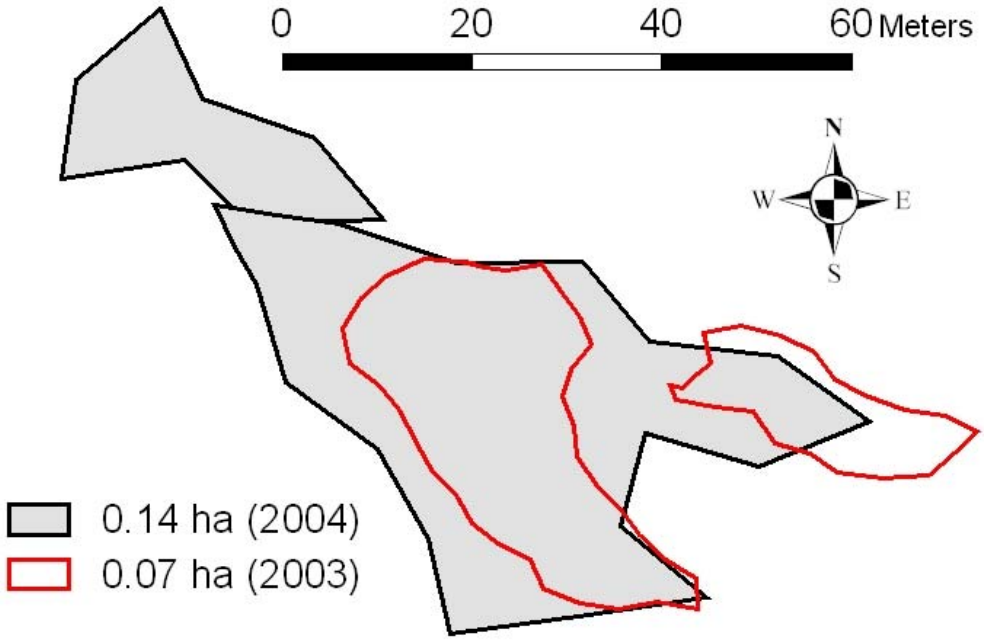
Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Year to year % change			% Change to date
			avg.	max.	avg.	max.	area (m^2)	avg. density	avg. height	
Leafy spurge - Monument Fire Center										
2001	4,096	83	34.97	382	51.61	99				
2002	4,310	115	17.39	210	29.04	69	5.24	-49.21	-36.30	
2003	393	2	12.30	32	43.71		-90.87	-39.92		
2004	1,374	72	12.60	82	40.32	69	249.72	2.44		-66.45

n - number of samples or observations.

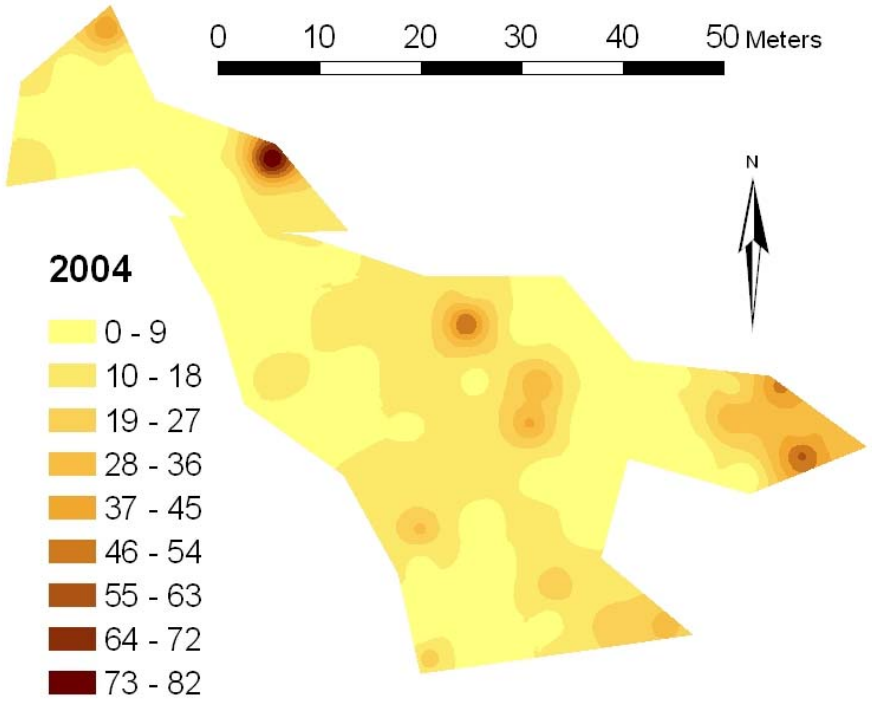
na - not applicable, data represent first year of sampling.

Table 9. Noxious weed biological control sites, target weeds, species released and recoveries at Monument Fire Center, 2004.

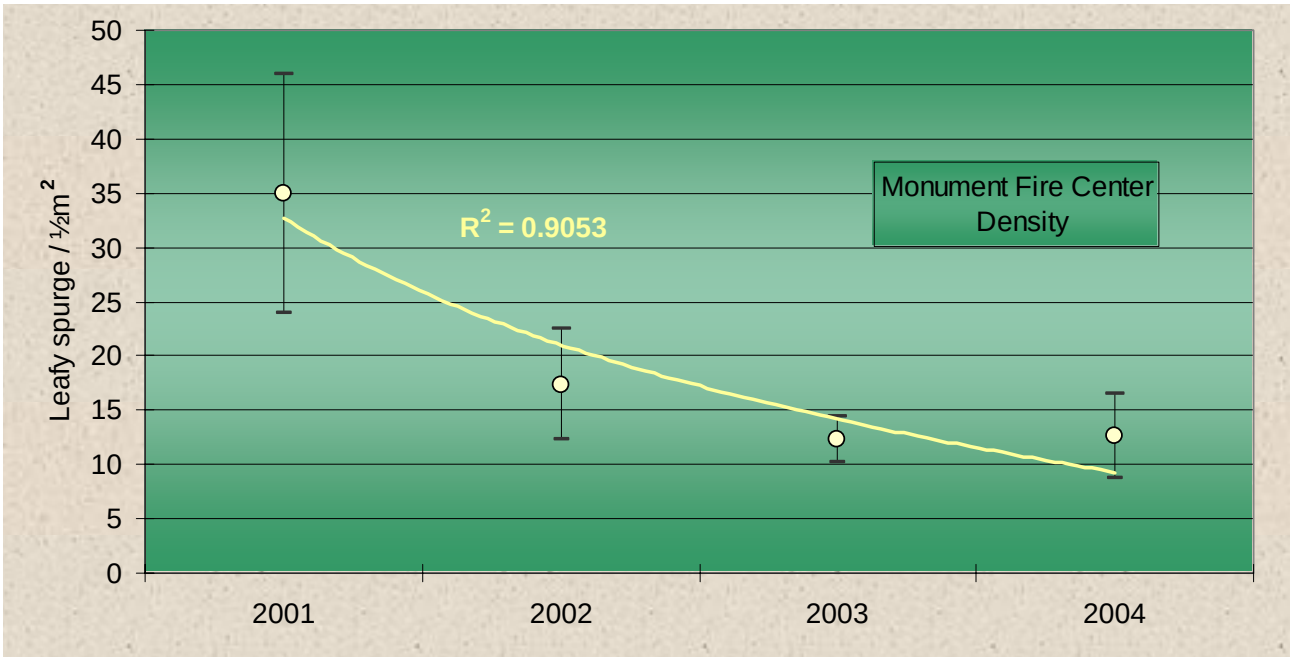
Location	Target weed	Species released	Species recovered
Monument Fire Center	Leafy spurge	*Aphthona czwalinae*	X
Monument Fire Center	Leafy spurge	*Aphthona lacertosa*	X
Monument Fire Center	Leafy spurge	*Aphthona nigriscutis*	X

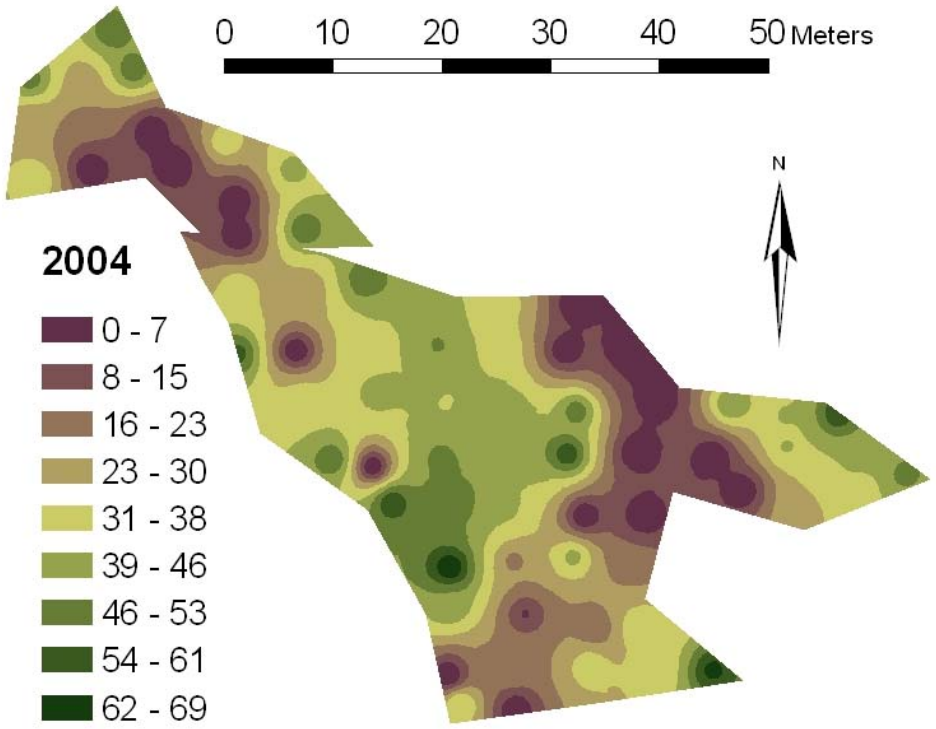


Monument Fire Center leafy spurge perimeter in 2004.

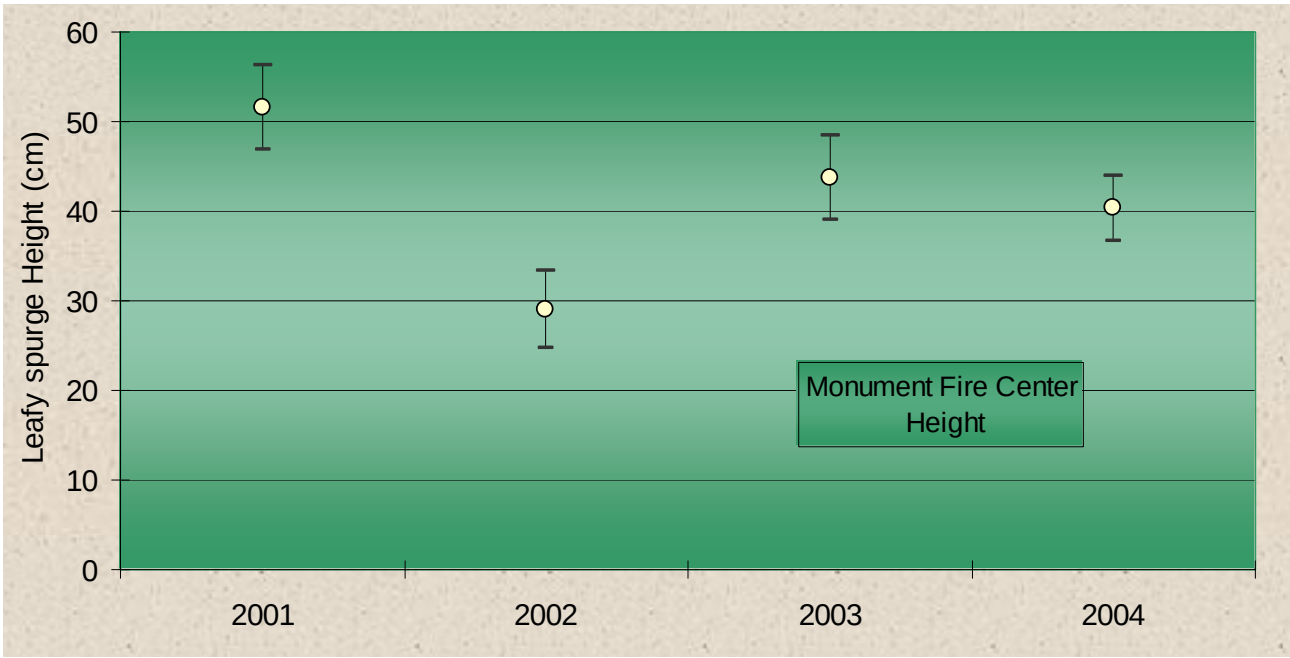


Monument Fire Center leafy spurge density in 2004.





Monument Fire Center leafy spurge height in 2004.



Rocky Flats Environmental Technology Site

Biological control efforts against noxious weeds at Rocky Flats have begun to show very promising results in 2004. Adaptations were made to sampling plans from 2003 to better align our weed control efforts with the most prolific weed patches identified to date. A total of three weed infestations were mapped and weed population parameters (i.e. density and plant height) were evaluated this season, including a patch of Canada thistle at the Lindsey Ranch site, newly monitored in 2004, and two dense and extensive Dalmatian toadflax infestations, Sites 3 & 4. The results of this sampling are presented in Table 10.

Figure 16. Summer students Joy Newton and Daniel Jimenez, along with Vanessa Carney (center), conduct diffuse knapweed line transect surveys to assess the population levels of several insect biological control agents released nearby.

Several weed infestations that had been mapped in 2003 were not sampled again in 2004, as the infestations were extremely patchy and widespread, such as Sites 1 & 2 for Dalmatian toadflax, and the musk thistle infestation in the North Buffer Zone. The difficulty arising in sampling musk thistle in this area, for example, is that most of the

North Buffer area contains a continuous infestation of musk thistle at relatively low densities. An alternative to attempting GIS mapping of these non-discreet weed perimeters was undertaken this year on one such infestation, diffuse knapweed in the Northwest Buffer Zone (Figure 16). This area was intensively sampled via line transects. In addition to performing the concentrated study on diffuse knapweed quantity and vigor, we were able to directly assess the impact and dispersal of several biological control agents released in 2001 and 2002 against this weed. Visual assessment of diffuse knapweed plants revealed an extremely high level of biocontrol agent establishment only 2-3 years post-release. One insect in particular, root-borer *Cyphocleonus achates*, was found in 2004 within 96% of the diffuse knapweed roots sampled along a line transect located over 300 m away from their original point of release. This weevil is large (Figure 17) and flightless, thus making the dispersal and establishment we observed this season extremely remarkable. Although it is not possible to directly attribute the dramatic decrease in diffuse knapweed density and plant height seen at this sample site to this particular insect, its size (resulting in extensive damage to knapweed roots) and density would indicate that *C. achates*, a species with well-documented efficacy as a knapweed biocontrol agent, is beginning to achieve suppression of its host in this area after only two years (see discussion, pp. 141-145).

Figure 17. Two years after its release nearby, root-boring weevil *Cyphocleonus achates*, was found in extremely high numbers in spotted knapweed roots throughout the

Northwest Buffer Zone. Typically, a single larva is found within each root but as many as 4 larvae were found in a single root, as shown above.

Other 2003 monitoring sites not mapped in 2004 include the Original Dalmatian toadflax site in the South Buffer Zone. This weed infestation declined dramatically between 2001 and 2002, after an introduction of the stem-boring weevil, *Mecinus janthinus*. This infestation was not mapped in 2003 nor this past season, as there was no longer a discrete patch of toadflax to be observed. Follow-up visual assessment of the site in 2004 indicated that a residual population of *M. janthinus* remained on the few, stunted and scattered Dalmatian toadflax plants. We will continue to monitor this area in future years. However, the patch of Dalmatian toadflax originally mapped in 2001 has been virtually eradicated.

Figure 18. One year after the release of stem-galling fly, *Urophora cardui*, at Lindsey Ranch, numerous large galls were observed on Canada thistle stems in 2004.

The diffuse knapweed infestations, Sites 1 & 2, were not mapped in 2003. These sites are located within the central area of Rocky Flats and demolition activities prevented sampling at this location. We will return in 2005 to sample these infestations.

It was an exciting year for discovering biocontrol insect establishment at Rocky Flats (Table 11). In 2004, there were three insect biocontrol agent species recovered at release sites. Large numbers of Canada thistle stem galls were observed at the Lindsey Ranch site, into which the gall fly *Urophora cardui* was released in 2003 (Figure 18), indicating a very successful establishment. A single root-boring biocontrol agent for diffuse knapweed, *Sphenoptera jugoslavica*, was found this year as well from unknown origins. Small numbers of a thistle rosette-feeding weevil, *Trichosirocalus horridus*, were found on musk thistle plants in the North Buffer Zone above Lindsey Ranch. We will continue to monitor established biological control agents and re-distribute as necessary to other weed infestations.

An augmentative release of 1000 *M. janthinus* was made at Sites 3 & 4 Dalmatian toadflax infestations. Although there were weevils recovered from this site in early spring 2004, there was not enough evidence of a significant establishment from the previous year's release. Once established at this site, we expect *M. janthinus* to spread and effectively suppress this large toadflax population.

Table 10. Historic noxious weed infestation parameters, Rocky Flats, Colorado, 2001-2004.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		Seedheads	Head size	Year to year % change			% Change
			avg.	max.	avg.	max.	per plant	mm	area (m^2)	avg. density	avg. height	to date
						Canada thistle - Lindsey Ranch						
2004	692	43	7.84	34.00	56.05	104	1.64	0.30	na	na	na	na
						Musk Thistle						
2003	25,422	67	1.67	8	69.29	140	10.03	23.69				
2004												
						Dalmatian Toadflax - Original Site						
2001	1,688	48	20.8	64	51.2	84						
2002	7,913	93	4.95	23	17.36	55.4			368.66	-76.20	-66.09	368.66
2003												
2004												
						Dalmatian toadflax - Sites I & II						
2003	9,133	44	3.72	10	59.89	110						
2004												
						Dalmatian toadflax - Site III & IV						
2003	13,479	88	3.24	16	68.92	130						
2004	692	179	4.97	46	46.92	86			-94.87	53.40	-31.92	-94.87
						Diffuse knapweed - Site I						
2003	1,624	18	3.06	9	49.44	70						
2004												
						Diffuse knapweed - Site II						
2003	3,841	40	3.03	13	36	65						
2004												

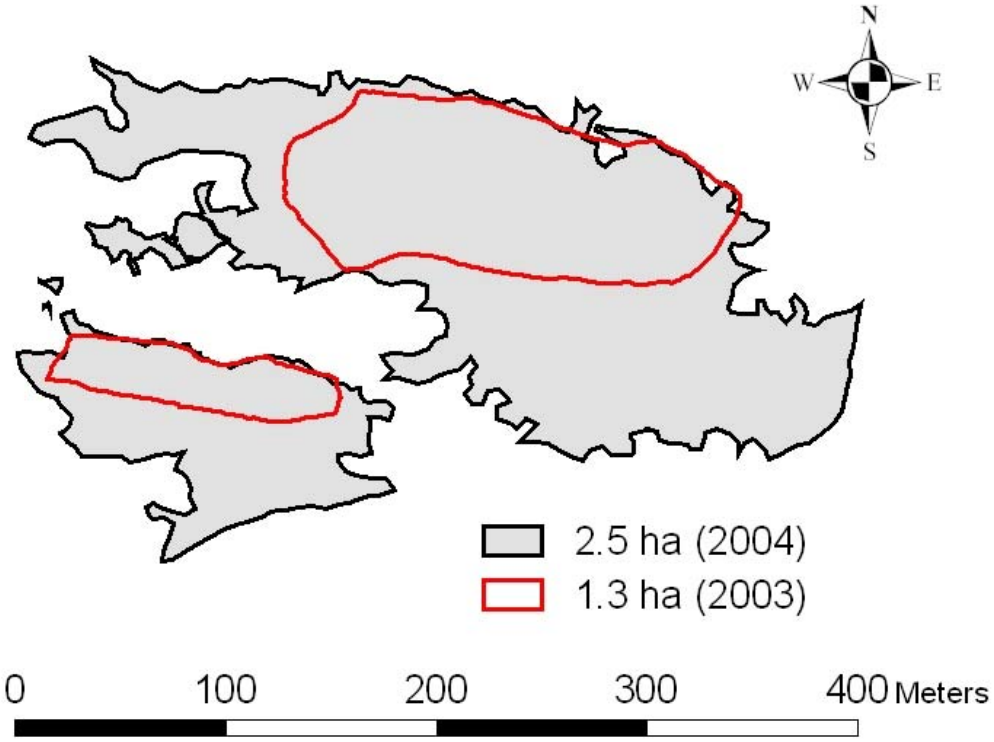
n - number of samples or observations.

na - not applicable, data represent first year of sampling.

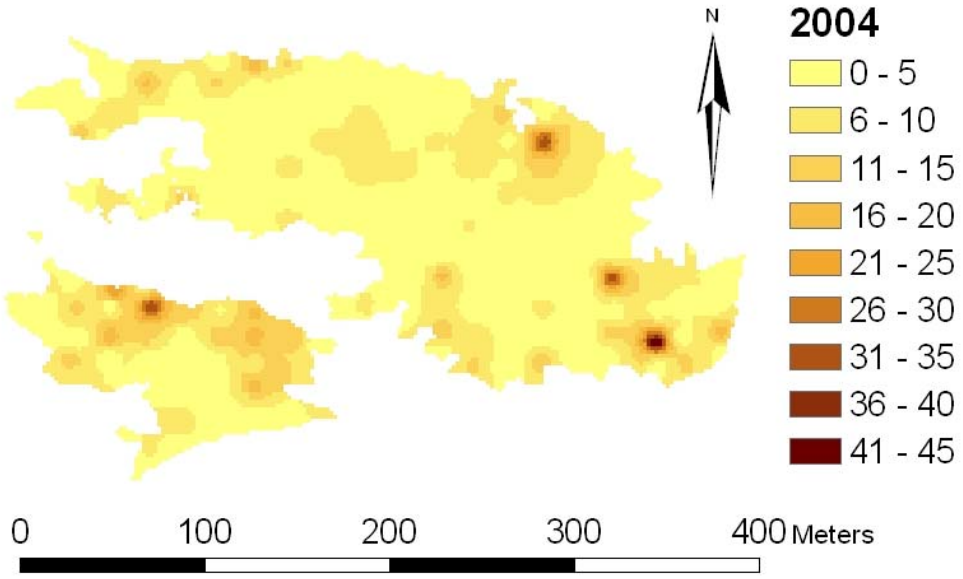
Table 11. Noxious weed biological control sites, target weeds, species released and recoveries at Rocky Flats, 2003.

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 [1]		
Rocky Flats	Musk thistle	North Buffer	*Trichosirocalus horridus*	X		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Cyphocleonus achates*	X [1]		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Larinus minutus*	X		
Rocky Flats	Diffuse knapweed	Northwest Buffer Zone	*Sphenoptera jugoslavica*	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	Southeast Buffer Zone	*Mecinus janthinus*	X		
Rocky Flats	Dalmatian toadflax	Sites 3 & 4	*Mecinus janthinus*	X [1]	X	

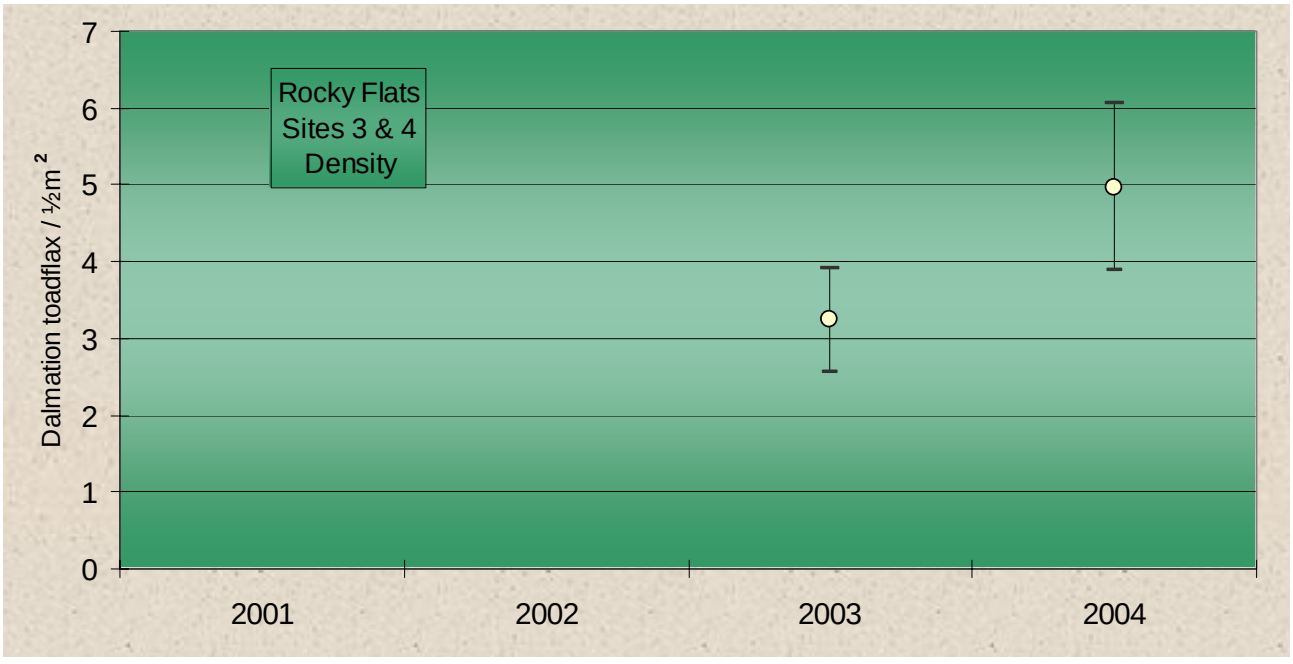
[1] New recovery in 2004

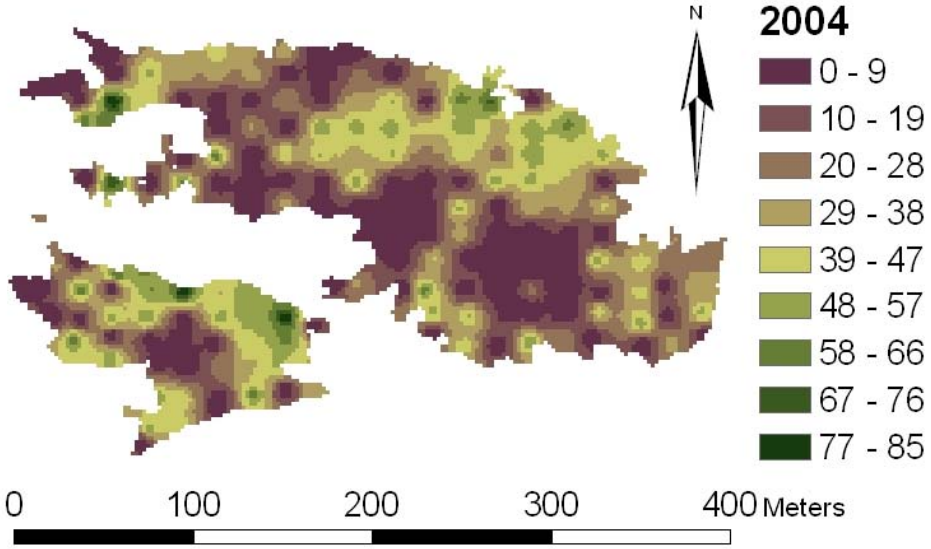


Sites 3 & 4 Dalmatian toadflax perimeters in 2004.

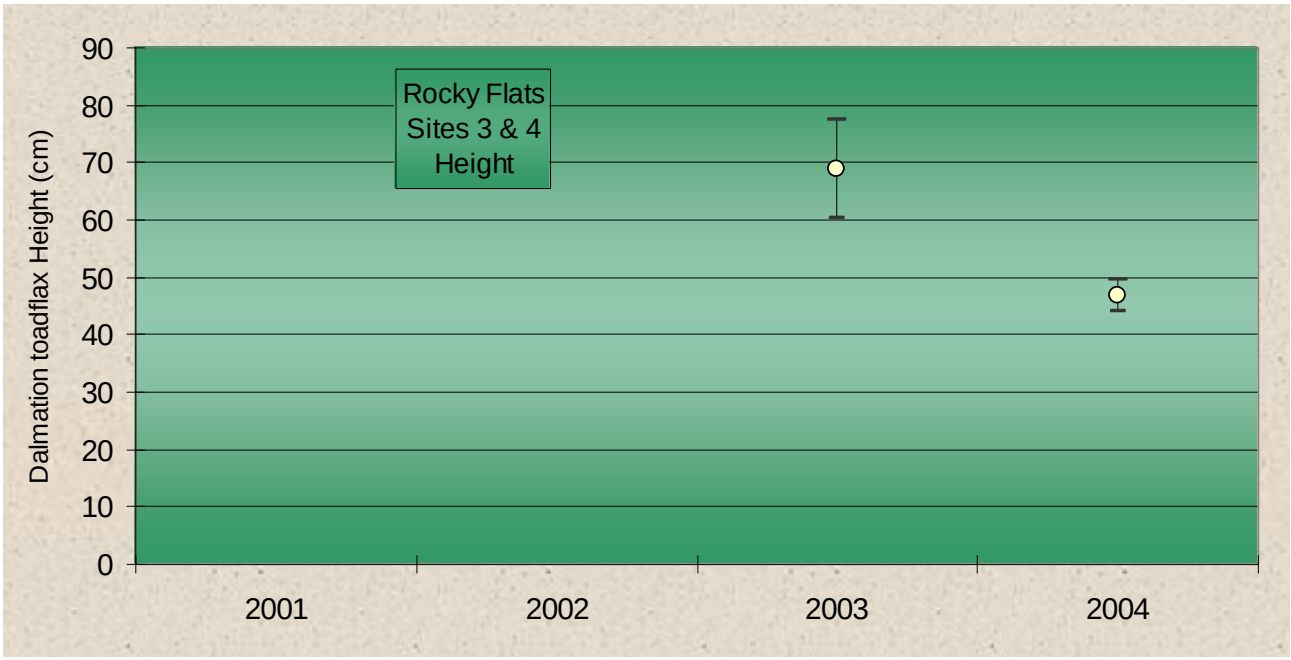


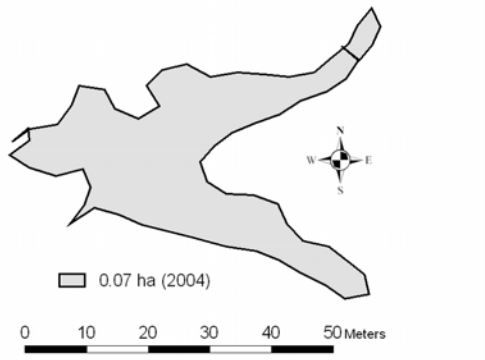
Sites 3 & 4 Dalmatian toadflax density in 2004.



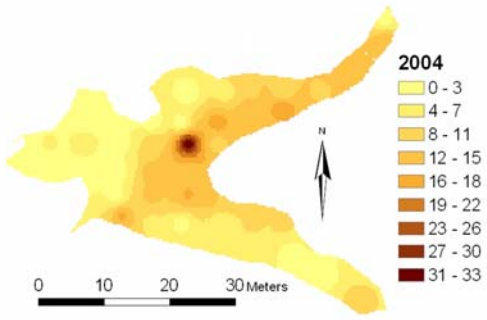


Sites 3 & 4 Dalmatian toadflax height in 2004.

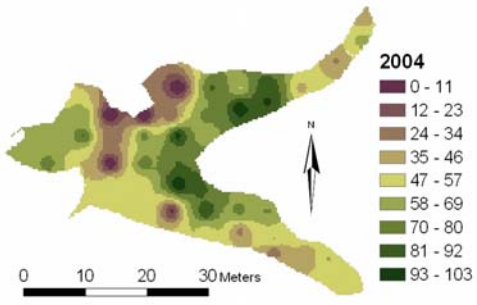




Lindsey Ranch Canada thistle perimeter in 2004.



Lindsey Ranch Canada thistle density in 2004.



Lindsey Ranch Canada thistle height in 2004.

Diffuse Knapweed Sampling at Rocky Flats

In addition to our yearly sampling for weed density at Rocky Flats, we selected two areas of diffuse knapweed infestations located in the North Buffer Zone to sample for insect and plant density. In the first area, we laid out a west-to-east transect and sampled the infestation at 20-25 meter intervals (depending on terrain) for biocontrol agents. The results are contained in Figure 19. The predominant biocontrol agent was *Cyphocleonus achates*, which was found in all samples, with an average of a little over three larvae per 5 plants (root samples). The two other insects were Tehpritid flies *Urophora affinis* and *U. quadrifasciata*, occurring in most samples. *Larinus minutus* was not found at this sampling date, but that was probably due more to the time of the sample rather than an indication of their presence (see second sampling below).

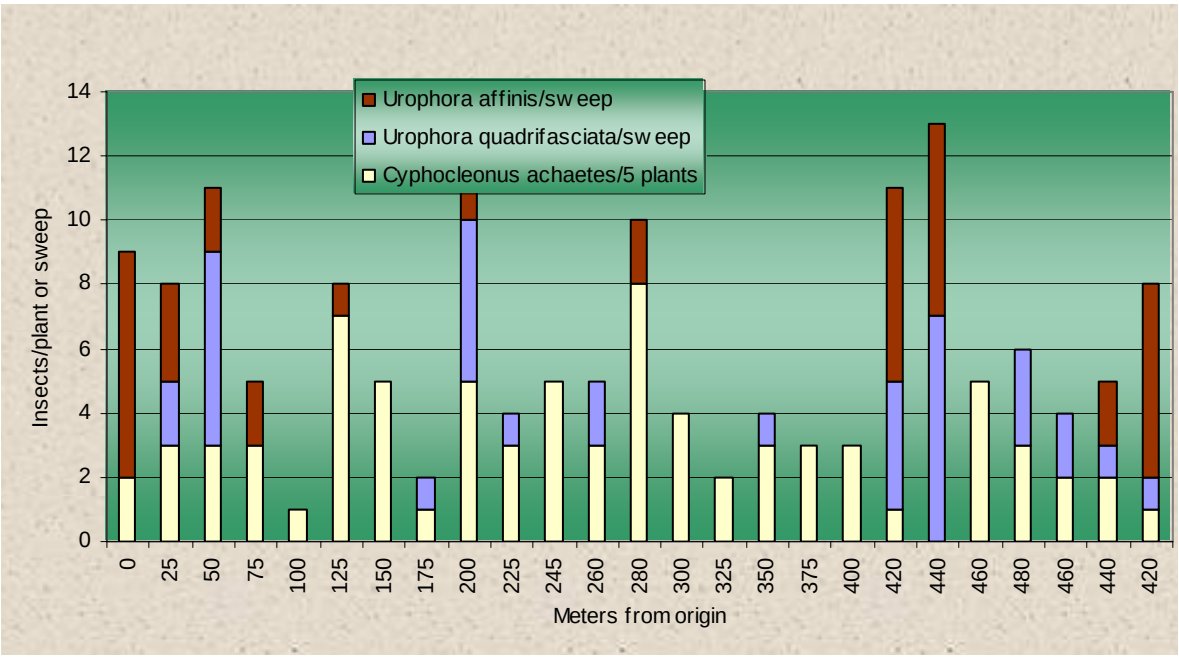


Figure 19. Total numbers of each biological control agent found at 20 meter intervals during sweep samples (*Urophora affinis* and *U. quadrifasciata*) and visual examination (*Cyphocleonus achates*) of plant roots on diffuse knapweed at Rocky Flats.

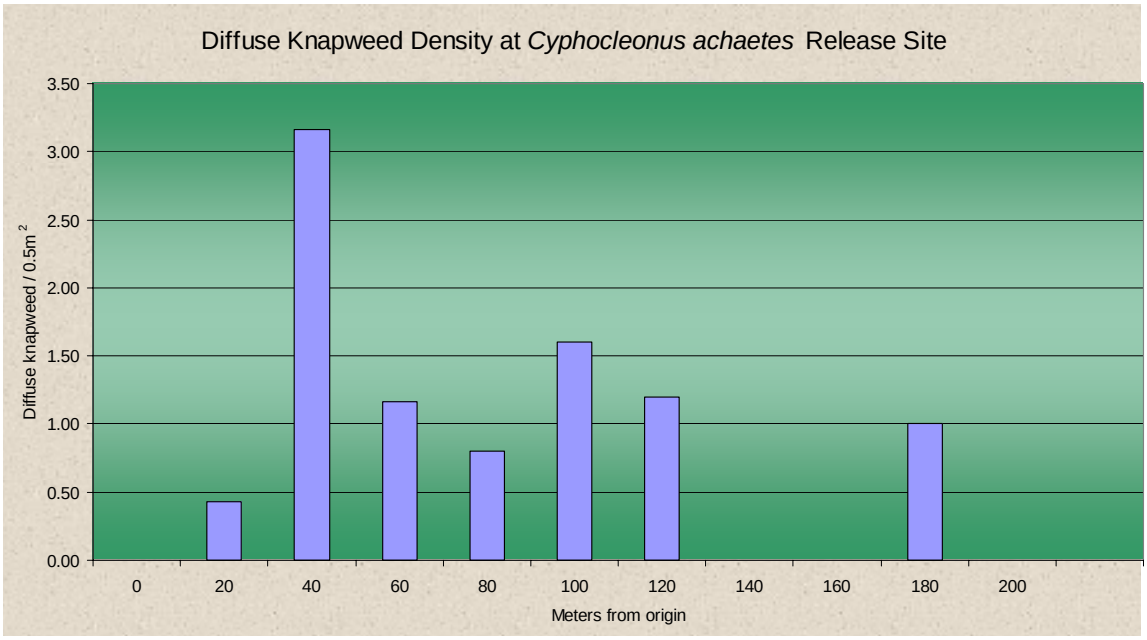
Cyphocleonus achates and *Larinus minutus* were released at separate areas in the Northwest Buffer Zone in 2002 and 2001, respectively. Both species were recovered by 2003. We conducted transect samples at both initial release sites, and one randomly-selected site where no releases had been made (see Figure 22). At the original *C. achates site*, two origins were established at the original points of weevil release. At the first origin, samples were taken every 20 meters along 200 meter transects proceeding north, east, and south from the release site. Each sample is represented by the total number of

insects found within a ½ m^2 sampling frame or quadrat (see Figure 20). No western transect was possible because the release site was near the installation border. At the second origin, samples were taken every 20 meters along 120, 200, and 60 meter transects running to the west, east, and south, respectively. The length of each transect was limited by geographic features. At the original *L. minutus* release site, a similar sampling process occurred (see Figure 21). At the first origin, samples were taken every 20 meters along 100, 200, and 200 meter transects running north, east and south, respectively. At the second origin, the transects were 140, 220, and 200 meters, running north, south and east, respectively. The graphs below are grouped by species released (i.e. *Cyphocleonus* release site vs. *Larinus* release site). The first graph in each of the following figures illustrates the average diffuse knapweed density for all transects. The second graph illustrates the average number of insects collected from all transects.

C. achates, *L. minutus*, and *S. jugoslavic*a were found at all three sites. There did not seem to be a directional trend to the data, so the transects were combined into the average number of insects found at the specific distances from the origins of the transects. All three insects were found to be well established, with *C. achates* being the dominant insect at all three sites. *S. jugoslavica* was a surprise, since the first releases were made in 2003.

The diffuse knapweed infestation at all sites was variable and patchy, ranging from up to six plants/0.5m^2 to none. The samples were selected by tossing a ½ m^2 sampling frame, so there are times when the frame fell into an area where there was no knapweed, but insects were found on plants located adjacent to the sampling frame. This is the reason some of the graphs indicate no knapweed, but insects being present.

In general, the two transect sampling projects indicated that five insects are well established on diffuse knapweed in the North Buffer Zone, and are impacting the plants. We expect to see major reductions in diffuse knapweed in this area over the next two to three years. The insects, even the seemingly flightless *C. achates*, are well distributed and have spread rapidly. We will continue to monitor these areas for insect and plant density.



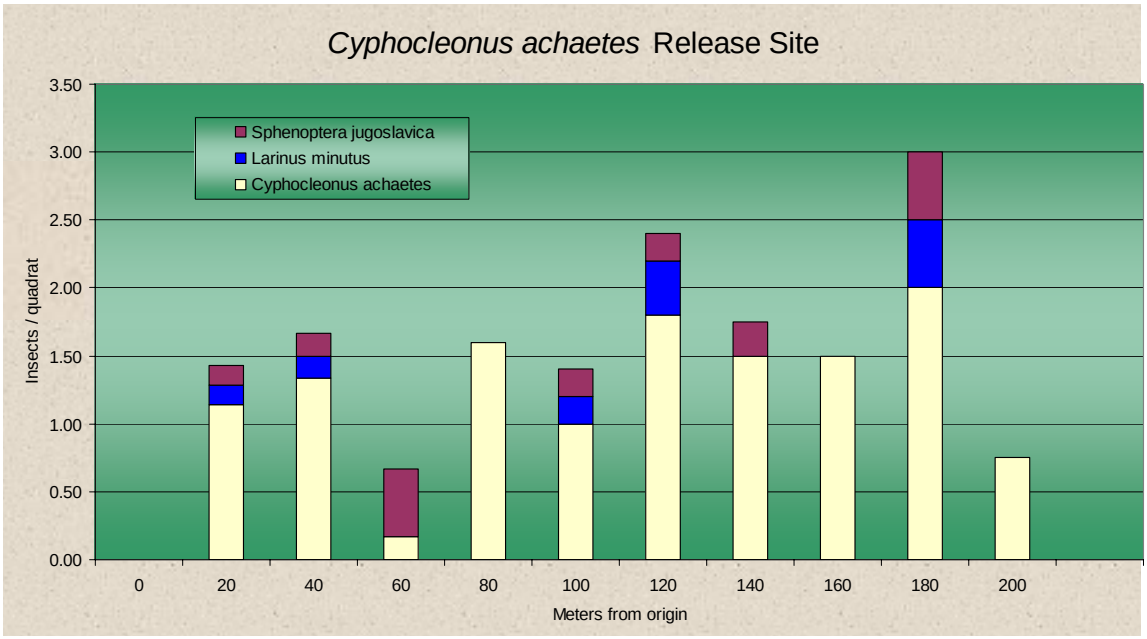
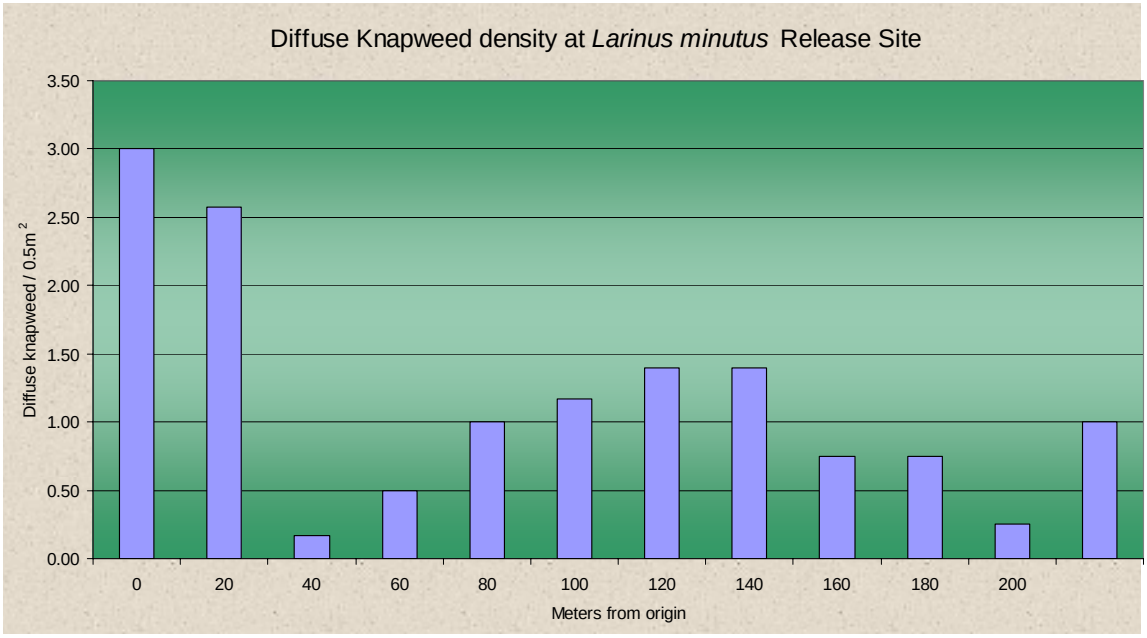


Figure 20. Diffuse knapweed (above) and insect control agent densities (below) at *C. achates* release site, Rocky Flats.



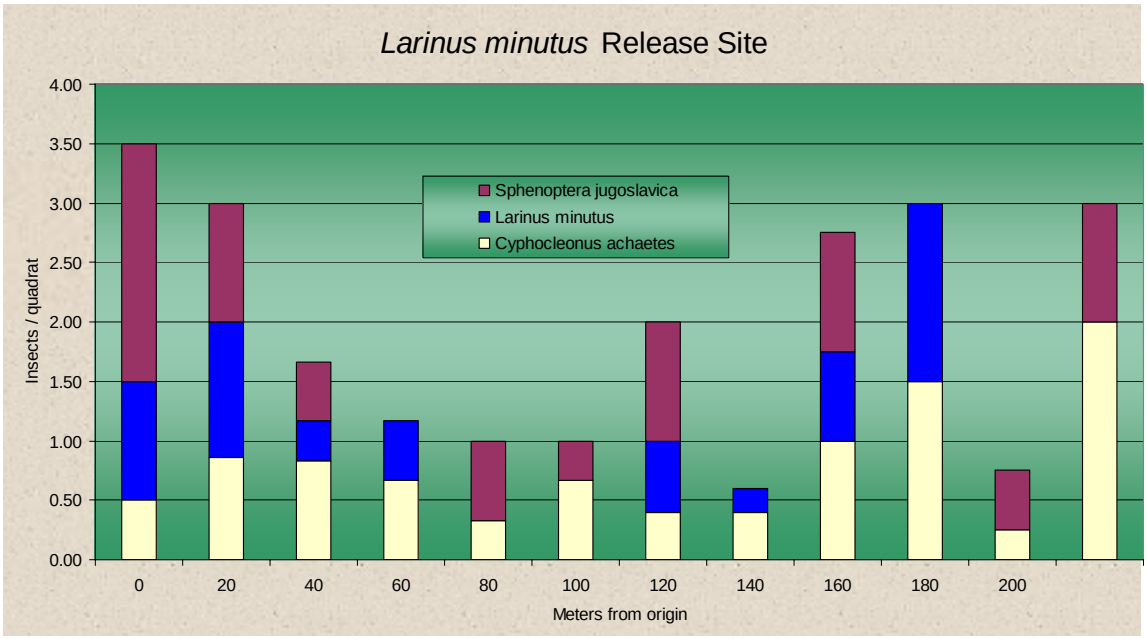
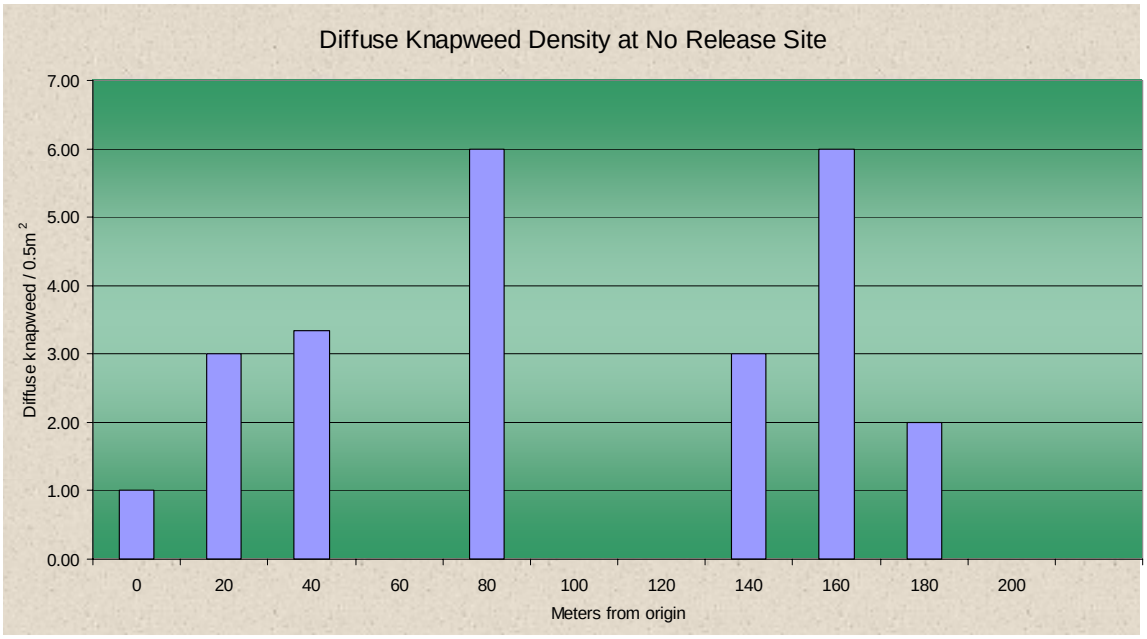


Figure 21. Diffuse knapweed (above) and insect control agent densities (below) at *L. minutus* release site, Rocky Flats.



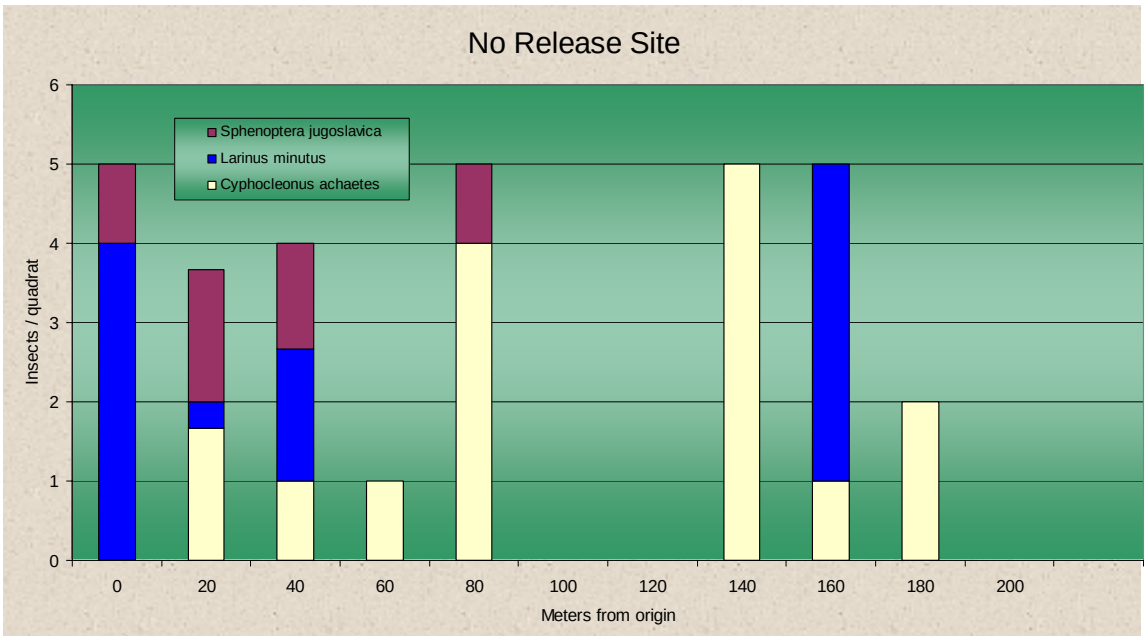


Figure 22. Diffuse knapweed (above) and insect control agent densities (below) at the "no release" site, Rocky Flats.

Warren Airbase

This was the first year for the biocontrol program at Warren Airbase in Cheyenne, WY. Three leafy spurge (*Euphorbia esula*) and three Dalmatian toadflax (*Linaria dalmatica*) infestations (0.9 ha and 8.4 ha in total area, respectively) were identified and mapped (Figure 23). Baseline data on weed coverage, plant density and height were collected for all 6 weed patches. Each of the leafy spurge patches selected is relatively large with high densities of healthy spurge plants. The Dalmatian toadflax sites have extensive area coverage and a typically patchy distribution, with each infestation spreading over at least 18,000 m^2 (Table 12).

Figure 23. Cody Evers (left) and Vanessa Carney begin mapping an extensive leafy spurge infestation at Warren Airbase using a handheld GPS unit.

Releases of *Mecinus janthinus*, a stem-boring weevil that has displayed great success in some areas of Canada and the United States suppressing Dalmatian toadflax populations, were made into two of the mapped Dalmatian toadflax infestations on Warren Airbase (Figure 24; Table 13). The remaining toadflax infestation will be

monitored as a no-impact control site to compare changes in weed density and height as populations of the weevil biocontrol agent establish elsewhere and begin to impact their target host. Redistribution of *M. janthinus* to the Control site is anticipated in future years. There were 1000 and 1500 weevils released at the Missile and Nature sites this past spring, respectively.

Similarly, releases of leaf and flower-feeding beetles, *Aphthona nigriscutis*, were made into two of the three mapped leafy spurge infestations (Table 13). Nature 1 and 2 received 186 and 288 beetles, respectively. This species of leafy spurge beetle has established well in the Colorado Springs and Denver, CO areas and similar success is expected at Warren Airbase. The third leafy spurge site that was mapped and monitored in 2004 (Control) was originally intended to act as the no-impact control for comparison to the leafy spurge populations under attack by the biocontrol beetles as they establish. However, in June 2004, a naturally-occurring population of *A. lacertosa* was discovered at the Control site. Efficacy of this population will be monitored and redistributions of beetles amongst these and other leafy spurge infestations are anticipated for future years.

Figure 24. Summer student Sarah Bruno makes one of several releases of 500 stem-boring weevils (*Mecinus janthinus*) onto Dalmatian toadflax.

Plans are underway to increase the biological control efforts at Warren Airbase on these two weed species, along with potential introductions of insect agents for the control of purple loosestrife, *Lythrum salicaria*. There is also a significant population of houndstongue (*Cynoglossum officinale*) on Warren Airbase that would benefit from control efforts. As yet, there are no insect biological control agents approved for houndstongue control in the United States, but as insects become available in the future releases may be coordinated.

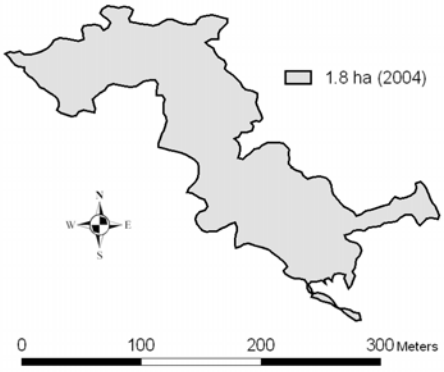
Table 12. Noxious weed infestation parameters, Warren Air Base, Wyoming, 2004.

Year	Area (m^2)	n	Density ($1/2m^2$)		Height (cm)		% change area (m^2)	% Change to date
			avg.	max.	avg.	max.		
Dalmatian toadflax - Control								
2004	18,424	45	2.67	21	32.73	91	na	na
Dalmatian toadflax - Missile								
2004	20,356	49	0.63	3	24.14	80	na	na
Dalmatian toadflax - Nature								
2004	45,471	80	1.16	8	25.01	84	na	na
Leafy spurge - Control								
2004	5,526	31	41.7	98	48.71	69	na	na
Leafy spurge - Nature I								
2004	1,849	44	36.95	88	67.14	95	na	na
Leafy spurge - Nature II								
2004	1,703	42	66.19	129	55.98	81	na	na

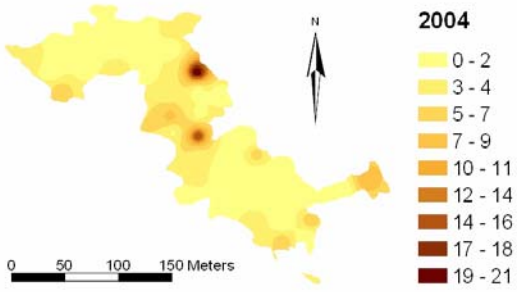
Table 13. Noxious weed biological control sites, target weeds, species released and recoveries at Warren Airbase, 2004.

Target weed	Site	Species released	New releases	New site
Leafy spurge	Control	*Apthona lacertosa*	X [1]	X
Leafy spurge	Nature 1	*Apthona nigriscutis*	X	X
Leafy spurge	Nature 2	*Apthona nigriscutis*	X	X
Dalmatian toadflax	Control			X
Dalmatian toadflax	Nature	*Mecinus janthinus*	X	X
Dalmatian toadflax	Missile	*Mecinus janthinus*	X	X

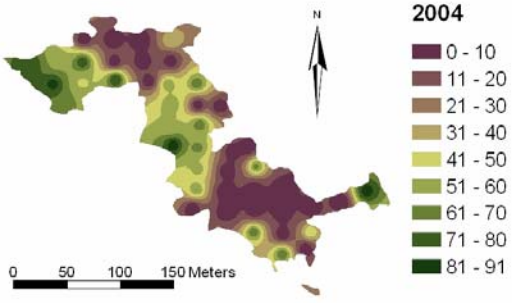
[1] Adventitious recovery, no release made at this site



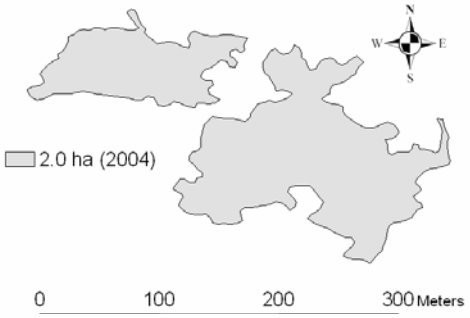
Control Dalmatian toadflax perimeter in 2004.



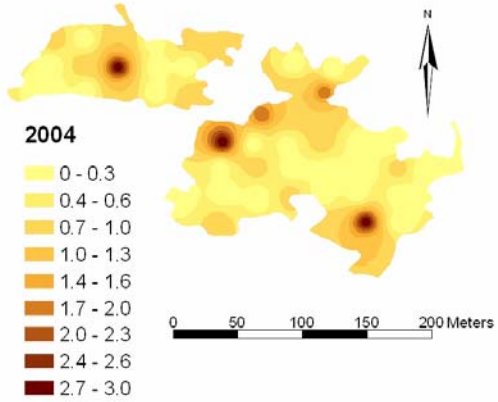
Control Dalmatian toadflax density in 2004.



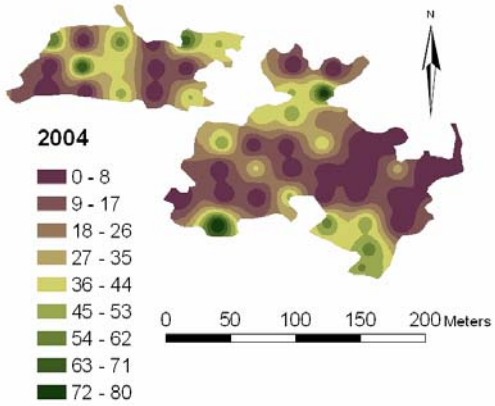
Control Dalmatian toadflax height in 2004.



Missile Dalmatian toadflax perimeter in 2004.

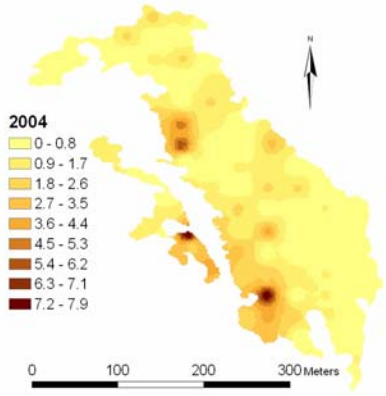


Missile Dalmatian toadflax density in 2004.



Missile Dalmatian toadflax height in 2004.

Nature Dalmatian toadflax perimeter in 2004.



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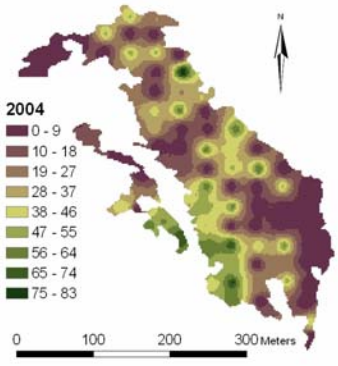

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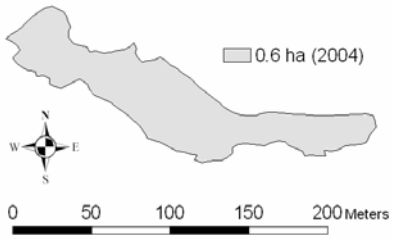
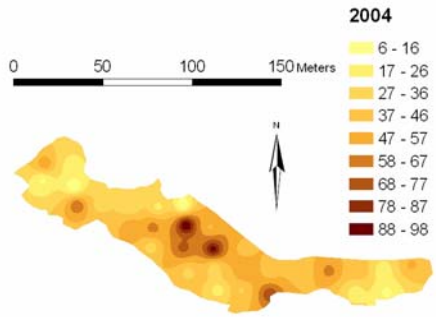


Control leafy spurge perimeter in 2004.



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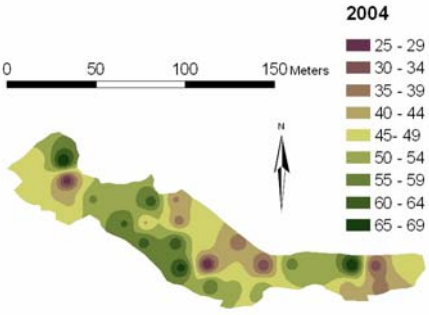

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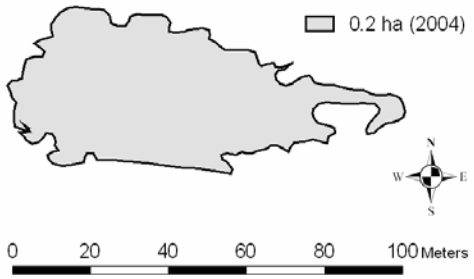

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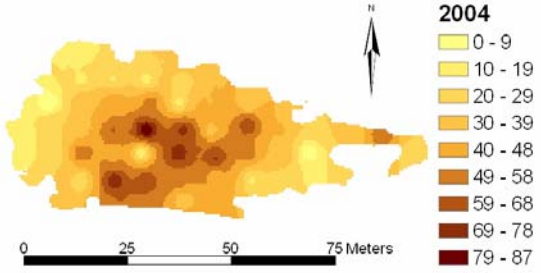

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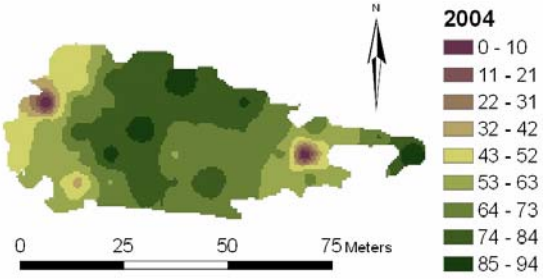
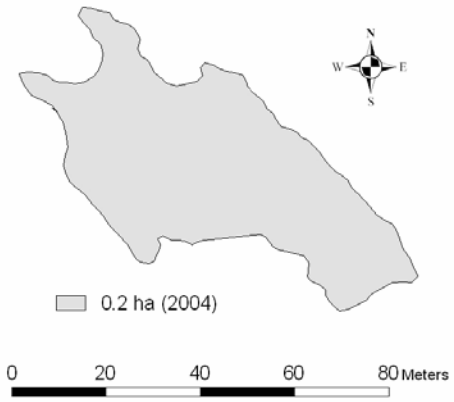


Nature I leafy spurge height in 2004.



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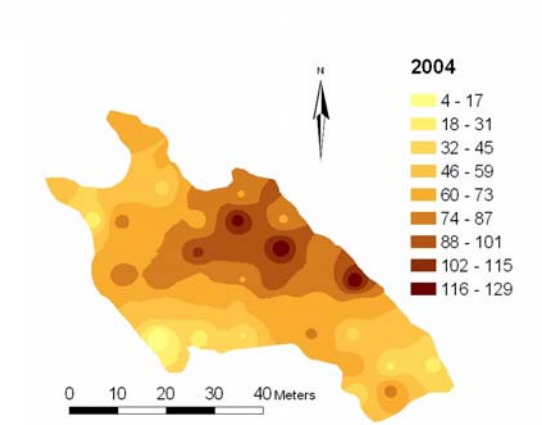

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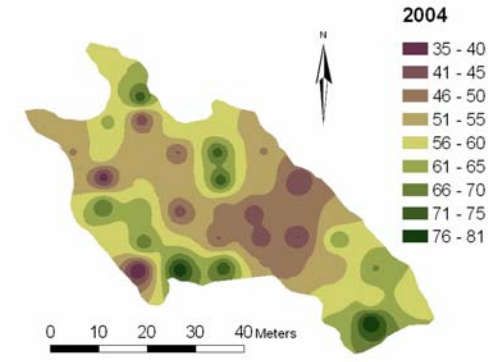

Nature II leafy spurge height in 2004.