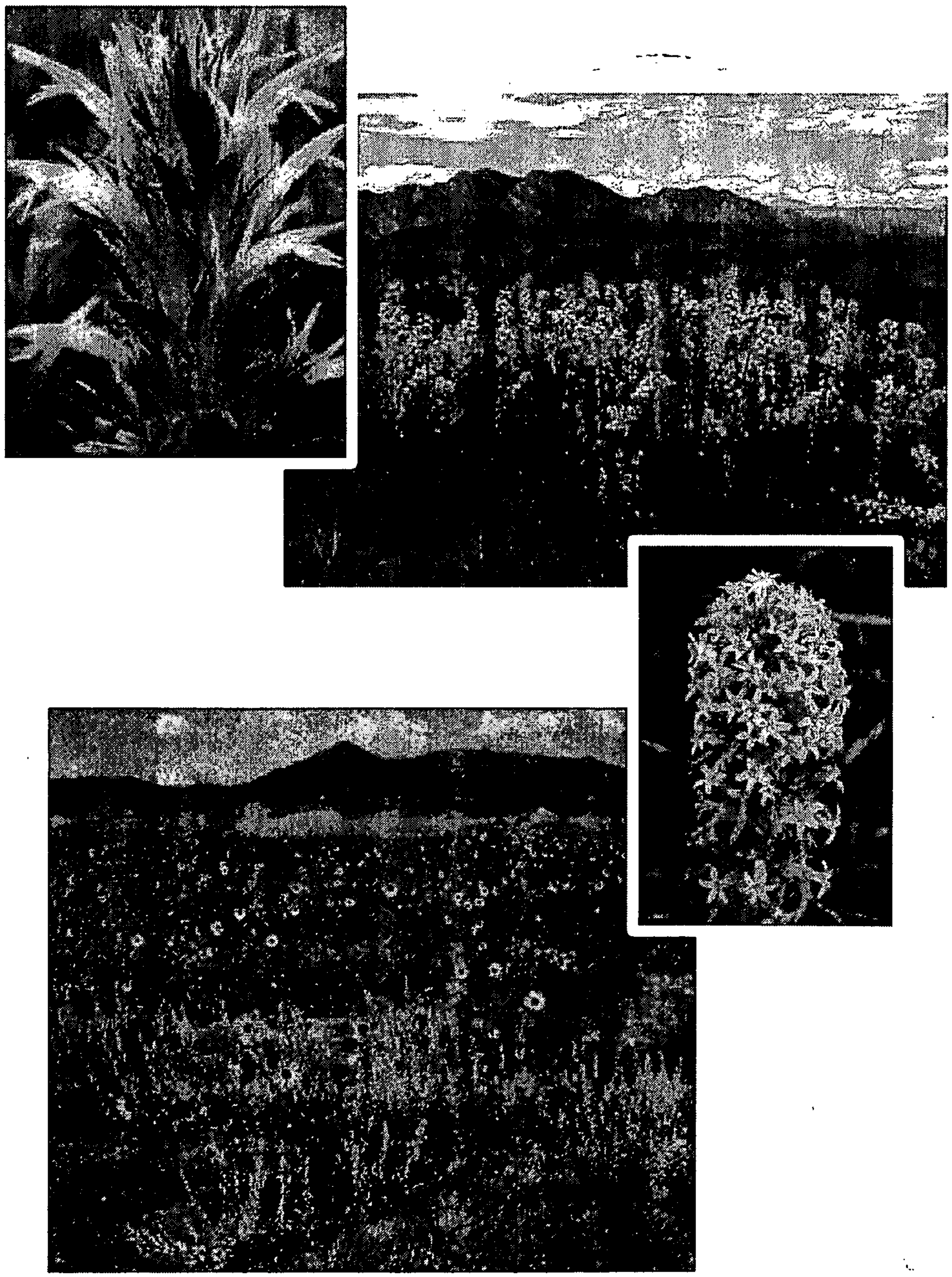
ECOLOGY

# 2001 Annual Vegetation Report for the Rocky Flats Environmental Technology Site



# 2001 Annual Vegetation Report for the Rocky Flats Environmental Technology Site

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# Executive Summary

The Kaiser-Hill Company (K-H) Ecology Group conducts ecological monitoring of the Site's natural resources to ensure regulatory compliance and to preserve and protect those resources during cleanup and closure operations. Ecological monitoring is an integral aspect of determining whether the management objectives and goals for the plant communities at the Site are being achieved. One component of the ecological monitoring program is annual vegetation monitoring. The objectives are to assess the status and quality of the plant communities on the Site, document any trends, and assess the effectiveness of various management techniques. This report summarizes the results of the vegetation monitoring that was conducted at the Rocky Flats Environmental Technology Site (the Site) during 2001.

At an elevation of approximately 6,000 ft., the Site contains a unique ecotonal mixture of mountain and prairie plant species resulting from the topography of the area and its proximity to the mountain front. The Buffer Zone, the area surrounding the Industrial Area, is one of the largest remaining undeveloped tracts of its kind along the Colorado Piedmont (Figure EX-1). A number of plant communities present at the Site have been identified as increasingly rare and unique by the K-H Ecology Group and the Colorado Natural Heritage Program (CNHP). These communities include the xeric tallgrass prairie, tall upland shrubland, wetlands, and Great Plains riparian woodland communities. Small inclusions of a number of other increasingly rare plant communities are also found on the Site. Many of these communities support populations of increasingly rare animals as well, including the federally protected Preble's meadow jumping mouse, and other uncommon species such as the grasshopper sparrow, loggerhead shrike, Merriam's shrew, black crowned night heron, hops blue butterfly and Arogos skipper.

Vegetation monitoring is conducted at the Site using several methods, to meet the monitoring objectives. During 2001, these objectives included species richness inventories, noxious weed and rare plant species mapping, photographic documentation, qualitative habitat assessment surveys, quantitative monitoring of long-term plant community changes, quantitative assessments of the effectiveness of herbicide applications and potential associated impacts to the native plant communities, and an evaluation of the effects of a prescribed burn on the xeric tallgrass prairie.

A brief summary of the highlights from the 2001 field season are found below with detailed summaries and analyses for each field monitoring effort presented in the following chapters. In addition, electronic versions of the entire report and other monitoring results are contained on the CD-ROM found at the end of the report.

## Site Flora

As a result of the 2001 field work, a total of eight new records of vascular plant species are reported for the Site. None of the new species recorded on Site in 2001 are rare species or Colorado State-listed noxious weeds. The addition of these new species brings the total number of plant species known to occur at the Site to 599. The flora of the Site is extremely rich for an area of its size, due to the proximity of the mountain front and the mixing of the Great Plains and mountain species.

In fall 2001, the Site herbarium (containing the plant voucher specimens of all species known to occur at the Site) was transferred as a donation by the U. S. Department of Energy (DOE) and Kaiser-Hill Company, L.L.C. to the University of Colorado Herbarium (COLO) in Boulder, Colorado. Placement of the herbarium collection at COLO provides a permanent home for the plant collections documenting the flora of Rocky Flats, which are important for both their biological and historical value. In addition, it makes the Site collection available to researchers, students, and the public, while still providing accessibility for future studies at the Site.

Four plant species of concern listed by the CNHP as rare or imperiled occur at the Site. During 2001, populations of mountain-loving sedge (*Carex oreocharis*), forktip three-awn (*Aristida basiramea*), carrionflower greenbriar (*Smilax herbacea*), and dwarf wild indigo (*Amorpha nana*) were visited and evaluated. All four species were observed in vegetative, flowering, and fruiting condition. New populations of forktip three-awn grass were discovered in the Buffer Zone during an attempt to establish some new populations of this species at the Site by seeding at new locations. The new locations of forktip three-awn have more than doubled the documented area where the species occurs at the Site. Statewide, the species is only known to occur from three other localities besides Rocky Flats: White Rocks in Boulder County, Ken Caryl Ranch in Jefferson County, and from a canyon southwest of Ft. Collins in Larimer County. So the additional locations at the Site increase the known occurrence of this species in the State substantially.

The high diversity of plant life and the presence of several rare plant species attests to the significance of the natural resources at the Site within the regional ecological context along the Front Range of Colorado.

## Xeric Tallgrass Prairie

A total of 292 plant species were recorded on the xeric tallgrass prairie at the Site during 2001. Of these, 79 percent were native species. This compares to 295 species recorded 1998 and 274 in 1997, with 81 percent and 79 percent native, respectively in those years. Comparisons between years indicated a very high floristic similarity between years, as would be expected. Examination of the species lists from all three years shows no substantial difference in the inventory results. Most differences are attributable to annual fluctuations in the abundance and presence of species in response to varying climatic factors. Comparison to 1999 and 2000 species richness data were not possible because only late summer data were collected in those years.

The xeric tallgrass prairie has been identified as a rare plant community in Colorado and North America and its presence at the Site is a significant ecological resource. The CNHP has identified this plant community at the Site and on City of Boulder Open Space to the west of highway 93 as the largest remaining tract of this community type in North America. The community is considered to be a relict plant community that has remained in a narrow band along the base of the mountains since the last ice age. While the ecological value of the community remains very high, qualitative habitat assessment data on the xeric tallgrass prairie from 2001 continues to reveal many of the same concerns reported previously. Plant litter buildup resulting from the lack of fire and/or grazing on the prairie continues to be a problem. The small 48-acre prescribed fire conducted in spring 2000, in addition to several wildfires in recent years, have shown that substantial reduction in litter amounts and improved conditions for the native species occurs when this natural process is restored. The increasing occurrence of wildfires in the Buffer Zone attests to the high fuel loads caused by years of litter accumulation. Noxious weeds also continue to be a problem at various locations. The most significant problem species on the xeric tallgrass prairie are diffuse knapweed (*Centaurea diffusa*), Dalmatian toadflax (*Linaria dalmatica*), musk thistle (*Carduus nutans*), and annual rye (*Secale cereale*). Others that have potential to become more problematic include common mullein (*Verbascum thapsus*) and jointed goatgrass (*Aegilops cylindrica*). Herbicide applications have helped control many of these infestations and compared to four or five years ago the prairie has been improved with far fewer of these noxious species present.

Aside from these concerns, however, the xeric tallgrass prairie appeared generally healthy and diverse. The dominant plant species were all observed as having flowered and produced fruit/seed in 2001. No substantial signs of disease, predation, injury, or die-off of any of the dominant tallgrass prairie species were observed. The xeric tallgrass prairie continues to be a plant community of high importance, providing critical habitat for many plant and animal species at the Site.

## Xeric Mixed Grassland

During 2001, three permanent monitoring sites (TR01, TR06, and TR12) on the xeric mixed grassland were monitored to reassess conditions and compare to past data sets. Monitoring of these sites dates back to

1993. During this timeframe, annual fluctuations in the abundance of individual species and groups of species has occurred in response to varying environmental conditions. These longer-term data sets are now providing a baseline of the natural variability for the xeric mixed grassland and will be useful in future years to compare over longer periods of time to detect change. Results from 2001 show that both species richness and species diversity continue to remain stable at these sites and have remained largely unchanged by management actions. The differences in species composition that were previously noted persist. Sites TR01 and TR12 are still classified as the xeric tallgrass prairie community type while TR06 remains a needle and thread grass community. Herbicide applications for weed control at each site have shown varying responses. In general, graminoid cover has increased, while forb cover declined, in response to the herbicide applications. At sites TR01 and TR12 on the western edge of the Site, declines in forb cover have been more pronounced than at TR06 near the eastern edge of the Site. Some return of the depressed forb cover has begun at these locations as of 2001. At TR06, cover of the noxious weed Dalamtian toadflax has declined where it had previously been one of the dominant species in the community. This is presumably as a result of treatment with Tordon22K®. At all three locations however, a increase in non-native, cool-season graminoid cover has been observed since 1993. This is undesirable because most of the tallgrass prairie components that comprise the uniqueness of the community are warm-season species. This change may be attributable to timing and amounts of precipitation, other climate factors, or potentially even atmospheric nitrogen deposition. However, the lack of grazing and prescribed fire for over 25 years at these monitoring locations may also be stressing the warm-season species and giving an advantage to the cool-season species. Re-establishment of fire and grazing could help reverse the trend of the invasive cool-season graminoid species.

## Vegetation Management and Monitoring

Sitewide weed mapping continued for selected species, as a means of monitoring the distribution of specific noxious weed species on the Site, identifying high-priority treatment areas, and tracking the effectiveness of weed control efforts. The noxious weed species with the greatest extent on the Site in 2001 were diffuse knapweed (1,957 acres), common mullein (1,357 acres), and musk thistle (869 acres). Dalmatian toadflax was not mapped because flowering, necessary for large-scale mapping, was reduced across much of the Site due to the herbicide applications and a late frost. Since 1998, the total Site acreage infested by diffuse knapweed has decreased annually, largely due to the aerial herbicide applications conducted in 1999, 2000, and 2001. The Site currently has approximately 1,000 acres less of diffuse knapweed than was present in 1998, and at many of the remaining areas that have been treated, the abundance of diffuse knapweed is substantially lower than initial levels. Thus the herbicide applications have proven to be quite successful at reducing the number of adult, seed producing plants at the Site. Both musk thistle and common mullein showed an overall increase in the total number of acres infested at the Site in 2001 compared to 2000 values. However, for both species the increases were largely in the low infestation classifications, indicating the spraying efforts have reduced the overall abundance of these species, while the species have cropped up in some new areas.

The vegetation management program at the Site continued to employ several techniques to control weeds and enhance conditions for desired native species during 2001. Integration of administrative and cultural, physical and mechanical, biological, and chemical control methods, in addition to revegetation of disturbances, were used to provide a multi-faceted approach to natural resource management.

Native seed mixtures and weed-free straw and mulch were required of all projects needing to revegetate Buffer Zone project disturbances. Physical and mechanical controls used at the Site in 2001 consisted of mowing, grading, and selective hand control. Mowing was done along the margins of the main east and west access roads, in addition to several miles of firebreak roads in the Buffer Zone, to prevent the roadside weeds from producing seed and spreading further. Mowing was also conducted on the xeric tallgrass prairie adjacent to a firebreak road in the northern Buffer Zone where annual rye has begun to invade the prairie. Mowing was conducted at the time when the seed heads were starting to form to prevent seed set.

Grading was conducted along firebreak roads in the Buffer Zone to maintain these firebreak roads and prevent roadside weeds from going to seed and spreading further. Hand control in 2001 was conducted at several locations to control localized infestations of Scotch thistle (*Onopordum acanthium*), annual rye, bouncingbet (*Saponaria officinale*), dame's rocket (*Hesperis matronalis*), crown vetch (*Coronilla varia*), bird's-foot trefoil (*Lotus corniculatus*), lens-padded hoary cress (*Cardaria chalepensis*), pepperweed whitetop (*Cardaria draba*), Dalmatian toadflax (*Linaria dalmatica*), and Texas blueweed (*Helianthus ciliaris*). Hand control consisted of hand pulling, using sickles or sling blades, and spot herbicide spraying. The use of hand control has proven valuable to prevent these small infestations from becoming larger problems, and has at several locations, eliminated the infestations.

During 2001, several species of biocontrol insects were released at the Site. Site ecologists and Texas A&M researchers working in conjunction with the U.S. Fish and Wildlife Service (USFWS) released approximately 2,185 adults of *Larinus minutus*, a seedhead weevil that feeds on diffuse knapweed, at several locations in different drainages at the Site. Locations were chosen to establish populations near the streams where other forms of weed control (such as chemical or mechanical) for this species are impractical. This and other species of diffuse knapweed biocontrol insects have been released in recent years at the Site and will continue to be released at the Site in attempts to replicate promising results seen on Boulder County Open Space to the north of the Site. Other biocontrol insects released during 2001 included: *Sphenoptera jugoslavica*, a root boring beetle that attacks diffuse knapweed; *Mecinus janthinus*, a stem mining beetle that attacks Dalmatian toadflax; *Trichosirocalus horridus*, a weevil that attacks the rosettes of musk thistle; *Aceria malherbae*, a gall mite that can help to control field bindweed (*Convolvulus arvensis*); and *Cassida rubiginosa*, a defoliating beetle for control of Canada thistle (*Cirsium arvense*).

Over 1,100 acres were treated with Transline® and Tordon22K® using both ground and aerial applications in 2001. Primary target areas for treatment were heavy infestation areas of diffuse knapweed, musk thistle, and mullein; however, other species such as Dalmatian toadflax, Canada thistle, goatsbeard (*Tragopogon dubius*), alyssum (*Alyssum minus*), wild lettuce (*Lactuca serriola*), small-seeded false flax (*Camelina microcarpa*), and some of the tansymustards (*Descurania* ssp.) were also treated. Ongoing studies at the Site have shown that Tordon22K® applications can provide approximately two to four years of control for diffuse knapweed (depending on location) before additional herbicide applications are required. Lower effectiveness of control has been observed where flightlines have been missed or where small mammal mounds or other activities continue to disturb the ground surface. Dalmatian toadflax has shown reduced flowering and vigor in the areas treated with Tordon22K®.

Small mammal mounds are a common occurrence on the Rocky Flats Alluvium outwash fan, both on- and off-site. It has been observed that noxious weeds tend to return after spraying much more rapidly on the small mammal mounds than in the surrounding intermound areas. During 2001, the impact and role of small mammal mounds on prairie species composition and noxious weeds was evaluated at the Site. Results indicate that the small mammal mounds on the xeric tallgrass prairie at the Site have a distinctly different plant community composition than that of the intermound areas. The mounds are generally devoid of the native, warm-season, perennial graminoid species that are common in the intermound areas. Instead they are dominated by non-native, cool-season forb and graminoid species. The mounds are in effect "weed islands" on the prairie and noxious weeds such as diffuse knapweed, Dalmatian toadflax, and downy brome (*Bromus tectorum*), all occur with much higher frequency on the mounds than on the intermound areas. The high density of mounds on the prairie creates a challenge for resource management because each individual mound requires management. The long-term preservation and sustainability of the native xeric tallgrass prairie that exists between the mounds will require development of innovative management strategies, given the presence and abundance of noxious weeds that are available to colonize the mounds in today's regional environment.

An ongoing study, conducted on the Site's xeric tallgrass prairie for the past five years, has been evaluating the impact of an application of Tordon22K® on diffuse knapweed, the primary target species, as well as on native prairie species. The results have shown that the herbicide application provided four years of effective control for diffuse knapweed. With respect to the non-target species, initial declines in species richness were transitory, and no changes in overall foliar cover were observed. Forb abundance has been impacted by the herbicide applications, however. Total forb cover declined and remains significantly lower than it was originally, but compared to the untreated control plot, it has generally recovered. Late summer native forb cover however, continues to remain significantly lower in the treatment area after five years. This warrants concern because many of these species contribute to the uniqueness and diversity of the xeric tallgrass prairie at the Site. Additional recovery time for the native, late summer forb component of the community is required before additional non-selective herbicide applications are used. Otherwise, further declines in the forb component of the community are likely. In contrast however, increases in graminoid cover have made up for losses in forb cover, although some evidence exists to suggest that other factors may be still limiting plant growth. Integration with other control methods such as biocontrol, prescribed burning to increase vigor of the native species, fencing, and potentially grazing will be necessary to improve environmental conditions for the desired native species and succeed in ultimately reducing and controlling diffuse knapweed infestations to acceptable levels in the long-term.

As mentioned above, the use of herbicides to control diffuse knapweed at the Site have proven very effective at keeping seed production and the number of adult plants to a minimum for several years in the areas sprayed. One of the problems with maintaining control, however, is that in addition to the fact that viable diffuse knapweed seed can exist in the seed bank for up to 10 years, off-site populations continue to spread new seed onto Site property. Often new seed is spread into the areas that have been treated with herbicides thereby limiting the effectiveness of the control efforts. Additionally, where no control has been conducted or less effective control has been achieved, diffuse knapweed plants continue to blow across the landscape throughout the winter months, further infesting new locations. Therefore diffuse knapweed movement has the potential to dramatically effect control efforts.

During the winter of 2000-2001 a study was conducted to evaluate the significance of diffuse knapweed movement at the Site. Results indicate that a substantial portion (56 percent) of the current year's on-site population of diffuse knapweed plants may be blown across the Site each winter during periods of high wind. The average distance these plants can move was shown to be approximately a quarter of a mile with the maximum distance observed at almost one mile. Using conservative assumptions, it was estimated that over 2.3 million diffuse knapweed plants moved at the Site during the winter of 2000-2001 alone. These data show that a large proportion of an infestation can become mobile and disperse during periods of high wind, resulting in the potential for significant movement of seed. This can result in continued re-infestation of treated areas, in addition to infestation of currently uninfested areas. Blocking the movement of individual diffuse knapweed plants originating from current infestations and from off-site locations with strategically located fencing could be an effective tool, in addition to current control measures, for reducing and controlling the diffuse knapweed problem at the Site.

## Revegetation Monitoring

Monitoring was conducted during fall 2001 to evaluate the revegetation efforts on the landfill cover north of the Industrial Area at the Site. The landfill cover was seeded with native species in spring 1998. Weed control (Tordon22K®) was applied to the cover in spring 1999 to control the noxious weed diffuse knapweed that was becoming a problem on the cover. Otherwise no further specific management of the area has taken place. The vegetation present on the cover in 2001 is dominated by native, warm-season, perennial, graminoid species. The species providing the greatest cover include blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), buffalo grass (*Buchloe dactyloides*), and side-oats grama (*Bouteloua curtipendula*), all of which were planted species in the seed mix. In addition, other seeded species that account for smaller cover amounts included big bluestem (*Andropogon gerardii*) and little bluestem (*Andropogon scoparius*). The vegetation appears healthy and thriving, based on the size of the plants and the flowering observed during the monitoring fieldwork. Although rock and bare ground cover remains higher than that found on the native grassland, the native species are filling in the spaces between the original plants and should in time form a solid stand of vegetation across most of the cover. Weed control will continue to be necessary to keep competition from noxious weeds low and allow the native species to expand across the cover. The results suggest a very successful revegetation project thus far.

## Disturbances

During the winter of 2000-2001, high winds deposited several inches of sand on the xeric tallgrass prairie in the northwest Buffer Zone. The source of the material originated from the gravel mine, not operated by K-H or DOE, in the northwest corner of the Site. In late May 2001, when the deposition was discovered, most of the existing vegetation in the area had been buried. Only Canada bluegrass, white sage (*Artemesia ludoviciana*), and some junegrass (*Koleria pyrimidata*) were still surviving where deposition was less deep. Otherwise the area was mostly sand. By late summer, the area was covered with annual weedy species. Much of the area was dominated by common sunflower (*Helianthus annuus*), a native species that often comes in after disturbance. Other species that established, however, included noxious weeds such as diffuse knapweed, Russian thistle (*Salsola iberica*), and kochia (*Kochia scoparius*), all of which will need to be controlled in the area now. By late September, although most of the area was still dominated by the annual forbs mentioned above there was some recovery of big bluestem, white sage, and some stiff sunflower (*Helianthus rigidus*; all native species). It will remain to be seen, however, whether the xeric tallgrass prairie can recover. Reseeding of the area and weed control may be required to re-establish the native cover if it does not return on its own and to prevent the area from becoming a solid infestation of noxious weeds. This situation is likely to be repeated in coming years as the mine continues to expand its operation to the south, creating more potential to impact the xeric tallgrass prairie.

## Prescribed Burn

In April 2000, a prescribed burn was conducted on 48 acres of the xeric tallgrass prairie at the Site. The prescribed burn accomplished several objectives and demonstrated the potential that prescribed fire has for managing the native plant communities at the Site. The potential for a catastrophic wildfire at that location was reduced through the removal of plant litter on the prairie without substantially increasing the potential for wind or water erosion. The fire also released nutrients tied-up in the plant litter back to the soil, thus enhancing nutrient cycling and stimulating plant growth. Species richness and native species cover increased as a result of the burn and at least in the short-term, the species composition shifted from a cool-season dominated community to a warm-season dominated one, albeit for only one year. Properly timed and used when environmental conditions such as moisture are appropriate, prescribed fire could be used on the xeric tallgrass prairie to reduce the dominance and abundance of the non-native, cool-season species like Canada bluegrass (*Poa compressa*) and Kentucky bluegrass (*Poa pratensis*) and enhance conditions for native, warm-season species. Prescribed burns should be used as part of the long-term resource management for the plant communities at the Site

## Summary

The Site contains a unique biodiversity in a region where much of the native diversity is rapidly being lost to urbanization. Passage of a recent federal law that will make the Site a U.S. Fish and Wildlife National Wildlife Refuge after cleanup and closure will help ensure the long-term preservation of the natural resources at the Site. Monitoring in 2001 continues to substantiate the significant ecological resources that exist at the Site. A number of rare plant species and plant communities are present at the Site. Results however, also continue to underscore some of the issues that threaten the quality and long-term sustainability of the Site's ecological resources. These threats come primarily from noxious weeds, human disturbances, and plant litter build-up, the latter of which has resulted from an absence of fire and/or grazing over the past several decades. The data indicate however that, beneath the sometimes visually weed dominated appearance at some locations, the native plant communities are still present and viable. Management actions taken in recent years, including weed control and a small prescribed burn, have improved the condition of the plant communities at many locations across the Site. Continued proactive management of these native communities is necessary if these communities are to survive over the long-term and maintain their ecological value.

One of the big challenges facing a resource management program at the Site is that only a limited selection of management tools are currently available for use due to Site policies. Currently the only practical, significant tool for management is weed control. Although this incorporates several techniques in itself; including administrative, mechanical, biological, and chemical controls, it must be noted that weed control alone is not a long-term solution for effective management of the plant communities at the Site. Long-term control of noxious weeds (the greatest current threat to the communities) will ultimately depend on restoring the natural processes (i.e., fire and grazing) that originally kept the ecosystem healthy. Most noxious weeds invade ecosystems because of disturbance, degradation, or changes in the natural system that alters resource availability, thus making the community more prone to invasions. Reliance on control of invasive plants alone often opens up space (niches) in the community for the establishment of other undesirable plants, if desired native species are not available or able to fill these spaces. By concentrating solely on controlling the problem species, without restoration of the natural processes needed to maintain a healthy ecosystem, we only treat the symptoms of the problem and not the cause. A more comprehensive, ecosystem approach to resource management must incorporate management techniques to restore natural processes, in addition to species-specific weed control. A goal must be to improve and enhance environmental conditions such that the desired native prairie species are healthy and able to compete with the noxious weeds. The lack of fire and/or grazing over much of the Site for the past 50 years combined with overgrazing that occurred before that, has left the native plant communities stressed and less vigorous. These conditions predispose the Site for many of the noxious weed problems it is currently facing. In addition, building evidence suggests that anthropogenic atmospheric nitrogen deposition from urban, agricultural, and industrial sources may be altering soil conditions away from conditions that previously existed. This alteration of soil conditions may also impact the native plant communities.

Thus challenges exist for resource management on many fronts and the practical implementation of mangement techniques remains a key hurdle at the Site. It should also be noted that the current conditions at the Site have not occurred overnight, nor will the solution be achieved overnight. A long-term commitment to sustainable resource management will be needed.

Over the past few years DOE has made strides in implementing a more proactive resource management program. The use of administrative, mechanical, biocontrol, and chemical controls have helped reduce noxious weed abundance across the Site. A small prescribed fire demonstrated the utility of this tool for grassland resource management at the Site. Continuation of these techniques and implementation of others should be explored. As the Site is closed over the next few years and becomes a National Wildlife Refuge, the USFWS will be developing long-term natural resource management plans. The use of prescribed fire and grazing are both highly recommended as tools for prairie management at the Site. Implementation of an adaptive, ecosystem approach to resource management will help sustain and preserve the valuable and unique ecological resources of Rocky Flats for future generations to enjoy.

# 1. 2001 High-Value Vegetation Surveys

## 1.1 Introduction

The Rocky Flats Environmental Technology Site (the Site) is located along the Front Range of Colorado in an ecotonal position between the Great Plains and Rocky Mountains. As a result it contains plant species common to both physiographic regions. Several plant communities have been identified by Site ecologists and the Colorado Natural Heritage Program (CNHP) as containing significant or rare ecological resources at both the local and regional scale (Kaiser-Hill [K-H] 1997a; CNHP 1994, 1995). These high-value plant communities, as they are called at the Site (xeric tallgrass prairie, tall upland shrubland, selected wetlands, and Great Plains riparian woodland), have been selected for special qualitative monitoring to assess their status, quality, and condition. These qualitative surveys evaluate conditions at a community-wide scale across the Site as a whole. This qualitative information, coupled with other quantitative monitoring data gathered at specific locations within the plant communities, provides important information at appropriate scales for resource management.

Objectives of the high-value vegetation monitoring are to qualitatively:

- Assess the species richness of the plant communities
- Identify any rare plant populations, and document the locations and continued presence of any rare plant populations
- Identify and document any infestations of noxious weeds
- Document the effectiveness of weed-control efforts
- Assess the impacts of disturbance on the plant communities
- Provide a general assessment of the overall status and quality of the plant communities.

## 1.2 Methods

### 1.2.1 Species Richness Inventory

As part of the rotating schedule for monitoring high-value vegetation communities on the Site, the xeric tallgrass prairie community was monitored in 2001. Species richness was inventoried in each of the 12 xeric tallgrass prairie management units (Figure 1-1). Inventories were conducted by traversing each management unit twice during the growing season (spring and late summer) and recording all vascular plant species observed. Attempts were made to visit, as completely as possible, all areas and microhabitats that occur within each management unit.

### 1.2.2 Weed Mapping

Sitewide weed mapping continued for selected species as a means of identifying high-priority treatment areas, monitoring the distribution of specific noxious weed species, discovering new weed species (if any), and tracking the effectiveness of weed control. Weed mapping was conducted on foot during the high-value vegetation surveys and from a vehicle using binoculars for the remainder of the Site. Species were mapped during their respective flowering periods and/or when they were most visible. The species mapped in 2001 included diffuse knapweed (*Centaurea diffusa*), musk thistle (*Carduus nutans*), common mullein (*Verbascum thapsus*), Russian knapweed (*Centaurea repens*), annual rye (*Secale cereale*), Scotch thistle

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(*Onopordum acanthium*), Dame's rocket (*Hesperis matronalis*), bouncing bet (*Saponaria officinalis*), and jointed goatgrass (*Aegilops cylindrica*). Mapping was also done and is reported for small infestations of several other species that underwent control efforts in 2001. Canada thistle (*Cirsium arvense*) was not mapped, because it is common throughout most of the wetlands and riparian corridors on the Site, and therefore, the wetlands map would provide a good indication of the infested areas. Dalmatian toadflax (*Linaria dalmatica*) was not mapped in 2001 because continued effects of past herbicide treatments and a late-spring frost top-killed most of the plants at the Site, and prevented any consistent flowering needed for effective mapping.

Infestation areas of the three dominant noxious weeds that were mapped (diffuse knapweed, musk thistle, and mullein) were classified into general density categories of high, medium, low, and scattered, based on a subjective interpretation of the extent, visual density, need for control, and aggressive nature of the species. The other species were mapped for presence/absence. In general, a high-density category indicated that an area that was dominated by a nearly solid infestation and/or very high cover of the species. A medium-density category was used where the infestation provided less cover and was less homogeneous in the distribution of the species. The low-density category was used where individuals of the species were present in fewer numbers and were not visually dominating the landscape, but were beginning to establish a foothold in the community and were in need of control. The scattered-density category was used only in a few cases and indicated a sporadic occurrence of the species.

The noxious weed populations and distributions for the four dominant species mapped were drawn in the field on 44- × 34-inch sitewide base maps. The distributions of the other species were drawn on 11- × 17-inch sitewide base maps. With regard to the resulting maps, it should be noted that the boundaries shown on the maps are only approximate and are based on professional judgement. They should not be interpreted as a precise outline of the distribution of these species, because no surveying or global positioning system (GPS) equipment was used to locate boundary edges, nor do the maps necessarily represent every location of the species on the Site. Attempts were made to visit the entire Site, but some infestations may still have been missed.

### 1.2.3 Photographic Documentation

Photographs were taken at all the permanent photo points in the Buffer Zone during the summer of 2001 to document changes since the photographs were last taken in 1999, and show any changes resulting from resource management actions. Photographs were taken from established photo points in the same compass directions as past photographs. Photographs were then compared to those taken previously. Time-series photographs can be viewed in Appendices on the CD-ROM.

### 1.2.4 Qualitative Habitat Assessments

Qualitative habitat assessments were made in all of the high-value vegetation community management units on the Site during 2001. Assessment objectives dealt primarily with habitat loss, threats to the plant community, weed issues, rare plant species, dominant plant species health in the community, and general community quality. Attempts were also made to revisit populations of CNHP-listed plant species of special concern that are known to occur on the Site. These species include the mountain-loving sedge (*Carex oreocharis*), forktip three-awn (*Aristida basiramea*), dwarf wild indigo (*Amorpha nana*), and carrionflower greenbriar (*Smilax herbacea* var. *lasioneuron*). Population locations were mapped originally during the 1997 field season. Most locations have been revisited annually to confirm the continued presence of these species on the Site and to evaluate any concerns about them. Further details on the methods used are found in the document *High-Value Vegetation Survey Plan for the Rocky Flats Environmental Technology Site* (K-H 1997b), the *Environmental Management Department Operating Procedures Manual* (DOE 1995), and 2001 *Ecological Field Sampling Plans for the Rocky Flats Environmental Technology Site* (K-H 2001a).

## 1.3 Results and Discussion

### 1.3.1 Site Flora

As a result of the 2001 fieldwork, a total of 8 new records of vascular plant species are reported for the Site. Plant nomenclature follows that of GPFA (1986), Weber (1976), and Weber (1990), in that order of determination. The new plant species reported for the Site are:

| | |
|---|---|
| *Andropogon saccharoides* Sw. var. *torreyanus* (Steud.) Hack. | Silver Bluestem |
| *Aster campestris* Nutt. | Meadow Aster |
| *Cleome serrulata* Pursh | Rocky Mountain Beeplant |
| *Eragrostis minor* Host | Little Lovegrass |
| *Eragrostis trichodes* (Nutt.) Wood. | Sand Lovegrass |
| *Lycurus phleoides* H.B.K. | Wolftail |
| *Physalis pumila* Nutt. ssp. *hispida* (Waterfall) Hinton | Prairie Ground Cherry |
| *Triodanis perfoliata* (L.) Nieuw. | Venus Looking Glass |

None of the new species recorded on Site in 2001 are rare species or Colorado State-listed noxious weeds. The addition of these new species brings the total number of plant species known to occur at the Site to 600. The complete list of plant species known to occur at Rocky Flats as of the end of the 2001 field season is found in Appendices on the CD-ROM at the end of the report. In general, the flora of the Site is extremely rich for an area of its size, due to the proximity of the mountain front and the mixing of the Great Plains and mountain species.

In fall 2001, the Site herbarium (containing the plant voucher specimens of all species known to occur at the Site) was transferred as a donation by the U.S. Department of Energy (DOE) and Kaiser-Hill to the University of Colorado Herbarium (COLO) in Boulder, Colorado. Placement of the herbarium collection at COLO provides a permanent home for the plant collections documenting the flora of Rocky Flats which are important for both their biological and historical value. In addition, it makes the Site collection available to researchers, students, and the public, while still providing accessibility for future studies at the Site.

### 1.3.2 Xeric Tallgrass Prairie

A total of 292 plant species were recorded on the xeric tallgrass prairie at the Site during 2001 (Table 1-1). Of these, 79 percent were native species. This compares to 295 species recorded 1998 and 274 in 1997, with 81 percent and 79 percent native, respectively in those years. For comparison to past years' results, a Sorensen similarity index (Brower and Zar 1977) was conducted, using presence/absence data. Comparisons between all combinations of years yielded values ranging from 0.85 to 0.87, indicating a very high floristic similarity between years, as would be expected. Examination of the species lists from all three years shows no substantial difference in the inventory results (Table 1-1). The different species observed during the different years are mostly a result of the slight differences in routes used to traverse the management units and of the natural variability in abundance of individual species. Nothing in the species lists stood out as a potential management concern.

The xeric tallgrass prairie has been identified as a rare plant community in Colorado and North America (CNHP, 1994, 1995) and its presence at the Site is a significant ecological resource. This community is thought to be a relict plant community that has remained in a narrow band along the base of the mountains since the last ice age (Weber 1990). While the ecological value of the community remains very high, qualitative habitat assessment data on the xeric tallgrass prairie from 2001 continues to reveal many of the same concerns reported previously (K-H 1998, 1999, 2000, 2001b). Plant litter buildup resulting from the lack of fire and/or grazing on the prairie continues to be a problem. The small 48-acre prescribed fire conducted in spring 2000 along with several wildfires in recent years have shown that substantial reduction in litter amounts and improved condition for the native species occurs when this natural process is restored. The increasing occurrence of wildfires in the Buffer Zone attests to the higher fuel loads caused by years of litter accumulation. Noxious weeds also continue to be a problem at various locations. The most significant problem species on the xeric tallgrass prairie are diffuse knapweed, Dalmatian toadflax, musk thistle, and annual rye. Others that have potential to become more problematic include common mullein and jointed goatgrass. Herbicide applications have helped control many of these infestations. Compared to four or five years ago the prairie's appearance has been improved, with far fewer of these species present. Unfortunately, after three or four years many of the undesirable species begin to return, as the residual effect of the herbicide wears off, requiring additional treatment. As part of an integration with other weed control methods, several hundred biocontrol insects were released at the Site (to compliment those already present) to provide additional control of noxious weeds and try to lessen the long-term dependence on chemical control efforts (for more information on the vegetation management conducted in 2001 see chapter 3 of this annual report).

It should be noted however, that weed control alone is not a long-term solution for management of the xeric tallgrass prairie or other plant communities at the Site. Long-term control of these noxious weeds will ultimately depend on restoring the natural processes (i.e., fire, grazing) that originally kept the ecosystem healthy. Most noxious weeds invade ecosystems because of disturbance, degradation, or changes in the natural system that alters resource availability thus making the community more prone to invasions (Davis et al. 2000). Control of invasive plants often opens up space (niches) in the community for the establishment of other undesirable plants if desired native species are not available or able to quickly fill these spaces. By concentrating solely on controlling the problem species without restoration of the natural processes needed to maintain a healthy ecosystem, we only treat the symptoms of the problem and not the cause. A more comprehensive, ecosystem approach to resource management must incorporate management techniques to restore natural processes, in addition to specific species weed control. A goal must be to improve and enhance environmental conditions such that the desired native prairie species are healthy and able to compete with the noxious weeds. The lack of prescribed fire and/or grazing over much of the Site for the past 50 years combined with overgrazing that occurred before that has left the native plant communities stressed and less vigorous, all suitable conditions for the noxious weed invasions currently in process. While a small 48 acre prescribed burn was conducted in spring of 2000, for all practical purposes, neither prescribed fire nor grazing, both crucial processes necessary for grassland health and management, are currently used for resource management. As a result, the native plant communities at the Site remain stressed and unable to compete as effectively with the invading noxious weeds.

As the Site is closed over the next few years and becomes a National Wildlife Refuge, the USFWS will be developing long-term natural resource management plans. The use of prescribed fire and grazing are both highly recommended as tools for prairie management at the Site. These are likely to be instituted by the USFWS as the natural resource management responsibility shifts to them during the closure process.

### 1.3.3 Rare-Plant Monitoring

Four plant species that occur at the Site are listed as rare and imperiled in Colorado by the Colorado Natural Heritage Program (CNHP 1999). The presence of these species underscores the significance of the natural resources found at the Site and its value in the regional landscape. Although none of them have any legal protection under state or federal law, they are protected at the Site and projects are conducted to minimize potential impacts. On-Site populations of mountain-loving sedge, forktip three-awn, carrionflower greenbriar, and dwarf wild indigo were revisited during 2001. All four species were observed in vegetative, flowering, and fruiting condition in 2001. All known locations where the species have been observed at the Site from 1997 through 2001 are shown in Figure 1-2.

Over the past several years qualitative observations of the only known location of forktip three-awn at the Site have shown that the open, gravelly substrate that the species grows on has begun to fill in with other species of plants, slowly eliminating habitat for the species. During fall 2001, an attempt was begun to try and establish some new populations of forktip three-awn at the Site. In October 2001, approximately 200 seeds were collected from mature, adult plants for seeding at a new location. On arrival at the new location in the west-central Buffer Zone where the seeds were going to be sown, it was discovered that hundreds of forktip three-awn plants were already growing at the location (Figures 1-3 and 1-4). Another location with similar habitat was chosen in the south Buffer Zone, where no forktip three-awn plants were found, and the seeds were sown by broadcasting in two – one meter square plots (approximately 100 seeds per plot, Figure 1-5). Monitoring will be conducted in fall 2002 to see whether any of the seeds germinated and produced adult plants.

Based on the discovery of a new population of this rare species at the Site, further searches of similar habitat in the Buffer Zone were made and several additional locations of the species were found (Figure 1-6). The new locations of forktip three-awn have more than doubled the area where the species is known to occur at the Site. Statewide, the species is only known to occur from three other localities besides Rocky Flats. These locations include areas near White Rocks in Boulder County, at Ken Caryl Ranch in Jefferson County, and in a canyon southwest of Ft. Collins in Larimer County. So the additional locations at the Site increase the known occurrence of this species in the State substantially.

The forktip three-awn at the Site is typically found in areas where surface disturbances have scraped off the vegetation leaving weathered, brown (oxidized), native gravels (0.5 – 7cm in size) for substrate. The gravel surfaces have a similar appearance to "desert pavement", common in the desert southwest. The original location where the species was found on Site occurs along the railroad tracks where disturbance had left a gravelly surface (Figure 1-6). The largest new population (Figure 1-6) occurs at a location that was used as a borrow area in the 1970's and early 1980's, and has a gravelly surface. In the mid-1980's the area was seeded with switchgrass (*Panicum virgatum*) which now grows sporadically across the area. At other locations common plants growing in conjunction with the forktip three-awn include: little bluestem (*Andropogon scoparius*), Canada bluegrass (*Poa compressa*), rough dropseed (*Sporobolus asper*), Porter's aster (*Aster porteri*), soft goldenrod (*Solidago mollis*), and western ragweed (*Ambrosia psilostachya*). Generally the vegetation is sparse on the gravels where the forktip three-awn grows. If the density of the vegetation gets too great, as in places where Canada bluegrass has taken over the gravel and produced a litter layer, the three-awn does not seem to grow at these locations. Only in one case along the edge of a graded Buffer Zone road was the species found growing on light-colored roadbase gravel, otherwise it was always on the native, weathered gravel.

### 1.3.4 Revegetation and Plant Community Disturbance in 2001

During 2001, only two small projects disturbed the native plant communities in the Buffer Zone (Figure 1-7). Both were less than an acre in size and at each location, native seed will be planted to restore the native plant community and help prevent weed infestations. In 1999, several large projects disturbed the native plant communities at different locations in the Buffer Zone. The locations and photographs of these disturbances were documented in the 1999 and 2000 Annual Vegetation Report for the Rocky Flats Environmental Technology Site (K-H 2000, 2001b). Photographs from 1999, 2000, and 2001, and maps of the project areas and revegetation efforts are found in the Appendices on the CD-ROM (end of report).

During the winter of 2000-2001, high winds deposited several inches of sand in an area on the xeric tallgrass prairie in the northwest Buffer Zone (Figure 1-8). The material originated from the gravel mine, not operated by K-H or DOE, in the northwest corner of the Site. In late May 2001, when the deposition was discovered, most of the existing native vegetation in the area had been buried. Only Canada bluegrass, white sage (*Artemesia ludoviciana*), and some junegrass (*Koleria pyrimidata*) were still surviving where deposition was less deep. Otherwise the area was mostly sand (Figures 1-9). By late summer, the area was covered with annual weedy species (Figure 1-10). Much of the area was dominated by common sunflower (*Helianthus annuus*), a native species that often comes in after disturbance. Other species that established however, included noxious weeds such as diffuse knapweed, Russian thistle (*Salsola iberica*), and kochia (*Kochia scoparius*), all of which will need to be controlled in the area now. By late September, although most of the area was still dominated by the annual forbs mentioned above there was some recovery of big bluestem, white sage, and some stiff sunflower (*Helianthus rigidus*; all native species). It will remain to be seen, however, whether the xeric tallgrass prairie can recover. Reseeding of the area and weed control may be required to re-establish the native cover if it does not return on its own, and to prevent the area from becoming a solid infestation of noxious weeds.

In September, monitoring was conducted in the sand deposition area using a grid layout to measure the depth of the deposition across the area. A total area of approximately 4.5 hectares (11 acres) was measured and had deposition on it. The deposition depths ranged from under 1cm to 21cm (< 1 in. to >8 in.; Figure 1-8). Away from the area of deepest deposition that occurred in 2001, general observations suggest that deposition has been occurring over the past several years and has not substantially impacted or altered the plant community since most species in these areas were native, appeared healthy, and were doing fine. It is apparent however, from the depths at these locations (generally < 5cm [< 2 in.] total) that deposition occurred gradually over a longer timeframe. Thus how deposition of four times that amount, that occurred in a single season, will affect the prairie community and its ability to recover, will be monitored during the next few years.

This event and its impact on the xeric tallgrass prairie illustrates, and brings to the forefront yet another factor that creates disturbance on the landscape and further increases degradation of the native plant communities at the Site. The mine company should be contacted and notified that the problem must be remedied. This may be a violation of their mining permit to have material moving off their site in these quantities. From a resource management standpoint at the Site, however, the issue is likely to continue and become a greater concern in the future as the mine continues to expand its operation to the south. During 2001, the mine expanded several hundred feet to the south along the western edge of the Buffer Zone. Even larger sand piles than those present in 2000 were being created in the late summer of 2001. With the high winter winds that buffet the Site from the northwest each winter, it is likely that other downwind areas adjacent to the new sand piles will receive some deposition during the 2001-2002 winter. In order to document any potential impacts, a set of photo monitoring plots were established on the xeric tallgrass prairie in the fall of 2001, downwind of the new sand piles. Landscape photographs as well as quadrat photographs looking at the ground surface were taken to show pre-deposition conditions should any problems arise in winter 2001-2002.

### 1.3.5 Weed Mapping

The 2001 weed distribution maps for diffuse knapweed, musk thistle, and common mullein are shown in Figures 1-11 through 1-13, respectively. Several additional species—annual rye, Russian knapweed, Scotch thistle, dame's rocket, bouncing bet, and jointed goatgrass—were mapped in 2000 because of their aggressive nature and their recent appearance at various locations on the Site. The distributions of these species are shown in Figures 1-14 and 1-15. Small infestations of several other weed species where weed control was conducted in 2001 are also shown on Figure 1-14. After being entered into the Site Geographic Information System (GIS), the overall extent of these species across the Site was estimated by species and by infestation level. Table 1-2 contains the estimated total acreage and acreage-by-density category for each of the listed species, based on the 2001 maps. The noxious weed species with the greatest extent on the Site were diffuse knapweed (1,957 acres), common mullein (1,357 acres), and musk thistle (869 acres). The total acreage of the Site is approximately 6,500 acres (K-H 1997c). The total numbers of acres for annual rye, Russian knapweed, Scotch thistle, dame's rocket, bouncing bet, and jointed goatgrass are also shown in Table 1-2. It should be noted that all these acreages are only approximate and should not be interpreted as exact areas. These values are also only representative of known locations for these species. It is possible that unmapped infestations are present as well.

Table 1-3 shows the annual total infested acreages for diffuse knapweed, musk thistle, and common mullein from 1997 to 2001. Most of the large increases in infestation acreages from 1997 to 1998 were a result of the time of year in which mapping was conducted. Mapping in 1997 was conducted in August for each of the species. Beginning in 1998, weed mapping was conducted for each species when that species was in flower and/or most visible. Therefore, the higher visibility of the species at the time of mapping allowed more accurate estimates of their infestation levels from 1998 through 2001, and thus resulted in higher acreages.

Since 1998, the total Site acreage infested by diffuse knapweed has decreased annually, largely due to the aerial herbicide applications conducted in 1999, 2000, and 2001. During 2001, over 1,100 acres were treated with Transline® and Tordon22K® using both ground and aerial applications. The Site currently has approximately 1,000 acres less of diffuse knapweed than was present in 1998 and the high density classification is the lowest it has been since the aerial applications began. So the spraying program at the Site has been very successful. At some locations sprayed in 1999, however, gradual return of diffuse knapweed has begun and future control will again be required. At other locations, primarily along the stream drainages the infestations have continued to increase through time because no chemical treatments have been done due to the close proximity of riparian vegetation and Preble's mouse habitat. Examination of the 2001 diffuse knapweed map (Figure 1-11) shows that many of the high density infestations occur near the drainage bottoms. In 2001, several hundred biocontrol insects (*Larinus minutus* and *Sphenoptera jugoslavica*) were released in the drainages at the Site to begin to attempt to control the dense infestations present at these locations. Other biocontrol insects for diffuse knapweed, such as *Urophora* sp. and *Cyphocleonus achates* already occur at the Site from previous on-site releases and off-site immigration. Monitoring of the release locations in the future will help determine whether the species establish and begin to have an impact on these infestations. If the species can be shown reduce population levels in the drainages, it may be feasible to allow them to spread (and introduce them) to the upper hillsides and pediment tops and control the diffuse knapweed at these locations as well, thus reducing the dependence on herbicide applications. (Additional information on biocontrol releases and monitoring results are described in chapters 3 and 6 of this annual report).

Both musk thistle and common mullein showed an increase in the total number of acres infested at the Site in 2001 compared to 2000 values (Table 1-3). For both species the increases were largely in the scattered and low density classifications. The increases in musk thistle are largely attributable to the return of plants in areas that had previously been sprayed. Similar reasoning also applies to some of the common mullein increases, but interestingly the number of acres infested by common mullein have continued to increase since 1997. The differences in acreage from 1997 to 1998 are attributable largely to methodology changes (as mentioned above). But increases have continued consistently from 1998 to 2001, with only a slight leveling off from 1999 to 2000. All of the increase in common mullein has been in the scattered and low classifications (Table 1-3), so it is not as though these areas are now dominated by common mullein, but in some instances it has begun to appear in areas where it was not previously present (Figures 1-13 and 1-16). It is also interesting that at many of the locations the increases have occurred during the timeframe when aerial herbicide applications have been applied (1999 through 2001). At some locations in 1998, prior to spraying, no common mullein was observed and yet mullein have begun to show up in these areas now. One possible explanation for this is that sometimes when a native ecosystem is in stressed or degraded condition and weed control is done for a certain species or group of species, if the native species in the community cannot respond and fill in the gaps left vacant by the target species, other weeds will simply take their place. This may be what is occurring at some locations on the xeric tallgrass prairie. If correct, this provides further support for the need to employ management techniques such as fire and grazing to help reverse the current stressed condition of the prairie and enhance environmental conditions for the desired native plants. Continued monitoring in 2002 will help evaluate the common mullein situation.

In general, the applications of Transline® and Tordon22K® for control of diffuse knapweed and other noxious weed species has been beneficial and generally improved the quality and appearance of the Site's grasslands. Mapping data have shown substantial reductions in the amounts of diffuse knapweed and musk thistle at the Site since 1998. (For quantitative results from both aerial and ground-based applications see other chapters 3, 4, and 5 in this report and past Annual Vegetation Reports for the Rocky Flats Environmental Technology Site [K-H, 1998, 1999, 2000, 2001b]).

## 1.4 Conclusions

Qualitative monitoring of the high-value plant communities during 2001 revealed both positive and negative findings. Floristically, the xeric tallgrass prairie remains diverse and has not changed substantially since monitoring began. It remains a significant, rare natural resource at the Site and regionally. No new species of noxious weeds were found at the Site during 2001. The rare and imperiled plant species populations (as listed by the CNHP) at the Site appear to be healthy; all four rare species were observed in vegetative and flowering condition during 2001. Several new populations of forktip three-awn were discovered in the Buffer Zone at the Site. An attempt to transplant the forktip three-awn grass in new suitable habitat was also initiated to expand the range of this rare species at the Site. As a whole, the ecological resources of the Site remain of high quality and comprise a significant component of the larger surrounding regional ecosystem, however several management concerns remain.

The threat from noxious weeds continues to be a high management priority. Several noxious weed species continue to degrade the quality of the plant communities at the Site. Diffuse knapweed, Dalmatian toadflax, musk thistle, common mullein, and Canada thistle are the most significant noxious weed problems. Substantial declines in the total number of acres currently infested by diffuse knapweed and musk thistle have been made since 1998. However, the scale of these infestations at the Site continue to challenge control efforts for the long-term. Other smaller infestations of newly discovered or recently invaded species like bouncing bet, Scotch thistle, Russian thistle, dame's rocket, and others continue to be controlled with the goal of eradication. In addition to herbicide applications in 2001, several hundred biocontrol insects were released at the Site to help control several different noxious weed species.

Efforts continued to preserve and improve the quality of the natural resources at the Site. The value of the Site's ecological resources in the larger regional context has played an important role in the passage of a Congressional bill that will make the Site a National Wildlife Refuge after cleanup and closure. Efforts to integrate more of a comprehensive, ecosystem approach to resource management must be continued to restore natural processes if long-term sustainability of the native communities is to be achieved. Recent efforts have focused substantively on the noxious weeds themselves, without addressing the underlying conditions that have lead to the stressed condition of the native communities and contributed to the large-scale weed invasions. The use of prescribed fire and grazing are both crucial processes necessary for grassland health and management. As long-term management plans are developed for the National Wildlife Refuge the use of these and other resource management tools should be included to provide the best chance for long-term sustainability of the ecosystems at the Site.

## 1.5 References


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# 2. 2001 Xeric Mixed Grassland Monitoring Summary

## 2.1 Purpose

Monitoring is an integral part of determining whether the management objectives and goals for the plant communities at Rocky Flats Environmental Technology Site (the Site) are being achieved (K-H 1997a,b). Consistent with this goal, long-term quantitative monitoring is necessary to determine whether changes are taking place in the plant communities that would otherwise go undetected through the use of broader-scale qualitative monitoring techniques. During 2001, three permanent monitoring sites (TR01, TR06, and TR12) on the xeric mixed grassland at the Site were monitored. Data were compared to past monitoring efforts.

## 2.2 Background Information

The plant communities monitored at the Site from 1993 through 1995 were organized along a soil moisture (hydrologic) gradient that ranged from xeric (dry) to mesic (moderate moisture) to hydric (wet). This followed the plant community classification that was outlined in the baseline study (DOE 1992), which identified xeric (xeric mixed grassland), mesic (mesic mixed grassland), hydric (riparian community), in addition to reclaimed (reclaimed grassland – classified as analagous to mesic on the moisture gradient) communities at the Site. Since 1995, the xeric mixed grassland sites (TR01, TR06, and TR12; Figure 2-1) have been monitored on a three year rotating schedule. Monitoring was conducted at all three sites in 1998, however, TR01 was also monitored in 1999 and 2000, as a control area for the prescribed burn conducted in spring 2000. In June 1997, TR12 was treated with Tordon22K®, using ground equipment to control the noxious weed diffuse knapweed (*Centaurea diffusa*). Since the last complete monitoring effort in 1998, all three sites have been treated by helicopter with Tordon22K® for additional control of diffuse knapweed. All application rates were one pint/acre of Tordon22K®. Sites TR01 and TR12 (retreatment) were sprayed in May 1999 and TR06 was treated in May 2000.

## 2.3 Methods

During 2001, the xeric mixed grassland sites, TR01, TR06, and TR12 (Figure 2-1), were monitored for species richness, cover, and frequency. The sampling methods and procedures used at these sites during 2001 were the same as those used in 1993–1995, 1998–2000, with the addition of a measure for species frequency which was added in 1998. Fifteen 50-m transects (five at each site) were monitored in 2001. Transects were sampled in the spring and again in late summer. During 1999, when sampling was conducted at TR01, only late summer data was collected. Otherwise species richness and frequency were monitored during both sampling sessions. Cover was sampled only during the late-summer session. Species richness was determined in a 2-m-wide belt centered along the length of each 50-m transect. Every plant species rooted within the 100-m$^2$ area was recorded. In addition, the numbers of woody plant stems and cactus stems were counted and recorded for the 100-m$^2$ area during the spring sample session only.

Basal cover and foliar cover were estimated using a point-intercept method along each 50-m transect. A 2-m-long, 6-mm-diameter rod was dropped vertically at 50-cm intervals along the transect to record a total of 100 intercept points. Two categories of hits were recorded, basal and foliar. Basal cover hits were recorded based on what material was hit by the rod at the ground surface. Hits could be vegetation (live plants), litter (fallen dead material), rock (pebbles and cobbles greater than the rod diameter), bare ground, or water, in that order of priority based on the protection from erosion provided by each type of cover. Basal vegetation hits were recorded by species only if the rod was touching the stem or crown of the plant where the plant entered the ground. Foliar vegetation hits (defined as a portion of a plant touching the rod) were recorded by species in three categories as defined by height and growth form. The topmost hit of each growth form was recorded. The growth forms measured were herbaceous, woody <2 m in height, and woody >2 m in height.

Frequency information by species was gathered by randomly locating 25 1-$m^2$ quadrats (five per transect) at each site. Additionally, a single photograph was taken of each transect during the late summer sampling session to visually document the condition of the transect. Photographs were taken from near the 0-m end of the transect near the permanent marker, looking toward the 50-m endpoint. A placard was placed in the photograph against the 0-m endpoint to provide the site and transect number, and date.

For more detailed information on these methods see, the *Ecological Monitoring Program, Final Program Plan* (DOE 1993), the *Environmental Management Operating Procedures Manual, Volume V, Ecology, 5-51200-OPS-EE* (DOE 1995a), and the *1999, 2000, and 2001 Ecological Field Monitoring Plans for the Rocky Flats Environmental Technology Site* (K-H 1999a, 2000a, 2001a).

Species richness data were summarized by generating a species list for each site. Belt-transect data, point-intercept data, and quadrat data were combined to provide overall species richness for each site. Other species richness variables were calculated from the species lists and used for comparison. Foliar cover data are reported as absolute cover, and relative cover for each species encountered. Absolute foliar cover was the percentage of the number of hits on a species out of the total number of hits possible at a site (500). This value is the actual cover of a species. Relative foliar cover was the number of hits a species had relative to the total number of vegetative hits recorded per site (i.e., the percent of total vegetative cover [100 percent] represented by the species). Both absolute and relative foliar cover values are presented as means (n=5). A Shannon-Weaver diversity index was used to calculate diversity and was conducted using the relative foliar cover data (Brower and Zar 1977). Frequency based on quadrats (n=25) was defined as the number of quadrats in which a species was recorded, divided by 25 (the total number of quadrats possible), and multiplied by 100. Descriptive comparisons between the 1993–2001 data sets were conducted to examine potential changes over time. A detrended correspondence analysis (DCA; PC-ORD 1999) ordination technique was used to evaluate the relationships between TR01, TR06, and TR12 for each sampling session based on species cover.

## 2.4 Results and Discussion

A total of 124 species were recorded at all three xeric mixed grassland sites monitored in 2001. Species richness data are found in Table 2-1. The number of species found at each site varied from 81 (TR06) to 85 (TR12). The percentage of native species found across all sites combined was 82 percent, with individual sites ranging from 80 to 81 percent. Total species richness in 2001 was within the range of past measurements at all three sites. Richness was highest across all three sites in 1994 and 1995, with the exception of TR12 when it was high only in 1994. The highest values in 1995 were largely attributed to the high precipitation amounts received that year (Figure 2-2). The lower richness totals in 1993 are best attributed to sampling bias, because different personnel conducted the surveys in that year compared to most of the years since. An important observation is that no substantial changes (declines) in species richness occurred at any of the sites as a result of herbicide applications that have been applied at each site. Tordon22K® was applied in 1997 and 1999 at TR12, in 1999 at TR01, and in 2000 at TR06. This is in agreement with other studies at the site that have shown a similar species richness response to herbicide applications (K-H 1998, 1999b, 2000b, 2001b).

Species diversity (Shannon-Weaver diversity index) analysis results for 1993 through 2001 are shown in Figure 2-3. Diversity was highest at TR01 (1.166) and lowest at TR06 in 2001 (0.876). Compared across all years of available data, TR01 has always been the most diverse site, followed by TR12 and then TR06. Annual variation at each site has fluctuated slightly, but shows no particular trends. Thus both species richness and species diversity continue to remain stable at these sites and have remained largely unchanged by management actions.

Cactus and woody plant densities at all three sites for 2001 are shown in Table 2-2. In 2001, overall cactus density was highest at TR01 and TR12 (0.24 plants/$m^2$). Twistspine prickly pear (*Opuntia macorhiza*) density was highest at TR12 in 2001 (0.08 plants/$m^2$). Hedgehog cactus (*Echinocereus viridiflorus*) density in 2001 was highest at TR01 (0.22 plants/$m^2$). Overall woody plant density in 2001 was highest at TR06 (0.318 plants/$m^2$) and lowest at TR12, which had no wood plant density. Most of the woody plant density came from Spanish bayonet (*Yucca glauca*) at TR06. Decreased density in twistspine prickly pear and hedgehog cacti at TR01 and TR12 in 2001 compared to past years is most likely attributable to applications of Tordon22K® for controlling noxious weeds at these locations. Similar decreases in cactus density have been observed from another study at the Site that is evaluating impacts of Tordon22K® on native prairie species (see other sections of this annual report and past annual reports for results; K-H 1998, 1999b, 2000b, 2001b). Interestingly though, the substantial declines in cactus density at TR01 and TR12 have not been observed at TR06 where the same herbicide was applied in 2000. In fact, hedgehog cacti have actually increased in density since 1998 at TR06.

Foliar cover data are summarized in Table 2-3. Total foliar cover did not vary substantially between sites in 2001 (from 82.6 percent at TR01 to 83.6 percent at TR06 and TR12). The 2001 total foliar cover amounts were within the range of previously observed values from sampling efforts dating back to 1993. Total absolute native cover was highest at TR01 (69.2 percent) and lowest at TR06 (52.4 percent). Native cover has consistently been higher at TR01 and TR12 compared to TR06 for all years of sampling. Native cover in 2001 was the lowest of any previous years at TR06 and TR12, however, given the year to year variability in the datasets, it is likely that the values are within the normal natural variability of the community. Some of the is may be attributable the previous herbicide applications or to a late freeze that occurred in May 2001 that caused freeze damage to may of the plant species on the prairie at the Site. Future monitoring will evaluate any longer term trends and see if there is an increase in native cover.

Graminoid cover provided approximately 86 to 89 percent of the total relative vegetation cover at all three sites in 2001. At TR01, a general increase in total absolute graminoid cover has occurred since 1993 (46%-71%). The largest increase occurred in 1999 after the area was treated with Tordon22K®. Both native and non-native graminoids have increased at TR01 during this time, but native graminoids accounted for the most of the increase. A similar overall increase in graminoid cover, though not as dramatic, also is shown at TR12 (64%-74%). However, at TR12 most of the increase came from non-native graminoids while native graminoid cover remained relatively stable. At TR06, total graminoid cover has fluctuated each year but without any apparent trend during this time. However, there has been a consistent decline of native graminoid cover along with a concurrent increase in non-native graminoid cover at this location. Much of the non-native graminoid cover increase at TR06 is attributable to increases in Japanese brome (*Bromus japonicus*). The cool-season versus warm-season graminoid composition differs substantially between the sites. TR06 is almost completely dominated by cool season grasses (81.3 percent relative cover). Over 50 percent of this is from the native species, needle-and-thread grass (*Stipa comata*). Cool-season grasses also provide more than half the total relative foliar cover at TR12, while at TR01, warm-season grasses dominate the prairie. Since 1993, both cool- and warm-season grasses have increased at TR01, with the largest increases occurring after treatment with Tordon22K®.

In general, one disconcerting observation across all three sites since 1993, is that there has been a general increase (ranging from 6 to 16 percent absolute cover) in non-native graminoid cover. Much of this is from the non-native, cool-season graminoid species, Japanese brome, Canada bluegrass (*Poa compressa*), and Kentucky bluegrass (*Poa pratensis*). These increases represent a two to four-fold increase in cover of this group of non-native species over the past eight years. There are several potential reasons that might explain this increase. One is that it is simply a natural cyclic pattern for the grasslands with response to varying climatic conditions. Atmospheric nitrogen deposition is another potential cause. In recent years studies have begun to show that atmospheric nitrogen deposition is increasing nitrogen levels in soils (Baron et al. 2000, Lee and Caporn 1998, SERG 2000). Increased nitrogen levels have been shown to increase weeds (broadleaf forbs) and cool-season graminoids over warm-season species (Gillen et al. 1987, Rauzi 1979, Wight 1976, Morghan and Seastedt 1999). It is possible this may be partially responsible for the increase. Another factor is the lack of grazing and prescribed fire on the grasslands at the Site. These two key processes are essential for maintaining ecosystem health and keeping native species vigorous and healthy so they can better compete with non-native species. The lack of these two processes at these locations for over 25 years may be hindering the ability of the warm-season species to compete with the cool-season species. Properly timed prescribed fire could be used to help reverse this trend. In any case, continued monitoring will determine whether this trend persists.

In 2001, forbs varied between 11 and 14 percent relative cover at the three sites. All three sites showed a general increase in forb cover from 1993 to 1995 when it peaked. The peak in 1995 may have been due to the above average annual precipitation received that year (Figure 2-2). At TR01 and TR12, the large declines of forb cover observed in 1999 and 1998 respectively, came after the sites were treated with Tordon22K®. This was not an unexpected result because other studies, both on, and off-site have shown a similar response (K-H 2001b, Rice and Toney 1996, Rice et al. 1997). At TR01 forb cover in 2001 was beginning to rebound, while at TR12 it continued to remain depressed.

Considerable variation existed among individual xeric grassland sites in terms of dominant species. These differences were first reported based on the 1994 data (DOE 1995b, 1997c). In 2001 these differences are still distinct. In 2001, TR01 was dominated by the native species, mountain muhly (*Muhlenbergia montana*) and big bluestem (*Andropogon gerardii*), and needle-and-thread grass. At TR06, the dominant species were needle-and-thread grass, a native species, and the two non-native species, Japanese brome and Kentucky bluegrass. At Site TR12, needle-and-thread grass, big bluestem, and sun sedge (*Carex heliophila*), all native species, were dominant. The dominant species at each site have generally remained consistent at each of the sites since 1993, although their order of dominance has sometimes changed on an annual basis. It is not uncommon for species to show substantial variation in annual cover based on responses to climatic conditions. Examination of the individual species responses in Table 2-3 show this for many species. This is discussed below.

Species frequency results from the 1998 and 2001 quadrat data for both spring and summer sampling sessions are found in Table 2-4. Only two years of frequency data exist because frequency quadrats were not added to the sampling methodology until 1998. The species on the xeric mixed grassland that occurred with 80 percent frequency or greater in 2001 were the native species, sun sedge, big bluestem, needle-and-thread grass, dotted gayfeather (*Liatrus punctata*), mountain bladder-pod (*Lesquerella montana*), and blue grama (*Bouteloua gracilis*), and the non-native species, Japanese brome and Dalmatian toadflax (*Linaria dalmatica*). The frequency of the noxious weed, diffuse knapweed, was reduced after spraying at TR01 in 1999, and continues to be largely suppressed. At TR12, knapweed frequency is increasing however. Dalmatian toadflax frequency was not substantially changed by the herbicide application applied at TR06 in 1999. The cover response of toadflax is discussed below.

Individual species responses vary on an annual basis in response to temporal and spatial variations in climatic conditions. This makes trend analysis of short-term datasets challenging. A comparative baseline is not simply a single point value, but rather a range of variation that occurs over time in response to normal climatic perturbations for a given locality. This range of variability, in terms of cover or biomass, is unknown for most species at a given location, unless long-term datasets have previously collected such information. So, in attempting to interpret trends with short-term datasets it is often unknown whether changes observed are simply part of the normal annual fluctutations, or are real trends. With this in mind, Table 2-5 lists species, by site, which based on absolute cover which have shown different "trends" from 1993-2001. To be included on the list, a minimum change of three percent cover from the minimum to maximum must have occurred. Four trend types were classified based on response patterns. Increasers were those species that showed an overall consistent increase in cover during the study period. Decreasers were those species that showed an overall consistent decrease in cover during the study period. Those species that showed a high to low to high cover response during the study period were designated HLH. Those species that showed a low to high to low cover response during the study period were designated LHL.

Of particular interest is the continued loss of little bluestem (*Andropogon scoparius*) cover at both TR01 and TR12 since 1993. This was noted in the 1998 annual vegetation report (K-H 1999b), and the trend still has not reversed substantially. Why this is occurring at these locations is unknown because qualitative observations at other locations in the Buffer Zone would seem to contradict this. It is quite abundant at these locations. At TR06, the noxious weed, Dalmatian toadflax provided the second highest amount of foliar cover from 1993 through 1998. However, apparently as a result of the herbicide Tordon22K®, applied in 2000, Dalmatian toadflax cover dropped from 9.8 percent in 1998 to only 4 percent in 2001. Although it makes sense to attribute the loss of toadflax cover to the herbicide, it must be stated tentatively, because no untreated control transects are available to determine what amount of change might be attributed to natural causes. But, it appears the Tordon22K® application has reduced the overall cover of this noxious weed at this location. It certainly reduced the vigor and flowering of the species as can be seen in the comparison photos in Figure 2-4.

A detrended correspondence analysis (DCA) ordination technique was used to summarize the multiple years of data from the xeric mixed grassland community to reveal patterns (differences) between sites through time based on species richness and abundance parameters (in this case species cover). Results of a DCA are projected onto two dimensions in such a way that samples most similar to one another are close together, and samples most dissimilar from one another will appear farther apart (Gauch 1982). Using additional information on soils, habitat requirements of specific plant species, environmental gradients, and other factors, ecological interpretation of the results may be conducted to explain the patterns revealed by the analysis (Clark 2002). DCA ordination results based on species cover at each site (where available) for the years 1993, 1994, 1995, 1998 through 2001 is shown in Figure 2-5. The ordination results show a clear separation of the sites TR01, TR06, and TR12 along axis 1. This separation along axis 1 is best explained by the differences in species composition found at each site (discussed above). This axis also reveals a moisture gradient between the three sites. Needle and thread grass, a species that prefers well drained, lower soil moisture sites, increases in cover from TR01 to TR12 to TR06 (Table 2-3; FIES 2002). Big bluestem on the other hand a species that prefers moister conditions increases in cover the opposite direction (Table 2-3; FIES 2002). Additionally, Spanish bayonet, a species that prefers well drained locations is only abundant at TR06 (Webber 1953). Axis 2 is best explained as changes in community composition over time at the three sites in response to climatic variation and management actions. The general trend over time is from top to bottom along axis 2 at each site. A similar response through time is seen at sites TR06 and TR12, both cool-season species dominated sites, although some small differences exist. In contrast, is TR01, a warm-season species dominated site, where initial responses were similar to TR06 and TR12, until 1998. Since then there has been a reversal in the composition trend at TR01 which is not seen at either TR06 or TR12. This may be due to the herbicide applications in 1999. However, no similar changes are shown in the data at sites TR06 (2000) and TR12 (1997 and 1999) after they were treated with herbicides. The lack of further abiotic data precludes more conclusive interpretation.

## 2.5 Conclusions

Monitoring in 2001 on the xeric mixed grassland revealed mixed results. Differences in species composition between sites TR01, TR06, and TR12 continue, as would be expected, with some minor variations. Species richness and diversity remain stable. Herbicide applications for weed control at each site have had shown varying responses. Dalmatian toadflax cover at TR06 has declined, presumably as a result of treatment with Tordon22K®, where previously it had been one of the dominant species in the community. At sites TR01 and TR12 on the western edge of the Site, declines in forb cover have been more pronounced than at TR06 near the eastern edge of the Site. Some return of the depressed forb cover has begun as of 2001 at these locations. At all three locations however, an increase in non-native, cool-season graminoid cover has been observed since 1993. This could be attributed to a number of factors, however, the lack of grazing and prescribed fire for over 25 years at these monitoring locations may be stressing the warm-season species and giving an advantage to the cool-season species.

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# 3. 2001 Vegetation Management Program Summary for the Rocky Flats Environmental Technology Site

## 3.1 Introduction

The vegetation management program at the Rocky Flats Environmental Technology Site (the Site) continued to direct a multi-faceted attack on the noxious weeds at the Site during 2001. The regulatory framework governing weed control at the Site includes (K-H 1997a):

- Federal Noxious Weed Act, Section 15—Management of Undesirable Plants on Federal Lands
- Federal Noxious Weed Act, Title 7—Agriculture, Chapter 61—Noxious Weeds
- Colorado Weed Management Act, § 35-5.5-115, C.R.S. (1996 Supp.)
- Jefferson County, Colorado, Undesirable Plant Management Plan
- Memorandum of Understanding for the Establishment of a Federal Interagency Committee for the Management of Noxious and Exotic Weeds.

The Site vegetation management program is guided by the Integrated Weed Control Strategy plan (K-H 1997a), and by the annual vegetation management plans (K-H 1997b, 1999a, 2000a, 2001a) that specify weed control efforts for each year at the Site. The integrated strategy for the Site includes the use of administrative and cultural, mechanical and physical, biological, and chemical control methods. This report summarizes, by method, the weed control and revegetation/ reclamation activities conducted at the Site during FY2001.

## 3.2 Administrative and Cultural Controls

Two minor projects (less than one acre each) disturbed small areas of the Buffer Zone during 2001. At both locations (Figure 3-1) the disturbances were revegetated with a native seed mix. On the xeric tallgrass prairie east of the gravel mine operation in the northwest Buffer Zone, an area of approximately 10 acres became a potential problem area when it was buried by windblown sand (Figure 3-1; see the High-Value Vegetation Summary section in this annual report for more details). As a result, much of the existing native vegetation was buried, and by late summer the area was dominated by annual species, including the noxious weeds diffuse knapweed (*Centaurea diffusa*) and Russian thistle (*Salsola iberica*). Weed control and possibly revegetation of the area will be necessary to prevent further encroachment of the noxious weed species that have now established in the area.

Monitoring of several large revegetation projects done in 1999 (K-H, 2000b, 2001b) was continued in 2001. For each of these projects, photo monitoring and qualitative assessments of the resulting revegetation effort was initiated 1999 and continued in 2000 and 2001, in order to evaluate the effectiveness of the revegetation efforts and to continue learning what works best for conditions at the Site. The photo monitoring results of these efforts can be found in the Appendices on CD-ROM at the end of this report. Additional monitoring conducted in 2001, related to weed control, consisted of mapping the distribution of several weed species on the Site, including diffuse knapweed, musk thistle (*Carduus nutans*), common mullein (*Verbascum thapsus*), dame's rocket (*Hesperis matronalis*), annual rye (*Secale cereale*), jointed goatgrass (*Aegilops cylindrica*), bouncingbet (*Saponaria officinalis*), Russian knapweed (*Centaurea repens*), scotch thistle (*Onopordum acanthium*), and several other minor weeds. Several other monitoring efforts related to vegetation management that continued in 2001 included monitoring of herbicide impacts to native and target species, prescribed burn effects on the xeric tallgrass prairie, the role small mammal mounds have with respect to noxious weed establishment and spread, and the initiation of monitoring to evaluate biocontrol release effectiveness. Results of these monitoring efforts are summarized in other sections of this annual report as well as in earlier annual reports (K-H 1998, 1999b, 2000b, 2001b).

As part of the ongoing vegetation management program, the sharing of information and planning strategies with other local agency weed coordinators and resource managers is important because coordinated efforts between neighboring land owners is essential for long-term control. During 2001, the K-H Ecology Group disseminated information on weed control and vegetation management to onsite personnel, through meetings, personal communication, and Site newspaper articles. In addition, K-H Ecologists attended regional and national weed control meetings and the 2001 Colorado Weed Management Association conference to present information on Site efforts and to keep up to date with the most recent knowledge and advances in weed control.

## 3.3 Physical and Mechanical Controls

Physical and mechanical controls used at the Site in 2001 consisted of mowing, grading, and selective hand control. Mowing was done along the margins of the main east and west access roads, in addition to several miles of firebreak roads in the Buffer Zone, to prevent the roadside weeds from producing seed and spreading further. Mowing was also conducted on the xeric tallgrass prairie adjacent to a firebreak road in the northern Buffer Zone where annual rye has begun to invade the prairie. Mowing was conducted at the time when the seed heads were starting to form. The plan is to continue to mow the annual rye annually to prevent further seed set and exhaust the seed bank.

Grading was conducted along approximately 18 miles of firebreak roads in the Buffer Zone to maintain these firebreak roads and prevent roadside weeds from going to seed and spreading further (Figure 3-2). Hand control in 2001 was conducted at several locations to control localized infestations of Scotch thistle, annual rye, bouncingbet, dame's rocket, crown vetch (*Coronilla varia*), bird's-foot trefoil (*Lotus corniculatus*), lens-padded hoary cress (*Cardaria chalepensis*), pepperweed whitetop (*Cardaria draba*), Dalmatian toadflax (*Linaria dalmatica*), and Texas blueweed (*Helianthus ciliaris*). Hand control consisted of hand pulling, using sickles or sling blades, and spot herbicide spraying. The use of hand control has proven valuable to prevent these small infestations from becoming larger problems, and has at several locations, eliminated the infestations.

## 3.4 Biological Control

During 2001, several species of biocontrol insects were released at the Site. Site ecologists and Texas A&M researchers working in conjunction with the U.S. Fish and Wildlife Service (USFWS) released approximately 2,185 adults of *Larinus minutus*, a seedhead weevil that feeds on diffuse knapweed, at several locations in different drainages at the Site (Figure 3-3). Locations were chosen to establish populations near the streams where other forms of weed control (such as chemical or mechanical) for this species are impractical. This and other species of diffuse knapweed biocontrol insects have been released in recent years at the Site and will continue to be released at the Site in attempts to replicate promising results seen on Boulder County Open Space to the north of the Site (Seastedt et al. 2001). Other biocontrol insects released during 2001 included: *Sphenoptera jugoslavica*, a root boring beetle that attacks diffuse knapweed; *Mecinus janthinus*, a stem mining beetle that attacks Dalmatian toadflax; *Trichosirocalus horridus*, a rosette weevil that attacks musk thistle; *Aceria malherbae*, a gall mite that can help to control field bindweed (*Convolvulus arvensis*); and *Cassida rubiginosa*, a defoliating beetle for control of Canada thistle (*Cirsium arvense*; Figure 3-3).

In 2000, 200 adults of *Urophora carduii*, a gall-forming fly, were released at 2 locations in the Rock Creek drainage where other methods of controlling Canada thistle are impractical. The insects were obtained from the Colorado Department of Agriculture (CDA) in an attempt to establish a reproducing population at the Site. The release sites were observed during 2001 to see if the flies had become established and to determine the level of impact on the thistles, if any. At one of the locations a single gall was observed on a

Canada thistle plant (Figure 3-4). During 2002, continued observation of these release sites will be made and attempts to get more of the adult flies for release will be made through the CDA.

For more specifics on the biocontrol release and monitoring efforts conducted at the Site during 2001, see the High-Value Vegetation Monitoring Summary section of this annual report.

## 3.5 Chemical Control

Herbicide applications were used to control several hundred acres of noxious weed-infested grasslands at the Site during 2001. Figures 3-5 and 3-6 show the locations of ground and aerial applications of the herbicide Tordon22k®, Transline®, and Telar® in 2001. Primary target areas for treatment were heavy infestation areas of diffuse knapweed, musk thistle, and mullein; however, other species such as Dalmatian toadflax, Canada thistle, goatsbeard (*Tragopogon dubius*), alyssum (*Alyssum minus*), wild lettuce (*Lactuca serriola*), small-seeded false flax (*Camelina microcarpa*), and some of the tansymustards (*Descurania* ssp.) were also treated. Approximately 134 acres were treated on the ground, while almost 1,000 acres were treated with a helicopter during 2001 (Figures 3-5 and 3-6). The residual effect of the Tordon22K® is expected to help provide continuing control of these species for the next few years, precluding the need for annual retreatment at these locations. Ongoing studies at the Site have shown that Tordon22K® applications can provide approximately two to four years of control (depending on location) before additional herbicide applications need to be made. For more specifics on the chemical control and monitoring efforts conducted at the Site during 2001, see the High-Value Vegetation Monitoring Summary section of this annual report.

## 3.6 Conclusions

During 2001, the vegetation management program at the Site continued to work toward controlling infestations of several noxious weed species in the Buffer Zone. Several methods were applied to control current infestations and prevent new ones. These included the use of administrative and cultural controls, physical and mechanical methods, biological controls, and chemical controls. Progress was made in controlling several large infestations of diffuse knapweed, musk thistle, and mullein, in addition to other smaller infestations of scotch thistle, annual rye, dame's rocket, and several other weed species. Using the knowledge gained from onsite monitoring of the current efforts, and by keeping in contact with other local agency weed coordinators and resource managers, improvements will continue to be made to the vegetation management program at the Site.

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# 4. Monitoring Summary for Diffuse Knapweed Control Study

## 4.1 Introduction

Diffuse knapweed (*Centaurea diffusa*) is a noxious weed that has become increasingly widespread across the Front Range of Colorado. Over the past several years, the spread of this species has become a serious threat with regard to managing the natural resources in the Buffer Zone at the Rocky Flats Environmental Technology Site (the Site). Under the Colorado Noxious Weed Act, diffuse knapweed is listed as a noxious weed that must be controlled by property owners, and it is listed as one of the top ten prioritized species for control in the state (CRS 1996).

Diffuse knapweed is a very aggressive competitor in dry conditions such as those found at the Site. Studies elsewhere have shown that it rapidly invades overgrazed range lands, disturbed sites, and even undisturbed plant communities, often becoming a dominant species and altering the species composition of the plant community (Powell 1990; FEIS 1996; Sheley et al. 1998). Studies have also shown that diffuse knapweed–infested lands exhibit increased soil erosion, degraded water quality, lower wildlife habitat value, reduced grazing capacity, and less aesthetic and recreational value (Sheley et al. 1997, 1998).

At the Site, one of the rare plant communities that is increasingly affected by the spread of diffuse knapweed is the relict xeric tallgrass prairie. The Site contains a significant portion of what has been identified as the largest remaining stand of this plant community known to occur in Colorado, and potentially in all of North America (CNHP 1995). The herbicide Tordon22K® (trademark of DowElanco [picloram]) is one of the more effective chemicals used for treatment of diffuse knapweed infestations, because its multi-year residual effect can prevent the seeds from germinating for several years after application (Beck 1994). Because this is an important plant community, the issue of what effect the spraying of Tordon22K® might have on the native species in the xeric tallgrass prairie is a management concern. A study was begun on the Site in 1997 to evaluate the effectiveness of Tordon22K® in controlling diffuse knapweed on the Site and to identify any potential effects on desirable species in the xeric tallgrass prairie. This report summarizes the five years of data collected thus far.

The following general questions were proposed for investigation:

- How effective is Tordon22K® on controlling diffuse knapweed under Site conditions?
- How long is a single application of Tordon22K® effective in controlling diffuse knapweed?
- How does Tordon22K® affect species richness, cover, and individual species abundance on the xeric tallgrass prairie?

## 4.2 Study Site Location and Characteristics

The study site is located north of the T130 trailer complex, west of the Industrial Area (Figure 4-1). The xeric tallgrass prairie at the Site is located primarily on the pediment, which is underlain by Rocky Flats Alluvium (SCS 1980). The soils are classified as Flatirons very cobbly sandy loams (SCS 1980). The study site is essentially flat, with only a 1° slope to the northeast. The area was chosen because it was large enough for placement of both control and treatment plots (each 60 × 65 m), and an abundance of diffuse knapweed was present where the two plots would be located.

## 4.3 Methods

A control plot (no herbicide applied) and a treatment plot (herbicide applied) were established. Within both the control and treatment plots, five parallel, randomly located, 50-m transects were established from a baseline using X and Y coordinates generated by a computerized random number generator. Transects were permanently marked, assigned numbers, and labeled. Although it would have been preferable to collect a full year's worth of data prior to herbicide application in 1997, logistics and the required time frame only allowed for a single spring sampling prior to herbicide application. The treatment plot was sprayed with Tordon22K®, applied at a rate of 1 pint/acre, on June 23–24, 1997, using a truck-mounted spray unit with a 16.75-m (55-ft) boom. The boom was held approximately 0.6–1.0 m (2–3 ft) above the vegetation. A uniform application rate was obtained across the area using a computerized spray system that regulated the application pressure rate according to the speed of the truck. Some diffuse knapweed plants had already bolted and were in the bud stage at the time the spraying occurred, but many rosettes were also still present. Sampling during 1997 was conducted on June 16–19 and again on September 2–4. In 1998, sampling was conducted on June 17–19 and August 24–27. In 1999, sampling was conducted on June 14–18 and August 30–September 1. In 2000, sampling was conducted on June 12-16 and August 28-31. During 2001, sampling was conducted on June 11-14 and August 20-23.

Species richness was determined in a 2-m-wide belt centered along the length of each 50-m transect. Every plant species rooted within the 100-$m^2$ area was recorded. In addition, the numbers of woody plant stems and cactus stems were counted for the 100-$m^2$ area and recorded. Basal cover and foliar cover estimates were made using a point-intercept method along each of the 50-m transects. A 2-m-long rod, with a 6-mm diameter, was dropped vertically at 50-cm increments along the transect to record a total of 100 intercept points. Two categories of hits were recorded, basal and foliar. Basal cover hits indicated what material the rod contacted at the ground surface. Hits could be vegetation (live plants), litter (fallen dead material), rock (pebbles and cobbles that were greater than the rod diameter), bare ground, or water, in that order of priority based on the protection from erosion each type of cover provided. Basal vegetation hits were recorded by species only if the rod was touching the stem or crown of the plant where the plant entered the ground. Foliar vegetation hits (defined as a portion of a plant touching the rod) were recorded by species in three categories as defined by height and growth form. The topmost hit of each growth form was recorded. The growth forms measured were herbaceous, woody <2 m in height, and woody >2 m in height.

Frequency information by species was gathered by randomly locating 25 1-$m^2$ quadrats (5 per transect) in each of the control and treatment plots and recording all species present in each plot. Stem density counts for diffuse knapweed also were made using these same quadrats. No distinctions were made during counts between seedlings, rosettes, or adult plants. More detailed summaries of these specific methods are found in the *Environmental Monitoring Department Operating Procedures Manual* (DOE 1995), the *High Value Vegetation Survey Plan for the Rocky Flats Environmental Technology Site* (K-H 1997), and the 2001 *Ecological Field Monitoring Plans for the Rocky Flats Environmental Technology Site* (K-H 2001).

Species richness data were summarized by generating species lists for the control and treatment plots for each sampling period. In addition, other species diversity variables were calculated from the species lists. Basal cover data were reported as total percent cover of vegetation, litter, rock, and bare ground. Foliar cover data were reported as frequency, absolute cover, and relative cover for each species encountered. Frequency from the cover data was defined as the percent of point-intercept transects in which a species occurred, out of the total five possible sampled per plot. Absolute foliar cover was the percentage of the number of hits on a species out of the total number of hits possible at a plot (500). This value is the actual cover of a species. Relative foliar cover was the number of hits on a species relative to the total number of vegetative hits recorded per plot (i.e., the percent of total vegetative cover [100 percent] represented by the species).

Both absolute and relative foliar cover values are means averaged over the five transects. Frequency based on quadrats (n=25) was defined as the number of quadrats in which a species was recorded, divided by 25 (the total number of quadrats possible), multiplied by 100. Density count data were summarized as the mean number of stems per square meter based on the 25 quadrats sampled within each plot (n=25).

For most results, descriptive comparisons were made between the control and treatment plots from the five years of data to examine potential changes over time—pre-treatment to post-treatment. Summaries of species richness, cover, and frequency were summarized by combining data from the five control transects and five treatment transects for each sampling event, respectively. A Sorensen coefficient of similarity was used to assess the species richness similarity between the control and treatment data (Brower and Zar 1977). A Shannon-Weaver diversity index was used to calculate diversity and was conducted using the relative foliar cover data (Brower and Zar 1977). Statistical analysis of the results was conducted only when mean values were different enough to suggest a meaningful interpretation. Where normality, variance, and dependence requirements were met, parametric tests were used to compare results, otherwise non-parametric tests were used. Independent samples (i.e., the control versus treatment for specific sampling periods) were compared using t-tests, or Mann-Whitney U tests (SigmaStat 1997; Fowler and Cohen 1990; Sheskin 1997), as appropriate. Dependent sample comparisons (i.e., within treatment over time) were done using repeated measures ANOVA tests, paired t-tests, Wilcoxon's test for matched pairs, or Friedman's repeated measures ANOVA (SigmaStat 1997; Fowler and Cohen 1990; Sheskin 1997), as appropriate. Where applicable, a Bonferroni, Dunnett's, or Tukey tests were used for pairwise multiple comparison procedures to isolate groups that differed from one another (SigmaStat 1997). Frequency analyses were done using a McNemar test (Sheskin 1997). A detrended correspondence analysis (DCA; PC-ORD 1999) ordination technique was used to evaluate the relationships between the control and treated areas for each sampling session based on species abundances.

## 4.4 Results

### 4.4.1 Species Richness

Species richness was originally higher in the treatment plot compared to the control plot by 6 species (Tables 4-1 and 4-2; Figure 4-2). After the herbicide application in 1997, overall species richness in the treatment plot declined initially by 12 species (from 74 to 62 species). However, by the following spring (1998) it had returned to 70 species (equal that in the control plot). Since spring 1999, the treatment plot has had 5 to 15 more species than the control plot during each monitoring session.

A Sorensen coefficient of similarity was used to compare initial 1997 species richness to that in 2001 for both the control and treatment plots. Comparing spring 1997 to spring 2001 resulted in a Sorensen index value of 0.86 for the control plot and 0.80 for the treatment plot, indicating slightly greater similarity in species richness in the control plot, five growing seasons after the herbicide application. The spring 1997 control-versus-treatment Sorensen index value was 0.85, and 0.81 in summer 2001. Thus, five growing seasons after the herbicide application, the similarity of species richness between the control and treatment plots is slightly less than prior to the start of the study.

### 4.4.2 Diffuse Knapweed Response

Diffuse knapweed densities declined significantly in the treatment plot after the herbicide application and continued to remain at low levels through 2000, four growing seasons after the herbicide application (Table 4-1, Figure 4-3; Friedman's repeated measures ANOVA by Ranks, $X^2 = 82.36$, df = 9, $P < 0.001$). However, in spring 2001, diffuse knapweed density in the treatment plot increased to over 40 plants/m$^2$ and was no longer significantly different from the original density in 1997 (Table 4-1, Figure 4-3; Friedman's repeated measures ANOVA by Ranks, $X^2 = 82.36$, df = 9, $P < 0.001$).

Seasonal fluctuations were observed in diffuse knapweed densities in the control plot (Table 4-1, Figure 4-3). However, only the spring 1999 diffuse knapweed density showed a statistically significant increase in the control plot, from 5.6 plants/m$^2$ in 1997 to 26.1 plants/m$^2$ (Table 4-1, Figure 4-3; Friedman's repeated measures ANOVA by Ranks, $X^2 = 78.40$, df = 9, $P < 0.001$). None of the other spring spikes in diffuse knapweed density in the control plot were statistically different from initial conditions (Figure 4-3; $P > 0.05$).

Diffuse knapweed frequency has remained fairly stable in the control plot from 1997 through 2001, with the exception of a sharp peak (increase) during spring 1999 (Table 4-1; Figure 4-4). In the treatment plot, during the same time period, diffuse knapweed frequency declined steadily, from 80 percent before herbicide treatment in 1997 to a low of 20 in summer 1998. However, since then it has increased, peaking in spring 2001 at 72 percent, only 8 percent less than the original frequency of 80 percent in 1997.

Diffuse knapweed cover declined sharply in both the control and treatment plots after the herbicide application (Figure 4-5). However, since spring 2000, diffuse knapweed cover has increased significantly in the control plot compared to the treatment plot and continues to remain significantly higher (Figure 4-5).

### 4.4.3 Cactus Density Response

Cactus densities and frequencies in the control plot for twistspine prickly pear (*Opuntia macorhiza*) and hedgehog cacti (*Echinocereus viridiflorus*) remained generally stable from 1997 to 2001, ($P > 0.05$; Table 4-1; Figures 4-6 and 4-7). In the treatment plot, however, densities for these two species both declined significantly after the herbicide treatment (Table 4-1; Figures 4-6 and 4-7). The twistspine prickly pear density decreased significantly by 94 percent from 1997 to 2001 (Figure 4-6; One Way Repeated Measures ANOVA, $F = 54.559$, $P < 0.001$) and remains far below that of pre-treatment levels or that found in the control plot. The frequency of the twistspine prickly pear decreased significantly by more than 80 percent (Table 4-3; McNemar test, $X^2 = 11.1$, $df = 1$, $P < 0.01$). Hedgehog cactus density and frequency also decreased significantly in the treatment plot from spring 1997 to spring 2001 (Tables 4-1 and 4-3, Figure 4-7; One Way Repeated Measures ANOVA, $F = 9.287$, $P < 0.001$; McNemar test, $X^2 = 6.1$, $df = 1$, $P < 0.05$), with the density decreasing by 95 percent. Continued monitoring will detect when and if the cacti begin to return to these areas.

### 4.4.4 Diversity Response

Shannon-Weaver diversity indices for the control and treatment plots are shown, by sampling event, in Table 4-1 and Figure 4-8. No significant changes were observed in the control plot from 1997 through 2001 ($P > 0.05$; Figure 4-8). In the treatment plot, a statistically significant loss of diversity was observed after the herbicide application in spring 1997, lasting through summer 1999 (Figure 4-8; One Way Repeated Measures ANOVA, $F = 3.913$, $P < 0.05$). However, in spring 2000 and throughout all of 2001, diversity was no longer statistically different from the initial diversity in the treatment plot (Figure 4-8; $P > 0.05$). In comparison to the control plot however, during the summers of 2000 and 2001, diversity in the treatment plot remained significantly lower than that in the control plot (Figure 4-8; summer 2000: T-test, $t = 3.54$, $df = 8$, $P < 0.05$; summer 2001: T-test, $t = 2.54$, $df = 8$, $P < 0.05$).

### 4.4.5 Plant Frequency Response

Individual species frequencies measured during each sampling event are presented in Table 4-3 for both the control and treatment plots. Taking into account changes that occurred in the control plot from spring 1997 to spring 2001 (i.e., assumed to be natural variability in species frequency), those species in the treatment plot that showed the greatest change in frequency are shown in Table 4-4. Only those species that showed changes of 12 percent or more (negative or positive) are listed, because the presence of a species in a single quadrat represents 4 percent ($n = 25$). Changes of 8 percent or less are as likely explained by chance as by any response to the herbicide application, given the natural variability of species on the prairie. Eleven species continue to show declines in frequency (Table 4-4). The species showing the greatest decreases were twistspine prickly pear and Fendler's sandwort (*Arenaria fendleri*), with decreases of 52 and 28 percent, respectively, in the treatment plot compared to the control plot. Of the other nine species listed as having experienced declines in frequency, seven were native species and two were non-native (Table 4-4). Several species also showed increases in frequency in the treatment plot versus control plot analysis (Table 4-4).

### 4.4.6 Vegetation Cover Response

Foliar cover results, by species and species groupings, for the control and treatment plots from 1997 to 2001, by sampling session, are presented in Tables 4-5 and 4-6, respectively. Change in species composition was evaluated by examining changes in the amounts of foliar cover provided by different species or groups of species. For this year's analyses absolute (actual) foliar cover values are discussed in most cases. Relative foliar cover values are presented in the tables, however, and are included in the discussion where applicable.

Examination of the cover data showed seasonal shifts in cover amounts for many of the species groupings (Tables 4-5 and 4-6). Total foliar cover, total native foliar cover, and total non-native foliar cover values for both the control and treatment plots showed essentially parallel responses from 1997 through 2001 (Tables 4-5 and 4-6; Figure 4-9). The only fluctuation in total foliar cover in the treatment plot compared to the control plot occurred in summer 1997, and most of this resulted from the loss of non-native foliar cover (Tables 4-5 and 4-6; Figure 4-9). It was not significantly different ($P > 0.05$), however, and thus the total foliar cover present on the grassland was not affected by the herbicide treatment.

Species composition was affected though. In the control plot, total forb cover did not change significantly from 1997 through 2001, varying from about 9 to 15 percent ($P > 0.05$; Figure 4-10). Total forb cover in the treatment plot, however, dropped significantly—from more than 12 percent initially in 1997 to a low of less than 4 percent in summer 1998—in response to the herbicide (Figure 4-10; One Way Repeated Measures ANOVA, $F = 3.996$, $P < 0.05$). With the exception of summer 1999 and spring 2001, the total forb cover has remained significantly lower than the initial 12.2 percent found in spring 1997 (Figure 4-10; One Way Repeated Measures ANOVA, $F = 3.996$, $P < 0.05$). Taking into account changes in the control plot however, total forb cover in the treatment plot has only been significantly different in spring and summer 1998 and again in summer 2001 (Figure 4-10; T-tests, $t = 4.346$, $t = 3.444$, $t = 5.379$, respectively, $df = 8$, $P < 0.05$).

Non-native foliar cover was eliminated from the treatment plot throughout 1998, the second growing season after treatment, but began to return again in 1999 and has increased to just over 2 percent in the summer of 2001 (Figure 4-11). Non-native cover in the treatment plot continued to be significantly below that of the control plot in the late summer of 2001 (Figure 4-11; T-test, $t = 2.882$, $df = 8$, $P < 0.05$). In the control plot, non-native cover also declined throughout 1998 and spring 1999, but then increased to 6 percent by summer 2001 (Figure 4-11). Diffuse knapweed accounted for the largest portion of non-native cover in both the control and treatment plots in summer 2001 (Tables 4-5 and 4-6). Native forb cover was equal in the control and treatment plots prior to the herbicide application (Figure 4-11). However, after the herbicide application, native forb cover dropped in the treatment plot and was significantly different from the control plot throughout 1998 (Figure 4-11; spring 1998, T-test, $t = 3.523$, $df = 8$, $P < 0.05$; summer 1998, T-test, $t = 2.603$, $df = 8$, $P < 0.05$). By 1999, however, native forb cover was no longer significantly different from the control plot and remained that way through spring 2000, by which time it was essentially equal to that in the control plot ($P > 0.05$). The past two summers (2000 and 2001), however, the native forb cover has declined in the treatment plot and been significantly different from the control plot (Figure 4-11; summer 2000, T-test, $t = 3.226$, $df = 8$, $P < 0.05$; summer 2001, T-test, $t = 3.592$, $df = 8$, $P < 0.05$).

Total graminoid cover amounts in the control and treatment plots have essentially paralleled each other since the herbicide application (Figure 4-12). Although some significant increases have been seen in total graminoid cover since the herbicide application ($P < 0.05$), these increases have occurred in both the control and treatment plots with no significant differences between them (Figure 4-12; $P > 0.05$). Split out by cool-season and warm-season graminoid species, the cover of both the control and treatment plots have shown generally parallel, seasonal fluctuations with no significant differences between the control and treatment plots ($P > 0.05$).

Detrended correspondence analysis (DCA) results based on species cover by sample session show that the control and treatment areas had some initial separation along axis 1 and axis 2 (Figure 4-13). The control plot shows the natural annual and seasonal variability of cover, to which the treatment plot is compared. So differences between them should be attributable to the herbicide application. Both the control plot and treatment plot data show a consistent spring to summer, right to left shift along axis 1. Total foliar cover and total graminoid cover (Tables 4-6 and 4-7) showed large seasonal increases from spring to summer, thus perhaps best explaining axis 1. During 1998 and 1999, the control plot shifted toward the lower end of axis 2, before returning to a position above its original starting location in 1997, and ending slightly higher in 2000 and 2001. Comparing the locations of the treatment plot over the same period of time, the same shift to the lower end of axis 2 was present in 1998 and 1999. However, the 2000 and 2001 positions while shifting back toward the original location in 1997 are still below where they are in the control plot and below the original treatment plot origin. Thus there is still some difference in the treatment plot resulting from the herbicide application.

## 4.5 Discussion

The effect of the herbicide Tordon22K® on diffuse knapweed and other species on the xeric tallgrass prairie was examined to provide important information for weed control and resource management activities at the Site. The herbicide application was effective at controlling diffuse knapweed at the study location on the xeric tallgrass prairie for approximately four field seasons after treatment. In the fifth year, diffuse knapweed densities and frequencies returned to above and near pre-treatment levels, respectively, showing little difference as compared to the control plot. The increased germination of diffuse knapweed seed in the seed bank (based on increased knapweed density) is indicative of the waning residual effect of the Tordon22K®. Diffuse knapweed cover, however, still remains significantly lower in the treatment plot compared to the control plot. The delayed response of diffuse knapweed cover is largely attributable to the biennial growth habitat of the species. After germination, the species typically overwinters as a rosette, so most of the density and frequency increases for diffuse knapweed seen in 2001 were of seedlings and rosettes. Those that survive the winter will then bolt and become adult plants in 2002, thus increasing the amount of diffuse knapweed cover (i.e., due to the much larger size of the adult plants compared to the seedlings and rosettes). So it is likely that with sufficient overwinter survival, diffuse knapweed cover will increase substantially in 2002 if no additional control efforts are applied.

The response of the xeric tallgrass prairie species to the herbicide application has been more or less what was expected. Declines in species richness in the treated area were temporal, recovering within a year after the herbicide application, and remaining higher in the treated area than that in the control area. Species richness similarity from 1997 to 2001 was slightly higher in the control plot than in the treatment plot, suggesting some possible changes resulting from the herbicide application. However, examination of annual/seasonal species lists (Table 4-2) showed no substantial changes in species richness at the treatment plot resulting from the herbicide application. The natural variability of many of the species makes it impractical to attribute any changes to the herbicide.

Species diversity declined significantly in the treated area and remained significantly less compared to the initial 1997 values until 2001 (Figure 4-8), thus showing a similar response to the herbicide as did diffuse knapweed abundance. Compared to the control plot however, significant differences in species diversity were only noted during the summer sampling sessions from 1997 to 2001. Spring comparisons between the control and treatment were not significantly different, thus suggesting a seasonality effect.

Further investigation into this showed that most of the change in the diversity index in the treated area is attributable to the loss of forb cover (Figure 4-10). Total forb cover in the treated area declined significantly after the herbicide application and has remained significantly lower than the original amount throughout the duration of the study with the exception of spring 2001. The general appearance of the species diversity graph and total forb cover graph are strikingly similar (Figures 4-8 and 4-10). Compared to the control area however, forb cover in the treated area was only significantly different in 1998 and again in summer 2001. It was no different from the control area in 1999, two field seasons after the herbicide was applied. Thus total forb cover does not seem account for the seasonality effect seen in the diversity data. However, split out by native versus non-native forb cover, the data reveal that reduced summer native forb cover in the treated areas, combined with increased summer native forb cover in the control areas seems to be largely responsible for the seasonality difference in the diversity measure (Figure 4-11).

Efforts to determine which native species are accounting for the lower late summer forb cover in the treatment plot are confounded by the fact that native forb composition was not the same in the control and treatment plots prior to the herbicide application. In addition, the problem is compounded by the fact that most of the forbs are rarely encountered using the point-intercept method, so few hits are available for analysis by individual species. Nevertheless, late summer native forb cover in the treated areas remains significantly below that in the control areas five years after the herbicide application.

The response of the graminoid component of the plant community has been to increase and replace the significant loss of forb cover resulting from the herbicide application. The fact that total foliar cover in the treated area did not change even after the loss of forb cover demonstrates this. Qualitative observations have also noted the increased health, vigor, and flowering of the grasses in treatment areas after the herbicide application. It is important to note however, that the increase in graminoid cover in the treatment area was not enough to make it statistically significantly different from the control area. Some of this is explained by the fact that the original amount of graminoid cover in the treated area was lower than that in the control. After the herbicide application, however, graminoid cover in the treated area rose above that in the control, but not enough to reach a point where it was significantly different from the control. No significant changes in warm-season versus cool-season graminoid cover were observed during the study. The control and treatment responses paralleled each other. The increase in graminoid cover is a desired response because it is hoped that the increased perennial cover will help to compete against the diffuse knapweed and other noxious weeds in the future.

In general, the data from the Site are consistent with data from other studies that have shown an initial decline of species diversity, loss of forb and weed cover, and increase in graminoid vigor and cover after application of Tordon22K®. Rice and Toney (1996) reported decreases in forb cover due to herbicide treatments on native prairie in Montana. They reported that these responses were transitory, however, and that forb values returned to pre-treatment levels after about three years. Rice et al. (1997) found that species diversity also declined after spraying with Tordon22K®, but recovered after 2–3 years. Both of these studies also indicated that, as a result of lost weed and forb cover (i.e., reduced competition), the graminoid component of the community responded vigorously. In the Lolo National Forest in Montana, Henry (1998) reported that two years after spraying with Tordon22K®, a mountain grassland community had a 95 percent reduction in weed biomass and an 86 percent decrease in forb biomass. Associated with this was a 714 percent increase in grass biomass. The major difference observed during this study at the Site, however, has been the lack of return of the late summer native forb component. Thus differences due to species composition, soils, and/or climate are apparently having some effect on the results seen here.

These data raise some important points to consider for diffuse knapweed control on the xeric tallgrass prairie at the Site. It is important to note that the overall species richness of the prairie was not altered. However, the abundance of many species was changed, especially with respect to the forbs. The continued reduced cover of native forb species, five years after treatment, is of particular concern, since many of these species contribute to the uniqueness of the xeric tallgrass prairie at the Site. Continued reapplication of broad-leaf, non-species-specific, herbicides (such as Tordon22K®) without allowing enough time for complete recovery of the native forb component of the community will only lead to the further reduction of the native forb component of the community and inhibit its ability to compete with the ever increasing number of exotic species. The use of a more selective herbicide such as Transline® will be necessary until the community has recovered. It is also apparent, however, that sole reliance on the continual reapplication of herbicides is not a viable long-term solution by itself. The cost in both dollars, and to the environment, is high. Integration with other control methods such as biocontrol, prescribed burning, fencing, and potentially grazing are necessary to improve environmental conditions for the desired native species and to succeed in controlling and reducing diffuse knapweed infestations to acceptable levels in the long-term.

The lack of more substantial increases of graminoid cover, given the reduction in competition from the forbs, suggests that perhaps there are other limiting factors (such as moisture or nitrogen) controlling plant growth on the xeric tallgrass prairie. If these could be identified and adjusted in combination with weed control measures it may be possible to further enhance conditions for the native species to the detriment of the exotics.

One additional "lessons learned" worth mentioning is the temporal aspects of monitoring. The importance of long-term datasets cannot be underestimated; this study is a good example. The notable decline of species diversity and native forb cover in the 2000 late summer dataset was noticed and mentioned first in the 2000 annual vegetation report. Given that these variables had previously "recovered", based on earlier data, the explanation given for that "fluke" in the data was that it was a combination of drought and herbicide interaction. With the additional year of data it has now become more apparent that perhaps this is a longer-term depression of the summer native forb component of the grassland. Without the fifth year of data, however, this would not have been known and potentially erroneous conclusions might have been drawn. Continued monitoring of these sites may help answer the question concerning recovery time before reapplication of a non-selective herbicide is warranted on the xeric tallgrass prairie.

## 4.6 Conclusions

An application of Tordon22K® on the xeric tallgrass prairie at the Site provided four years of control for diffuse knapweed, the primary target species. Initial declines in species richness were transitory, and no changes in overall foliar cover were observed. Total forb cover remains significantly lower than it was originally, but compared to the control has generally recovered. However, native forb cover continues to remain significantly lower, during the late summer, in the treatment area after five years. This warrants concern since many of these species contribute to the uniqueness and diversity of the xeric tallgrass prairie at the Site. Additional recovery time for the native, late summer forb component of the community is required before additional non-selective herbicide applications are used. Otherwise, further declines in the forb component of the community are likely. In general, the loss of forb cover has been made up by increases in graminoid cover, although it is likely that other factors may be limiting plant growth. Integration with other control methods such as biocontrol, prescribed burning to increase the vigor of native species, fencing, and potentially grazing are necessary to improve environmental conditions for the desired native species and succeed in ultimately controlling and reducing diffuse knapweed infestations to acceptable levels in the long-term.

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# 5. Aerial Herbicide Application Diffuse Knapweed Monitoring

## 5.1 Introduction

During May 1999, the herbicide Tordon22K® was applied from a helicopter to control diffuse knapweed (*Centaurea diffusa*) and other noxious weeds on approximately 1,500 acres at the Rocky Flats Environmental Technology Site (Site). To evaluate the effectiveness of the aerial herbicide application on diffuse knapweed, the primary target species, a monitoring effort was undertaken.

The following questions were proposed for investigation:

1. Is the aerial herbicide application effective at reducing the frequency and cover of diffuse knapweed?

2. How does the aerial herbicide application compare to previous ground applications for controlling diffuse knapweed at the same application rates?

3. Is there evidence of undesirable drift or other unintentional application outside the specified application areas? If so, what were the impacts?

This report presents and updates the results of the 2001 monitoring with respect to question 1 above. Answers to questions 2 and 3 were answered and reported in the 1999 Annual Vegetation Report for the Rocky Flats Environmental Technology Site (K-H 2000).

## 5.2 Methods

The study was conducted at three replicated circular plots (AS-1, AS-2, and AS-3) chosen subjectively for their high infestation of diffuse knapweed in the xeric tallgrass prairie at the Site (Figure 5-1). Each plot was 30 m in diameter, and the center of each plot was permanently staked with rebar. Using randomly generated X (distance from center stake) and Y (aspect) coordinates, a total of 20 quadrats (0.5 × 1 m; 10 control and 10 treatment) were located in each plot. No overlapping of quadrats was allowed. The southwest corner of each quadrat location was permanently staked, assigned a number, and tagged. Quadrats were aligned using a compass, with the 1-m side of the quadrat running east-west and the southwest corner of the quadrat touching the stake. Quadrats were sampled in mid-May 1999 on the day before and morning of the aerial herbicide application, and again in August 1999, May 2000, August 2000, April/May 2001, and August 2001. At each quadrat, diffuse knapweed cover was estimated using the cover class system shown in Table 5-1. Only live diffuse knapweed plants were used to estimate cover. It should be noted therefore that the spring cover data represent only seedling and rosette cover, while the summer data represents the cover of seedling, rosette, and adult plants. At each plot, photographs were taken of five control and five treatment quadrats. Photographs were taken with a single-lens reflex (SLR) camera with a 35-mm lens. Photographs were taken looking straight down on the center of each quadrat from eye level (approximately 1.5 m), while standing facing south so that the permanent stake is in the upper right hand corner of the photograph.

After the initial monitoring of the quadrats, but prior to the 1999 aerial herbicide application, the 10 control quadrats at each plot were covered with black plastic that was weighted down to hold it in place during spraying. This was done to prevent the herbicide from reaching the plants and surface of the ground. The aerial herbicide application was conducted on May 12 and 13, 1999. The black plastic was removed within a few hours after the aerial herbicide application had taken place. A helicopter was used to apply the herbicide.

Diffuse knapweed cover was summarized for the control and treatment areas during each sampling session. Cover data were summarized and analyzed using the midpoint of each cover class (Table 5-1). Monitoring results in 2001 are summarized for plots AS-1 and AS-2 only. During the aerial herbicide application in spring 2001, parts of the AS-3 plot were inadvertantly sprayed with Tordon22K®. For comparison to past results, all previous years were reanalyzed using only AS-1 and AS-2 data. All 20 quadrats for the control and treatment analyses, respectively, were summarized together for both cover and frequency comparisons. Statistical comparisons were made between and within the control and treatment areas for each sample session and across time (pre- and post-treatment) using non-parametric tests because the data failed normality criteria. Independent samples (control versus treatment) were tested using a Mann-Whitney rank sum test, and dependent samples (control and treatment through time, respectively) were tested with a Friedman repeated measures ANOVA (SigmaStat 1997). Multiple comparison tests (Bonferroni t–test or Dunnett's) were used to separate means or medians at the 5% level of probability. Frequency analyses were conducted using a McNemar test (Sheskin 1997).

## 5.3 Results

Initial cover amounts for diffuse knapweed (seedlings and rosettes) at the control and treatment plots prior to aerial herbicide application were not statistically different, averaging approximately 11 and 8 percent, respectively (Figure 5-2; $P > 0.05$). However, approximately 3 months after the herbicide application, diffuse knapweed cover amounts (seedlings, rosettes, and adults) were statistically different between the late summer control and treatment plots, averaging 30 percent and less than 1 percent, respectively (Figure 5-2; Mann-Whitney rank sum test, $P < 0.001$; median: control = 26.25, treatment = 0). Throughout 2000, diffuse knapweed cover in the treatment plots remained significantly lower than that in the control plots in both the spring (Figure 5-2; Mann-Whitney rank sum test, $P < 0.001$; median: control = 15, treatment = 0) and summer (Figure 5-2; Mann-Whitney rank sum test, $P < 0.001$; median: control = 62.5, treatment = 0). In 2001, the differences in diffuse knapweed cover between the control and treatment plots continued to be significantly different in the spring (Table 5-2; Mann-Whitney rank sum test, $P < 0.01$; median: control = 15, treatment = 0), and in the summer (Table 5-2; Mann-Whitney rank sum test, $P < 0.001$; median: control = 50, treatment = 2.5). Additionally, comparison of the pre-application versus post-application diffuse knapweed cover amounts for the control and treatment plots, respectively, showed statistically significant changes. At the control plots, diffuse knapweed cover has increased significantly from a mean of 11 percent to over 43 percent from May 1999 to August 2001 (Figure 5-2; Friedman repeated measures ANOVA, $P < 0.001$). At the treatment plots, diffuse knapweed cover decreased significantly from 8 percent to less than 1 percent cover from May 1999 to August 2000 (Figure 5-2; Friedman repeated measures ANOVA, $P < 0.001$). However, in both spring and summer 2001, diffuse knapweed density increased slightly and was no longer statistically different from the original cover value in May 1999 (Figure 5-2; Friedman repeated measures ANOVA, $P > 0.05$). Diffuse knapweed frequency in the control plots did not change significantly from 1999 to 2001 (Figure 5-3; $P > 0.05$). In the treatment plots, however, the frequency of diffuse knapweed dropped significantly from 75 percent before treatment in 1999 to 5 percent in summer 2000 (Figure 5-3; McNemar test, $X^2 = 12.1$, $df = 1$, $P < 0.01$). By spring 2001, diffuse knapweed was increasing, but was still significantly lower than the original frequency in 1999 (Figure 5-3; McNemar test, $X^2 = 4.2$, $df = 1$, $P < 0.05$). By summer 2001, however, it was no longer significantly different from the original frequency (Figure 5-3; $P > 0.05$).

## 5.4 Discussion

The aerial herbicide application of Tordon22K® by helicopter has been shown to effectively control diffuse knapweed for two to three years at the study locations since the original application in May 1999. Diffuse knapweed cover dropped to less than 1 percent in the sprayed areas where monitoring was conducted. Additionally, diffuse knapweed frequency was significantly reduced in the sprayed areas. Qualitative observations elsewhere indicated similar success at most treatment areas on the xeric tallgrass prairie. At most of these locations, essentially no adult diffuse knapweed plants were observed in late summer 1999, except where small spots were missed. As a result, the annual seed set in these areas was reduced to near zero, and little spread of diffuse knapweed occurred from these areas because no adult plants were available to blow across the landscape. In 2000, the second year after application, quantitative data continued to show significantly less diffuse knapweed in the treatment plots compared to the control plots. However, qualitative observations near the study sites began to show that some diffuse knapweed was returning, largely in areas of missed flight lines and on burrow mounds disturbed by small mammals. In 2001, data from this study have shown that although diffuse knapweed cover in the treatment plots is still significantly less than the control plots, the frequency of diffuse knapweed has increased in the treatment plots and is no longer significantly lower than the control plots. It is likely that by 2002, diffuse knapweed cover will increase substantially because the higher frequency of diffuse knapweed observed in 2001 is largely from rosettes that will bolt and become adult plants in 2002. Thus an increase in frequency of diffuse knapweed, without a concurrent increase in cover, could be used as a trigger that signals the need for treatment the following year to prevent the production of adult seed producing plants. Mapping data from 2001 near the study plots also shows that diffuse knapweed is returning to the areas and will need additional control in the near future (see the chapter 1 in this annual report). In general, these data agree with data from a larger quantitative study conducted at the Site that has been evaluating the impacts of Tordon22K® on the native plants on the xeric tallgrass prairie at the Site (see the 2001 Monitoring Summary for Diffuse Knapweed Control Study in this annual report). The fact that diffuse knapweed is beginning to return more quickly than was originally intended is somewhat disheartening. Reapplication with Tordon22K® is not recommended so soon after the original application because of potential impacts to the native forb community that is still recovering from the first application. Reapplication with a more species-specific compound such as Transline® is possible, although costs are higher and reapplication on an annual basis is necessary. Although not unexpected, it is apparent that without the ability to conduct effective spot control along missed flightlines and on small mammal mounds where diffuse knapweed is a continual problem (sometimes within a year after treatment) repeated application on a large scale will be necessary to control the large infestations present at the Site. Integration with other techniques such as biocontrols that have been shown to be effective on Boulder County Open Space lands to the north of the Site (Seastedt 2001) are in progress now and, if these can be shown to be effective here at the Site, should reduce future reliance on herbicides alone as an effective control method. The use of prescribed fire in conjunction with herbicide applications in these areas may also help increase and prolong the effectiveness of such herbicide applications and improve the competitive ability of the native species.

## 5.5 Conclusions

In summary, the 1999 aerial herbicide application of Tordon22K® on the xeric tallgrass prairie at the Site has effectively controlled diffuse knapweed at the treatment study plots for two to three years. As a result, annual seed set at these locations has been dramatically reduced, and the chance of these infestations spreading from these treated areas greatly reduced, because fewer adult plants are available to tumble across the landscape. In 2001, diffuse knapweed has begun to return and increase at many of the treated locations and will require additional control efforts in the near future. Integration with other control techniques such as biocontrols that have been released at the Site could help reduce the long-term reliance on herbicides alone as an effective tool for managing the large infestations at the Site. Improvements will continue to be made in the management of diffuse knapweed at the Site, integrating chemical control with other methods, while proactively managing the Site's ecological resources.

## 5.6 References

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# 6. 2001 Diffuse Knapweed Biocontrol Monitoring Summary

## 6.1 Introduction

During 2001, a diffuse knapweed seedhead weevil (*Larinus minutus*), was released at six locations (Figure 6-1) at the Rocky Flats Environmental Technology Site (the Site) to help control diffuse knapweed (*Centaurea diffusa*) infestations at the Site. *Larinus minutus* has been shown to be an effective biocontrol agent when used in conjunction with other biocontrol insects at a research site located on Boulder County Open Space north of the Site (Seastedt et al. 2001). In order to evaluate the effectiveness of the biocontrol releases, a simple monitoring program was established using both qualitative and quantitative measures. This report summarizes the pre-release conditions at five of the release locations chosen for study.

Objectives of the study include:

1. Evaluate changes in pre- and post-treatment diffuse knapweed cover and density at the release locations.
2. Document visually, through photo-monitoring, changes in diffuse knapweed infestations at the release locations.

## 6.2 Methodology

At each of the five release locations chosen for monitoring (Figure 6-1), a total of ten 1-$m^2$ quadrats were randomly located. Within each of the quadrats the cover and density of diffuse knapweed was measured and recorded. Cover was visually estimated by cover class (1 = <5%; 2 = 6-25%; 3 = 26-50%; 4 = 51-75%; 5 = >75%). Cover was estimated using all plants that had a canopy within the quadrat frame, regardless of whether they were rooted within the quadrat frame. Diffuse knapweed density was counted and recorded as the number of adult, reproducing plants rooted within the quadrat frame. No counts of diffuse knapweed seedlings or rosettes were made.

Random locations were determined using random aspects and distances from the center flag at the release location. Distances consisted of whole numbers and were paced off from the center flag. At each release location, the maximum distance used did not exceed the boundaries of the knapweed infestation. Placement of the quadrat was done such that one side of the quadrat was approximately centered and perpendicular to the line paced from the center flag. Future sampling will be conducted using new random locations.

Photographs were taken in the four cardinal directions from the center flag and from a location looking back to the overall infestation in order to document visually the level of infestation.

## 6.3 Results and Discussion

A total of approximately 2185 *L. minutus* weevils were released at the Site during 2001. The total number of *L. minutus* insects released at each location is shown in Table 6-1. The high number released in the one Rock Creek drainage (Site LM6) are part of a study being conducted by Texas A&M University. No cover or density data were collected at LM6 as part of the on-Site monitoring because the Texas A&M researchers are collecting their own data at that location. The overall mean cover of diffuse knapweed plants at the five monitored release locations was 21.4% (Table 6-2, Figure 6-2). The overall mean density of adult plants at the release locations was 9.1 plants/$m^2$ (Table 6-2, Figure 6-2). The percent cover and density of diffuse knapweed plants at each release location is shown in Table 6-2 and Figure 6-2. Future monitoring will be conducted to evaluate the effectiveness of the biocontrols. Photo monitoring results



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showing the pre-release conditions at each release location can be found in the Appendices on the CD-ROM at the end of this report.

## 6.4 Conclusions

Approximately 2185 *L. minutus* insects were released at several locations across the Site during 2001 to assist in the control of diffuse knapweed. Monitoring was established to document the effectiveness of the control efforts over the next several years.

## 6.5 References

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# 7. Diffuse Knapweed Movement and Dispersal Investigation

## 7.1 Introduction

Diffuse knapweed (*Centaurea diffusa*) is an aggressive noxious weed that can disperse across large expanses of open land by tumbling during periods of high wind. The use of herbicides to control diffuse knapweed at the Rocky Flats Environmental Technology Site (the Site) have proven very effective at keeping seed production and the number of adult plants to a minimum in the areas sprayed. One of the problems with maintaining control, however, is that in addition to the fact that viable diffuse knapweed seed can exist in the seed bank for up to 10 years, off-site populations continue to spread new seed onto DOE property. Often new seed is spread into the areas that have been treated with herbicides thereby limiting the effectiveness of the control efforts. Some of the seed comes onto the Site from the mining operations to the west. Additionally, where no control has been conducted or less effective control has been achieved at some locations at the Site, diffuse knapweed plants continue to blow across the landscape throughout the winter months, further infesting new locations. In fall 2000, a study was designed to evaluate significance of diffuse knapweed movement at the Site. The following questions were proposed for investigation:

- What percentage of a diffuse knapweed infestation blows away each winter during the high winds at the Site?
- What are the average and maximum distances that diffuse knapweed plants are observed to move across the Site?
- What is the pattern of their movement and dispersal from their point of origin?
- What are the most common obstructions to diffuse knapweed movement?
- What recommendations for management can be made based on the results of this investigation?

## 7.2 Methodology

The study was conducted in the Buffer Zone at the Site during the winter of 2000-2001. Three locations were subjectively selected at the Site (Figure 7-1) on the basis that 1) they contained substantial numbers of diffuse knapweed plants, and 2) they were located in open areas that receive high winds throughout the winter months. At each location, adult plants were marked on October 17 and 18, 2000. Both larger and smaller stature plants were selected for marking. At each location plants were spray painted and tagged with different colored paint and flagging that uniquely identified their origin location (Figure 7-2). The inflorescence and stem of each plant was painted with brightly colored spray paint so that the plant was visible from a distance. Each plant stem also had a piece of colored flagging tied to the main stem, above the lowest branch. The combination of paint color and flagging color used as well as the number of plants marked at each location is shown in Table 7-1. Each plant was also labeled (on the flagging) with the site ID and a plant number. A total of 237 plants were marked at all three locations. The differences in the number of plants marked at each Site was determined by the number of plants that could be sprayed with the three cans of spray paint used at each location. The perimeter of the marked individuals at each location was located with a GPS unit. This information was added to the Site GIS.

Throughout the winter (2000-2001) monitoring was conducted to count the number of individuals remaining in the original marked populations and to locate missing individuals. Missing individuals were searched for in the surrounding areas (i.e., primarily downwind). As individuals were found their site ID and plant number was noted and their location marked on a map or recorded with a GPS unit. Monitoring was conducted in November 2000, and January, March, and April of 2001.

Data were summarized to determine the total number and percentage of plants that blew away from each site individually and also collectively. Mean and maximum distances traveled by the plants and plant movement distributions were determined using spatial data in the GIS. Distances were measured from a center point at each study plot.

In addition, counts of the number of diffuse knapweed plants caught in a north-south fence at the Site were made to determine the effectiveness of a fence for trapping diffuse knapweed plants. The fence used for the study was a 4-strand barbed wire fence with wooden fence posts spaced approximately 4.5 m (14.76 ft. apart. The number of plants caught in five sections (each section = 2.25 m [7.38 ft.] in length) were counted, averaged, and converted to the total number of plants captured per linear kilometer (and per mile) of fenceline.

## 7.3 Results

Of all the plants tagged in the plots (237; all sites combined), 132 (56%) blew away during the October 2000 to April 2001 time period (Table 7-2). Examined by individual plot, plot A lost 45% of its plants; plot B lost 52%, and plot C lost 70%, during this period (Table 7-2). The greatest period of movement occurred between November 2000 and January 2001 (Figure 7-3), when 34% of all tagged plants blew away. Individual plot losses were also highest during this same timeframe when plot A lost 32% of its plants, plot B lost 25%, and plot C lost 45%.

The maximum wind velocity (based on the Rocky Flats meteorological tower data [10m data]) during the study period was recorded on December 16, 2001 at approximately 134 kph (83 mph). A total of 28 days (15%) out of the 185 days in the study period (October 17, 2000 through April 19, 2001) had maximum wind velocities over 80 kph (50 mph). Examined by 15 minute timeframes, the total number of time periods that had maximum wind velocities exceeding 80 kph each month are shown in Figure 7-4. The month of December had the greatest number of high wind periods, which correlates well with when the greatest movement of diffuse knapweed plants occurred. Throughout the duration of the study the wind direction was primarily from the northwest.

The maximum distance that an individual diffuse knapweed plant was observed to have moved was approximately 1,480 m (4,857 feet; plot C; Table 7-3, Figure 7-5). The average distance that plants that blew away during the study period traveled was approximately 399 m (1,310 feet; Table 7-3, Figure 7-5). At individual plots, average diffuse knapweed movement was greatest at plot B (458 m; 1,501 feet) and least at plot C (334 m; 1,096 feet; Table 7-3, Figure 7-5). At all plots, the shortest maximum distance diffuse knapweed was observed to move was 1,120 m (3,676 feet; Plot B, Table 7-3, Figure 7-5). It should be noted that 30 percent (40 plants) of the plants that blew away were never relocated. So it is possible that some of these distances could be farther than these data show.

The pattern of diffuse knapweed movement from each of the three study plots is shown in Figure 7-6. In each case, the general pattern is more or less directly downwind from the origin location with relatively little lateral spread from the main axis. There was some slight variation from this at two of the plots. At plot A in Woman Creek, most plants blew straight down wind, but a couple plants actually ended up directly south of the plot. Because a ridgetop occurs between plot A and the location where the plants were found, they either blew south directly over the ridgetop or east to the end of the ridge and then back up the drainage. In Rock Creek, plot B was located on the northwest edge of the pediment top. Based on multiple data points for individual plants, the plants blew southeast across the pediment top until they dropped off the pediment edge at which point they then blew mostly eastward down the length of the drainage to end up at the locations where they were last found. This is consistent with the prevailing winds and the channeling effect of the terrain in the valleys below the pediment.

Many different obstacles stopped the diffuse knapweed plants as they moved across the landscape. Many plants were found at the bottom of embankments or ravines, and just beyond the pediment edges where, once the plants dropped over the edge, the wind velocity dropped. Other diffuse knapweed plants were found stuck in various plants that provided a rough or jagged surface in which the open, branched knapweed plants could become stuck. Common species that captured diffuse knapweed plants included Spanish bayonet (*Yucca glauca*), skunkbush sumac (*Rhus aromatica*), coyote willow (*Salix exigua*), and leadplant (*Amorpha nana*). No plants from this study were found stuck in fencelines, probably because few perpendicular fencelines were present downwind of the plots and those fencelines that were present were fallen down and/or in disrepair.

However, there is plenty of evidence from elsewhere at the Site to show that maintained fencelines can capture a great abundance of diffuse knapweed plants (Figure7-7). In spring 2001, the number of diffuse knapweed plants captured by a north-south fenceline (perpendicular to the general wind direction at the Site) were counted. The average number of plants captured by the fence was 119.73 plants per meter of fence. This equates to 119,733 plants per linear kilometer (192,651 plants per linear mile) of fence.

On the flat pediment tops or open hillsides there is very little to impede the diffuse knapweed plants and so they can travel substantial distances in a short period of time. Qualitative observations of diffuse knapweed plants moving across an open hillside in high winds in the south Buffer Zone, during the timeframe of this investigation, showed they could move approximately 762 m (2,500 feet; nearly a 1/2 mile) in a matter of a few minutes (Nelson 2000).

## 7.4 Discussion

Diffuse knapweed is a noxious weed that is highly adapted to conditions throughout the western United States and Canada (Sheley and Larson 1996). Individual plants produce high amounts of seed that remain in the seed heads until disturbance of the plant occurs. Disturbance typically occurs when the plants break off at ground level and tumble across the landscape, dispersing seed, during high winds (Sheley et al. 1998). At the Site, windy conditions are common during the winter months and diffuse knapweed is continually moved across the Site. This study evaluated the significance of this movement at the Site.

This study indicates that a substantial portion (56%) of the current year's on-site population of diffuse knapweed plants may be blown across the Site. The average distance these plants can move was shown to be approximately a quarter of a mile with the maximum distance observed at almost one mile. The pattern of movement in this study showed a prevailing downwind direction with plants often being caught in various obstacles. Given the scale and numbers in which these plants are capable of moving across the landscape, it is apparent that more traditional control efforts (mechanical, chemical, biological) must also include methods to prevent the movement of the species beyond current infestation locations. This is especially true where annual treatment of adult, seed producing plants is not possible due to the size of current infestations and associated costs. Additionally, treated areas must be protected from off-site immigration of seed dispersing plants to prevent continued addition of new seed, which effectively resets the seed bank clock.

Table 7-4 illustrates the significance of the problem of not controlling the movement of diffuse knapweed plants from infested areas. The fact that approximately 56% of the population of tagged diffuse knapweed plants blew away during the winter of 2000-2001 represents a significant amount of movement of this species across the Site. Results from another study to the north of the Site, on City of Boulder Open Space in 1997-1998, found that 16-21% of the diffuse knapweed plants blew away at that location (Beck and Rittenhouse 1999). Differences in wind speeds during each winter and topographic differences at the locations likely account for some of the differences observed in these studies. However, using the 2000 weed mapping data and monitoring data from quantitative studies at the Site, the significance of the problem of diffuse knapweed movement at the Site can be estimated (Table 7-4). The table outlines the initial assumptions and values used to calculate the total number of diffuse knapweed plants estimated to have moved across the Site during the winter of 2000-2001.

Based on this estimate, over 2.3 million diffuse knapweed plants moved at the Site this year alone. Combined with the fact that this study showed the average movement distance to be over 396m (1,300 feet; 1/4 mile) and a maximum distance of 1,480 m (4,857 feet; almost 1 mile), there is the potential for a very large amount of seed being distributed across large areas of the Site annually. Studies elsewhere have reported that individual diffuse knapweed plants can produce as much as 925 seeds/plant/year (FEIS 2001). Another study reported values for diffuse knapweed seed production ranging from 11,200 to 48,100 seeds/m$^2$ (Sheley et al. 1998). Unpublished data from the University of Colorado, Boulder, has shown that approximately 18% of seed produced by plants in one year was still present in the seedheads the following summer (Lindstrom and Seastedt 2001), suggesting that at a minimum, this amount of seed could have moved from its original location. Add to this the fact that some researchers believe it only takes from 0.1% to 10% of the seeds produced to maintain an existing diffuse knapweed population and the problem of movement becomes a huge obstacle when trying to control and contain existing infestation while preventing new infestations (Beck 1999; FEIS 2001).

Diffuse knapweed only reproduces by seed and one of the basic premises of diffuse knapweed control is that control efforts must reduce seed production. One of the problems faced at the Site is that although ground and aerial herbicide applications have been found to effectively control diffuse knapweed infestations for 2 to 4 years depending on the location (by preventing the development of adult, seed producing plants), immigration of seed from off-site locations continues to add new seed to the original seed bank at these locations. The use of biological and mechanical controls also helps reduce the amount of seed produced and added to the seed bank each year. But without a means to prevent the continual reintroduction of additional seed from off-site immigration (from off-site plants tumbling across the treated areas) or from on-site uncontrolled infestations, there is little hope of really gaining control and reducing the size of the infestations in the long-term.

At the Site, the general movement pattern of diffuse knapweed plants follows the wind patterns, which are generally west to east with some minor modifications resulting from topographic influence (Figure 7-6). This study suggests that there are numerous obstacles that can capture diffuse knapweed and prevent or at least slow its movement across the landscape. These obstacles include embankments, ravines, shrub and subshrub patches, and fences that capture the plants. However, many of these obstacles only occur in isolated patches or in insignificant amounts to have any real impact on the movement of diffuse knapweed across the Site. Fence counts of diffuse knapweed plants in spring 2001 at the Site have shown that substantial numbers of diffuse knapweed plants are captured by fences when they are in the appropriate positions. The suggestion has been made for several years that if fencing were strategically located in the Buffer Zone to capture plants, especially those coming from the mining operations on the western edge of the Site, we could prevent a major source of the constant reintroduction of seed onto the Site in areas that have been treated with herbicides. Additionally, if fencing were placed downwind of the highest density infestations at the Site, we could also more effectively prevent its movement into currently uninfested areas of the Site. The use of fencing would require the occasional removal of the collected diffuse knapweed plants and either burning or burying them. But used in conjunction with other control methods, a greater long-term effective control of this species at the Site would likely occur.

## 7.5 Conclusions

Diffuse knapweed movement (i.e., dispersal) is a major aspect of its control that is often overlooked and/or not integrated into management programs. Results of this study have shown that over half the plants in an infestation can become mobile and disperse during periods of high wind, resulting in the potential for significant movement of seed. Blocking the movement of individual diffuse knapweed plants from current infestations and from off-site locations with strategically located fencing could be an effective tool, in addition to current control measures, for reducing and controlling the diffuse knapweed problem at the Site.

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# 8. 2001 Small Mammal Mounds Vegetation Monitoring Summary

## 8.1 Introduction

The xeric tallgrass prairie is a relict grassland along the Front Range of Colorado. The Rocky Flats Environmental Technology Site (the Site) and City of Boulder Open Space and Mountain Parks Department own and manage the largest known remaining parcels of this plant community type in North America (CNHP 1995). Currently one of the greatest challenges for resource management of the xeric tallgrass prairie is the invasion of noxious weeds, in particular, diffuse knapweed (*Centaurea diffusa*). Using an integrated weed management program employing mechanical, biological, and chemical controls, substantial gains have been made in reducing the infestation levels of diffuse knapweed on the xeric tallgrass prairie at many locations at the Site. However, it has been observed that the hundreds of small mammal mounds that dot the xeric tallgrass prairie are a constant problem and source for renewed diffuse knapweed infestations, presumably because of their state of constant disturbance. In 2001, a study was conducted at the Site to evaluate the significance and role these small mammal mounds have with regard to noxious weed infestations and the native plant communities. The following questions were proposed for investigation:

- What is the density of small mammal mounds on the xeric tallgrass prairie?
- What percentage of the small mammal mounds are active?
- Does the species composition of the vegetation on the small mammal mounds differ from that of the surrounding intermound areas or between active and apparently non-active small mammal mounds?
- Are noxious weeds more abundant on the small mammal mounds compared to the surrounding intermound areas or between active and apparently non-active small mammal mounds?
- What effects do chemical herbicides have on the species composition and noxious weed abundance on the small mammal mounds?

## 8.2 Background

The study area is located on the Rocky Flats Alluvium, a glacial outwash fan, originating from Coal Creek canyon, southwest of the Site. The soil type on the gentle east sloping pediment tops is classified as the Flatirons very cobbly sandy loam (SCS 1980). The mounds themselves appear as circles on the prairie, varying from approximately 9-m to 18-m across and 15-cm to 20-cm in vertical height (Figure 8-1; Branson et al. 1965). The origin of the mounds on the Rocky Flats Alluvium has been under question for several decades. The mounds appear on the earliest aerial photographs of the Site (dated 1937). Branson et al. (1965) investigated the vegetation and soil characteristics of the mounds in an area southwest of the Site and concluded that although the mounds had been present for at least 100 years based on historic wagon trails in the area, they were still recently disturbed. He concluded that pocket gopher (*Thomomys talpoides*) activity was most likely the causative reason for the mounds. Other more recent theories for the mound origins revolve around the idea of historic prairie dog towns that were abandoned, taken over, and maintained by other burrowing small mammals (Murdock 2001). Small mammal trapping conducted within the study area and at nearby locations on the xeric tallgrass prairie at the Site during 2001 found deer mice (*Peromyscus maniculatus*), plains harvest mice (*Reithrodontomys montanus*), hispid pocket mice (*Chaetodipus hispidus*), western harvest mice (*Reithrodontomys megalotis*), prairie voles (*Microtus ochrogaster*), plains pocket mice (*Perognathus flavescens*), house mice (*Mus musculus*), and 13-lined groundsquirrels (*Spermophilus tridecemlineatus*), to be common inhabitants of the mound areas (K-H 2002).

## 8.3 Methods

The study was conducted in the south Buffer Zone (BZ) at the Site during 2001 (Figure 8-1). Within the boundaries of the study area, the location of every small mammal mound was flagged and located with GPS equipment. Each small mammal mound was classified as: active mounds - treated (i.e., with herbicides) and untreated, and non-active mounds - treated and untreated. Active mounds were identified as those with small mammal holes and/or recently disturbed soil present on the surface of the mound. Non-active mounds were those that had no evidence of recent small mammal use. Classification was done in the early spring before greenup, when the surface of the mounds was most visible. The treated and untreated mound classification was based on whether the mounds had received a herbicide application. This was possible because in 1999, when the area was treated by helicopter with Tordon22K®, portions of some flightlines were missed. Selection of mounds for the study was done randomly as follows. First, two exclusion areas were delineated within the overall study boundary where additional herbicide applications had been conducted in the past (Figure 8-1). All mounds that fell within these areas were excluded from selection for the actual study. Thus for this study all treated areas had received only the spring 1999 herbicide application of Tordon22K®. From the remaining small mammal mounds, 30 active-treated, 30 active-not treated, 30 not active-treated, and 30 not active-not treated mounds were randomly selected for sampling. Intermound areas were randomly selected in both treated and untreated areas using a randomization script in the ArcView® GIS software. The intermound areas are considered the "control plots" for the treated and untreated areas, with the untreated intermound areas representing the "control plot" for the entire study. Thirty treated-intermound locations and 30 untreated-intermound locations were selected. Thus a total of 120 small mammal mounds and 60 intermound areas were characterized. Notes were also made as to whether individual small mammal mounds had anthills present on them or not. The classification codes used for the tables and figures are as follows: TA = active treated, TI = treated intermound, TN = non active treated, UA = active untreated, UI = untreated intermound, UN = non active untreated.

The following assumptions are made for this study:

1. Prior to small mammal disturbance, the entire study area had a species composition like that of the untreated intermound areas. Thus the untreated intermound area is the control to which all the other classifications will be compared.
2. Treated classifications had a species composition like that of their untreated counterpart prior to herbicide application.

The vegetation fieldwork was conducted in July 2001. At each selected mound and intermound location a 2-m circle plot (1-m radius) was centered on the mound (Figure 8-2). Species richness and a visual estimate of cover for each species was recorded on datasheets for each plot. A visual estimate of cover was made using the following cover class system: 1 < 5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75, 5 = 76-100%.

Species richness data were summarized by generating species lists for each of the six small mammal mound classifications and calculating the mean number of species per plot for each classification. A Sorensen coefficient of similarity was used to assess the species richness similarity between the mound classifications (Brower and Zar 1977). Species frequency and cover were calculated from the cover data. Frequency based on the plots (n=30 per classification) was defined as the number of plots in which a species was recorded, divided by 30 (the total number of quadrats possible), multiplied by 100. Midpoints of cover classes were used for cover data analyses. The midpoints used were 1 = 2.5%, 2 = 15%, 3 = 37.5%, 4 = 62.5%, and 5 = 87.5%. Relative foliar cover was defined as the mean cover of a species (n=30) relative to the total cover of all species recorded per plot (i.e., the percent of total vegetative cover [100 percent] represented by the species). A Shannon-Weaver diversity index was used to calculate diversity for each mound classification and was conducted using the relative foliar cover data (Brower and Zar 1977). Statistical analysis of the results was conducted only when mean values were different enough to suggest a meaningful interpretation. Where normality, variance, and independence requirements were met, parametric tests were used to compare results; otherwise non-parametric tests were used. One way analysis of variance (ANOVA) or Kruskal-Wallace one way analysis of variance on ranks (KW) were used for most analyses. Occasionally a t-test was used for some analyses. Untreated data and treated data were analyzed separately except in cases where comparisons of untreated to treated areas were done. In the latter case all the data were analyzed together. A Bonferroni multiple comparison test was used to determine which classifications were different from each other after ANOVA tests. A Tukey multiple comparison test was used for the KW tests. Statistical analyses were conducted using a SigmaStat software package (SigmaStat 1997). A detrended correspondence analysis (DCA; PC-ORD 1999) ordination technique was used to evaluate the relationships between all treated and untreated active and non-active mounds, and intermound areas based on species abundance's.

## 8.4 Results

The study area encompassed approximately 28.3 hectares (70 acres). A total of 287 small mammal mounds were mapped initially and characterized prior to selection for the vegetation aspect of the study. The small mammal mound density in the study area was approximately 10 mounds/hectare (4 mounds/acre). Of these 287 mounds, 122 (43%) were active mounds and 165 (57%) were non-active mounds. Anthills were present on 61 (21%) of all the mounds with no preference for active or non-active mounds (occurring on 21% of either classification).

A total of 112 plant species (74% native) were recorded from all plots during this study. The greatest number of species was found on the untreated active mounds (75) while the treated intermound areas had the fewest species (58; Table 8-1). The untreated mounds, both active and non-active, had 13 and 11 species more, respectively, than the untreated intermound area (Table 8-1). The mean number of species per plot was significantly higher in untreated areas (15.5) compared to the treated areas (12.5; T-test, $t = 4.163$ $df = 178$, $P < 0.001$; Table 8-1). The non-active untreated mounds had the highest mean species richness (16.6 species/plot) while the active treated mounds had the lowest mean species richness (10.7 species/plot; Table 8-1). No statistically significant differences were observed in the mean number of species per plot between any of the untreated classifications ($P > 0.05$). In the treated areas, however, a significant difference in the mean number of species was observed only between the active treated mounds (10.7) and the non-active treated mounds (13.6; ANOVA, $F_{2,87} = 3.589$, $P < 0.05$; Table 8-1). The intermound areas in both the treated and untreated classifications had a slightly higher percentage of native species than the mounds in their respective categories (Table 8-1).

A Sorensen coefficient of similarity was used to compare species richness similarity between classifications. The untreated intermound areas (the control) were compared to each of the other classifications. The highest similarity for all comparisons was between the untreated intermound and treated intermound areas (0.83; Table 8-2). The next highest similarities were between the untreated intermound areas and the non-active untreated (0.73) and non-active treated mounds (0.75; Table 8-2). The lowest similarity was with the active mounds (both untreated [0.66] and treated [0.60]; Table 8-2).

Species diversity (Shannon-Weaver diversity index) was the highest on both the active untreated and non-active untreated mounds (1.277 and 1.274, respectively; Table 8-1). The untreated intermound area had slightly lower species diversity at 1.128 (Table 8-1). The species diversity was slightly lower in the treated areas for each of the respective classifications compared to the untreated areas (Table 8-1).

The species composition of the vegetation present on the different mound and intermound classifications varied substantially, dependent on the amount of disturbance and whether or not the area had been treated with the herbicide. Table 8-3 shows the frequency and foliar cover amounts for each species by mound and intermound classification. In the untreated areas, total forb cover was significantly higher on the active (33.8%) and non-active (39.8%) mounds compared to the intermound areas (15.8%; ANOVA, $F_{2,87} = 16.728$, $P < 0.001$; Table 8-3, Figure 8-3). Most of this difference was attributable to significantly higher amounts of non-native forb cover on the untreated mounds compared to the untreated intermound areas (Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 43.697$, $P < 0.001$;Table 8-3, Figure 8-3). Over 63% of the mound forb cover comes from non-native species while less than 20% of the intermound cover is from non-native forbs. Much of this difference was due to the significantly higher amounts of diffuse knapweed cover on the untreated mounds (active = 11.5%, non-active = 18.5%) compared to the untreated intermound areas (0.8%; Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 30.151$, $P < 0.001$; Table 8-3).

In areas treated with herbicides, both active and non-active mound total forb cover was significantly less by over 50% compared to their respective untreated mounds (Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 55.883$, $P < 0.001$; Table 8-3, Figure 8-3). Most of the lower forb cover was from significantly less non-native forb species cover (Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 86.143$, $P < 0.001$; Table 8-3, Figure 8-3) with much of this coming from significantly lower diffuse knapweed cover amounts (Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 73.058$, $P < 0.001$; Table 8-3). No significantly lower total forb cover or non-native forb cover was observed between the treated and untreated intermound areas ($P > 0.05$; Table 8-3, Figure 8-3). No significant difference in native forb cover was observed between the treated versus untreated classifications, with the exception of the active treated and active untreated mounds (Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 13.192$, $P < 0.05$; Table 8-3, Figure 8-3).

The frequencies of several Colorado state-listed noxious weeds are shown in Figure 8-4. Only data from the untreated classifications, where the species occurred in more than one plot (frequency value > 3.3%), are shown. In every case except one, the noxious weeds occurred in higher frequency on the mounds compared to the intermound areas (Figure 8-4). The most commonly occurring noxious weeds on the mounds are downy brome (*Bromus tectorum*), diffuse knapweed, Dalmatian toadflax (*Linaria dalmatica*), and Japanese brome (*Bromus japonicus*; Figure 8-4). The only noxious weed that occurred with a higher frequency on the intermound areas was St. John's-wort (*Hypericum perforatum*; Figure 8-4).

In the untreated areas, graminoid cover was significantly higher at the intermound areas (82.6%) compared to the active untreated mounds (63.9%) and non-active untreated mounds (58.9%; ANOVA, $F_{2,87} = 16.276$, $P < 0.001$; Table 8-3, Figure 8-5). In the treated areas, graminoid cover was significantly higher on the active and non-active mounds compared to their untreated counterparts (Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 56.941$, $P < 0.001$; Table 8-3, Figure 8-5). The higher graminoid cover in the treated areas, however, was largely from non-native graminoids (Table 8-3, Figure 8-5). On the active treated mounds, the increase came mostly from downy brome and Kentucky bluegrass (*Poa pratensis*; Table 8-3), both cool-season, non-native graminoids. On the non-active treated mounds, the increase was largely from Canada bluegrass (*Poa compressa*; Table 8-3), also a cool-season, non-native species.

Warm-season graminoid cover was significantly higher at the untreated intermound areas (21.0%) compared to the active untreated (3.3%) or non-active untreated mounds (4.8%; Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 39.510$, $P < 0.001$; Table 8-3, Figure 8-6). In the treated areas, warm-season graminoid cover was also significantly higher in the intermound area (28.3%) compared to the non-active mounds (9.1%), and active mounds (7.5%; Kruskal-Wallis One Way Analysis of Variance on Ranks, $H = 29.784$, $P < 0.001$; Table 8-3, Figure 8-6). Warm-season graminoid cover differences within classification type between untreated and treated areas were not significantly however ($P > 0.05$). Cool-season graminoid cover was not significantly different between the three untreated classifications ($P > 0.05$; Table 8-3, Figure 8-6). In the treated classifications, however, the both the active (77.2%) and non-active mounds (70.5%) had significantly higher cool-season graminoid cover than the intermound area (58.1%; ANOVA, $F_{2,87} = 8.100$, $P < 0.001$; Table 8-3, Figure 8-6).

The four dominant species for each of the mound and intermound classifications are presented in Table 8-4. The intermound areas (both untreated and treated) are dominated by Canada bluegrass, Kentucky bluegrass, big bluestem (*Andropogon gerardii*), and mountain muhly (*Muhlenbergia montana*). The small mammal mounds (both untreated and treated) are dominated largely by downy brome, Kentucky bluegrass, and Canada bluegrass. However, on the untreated small mammal mounds, diffuse knapweed is a dominant species on both the active and non-active mounds. On the treated small mammal mounds, diffuse knapweed cover dropped significantly and needle and threadgrass (*Stipa comata*) became a dominant species.

Evaluation of the species frequency data showed that several species have affinities for either the disturbed mounds or the undisturbed intermound areas. For this analysis, only the untreated mound and intermound frequency data were used (Table 8-3). A species was listed as having an affinity for disturbed areas if both the active untreated and non-active untreated mound frequency for a given species was at least 10% higher than that of the untreated intermound area. If the untreated intermound frequency for a species was at least 10% higher than both the active untreated and non-active untreated mound frequencies, then the species was listed as having an affinity for undisturbed areas (i.e. intermound areas). Table 8-5 lists the species with affinities towards disturbed areas and undisturbed areas. Of the species with affinities for undisturbed areas, 73% are graminoids, with 10 of 11 (91%) graminoids being native, perennial species. Seven of the 11 graminoids (64%) were warm-season species. Overall, 87% of the undisturbed affinity species are native species. Only 27% of the species with affinities for undisturbed areas were forbs. The opposite is the case for the disturbed areas where forbs account for 76% of the species. Graminoids only account for 24% of the species with affinities for disturbed areas and of these all were cool-season species (2 native, 2 non-native). No warm-season graminoids showed affinities towards disturbed areas. Overall, only 53% of the disturbed area affinity species were native.

A detrended correspondence analysis (DCA; an ordination technique) using species richness and cover data, was used to evaluate the relationship of the untreated intermound (control) areas to the active untreated and non-active untreated mounds. The unit of measure was each of the 90 plots that were sampled in the untreated areas. Figure 8-7 shows that the intermound plots segregated to the far right of axis 1, while the plots that were located on the small mammal mounds, regardless of whether they were active or non-active showed little separation based on overall species composition. Thus axis 1 is most likely a measure of disturbance, with the plots on the left side of the figure representing the greatest disturbance and least similarity in species composition, compared to the undisturbed intermound plots on the right side (Figure 8-7).

Because this analysis included all species present in each plot, and little separation between the mounds themselves was seen, two other DCA ordinations were conducted. One was done using only the four dominant species for each classification type listed in Table 8-4. All six classifications were used for this ordination. Figure 8-8 shows the results of this analysis. Using only the four species from each classification that provided the highest cover amounts, substantial separation of all the mounds and intermound areas becomes apparent. The intermound areas (untreated and treated) separate distinctly to the far left of the small mammal mounds. Additionally, distinct separation of the different classifications of small mammal mounds also occurs. Active mounds and non-active mounds become distinct with the non-active mounds most similar to the intermound areas. The effect of the herbicide applications also stands out with the treated active and non-active mounds shifting closer to the intermound areas on axis 1 while shifting away from the untreated active and non-active mounds on axis 2.

A third DCA was conducted using the complete species list and cover values for each of the six classifications. Results of this, shown in Figure 8-9, and look very much like that in Figure 8-8 with the exception of more separation along axis 2. In Figures 8-8 and 8-9, axis 1 seems to best describe a measure of disturbance with the least disturbed areas (the intermound areas) being on the left and most disturbed (active mounds) being on the right. Axis 2 seems related to the herbicide application and the resulting losses of non-native forb cover. The larger shift seen among the small mammal mound positions may be because of the much higher losses of non-native forb cover these areas experienced after treatment as compared to that at the intermound locations (Table 8-3, Figure 8-3).

## 8.5 Discussion

During 2001, a study was conducted at the Site to characterize the vegetation on the small mammal mounds commonly found on the xeric tallgrass prairie and evaluate the significance and role they play with respect to plant community composition and noxious weed infestations. While the nature and origin of the small mammal mounds on the Rocky Flats Alluvium is still uncertain, the impact these mounds have on the plant communities is not.

The plant communities on the small mammal mounds are distinct from that of the surrounding intermound areas. The various measures of species richness, species diversity, species similarity, species cover, and ordination results all show substantial differences in the species composition of the plant communities on the small mammal mounds compared to the intermound areas. Additionally, similarity indices and ordination results show that compositional differences also exist between the active and non-active mounds, with the active mounds being the least similar to the intermound areas. Disturbance and whether the mounds are still actively being disturbed and/or how long ago it stopped seems to account for most of the composition differences observed.

Two key differences in the species composition on the small mammal mounds are the lack of warm-season native perennial graminoid cover and the high abundance of non-native forbs. The lack of the warm-season graminoid species is particularly significant because many of these species (big bluestem, little bluestem [*Andropogon scoparius*], and mountain muhly) are the dominant species of the rare xeric tallgrass prairie community type. In addition, Indian grass (*Sorghastrum nutans*), side-oats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), other warm-season species, also had reduced frequency and cover on the small mammal mounds. So the presence of the small mammal mounds has limited the overall abundance of many of the dominant xeric tallgrass prairie species on the prairie. Qualitative observations from other locations at the Site, where projects have scraped off the surface soil, but not killed or removed the root systems of the tallgrass prairie plants, have shown that these native warm-season species will usually return in one or two seasons. However, in this case or others where the root systems of these native species have been destroyed and the soil profile has been altered, recovery times are much longer and it is questionable as to whether the native composition will ever return. The continued disturbance as seen on the small mammal mounds inhibits the return of these species and the native community.

Perhaps even more significant from a resource management standpoint however, is the role the mounds have today and will have in the future with respect to noxious weeds. Examination of the entire species list from the study Branson et al. (1965) conducted on the small mammal mounds in 1960 show only four non-native species listed, Japanese brome, downy brome, Kentucky bluegrass, and goat's beard (*Tragopogon dubius*). Of these, only downy brome (50%) and Kentucky bluegrass (1.5%) were reported for the mounds, with these two species providing 51.5% of the total foliar cover. This compares with 22 non-native forb species and six non-native graminoid species that were recorded on the small mammal mounds during this study and averaged approximately 64% of the cover on the untreated mounds (Table 8-3). Of the non-native species found on the mounds in 2001, 13 species are considered noxious weeds under Colorado state law (CRS 1996). Differences in methodology and/or climatic conditions at the time of the studies may account for some of the differences in the total numbers of species observed and resulting cover values between these studies. However, it does not seem unwarranted to suggest that the number and abundance of non-native species available for invasion into disturbed habitats is probably substantially higher in the region today than it was 40 years ago. Thus environmental factors are different now and although the Branson et al. (1965) data show the small mammal mounds dominated largely by a single non-native species, downy brome, today the disturbances present on the small mammal mounds provide habitat for a great diversity noxious forb and graminoid species.

In 2001, overall non-native forb cover is significantly higher on the untreated mounds by a factor of six to eight times when compared to the untreated intermound areas (Table 8-3, Figure 8-3). As a result, the small mammal mounds act as weed islands, in an otherwise generally undisturbed prairie matrix, allowing for the establishment and propagation of noxious weeds. The frequency of noxious weeds like downy brome, diffuse knapweed, Dalmatian toadflax, common mullein (*Verbascum thapsus*), Canada thistle (*Cirsium arvense*), and musk thistle (*Carduus nutans*), is much higher on the mounds than in the intermound areas (Figure 8-4). Qualitative observations and these data substantiate the fact that many of these noxious weeds first establish on the prairie where disturbance occurs (i.e., often on the small mammal mounds). The species establish and increase in abundance and then begin to spread into the surrounding undisturbed prairie. The significance of the problem with the small mammal mounds is magnified when one considers that these mounds occur across most of the xeric tallgrass prairie with mound densities averaging 10 mounds/hectare (4 mounds/acre). Thus if each of these mounds is a weed island, a disturbed area providing suitable conditions for noxious weed species establishment, instead of having perhaps a few larger patches or areas that need control, one now has hundreds of small infestations that each need control in order to prevent spread into the surrounding intermound areas. In addition, observations of areas at the Site where aerial herbicide applications have been made on the xeric tallgrass prairie, suggest that control is less effective and of shorter duration on the small mammal mounds than elsewhere on the prairie. Typically after an application of Tordon22K®, diffuse knapweed comes back within a year or two on the mounds while it takes three or four years for it to start returning substantially in the intermound areas. Thus a "blanket" control approach (i.e., spraying the entire prairie rather than just the individual mounds) is having only limited long-term success on the mounds.

Several challenges exist from a resource management standpoint. The data suggest that if the disturbance of the small mammal mounds were to be stopped there would be some return to a more native community on the mounds. Decades ago, natural succession to a more native community would have occurred more or less naturally, without any intervention. In today's environment however, given the invasive species present at the Site and on nearby lands, this is not as likely to occur without some help. This of course is all based on the invalid assumption that the disturbance from small mammals could be or is desired to be stopped. Since the small mammals presently active on these mounds are an integral part of the ecosystem, this is not a valid or practical solution.

Regarding the use of herbicides, the data show that after treatment, the non-native forb cover was reduced significantly on the small mammal mounds (Table 8-3, Figure 8-3). Cover of diffuse knapweed, the most abundant noxious weed on the mounds, was significantly reduced on the mounds (by >92% after treatment; Table 8-3). Thus with respect to the non-native forb component of the plant community on the mounds a substantial decrease occurred after the herbicide application. However, overall non-native cover did not significantly change on the mounds after treatment, because the non-native graminoid cover increased significantly (Table 8-3, Figure 8-5). Therefore, although the non-native forbs were reduced by the herbicide application, the non-native graminoids took advantage of the reduced competition and significantly increased in cover. No significant changes in non-native forb or non-native graminoid cover was observed at the intermound locations. (Table 8-3, Figures 8-3 and 8-5). So a problem exists on the mounds in that while the use of herbicides can reduce much of the non-native forb cover, it also tends to increase the non-native graminoid cover. The increase in non-native graminoid cover results largely because the native, warm-season species are not available in sufficient quantities on the mounds to be able to take advantage of the reduction in competition and effect a shift in species composition. Thus from the management goal of trying to preserve and sustain the native xeric tallgrass prairie, the use of herbicides alone on the mounds has not been very effective. Dominance by one group of non-native species has been exchanged for another.

Another alternative is to reseed the mounds with native species to increase competition with the non-native species. The fact that few of the native, warm-season perennial grasses occur on the mounds today suggests that reseeding with these species, given the continuing disturbance by small mammals, would likely fail. However, examination of the list of species that have affinities for the mounds reveals several native species that might be best suited for seeding. Needle and threadgrass and sun sedge (*Carex heliophila*), both native graminoids, were relatively common on the mounds (Tables 8-3 and 8-5). Several native forbs including western sagewort (*Artemesia campestris*), fringed sage (*Artemesia frigida*), hairy goldenaster (*Chrysopsis villosa*), green penstemon (*Penstemon virens*), wild alfalfa (*Psoralea tenuiflora*), and prairie coneflower (*Ratibida columnifera*), also showed affinity for the mounds (Table 8-5). Seeding with these species could help increase the cover of natives on the mounds and increase competition for the non-natives. Combined with more selective herbicide applications, this could help reduce the establishment and spread of non-natives on and from the small mammal mounds.

Biocontrol insects could also be released for those species that have biocontrols available. For diffuse knapweed in particular, several insects used in combination have been shown to be effective on Boulder County Open Space property to the north of the Site (Seastedt et al. 2001). Although these species have been released and are beginning to establish at the Site, to date most releases have been in the drainage bottoms where herbicide applications are impractical. Future releases should begin to focus on specific upland areas, and if used in conjunction with reseeding efforts, could eventually help to shift the species composition of the mounds to a more native plant community.

The lack of warm-season native graminoid cover and the high amount of forb cover on the small mammal mounds may also be indicative of higher nitrogen levels on the mounds compared to the intermound areas. Nitrogen additions to native prairies have previously been shown to decrease warm-season graminoid abundance while increasing cool-season graminoid cover and overall forb cover (Gillen et al. 1987, Rauzi

1979, Wight 1976, Morghan and Seastedt 1999). Recent studies have suggested that nitrogen levels in native ecosystems in Colorado and across much of the country are increasing as a result of human activities (atmospheric deposition, lack of fire, cattle grazing) and these increases may be responsible for the noxious weed problems we are increasingly facing (Baron et al. 2000, Lee and Caporn 1998, LeJuence and Seastedt 2001, SERG 2002). Perhaps higher nitrogen levels, the lack of fire, and the constant disturbance are preventing the warm-season, perennial graminoid species from establishing on the mounds.

Data from other monitoring efforts on the xeric tallgrass prairie at the Site have documented the high cover amounts of non-native, cool-season graminoids and have suggested the use of fire to reduce the presence of these species (DOE 1995; K-H 1998; K-H 2001). In spring 2000, a small prescribed fire was used on the xeric tallgrass prairie in the south Buffer Zone at the Site. Monitoring results from this study showed that in the summer following the fire the warm-season graminoid cover (all native species) had increased significantly while the cool-season graminoid cover (80% from non-native species) had decreased significantly (K-H 2001). The fire shifted dominance in the community from cool-season dominated to warm-season dominated. Prescribed fire is an important tool for management of the xeric tallgrass prairie and can be used to decrease the abundance of non-native graminoids. Its use should be continued were feasible to further enhance conditions for the desired species.

## 8.6 Conclusions

The small mammal mounds on the xeric tallgrass prairie at the Site have a distinctly different plant community composition than that of the intermound areas. The mounds are generally devoid of the native, warm-season, perennial graminoid species that are common in the intermound areas. Instead they are dominated by non-native, cool-season forb and graminoid species. The mounds are in effect "weed islands" on the prairie and noxious weeds such as diffuse knapweed, Dalmatian toadflax, and downy brome, all occur with much higher frequency on the mounds than on the intermound areas. The high density of mounds on the prairie creates challenge for resource management because each individual mound requires management. The long-term preservation and sustainability of the native xeric tallgrass prairie that exists between the mounds will require some innovative management given the presence and abundance of noxious weeds that are available to colonize the mounds in today's regional environment. Management will need to integrate a variety of management tools including reseeding, biocontrol releases, chemical control, and prescribed fire.

## 8.7 References

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# 9. 2001 Landfill Revegetation Monitoring Summary

## 9.1 Purpose

Monitoring was conducted during fall 2001 to evaluate the revegetation efforts on the landfill cover at the Rocky Flats Environmental Technology Site. The study was conducted as part of a project that was evaluating methane at the landfill. The goal was to quantify the vegetation composition and qualitatively assess the condition of the vegetation on the landfill cover.

## 9.2 Background Information

The landfill cover was seeded with native species in spring 1998 (Table 9-1). In May 1999, the landfill cover was sprayed with Tordon22K® by helicopter to control the noxious weed diffuse knapweed (*Centaurea diffusa*) that was becoming a problem on the cover.

## 9.3 Methods

In late September 2001, species composition was measured on the landfill cover using a point-intercept methodology. A total of five 50-m transects were monitored (Figure 9-1). The transects were located parallel to two methane sampling transects that were established on top of the cover. Three were located parallel to the E-W transect and two were located along the N-S transect. Endpoints of all transects were recorded using global positioning system (GPS) equipment for entry into the Site geographic information system (GIS).

Basal cover and foliar cover were estimated using a point-intercept method along each 50-m transect. A 2-m-long, 6-mm-diameter rod was dropped vertically at 50-cm intervals along the length of the transect to record a total of 100 intercept points. Two categories of hits were reorded, basal and foliar. Basal cover hits were recorded based on what material was hit by the rod at the ground surface. Hits could be vegetation (live plants), litter (fallen dead material), rock (pebbles and cobbles greater than the rod diameter), bare ground, or water, in that order of priority based on the protection from erosion provided by each type of cover. Vegetation hits were identified to species. Basal vegetation hits were recorded only if the rod was touching the stem or crown of the plant where the plant entered the ground. Foliar vegetation hits (defined as a portion of a plant touching the rod) were recorded by species in three categories as defined by height and growth form. The topmost hit of each growth form was recorded. The growth forms measured were herbaceous, woody <2 m in height, and woody >2 m in height.

Additionally, a single photograph was taken of each transect to visually document the condition of the transects. Photographs were taken from near the 0-m end of the transect looking toward the 50-m endpoint. A placard was placed in the photograph against the 0-m endpoint to provide the site and transect number, and date.

For more detailed information on these methods see, the *Ecological Monitoring Program, Final Program Plan* (DOE 1993), the *Environmental Management Operating Procedures Manual, Volume V, Ecology, 5-51200-OPS-EE* (DOE 1995).

Cover data were summarized for both basal and foliar cover by combining the data from the five transects. Basal cover data are reported as total percent cover of vegetation, litter, rock, and bare ground. Foliar cover data are reported as frequency, absolute cover, and relative cover for each species encountered. Frequency from the cover data was defined as the percent of point-intercept transects on which a species occurred, out of the total possible five sampled at each site. Absolute foliar cover was the percentage of the number of hits on a species out of the total number of hits possible at a site (500). This value is the actual cover of a species. Relative foliar cover was the number of hits a species had relative to the total number of vegetative hits recorded per site (i.e., the percent of total vegetative cover [100 percent] represented by the species). Both absolute and relative foliar cover values are presented as means. A Shannon-Weaver diversity index (Brower and Zar 1977) was used to estimate diversity for each dataset and was calculated using the relative foliar cover data. Data are compared to previously sampled native grassland locations in the Buffer Zone at the Site.

## 9.4 Results

A total of 25 species were recorded at LF1 (the landfill monitoring site name) in 2001. Of these, 56 percent were native species. Total vegetation foliar cover at LF1 is 71.2 percent (Table 9-2). Basal or ground cover on the landfill cover is dominated by rock (41.2 percent), litter (28.6 percent), bare ground (23 percent), and vegetation (7.2 percent). The vegetation on the landfill cover is dominated by graminoid species that comprise approximately 92 percent of the total relative foliar cover. The dominant plant species are blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), buffalo grass (*Buchloe dactlyoides*), and side-oats grama (*Bouteloua curtipendula*; Table 9-2), all of which are native, perennial grass species. Total relative native species cover on the landfill cover is approximately 89 percent with 85 percent of this coming from native grasses (Table 9-2). Graminoid cover was dominated by warm-season species which comprise approximately 74 percent of the total relative foliar cover (Table 9-2). Approximately 18 percent of the total foliar cover comes from cool-season graminoids. Forbs account for only approximately 8 percent of the total foliar cover. A Shannon-Weaver diversity index value of 0.88 was calculated from the relative foliar cover data.

## 9.5 Discussion

Vegetation monitoring of the landfill cover was conducted to evaluate the condition of the revegetation efforts that were begun in 1998 and to provide information on the vegetation composition for a methane study on the landfill cover. The vegetation on the landfill cover in 2001 is predominantly native, warm-season, perennial, graminoid species. It is dominated by blue grama (which accounts for almost half the total relative foliar cover [46.6 percent]) on the cover), western wheatgrass, buffalo grass, and side-oats grama, all of which were planted species in the seed mix (Table 9-2). Other seeded species that accounted for smaller cover amounts included big bluestem (*Andropogon gerardii*) and little bluestem (*Andropogon scoparius*; Table 9-2). Compared to native plant communities at the Site, the vegetation on the landfill cover has the greatest similarity to that of the mesic mixed grassland, the dominant native grassland community at the Site (K-H 2001). The health and vigor of these grasses on the landfill cover is very good, as indicated by the size of the plants and amount of flowering observed during sampling. No sign of chlorosis or wilting was observed. Although total vegetation cover on the cover is approximately 15-20 percent below that of the native grasslands in an average year (K-H 2001), the plants have begun to spread and fill in the spaces between the initial seeding rows. Thus overall vegetation cover should increase over the next few years. From a revegetation standpoint, however, the vegetation on the landfill cover is already a success because the amount of native species cover is already equal to or greater than that found on the native grasslands. In addition, weeds are not currently a major component of the landfill cover vegetation. The success of this effort goes far beyond that found at most other revegetation efforts undertaken at the Site in recent years.

Species diversity on the landfill cover is still somewhat low (Shannon-Weaver index = 0.880) compared to the native mesic mixed grassland which in 2000 ranged in diversity from 0.984 to 1.276 at three different locations. However, the lower diversity is not unexpected given that only one forb species was in the seed mix planted on the landfill cover and considering that the landfill cover was also sprayed with Tordon22K®, a broadleaf herbicide, used to control diffuse knapweed, in 1999. Eventually more forbs may immigrate onto the cover, increasing diversity. Currently noxious weeds, mainly diffuse knapweed, were only noticed at a few spotty locations.

Ground cover on the landfill cover is dominated by rock (41.2 percent). The amount of rock and bare ground (23 percent) cover combined (64.2 percent) is considerably higher than that found in the native mesic mixed grassland community at the Site. In 2000, at three locations on the mesic mixed grassland, rock cover ranged from 8.4 to 23 percent while bare ground cover varied from 2.6 to 9.2 percent. Much of this is due to the low level of litter cover currently present on the landfill cover (28.6 percent), which is far below that on the native mesic mixed grass prairie (64 to 79 percent in 2000). Because unvegetated areas still exist between many of the individual plants and the revegetation effort is only three years old, only a small amount of dead plant litter has built up on the ground surface. This will change as the vegetation continues to grow, produce litter, and expand into the spaces between the plants.

Currently, numerous rocky/barren spots are present at various locations on the landfill cover, particularly near the crown of the cover and on the windward side of the cover. Vegetation is sparse at these locations. Many of these locations are similar in landscape position to rocky/barren spots that can be found on the native grasslands at the Site. It is likely that at these locations on the landfill cover, the original seed that was planted, as well as the mulch and many of the fines in the soil, were blown away by high winds common during winters at the Site. Thus many of these areas have a desert pavement type appearance because of the pebbles left behind. These areas may fill in with plants in time, if left on their own or they may need to be reseeded and more heavily mulched if the barren spots are a problem from a landfill management standpoint. Weed control will continue to be necessary in the future to allow the native species to continue to thrive and expand, creating a more solid stand of vegetation on the cover.

Patches of taller vegetation are also visible on the landfill cover at some locations. Most of these patches run generally N-S in direction. In the areas adjacent to the methane transects, these patches were mapped using a GPS unit and are shown in Figure 9-1. Two classifications of these patches are distinguished based on the general species composition. All of the patches with the exception of the most eastern one had obviously been planted with the native species in the seed mix. However, the most eastern patch appears not to have been planted at all. Evidence for this is based on the fact that none of the native species planted everywhere else are present in any quantity in this area. In addition, the ground surface in this area is very rough and littered with large pieces of concrete that would have made drill seeding the area practically impossible. In the planted patches, however, the vegetation composition contains a higher component of taller growing native plant species, such as big bluestem, little bluestem, and side-oats grama, along with taller weed species such as yellow and white sweet clover (*Melilotus officinale* and *Melilotus alba*). Hence these areas appear taller and therefore perhaps, at least to the untrained eye, healthier. In reality however, the species composition is what accounts for the taller vegetation compared to the areas in between these patches that are dominated largely by blue grama and buffalo grass, both short-stature grasses. Possible explanations for these patterns may be uneven seed distribution during the drill seeding process, microclimate differences related to germination and establishment success, water availability, soil structure, nutrient availability, or wind.

The rooting depth of some of the plants was observed at four holes dug for soil samples on the landfill cover. The maximum depth to which roots were observed at these holes was approximately 30 cm (12 in), with most being observed within the top 15 cm or so. It is likely that the plant roots actually go deeper than this, but at most of the holes it was rare to find a plant growing right at the edge of the hole. Based on studies done elsewhere, many of the seeded native species growing on the cover can have roots that go down as much as two or three meters (Table 9-3).

## 9.6 Conclusions

The vegetation found growing on the landfill cover during 2001 is dominated by native, warm-season, perennial, graminoid species. The vegetation appears healthy and thriving based on the size of the plants and the flowering observed during the monitoring fieldwork. Although rock and bare ground cover remains higher than that found on the native grassland, the native species are filling in the spaces between the seeding rows and should in time form a solid stand of vegetation across most of the cover. Weed control will continue to be necessary to keep competition from noxious weeds low and allow the native species to expand their range. Thus far these results suggest a very successful revegetation project.

## 9.7 References

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# 10. Prescribed Burn Monitoring Summary

## 10.1 Purpose

Prescribed burning is an important tool for native grassland management. To maintain the health and vigor of the native plant species, reduce plant litter and the potential for wildfire, recycle nutrients, and help with weed control, the use of prescribed burns has been proposed to help manage the grassland communities at the Rocky Flats Environmental Technology Site (Site). As with all land management actions, monitoring is an integral part of determining whether the management objectives and goals for a particular management technique are being achieved. On April 6, 2000, a 48 acre prescribed burn was conducted by the U.S. Forest Service on the xeric tallgrass prairie in the south Buffer Zone at the Site. To evaluate the effect of the prescribed burn on the plant community, a quantitative monitoring program was instituted in the summer of 1999 to provide pre-burn data. After the fire, monitoring was conducted in summer 2000 and 2001 to gather post-fire data.

The following general questions were proposed for investigation:

1. How will a prescribed burn affect the species richness and species diversity of the xeric tallgrass prairie?

2. What impact will a prescribed burn have on the foliar cover of the xeric tallgrass prairie? Specifically, what impact is there to the following categories of foliar cover: overall cover, native cover, non-native cover, forb cover, overall graminoid cover, warm-season graminoid cover, and cool-season graminoid cover?

3. What impact will a prescribed burn have on the frequency of individual plant species on the xeric tallgrass prairie?

4. What impact will a prescribed burn have on specific weed species?

5. How much litter biomass will be removed during a prescribed burn?

6. How does the fire response of the xeric tallgrass prairie at the Site compare to other locations of the tallgrass prairie?

7. What recommendations can be made with regard to the use of prescribed burns for management of the xeric tallgrass prairie at the Site?

This report summarizes the 1999, 2000, and 2001 pre- and post-burn data.

## 10.2 Methods

The xeric tallgrass prairie at the Site is located primarily on the pediment, which is underlain by Rocky Flats Alluvium (SCS 1980). The soils are classified as Flatirons very cobbly sandy loams (SCS 1980). Historically the 48 acre burn area had not been grazed since the early 1950's and the unburned monitoring plot locations had not been grazed since the early 1970's. Both the unburned and burned areas have had little human influence or activity over the past 25 to 50 years. However, a year prior to the burn, in May 1999, the unburned and burned locations were sprayed by helicopter with Tordon22K® (application rate = 1 pint/acre) to help control the noxious weed diffuse knapweed (*Centaurea diffusa*) and other noxious weed species.

During 1999, a monitoring program was developed and initiated to provide quantitative pre-burn and post-burn information to help answer the questions listed above. A stratified, random sampling design was used. Initially, six plots—three control (no burn), and three treatment (burned)—were chosen for monitoring the response of the Site's xeric tallgrass prairie to the prescribed burn (Figure 10-1).

The no burn plots selected were BC1, BC2, and TR01. Plots BC1 and TR01 were pre-existing sites that had been used previously for other quantitative monitoring. BC2 was set out specifically for this study as a third replicate. The burn plots were BT1, BT2, and BT3. Sites BT1 and BT2 were also pre-existing plots used for other monitoring, and BT3 was set out specifically for this study to provide a third replicate burned site. At each plot, a total of five randomly located 50-m transects were sampled. Pre-burn sampling was conducted from September 9 through 24, 1999. The decision to conduct a controlled burn was made at a time that precluded collecting any spring pre-burn data. Thus, the study evaluates only the late-summer effects on the prairie. The study design was modified in spring 2000, because the actual prescribed burn was not conducted over the entire area originally scheduled to be burned. Only plots BT1 and BT2 were actually burned. Plot BT3 was not burned. Therefore data were summarized by combining the data from two of the three no burn plots (BC1 and TR01) and two of the three burn plots (BT1 and BT2), respectively. Plot TR01 was chosen over plot BC2 because it was more similar to plots BC1, BT1, and BT2. In 2000, post-burn monitoring data was gathered throughout the summer using qualitative photographs and quantitative measurements from September 5 through 21, 2000. In 2001, monitoring was conducted from September 4 through 18.

Species richness, cover, and frequency were measured at each of the 50-m transects. Species richness was determined in a 2-m-wide belt centered along the length of each 50-m transect. Every plant species rooted within the 100-$m^2$ area was recorded. In addition, the number of woody plant stems and cactus stems were counted for the 100-$m^2$ area and recorded. Basal cover and foliar cover estimates were made using a point-intercept method along each of the 50-m transects. A 2-m-long rod, with a 6-mm diameter, was dropped vertically at 50-cm increments along the transect to record a total of 100 intercept points. Two categories of hits were recorded, basal and foliar. Basal cover hits indicated what material the rod contacted at the ground surface. Hits could be vegetation (live plants), litter (fallen dead material), rock (pebbles and cobbles that were greater than the rod diameter), bare ground, or water, in that order of priority based on the protection from erosion provided by each type of cover. Basal vegetation hits were recorded by species only if the rod was touching the stem or crown of the plant where the plant entered the ground. Foliar vegetation hits (defined as a portion of a plant touching the rod) were recorded by species in three categories as defined by height and growth form. The topmost hit of each growth form was recorded. The growth forms measured were herbaceous, woody <2-m in height, and woody >2-m in height. Frequency information by species was gathered by randomly locating five 1-$m^2$ quadrats along each of the 50-m transects (total of 25 quadrats/site) and recording all species present in each plot. Density stem counts for diffuse knapweed were also made using these same quadrats. No distinctions were made during counts to differentiate seedlings, rosettes, or adult plants.

Biomass sampling was conducted on different transects than those described above in order to prevent disturbance of those transects. Sampling was conducted along a single transect in the burn area and another transect outside the burn area. Five randomly located 0.25-$m^2$ quadrats were located along the right-hand side of each transect. Vegetation was clipped and sorted as current year live or litter and placed into separately labeled paper bags. Bags were dried in an oven at 65$^{\circ}$ C until no further weight loss was observed and then the vegetation weight was recorded. More detailed summaries of these specific methods are found in the *Environmental Monitoring Department Operating Procedures Manual* (DOE 1995), the *High-Value Vegetation Survey Plan for the Rocky Flats Environmental Technology Site* (K-H 1997), and the *Ecological Field Monitoring Plans for the Rocky Flats Environmental Technology Site* (K-H 1999a, 2000a, 2001a).

Photographs were taken before and after the burn to document the recovery of the vegetation on the prairie in 1999, 2000, and 2001. A photograph was taken of each transect during the sampling session to visually document the condition of the transect. Photographs were taken from near the 0-m end of the transect near the permanent marker, looking toward the 50-m endpoint. A placard was placed against the 0-m endpoint to provide the site and transect number, and date in the photograph. Photographs were taken with a digital camera with the lens set at approximately the 50 mm setting. Additional photographs were also taken looking straight down on the grassland along the transects in the area that burned. Each of these photographs was taken of a quadrat (1-m x 0.5-m) placed at the 50-m end of the transect and aligned north-south, with the 50-m stake at the southwest corner of the quadrat. The photographs were taken with the digital camera centered over the middle of the quadrat at eye level (approximately 1.5-m). A total of 10 quadrats (one at each transect) were photographed during each photography session. The lens was set at the 35 mm setting. Photographs were taken from the north side facing south so that the permanent stake was in the upper right hand corner of the photograph. A placard was placed in the photoplot to provide the site and transect number, and date.

Species richness data were summarized by generating a species list for the unburned and burned locations. In addition, other species richness variables were calculated from the species lists. A Sorensen coefficient of similarity was used to assess the species richness similarity between the no burn and burn data (Brower and Zar 1977). Basal cover data were reported as total percent cover of vegetation, litter, rock, and bare ground. Foliar cover data were reported as frequency, absolute cover, and relative cover for each species encountered. Frequency from the cover data was defined as the percent of point-intercept transects in which a species occurred, out of the total 10 possible. Absolute foliar cover was the percentage of the number of hits on a species out of the total number of hits possible (1000). This value is the actual cover of a species. Relative foliar cover was the number of hits on a species relative to the total number of vegetative hits recorded (i.e., the percent of total vegetative cover [100 percent] represented by the species). A Shannon-Weaver diversity index was used to calculate diversity based on the relative foliar cover data (Brower and Zar 1977). Frequency based on quadrats (n=50; 2 transects× 25 quadrats each) was defined as the number of quadrats in which a species was recorded, divided by 50 (the total number of quadrats possible), multiplied by 100. Density count data were summarized as the mean number of stems per square meter. Biomass data were summarized as the mean litter, current year live, and total biomass (litter and current year live combined).

Statistical analysis of the results was conducted only when mean values were different enough to suggest a meaningful interpretation. Where normality, variance, and dependence requirements were met, parametric tests were used to compare results. Nonparametric tests were used for all analyses where normality, variance, and independence requirements were not met. All tests were done using SigmaStat Version 2.03. Independent samples (i.e., the unburned and burned plots) were compared using t-tests or Mann-Whitney U tests (SigmaStat 1997; Fowler and Cohen 1990; Sheskin 1997). Dependent sample comparisons (i.e., within treatment over time) were done using One Way Repeated Measure ANOVA, paired t-tests or Wilcoxon's test for matched pairs (SigmaStat 1997; Fowler and Cohen 1990; Sheskin 1997). A Bonferroni t-test multiple comparison test (multiple comparisons versus a control) to detect differences within treatments over time. The control used for the Bonferroni t-tests was the 1999 data within the treatment being analyzed (i.e., 2000 and 2001 data were compared back to the 1999 data).

## 10.3 Results

Species richness from 1999 through 2001 is summarized in Table 10-1. In 1999, the unburned plots had a total of 66 species, and the burned plots had 73 species. In 2000, both the unburned and burned plots showed an increase of six species to 72 and 79 species, respectively. By 2001, species richness in the unburned and burned plots had continued to increase to 84 and 85 species, respectively. A Sorensen coefficient of similarity index showed a high similarity in species richness within the unburned (0.84) and burned plots (0.84) from 1999 to 2001. Comparing the unburned plots to the burned plots, species similarity has increased slightly from 1999 (0.76) to 2001 (0.79). The percentage of native species decreased by five percent in the unburned plots and increased by one percent in the burned plots during the same time period. The mean number of species per quadrat in the burned plots increased significantly from 1999 to 2001 (10.6 to 12.9 species/quadrat; paired t-test, $t = 6.379$, 49 df, $P < 0.001$; Figure 10-2) while the unburned plots showed no significant change ($P > 0.05$). Shannon-Weaver diversity indices were calculated using the relative cover data. In the unburned plots, diversity increased from 1.068 in 1999 to 1.106 in 2001, with a slight dip in 2000 (1.036). In the burned plots, diversity increased from 0.931 in 1999, to 0.963 in 2000, to 0.998 in 2001.

Cactus densities were higher in the burned areas than in the unburned areas (Table 10-2). Twistspine prickly pear (*Opuntia macorhiza*) density declined significantly in both the unburned and burned areas from 1999 to 2001 (unburned: One Way Repeated Measures ANOVA, $F = 19.604$, $P < 0.001$; burned: One Way Repeated Measures ANOVA, $F = 78.837$, $P < 0.001$). Declines in hedgehog cacti (*Echinocereous viridiflorus*) density were only statistically significant in the burned plots for the same time period (One Way Repeated Measures ANOVA, $F = 11.697$, $P < 0.001$).

Vegetation cover data are summarized in Tables 10-3 and 10-4. Total foliar vegetation cover increased significantly from 79.2 to 85.1 percent in the unburned plots from 1999 to 2001 (One Way Repeated Measures ANOVA, $F = 27.564$, $P < 0.001$) and from 77.2 to 83.9 percent in the burned areas during the same timeframe (One Way Repeated Measures ANOVA, $F = 12.916$, $P < 0.001$; Figure 3). In 2000, both the unburned and burned plots showed small declines of approximately 2.5 percent. Of the total vegetation cover, more than 90 percent (relative cover) has been provided by graminoids at both the unburned and burned locations from 1999 to 2001. Changes in total absolute graminoid cover in both the unburned and burned plots were not significantly different from 1999 to 2001 ($P > 0.05$; Figure 10-4). Three graminoid species—big bluestem (*Andropogon gerardii*), Canada bluegrass (*Poa compressa*), and mountain muhly (*Muhlenbergia montana*)—dominated the vegetative cover at both the unburned and burned locations (Tables 10-3 and 10-4). Only the order of dominance of these three species differed between the unburned and burned areas. At the unburned plots, absolute cool-season graminoid cover and absolute warm-season graminoid cover did not change significantly from 1999 to 2001 ($P > 0.05$; Figure 10-5). In the burned plots however, absolute cool-season graminoid cover decreased significantly in 2000 after the prescribed fire, but by 2001 had rebounded to near pre-fire levels (One Way Repeated Measures ANOVA, $F = 4.310$, $P < 0.05$). Absolute warm-season graminoid cover did not change significantly in the burned plots from 1999 to 2001 ($P > 0.05$). Warm-season versus cool-season graminoid cover shifted in the burned plot from cool-season dominated before the prescribed fire to warm-season dominated in 2000 after the fire. However, in 2001, the burned area had shifted back to cool-season dominated.

In the burned plots, absolute native cover increased significantly by almost 8 percent from 1999 to 2001 after the fire (from 44.6 to 52.2; Figure 10-6; One Way Repeated Measures ANOVA, $F = 10.947$, $P < 0.001$) while not changing significantly in the unburned plots ($P > 0.05$). Absolute non-native cover in the burned plot dropped significantly in 2000 after the fire but was no longer significantly different from pre-fire levels by 2001 (One Way Repeated Measures ANOVA, $F = 7.456$, $P < 0.05$). Absolute non-native cover in the unburned plots did not change significantly during the same time period ($P > 0.05$). The absolute forb cover response in the unburned and burned plots essentially paralleled one another from 1999 to 2001 (Figure 10-7) with significant increases in both from 1999 to 2001 (Unburned: One Way Repeated Measures ANOVA, $F = 9.586$, $P < 0.001$; Burned: One Way Repeated Measures ANOVA, $F = 12.717$, $P < 0.001$).

Ground cover was dominated in both the unburned and burned plots by litter (Figure 10-8). In 2000, the year after the prescribed burn, litter cover decreased significantly in the burned plots - by 7.2 percent - (One Way Repeated Measures ANOVA, $F = 10.498$, $P < 0.001$). However, by summer 2001, litter cover (not biomass) had returned to pre-burn levels. In the unburned plots litter cover increased significantly by 5.7 percent from 1999 to 2000 (One Way Repeated Measures ANOVA, $F = 5.055$, $P < 0.05$), before returning to 1999 levels in 2001. Rock cover increased significantly in the burned plot after the fire and continues at significantly higher amounts than pre-burn cover 2 years after the burn (One Way Repeated Measures ANOVA, $F = 5.436$, $P < 0.05$; Figure 10-9). No change was observed in rock cover in the unburned plots ($P > 0.05$). Bare ground cover increased significantly for only one year after the burn before returning to pre-burn levels (One Way Repeated Measures ANOVA, $F = 18.931$, $P < 0.001$; Figure 10-9). At the unburned plots, bare ground cover declined significantly in 2000 and 2001 compared to 1999 (One Way Repeated Measures ANOVA, $F = 6.250$, $P < 0.01$; Figure 10-9).

Overall biomass on the grassland (combined current year live and litter) was significantly reduced in the burned area as a result of the prescribed burn from approximately 465 grams/$m^2$ (4,152 lbs/acre) to 124 grams/$m^2$ (1113 lbs/acre; One Way Repeated Measures ANOVA, $F = 14.032$, $P < 0.001$; Figure 10-10). It continued to remain significantly lower in the burned area in 2001. No significant changes in overall biomass were shown in the unburned area ($P > 0.05$). Litter biomass was significantly reduced and continues to be significantly less in the burned area after the prescribed burn compared to pre-treatment levels (One Way Repeated Measures ANOVA, $F = 8.734$, $P < 0.001$; Figure 10-11). No significant changes were shown in litter biomass in the unburned plot during the same timeframe ($P > 0.05$). Vegetation biomass (current year live) was reduced significantly only immediately after the fire in the burned area (One Way Repeated Measures ANOVA, $F = 18.867$, $P < 0.001$; Figure 10-11). In 2000 and 2001 current year biomass was not significantly different from pre-burn levels in the burn area ($P > 0.05$). In the unburned plots however, a significant increase in current year live biomass occurred in 2001 compared to 1999 levels (One Way Repeated Measures ANOVA, $F = 5.013$, $P < 0.05$; Figure 10-11).

Individual species frequency results from the 1-$m^2$ quadrats are presented in Table 10-5. The frequency of several species appears to have been affected by the prescribed fire. Many species in the Asteraceae (sunflower) family including, western ragweed (*Ambrosia psilostachya*), western sagewort (*Artemesia campestris*), diffuse knapweed, Canada horseweed (*Conyza canadensis*), trailing fleabane (*Erigeron flagellaris*), curly-top gumweed (*Grindelia squarrosa*), and prickly lettuce (*Lactuca serriola*), have shown substantial increases in the burned area in comparison to the unburned area. Each of these increased at least 14 percent more in the burned area than in the unburned. Mountain muhly was the only native graminoid that showed a decrease in response to the fire. In the burned plots, most others graminoids showed a slight increase in 2000, the year after the fire, and then a return to near pre-treatment levels by 2001. In the unburned plot many graminoid species showed overall declines from 1999 to 2001. So the increased frequency response of the graminoids in the burned plots was somewhat short-lived but compared to the unburned plots was still an increase. Two species, twistspine prickly pear and hedgehog cactus both showed consistent declines in both the unburned and burned areas, largely a result of the herbicide applications. Several species showed increases in both the unburned and burned areas including, goat's beard (*Tragopogon dubius*), western wallflower (*Erysimum capitatum*), mountain bladder-pod (*Lesquerella montana*), sleepy catchfly (*Silene antirrhina*), St. John's-wort (*Hypericum perforatum*), junegrass (*Koleria pyrimidata*), needle and threadgrass (*Stipa comata*).

## 10.4 Discussion

Fire is an integral natural process necessary for native prairie management. Historically fires were ignited by lightning or Native Americans and often occurred with frequencies of one to thirty years or more depending on location and local conditions (Seig and Fletcher 1998). The effects of fire have been documented in the literature for several decades. Some of the important aspects of prescribed fires for grassland management include litter reduction, recycling of plant nutrients, increased early season soil temperatures, increased flowering and vigor of native grasses, germination of forb and grass seeds, and increased landscape and biological diversity (Towne and Owensby 1984, Ehrenreich 1959, Collins and Wallace 1990). The timing of a prescribed fire can also alter the end results. Late spring burning can increase the yield of specific species such as big bluestem and Indian grass (*Sorghastrum nutans*) while early spring burning can reduce the yield of these species but increase diversity and benefit perennial forbs (Towne and Owensby 1984). Wright (1974) found that the post-fire responses of many dominant species was highly correlated to winter-spring precipitation and effected the long-term outcome of the fire effects on prairie composition.

The xeric tallgrass prairie at the Site has shown a variety of responses to the spring 2000 prescribed fire. The fact that historically the study area had not been grazed or burned since prior to 1951 likely has affected the results, in addition to the application of Tordon22K® in spring 1999, one year prior to the burn. Species richness was affected differently at different spatial scales. As measured in 1-$m^2$ quadrats, species richness showed a significant increase in the burned area in comparison to the unburned area that showed no similar increase. After two growing seasons, an average of 2.3 additional species were found in each quadrat in the burned area as compared to pre-burn species richness. An increase in species richness after a fire has been reported from other studies where a similar response has been observed (Collins and Gibson 1990). At a larger scale (1000-$m^2$, i.e., 10 x 100-$m^2$ transects) species richness (based on all burned transects combined) and diversity (Shannon-Weaver) increased in both the burned and unburned areas during the same timeframe. Thus this increase cannot be attributed to the fire, but is likely driven by climatic factors.

Total foliar cover, graminoid cover, and forb cover showed essentially parallel responses in the burned and unburned areas. The lack of an increase in cover of the graminoids as a whole in the burned area was somewhat unexpected because other studies have shown that fire typically increases flowering, biomass production, and cover in prairie ecosystems (Masters et al. 1992, Ehrenreich 1959, Towne and Owensby 1984, Ewing and Engle, 1988). The lower winter-spring precipitation amounts in spring 2000 (Figure 10-12), compared to the previous several years may have influenced the lack of an increased response more typical after a fire. Wright (1974) found a decreased response of many native graminoid species when below average winter-spring precipitation amounts preceded a prescribed fire. It may have also been affected or masked by the herbicide that was applied to both the unburned and burned areas the year before the prescribed burn. Observations from other locations at the Site have shown that graminoid cover typically increases after an herbicide application, likely resulting from reduced competition from forbs (K-H 1999b, 2000b, 2001b). Thus it may have been unreasonable to assume that graminoid cover could increase much more with the application of fire, particularly in a dry year. Both the burned and unburned plots were dominated by Canada bluegrass, big bluestem, and mountain muhly. No change in their order of dominance was observed in the burned area as a result of the burn.

A significant loss of cool-season graminoid cover occurred in the burned area the year following the burn, causing the burn area to shift to a warm-season dominated community. Much of this resulted from the loss of cover by the non-native species Canada bluegrass and Kentucky bluegrass (*Poa pratensis*). This response is typical of most grasslands that have both cool- and warm-season species when they are burned in the spring (Towne and Owensby 1984, Glenn-Lewin et al. 1990). However, the shift was short-lived and by 2001 the prairie in the burned area had returned to a cool-season dominated community. Since one of the goals of the prescribed burn was to shift the species composition of the grassland from the predominantly non-native, cool-season graminoids to the native warm-season species the fire was a step in the right direction. Although it only lasted one year, it showed that prescribed fire could be used as a management tool to shift the species composition of the xeric tallgrass prairie to favor the warm-season graminoid species that make the prairie unique. On the tallgrass prairie of the eastern Great Plains repeated annual spring burning of the prairie has been shown to increase dominance of the warm-season species (Svejcar 1990, Towne and Owensby 1984), however, here in the more arid west where moisture is much more a limiting factor for plant growth annual prescribed fire is not recommended (Shay et al. 2001, Hopkins-Arnold 1998). After studying the influence of fire on the mesic tallgrass prairie along South Boulder Creek to the north of the Site in Boulder County, Hopkins-Arnold (1998) recommended that fire should be used only infrequently (not annually) on more xeric sites to stimulate production. She also recommended that it only be used in years with normal or above normal precipitation and not when drought is expected or following a year of drought. Additionally, timing of a prescribed burn has been shown to substantially alter the vegetative outcome in terms of species composition, so adjustments to the timing of any future prescribed burns at the Site could help shift species composition more in the desired direction (Towne and Owensby 1984, Ehrenreich 1959, Ewing and Engle 1988). Fire injures plants that are actively growing more than those that are still dormant (Towne and Owensby 1984), so by adjusting the timing of a prescribed burn so that the cool-season species are more impacted a greater reduction in their abundance may be observed. A three week difference in timing can substantially change the long-term vegetation composition of an area (Town and Owensby 1984). The contrast in cool- versus warm-season graminoid cover between the burned and unburned prairie in this study may also have been much more dramatic had the herbicide application not been a factor.

Native and non-native cover on the xeric tallgrass prairie were both affected by the prescribed burn. Native cover in the burned area increased after the prescribed burn and remains significantly higher than original levels two growing seasons after the fire. No similar response was seen in the unburned area. Non-native cover was reduced significantly in the burned area for one year after the fire, while no change was observed in the unburned area. Thus the use of fire, assisted non-native weed control efforts for one year after the burn, and continued to enhance conditions for the native species. This is evidenced by the continued increase in cover by the native species.

Forb cover was initially low in both the unburned and burned areas due to the application of Tordon22K® in spring 1999. Forb cover however, has significantly increased in both the burned and unburned plots since the fire, largely because the residual effect of picloram in the soil is decreasing. No change in forb cover was observed that could be attributed to the prescribed burn. The overall loss of cactus density in both the burned and unburned plots is largely due to the herbicide application. Data from other studies at the Site and elsewhere have shown this is typical (K-H 1999b, 2000b, 2001b; Peterson et al. 1988). Aside from this the response of forbs to fire is less well documented. Forb responses to fire elsewhere have shown a variable species-specific response, often different depending on location and timing of the fire (Glenn-Lewin et al. 1990).

Above ground current year live plant biomass was not significantly changed by the fire, with the exception of its reduction immediately after the fire. By the end of the growing season in 2000, total current year live plant biomass was back to pre-fire levels in the area that was burned, but it was not significantly higher. It remained the same as pre-fire levels in 2001. This differs from most other studies from the eastern tallgrass prairie where biomass increases of two to four times pre-treatment levels are not uncommon in burned areas compared to unburned locations (Svejcar 1990). The Site data is also interesting considering that a significant increase in current year live biomass did occur at the unburned locations in 2001, whereas in the burned area, where an increase would have been expected, nothing changed. Shay et al. (2001) reported that on a mixed-grass prairie in southwestern Manitoba, where moisture is a key limiting factor for plant growth, removal of litter by fire increased soil temperatures thus drying out soils reducing available soil moisture and further stressing plants. Because the xeric tallgrass prairie is an outlying, relict community on the western edge of the Great Plains which receives an annual precipitation of only about 15 inches (compared to 30+ inches received by the tallgrass prairie on the eastern Great Plains), any additional moisture stress resulting from litter removal, in an already low moisture year (2000 was a below average moisture compared to previous five years at the Site) may have contributed to lower production by the tallgrass species. Hopkins-Arnold (1998) noted that planning for prescribed burns in arid environments must take into account pre-burn annual precipitation and post-burn precipitation predictions. Other factors that have been shown to account for variable responses after fire include species composition of the grassland, timing of the burn, frequency of burning, and species specific responses to fire (Svejcar 1990, Shay et al. 2001, Ewing and Engle 1988, Towne and Owensby 1984, Wright 1974).

Litter biomass (referring to the weight of thatch or dead plant material on the ground) however, was significantly reduced after the fire and still remains significantly lower than pre-burn levels in 2001. An important objective of the prescribed burn was to reduce overall litter biomass and thereby reduce the potential for catastrophic wildfire. This was accomplished and without converting all the ground surface between plant stems and crowns to bare ground. Overall litter cover (as distinguished from litter biomass; i.e., weight) was only reduced by approximately seven percent in 2000, while bare ground increased approximately 4 percent. These cover values returned to pre-burn levels in 2001. Thus while much of the litter volume or bulk (by weight = biomass) was removed there was still some material that remained on the surface of the ground (cover) protecting it from wind and water erosion. Therefore the potential for increased wind or water erosion was minimal as a result of the fire. The nearly flat surface of the pediment top where the fire was conducted also helped minimize this as well.

Diffuse knapweed frequency returned at a faster rate in the burned area than in the unburned area, after both areas had been treated with Tordon22K® the year prior to the burn. Further investigation is required to see whether this is a consistent fire response of diffuse knapweed or not, but it may be more appropriate to treat an infestation area after a prescribed burn rather than before it. If a flush of germinating diffuse knapweed were to come up after a fire, an herbicide application would likely be much more effective after the fire because no litter and other plant material would intercept the herbicide, so more of it would reach the plants and ground.

## 10.5 Recommendations

Based on the results of this study several recommendations can be made for consideration of any future prescribed burns at the Site:

- Fire should be considered as an essential tool for long-term resource management at the Site.

- Monitoring of any future prescribed burns should be a critical aspect of planning, in order to provide documentation of the response of the xeric tallgrass prairie to fire at the Site.
- Timing of prescribed burns should be done so as to inflict maximum injury to undesired species in order to achieve the desired burn objectives. Some experimentation with different fire dates should be conducted to determine what times are best for local conditions present at the Site.
- Repeated annual burns at the same location are not recommended due to the arid conditions of our climate and the potential to further stress the desired species, thus potentially opening new opportunities for undesired species.
- When burning where weed infestations are present, post-burn weed control should be integrated in the plan to take advantage of the reduced litter and plant cover.

## 10.6 Conclusions

In April 2000, a prescribed burn was conducted on 48 acres of the xeric tallgrass prairie at the Site. The prescribed burn accomplished several objectives and demonstrated the potential that prescribed fire could have for managing the native plant community resources at the Site. The potential for a catastrophic wildfire was reduced through the removal of plant litter on the prairie without substantially increasing the potential for wind or water erosion. Species richness and native species cover increased as a result of the burn and at least in the short-term, the species composition shifted from a cool-season dominated community to a warm-season dominated one, albeit for only one year. Properly timed and used when environmental conditions such as moisture are appropriate, prescribed fire could be used on the Site's xeric tallgrass prairie to reduce the dominance and abundance of the non-native, cool-season species like Canada bluegrass and Kentucky bluegrass and enhance conditions for native, warm-season species. Prescribed burns should be used as part of the long-term resource management for the plant communities at the Site.

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K-H. 2000b. 1999 Annual vegetation report for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, LLC, Rocky Flats Environmental Technology Site, Golden, CO.

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# 11. Glossary

Annual – A plant that lives its entire life cycle during the course of a single growing season.

Biocontrol – A method of weed control that uses insects or fungi to stress, damage, or destroy the plant tissue of undesirable species.

Biodiversity – The existence of a wide range of different types of organisms in a given place at a given time.

Biomass – A measure of the productivity of a community, usually measured by clipping the vegetation and obtaining the dry weight of the vegetation; expressed per unit area (grams/square meter).

Control – The plot, quadrat, transect, site, or location, that receives no treatment or management action (e.g., weed control, prescribed burning, mowing). It serves as an unaffected plot that can be compared to the treatment plot to evaluate whether or not the treatment had any impact.

Cool-season graminoids – Grasses that green up early in the growing season (March–May) and produce mature fruits by late June or early July.

Cover – Vegetation cover is a measure of abundance for individual plant species in a specified area. The cover of different species can be grouped and summed to provide the cover for that grouping of species (e.g., graminoid cover or forb cover).

Density – A measure of the number of individuals per unit area.

Diversity – A measure of the number of species present and their relative abundance in a community.

Dominant plant species – One or more species that occur in the greatest abundance (usually based on cover or biomass) in a given plant community.

Ecotonal – An ecotone is the boundary area between two different plant communities.

Forbs – Herbaceous, broad-leaved, non-woody plant species.

GIS – Geographic information system

GPS – Global positioning system

Graminoids – Grasses, sedges, or rushes.

Litter – Dead plant matter that has accumulated on the surface of the ground.

Management units – Arbitrary divisions of the different plant communities at the Site used to facilitate vegetation sampling. Roads, fence lines, and streams were often used as boundaries.

Mesic – Referring to conditions of moderate moisture or water availability.

Perennial – A plant whose lifecycle spans multiple years.

Prescribed burn or fire – A planned, controlled fire, intentionally set to burn off the vegetation to meet a set of management objectives.

Relict – Persistent remnants of a pre-existing, once more widespread flora or fauna that now exist in more restricted or isolated areas.

Riparian – On or pertaining to the banks of a stream (e.g., riparian vegetation or riparian woodland).

Species richness – The complete list and number of species found in a given area.

Species richness similarity – A mathematical coefficient that quantifies how similar or dissimilar the species composition of two communities is. A common coefficient is the
Sorensen coefficient of similarity index, which compares species lists between two areas by taking into account the total number of species present in each community and the number in common between them.

Target species – Species specifically chosen for weed control (e.g., diffuse knapweed or musk thistle).

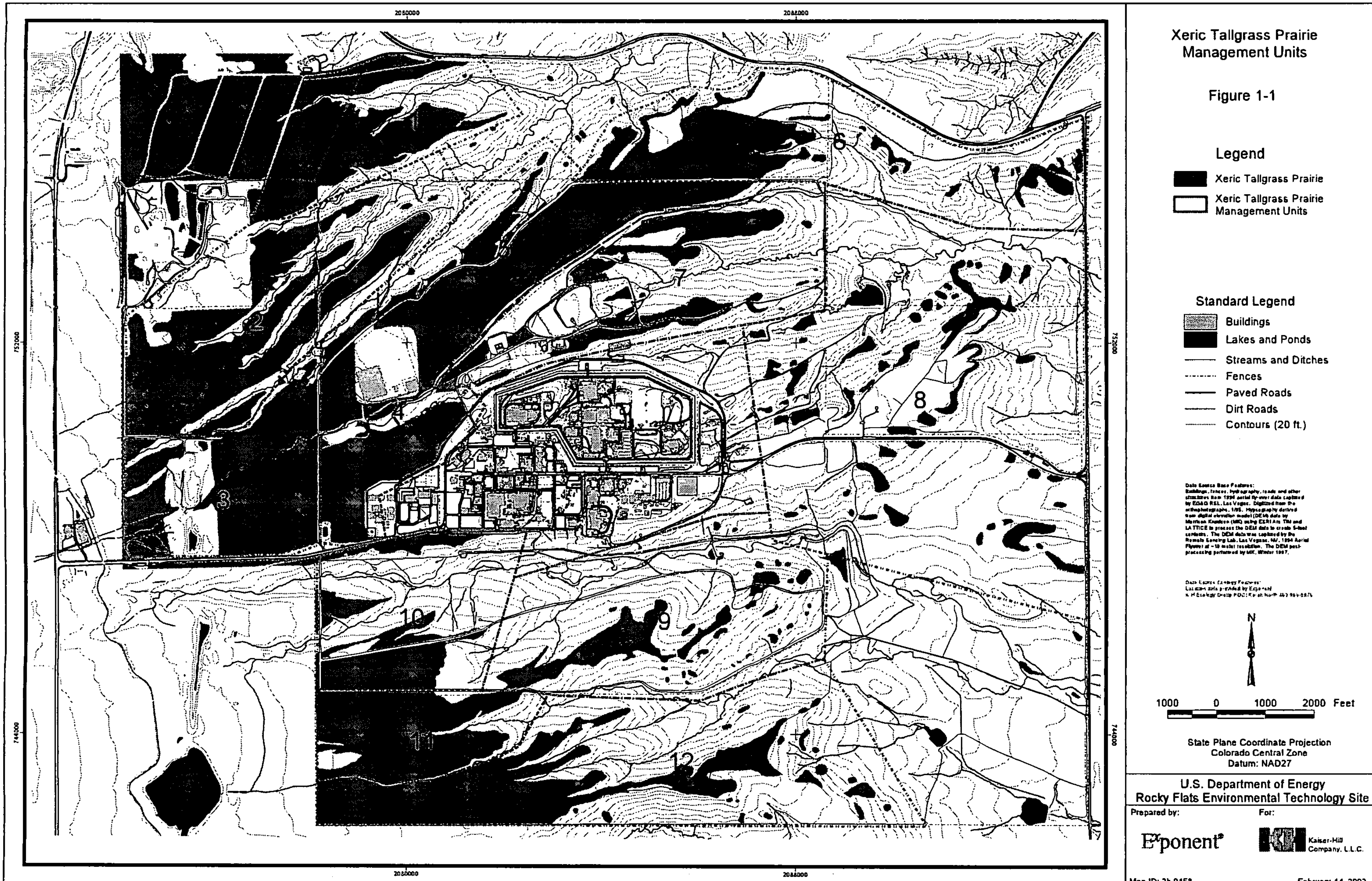
Treatment – The plot, quadrat, transect, site, or location, that receives a specific management action (e.g., weed control, prescribed burn, mowing).

Vascular plants – Plants that have xylem and phloem (i.e., conductive tissue) for internal movement of water, minerals, and nutrients. This excludes plants such as mosses, liverworts, and hornworts that have no such tissues.

Warm-season graminoids – Grasses that green up later in the growing season (late May–June) and don't produce mature fruits until September.

Xeric – Dry or characterized by scant moisture; tolerating or adapted to arid conditions.

## Figures


Xeric Tallgrass Prairie
Management Units
Figure 1-1
Legend
Xeric Tallgrass Prairie
Xeric Tallgrass Prairie Management Units
Standard Legend
Buildings
Lakes and Ponds
Streams and Ditches
Fences
Paved Roads
Dirt Roads
Contours (20 ft.)
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1000 0 1000 2000 Feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
For:
Exponent
Kaiser-Hill Company, L.L.C.
Map ID: 2k-0158
February 14, 2002
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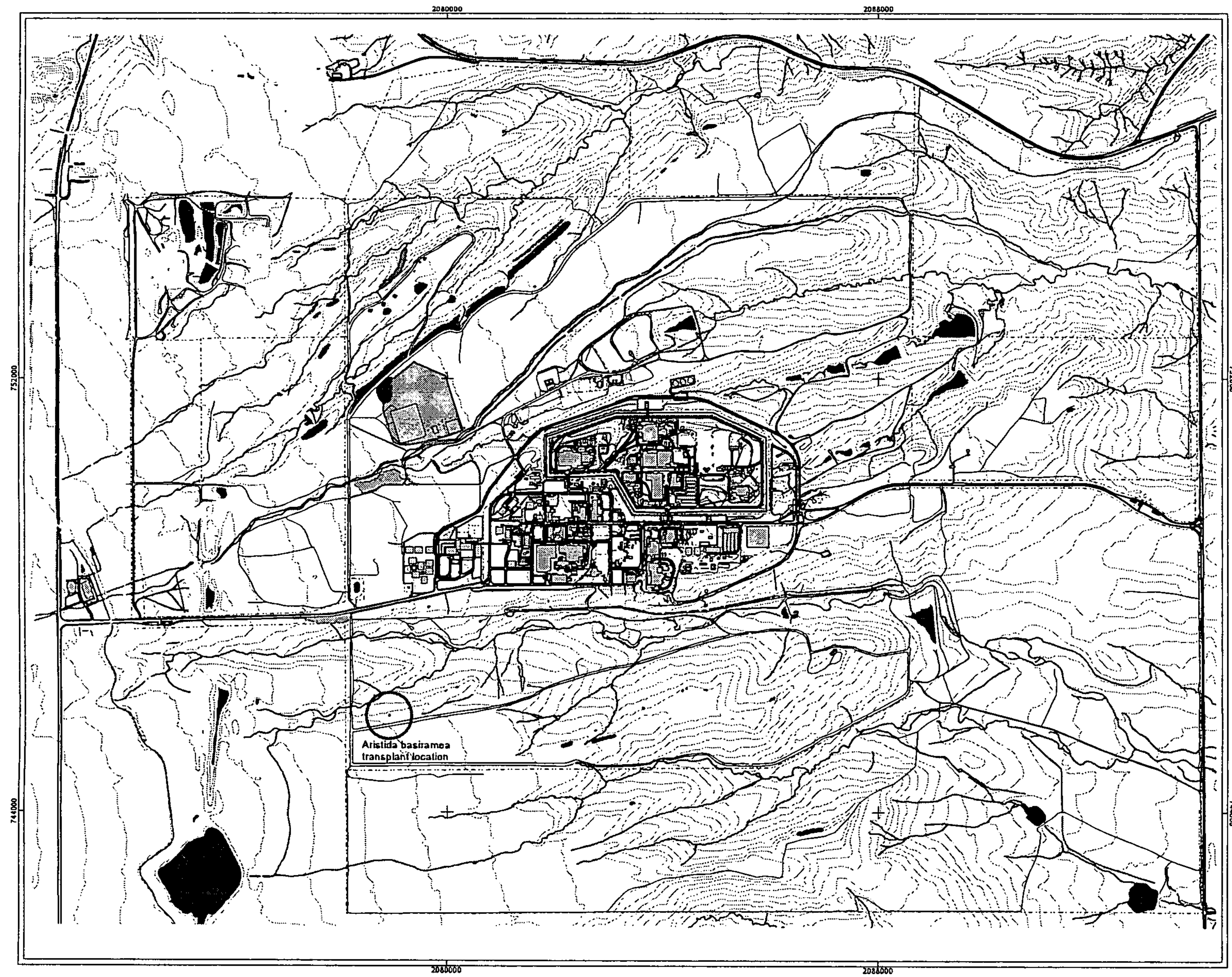


## 2001 Rare Plants Distribution

(All known locations from 1997 - 2001 shown)

### Figure 1-2

### LEGEND

- Dwarf Wild Indigo (Amorpha nana)
- Forktip Three-awn (Aristida basiramea)
- Mountain-Loving Sedge (Carex oreocharis)
- Carrionflower Greenbriar (Smilax herbacea)

### Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876.

N

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1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0156

February 14, 2002

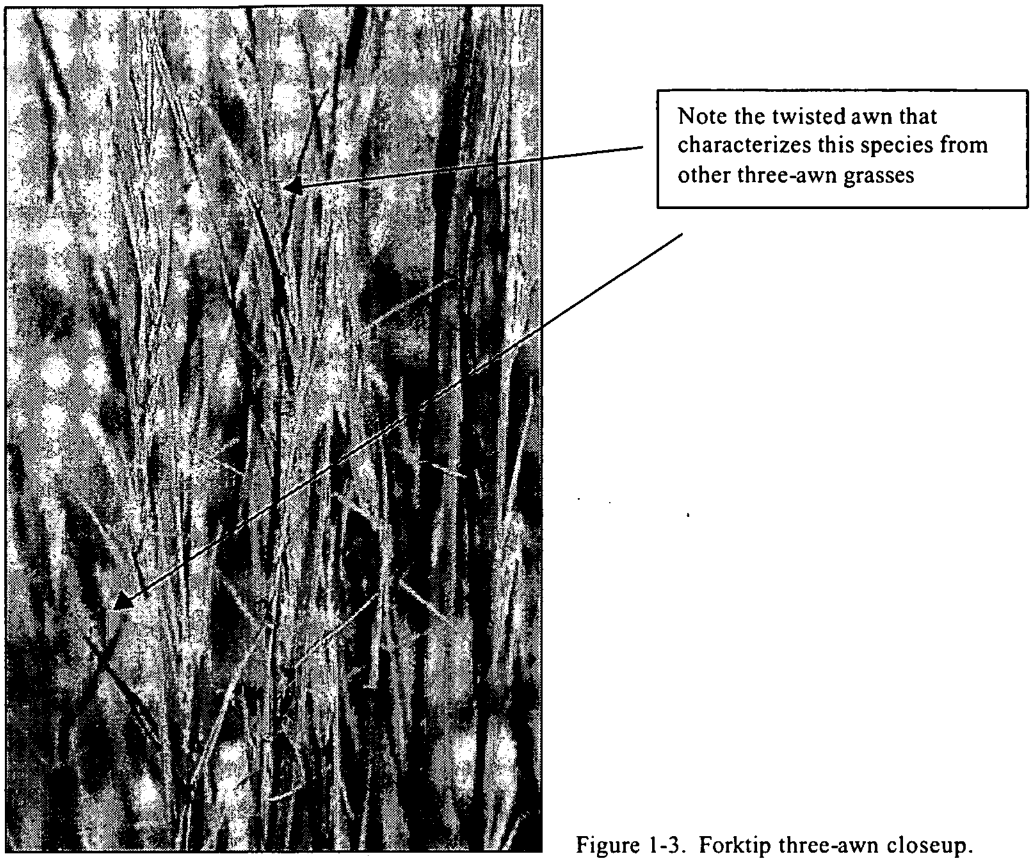



Figure 1-3. Forktip three-awn closeup.

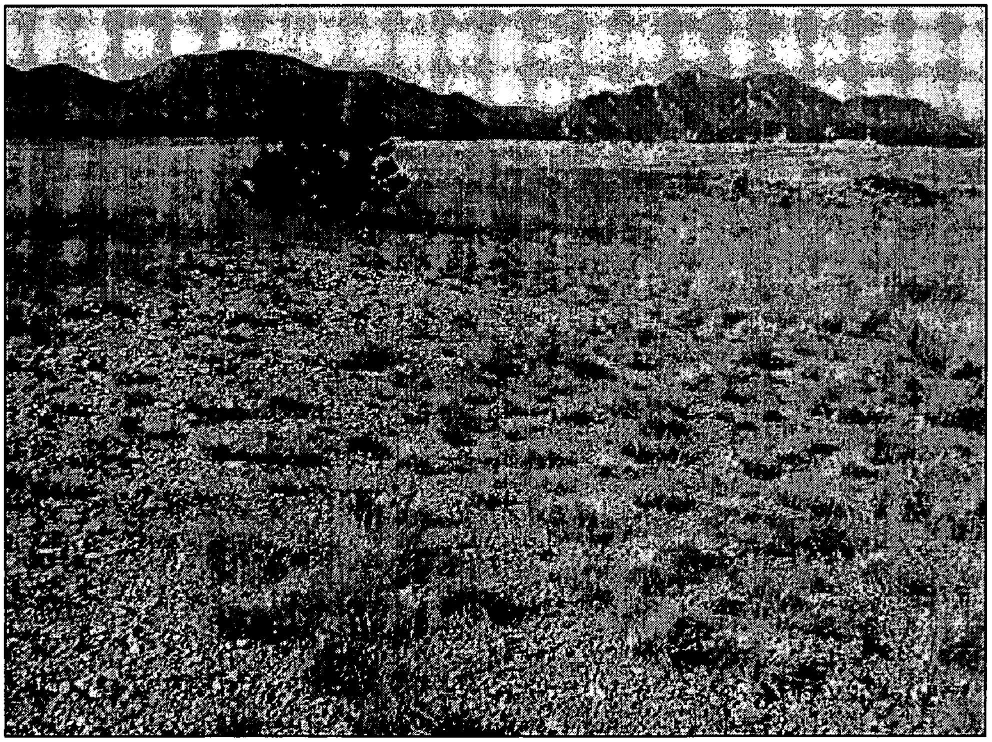
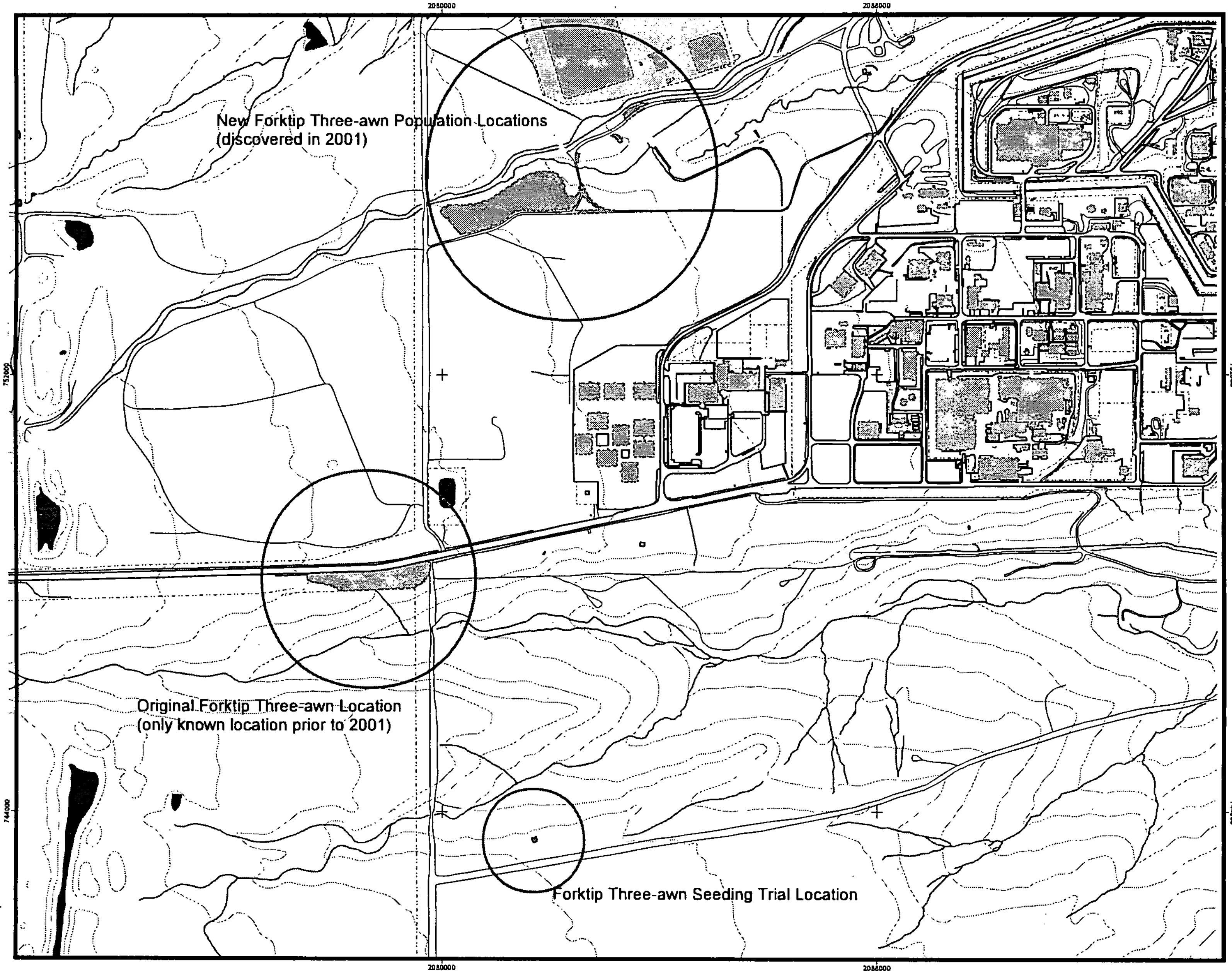


Figure 1-4. Habitat of forktip three-awn at new population discovered at Rocky Flats in 2001. It is an old borrow area that was reseeded in the 1980's. The forktip three-awn grows in the gravelly areas between these bunchgrasses.


Figure 1-5. Forktip three-awn was commonly found on oxidized gravelly surfaces such as this. This is an area where an attempt was made to seed the species and create a new population. Monitoring will be conducted in fall 2002 to determine whether any of the seeds germinated and established.




# Forktip Three-awn (Aristida basiramea) Distribution and Seeding Trial Location

## Figure 1-6

### Legend

- Forktip Three-awn Locations
- Forktip Three-awn Seeding Trial Location

### Standard Legend

- Buildings
- Lakes and Ponds
- Landfill
- Streams and Ditches
- Fences
- Paved Roads
- Dirt Roads
- Contours (20 ft.)

Data Source Base Features:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95. Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by [illegible]
K-H Ecology Group POC: Karen North [illegible]

N

400 0 400 800 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

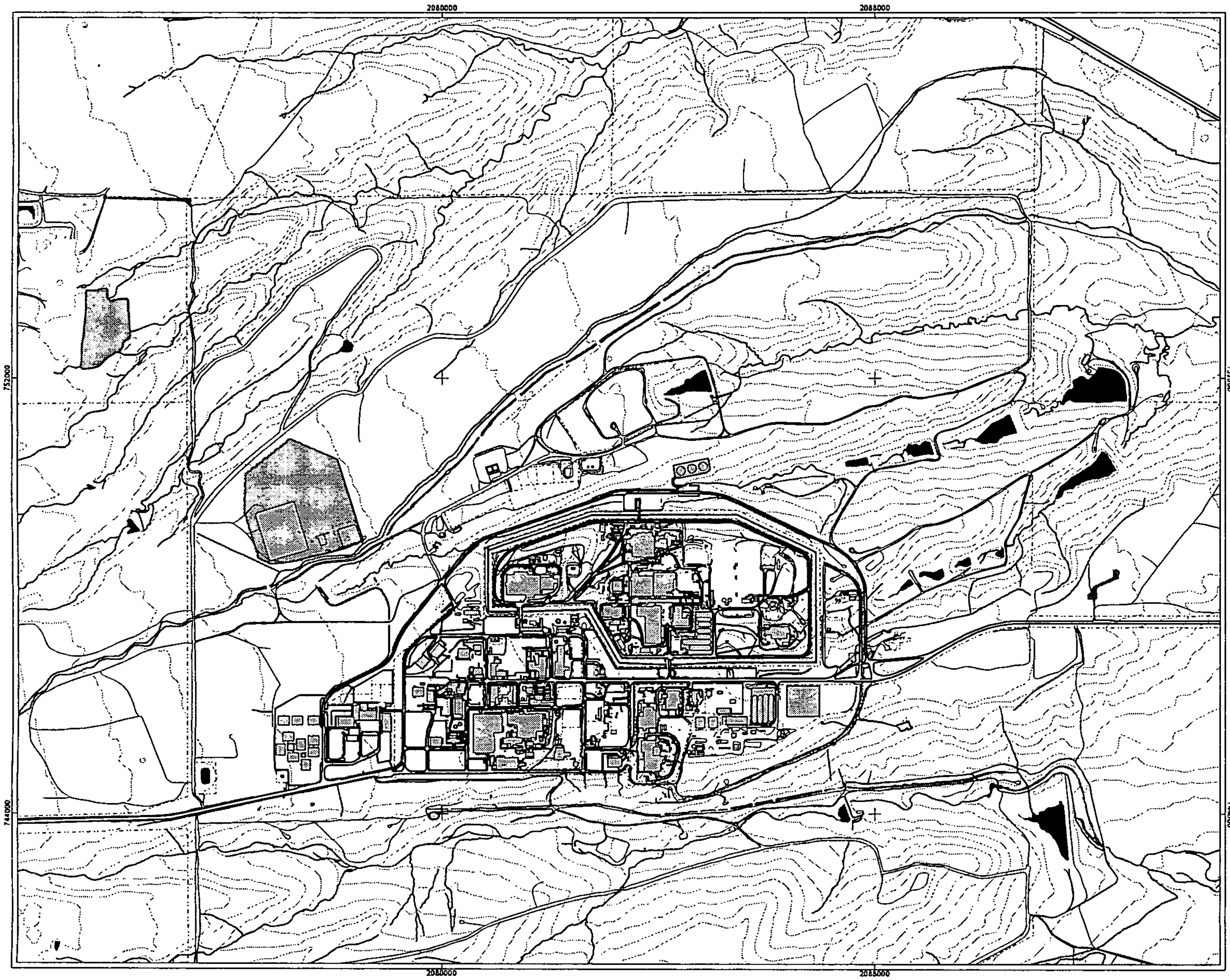
U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent

For: Kaiser-Hill Company, L.L.C.

Map ID: 02-156

February 14, 2002




# 2001 Ecological Disturbances in the Buffer Zone

Figure 1-7

LEGEND

Project Disturbance Locations
Windblown Sand Deposition

Standard Features

Buildings
Lakes & ponds
New Landfill
Streams & ditches
Fences
Paved roads
Dirt roads
Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-9376.

N

1:15870

1000 0 1000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

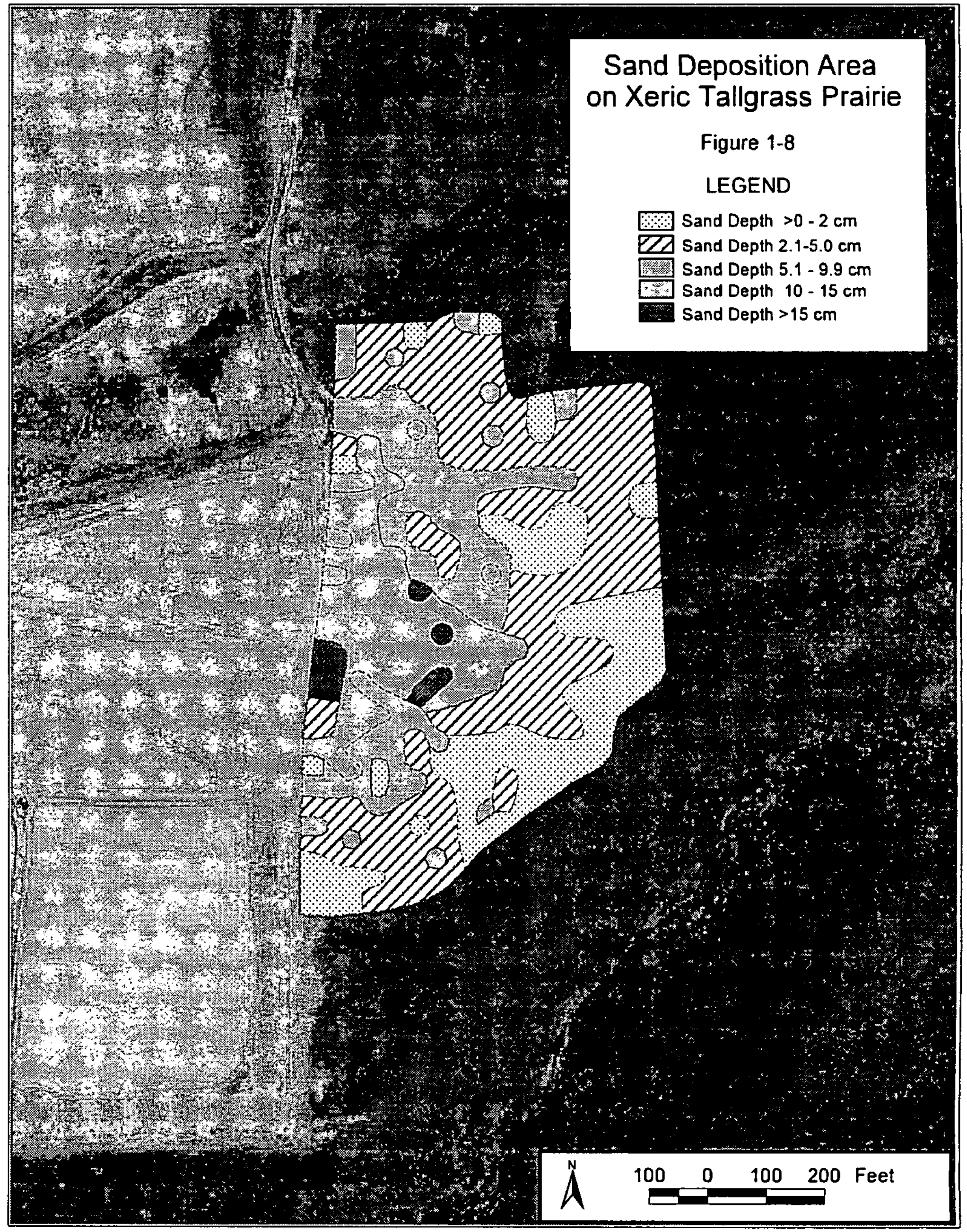
Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0168

December 3, 2001


Sand Deposition Area
on Xeric Tallgrass Prairie
Figure 1-8
LEGEND
Sand Depth >0 - 2 cm
Sand Depth 2.1-5.0 cm
Sand Depth 5.1 - 9.9 cm
Sand Depth 10 - 15 cm
Sand Depth >15 cm
N
100 0 100 200 Feet

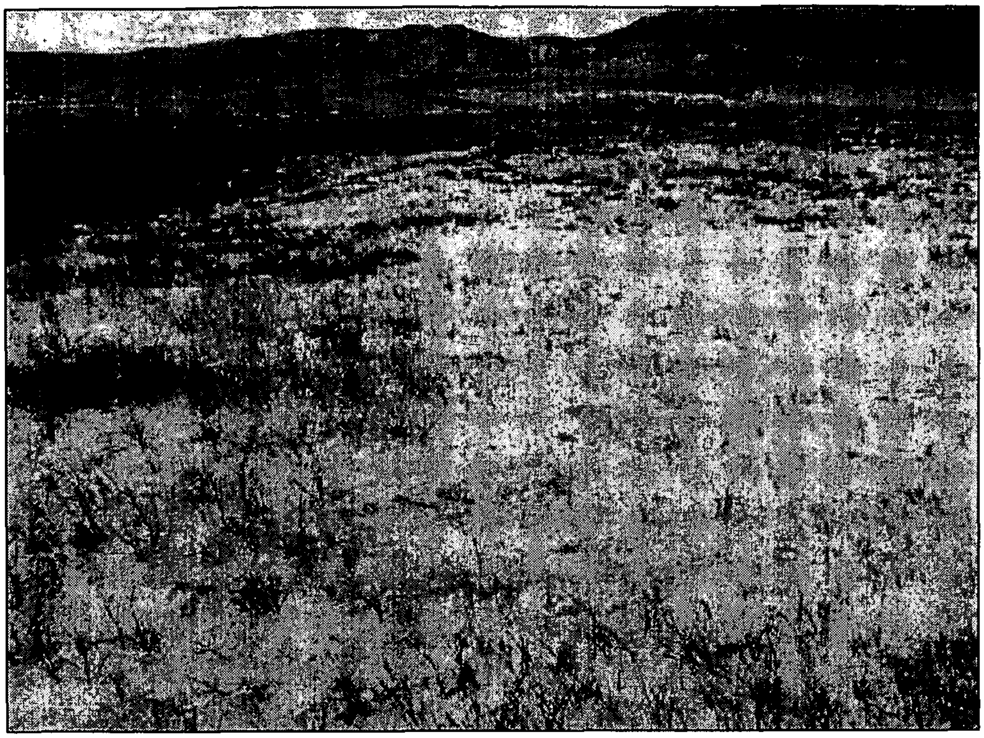


Figure 1-9. Sand deposition area in late May 2001. Sand blown from the mine buried the xeric tallgrass prairie up to six inches deep.

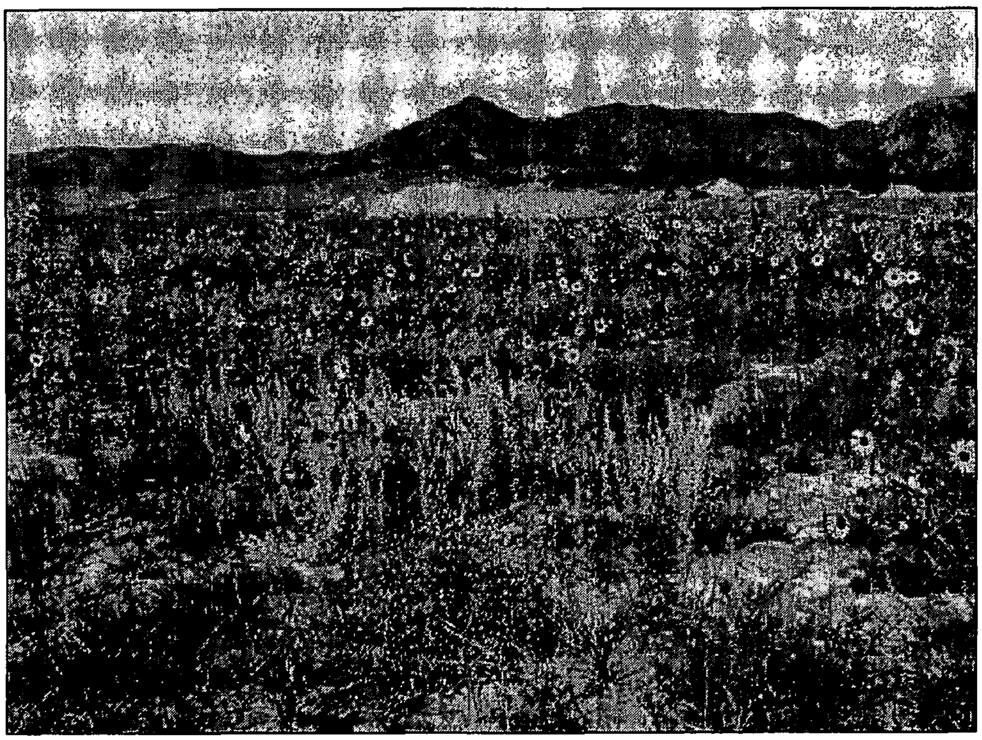
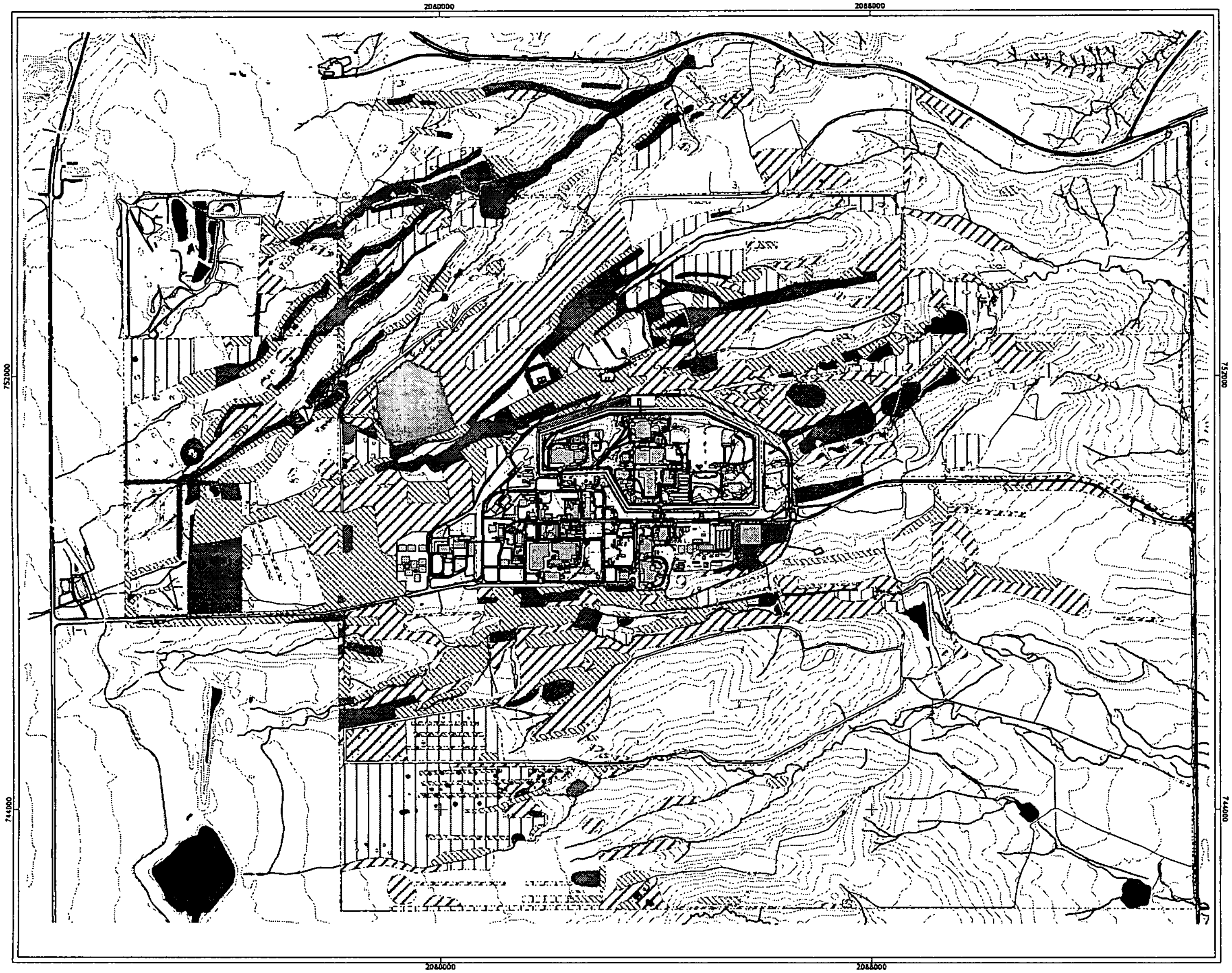


Figure 1-10. Sand dune area in late summer. In August 2001, the sandy area had become an annual sunflower patch (yellow flowers), but much of the area was also infested with the noxious weeds diffuse knapweed, Russian thistle, and kochia.




# 2001 Diffuse Knapweed (Centaurea diffusa) Distribution

Figure 1-11

## LEGEND

- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas

### Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876.

N

1:23552

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

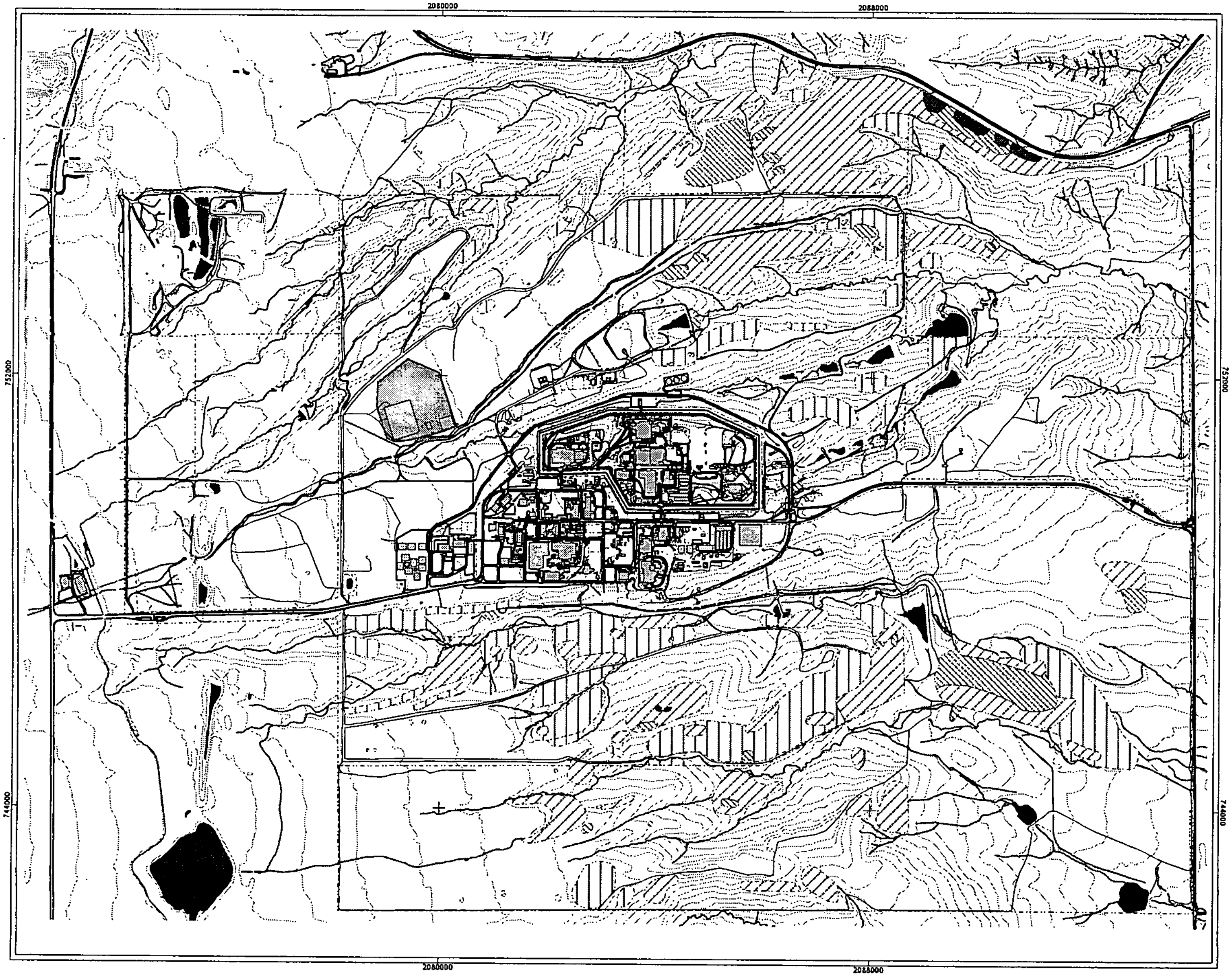
Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0147

November 28, 2001




## 2001 Musk Thistle (Carduus nutans) Distribution

Figure 1-12

### LEGEND

- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas

### Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876.

N

1:23552

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

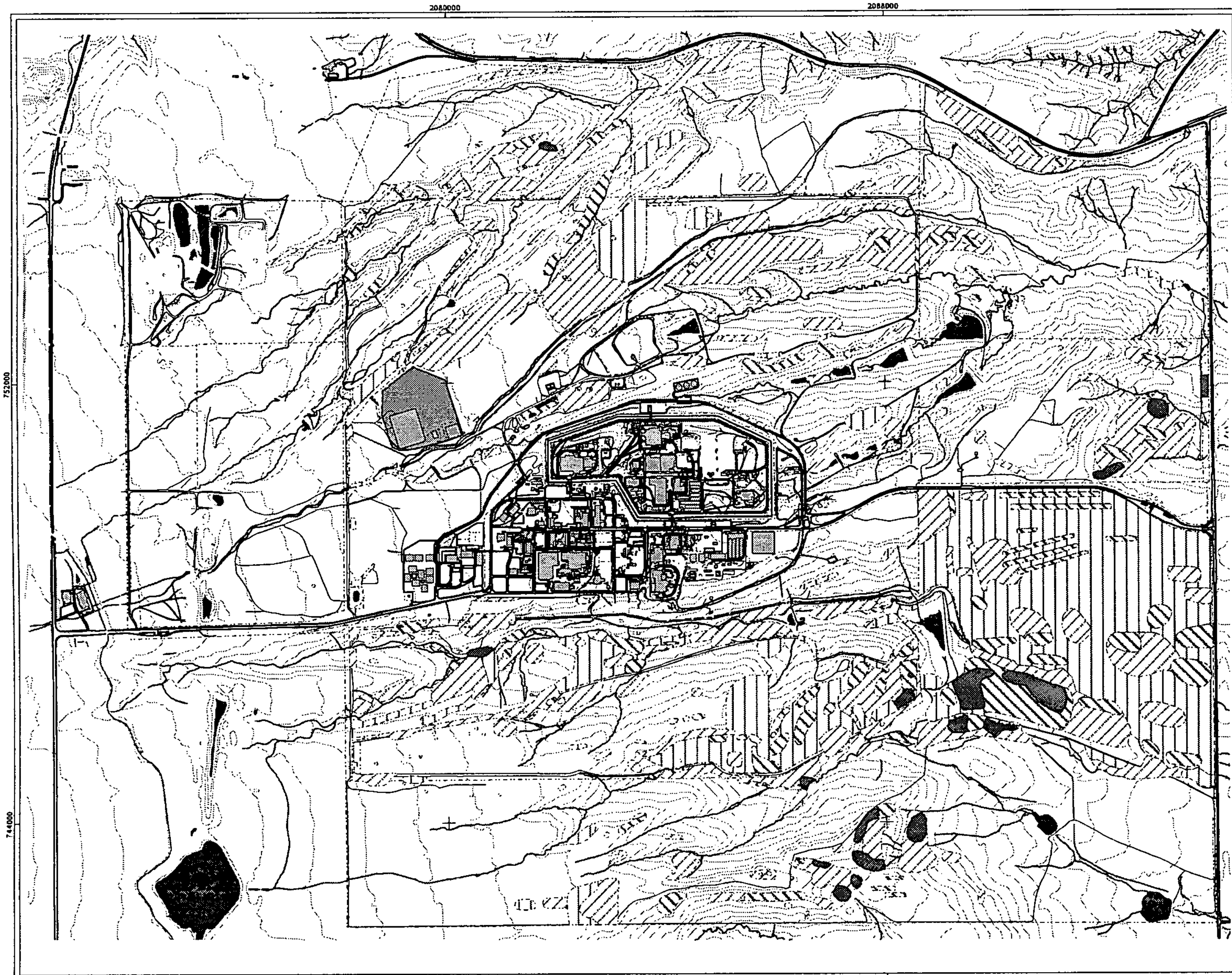
Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0006

February 14, 2002




# 2001 Common Mullein (Verbascum thapsus) Distribution

Figure 1-13

LEGEND

- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas

Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876.

N

1:23552

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

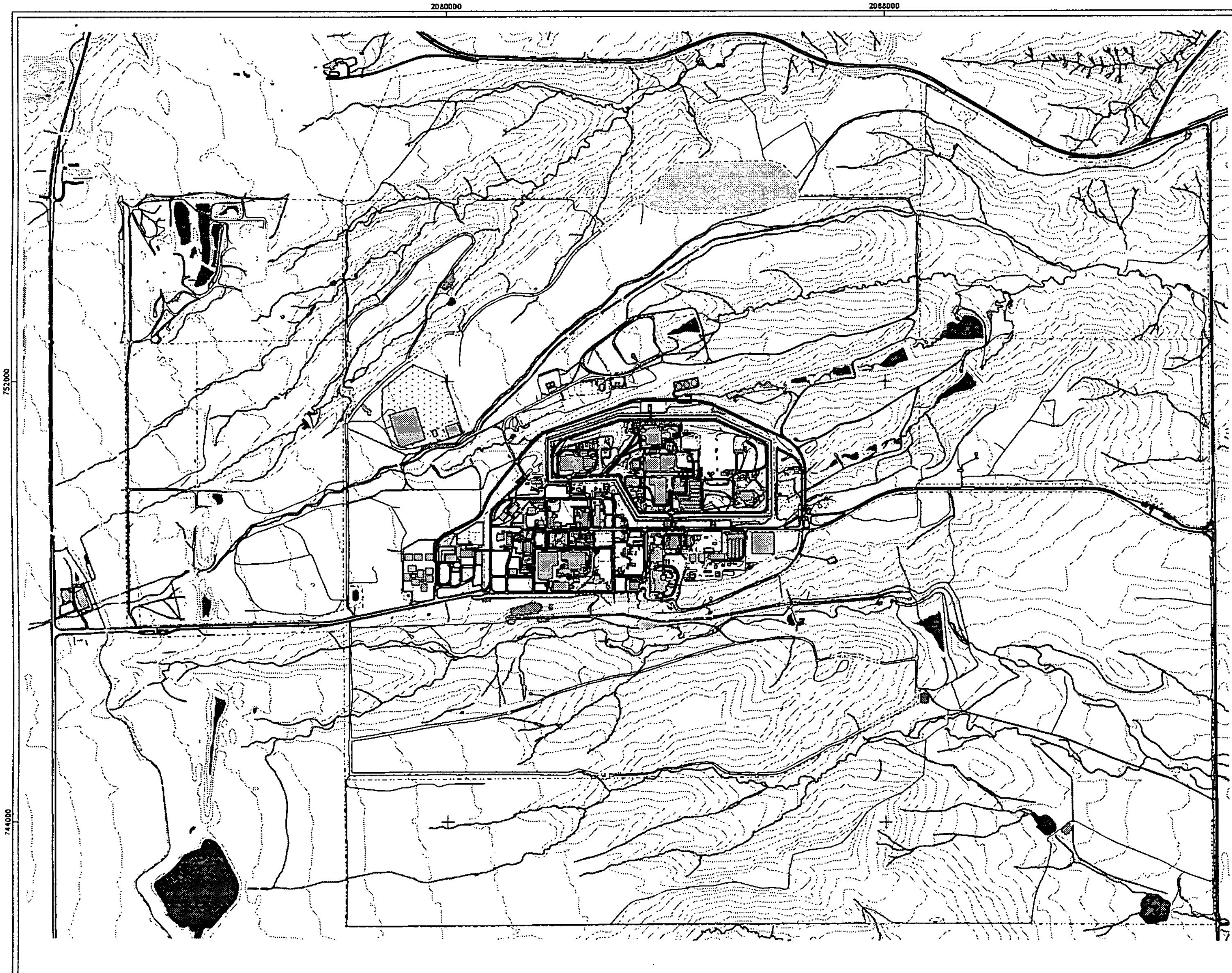
Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0072

February 14, 2002




# 2001 Multiple Weed Species Distributions

**Figure 1-14**

## LEGEND

- Scotch Thistle Infestations
- Russian Knapweed Infestations
- Dame's Rocket Infestations
- Annual Rye Infestations
- Bouncing Bet Infestations
- Bulbous Bluegrass Infestations
- Crown Vetch Infestations
- Bird's-foot Trefoil Infestations
- Lens-padded Hoary Cress Infestations
- Pepperweed Whitetop Infestations
- Texas Blueweed Infestations

### Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-9876.

N

1:23552

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent®

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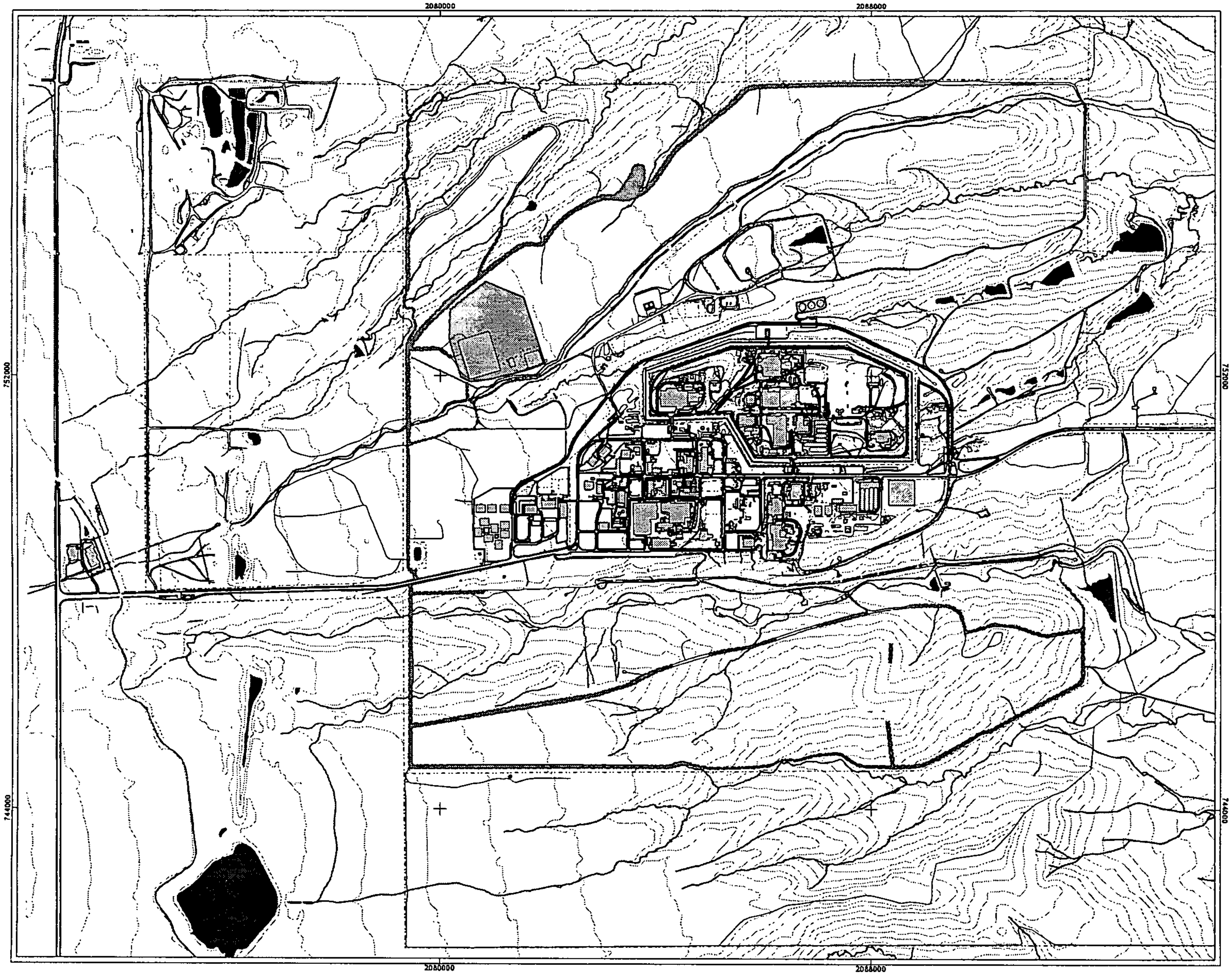
RFETS GIS Dept. 303-966-7707

MAP ID: 02-0154

February 14, 2002




# 2001 Jointed Goatgrass (Aegilops cylindrica) Distribution

Figure 1-15

## LEGEND

Jointed Goatgrass Infestations

### Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876.

N

1:19510

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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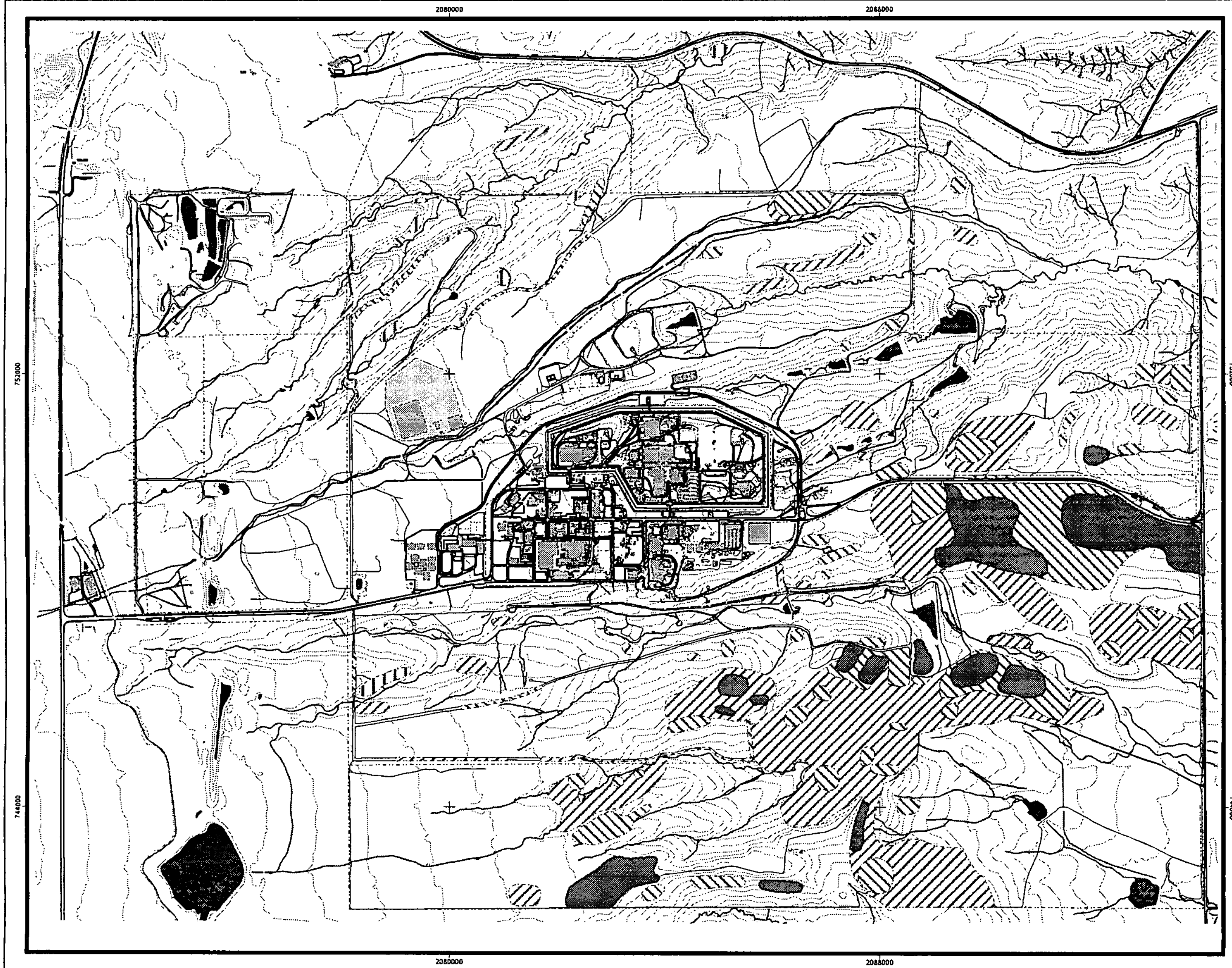
RFETS GIS Dept. 303-966-7707

MAP ID: 02-0153

February 14, 2002




# 1998 Common Mullein (Verbascum thapsus) Distribution

## Figure 1-16

### Legend

- High Density Areas
- Medium Density Areas
- Low High Density Areas
- Scattered Density Areas

### Standard Legend

- Buildings
- Lakes and Ponds
- Landfill
- Streams and Ditches
- Fences
- Paved Roads
- Dirt Roads
- Contours (20 ft.)

Data Source Base Features:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95. Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.

N

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

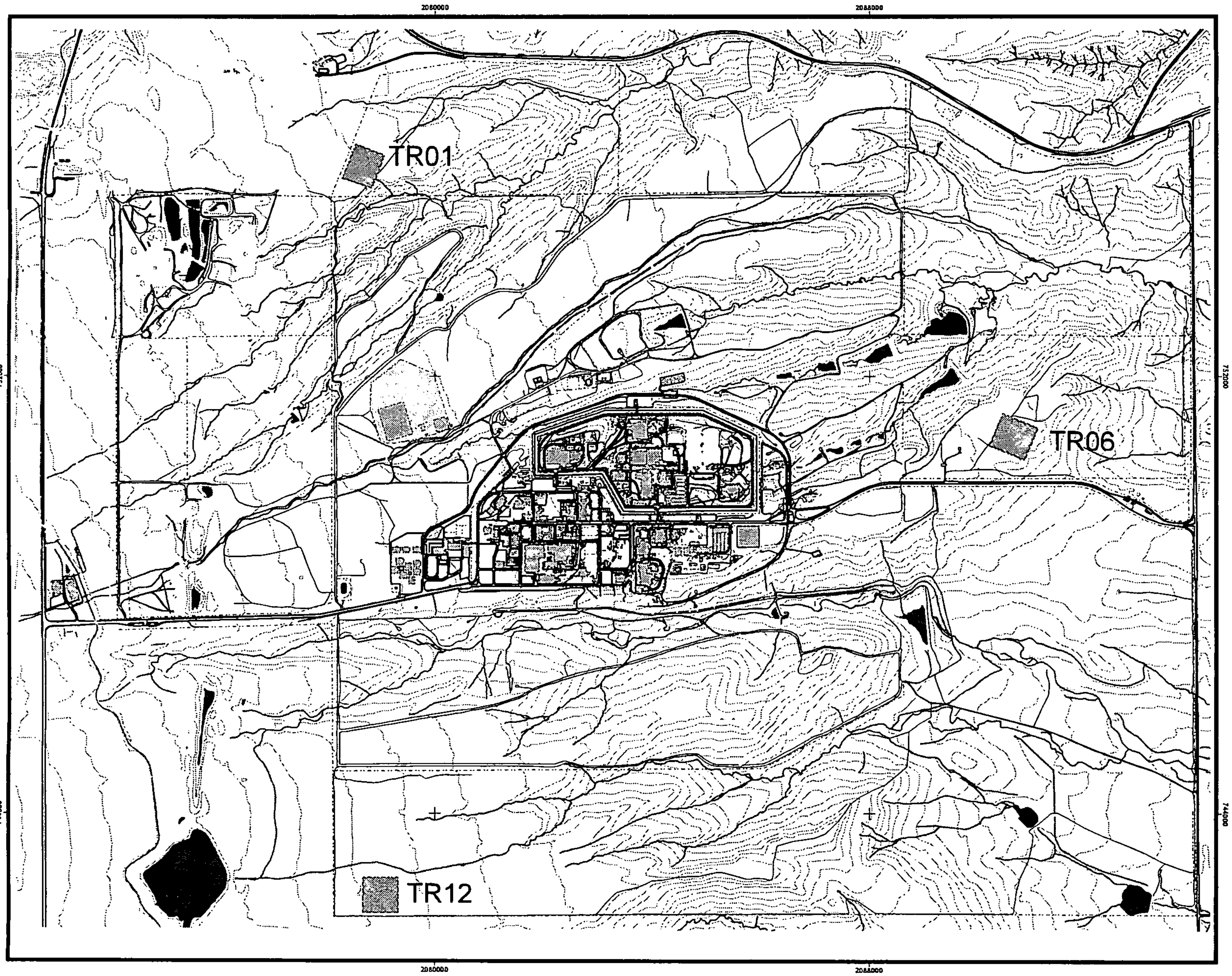
U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent

For: Kaiser-Hill Company, L.L.C.

Map ID: 02-0072

March 21, 2002




## Xeric Mixed Grassland Monitoring Sites

Figure 2-1

### Legend

Xeric Mixed Grassland Monitoring Locations

### Standard Legend

- Buildings
- Lakes and Ponds
- Landfill
- Streams and Ditches
- Fences
- Paved Roads
- Dirt Roads
- Contours (20 ft.)

Data Source Base Features:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95. Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent
& K-H Ecology Group POC: Karen North [illegible]

N

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent® For: Kaiser-Hill Company, L.L.C.

Map ID: 2k-038 December 13, 2001

\\Gassm\GIS\Eco-projects\projects\2k-038\2001 ann.rept.apr

**Figure 2-2. Annual Precipitation at Rocky Flats (1992-2001)**

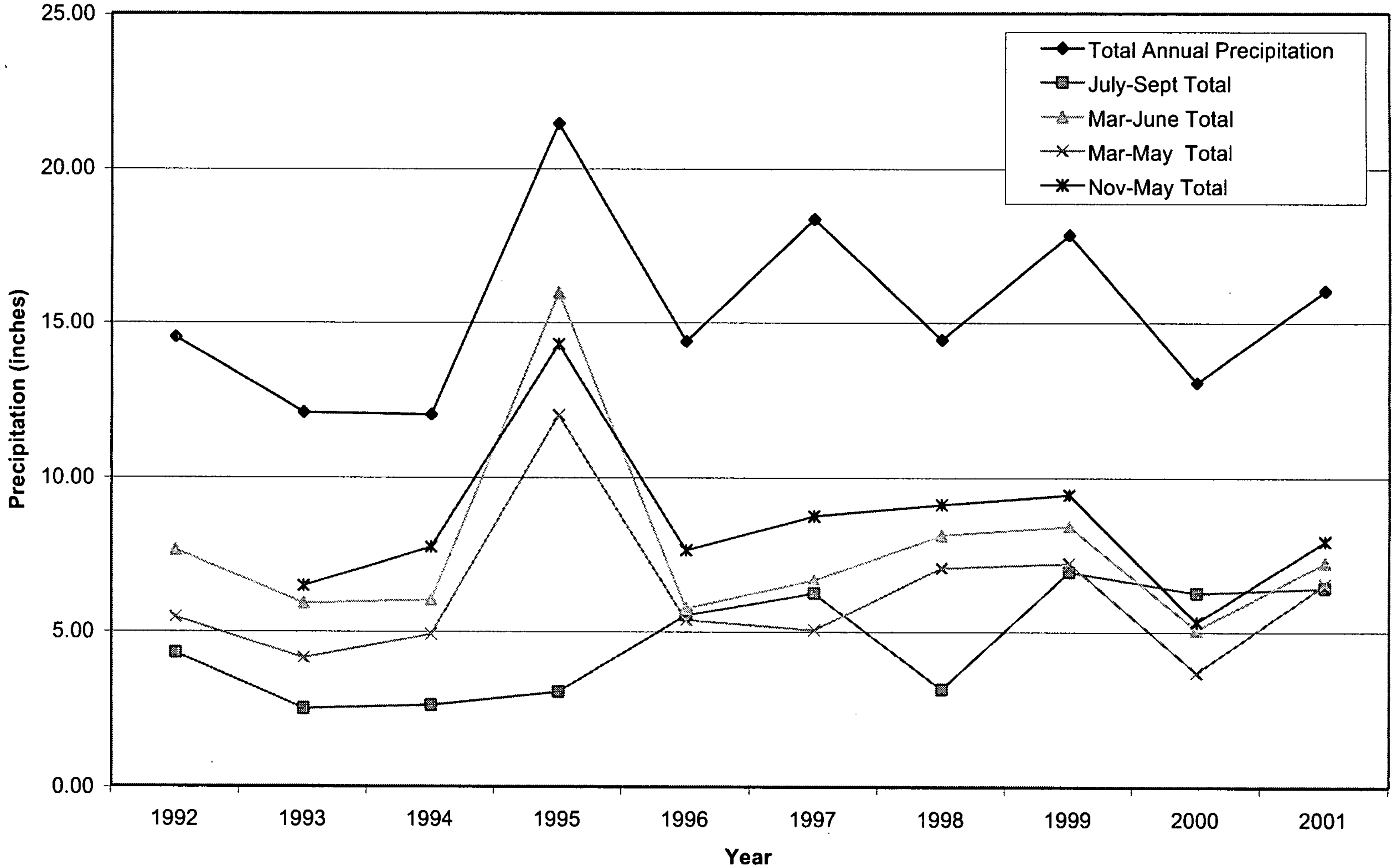
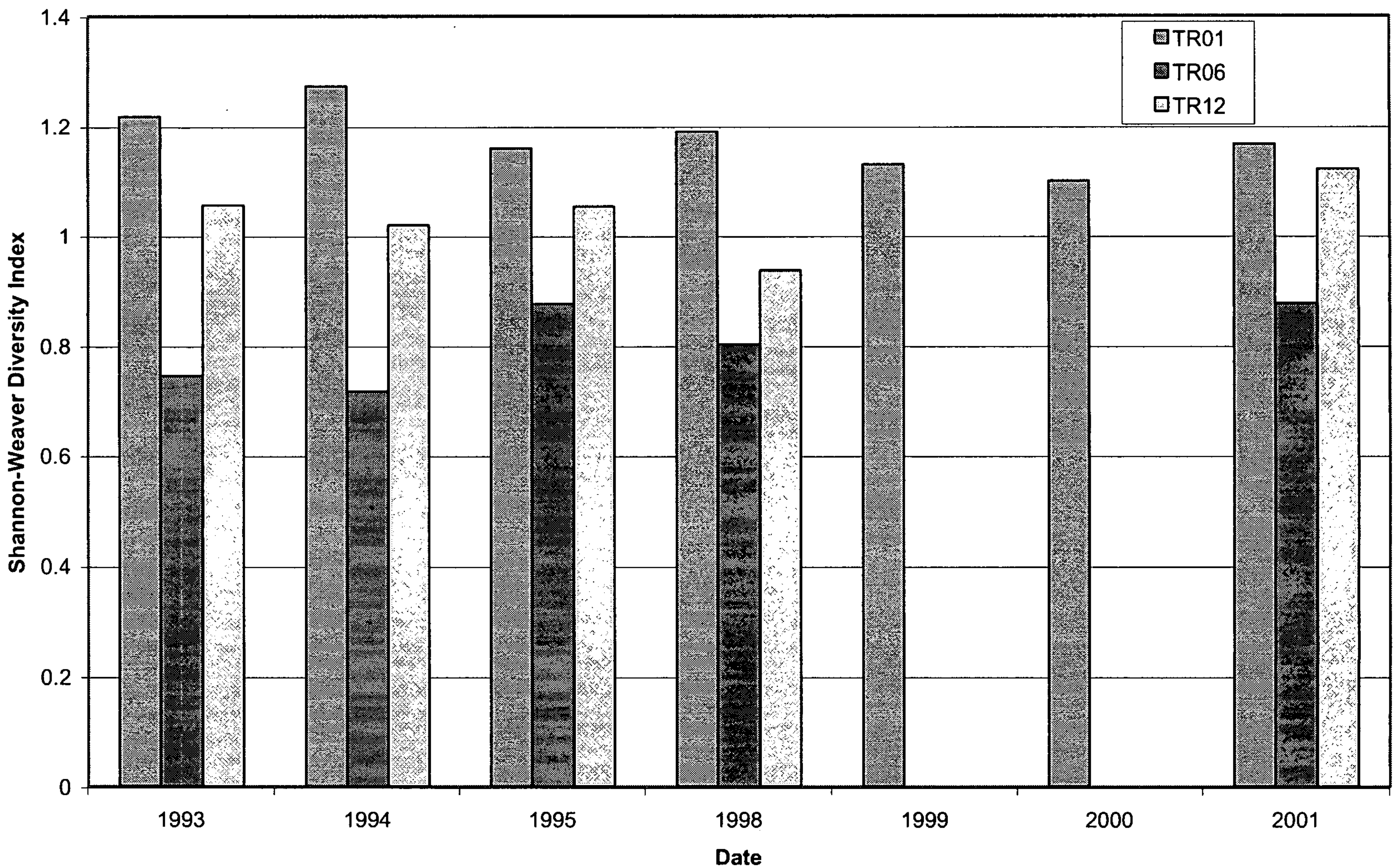
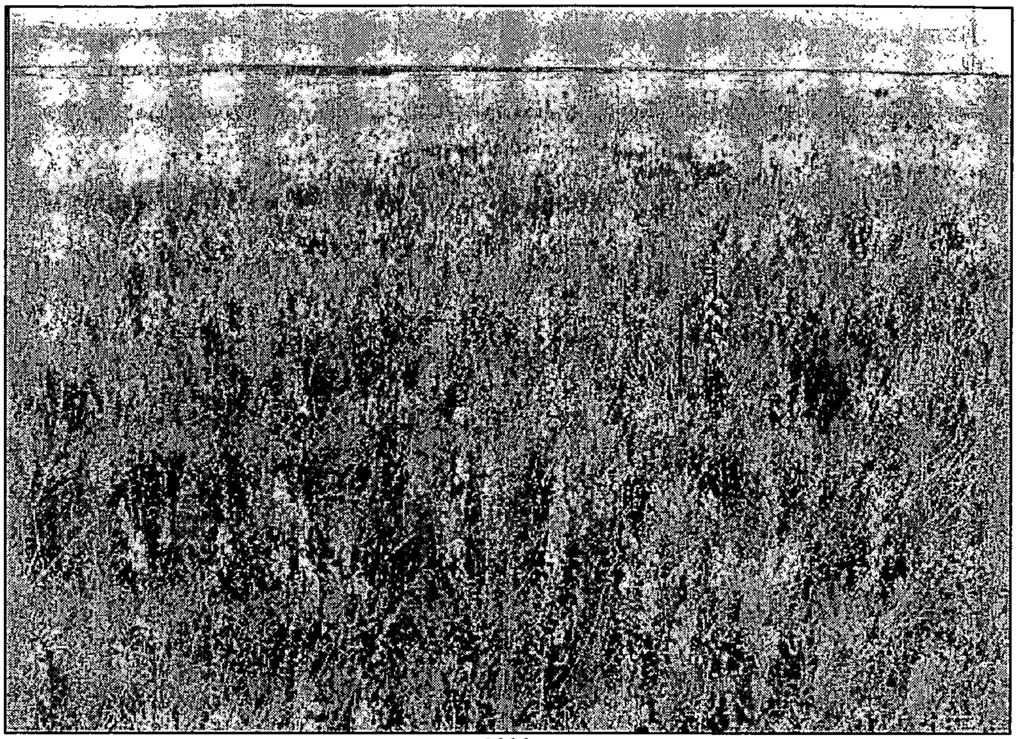
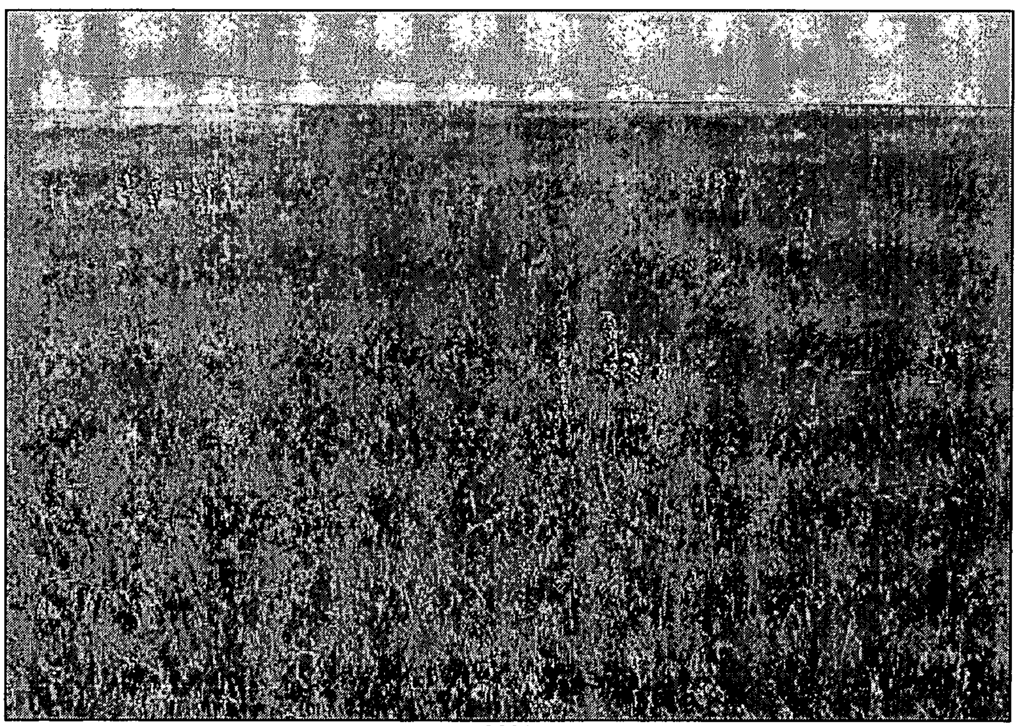


Figure 2-3. 1993-2001 Shannon-Weaver Diversity Indices - Xeric Mixed Grassland Summary





1999



2001

Figure 2-4. Dalmatian toadflax near TR06 site. The upper photo shows the infestation as of 1999. In spring 2000 the location was treated aerially with Tordon22K®. That summer little flowering was seen. In 2001, flowering and vigor of many of the plants continued to be inhibited by the herbicide and the fact that a late spring frost hit the plants.

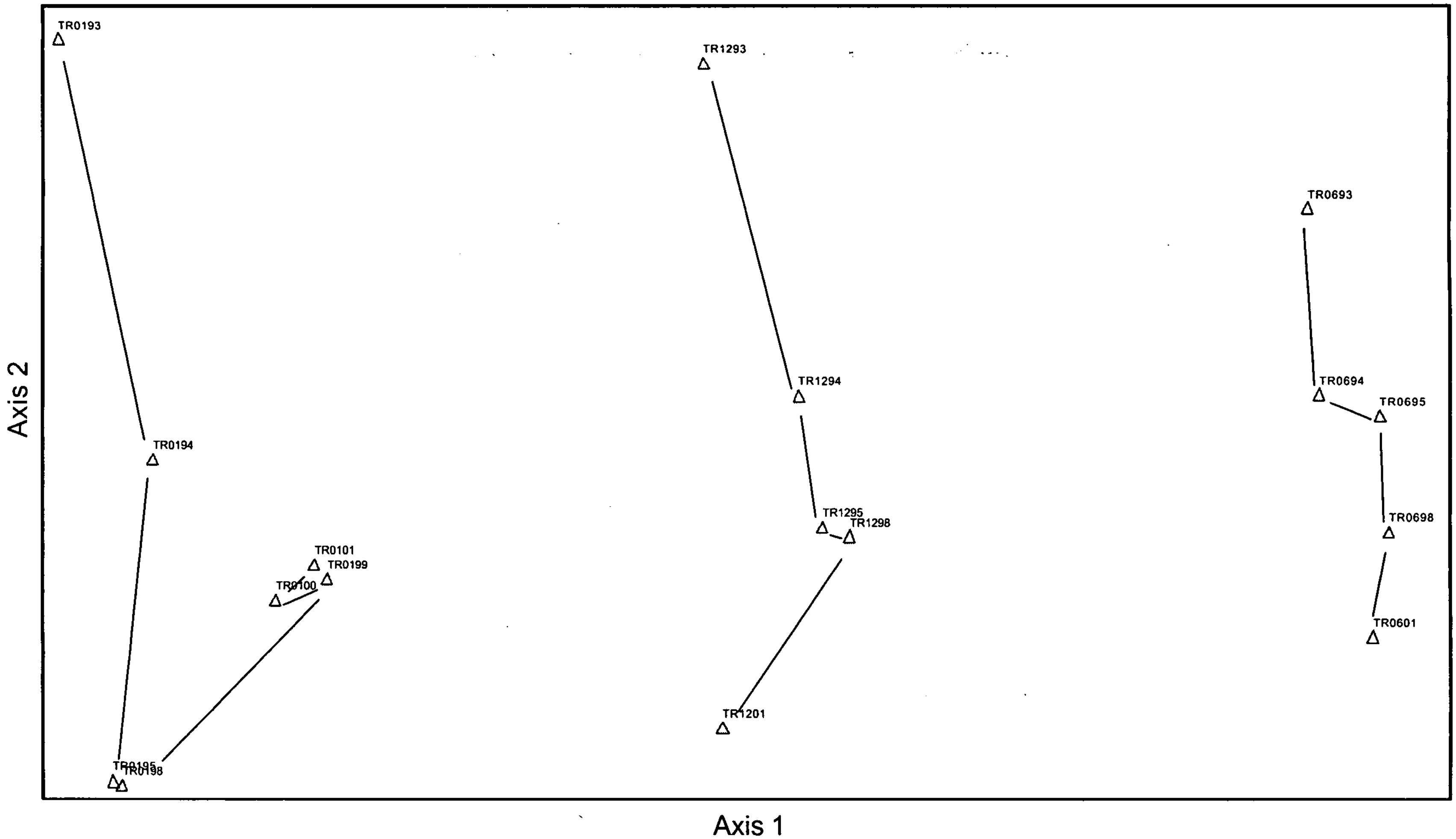
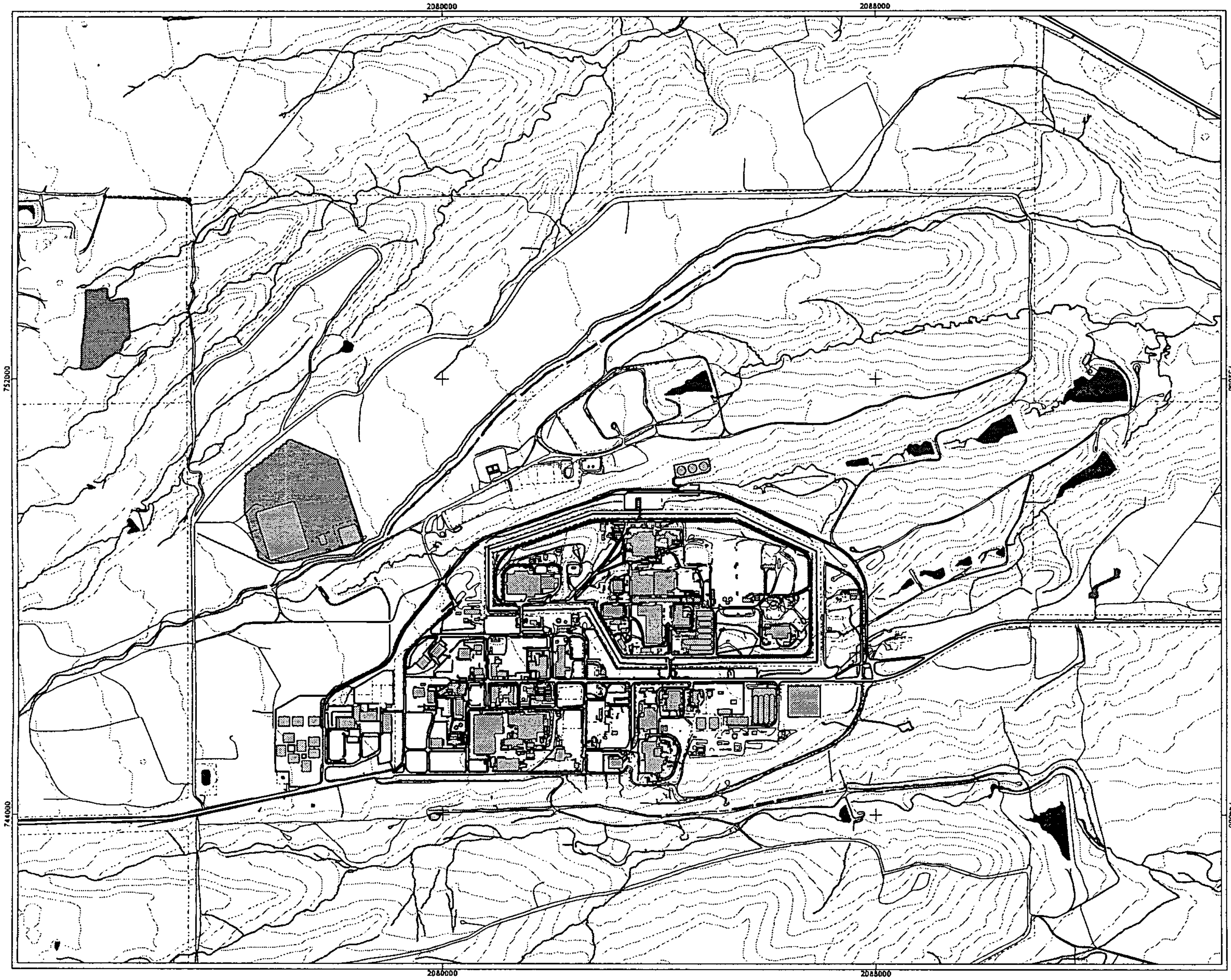



Figure 2-5. Detrended correspondence analysis (DCA). DCA results for TR01, TR06, and TR12 data from 1993-2001 (all available years per site). The first four digits of each site code stand for the site name (i.e. TR01). The last two numbers are the year of sampling (i.e. 2001 = 01).




## 2001 Ecological Disturbances in the Buffer Zone

Figure 3-1

### LEGEND

- Project Disturbance Locations
- Windblown Sand Deposition

### Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-9876.

N

1:15870

1000 0 1000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent®

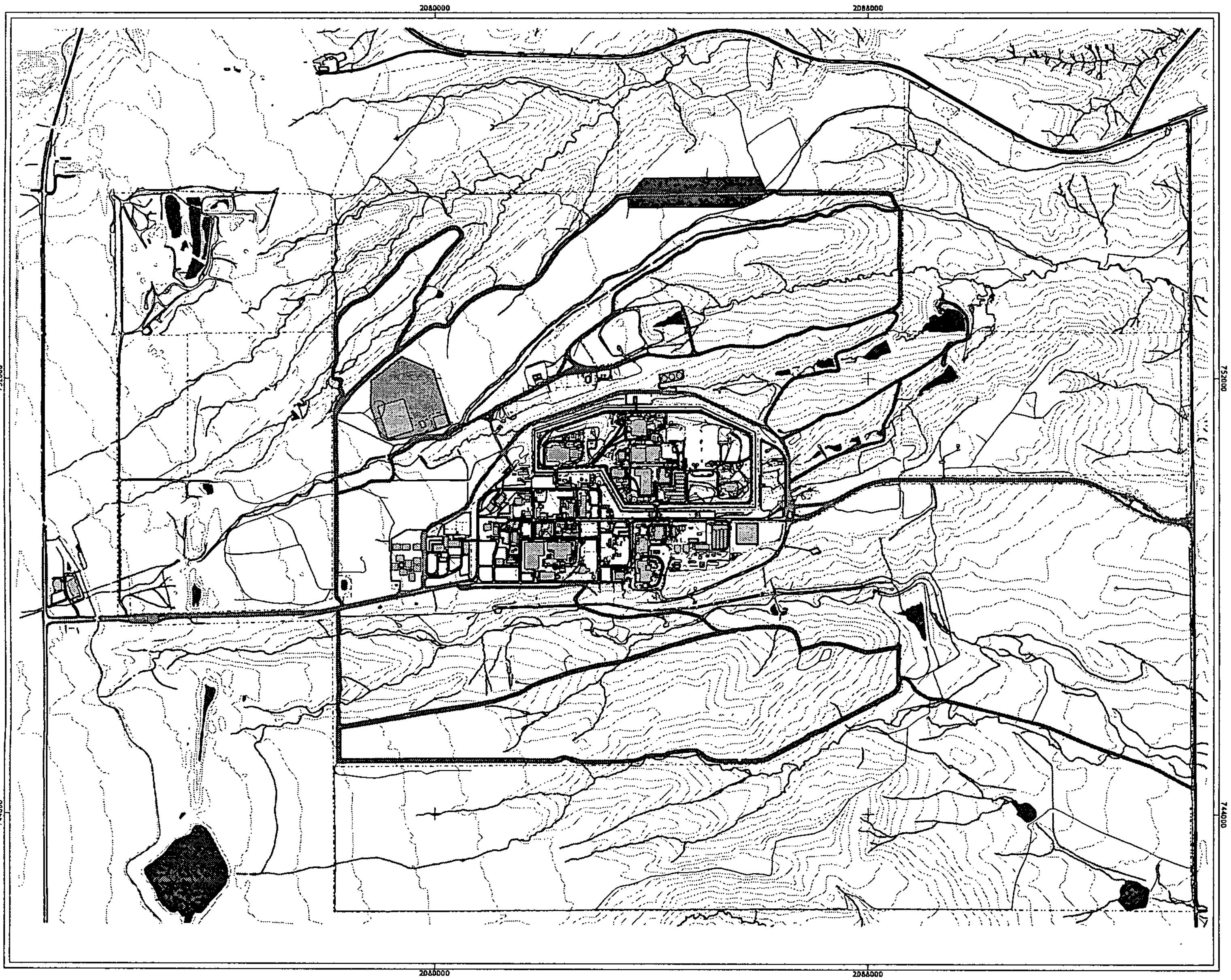
For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0168

December 3, 2001

\\Gis\\ArcGIS\\ECO-projects\\projects\\02-0168\\2001 disturbances.apr




# 2001 Road Grading and Mowing Areas

## Figure 3-2

### MAP LEGEND

- Annual Rye Mowing Locations
- Roadside Grading and Roadside Mowing Locations
- Roadside Mowing

### Standard Features

- Buildings
- Lakes & ponds
- Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-9876.
All locations are approximate.

N

1:23552

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

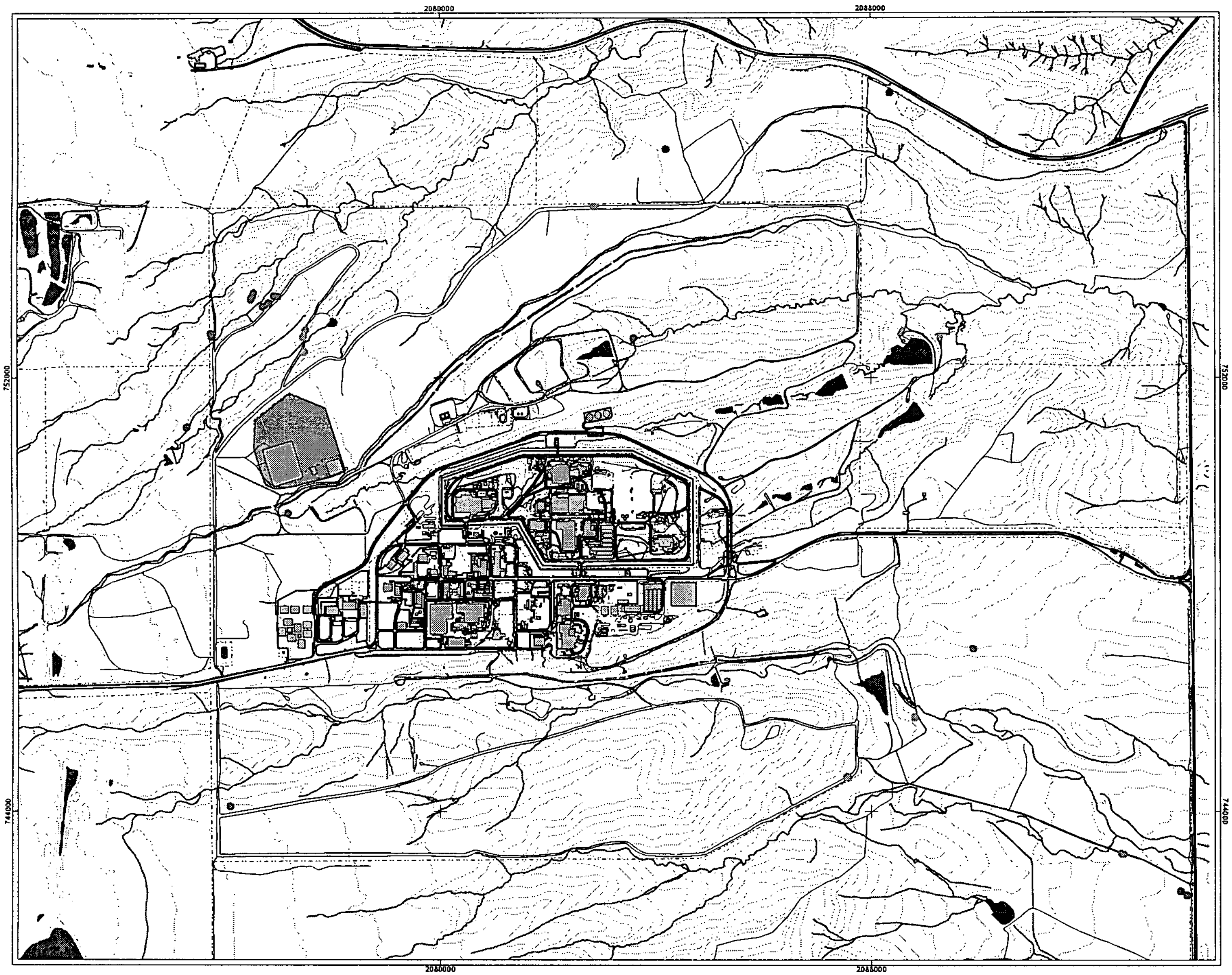
Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0174

December 4, 2001




## 2001 Biocontrol Release Locations

Figure 3-3

### LEGEND

- Larinus minutus
- Sphenoptera jugoslavica
- Mecinus janthinus
- Trichosirocalus horridus
- Cassida rubinginosa
- Aceria malherbae

### Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV. 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876.

N

1:20555

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent

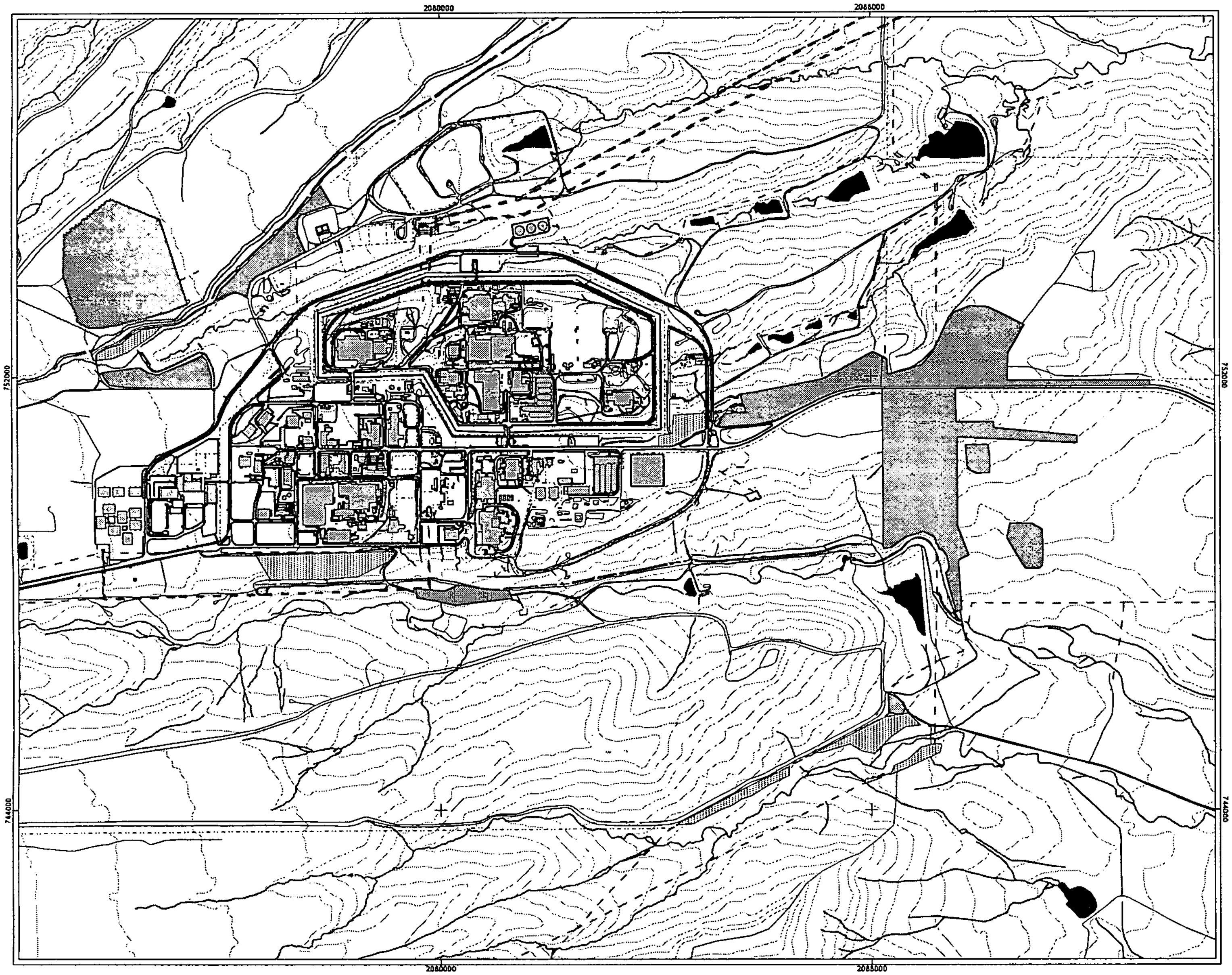
For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0167

December 3, 2001

Figure 3-4. Gall formed on a Canada thistle plant from the biocontrol agent, *Urophora carduii*, that was released at the Site during 2000. Monitoring in 2001 only found this single gall at the two release locations. However, continued monitoring in 2002 will determine whether more of the population survived.




# 2001 Ground Herbicide Application Locations (Broadcast)

## Figure 3-5

### MAP LEGEND

- Tordon 22K Locations
- Transline Locations
- Telar Locations

### Standard Features

- Buildings
- Lakes & ponds
- Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-8876.
All locations are approximate.

N

1:15125

1000 0 1000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

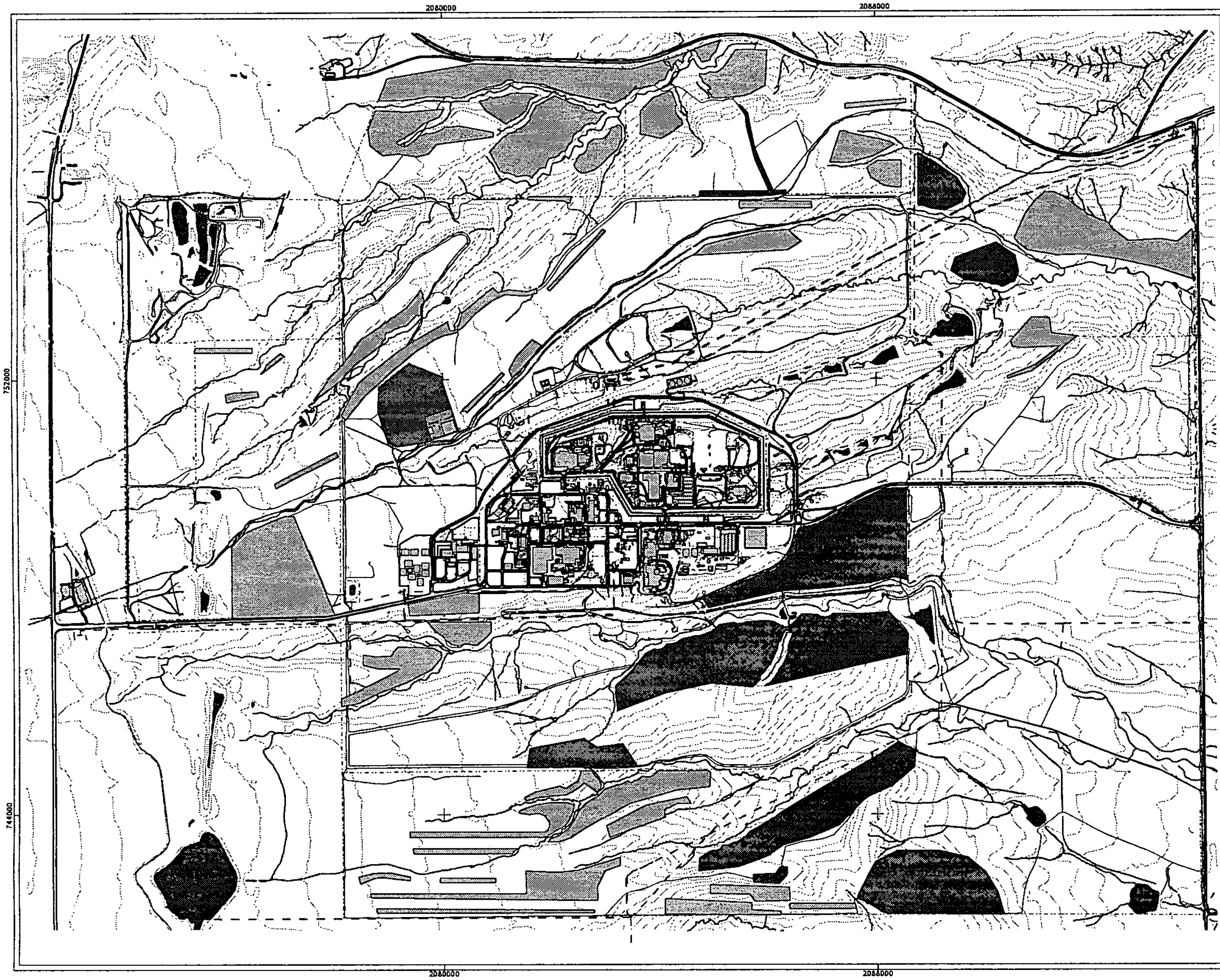
Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0174

December 4, 2001




# 2001 Aerial Herbicide Application Locations (Broadcast)

## Figure 3-6

### MAP LEGEND

- Tordon 22K Locations
- Transline Locations

### Standard Features

- Buildings
- Lakes & ponds
- Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours

**DATA SOURCE BASE FEATURES:**
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876.
All locations are approximate.

N

1:23552

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

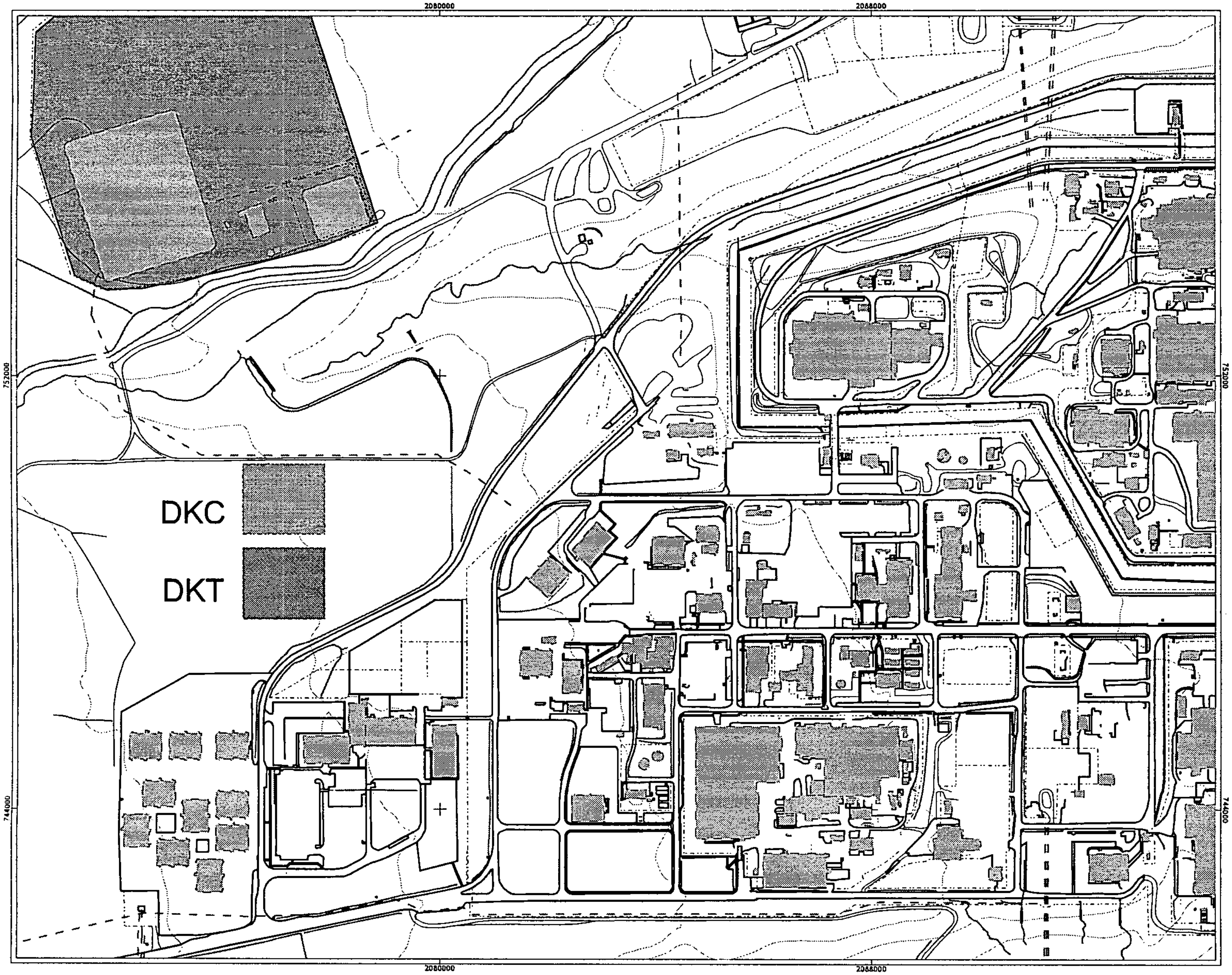
Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 02-0174

December 4, 2001




# Diffuse Knapweed Herbicide Monitoring Plot Locations

## Figure 4-1

**LEGEND**

- Control Plot
- Treatment Plot

**Standard Features**

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)
- Power Lines

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-9876.

N

1:5441

200 0 200 400 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 2k-0035

February 14, 2002

**Figure 4-2. Total Number of Species - Diffuse Knapweed Monitoring Study**

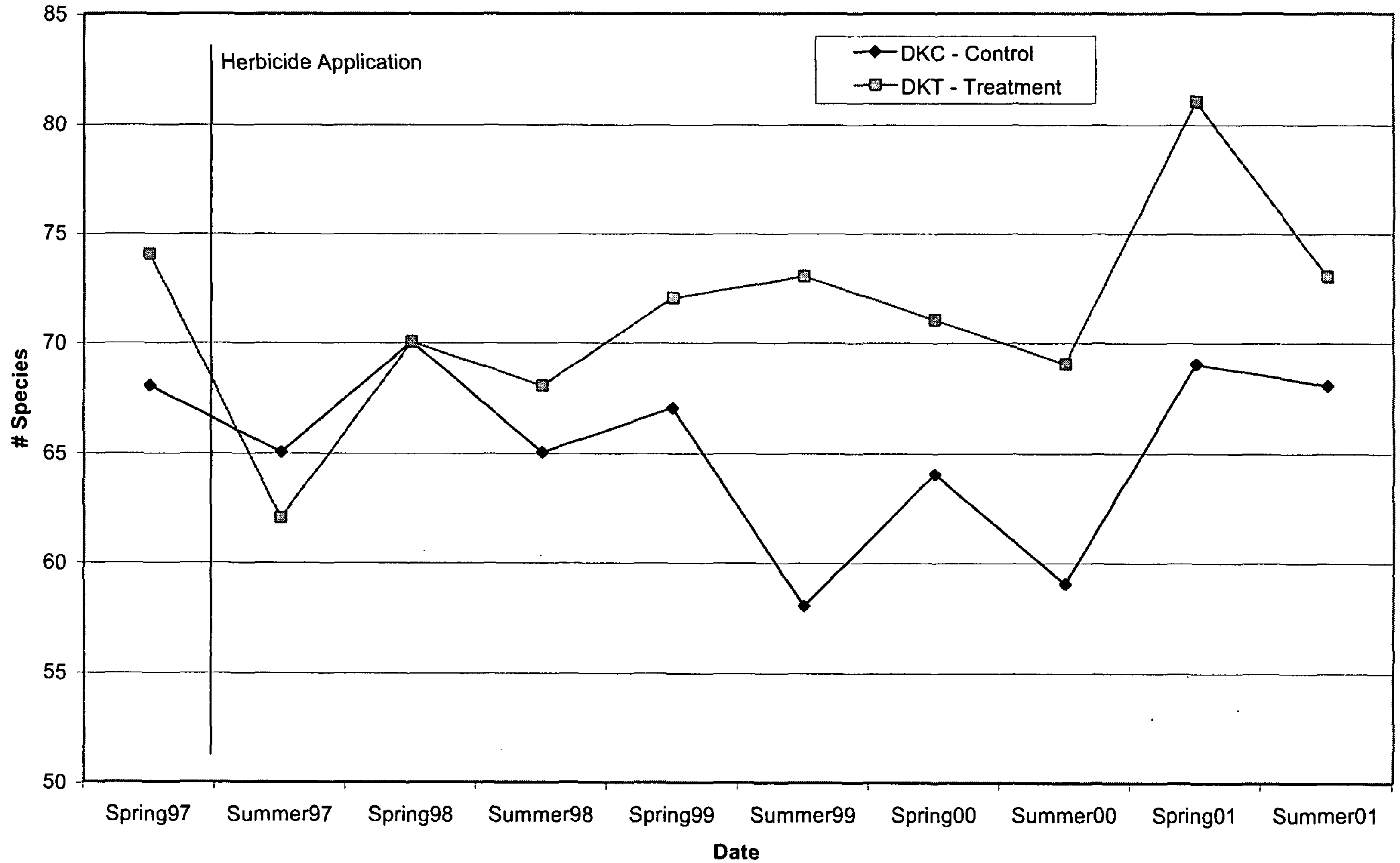


**Figure 4-3. Diffuse Knapweed Density Summary**

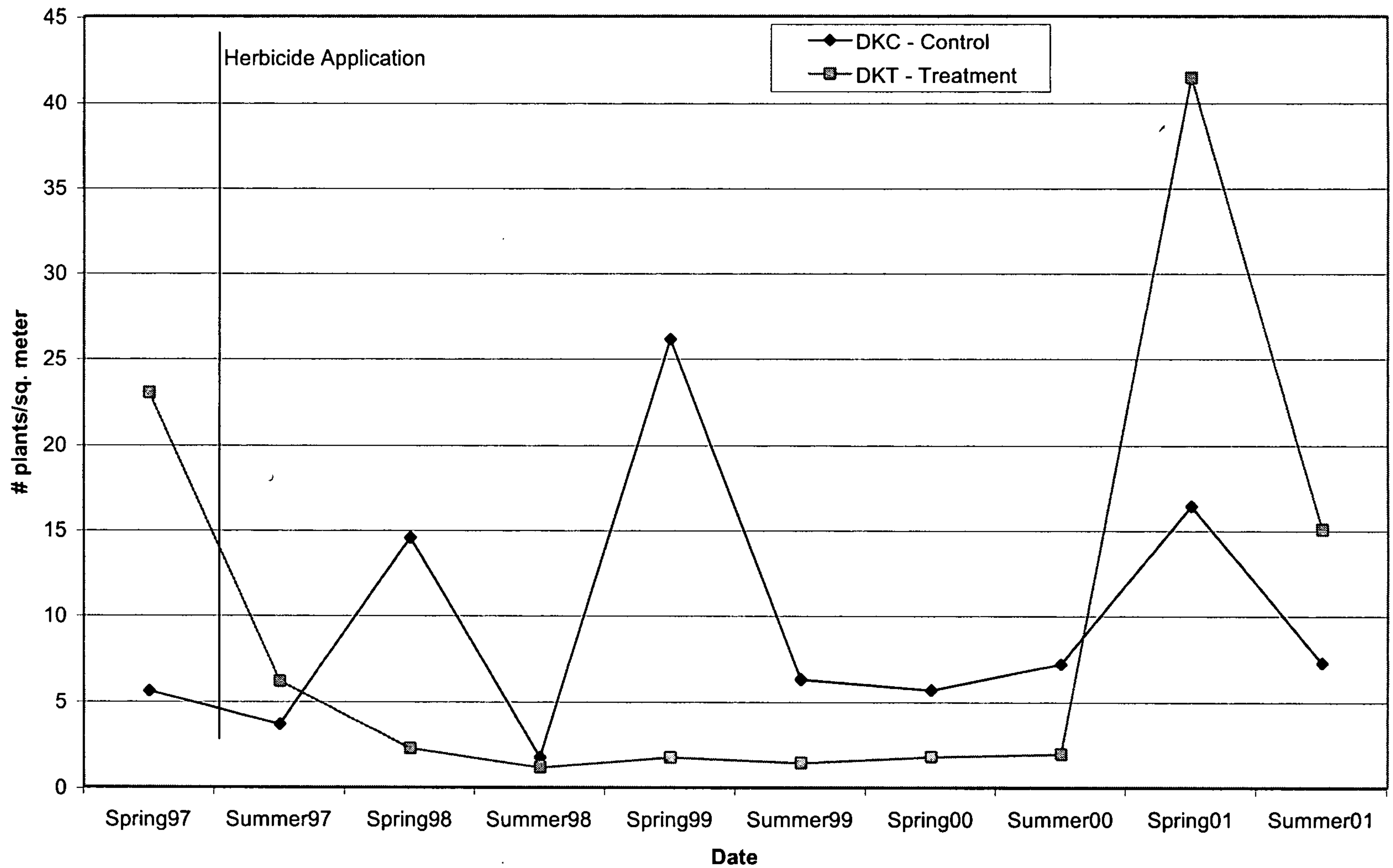


**Figure 4-4. Diffuse Knapweed Frequency - Diffuse Knapweed Monitoring Study**

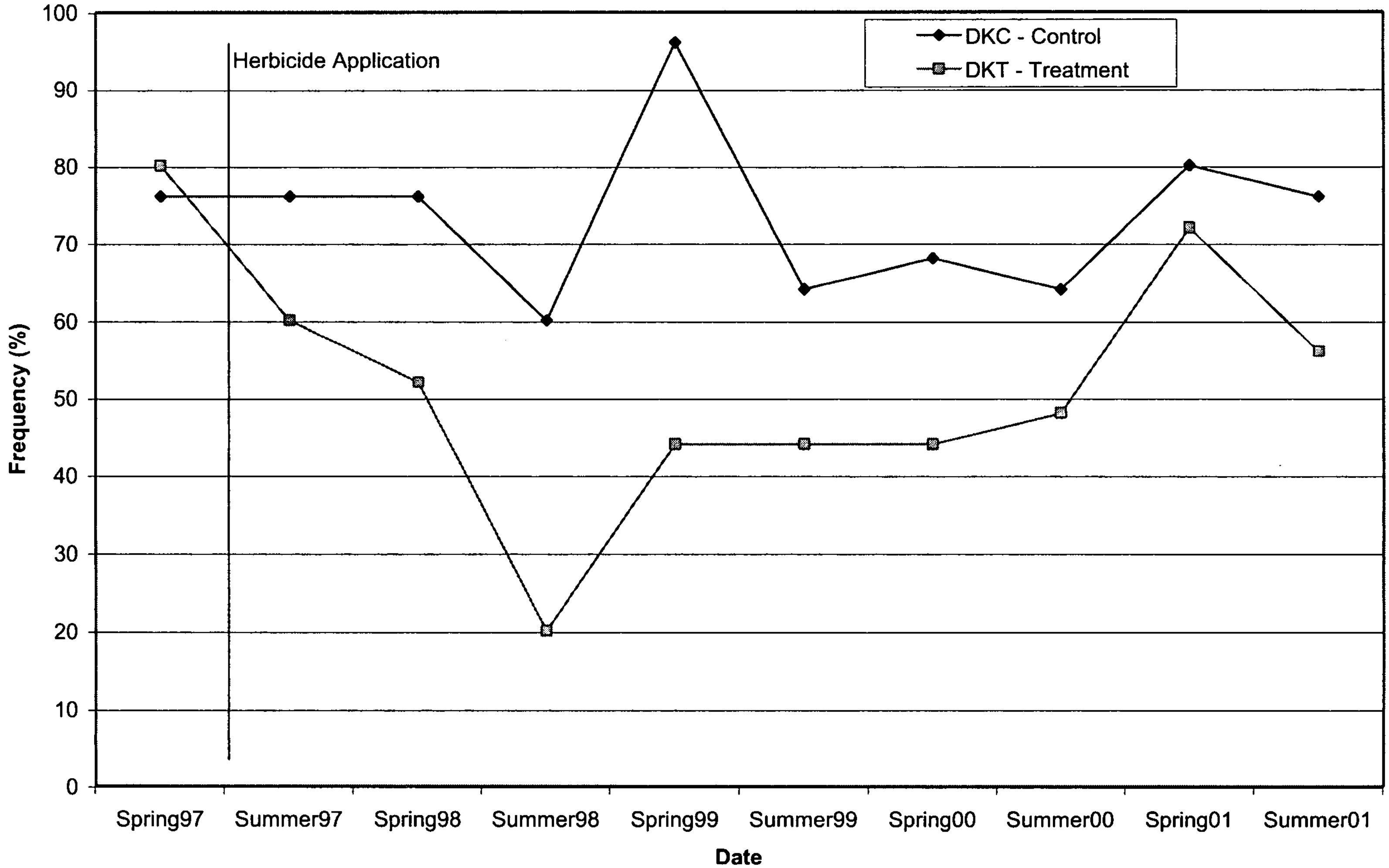


**Figure 4-5. Absolute Diffuse Knapweed Cover - Diffuse Knapweed Monitoring Study**

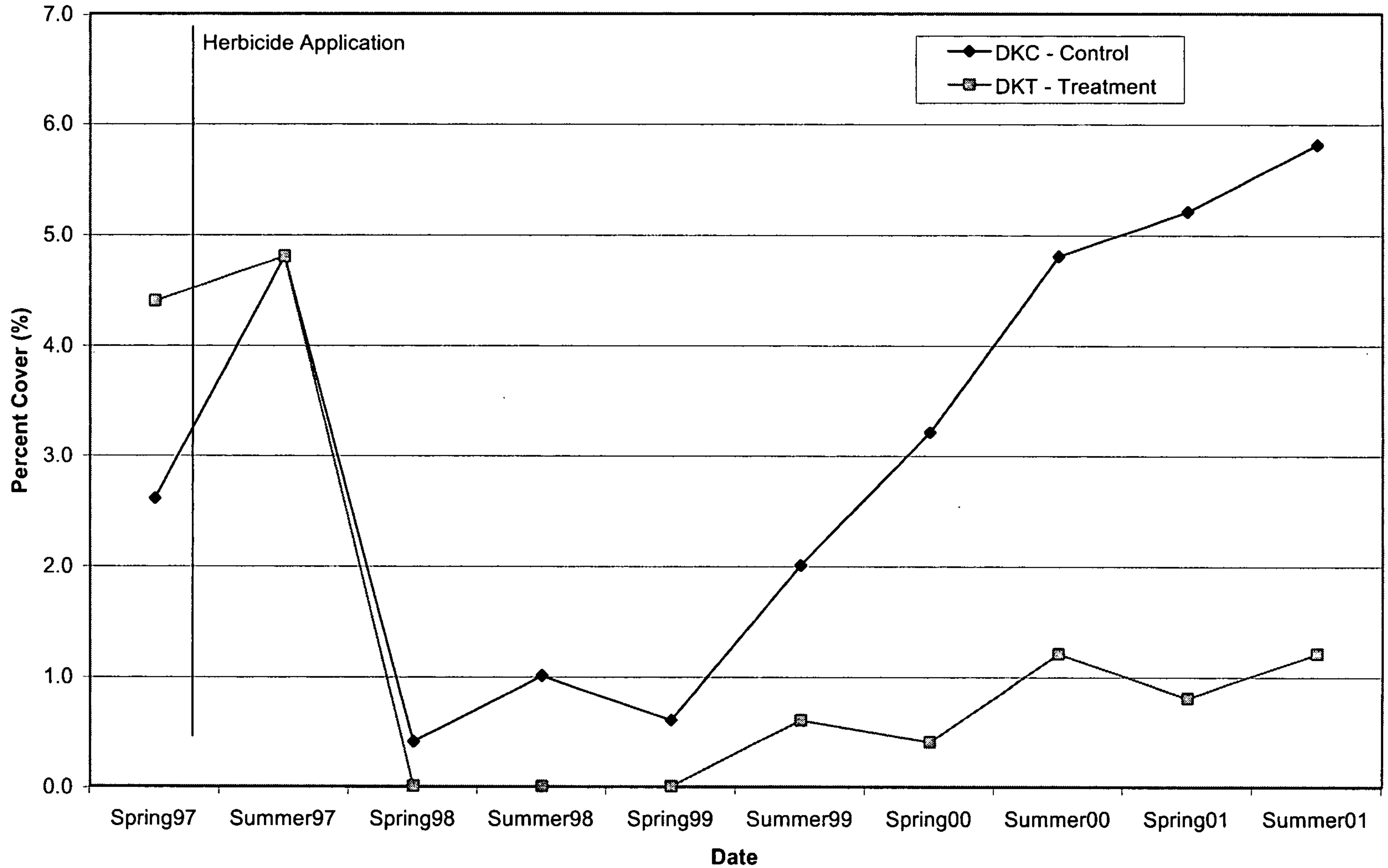


**Figure 4-6. *Opuntia macorhiza* Density Summary**

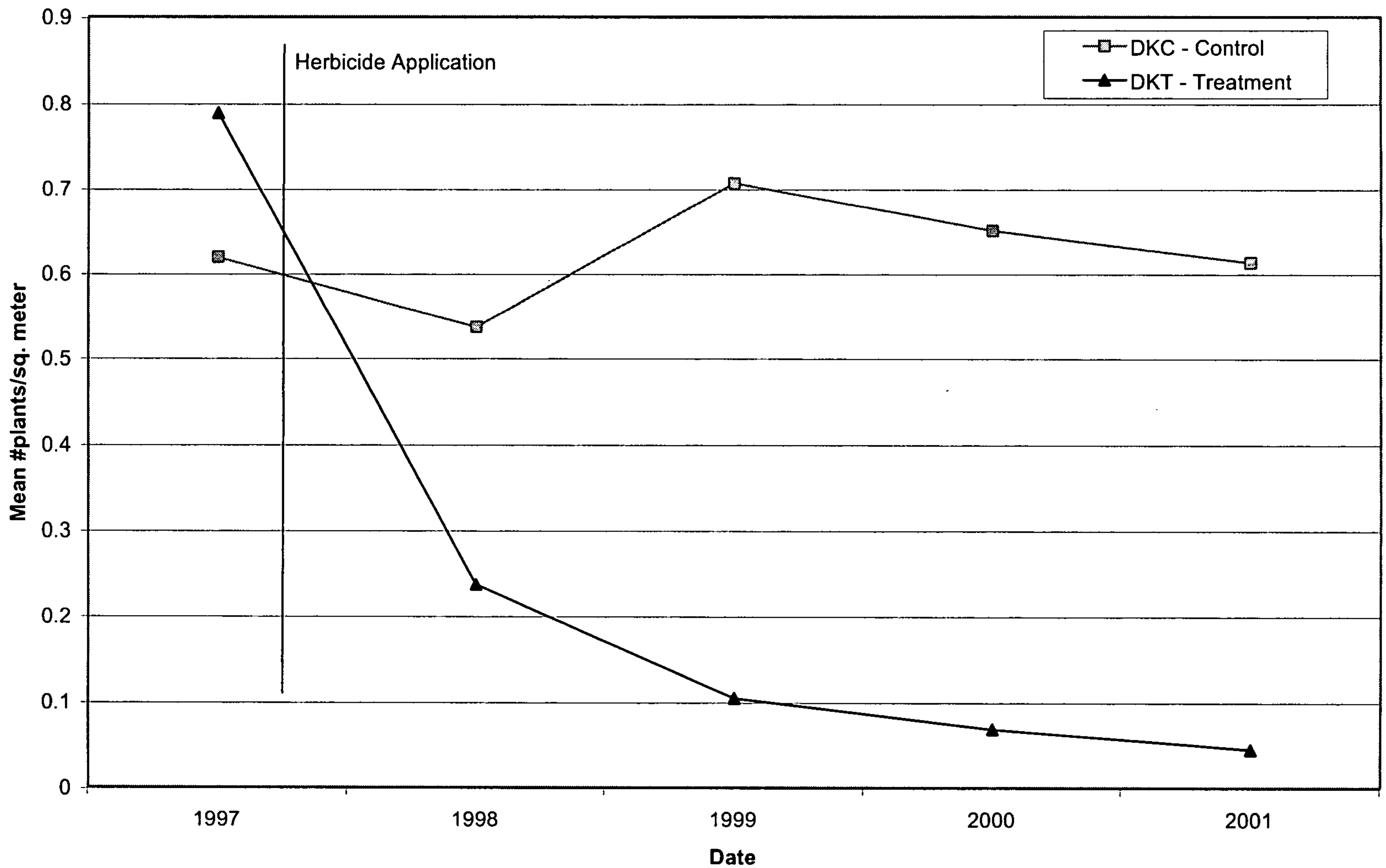


**Figure 4-7. *Echinocereus viridiflorus* Density Summary**

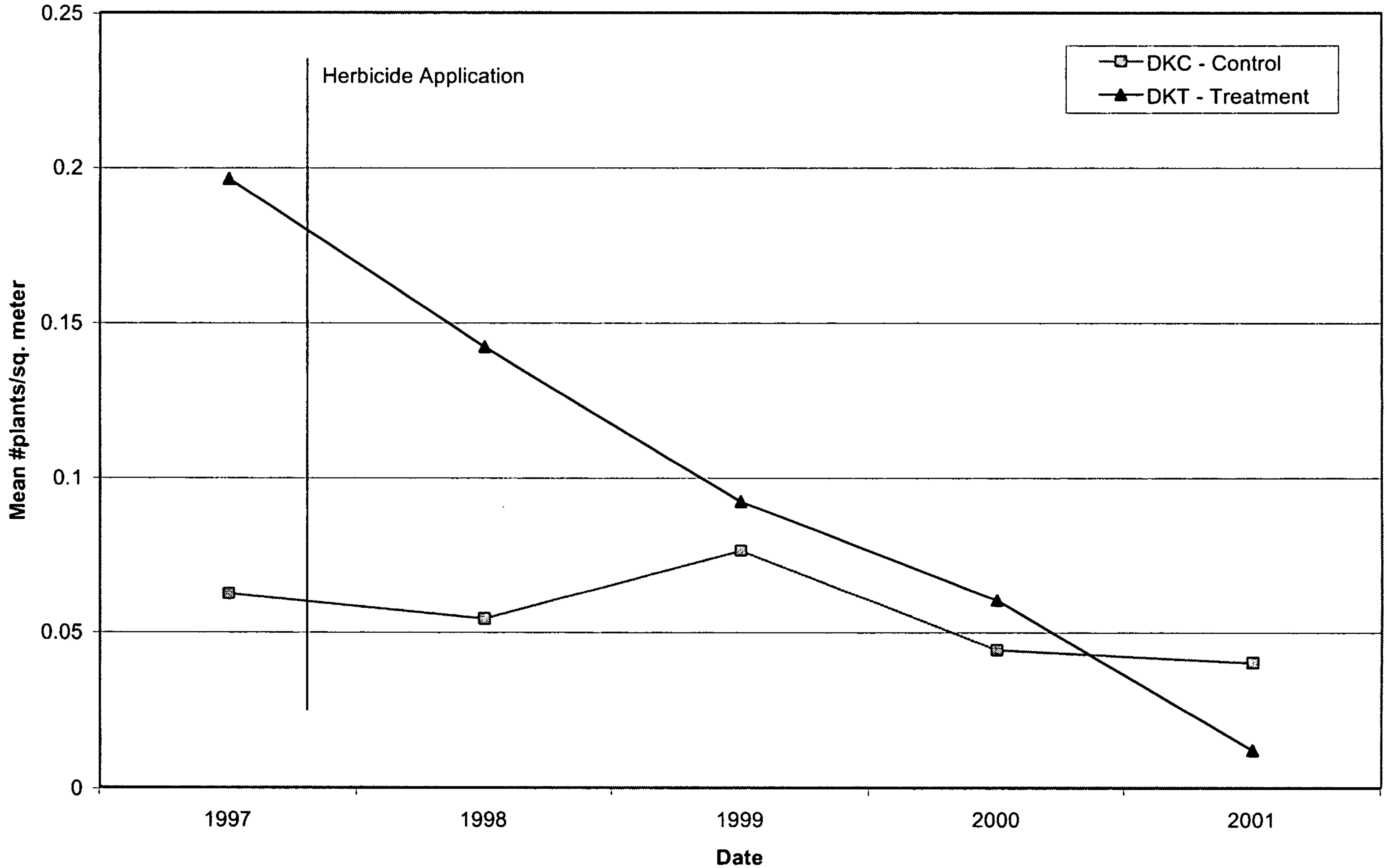


**Figure 4-8. Shannon-Weaver Index Summary - Diffuse Knapweed Monitoring**

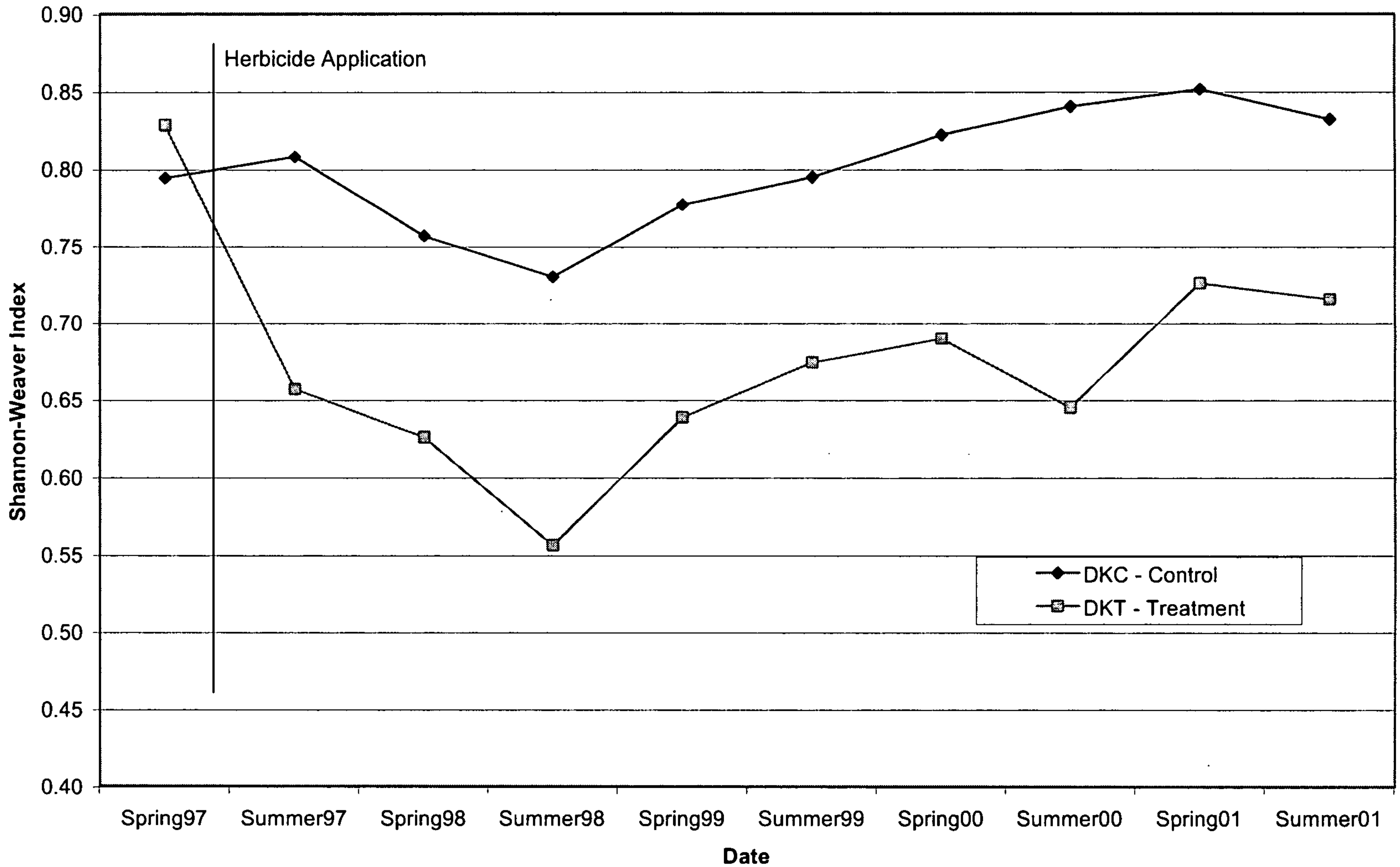


**Figure 4-9. Total Foliar Cover - Diffuse Knapweed Monitoring Study**

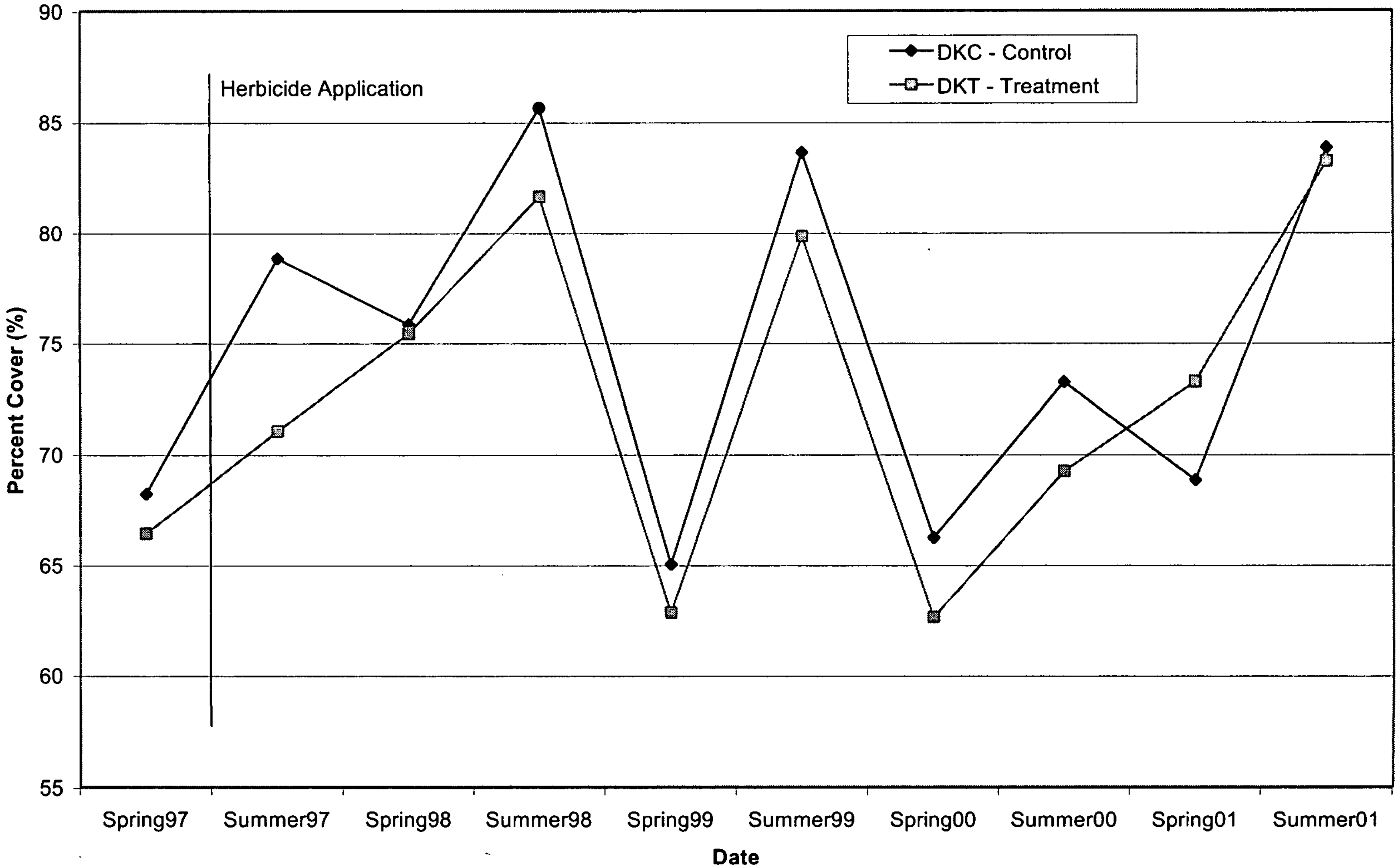


**Figure 4-10. Absolute Forb Cover - Diffuse Knapweed Monitoring Study**

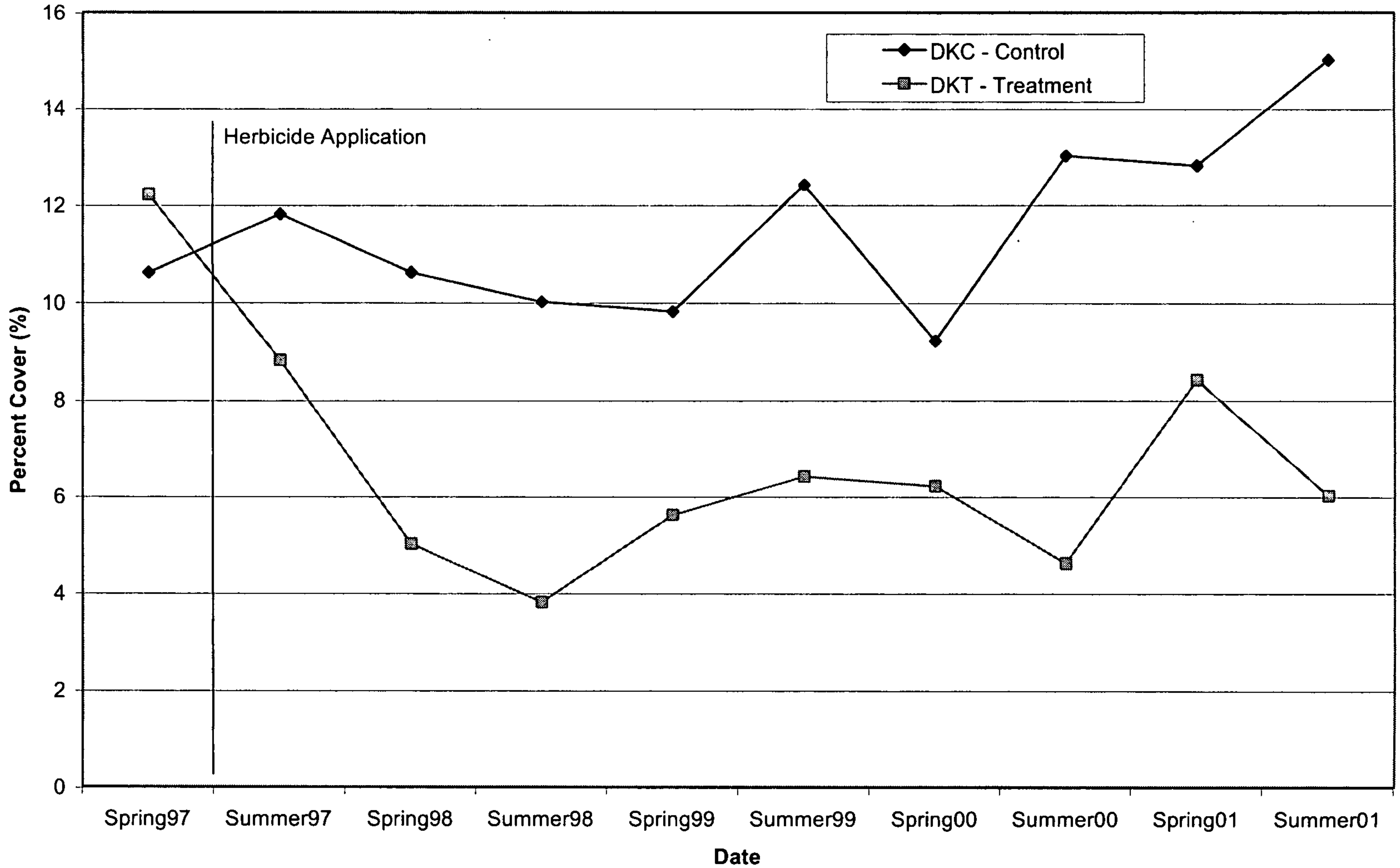


**Figure 4-11. Absolute Native vs. Non-Native Forb Cover - Diffuse Knapweed Monitoring Study**

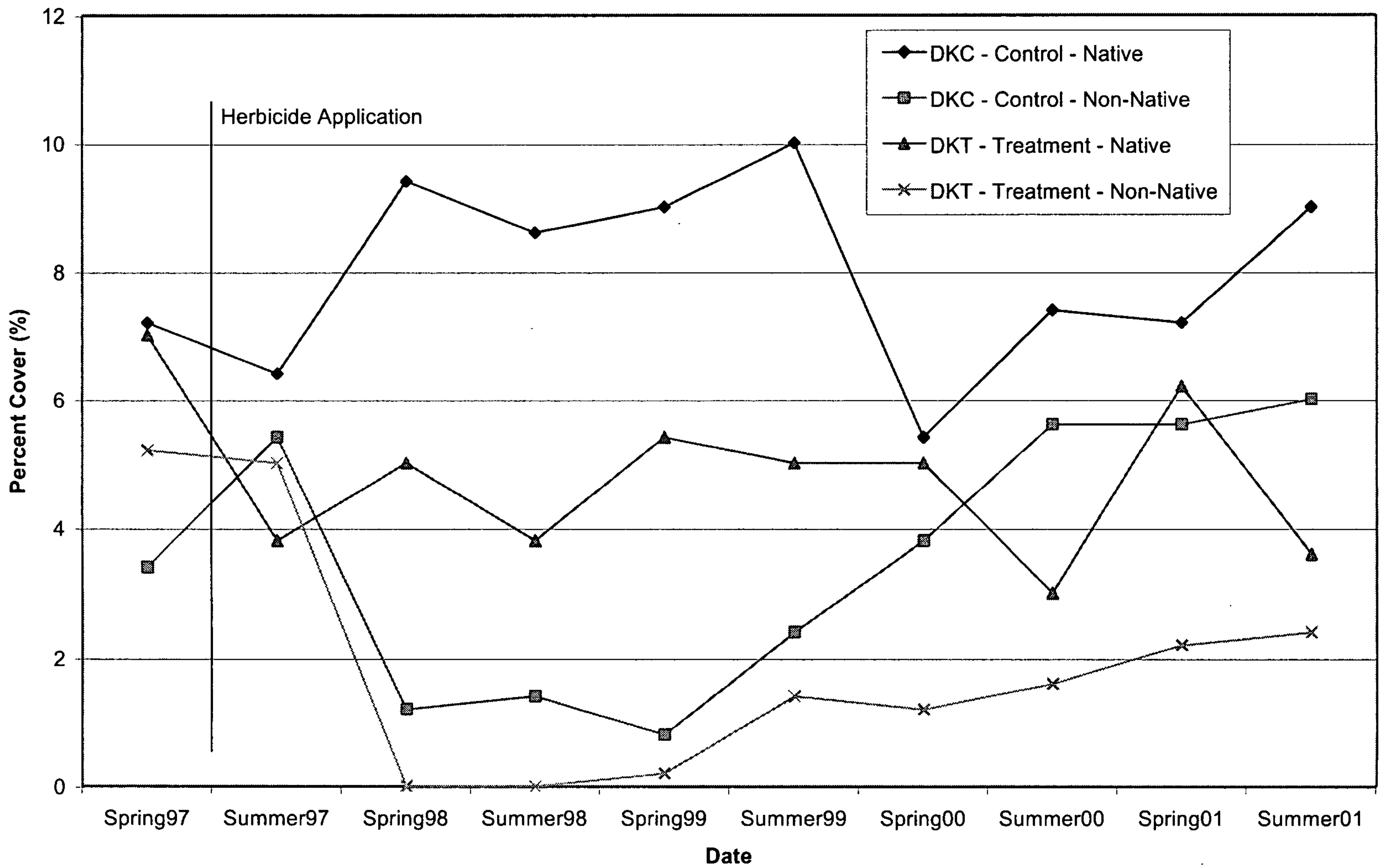


Figure 4-12. Absolute Graminoid Cover - Diffuse Knapweed Monitoring Study

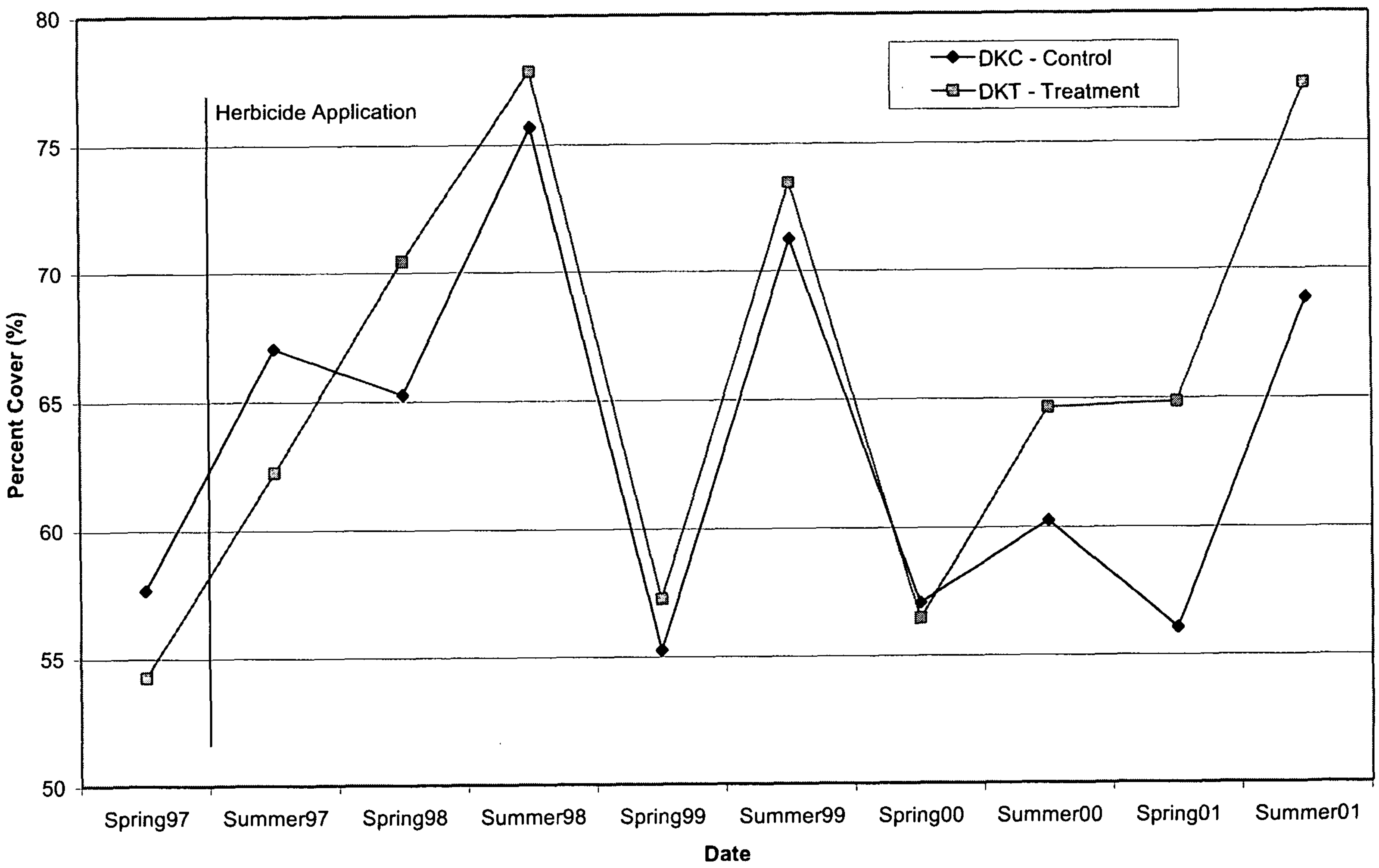
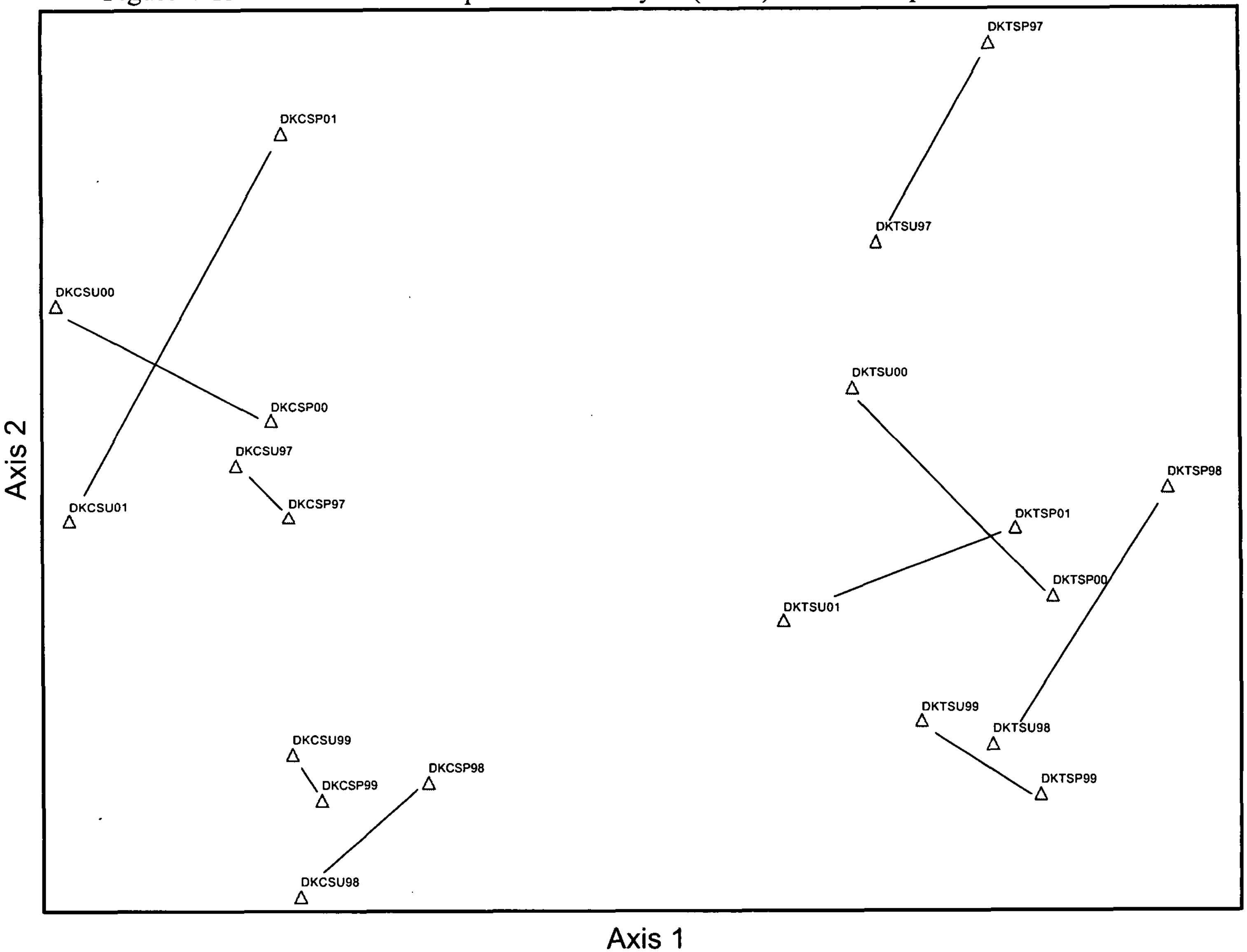
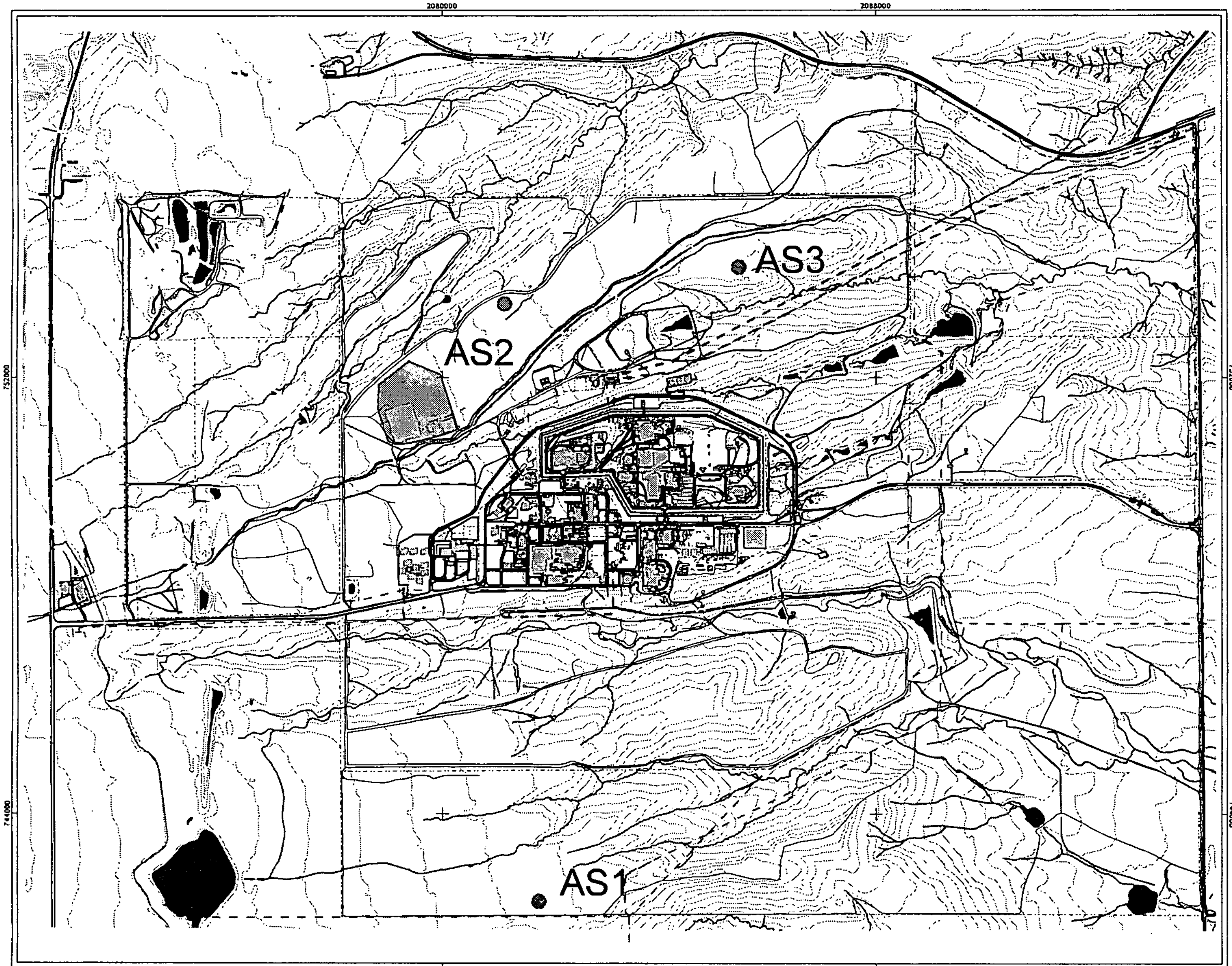


Figure 4-13. Detrended Correspondence Analysis (DCA) Results – Species Cover Data




Note: Code represent the site, season, and year of sampling. DKC = Control plot, DKT = Treatment plot, SP = Spring, SU = Summer, Numbers at end of code are the year of sampling. For example: DKTSU01 = Site:DKT (treatment plot), SU = Summer, 01 = 2001.




# Aerial Herbicide Monitoring Plot Locations

## Figure 5-1

**LEGEND**

- Control Plot

**Standard Features**

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)
- Power Lines

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-8876.

N

1:23552

1000 0 1000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent
For: Kaiser-Hill Company, LLC

MAP ID: 2k-0038
RFETS GIS Dept. 303-966-7707
February 14, 2002

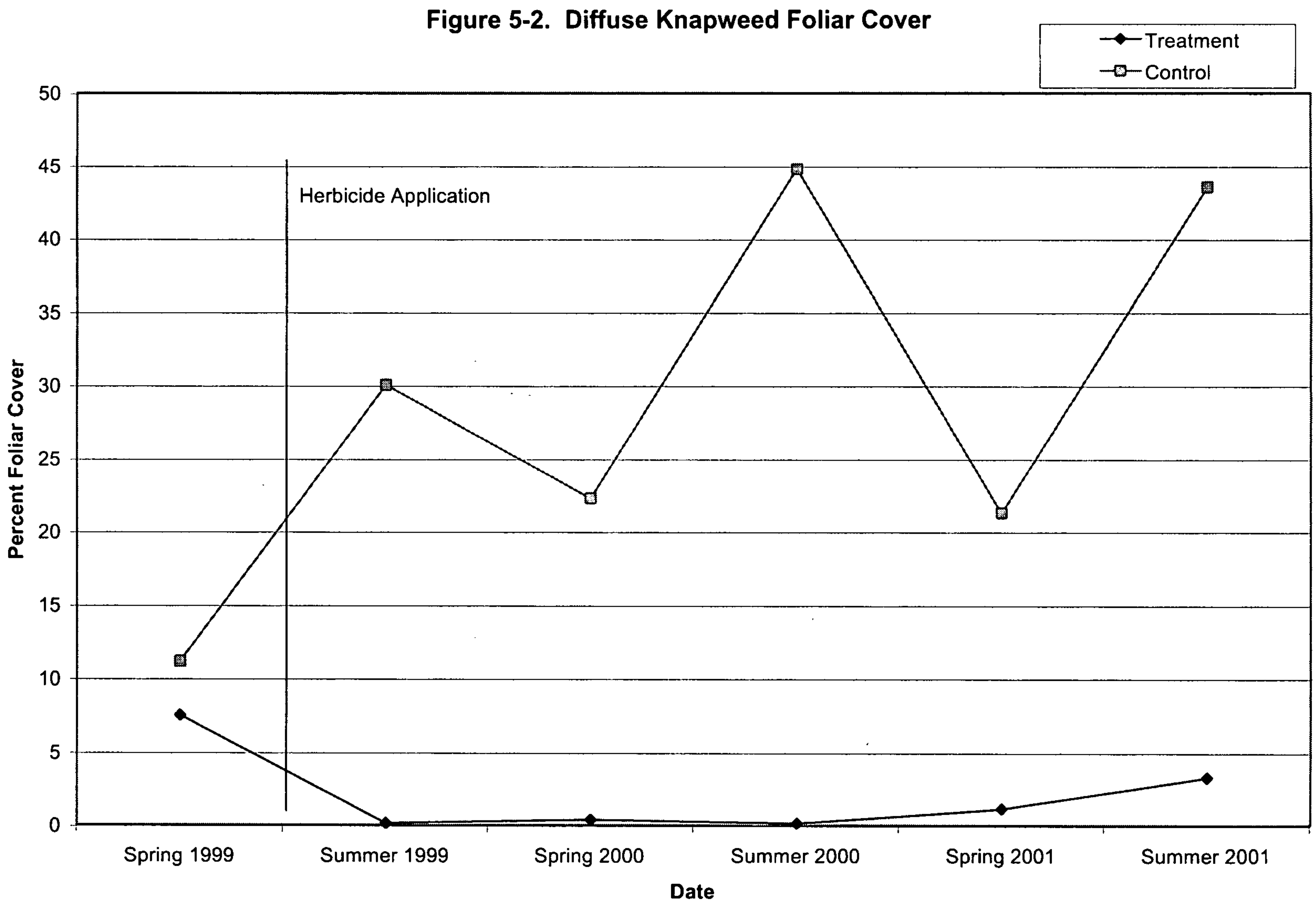
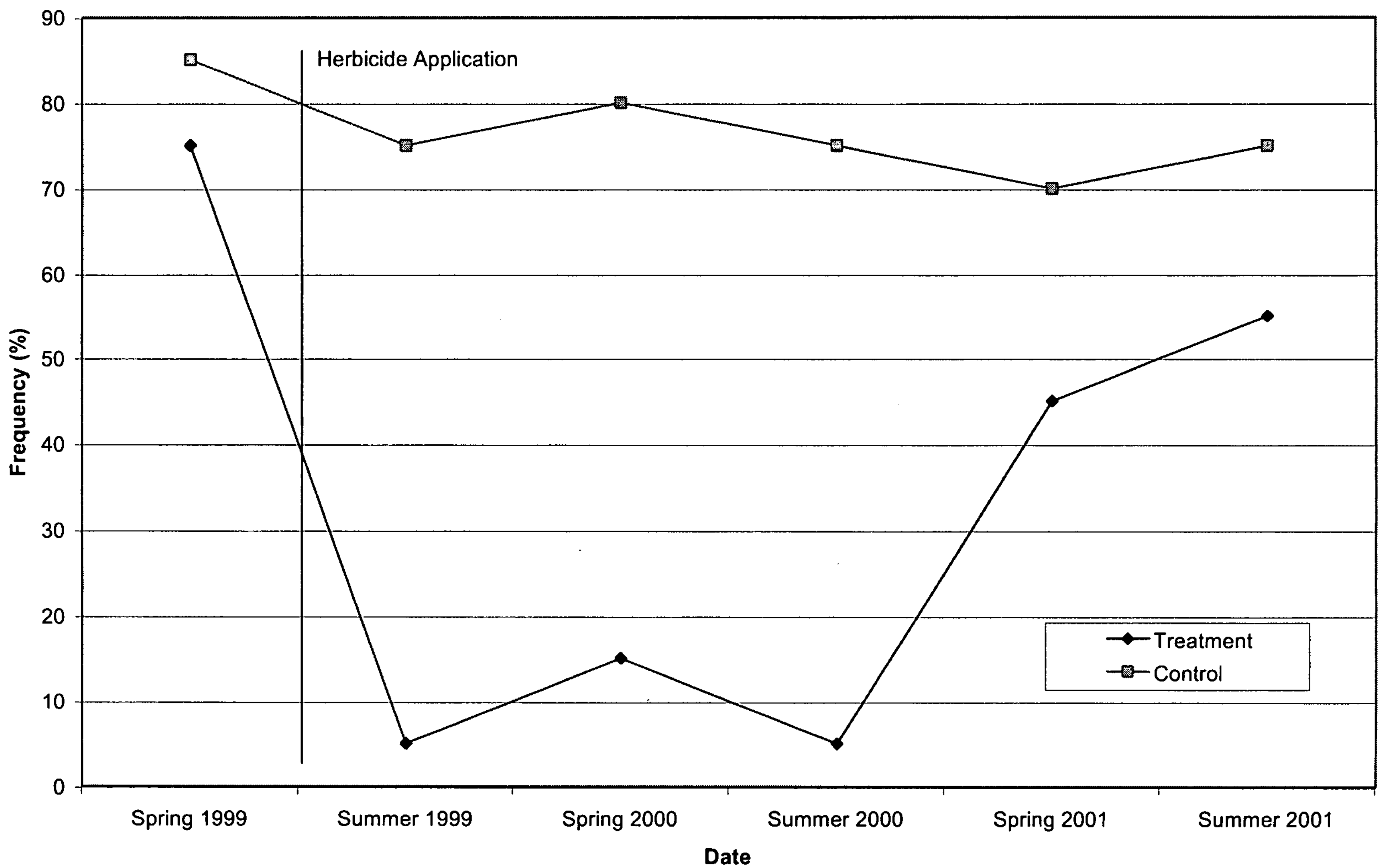
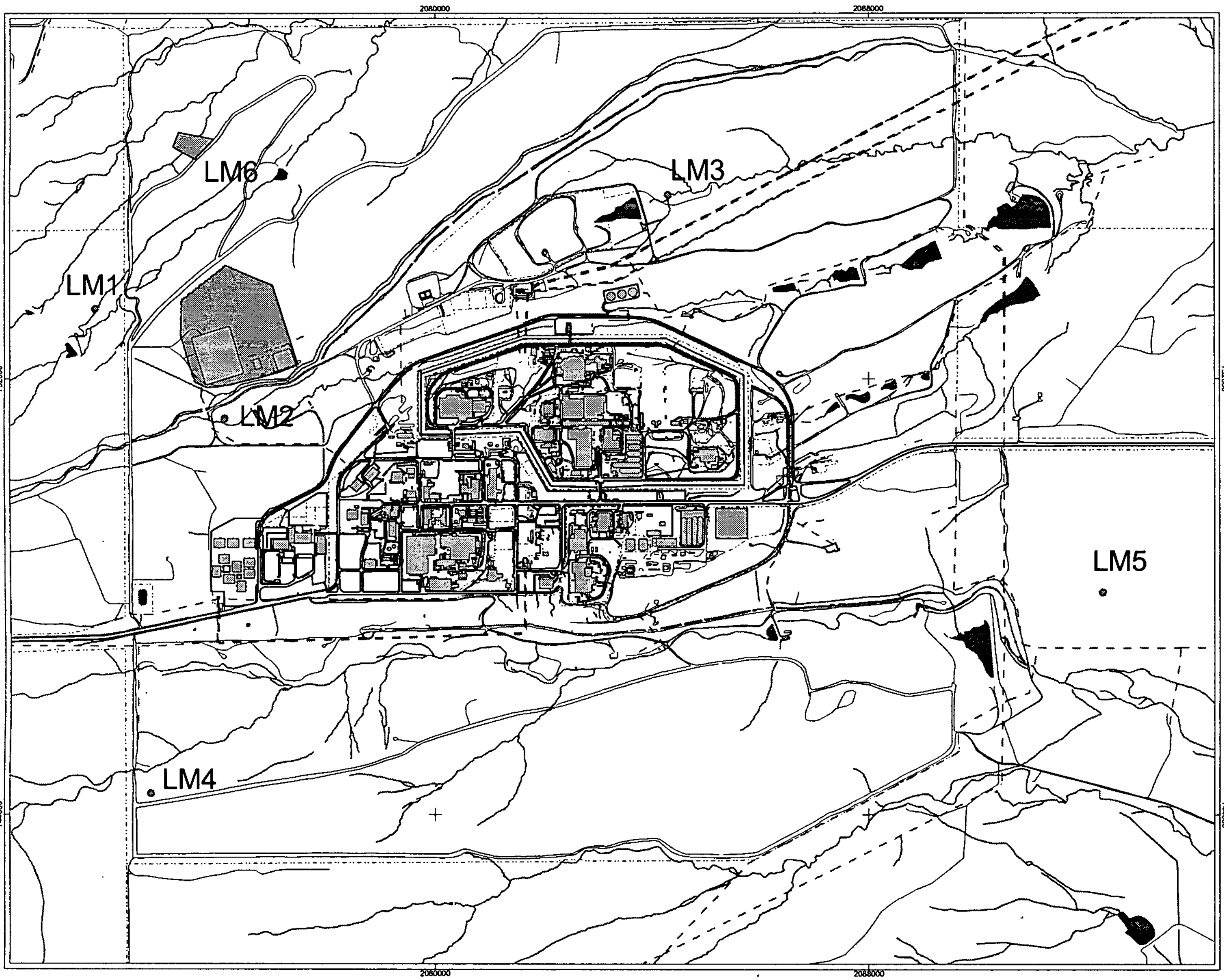


Figure 5-2. Diffuse Knapweed Foliar Cover
Treatment
Control
50
45
40
35
30
25
20
15
10
5
0
Percent Foliar Cover
Herbicide Application
Spring 1999
Summer 1999
Spring 2000
Summer 2000
Spring 2001
Summer 2001
Date

**Figure 5-3. Diffuse Knapweed Frequency**






## Larinus minutus Biocontrol Release and Monitoring Locations 2001

Figure 6-1

### LEGEND

- Larinus minutus monitoring locations
- Texas A&M monitoring location

### Standard Features

- Buildings
- Lakes & ponds
- New Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)
- Power Lines

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karen North 303-966-9876.

N

1:16129

1000 0 1000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

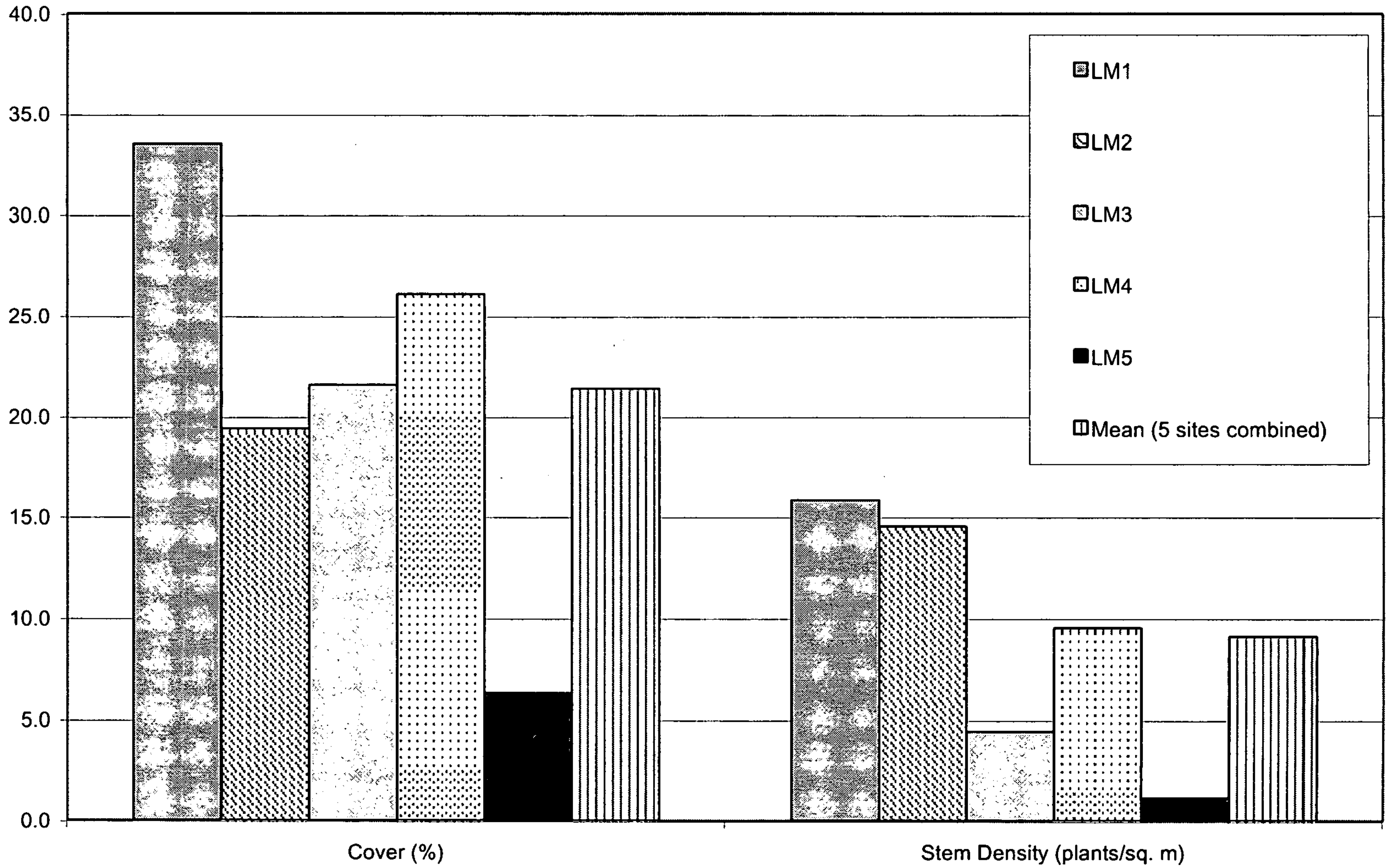
Prepared by: Exponent® For: Kaiser-Hill Company, LLC

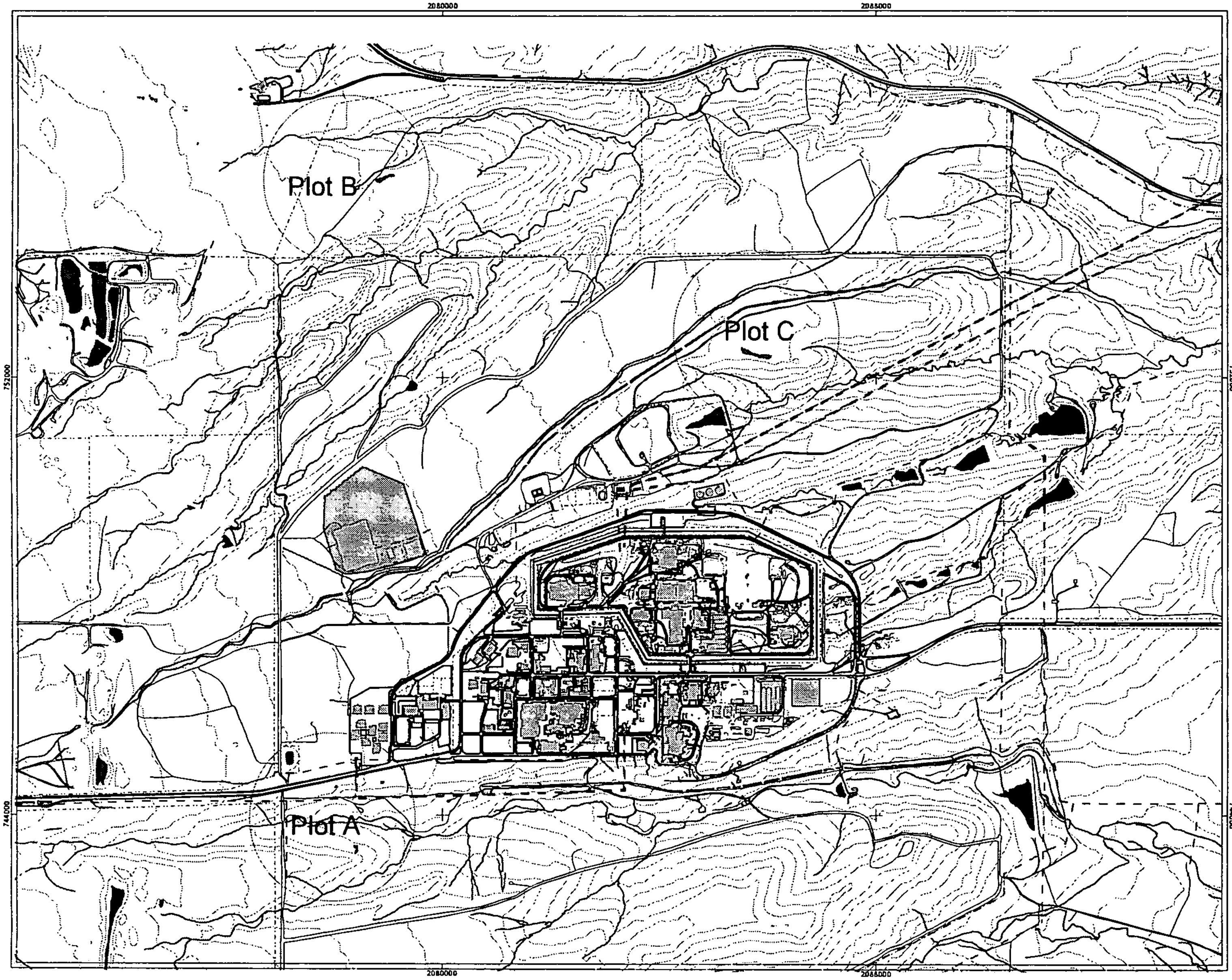
RFETS GIS Dept. 303-966-7707

MAP ID: 02-0067 November 26, 2001

\\Gissrv\GIS\ECO-projects\projects\02-0067\2001biocontrol.apr

**Figure 6-2. Diffuse Knapweed Cover and Density - Biocontrol Release Locations**






# Diffuse Knapweed Movement Study Plot Locations

## Figure 7-1

LEGEND

Diffuse Knapweed Plots

Standard Features

- Buildings
- Lakes & ponds
- Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)
- Power Lines

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-9876.

N

1:18429

1000 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent®

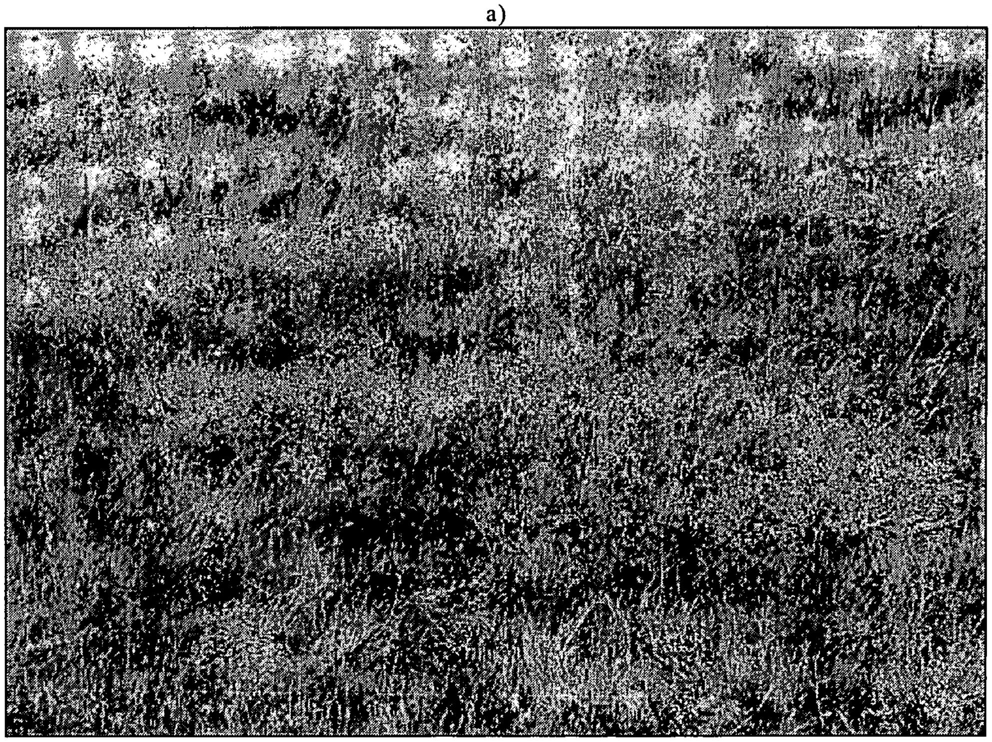
For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 01-0096

February 14, 2002

a)



b)

Figure 7-2. Painted diffuse knapweed plants. a) An individual diffuse knapweed plant after marking with red spray paint and pink flagging. b) A patch of marked diffuse knapweed plants waiting to be blown away in the winter winds.

**Figure 7-3. Percentage of Diffuse Knapweed Plants That Blew Away**

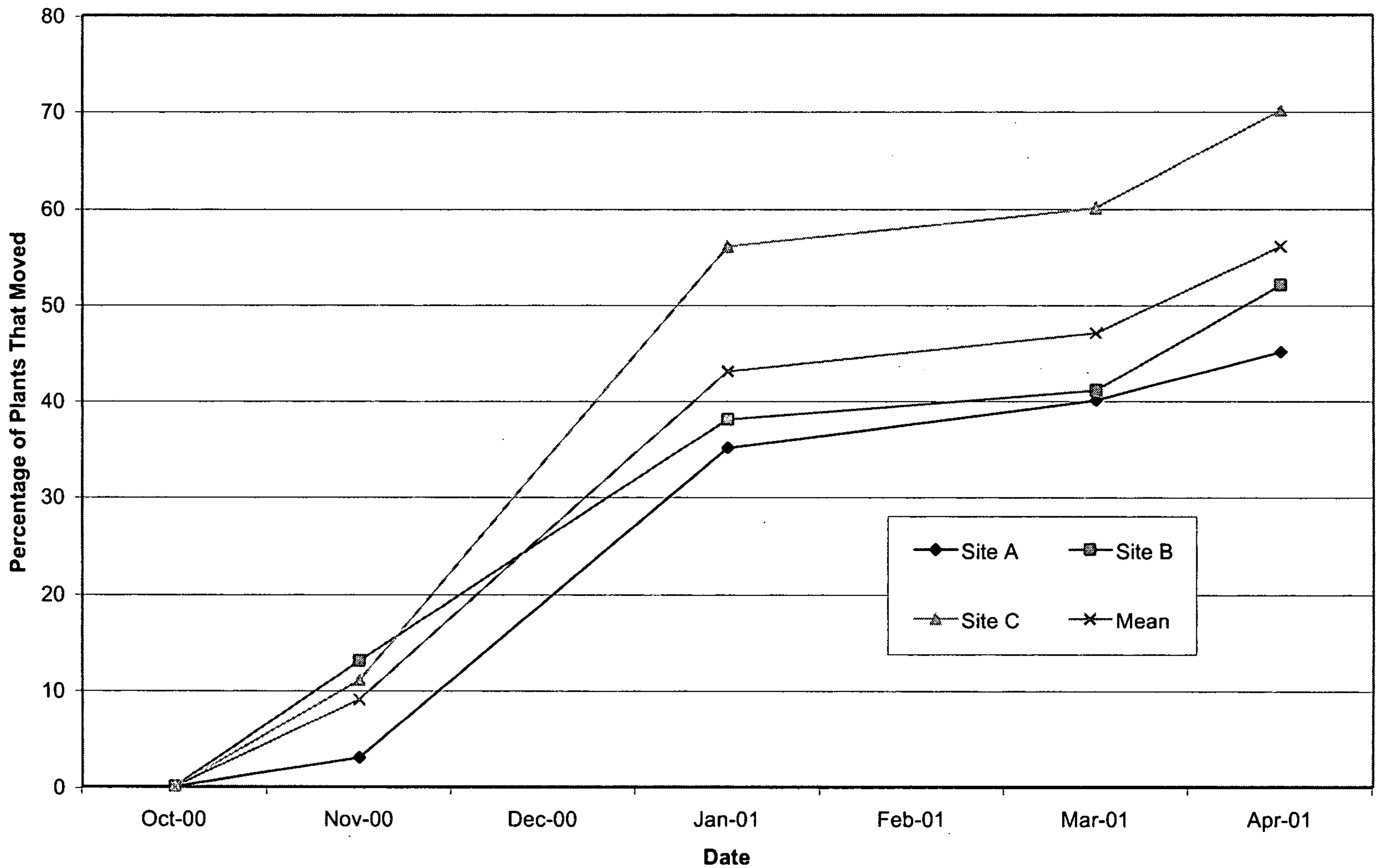


Figure 7-4. Number of 15 Minute Time Periods with >50mph Maximum Wind Speed

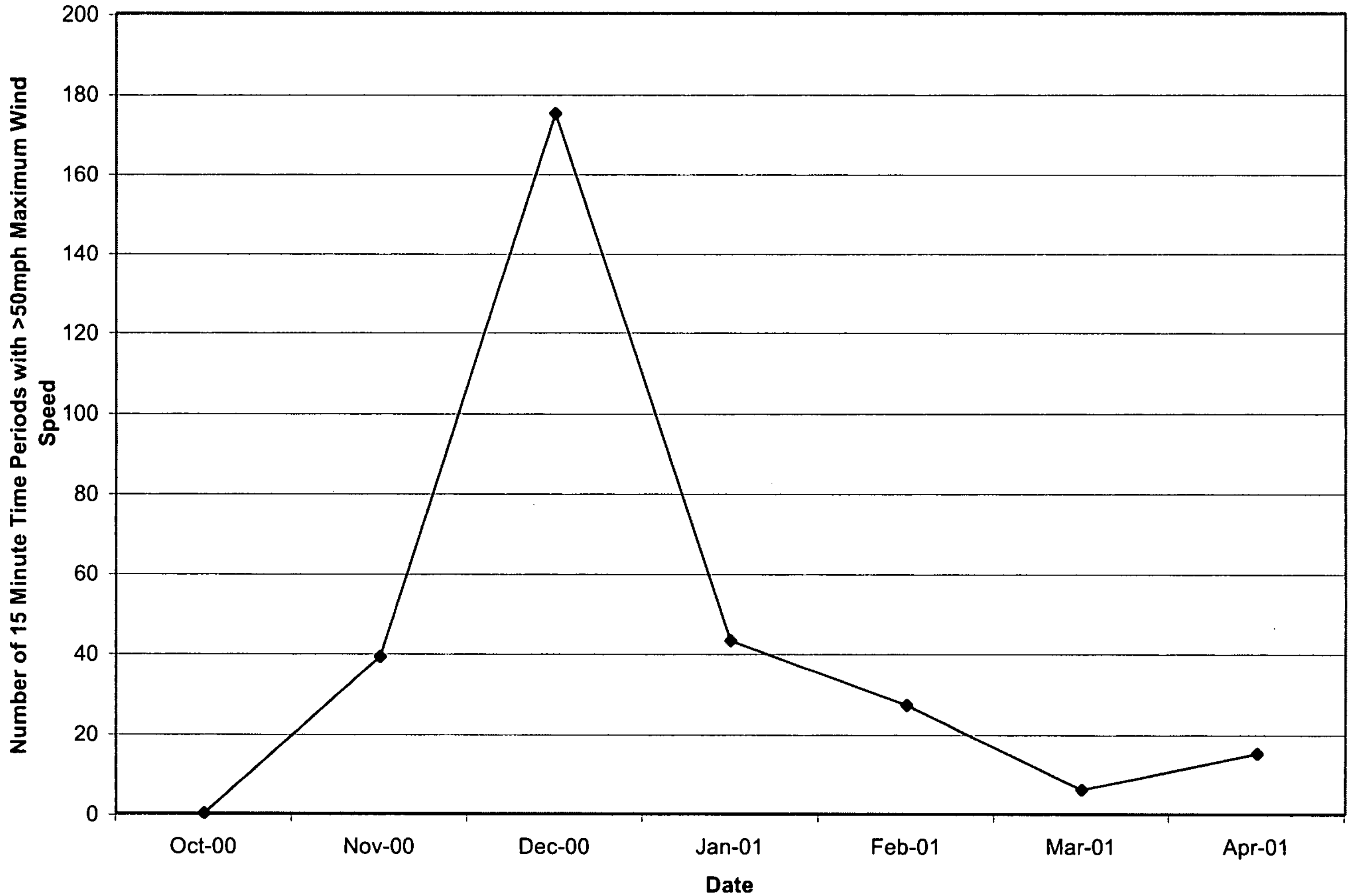
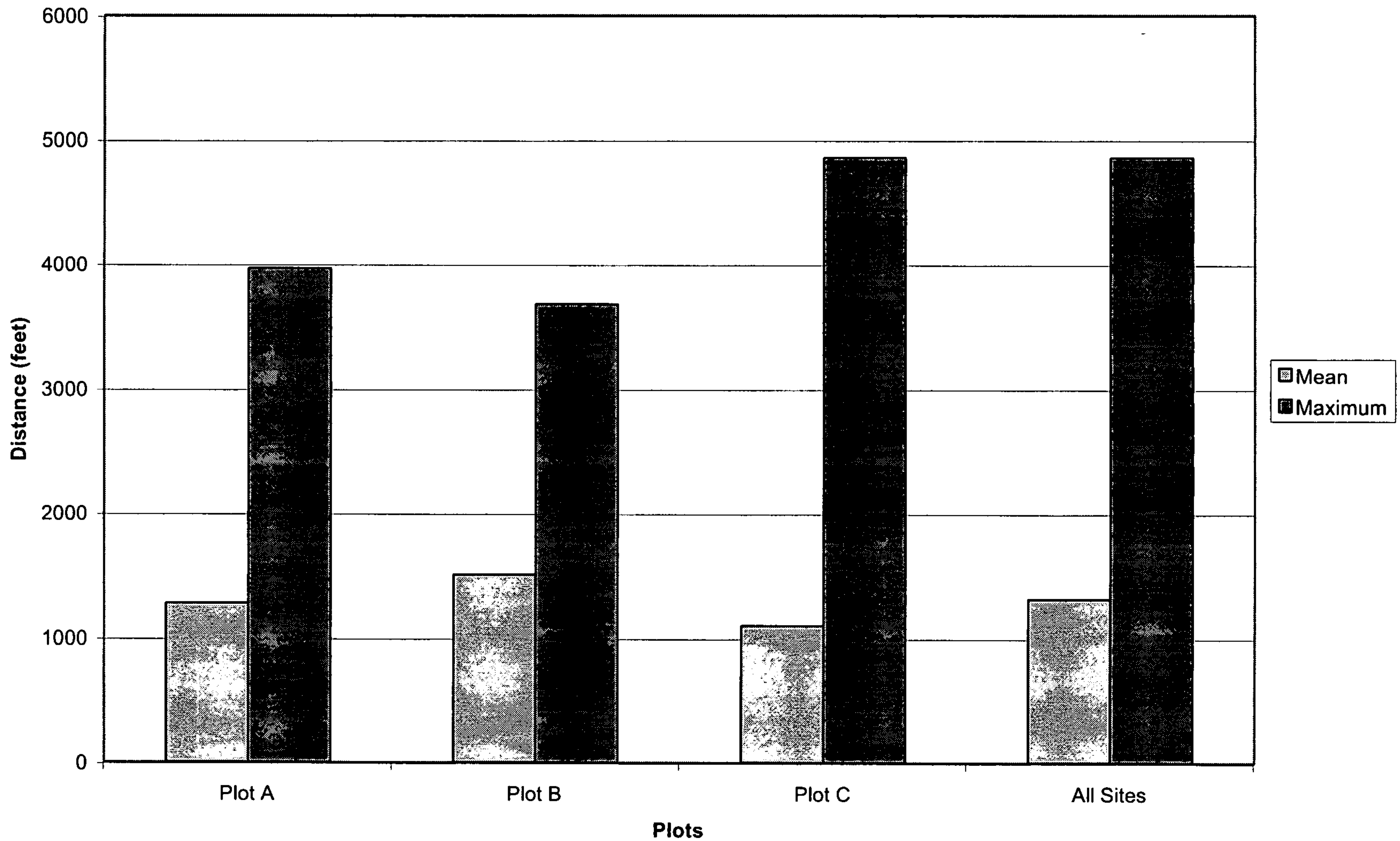
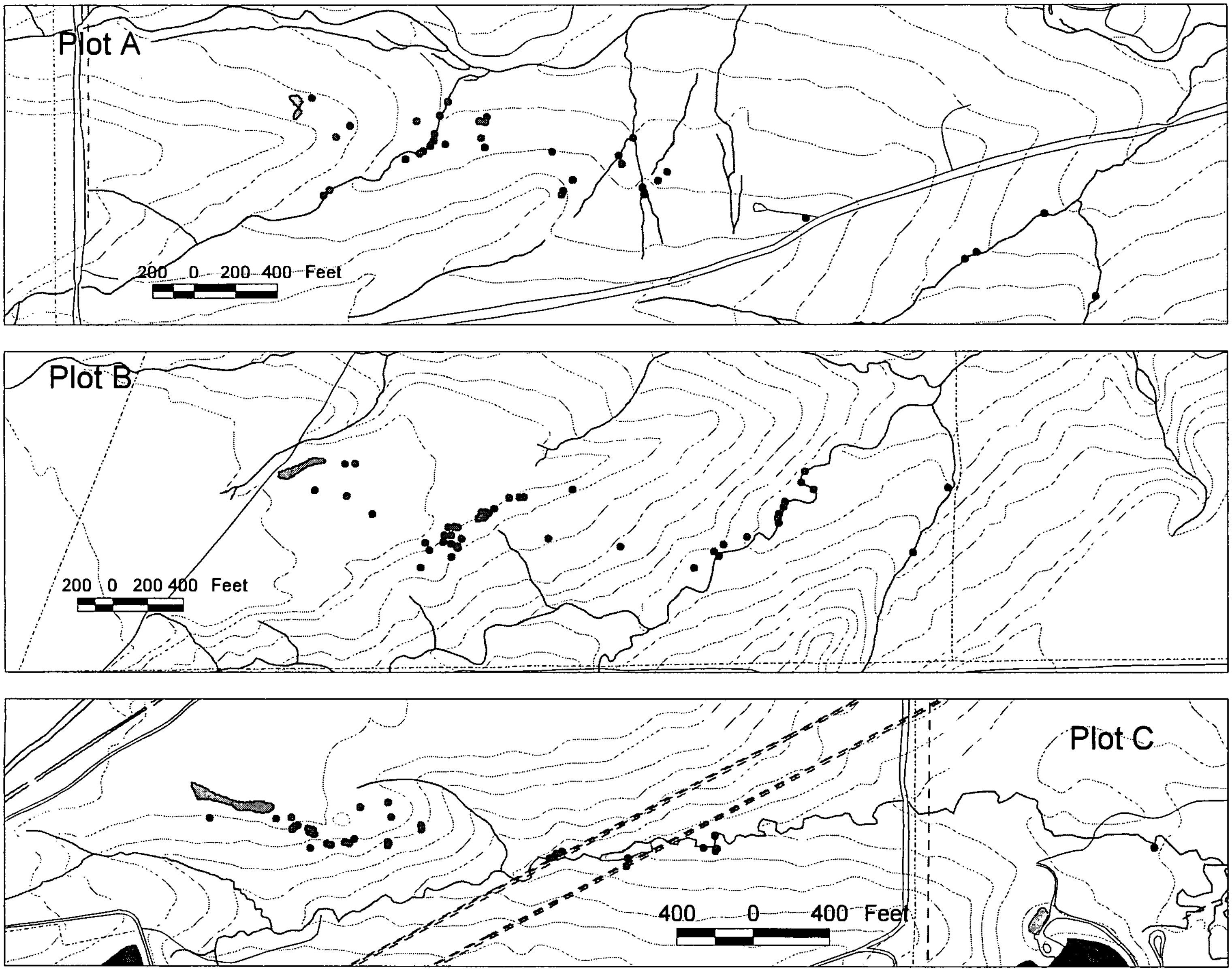


**Figure 7-5. Diffuse Knapweed Movement Summary**



# Diffuse Knapweed Movement Distributions

## Figure 7-6




LEGEND

- Diffuse Knapweed Plots
- Diffuse Knapweed Plant Downwind Locations
- Plot Centerpoint

Standard Features

- Buildings
- Lakes & ponds
- Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)
- Power Lines

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876

N

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 01-0096

February 14, 2002

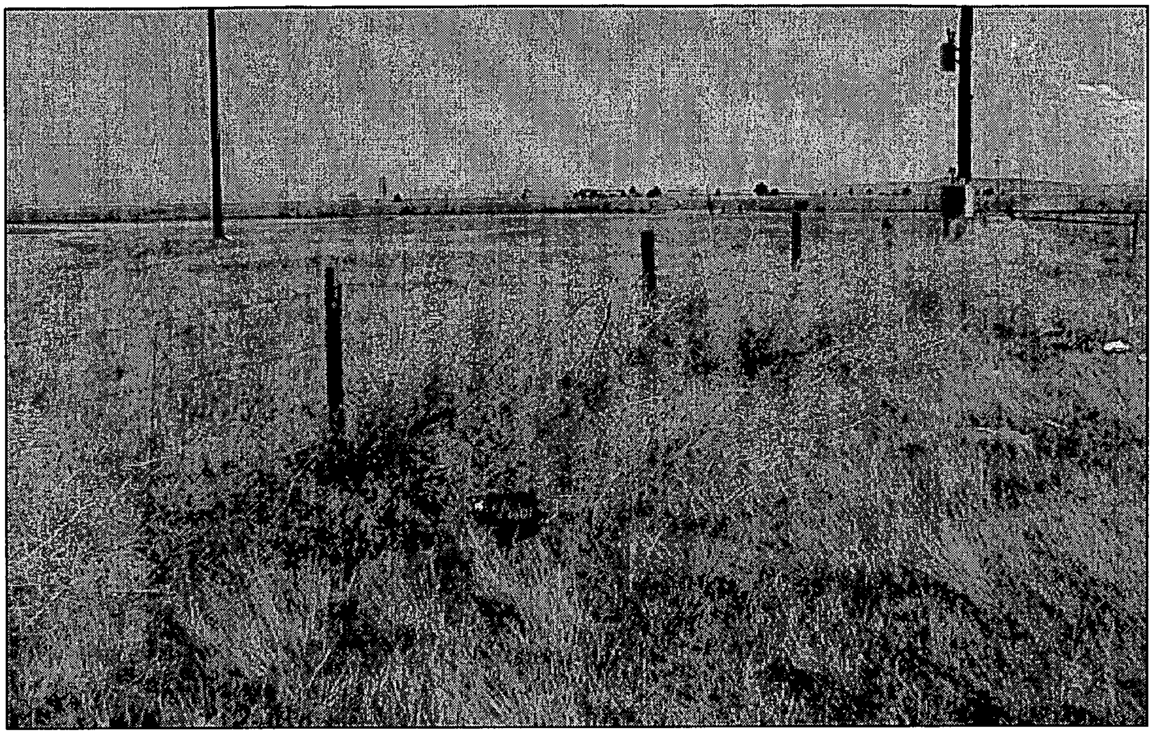
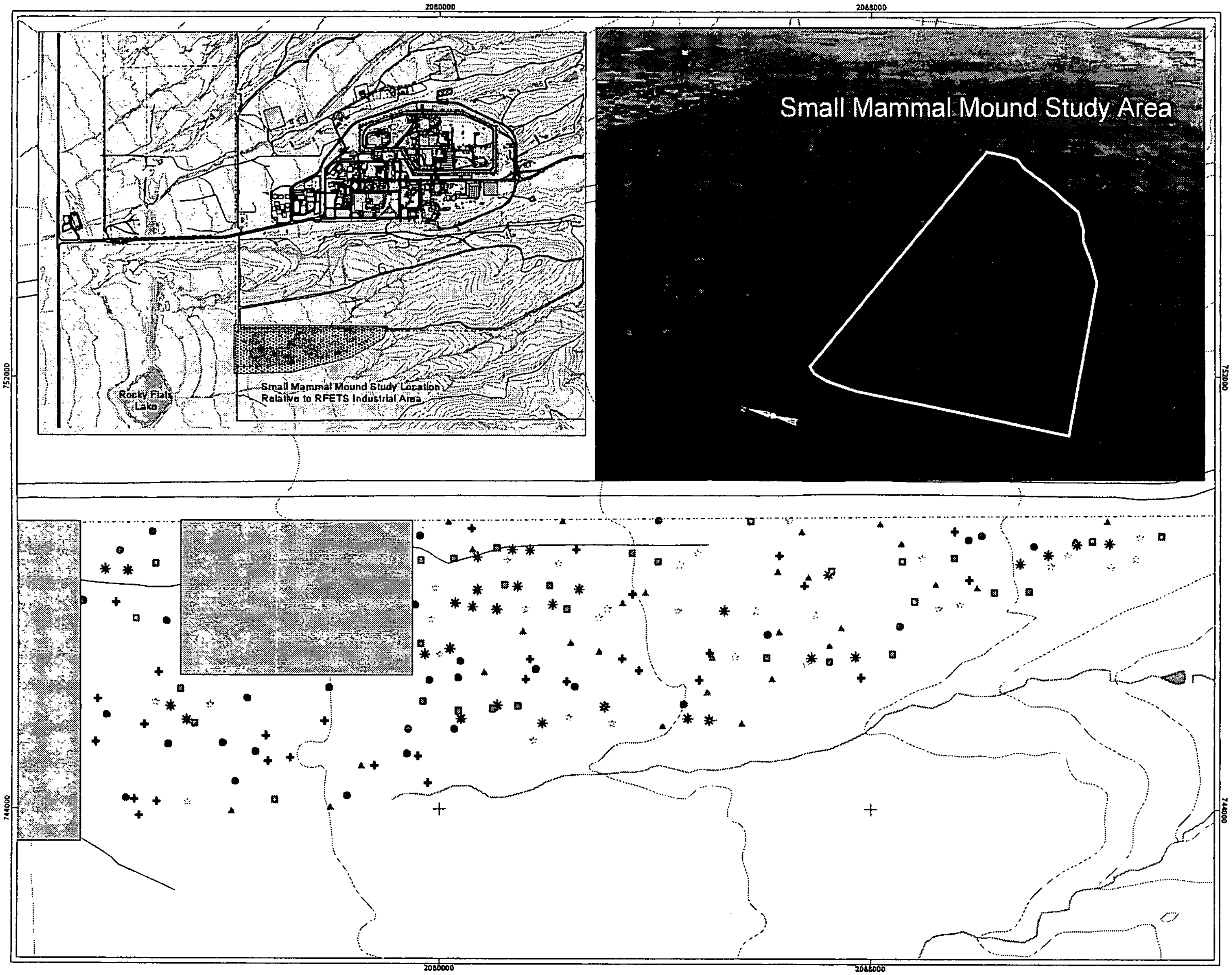


Figure 7-7. Diffuse knapweed "captured" by a typical 4-strand barbed wire fence. Note the area on the left where the knapweed plants have been cleared away.




# Small Mammal Mound Sampling Locations

## Figure 8-1

LEGEND

- Treated/Active
- Treated/NotActive
- NotTreated/Active
- NotTreated/NotActive
- Intermound/Treated
- Intermound/NotTreated
- Double Sprayed Exclusion Areas

**Standard Features**

- Buildings
- Lakes & ponds
- Landfill
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)
- Power Lines

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-9876.

N

1:13583

200 0 200 400 Meters

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 01-0154

February 14, 2002

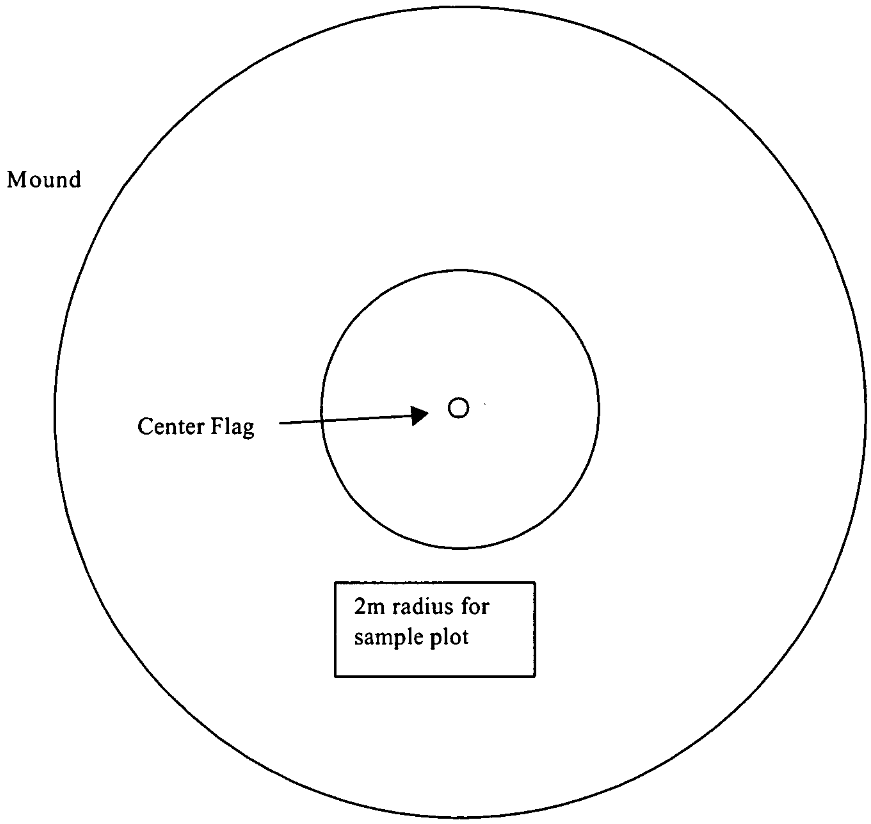
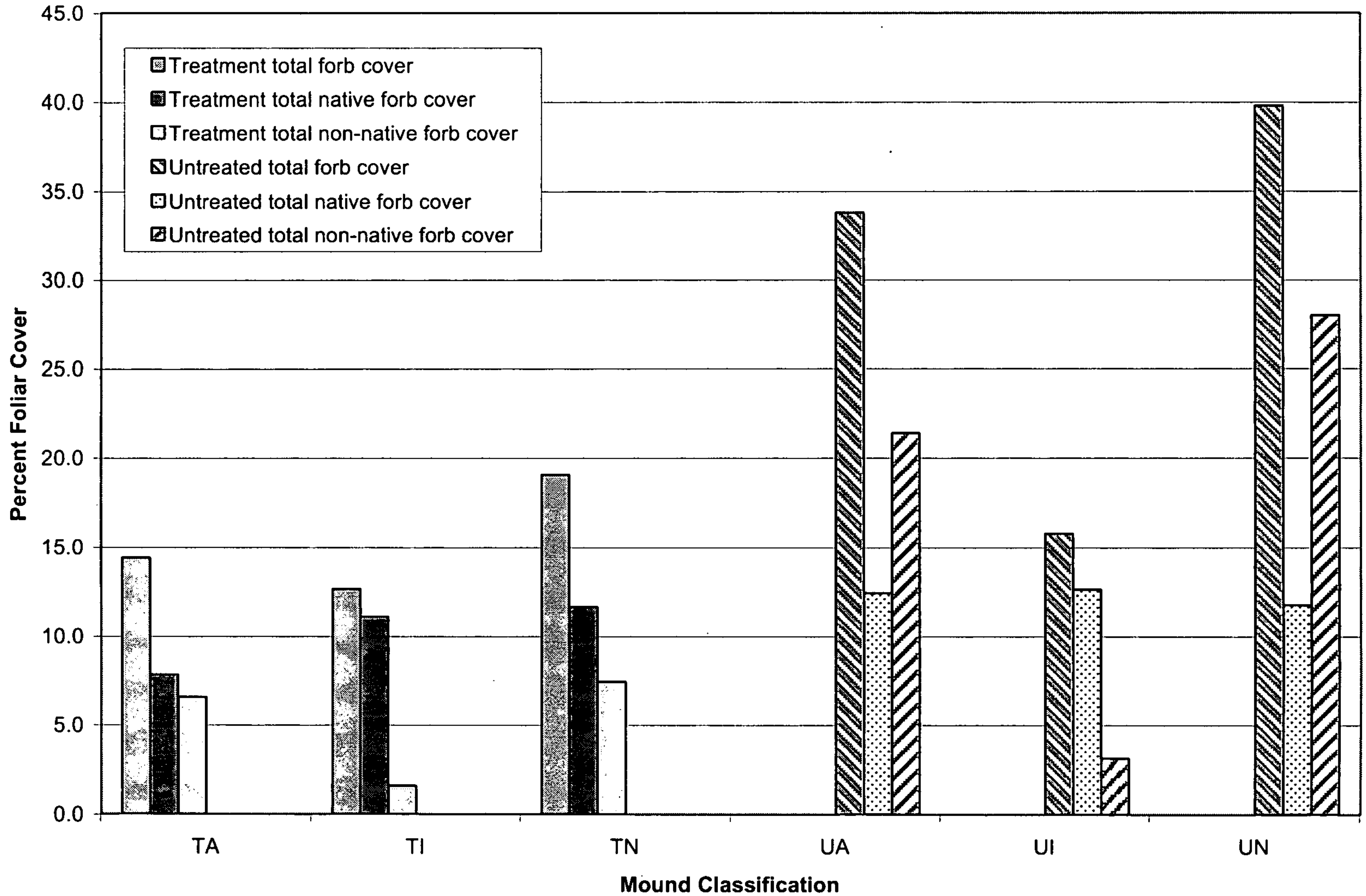


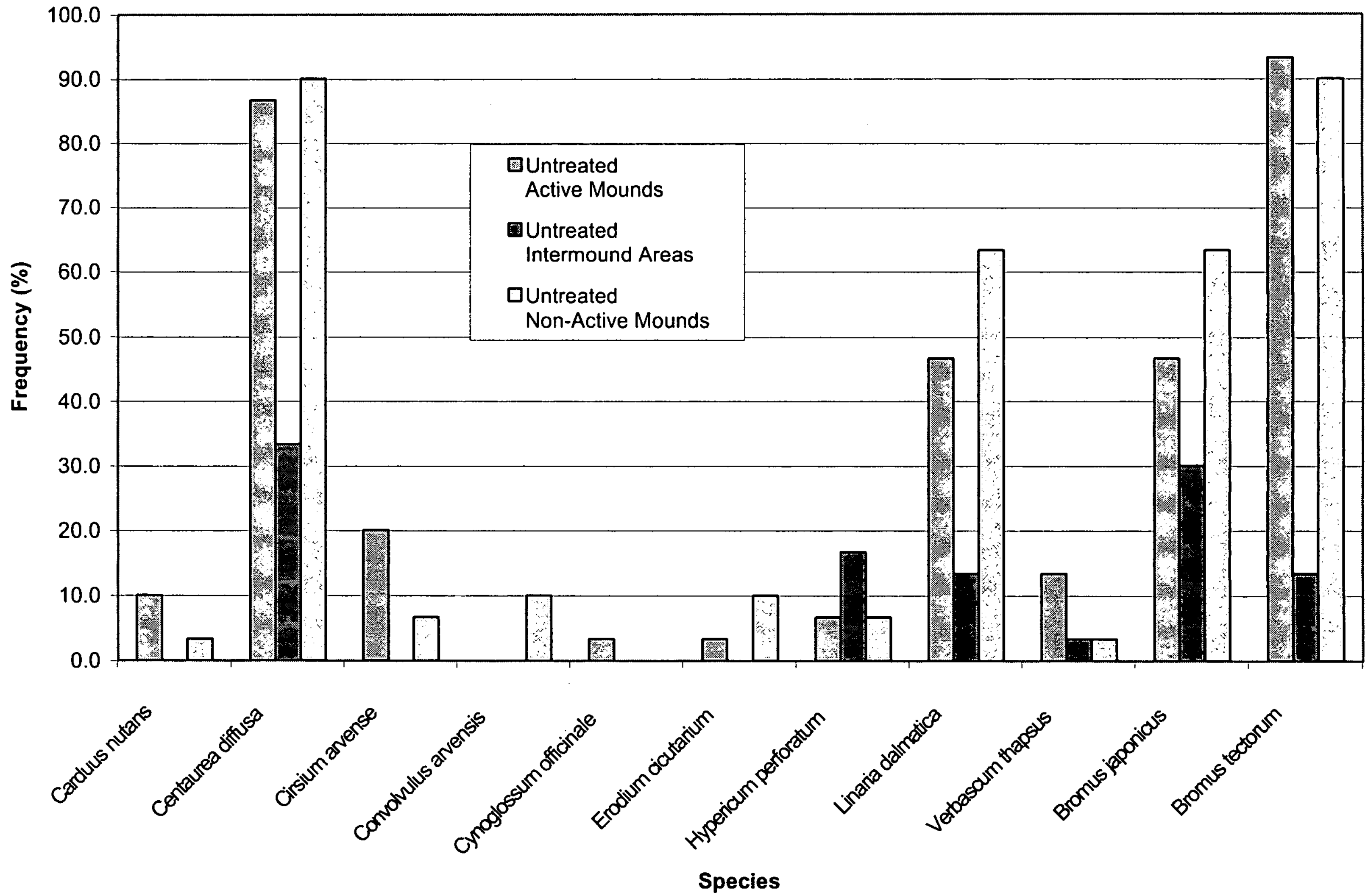

Figure 8-2. Mound vegetation characterization plot sampling design. Intermound sampling will use same pattern for the plot layout, but will be placed between the mounds.

**Figure 8-3. Small Mammal Mound Total Forb, Native Forb, and Non-Native Forb Cover Summary**



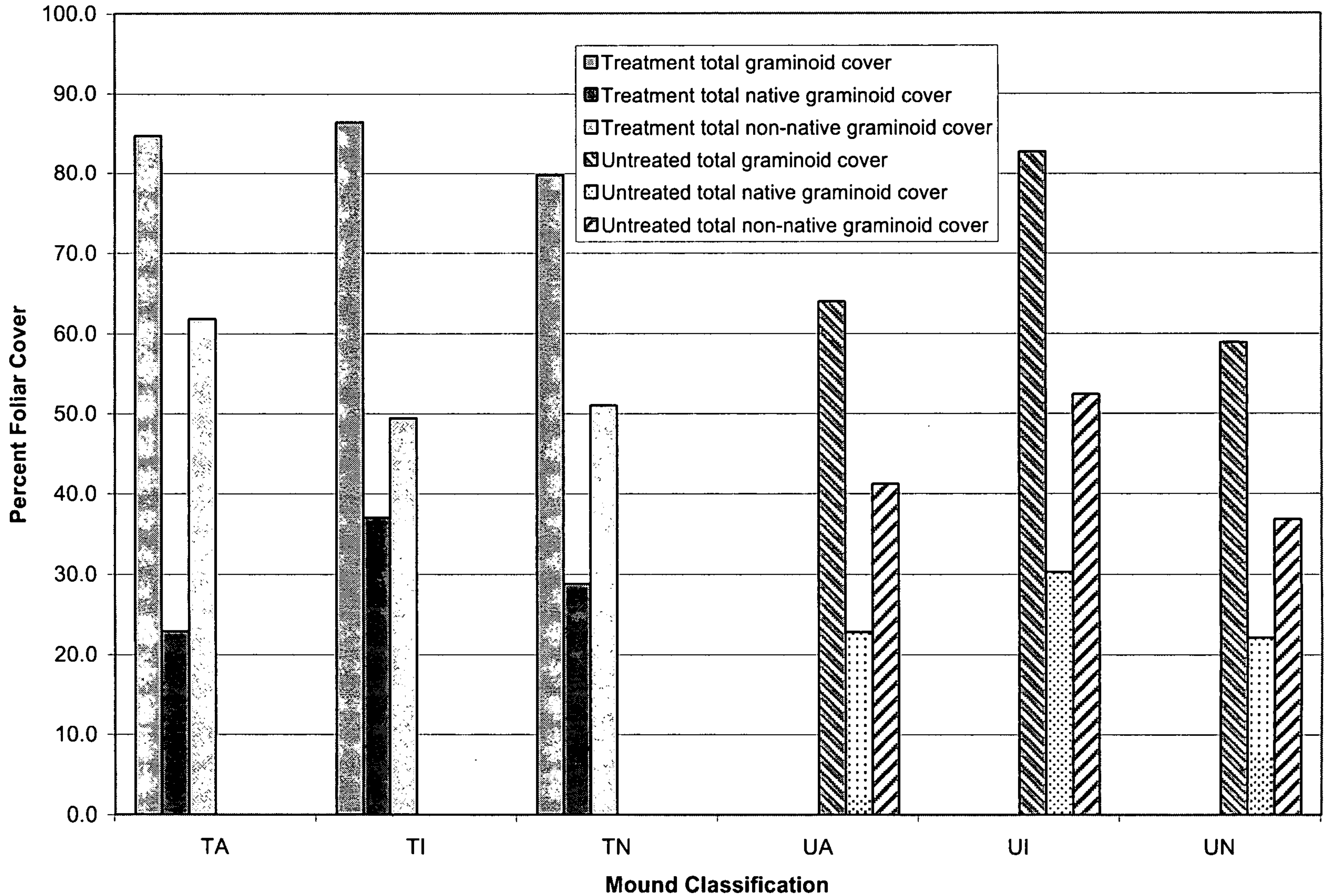

TA = treated active, TI = treated intermound, TN = treated not active, UA = untreated active, UI = untreated intermound, UN = untreated not active

## Figure 8-4. Small Mammal Mound Noxious Weed Frequency Summary

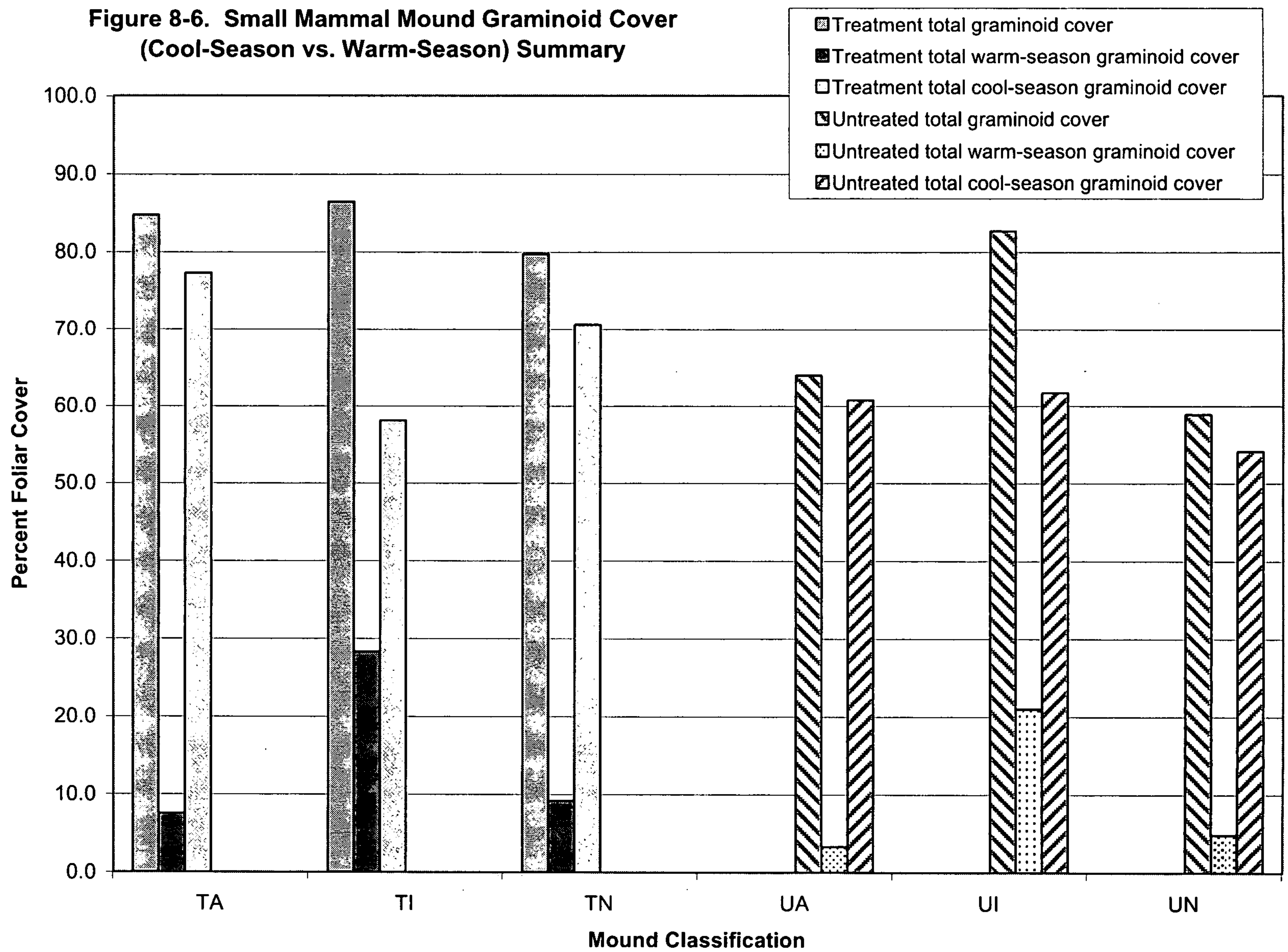



Bromus japonicus is a non-native cheatgrass, but is not on the State of Colorado list of noxious weeds.

**Figure 8-5. Small Mammal Mound Graminoid (Native vs. Non-Native) Foliar Cover Summary**




TA = treated active, TI = treated intermound, TN = treated not active, UA = untreated active, UI = untreated intermound, UN = untreated not active




TA = treated active, TI = treated intermound, TN = treated not active, UA = untreated active, UI = untreated intermound, UN = untreated not active

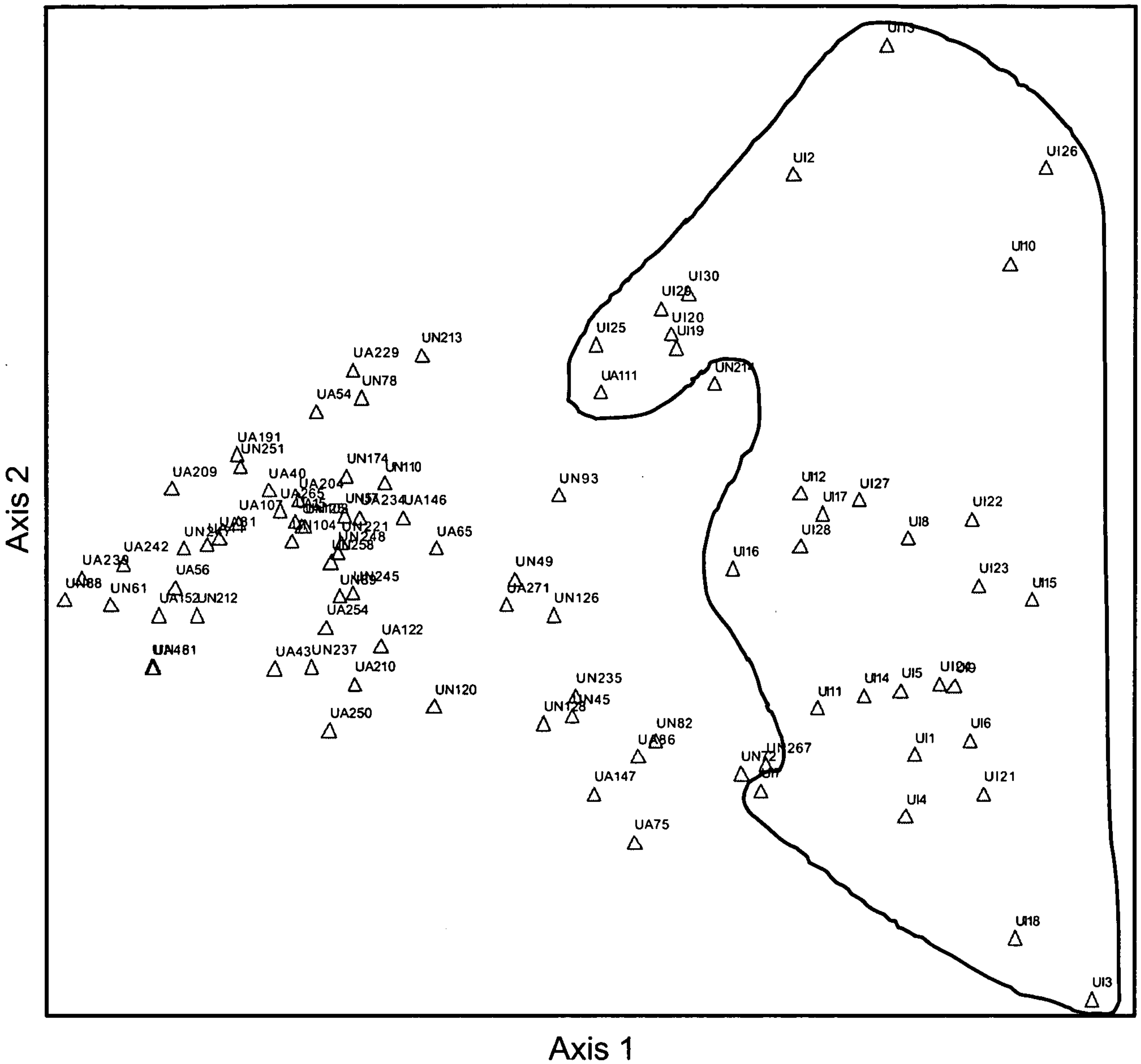



**Figure 8-7. Detrended Correspondence Analysis (DCA) Using Small Mammal Mound Study Full Species Lists and Cover Values For Untreated Classifications.**
(Mound Classifications: UA = untreated active, UI = untreated intermound, UN = untreated non-active; numbers refer to actual plot numbers).

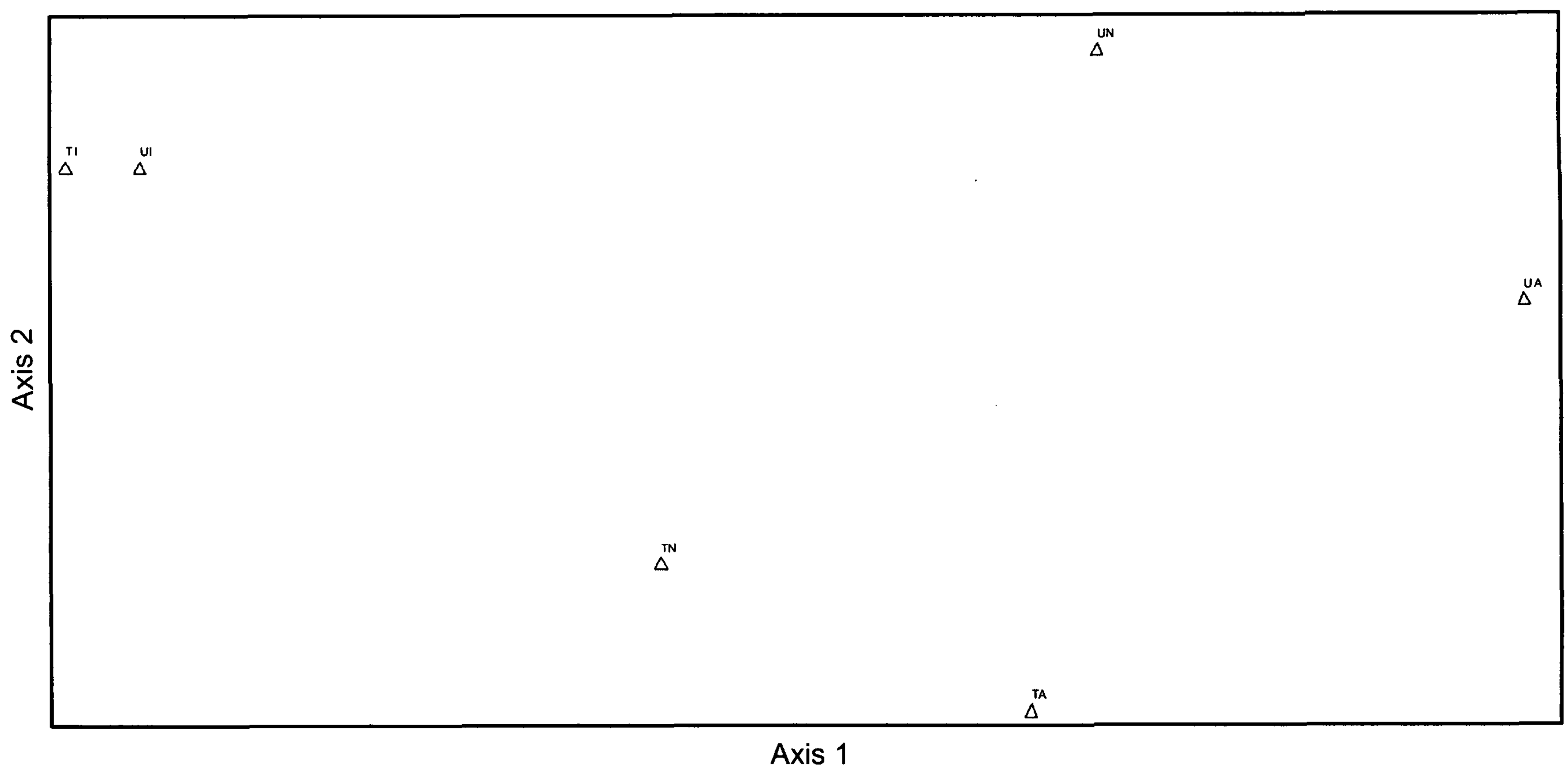



**Figure 8-8. Detrended Correspondence Analysis (DCA) Using Small Mammal Mound Study Dominant Species and Cover Values.**
(Mound Classifications: TA = treated active, TI = treated intermound, TN = treated non-active, UA = untreated active, UI = untreated intermound, UN = untreated non-active).

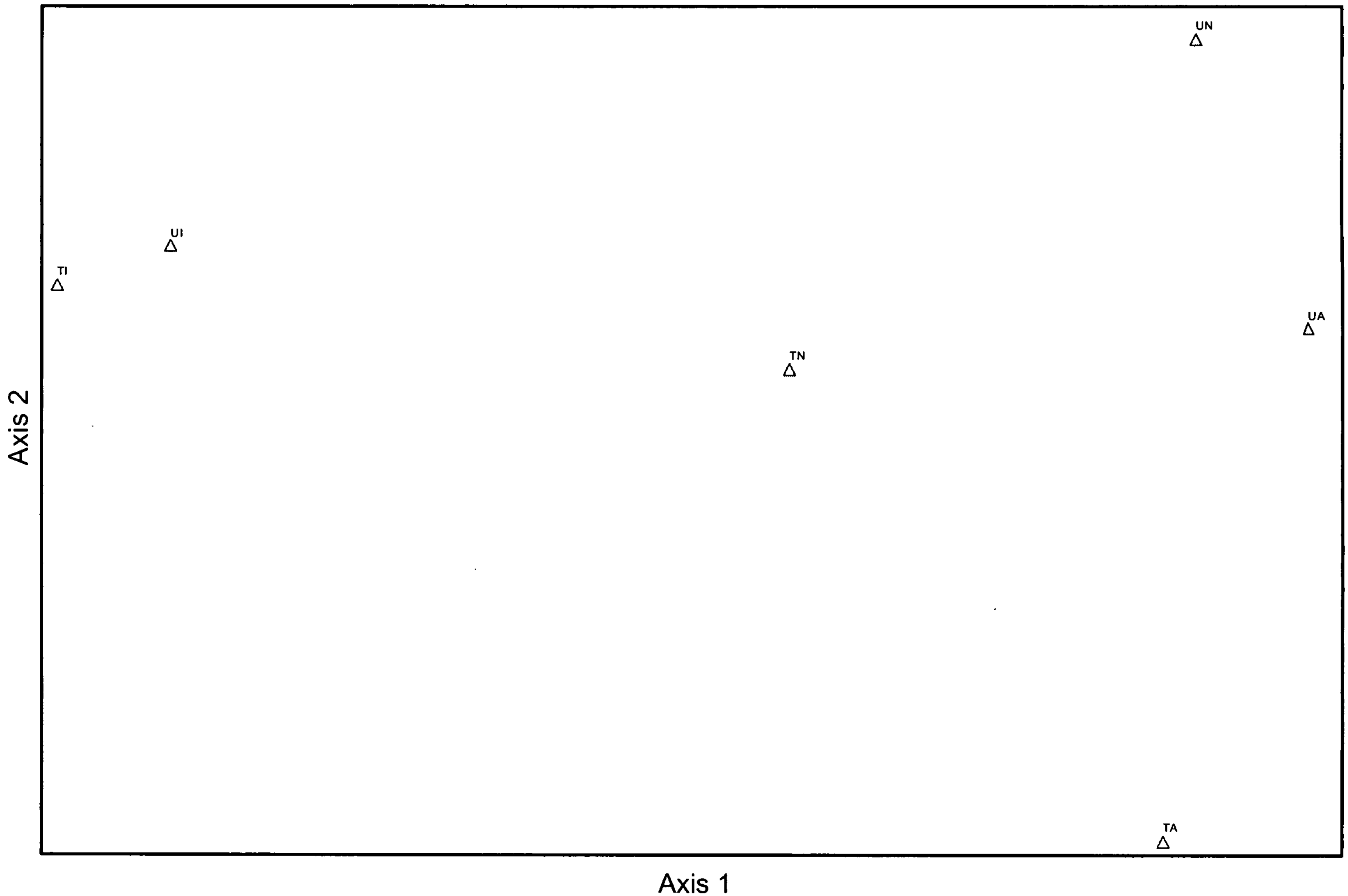



**Figure 8-9. Detrended Correspondence Analysis (DCA) Using Small Mammal Mound Study Full Species Lists and Cover Values.**
(Mound Classifications: TA = treated active, TI = treated intermound, TN = treated non-active, UA = untreated active, UI = untreated intermound, UN = untreated non-active).


## 2001 Landfill Monitoring Vegetation Transect Locations

### Figure 9-1

**LEGEND**

- Tall Vegetation (not seeded)
- Tall Vegetation (seeded)
- Vegetation Transects
- Methane Sampling Transects

**Standard Features**

- Buildings
- Lakes & ponds
- Streams & ditches
- Fences
- Paved roads
- Dirt roads
- Contours (20 ft)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV. 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC; Karan North 303-966-9876.

N

1:1656

100 0 100 200 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

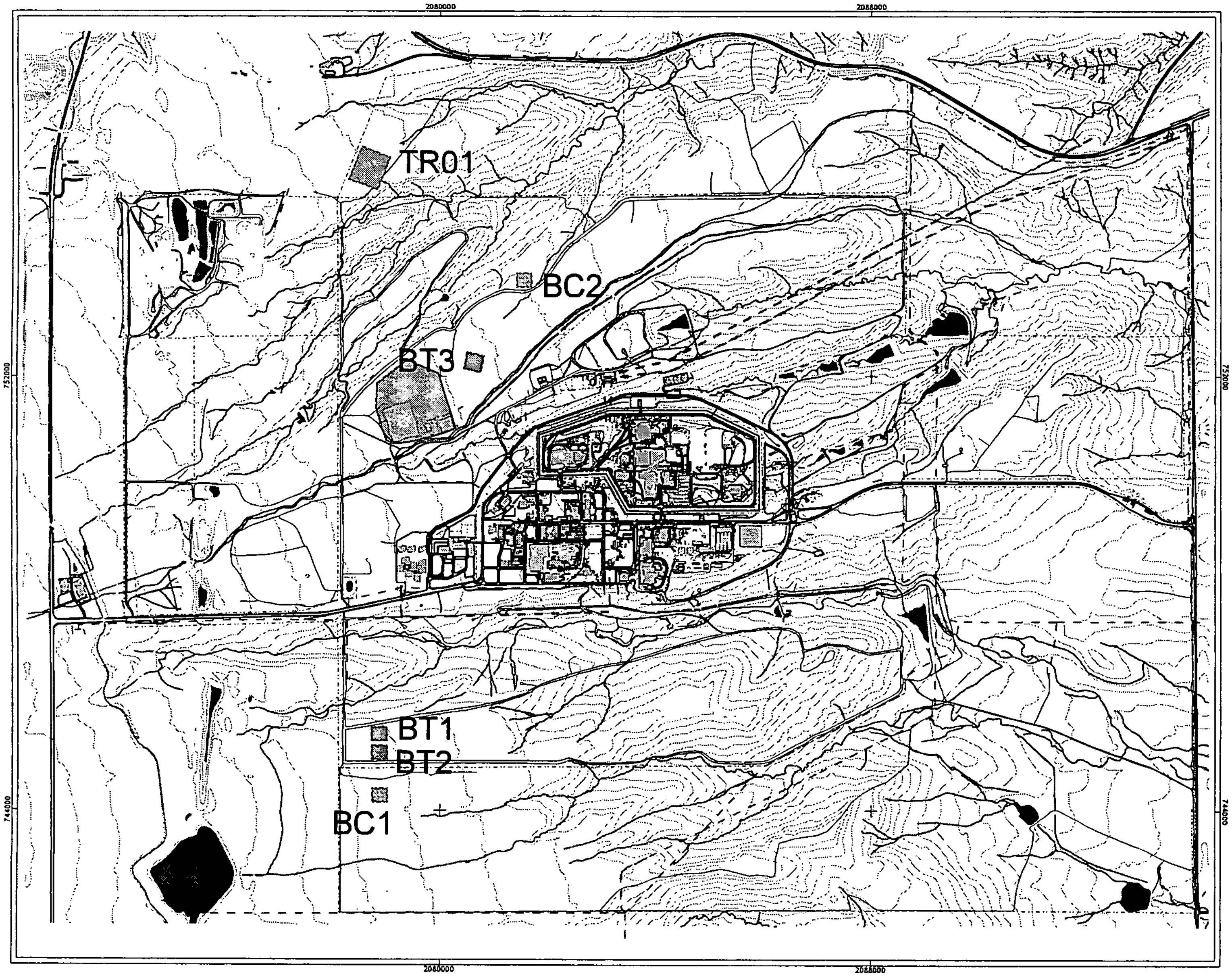
Prepared by: Exponent
For: Kaiser-Hill Company, LLC

RFETS GIS Dept. 303-966-7707

MAP ID: 01-0980 February 14, 2002

# Prescribed Burn Monitoring Plot Locations

## Figure 10-1




### LEGEND

Control Plots
Treatment Plots

### Standard Features

Buildings
Lakes & ponds
New Landfill
Streams & ditches
Fences
Paved roads
Dirt roads
Contours (20 ft)
Power Lines

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95
Hypsography derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Remote Sensing Lab. Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution.
The DEM post-processing performed by MK, Winter 1997.

Data Source Ecology Features:
Location data provided by Exponent.
K-H Ecology Group POC: Karan North 303-966-6876.

N

1:23552

1000 0 1000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Exponent®

For: Kaiser-Hill Company, LLC

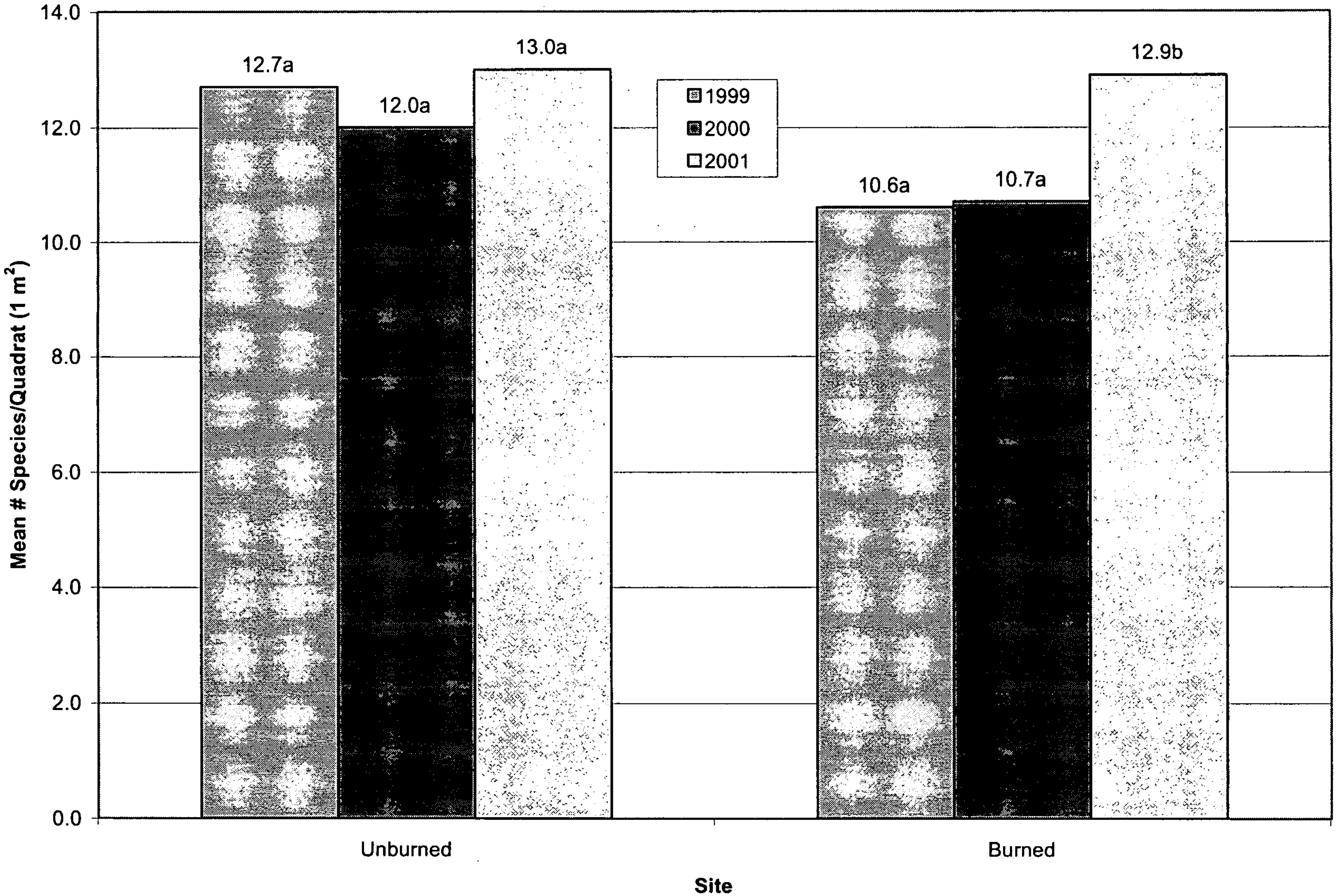
RFETS GIS Dept. 303-966-7707

MAP ID: 2k-0038

February 14, 2002

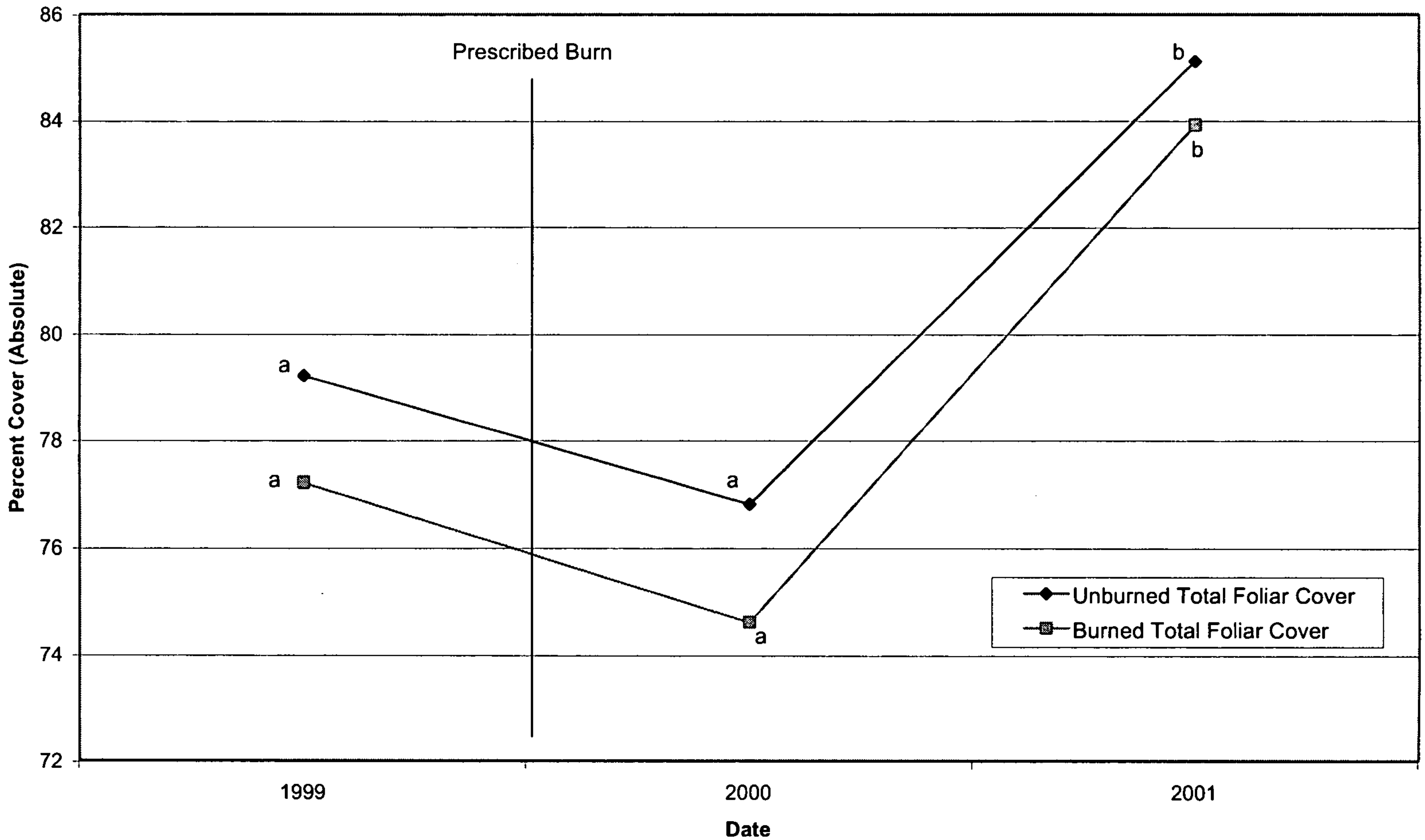
\Gis\s\GIS\ECO-projects\projects\2k-0038\wp monitoring locations 2001.apr\Burn plots

## Figure 10-2. Mean # Species/Quadrat - Prescribed Burn Monitoring



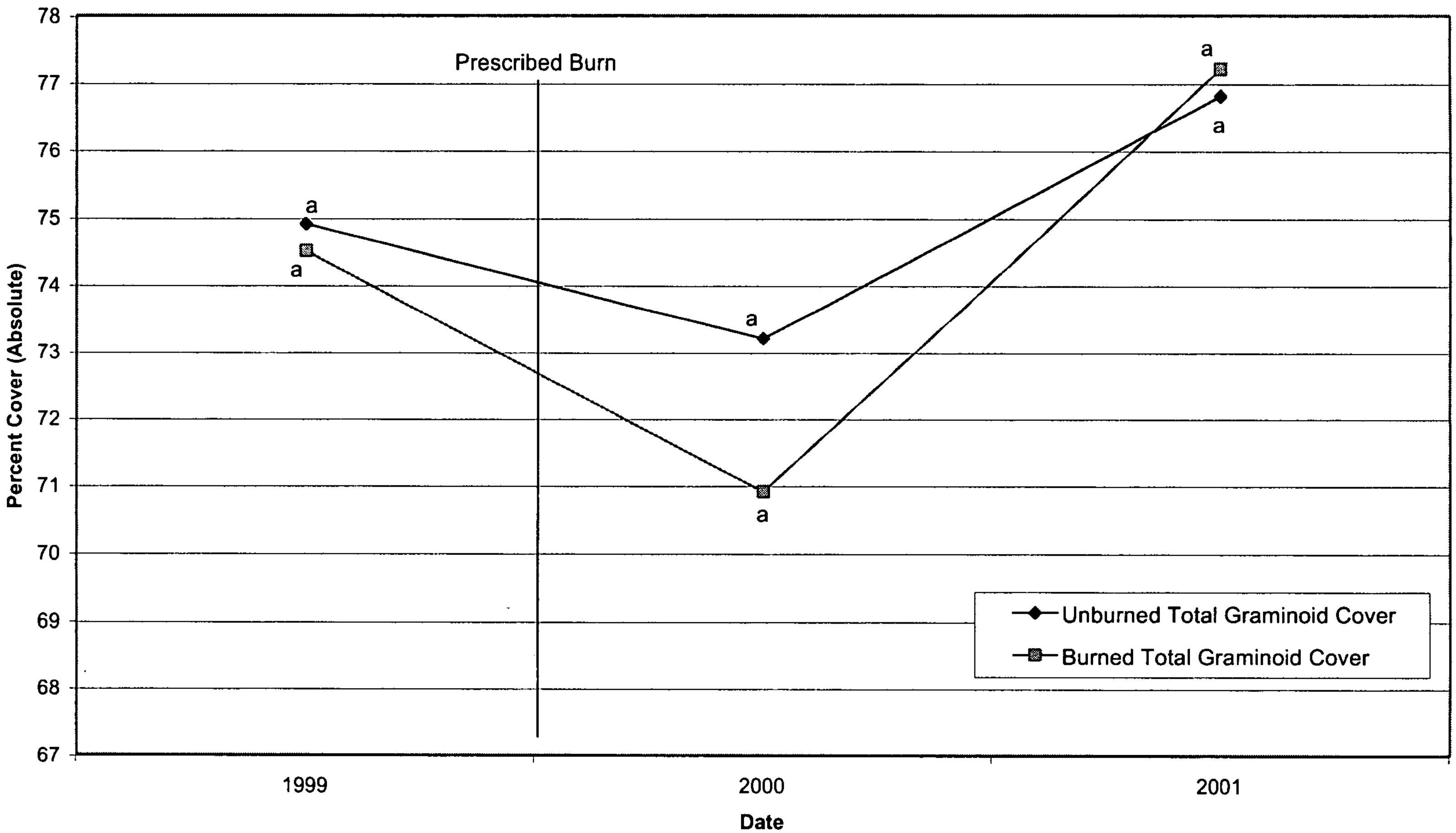

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05).

**Figure 10-3. Total Foliar Cover - Prescribed Burn Monitoring**



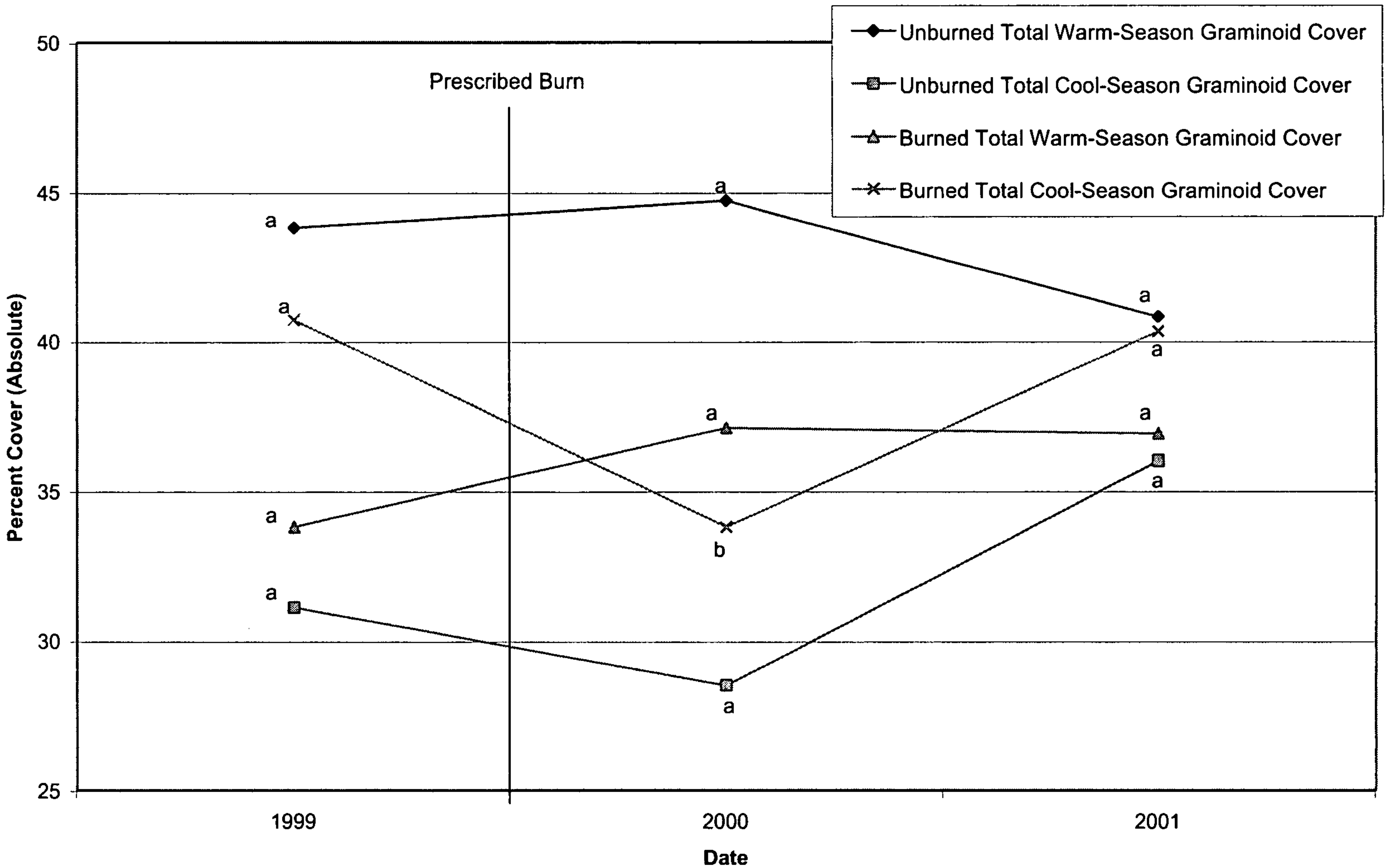

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05).

## Figure 10-4. Total Graminoid Cover - Prescribed Burn Monitoring



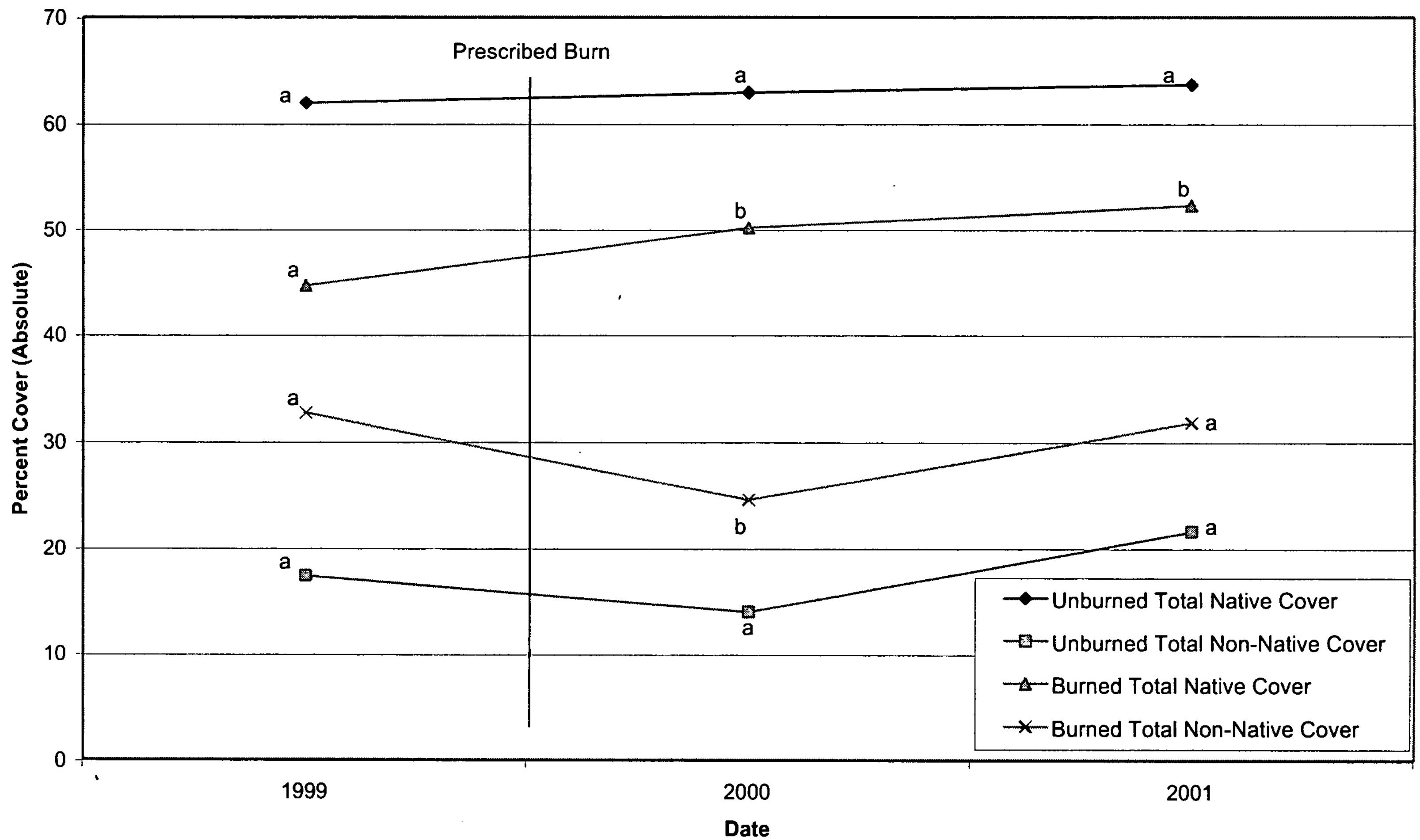

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05).

## Figure 10-5. Warm- vs. Cool-Season Graminoid Cover - Prescribed Burn Monitoring



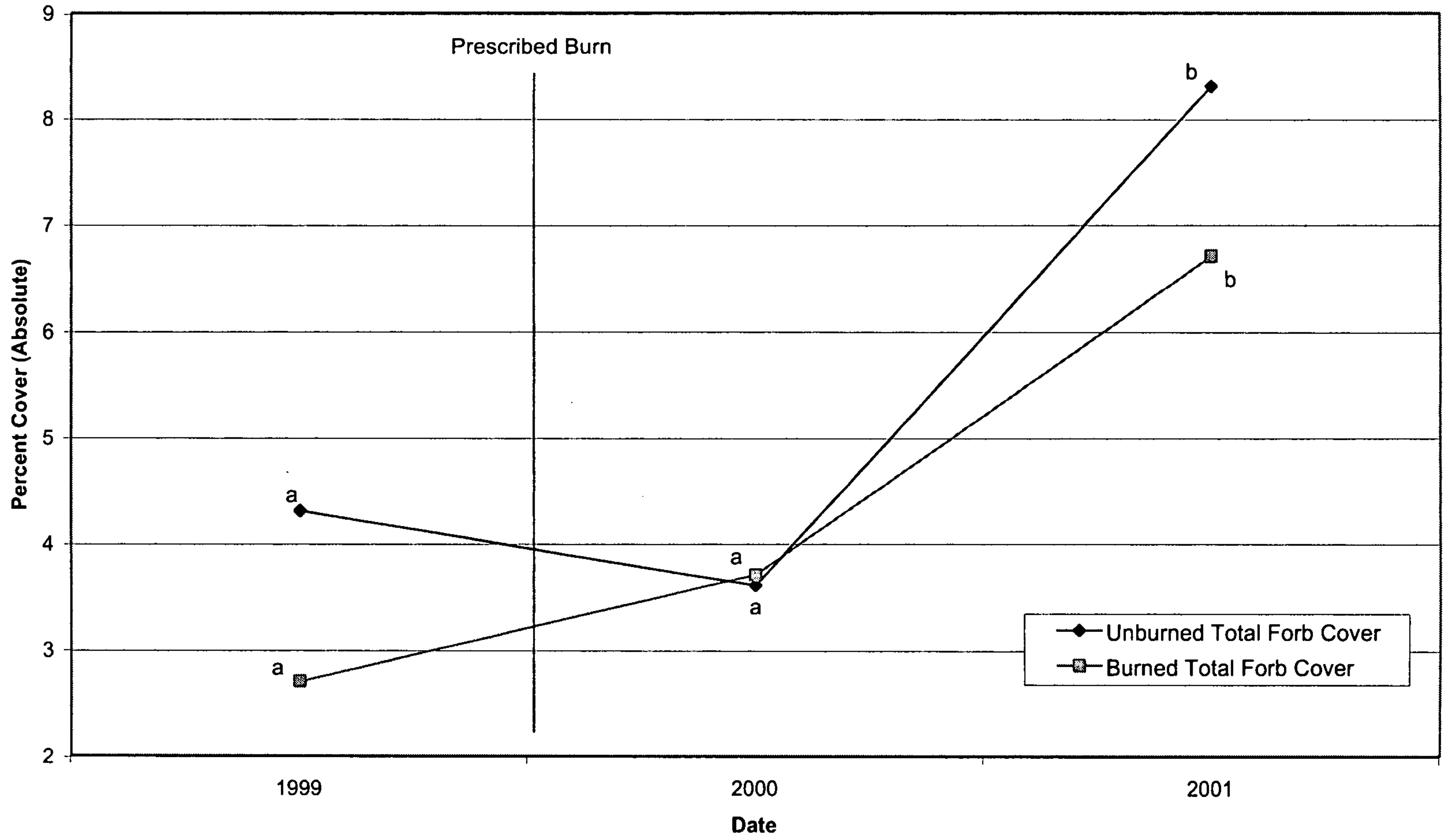

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05).

## Figure 10-6. Native and Non-native Foliar Cover - Prescribed Burn Monitoring



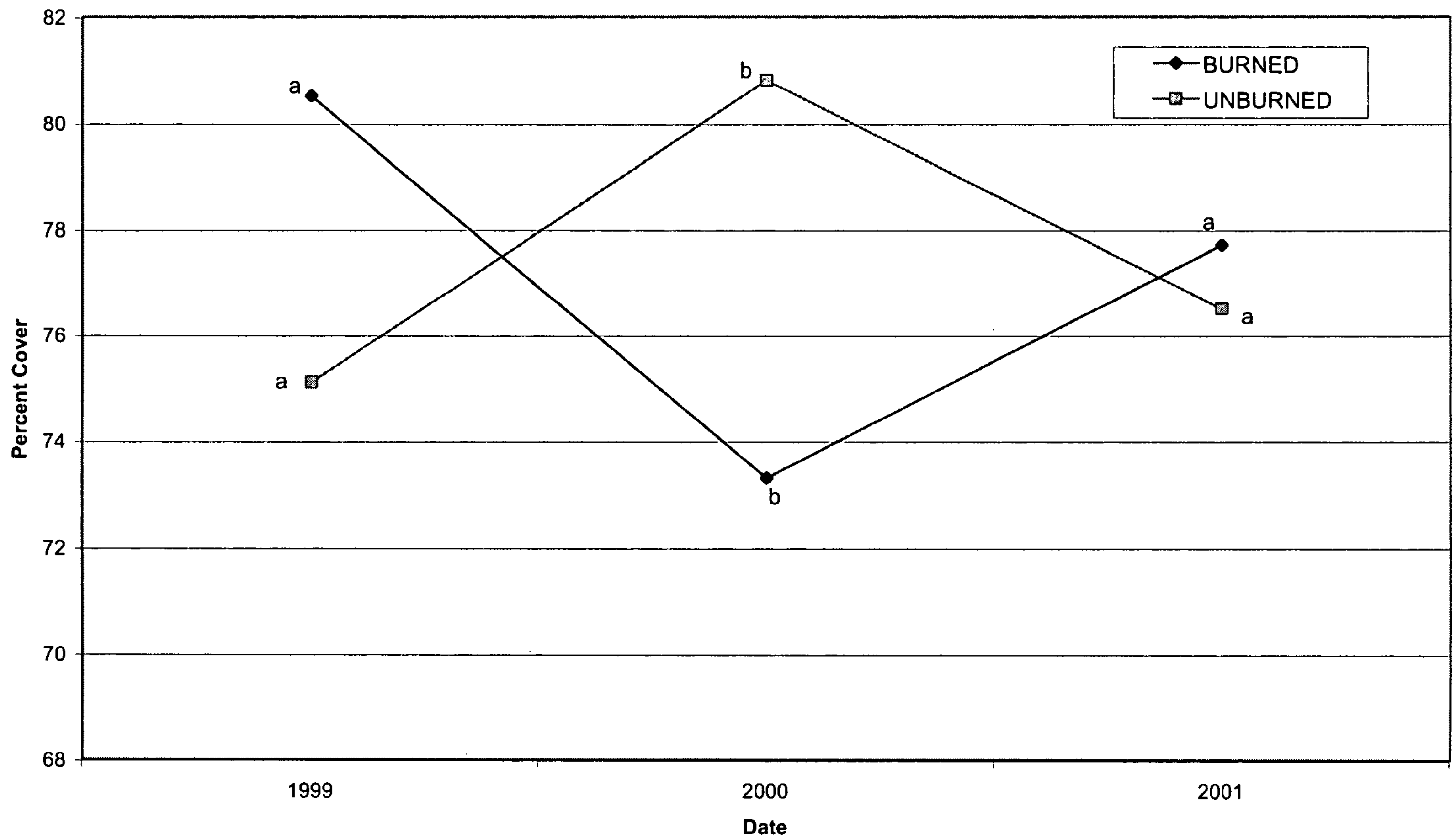

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05).

**Figure 10-7. Total Forb Cover - Prescribed Burn Monitoring**



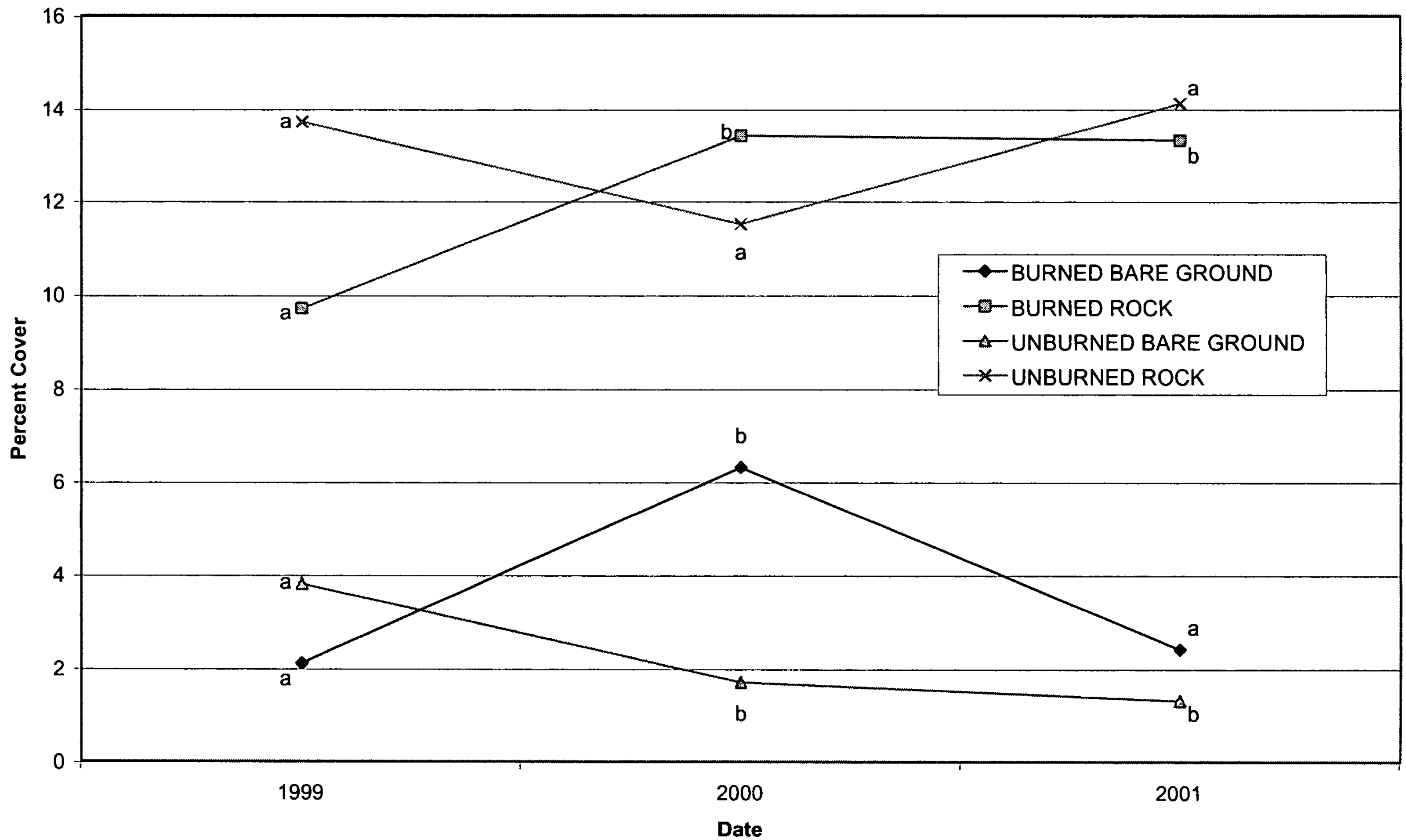

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05).

## Figure 10-8. Litter Cover - Prescribed Burn Monitoring



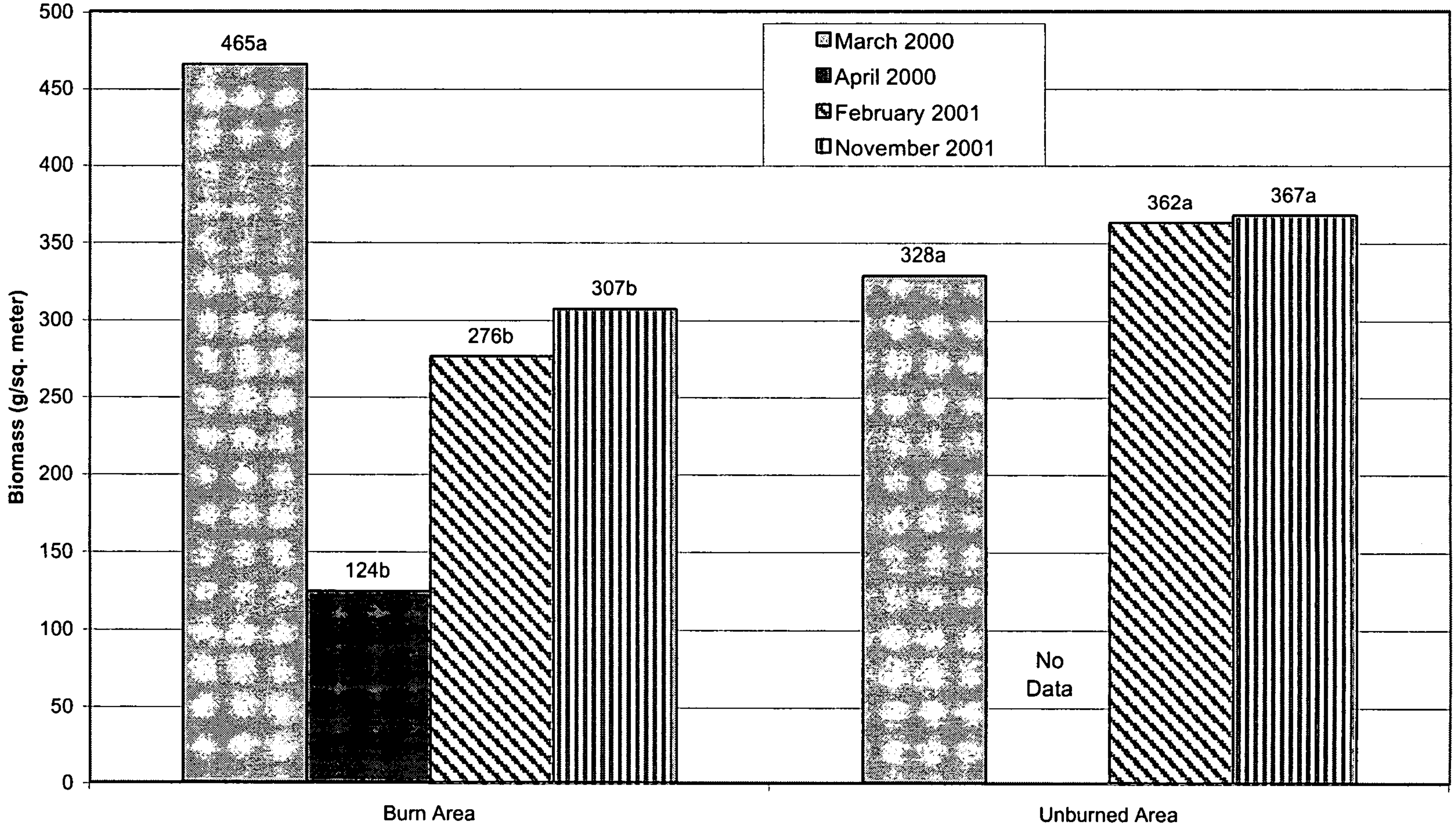

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05).

**Figure 10-9. Rock and Bare Ground Cover - Prescribed Burn Monitoring**



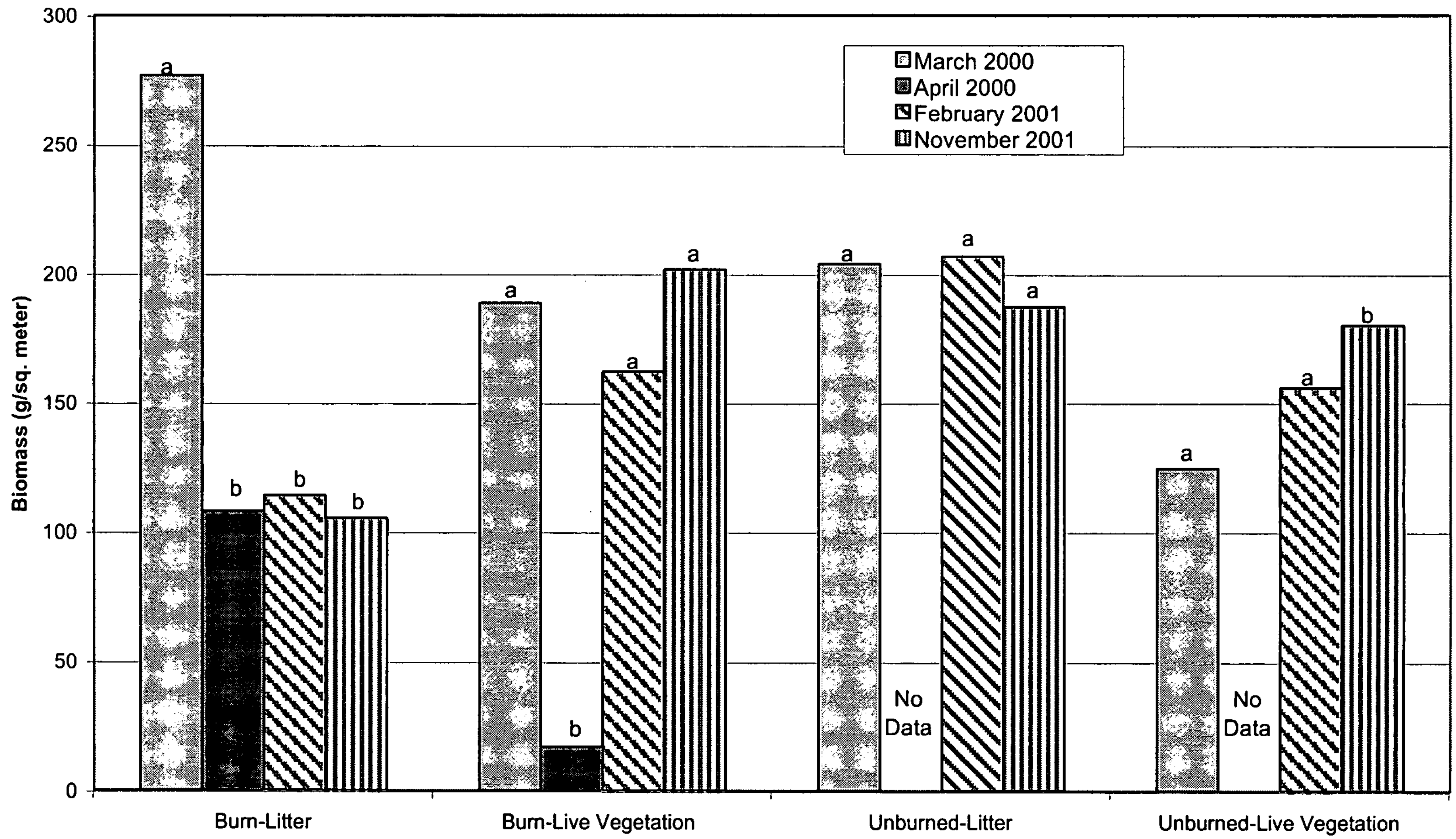

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05).

## Figure 10-10. Prescribed Burn Total Biomass Change



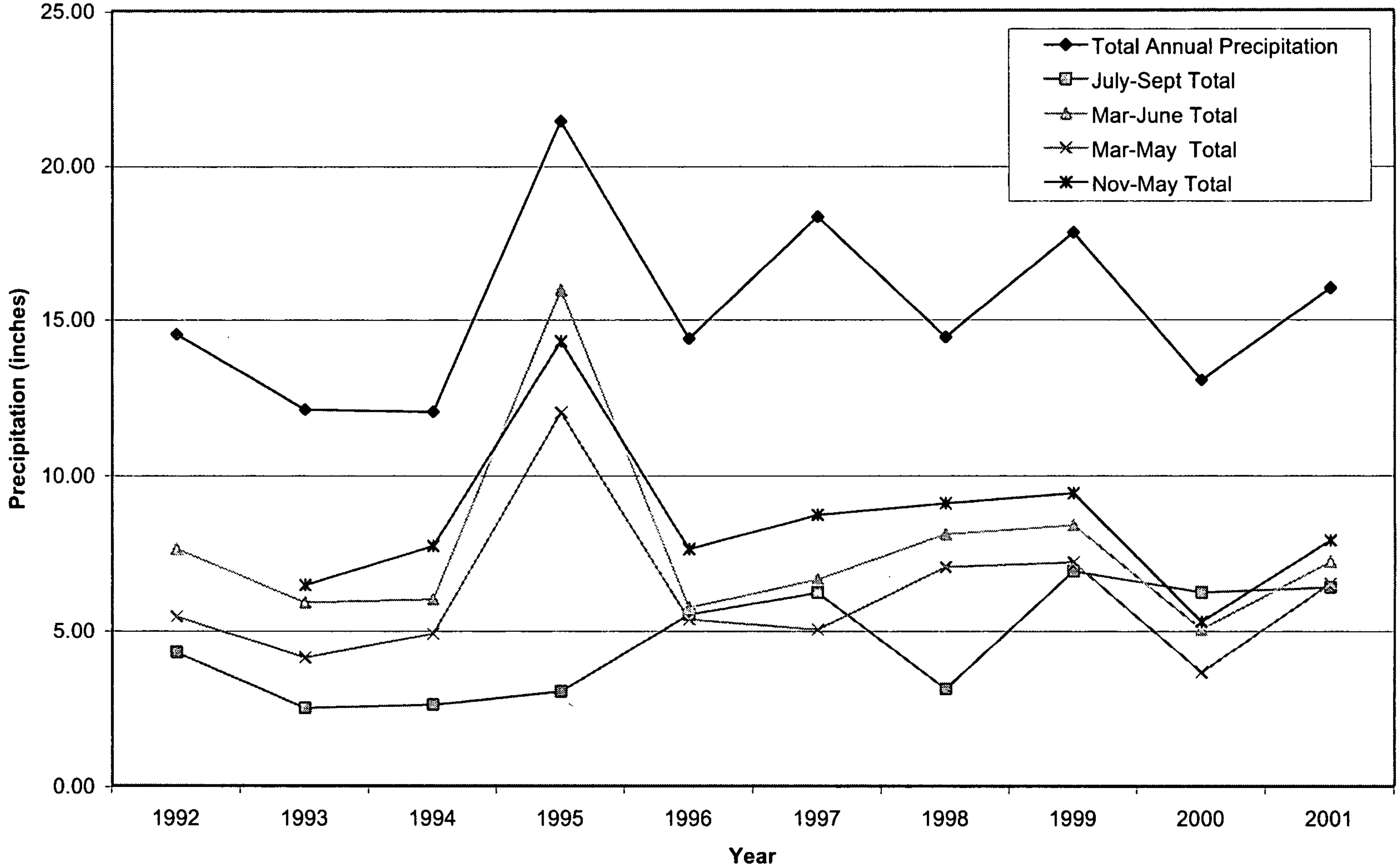

Means within the same treatment having the same letter are not significantly different from the March 2000 data (P > 0.05).

**Figure 10-11. Prescribed Burn Biomass Changes**




Means within the same treatment having the same letter are not significantly different from the March 2000 data (P > 0.05).

## Figure 10-12. Annual Precipitation at Rocky Flats (1992-2001)



## Tables

**Table 1-1. 1997 and 1998 Xeric Tallgrass Prairie Species Richness Summary**

| Family | Scientific Name | Speccode | Native | 1997 | 1998 | 2001 |
|---|---|---|---|---|---|---|
| AGAVACEAE | Yucca glauca Nutt. | YUGL1 | Y | X | X | X |
| ANACARDIACEAE | Rhus aromatica Ait. var. trilobata (Nutt.) A. Gray | RHAR1 | Y | X | X | X |
| ANACARDIACEAE | Toxicodendron rydbergii (Small) Greene | TORY1 | Y | | X | |
| APIACEAE | Daucus carota L. | DACA2 | N | X | | |
| APIACEAE | Harbouria trachypleura (Gray) C. & R. | HATR1 | Y | X | X | X |
| APIACEAE | Lomatium orientale Coult. & Rose | LOOR1 | Y | X | X | X |
| APIACEAE | Musineon divaricatum (Pursh.) Nutt. var. hookeri T. & G. | MUDI1 | Y | X | X | X |
| APOCYNACEAE | Apocynum cannabinum L. | APCA1 | Y | X | X | X |
| ASCLEPIADACEAE | Asclepias pumila (Gray) Vail | ASPU1 | Y | X | X | X |
| ASCLEPIADACEAE | Asclepias speciosa Torr. | ASSP1 | Y | X | X | X |
| ASCLEPIADACEAE | Asclepias stenophylla A. Gray | ASST1 | Y | X | X | X |
| ASCLEPIADACEAE | Asclepias viridiflora Raf. | ASVI1 | Y | X | X | X |
| ASTERACEAE | Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | Y | X | X | X |
| ASTERACEAE | Ambrosia psilostachya DC. | AMPS1 | Y | X | X | X |
| ASTERACEAE | Antennaria microphylla Rydb. | ANMI1 | Y | X | X | X |
| ASTERACEAE | Antennaria parvifolia Nutt. | ANPA1 | Y | X | X | X |
| ASTERACEAE | Arnica fulgens Pursh. | ARFU1 | Y | X | X | X |
| ASTERACEAE | Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | ARCA1 | Y | X | X | X |
| ASTERACEAE | Artemisia dracunculus L. | ARDR1 | Y | X | X | X |
| ASTERACEAE | Artemisia frigida Willd. | ARFR1 | Y | X | X | X |
| ASTERACEAE | Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | Y | X | X | X |
| ASTERACEAE | Aster campestris Nutt. | ASCA2 | Y | | | X |
| ASTERACEAE | Aster falcatus Lindl. | ASFA1 | Y | X | X | X |
| ASTERACEAE | Aster fendleri A. Gray | ASFE1 | Y | X | | |
| ASTERACEAE | Aster porteri Gray | ASPO1 | Y | X | X | X |
| ASTERACEAE | Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | CANU1 | N | X | X | X |
| ASTERACEAE | Centaurea diffusa Lam. | CEDI1 | N | X | X | X |
| ASTERACEAE | Chrysopsis fulcrata Greene | CHFU1 | Y | X | X | X |
| ASTERACEAE | Chrysopsis villosa Pursh. | CHVI1 | Y | X | X | X |
| ASTERACEAE | Chrysothamnus nauseosus (Pall.) Britt. ssp. graveolens (Nutt.) Piper | CHNA1 | Y | X | X | |
| ASTERACEAE | Chrysothamnus nauseosus (Pall.) Britt. ssp. nauseosus | CHNA2 | Y | | X | X |
| ASTERACEAE | Cichorium intybus L. | CIIN1 | N | X | X | X |
| ASTERACEAE | Cirsium arvense (L.) Scop. | CIAR1 | N | X | X | X |
| ASTERACEAE | Cirsium undulatum (Nutt.) Spreng. | CIUN1 | Y | X | X | X |
| ASTERACEAE | Cirsium vulgare (Savi) Ten. | CIVU1 | N | | X | X |
| ASTERACEAE | Conyza canadensis (L.) Cronq. | COCA1 | Y | X | X | X |
| ASTERACEAE | Dyssodia papposa (Vent) Hitchc. | DYPA1 | N | X | X | X |
| ASTERACEAE | Erigeron canus A. Gray | ERCA1 | Y | X | X | X |
| ASTERACEAE | Erigeron compositus Pursh var. dicoideus A. Gray | ERCO1 | Y | X | X | X |
| ASTERACEAE | Erigeron divergens T. & G. | ERDI1 | Y | X | X | X |
| ASTERACEAE | Erigeron flagellaris A. Gray | ERFL1 | Y | X | X | X |
| ASTERACEAE | Erigeron strigosus Muhl. ex Willd. | ERST1 | Y | | | X |
| ASTERACEAE | Erigeron vetensis Rydb. | ERVE1 | Y | X | X | X |
| ASTERACEAE | Gaillardia aristata Pursh. | GAAR1 | Y | X | X | X |
| ASTERACEAE | Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | Y | X | X | X |
| ASTERACEAE | Gutierrezia sarothrae (Pursh.) Britt. & Rusby | GUSA1 | Y | X | X | X |
| ASTERACEAE | Happlopappus spinulosus (Pursh) DC. | HASP1 | Y | X | | |
| ASTERACEAE | Helianthus annuus L. | HEAN1 | Y | X | X | X |
| ASTERACEAE | Helianthus petiolaris Nutt. | HEPE1 | Y | X | X | X |
| ASTERACEAE | Helianthus pumilus Nutt. | HEPU1 | Y | X | X | X |
| ASTERACEAE | Helianthus rigidus (Cass.) Desf. ssp. subrhomboideus (Rydb.) Heiser | HERI1 | Y | X | X | X |
| ASTERACEAE | Hymenopappus filifolius Hook. var. cinereus (Rydb.) I. M. Johnst. | HYFI1 | Y | X | X | X |
| ASTERACEAE | Kuhnia chlorolepis Woot. & Standl. | KUCH1 | Y | | X | X |
| ASTERACEAE | Kuhnia eupatorioides L. | KUEU1 | Y | X | X | X |
| ASTERACEAE | Lactuca oblongifolia Nutt. | LAOB1 | Y | | X | |
| ASTERACEAE | Lactuca serriola L. | LASE1 | N | X | X | X |
| ASTERACEAE | Leucelene ericoides (Torr.) Greene | LEER1 | Y | X | X | X |
| ASTERACEAE | Liatris punctata Hook. | LIPU1 | Y | X | X | X |
| ASTERACEAE | Machaeranthera canescens (Pursh) A. Gray | MACA1 | Y | X | X | |
| ASTERACEAE | Microseris cuspidata (Pursh.) Sch. Bip. | MICU1 | Y | X | X | X |
| ASTERACEAE | Onopordum acanthium L. | ONAC1 | N | | | X |
| ASTERACEAE | Ratibida columnifera (Nutt.) Woot. & Standl. | RACO1 | Y | X | X | X |

**Table 1-1. (cont.)**

| Family | Scientific Name | Speccode | Native | 1997 | 1998 | 2001 |
|---|---|---|---|---|---|---|
| ASTERACEAE | Scorzonera laciniata L. | SCLA1 | N | X | X | X |
| ASTERACEAE | Senecio fendleri Gray | SEFE1 | Y | X | X | X |
| ASTERACEAE | Senecio integerrimus Nutt. | SEIN1 | Y | X | X | |
| ASTERACEAE | Senecio plattensis Nutt. | SEPL1 | Y | X | X | X |
| ASTERACEAE | Senecio spartioides T. & G. | SESP1 | Y | X | X | X |
| ASTERACEAE | Senecio tridenticulatus Rydb. | SETR1 | Y | | X | |
| ASTERACEAE | Solidago missouriensis Nutt. | SOMI1 | Y | X | X | X |
| ASTERACEAE | Solidago mollis Bart. | SOMO1 | Y | X | X | X |
| ASTERACEAE | Solidago rigida L. | SORI1 | Y | X | X | X |
| ASTERACEAE | Sonchus asper (L.) Hill | SOAS1 | N | | X | |
| ASTERACEAE | Taraxacum officinale Weber | TAOF1 | N | X | X | X |
| ASTERACEAE | Thelesperma megapotanicum (Spreng.) O. Ktze. | THME1 | Y | X | X | X |
| ASTERACEAE | Townsendia grandiflora (Nutt.) | TOGR1 | Y | | X | X |
| ASTERACEAE | Townsendia hookeri Beaman | TOHO1 | Y | X | X | X |
| ASTERACEAE | Tragopogon dubius Scop. | TRDU1 | N | X | X | X |
| ASTERACEAE | Tragopogon porrifolius L. | TRPO1 | N | | | X |
| ASTERACEAE | Xanthium strumarium L. | XAST1 | Y | | | X |
| BERBERIDACEAE | Berberis repens Lindl. | BERE1 | Y | | X | X |
| BORAGINACEAE | Cryptantha virgata (Porter) Payson | CRVI1 | Y | X | X | X |
| BORAGINACEAE | Cynoglossum officinale L. | CYOF1 | N | | X | X |
| BORAGINACEAE | Lappula redowskii (Hornem.) Greene | LARE1 | Y | X | X | X |
| BORAGINACEAE | Lithospermum incisum Lehm. | LIIN1 | Y | X | X | X |
| BORAGINACEAE | Mertensia lanceolata (Pursh.) A. DC. | MELA1 | Y | X | X | X |
| BORAGINACEAE | Onosmodium molle Michx. var. occidentale (Mack.) Johnst. | ONMO1 | Y | X | X | X |
| BORAGINACEAE | Plagiobothrys scouleri (H. & A.) I. M. Johnst. | PLSC1 | Y | | X | |
| BRASSICACEAE | Alyssum alyssoides (L.) L. | ALAL1 | N | X | X | X |
| BRASSICACEAE | Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | N | X | X | X |
| BRASSICACEAE | Arabis fendleri (S. Wats.) Greene var. fendleri | ARFE3 | Y | X | X | X |
| BRASSICACEAE | Arabis glabra (L.) Bernh. | ARGL1 | N | | X | |
| BRASSICACEAE | Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | ARHI1 | Y | X | X | X |
| BRASSICACEAE | Barbarea vulgaris R. Br. | BAVU1 | N | X | X | X |
| BRASSICACEAE | Camelina microcarpa Andrz. ex DC. | CAMI1 | N | X | X | X |
| BRASSICACEAE | Descurainia pinnata (Walt.) Britt. | DEPI1 | Y | X | X | X |
| BRASSICACEAE | Descurainia richardsonii (Sweet) Schultz | DERI1 | Y | X | | X |
| BRASSICACEAE | Descurainia sophia (L.) Webb ex Prantl. | DESO1 | N | | X | |
| BRASSICACEAE | Draba nemorosa L. | DRNE1 | Y | X | X | |
| BRASSICACEAE | Draba reptans (Lam.) Fern. | DRRE1 | Y | X | X | X |
| BRASSICACEAE | Erysimum capitatum (Nutt.) DC. | ERCA2 | Y | X | X | X |
| BRASSICACEAE | Lepidium campestre (L.) R. Br. | LECA1 | N | X | X | X |
| BRASSICACEAE | Lepidium densiflorum Schrad. | LEDE1 | Y | X | X | X |
| BRASSICACEAE | Lesquerella montana (A. Gray) Wats. | LEMO1 | Y | X | X | X |
| BRASSICACEAE | Sisymbrium altissimum L. | SIAL1 | N | X | X | X |
| BRASSICACEAE | Thlaspi arvense L. | THAR1 | N | | | X |
| CACTACEAE | Coryphantha missouriensis (Sweet) Britt. & Rose | COMI1 | Y | X | X | X |
| CACTACEAE | Echinocereus viridiflorus Engelm. | ECVI1 | Y | X | X | X |
| CACTACEAE | Opuntia fragilis (Nutt.) Haw. | OPFR1 | Y | X | X | |
| CACTACEAE | Opuntia macrorhiza Engelm. | OPMA1 | Y | X | X | X |
| CACTACEAE | Pediocactus simpsonii (Engelm.) Britt. & Rose | PESI1 | Y | X | X | X |
| CAMPANULACEAE | Campanula rotundifolia L. | CARO1 | Y | X | X | X |
| CAPPARACEAE | Cleome serrulata Pursh. | CLSE1 | Y | | | X |
| CAPRIFOLIACEAE | Symphoricarpos occidentalis Hook. | SYOC1 | Y | X | X | X |
| CARYOPHYLLACEAE | Arenaria fendleri A. Gray | ARFE2 | Y | X | X | X |
| CARYOPHYLLACEAE | Cerastium arvense L. | CEAR1 | Y | X | X | X |
| CARYOPHYLLACEAE | Paronychia jamesii T. & G. | PAJA1 | Y | X | X | X |
| CARYOPHYLLACEAE | Silene antirrhina L. | SIAN1 | Y | X | X | X |
| CARYOPHYLLACEAE | Silene drummondii Hook. | SIDR1 | Y | X | X | X |
| CARYOPHYLLACEAE | Spergularia rubra (L.) K. Presl. | SPRU1 | N | X | X | X |
| CARYOPHYLLACEAE | Vaccaria pyramidata Medic. | VAPY1 | N | | X | |
| CHENOPODIACEAE | Chenopodium album L. | CHAL1 | N | | X | X |
| CHENOPODIACEAE | Chenopodium atrovirens Nutt. | CHAT1 | Y | | X | |
| CHENOPODIACEAE | Chenopodium leptophyllum Nutt. ex Moq. | CHLE2 | Y | X | X | X |
| CHENOPODIACEAE | Kochia scoparia (L.) Schrad. | KOSC1 | N | | | X |

**Table 1-1. (cont.)**

| Family | Scientific Name | Speccode | Native | 1997 | 1998 | 2001 |
|---|---|---|---|---|---|---|
| CHENOPODIACEAE | Salsola iberica Senn. & Pau. | SAIB1 | N | X | | X |
| CLUSIACEAE | Hypericum perforatum L. | HYPE1 | N | X | X | X |
| COMMELINACEAE | Tradescantia occidentalis (Britt.) Smyth | TROC1 | Y | X | X | X |
| CONVOLVULACEAE | Convolvulus arvensis L. | COAR1 | N | X | X | X |
| CONVOLVULACEAE | Evolvulus nuttallianus R. & S. | EVNU1 | Y | X | X | X |
| CRASSULACEAE | Sedum lanceolatum Torr. | SELA1 | Y | X | X | X |
| CUPRESSACEAE | Juniperus communis L. | JUCO1 | Y | X | X | X |
| CUPRESSACEAE | Juniperus scopulorum Sarg. | JUSC1 | Y | X | X | X |
| CYPERACEAE | Carex sp. | CAR1 | | | | X |
| CYPERACEAE | Carex brevior (Dew.) Mack. ex Lunell. | CABR1 | Y | | X | X |
| CYPERACEAE | Carex eleocharis Bailey | CAEL1 | Y | X | X | X |
| CYPERACEAE | Carex filifolia Nutt. | CAFI1 | Y | X | | X |
| CYPERACEAE | Carex heliophila Mack. | CAHE1 | Y | X | X | X |
| CYPERACEAE | Carex interior Bailey | CAIN1 | Y | X | | X |
| CYPERACEAE | Carex oreocharis Holm. | CAOR1 | Y | X | X | X |
| CYPERACEAE | Carex praegracilis W. Boott. | CAPR1 | Y | X | | X |
| CYPERACEAE | Eleocharis compressa Sulliv. | ELCO1 | Y | X | X | X |
| CYPERACEAE | Eleocharis macrostachya Britt. | ELMA1 | Y | X | X | X |
| EUPHORBIACEAE | Euphorbia fendleri T. & G. | EUFE1 | Y | X | X | X |
| EUPHORBIACEAE | Euphorbia robusta (Engelm.) Small | EURO1 | Y | X | X | X |
| EUPHORBIACEAE | Euphorbia serpyllifolia Pers. | EUSE1 | Y | | X | X |
| EUPHORBIACEAE | Euphorbia spathulata Lam. | EUSP1 | Y | X | X | X |
| EUPHORBIACEAE | Tragia ramosa Nutt. | TRRA1 | Y | X | X | |
| FABACEAE | Amorpha fruticosa L. | AMFR1 | Y | X | X | X |
| FABACEAE | Astragalus adsurgens Pall. var. robustior Hook. | ASAD1 | Y | X | X | X |
| FABACEAE | Astragalus agrestis Dougl. ex G. Don | ASAG1 | Y | X | X | X |
| FABACEAE | Astragalus crassicarpus Nutt. | ASCR1 | Y | | X | |
| FABACEAE | Astragalus drummondii Dougl. ex Hook. | ASDR1 | Y | X | X | X |
| FABACEAE | Astragalus flexuosus (Hook.) G. Don | ASFL1 | Y | X | X | X |
| FABACEAE | Astragalus shortianus Nutt. ex T.&G. | ASSH1 | Y | X | X | X |
| FABACEAE | Astragalus spathulatus Sheld. | ASSP2 | Y | | X | |
| FABACEAE | Astragalus tridactylicus Gray | ASTR1 | Y | X | X | X |
| FABACEAE | Dalea candida Michx. ex Willd. var. oligophylla (Torr.) Shinners. | DACA1 | Y | X | X | X |
| FABACEAE | Dalea purpurea Vent | DAPU1 | Y | X | X | X |
| FABACEAE | Glycyrrhiza lepidota Pursh. | GLLE1 | Y | X | X | X |
| FABACEAE | Lupinus argenteus Pursh var. argenteus | LUAR1 | Y | X | X | X |
| FABACEAE | Medicago lupulina L. | MELU1 | N | | | X |
| FABACEAE | Medicago sativa L. ssp. sativa | MESA1 | N | X | X | |
| FABACEAE | Melilotus alba Medic. | MEAL1 | N | | X | |
| FABACEAE | Melilotus officinalis (L.) Pall. | MEOF1 | N | X | X | X |
| FABACEAE | Oxytropis lambertii Pursh. | OXLA1 | Y | X | X | X |
| FABACEAE | Psoralea tenuiflora Pursh. | PSTE1 | Y | X | X | X |
| FABACEAE | Robinia pseudo-acacia L. | ROPS1 | N | X | X | |
| FABACEAE | Thermopsis rhombifolia var. divaricarpa (Nels.) Isely | THRH1 | Y | X | X | X |
| FABACEAE | Trifolium pratense L. | TRPR1 | N | | X | |
| FABACEAE | Vicia americana Muhl. ex Willd. | VIAM1 | Y | | X | |
| GENTIANACEAE | Gentiana affinis Griseb. | GEAF1 | Y | X | X | X |
| GENTIANACEAE | Swertia radiata (Kell.) O. Ktze. | SWRA1 | Y | X | X | X |
| GERANIACEAE | Erodium cicutarium (L.) L'Her. | ERCI1 | N | X | X | X |
| GERANIACEAE | Geranium caespitosum James ssp. caespitosum | GECA1 | Y | X | X | X |
| GROSSULARIACEAE | Ribes aureum Pursh | RIAU1 | Y | X | X | |
| GROSSULARIACEAE | Ribes cereum Dougl. | RICE1 | Y | X | | X |
| HYDROPHYLLACEAE | Hydrophyllum fendleri (Gray) Heller | HYFE1 | Y | | X | |
| HYDROPHYLLACEAE | Phacelia heterophylla Pursh. | PHHE1 | Y | X | X | X |
| IRIDACEAE | Iris missouriensis Nutt. | IRMI1 | Y | X | X | X |
| IRIDACEAE | Sisyrinchium montanum Greene | SIMO1 | Y | X | X | X |
| JUNCACEAE | Juncus balticus Willd. | JUBA1 | Y | X | X | X |
| JUNCACEAE | Juncus dudleyi Wieg. | JUDU1 | Y | X | | |
| JUNCACEAE | Juncus interior Wieg. | JUIN1 | Y | X | X | X |
| JUNCACEAE | Juncus longistylis Torr. | JULO1 | Y | X | | |
| LAMIACEAE | Hedeoma hispidum Pursh. | HEHI1 | Y | X | | X |
| LAMIACEAE | Marrubium vulgare L. | MAVU1 | N | X | X | X |

**Table 1-1. (cont.)**

| Family | Scientific Name | Speccode | Native | 1997 | 1998 | 2001 |
|---|---|---|---|---|---|---|
| LAMIACEAE | Monarda fistulosa L. var. menthifolia (Grah.) Fern. | MOFI1 | Y | X | X | X |
| LAMIACEAE | Monarda pectinata Nutt. | MOPE1 | Y | | | X |
| LAMIACEAE | Nepeta cataria L. | NECA1 | N | | X | X |
| LAMIACEAE | Prunella vulgaris L. | PRVU1 | Y | | X | |
| LAMIACEAE | Scutellaria brittonii Porter | SCBR1 | Y | X | X | |
| LILIACEAE | Allium cernuum Roth | ALCE1 | Y | X | X | X |
| LILIACEAE | Allium geyeri S. Wats. | ALGE1 | Y | X | X | X |
| LILIACEAE | Allium textile A. Nels. & Macbr. | ALTE1 | Y | X | X | X |
| LILIACEAE | Calochortus gunnisonii S. Wats. | CAGU1 | Y | X | X | X |
| LILIACEAE | Leucocrinum montanum Nutt. | LEMO2 | Y | X | X | X |
| LILIACEAE | Zigadenus venenosus Wats. var. gramineus (Rydb.) Walsh ex Peck | ZIVE1 | Y | X | | X |
| LINACEAE | Linum perenne L. var. lewisii (Pursh.) Eat. & Wright | LIPE1 | Y | X | X | X |
| LINACEAE | Linum pratense (Nort.) Small | LIPR1 | Y | | | X |
| MALVACEAE | Malva neglecta Wallr. | MANE1 | N | X | | |
| MALVACEAE | Sphaeralcea coccinea (Pursh.) Rydb. | SPCO1 | Y | X | X | X |
| NYCTAGINACEAE | Mirabilis hirsuta (Pursh.) MacM. | MIHI1 | Y | X | X | X |
| NYCTAGINACEAE | Mirabilis linearis (Pursh.) Heimerl | MILI1 | Y | X | X | X |
| ONAGRACEAE | Calylophus serrulatus (Nutt.) Raven | CASE2 | Y | X | X | X |
| ONAGRACEAE | Epilobium paniculatum Nutt. | EPPA1 | Y | | X | |
| ONAGRACEAE | Gaura coccinea Pursh. | GACO1 | Y | X | X | X |
| ONAGRACEAE | Oenothera howardii (A. Nels.) W. L. Wagner | OEHO1 | Y | X | X | X |
| ONAGRACEAE | Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven | OEVI1 | Y | X | X | X |
| OROBANCHACEAE | Orobanche fasciculata Nutt. | ORFA1 | Y | X | X | X |
| OXALIDACEAE | Oxalis dillenii Jacq. | OXDI1 | N | X | X | X |
| PAPAVERACEAE | Argemone polyanthemos (Fedde) G. Ownbey | ARPO1 | Y | X | X | X |
| PINACEAE | Pinus ponderosa Laws | PIPO1 | Y | X | X | X |
| PINACEAE | Pseudotsuga menziesii (Mirb.) Franco | PSME1 | Y | X | X | X |
| PLANTAGINACE | Plantago lanceolata L. | PLLA1 | N | X | X | X |
| PLANTAGINACE | Plantago patagonica Jacq. | PLPA1 | Y | X | X | X |
| POACEAE | Aegilops cylindrica Host | AECY1 | N | | X | X |
| POACEAE | Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc. | AGCA1 | Y | X | X | X |
| POACEAE | Agropyron cristatum (L.) Gaertn. | AGCR1 | N | X | X | X |
| POACEAE | Agropyron desertorum (Fisch.) Schult. | AGDE1 | N | X | X | X |
| POACEAE | Agropyron elongatum (Host) Beauv. | AGEL1 | N | | X | X |
| POACEAE | Agropyron griffithsii Scribn. & Smith | AGGR1 | Y | X | X | X |
| POACEAE | Agropyron intermedium (Host) Beauv. | AGIN1 | N | X | X | X |
| POACEAE | Agropyron smithii Rydb. | AGSM1 | Y | X | X | X |
| POACEAE | Agrostis scabra Willd. | AGSC1 | Y | X | | X |
| POACEAE | Agrostis stolonifera L. | AGST1 | N | | | X |
| POACEAE | Alopecurus geniculatus L. | ALGE2 | Y | X | | X |
| POACEAE | Andropogon gerardii Vitman | ANGE1 | Y | X | X | X |
| POACEAE | Andropogon scoparius Michx. | ANSC1 | Y | X | X | X |
| POACEAE | Aristida basiramea Engelm. ex Vasey var. basiramea | ARBA1 | Y | X | X | |
| POACEAE | Aristida purpurea Nutt. var. longiseta (Steud.) Vasey | ARFE1 | Y | X | X | X |
| POACEAE | Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | Y | X | X | X |
| POACEAE | Bouteloua curtipendula (Michx.) Torr. | BOCU1 | Y | X | X | X |
| POACEAE | Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | Y | X | X | X |
| POACEAE | Bouteloua hirsuta Lag | BOHI1 | Y | X | X | X |
| POACEAE | Bromus inermis Leyss. ssp. inermis | BRIN1 | N | X | X | X |
| POACEAE | Bromus japonicus Thunb. ex Murr. | BRJA1 | N | X | X | X |
| POACEAE | Bromus tectorum L. | BRTE1 | N | X | X | X |
| POACEAE | Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | Y | X | X | X |
| POACEAE | Dactylis glomerata L. | DAGL1 | N | X | X | X |
| POACEAE | Danthonia spicata (L.) Beauv. ex R. & S. | DASP1 | Y | X | X | X |
| POACEAE | Dichanthelium linearifolium (Scribn.) Gould | DILI1 | Y | | | X |
| POACEAE | Dichanthelium oligosanthes (Schultz) Gould var. scribnerianum (Nash) G | DIOL1 | Y | X | X | X |
| POACEAE | Echinochloa crusgallii (L.) Beauv. | ECCR1 | N | | X | X |
| POACEAE | Elymus canadensis L. | ELCA1 | Y | X | | X |
| POACEAE | Elymus juncea Fisch. | ELJU1 | N | X | | |
| POACEAE | Festuca octoflora Walt. | FEOC1 | Y | | | X |
| POACEAE | Festuca ovina L. var. rydbergii St. Yves | FEOV1 | Y | X | X | X |
| POACEAE | Festuca pratensis Huds. | FEPR1 | Y | | | X |

**Table 1-1. (cont.)**

| Family | Scientific Name | Speccode | Native | 1997 | 1998 | 2001 |
|---|---|---|---|---|---|---|
| POACEAE | Hordeum brachyantherum Nevski | HOBR1 | Y | | | X |
| POACEAE | Hordeum jubatum L. | HOJU1 | Y | | X | X |
| POACEAE | Koeleria pyramidata (Lam.) Beauv. | KOPY1 | Y | X | X | X |
| POACEAE | Lolium perenne L. var. aristatum Willd. | LOPE1 | N | X | | |
| POACEAE | Lycurus phleoides H.B.K. | LYPH1 | Y | | | X |
| POACEAE | Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | Y | X | X | X |
| POACEAE | Muhlenbergia wrightii Vasey | MUWR1 | Y | | X | X |
| POACEAE | Oryzopsis hymenoides (R. & S.) Ricker | ORHY1 | Y | X | X | X |
| POACEAE | Panicum capillare L. | PACA1 | Y | | X | X |
| POACEAE | Panicum virgatum L. | PAVI1 | Y | X | X | X |
| POACEAE | Phleum pratense L. | PHPR1 | N | X | X | X |
| POACEAE | Poa bulbosa L. | POBU1 | N | | X | X |
| POACEAE | Poa canbyi (Scribn.) Piper | POCA1 | Y | X | X | X |
| POACEAE | Poa compressa L. | POCO1 | N | X | X | X |
| POACEAE | Poa fendleriana (Steud.) Vasey | POFE1 | Y | X | X | X |
| POACEAE | Poa pratensis L. | POPR1 | N | X | X | X |
| POACEAE | Schedonnardus paniculatus (Nutt.) Trel. | SCPA2 | N | | X | |
| POACEAE | Secale cereale L. | SECE1 | N | X | X | X |
| POACEAE | Setaria viridis (L.) Beauv. | SEVI1 | N | X | X | |
| POACEAE | Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | Y | X | X | X |
| POACEAE | Sorghastrum nutans (L.) Nash | SONU1 | Y | X | X | X |
| POACEAE | Sporobolus asper (Michx.) Kunth | SPAS1 | Y | X | X | X |
| POACEAE | Sporobolus cryptandrus (Torr.) A. Gray | SPCR1 | Y | X | X | X |
| POACEAE | Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | Y | X | X | X |
| POACEAE | Stipa comata Trin. & Rupr. | STCO1 | Y | X | X | X |
| POACEAE | Stipa neomexicana (Thur.) Scribn. | STNE1 | Y | | X | X |
| POACEAE | Stipa robusta (Vasey) Scribn. | STRO1 | Y | | | X |
| POACEAE | Stipa spartea Trinius | STSP1 | Y | X | X | X |
| POACEAE | Stipa viridula Trin. | STVI1 | Y | X | X | X |
| POACEAE | Triticum aestivum L. | TRAE1 | N | | X | |
| POLEMONIACEAE | Collomia linearis Nutt. | COLI1 | Y | | | X |
| POLEMONIACEAE | Gilia opthalmoides Brand. ssp. clokeyi (Mason) A. & V. Grant | GIOP1 | Y | | X | |
| POLEMONIACEAE | Ipomopsis spicata (Nutt.) V. Grant ssp. spicata | IPSP1 | Y | X | X | X |
| POLEMONIACEAE | Navarretia minima Nutt. | NAMI1 | N | X | X | |
| POLYGONACEAE | Eriogonum alatum Torr. | ERAL1 | Y | X | X | X |
| POLYGONACEAE | Eriogonum effusum Nutt. | EREF1 | Y | X | X | X |
| POLYGONACEAE | Eriogonum umbellatum Torr. | ERUM1 | Y | X | X | X |
| POLYGONACEAE | Polygonum arenastrum Jord. ex Bor. | POAR1 | N | | X | X |
| POLYGONACEAE | Polygonum convolvulus L. | POCO2 | N | X | X | X |
| POLYGONACEAE | Polygonum douglasii Greene | PODO1 | Y | | X | |
| POLYGONACEAE | Polygonum persicaria L. | POPE2 | N | | | X |
| POLYGONACEAE | Polygonum ramosissimum Michx. | PORA1 | Y | X | | X |
| POLYGONACEAE | Polygonum sawatchense Small | POSA1 | Y | | X | |
| POLYGONACEAE | Rumex acetosella L. | RUAC1 | N | X | X | X |
| POLYGONACEAE | Rumex crispus L. | RUCR1 | N | X | X | X |
| POLYGONACEAE | Rumex salicifolius Weinm. ssp. triangulivalvis Danser | RUSA1 | Y | X | X | |
| PORTULACACEAE | Claytonia rosea Rydb. | CLRO1 | Y | | X | |
| PORTULACACEAE | Portulaca oleracea L. | POOL1 | N | | | X |
| PORTULACACEAE | Talinum parviflorum Nutt. | TAPA1 | Y | X | X | X |
| PRIMULACEAE | Androsace occidentalis Pursh. | ANOC1 | Y | X | X | X |
| RANUNCULACEAE | Anemone patens L. | ANPA2 | Y | X | X | X |
| RANUNCULACEAE | Clematis ligusticifolia Nutt. | CLLI1 | Y | X | | |
| RANUNCULACEAE | Delphinium nuttalianum Pritz. ex Walpers | DENU1 | Y | X | X | X |
| RANUNCULACEAE | Delphinium virescens Nutt. ssp. penardii (Huth) Ewan | DEVI1 | Y | X | X | X |
| RANUNCULACEAE | Myosurus minimus L. | MYMI1 | Y | X | X | |
| ROSACEAE | Amelanchier alnifolia Nutt. | AMAL1 | Y | X | X | X |
| ROSACEAE | Crataegus erythropoda Ashe | CRER1 | Y | X | X | X |
| ROSACEAE | Geum macrophyllum Willd. | GEMA1 | Y | X | | X |
| ROSACEAE | Potentilla fissa Nutt. | POFI1 | Y | X | X | X |
| ROSACEAE | Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc. | POGR1 | Y | X | X | X |
| ROSACEAE | Potentilla hippiana Lehm. | POHI1 | Y | X | X | X |
| ROSACEAE | Potentilla pensylvanica L. | POPE4 | Y | X | X | X |

**Table 1-1. (cont.)**

| Family | Scientific Name | Speccode | Native | 1997 | 1998 | 2001 |
|---|---|---|---|---|---|---|
| ROSACEAE | Prunus pumila L. var. besseyi (Bailey) Gl. | PRPU1 | Y | X | X | X |
| ROSACEAE | Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg. | PRVI1 | Y | X | X | X |
| ROSACEAE | Rosa acicularis Lindl. | ROAC1 | Y | | X | |
| ROSACEAE | Rosa arkansana Porter | ROAR1 | Y | X | X | X |
| ROSACEAE | Rosa woodsii Lindl. | ROWO1 | Y | | X | |
| ROSACEAE | Sanguisorba minor Scop. | SAMI1 | N | | | X |
| RUBIACEAE | Galium aparine L. | GAAP1 | Y | X | X | X |
| RUBIACEAE | Galium septentrionale Roemer & Schultes | GASE1 | Y | | X | |
| SALICACEAE | Populus alba L. | POAL1 | Y | | | X |
| SALICACEAE | Populus deltoides Marsh. ssp. monilifera (Ait.) Eckenw. | PODE1 | Y | X | X | X |
| SALICACEAE | Salix amygdaloides Anderss. | SAAM1 | Y | | | X |
| SANTALACEAE | Comandra umbellata (L.) Nutt. | COUM1 | Y | X | X | X |
| SAXIFRAGACEAE | Heuchera parvifolia Nutt. ex T.& G. | HEPA1 | Y | X | X | X |
| SAXIFRAGACEAE | Saxifraga rhomoidea Greene | SARH1 | Y | X | X | |
| SCROPHULARIACEAE | Castilleja integra A. Gray | CAIN2 | Y | X | X | X |
| SCROPHULARIACEAE | Castilleja sessiliflora Pursh. | CASE3 | Y | X | X | X |
| SCROPHULARIACEAE | Collinsia parviflora Doug. ex Lindl. | COPA1 | Y | X | X | |
| SCROPHULARIACEAE | Linaria dalmatica (L.) Mill. | LIDA1 | N | X | X | X |
| SCROPHULARIACEAE | Linaria vulgaris Hill | LIVU1 | N | X | | X |
| SCROPHULARIACEAE | Penstemon secundiflorus Benth. | PESE1 | Y | X | X | X |
| SCROPHULARIACEAE | Penstemon strictus Bentham in De Candolle | PEST1 | Y | X | | |
| SCROPHULARIACEAE | Penstemon virens Penn. | PEVI1 | Y | X | X | X |
| SCROPHULARIACEAE | Penstemon virgatus Gray ssp. asa-grayi Crosswhite | PEVI2 | Y | X | | |
| SCROPHULARIACEAE | Scrophularia lanceolata Pursh. | SCLA2 | Y | | X | |
| SCROPHULARIACEAE | Verbascum blattaria L. | VEBL1 | N | X | X | X |
| SCROPHULARIACEAE | Verbascum thapsus L. | VETH1 | N | X | X | X |
| SCROPHULARIACEAE | Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | Y | X | X | X |
| SELAGINELLACEAE | Selaginella densa Rydb. | SEDE1 | Y | X | X | X |
| SOLANACEAE | Physalis heterophylla Nees | PHHE2 | Y | X | X | X |
| SOLANACEAE | Physalis pumila Nutt. ssp. Hispida (Waterfall) Hinton | PHPU1 | Y | | | X |
| SOLANACEAE | Physalis virginiana P. Mill. | PHVI2 | Y | X | X | X |
| SOLANACEAE | Solanum rostratum Dun. | SORO1 | Y | | X | |
| SOLANACEAE | Solanum triflorum Nutt. | SOTR1 | Y | X | | X |
| TYPHACEAE | Typha latifolia L. | TYLA1 | Y | | | X |
| ULMACEAE | Ulmus pumila L. | ULPU1 | N | X | X | X |
| VERBENACEAE | Lippia cuneifolia (Torr.) Steud. | LICU1 | Y | X | X | X |
| VERBENACEAE | Verbena bracteata Lag. & Rodr. | VEBR1 | Y | X | X | X |
| VIOLACEAE | Viola nuttallii Pursh. | VINU1 | Y | X | X | X |
| | Total number of species | | | 274 | 295 | 292 |
| | Percent native species | | | 81 | 79 | 79 |

**Table 1-2. 2001 Estimated Weed Infestation Acreage Summary for the Rocky Flats Environmental Technology Site**

| | 2001 Acreage | | | | |
|---|---|---|---|---|---|
| | | Density Level | | | |
| **Common Name** | **Site Total** | **High** | **Medium** | **Low** | **Scattered** |
| Diffuse Knapweed | 1957 | 381 | 525 | 674 | 377 |
| Musk Thistle | 869 | 9 | 84 | 430 | 346 |
| Mullein | 1357 | 47 | 183 | 627 | 500 |
| Jointed Goatgrass | 69 | NA | NA | NA | NA |
| Annual Rye | 62 | NA | NA | NA | NA |
| Scotch Thistle | 4 | NA | NA | NA | NA |
| Dame's Rocket | 1 | NA | NA | NA | NA |
| Russian Knapweed | <1 | NA | NA | NA | NA |
| Bouncingbet | <1 | NA | NA | NA | NA |

All values are approximate acreages. NA = Data not collected by density level.

See text for density level descriptions.

**Table 1-3. Comparison of 1997-2001 Weed Infestation Extents at the Rocky Flats Environmental Technology Site**

| | | | Density Level | | | |
|---|---|---|---|---|---|---|
| **Weed Species** | **Year** | **Site Total** | **High** | **Medium** | **Low** | **Scattered** |
| Diffuse Knapweed | 1997 | 2678 | 696 | 893 | 658 | 431 |
| | 1998 | 2913 | 761 | 778 | 987 | 388 |
| | 1999 | 2295 | 466 | 613 | 873 | 343 |
| | 2000 | 2223 | 510 | 531 | 771 | 412 |
| | 2001 | 1957 | 381 | 525 | 674 | 377 |
| Musk Thistle | 1997 | 474 | 2 | 270 | 202 | 0 |
| | 1998 | 1685 | 32 | 515 | 1035 | 102 |
| | 1999 | 1353 | 1 | 311 | 684 | 357 |
| | 2000 | 792 | 0 | 55 | 242 | 494 |
| | 2001 | 869 | 9 | 84 | 430 | 346 |
| Mullein | 1997 | 575 | 117 | 238 | 203 | 17 |
| | 1998 | 867 | 168 | 225 | 460 | 13 |
| | 1999 | 1068 | 130 | 204 | 450 | 284 |
| | 2000 | 1010 | 69 | 184 | 451 | 307 |
| | 2001 | 1357 | 47 | 183 | 627 | 500 |

All values are approximate acreages.

See text for density level descriptions.

**Table 2-1. 1993-2001 Xeric Mixed Grassland Species Richness Summary**

| | | | | TR01 | | | | | TR06 | | | | | TR12 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Family | Scientific Name | Speccode | Native | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 |
| AGAVACEAE | Yucca glauca Nutt. | YUGL1 | Y | | | | | | X | X | X | X | X | | | | | |
| ANACARDIACEAE | Rhus aromatica Ait. var. trilobata (Nutt.) A. Gray | RHAR1 | Y | X | X | X | X | X | | | | | | | | | | |
| APIACEAE | Harbouria trachypleura (Gray) C. & R. | HATR1 | Y | | | | | | | | | | | X | | | | |
| APIACEAE | Lomatium orientale Coult. & Rose | LOOR1 | Y | | X | X | X | X | | X | X | X | X | | X | X | X | X |
| ASCLEPIADACEAE | Asclepias stenophylla A. Gray | ASST1 | Y | | | | | X | | | | | | | | | | |
| ASCLEPIADACEAE | Asclepias viridiflora Raf. | ASVI1 | Y | X | X | X | X | X | | | | | | X | X | X | X | X |
| ASTERACEAE | Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | Y | X | X | X | X | | | | | | | X | X | X | X | |
| ASTERACEAE | Ambrosia psilostachya DC. | AMPS1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Antennaria microphylla Rydb. | ANMI1 | Y | X | X | X | | | | | | | | X | X | X | | |
| ASTERACEAE | Antennaria parvifolia Nutt. | ANPA1 | Y | | | | X | X | | | | | | | | | X | X |
| ASTERACEAE | Antennaria sp. | ANT1 | | | | X | | | | | | | | | | | | |
| ASTERACEAE | Arnica fulgens Pursh. | ARFU1 | Y | | | X | | | | | | | | | | | | |
| ASTERACEAE | Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | ARCA1 | Y | | X | | | | | | X | X | X | | | | | |
| ASTERACEAE | Artemisia dracunculus L. | ARDR1 | Y | | | | | | X | X | X | X | X | | | | | |
| ASTERACEAE | Artemisia frigida Willd. | ARFR1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Aster ericoides L. | ASER1 | Y | X | X | X | | | | X | | | | | X | | | |
| ASTERACEAE | Aster falcatus Lindl. | ASFA1 | Y | | | | X | | | | | | | | | | | |
| ASTERACEAE | Aster porteri Gray | ASPO1 | Y | X | X | X | X | X | | | | | | X | X | X | X | X |
| ASTERACEAE | Aster sp. | AST1 | | | | | | | | X | | | | | | | | |
| ASTERACEAE | Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | CANU1 | N | | | | | | X | X | X | X | X | | | X | | |
| ASTERACEAE | Centaurea diffusa Lam. | CEDI1 | N | | X | X | X | X | | | X | | | X | X | X | X | X |
| ASTERACEAE | Chrysanthemum leucanthemum L. | CHLE1 | N | | | | | | X | | | | | | | | | |
| ASTERACEAE | Chrysopsis fulcrata Greene | CHFU1 | Y | X | X | X | X | X | | | | | X | X | X | X | X | X |
| ASTERACEAE | Chrysopsis villosa Pursh. | CHVI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Cirsium arvense (L.) Scop. | CIAR1 | N | | | | | | X | X | X | X | | | | | | |
| ASTERACEAE | Cirsium undulatum (Nutt.) Spreng. | CIUN1 | Y | X | X | X | X | | X | X | X | X | X | X | X | X | | |
| ASTERACEAE | Conyza canadensis (L.) Cronq. | COCA1 | Y | | | | | X | | | | | | | | | | X |
| ASTERACEAE | Erigeron canus A. Gray | ERCA1 | Y | | | | | X | | | | X | | | | | | |
| ASTERACEAE | Erigeron divergens T. & G. | ERDI1 | Y | | | X | X | | X | X | X | X | | | X | | X | X |
| ASTERACEAE | Erigeron flagellaris A. Gray | ERFL1 | Y | X | | X | | | X | X | X | | | X | X | X | X | X |
| ASTERACEAE | Erigeron sp. | ERI1 | | | | | | | | X | | | | | | | | |
| ASTERACEAE | Gaillardia aristata Pursh. | GAAR1 | Y | X | X | X | X | X | | | X | | | X | X | X | X | X |
| ASTERACEAE | Gutierrezia sarothrae (Pursh.) Britt. & Rusby | GUSA1 | Y | | | | | | X | X | X | | | X | X | X | X | X |
| ASTERACEAE | Helianthus annuus L. | HEAN1 | Y | | | | | | | | | | X | | | | | |
| ASTERACEAE | Helianthus petiolaris Nutt. | HEPE1 | Y | | X | | | | | | X | | | | | | | |
| ASTERACEAE | Helianthus pumilus Nutt. | HEPU1 | Y | X | X | X | X | X | X | X | X | X | X | | | | | |
| ASTERACEAE | Helianthus rigidus (Cass.) Desf. ssp. subrhomboideus (Rydb.) Heiser | HERI1 | Y | | | X | X | X | | | | | | | | | | |
| ASTERACEAE | Helianthus sp. | HEL1 | | | | | | | | | X | | | | | | | |
| ASTERACEAE | Hymenopappus filifolius Hook. var. cinereus (Rydb.) I. M. Johnst. | HYFI1 | Y | | | | | | X | | | | | | | | | |
| ASTERACEAE | Lactuca serriola L. | LASE1 | N | X | | | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Liatris punctata Hook. | LIPU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Microseris cuspidata (Pursh.) Sch. Bip. | MICU1 | Y | | X | X | X | | | X | X | X | X | | X | X | X | X |
| ASTERACEAE | Ratibida columnifera (Nutt.) Woot. & Standl. | RACO1 | Y | X | X | | X | | | | X | | | X | X | X | X | X |
| ASTERACEAE | Scorzonera laciniata L. | SCLA1 | N | | X | | | | | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Senecio integerrimus Nutt. | SEIN1 | Y | | | | | | | | | | | | X | | | |
| ASTERACEAE | Senecio plattensis Nutt. | SEPL1 | Y | | X | X | X | X | | | X | X | | X | X | X | X | X |
| ASTERACEAE | Senecio spartioides T. & G. | SESP1 | Y | | | | | | | X | X | | | X | X | X | X | X |
| ASTERACEAE | Solidago missouriensis Nutt. | SOMI1 | Y | X | X | | | | | | | | | | | | | |

Table 2-1. (cont.)

| | | | | TR01 | | | | | TR06 | | | | | TR12 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Family | Scientific Name | Speccode | Native | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 |
| ASTERACEAE | Solidago mollis Bart. | SOMO1 | Y | X | | X | X | | | | | | | X | X | X | X | X |
| ASTERACEAE | Solidago nana Nutt. | SONA1 | Y | | | | | | | | | | | | | | X | |
| ASTERACEAE | Solidago nemoralis Ait. | SONE1 | Y | | | | | | | | | | | | X | X | | |
| ASTERACEAE | Solidago sp. | SOL2 | | | | X | | | | | | | | | | | | |
| ASTERACEAE | Taraxacum officinale Weber | TAOF1 | N | | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Thelesperma megapotanicum (Spreng.) O. Ktze. | THME1 | Y | | | X | | | | X | X | X | X | | | | | |
| ASTERACEAE | Townsendia grandiflora (Nutt.) | TOGR1 | Y | | | | | | | X | | | | | | | | |
| ASTERACEAE | Townsendia hookeri Beaman | TOHO1 | Y | | X | X | | | | | | | | | | | | |
| ASTERACEAE | Tragopogon dubius Scop. | TRDU1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BORAGINACEAE | Lappula redowskii (Hornem.) Greene | LARE1 | Y | | | X | | X | | X | X | | X | | | | | X |
| BORAGINACEAE | Lithospermum incisum Lehm. | LIIN1 | Y | | | | | | X | X | X | X | X | X | | X | X | X |
| BORAGINACEAE | Mertensia lanceolata (Pursh.) A. DC. | MELA1 | Y | | X | X | X | | | X | | | | | X | X | | |
| BORAGINACEAE | Onosmodium molle Michx. var. occidentale (Mack.) Johnst. | ONMO1 | Y | | | | | | | | | X | | | | | | |
| BRASSICACEAE | | BR1 | | | | X | | | | X | | | | | | | | |
| BRASSICACEAE | Alyssum alyssoides (L.) L. | ALAL1 | N | | | X | X | | | | | | | | | | | |
| BRASSICACEAE | Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BRASSICACEAE | Arabis glabra (L.) Bernh. | ARGL1 | N | | X | X | | | | | | | | | | | | |
| BRASSICACEAE | Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | ARHI1 | Y | | | X | X | | | | | | | | | | | X |
| BRASSICACEAE | Arabis sp. | ARA1 | | | X | | | | | | | | | | | | | |
| BRASSICACEAE | Barbarea vulgaris R. Br. | BAVU1 | N | | | | | | | | | | | | | | | X |
| BRASSICACEAE | Barbarea vulgaris R. Br. | BAOR1 | N | | | | | | | | | | | | | X | | |
| BRASSICACEAE | Camelina microcarpa Andrz. ex DC. | CAMI1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BRASSICACEAE | Descurainia pinnata (Walt.) Britt. | DEPI1 | Y | | X | X | | X | X | X | X | X | X | | X | X | X | X |
| BRASSICACEAE | Descurainia richardsonii (Sweet) Schultz | DERI1 | Y | | | | | | | X | X | X | X | | | | | X |
| BRASSICACEAE | Descurainia sophia (L.) Webb ex Prantl. | DESO1 | N | | | | | | X | X | | | | | | | | |
| BRASSICACEAE | Draba nemorosa L. | DRNE1 | Y | | X | | | | | | | | | | | | | |
| BRASSICACEAE | Draba reptans (Lam.) Fern. | DRRE1 | Y | | X | X | | X | | X | X | X | X | | X | X | X | X |
| BRASSICACEAE | Erysimum capitatum (Nutt.) DC. | ERAS1 | Y | X | X | X | | | X | X | X | | | | X | X | | |
| BRASSICACEAE | Erysimum capitatum (Nutt.) DC. | ERCA2 | Y | | | | X | X | | | | X | X | | | | X | X |
| BRASSICACEAE | Lepidium densiflorum Schrad. | LEDE1 | Y | | | | | X | | | | | | | | X | X | X |
| BRASSICACEAE | Lepidium sp. | LEP1 | | | | | | | | | | | | | X | | | |
| BRASSICACEAE | Lesquerella montana (A. Gray) Wats. | LEMO1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BRASSICACEAE | Sisymbrium altissimum L. | SIAL1 | N | | | | | X | X | X | X | X | X | X | X | X | | X |
| CACTACEAE | Coryphantha missouriensis (Sweet) Britt. & Rose | COMI1 | Y | X | X | X | X | | X | X | X | X | X | | | | X | |
| CACTACEAE | Echinocereus viridiflorus Engelm. | ECVI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CACTACEAE | Opuntia fragilis (Nutt.) Haw. | OPFR1 | Y | | X | X | | | | | | | | | | | | |
| CACTACEAE | Opuntia macrorhiza Engelm. | OPHU1 | Y | X | X | X | | | X | X | X | | | X | X | X | | |
| CACTACEAE | Opuntia macrorhiza Engelm. | OPMA1 | Y | | | | X | X | | | | X | X | | | | X | X |
| CACTACEAE | Pediocactus simpsonii (Engelm.) Britt. & Rose | PESI1 | Y | | | | | | | X | X | X | X | | X | | | |
| CARYOPHYLLACEAE | Arenaria fendleri A. Gray | ARFE2 | Y | X | X | X | X | X | | | | X | | X | X | X | X | X |
| CARYOPHYLLACEAE | Paronychia jamesii T. & G. | PAJA1 | Y | X | X | X | X | X | X | X | X | X | | X | X | X | X | X |
| CARYOPHYLLACEAE | Silene antirrhina L. | SIAN1 | Y | | X | X | X | X | | | | X | X | | X | | X | X |
| CARYOPHYLLACEAE | Silene drummondii Hook. | SIDR1 | Y | X | X | X | X | X | X | X | X | | | X | X | X | X | X |
| CARYOPHYLLACEAE | Stellaria longifolia Muhl. ex Willd. | STLO1 | Y | X | | | | | | | | | | | | | | |
| CHENOPODIACEAE | | CH1 | | | | | | | | | X | | | | | | | |
| CHENOPODIACEAE | Chenopodium album L. | CHAL1 | N | | | | | | | | X | | | | | | | |
| CHENOPODIACEAE | Chenopodium leptophyllum Nutt. ex Moq. | CHLE2 | Y | | | | | X | X | X | X | X | | | | X | X | |
| CHENOPODIACEAE | Kochia scoparia (L.) Schrad. | KOSC1 | N | | | | | X | | | | | | | | | | |
| CHENOPODIACEAE | Salsola iberica Senn. & Pau. | SAIB1 | N | | | | | X | | | | | | | | | | |

Table 2-1. (cont.)

| Family | Scientific Name | Speccode | Native | TR01 1993 | TR01 1994 | TR01 1995 | TR01 1998 | TR01 2001 | TR06 1993 | TR06 1994 | TR06 1995 | TR06 1998 | TR06 2001 | TR12 1993 | TR12 1994 | TR12 1995 | TR12 1998 | TR12 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLUSIACEAE | Hypericum perforatum L. | HYPE1 | N | X | X | X | X | X | X | X | X | X | | X | X | X | X | X |
| COMMELINACEAE | Tradescantia occidentalis (Britt.) Smyth | TROC1 | Y | | | X | X | X | | | X | X | X | | | | | |
| CONVOLVULACEAE | Convolvulus arvensis L. | COAR1 | N | | | | | | | | X | X | X | | | | | |
| CONVOLVULACEAE | Evolvulus nuttallianus R. & S. | EVNU1 | Y | | | | | | X | | X | | | | | | X | |
| CRASSULACEAE | Sedum lanceolatum Torr. | SELA1 | Y | | | X | X | | | | | | | | | | | |
| CYPERACEAE | Carex eleocharis Bailey | CAEL1 | Y | X | | | | | X | | | X | | X | X | | | |
| CYPERACEAE | Carex filifolia Nutt. | CAFI1 | Y | | | | | | | X | X | X | X | | | | | |
| CYPERACEAE | Carex heliophila Mack. | CAHE1 | Y | | X | X | X | X | | X | X | X | X | | X | X | X | X |
| CYPERACEAE | Carex oreocharis Holm. | CAOR1 | Y | | | | | | | | | | | X | X | | | |
| EUPHORBIACEAE | Euphorbia robusta (Engelm.) Small | EURO1 | Y | | | | | | | | | | | | X | X | X | X |
| EUPHORBIACEAE | Euphorbia sp. | EUP1 | | | | | | | | | | | | X | | | | |
| FABACEAE | | FA1 | | | | | | | | | X | | | | | | | |
| FABACEAE | Astragalus agrestis Dougl. ex G. Don | ASAG1 | Y | X | X | X | X | | | X | X | X | | | | | | |
| FABACEAE | Astragalus crassicarpus Nutt. | ASCR1 | Y | | | | | | | | | | | | X | | | |
| FABACEAE | Astragalus flexuosus (Hook.) G. Don | ASFL1 | Y | X | | | | | X | X | X | X | X | | | | | |
| FABACEAE | Astragalus missouriensis Nutt. | ASMI1 | Y | | X | | | | | | | | | | | | | |
| FABACEAE | Astragalus shortianus Nutt. ex T.&G. | ASSH1 | Y | X | X | | X | | X | X | X | X | X | X | X | X | X | X |
| FABACEAE | Astragalus sp. | AST2 | | | X | X | | | | | X | | | | | | | |
| FABACEAE | Astragalus tridactylicus Gray | ASTR1 | Y | | | | | | | | | X | X | | | | | |
| FABACEAE | Astragalus tridactylicus Gray | ASSE1 | Y | | | | | | | X | X | | | | | | | |
| FABACEAE | Dalea purpurea Vent | DAPU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| FABACEAE | Oxytropis lambertii Pursh. | OXLA1 | Y | X | X | X | X | | X | X | X | X | X | X | X | X | X | X |
| FABACEAE | Psoralea tenuiflora Pursh. | PSTE1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| FABACEAE | Vicia americana Muhl. ex Willd. | VIAM1 | Y | X | | | | | | | | | | | | | | |
| GERANIACEAE | Erodium cicutarium (L.) L'Her. | ERCI1 | N | | | | | X | | | | | | | | | X | X |
| HYDROPHYLLACEAE | Phacelia heterophylla Pursh. | PHHE1 | Y | X | X | | | X | X | X | X | X | | X | X | X | X | X |
| JUNCACEAE | Juncus dudleyi Wieg. | JUDU1 | Y | | | X | | | | | | | | | | | | |
| JUNCACEAE | Juncus interior Wieg. | JUIN1 | Y | | | | X | | | | | | | | | | X | |
| LAMIACEAE | Hedeoma hispidum Pursh. | HEHI1 | Y | X | | | | | | | | | | | | | | |
| LILIACEAE | Allium textile A. Nels. & Macbr. | ALTE1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| LILIACEAE | Calochortus gunnisonii S. Wats. | CAGU1 | Y | | | | | | | | X | | X | | | X | | |
| LILIACEAE | Leucocrinum montanum Nutt. | LEMO2 | Y | X | | | | | | X | X | X | X | | X | X | X | X |
| LINACEAE | Linum perenne L. var. lewisii (Pursh.) Eat. & Wright | LIPE1 | Y | | | | | | X | X | X | X | X | | | | | X |
| MALVACEAE | Sphaeralcea coccinea (Pursh.) Rydb. | SPCO1 | Y | | | | | | | X | X | | X | | X | | | |
| NYCTAGINACEAE | Mirabilis linearis (Pursh.) Heimerl | MILI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ONAGRACEAE | Calylophus serrulatus (Nutt.) Raven | CASE2 | Y | X | X | X | X | | | | | | | X | X | X | X | |
| ONAGRACEAE | Gaura coccinea Pursh. | GACO1 | Y | X | X | X | | | X | X | X | X | X | X | | X | | |
| ONAGRACEAE | Oenothera coronopifolia T. & G. | OECO1 | Y | X | | | | | | | | | | X | X | | | |
| ONAGRACEAE | Oenothera howardii (A. Nels.) W. L. Wagner | OEBR1 | Y | | | | | | | X | X | | | | | | | |
| ONAGRACEAE | Oenothera howardii (A. Nels.) W. L. Wagner | OEHO1 | Y | | | | | | | | | X | | | | | | |
| ONAGRACEAE | Oenothera sp. | OEN1 | | | | | | | | | | | | | X | | | |
| OROBANCHACEAE | Orobanche fasciculata Nutt. | ORFA1 | Y | | X | X | X | | | X | X | | | | X | X | X | X |
| PLANTAGINACE | Plantago patagonica Jacq. | PLPA1 | Y | | | | | | | X | X | | X | | | | | |
| POACEAE | Agropyron smithii Rydb. | AGSM1 | Y | | | X | X | X | X | X | X | X | X | | X | | | |
| POACEAE | Andropogon gerardii Vitman | ANGE1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Andropogon scoparius Michx. | ANSC1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Aristida purpurea Nutt. var. longiseta (Steud.) Vasey | ARFE1 | Y | | X | | | X | X | X | X | | X | X | X | X | | |
| POACEAE | Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Aristida sp. | ARI1 | | | | | | | | X | | | | | | | | |

Table 2-1. (cont.)

| | | | | TR01 | | | | | TR06 | | | | | TR12 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Family | Scientific Name | Speccode | Native | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 |
| POACEAE | Bouteloua curtipendula (Michx.) Torr. | BOCU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Bouteloua hirsuta Lag | BOHI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Bromus inermis Leyss. ssp. inermis | BRIN1 | N | | | | | | | | | | X | | | | | |
| POACEAE | Bromus japonicus Thunb. ex Murr. | BRJA1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Bromus tectorum L. | BRTE1 | N | X | X | X | X | X | X | X | X | X | X | | X | X | X | X |
| POACEAE | Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | Y | | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Festuca octoflora Walt. | FEOC1 | Y | | | | | X | | | | | | | | | | |
| POACEAE | Koeleria pyramidata (Lam.) Beauv. | KOPY1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | Y | X | X | X | X | X | | | | | | X | X | X | X | X |
| POACEAE | Muhlenbergia torreyi (Kunth) Hitchc. ex Bush | MUTO1 | Y | X | | | | | | | | | | | | | | |
| POACEAE | Poa canbyi (Scribn.) Piper | POCA1 | Y | | | | | | | X | X | | X | | | | | |
| POACEAE | Poa compressa L. | POCO1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Poa pratensis L. | POPR1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Sorghastrum nutans (L.) Nash | SONU1 | Y | X | X | X | X | X | | | | | | X | X | X | X | X |
| POACEAE | Sporobolus asper (Michx.) Kunth | SPAS1 | Y | | | | | X | | | | | X | | | | | X |
| POACEAE | Sporobolus cryptandrus (Torr.) A. Gray | SPCR1 | Y | | | | X | | | | | X | | | | | X | |
| POACEAE | Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | Y | | X | X | X | X | | | | | | | X | | | |
| POACEAE | Stipa comata Trin. & Rupr. | STCO1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Stipa neomexicana (Thur.) Scribn. | STNE1 | Y | | | | | | | X | X | X | X | | | | | |
| POACEAE | Stipa sp. | STI1 | | | | | | | | X | | | | | | | | |
| POACEAE | Stipa viridula Trin. | STVI1 | Y | X | X | | | | | | | | | | | | | |
| POACEAE | Triticum aestivum L. | TRAE1 | N | | X | | | | | | | | | | | | | |
| POLEMONIACEAE | Ipomopsis spicata (Nutt.) V. Grant ssp. spicata | IPSP1 | Y | X | X | X | X | X | | | | | | | | | | |
| POLYGONACEAE | Eriogonum alatum Torr. | ERAL1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POLYGONACEAE | Eriogonum umbellatum Torr. | ERFL2 | Y | X | | | | | | | | | | | | | | |
| POLYGONACEAE | Polygonum aviculare L. | POAV1 | N | | | | | | X | | | | | | | | | |
| POLYGONACEAE | Polygonum ramosissimum Michx. | PORA1 | Y | | | | | X | | | | | X | | | | | |
| POLYGONACEAE | Polygonum sawatchense Small | POSA1 | Y | | | | | | | | X | | | | | | | |
| POLYGONACEAE | Polygonum sp. | POL1 | | | | | | X | | | | | | | | | | |
| PORTULACACEAE | Talinum parviflorum Nutt. | TAPA1 | Y | X | X | X | X | X | | | X | | | | | X | | X |
| PRIMULACEAE | Androsace occidentalis Pursh. | ANOC1 | Y | | | | | | | X | X | | X | | | | | X |
| RANUNCULACEAE | Delphinium nuttalianum Pritz. ex Walpers | DENU1 | Y | | | | | | | | | | | | | | X | X |
| RANUNCULACEAE | Delphinium virescens Nutt. ssp. penardii (Huth) Ewan | DEVI1 | Y | | | | | | | | X | | | | | | | |
| ROSACEAE | Potentilla fissa Nutt. | POFI1 | Y | | | X | X | X | | | | | | | X | X | X | X |
| ROSACEAE | Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc. | POGR1 | Y | X | X | | | | | | | | | X | | | | |
| ROSACEAE | Potentilla hippiana Lehm. | POHI1 | Y | X | X | X | X | X | | | | | | | X | | | |
| SANTALACEAE | Comandra umbellata (L.) Nutt. | COUM1 | Y | X | X | X | X | X | | X | | X | X | | X | | X | X |
| SCROPHULARIACEAE | Castilleja integra A. Gray | CAIN2 | Y | X | | | | | | | | | | | | | | |
| SCROPHULARIACEAE | Castilleja sessiliflora Pursh. | CASE3 | Y | | X | X | X | X | | | | | | | X | | X | X |
| SCROPHULARIACEAE | Linaria dalmatica (L.) Mill. | LIDA1 | N | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| SCROPHULARIACEAE | Penstemon angustifolius Nutt. ex Pursh | PEAN1 | Y | | | | | | | | | | | | X | | | |
| SCROPHULARIACEAE | Penstemon secundiflorus Benth. | PESE1 | Y | | | | | | | X | X | X | X | | | | | |
| SCROPHULARIACEAE | Penstemon virens Penn. | PEVI1 | Y | | X | X | X | X | | | | | | | X | X | X | X |
| SCROPHULARIACEAE | Verbascum blattaria L. | VEBL1 | N | | | | | | X | X | X | | | | | | | |
| SCROPHULARIACEAE | Verbascum thapsus L. | VETH1 | N | | | | | | X | X | X | X | X | | | | | |
| SCROPHULARIACEAE | Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | Y | | | X | | | | | | | | | | | | |
| SOLANACEAE | Physalis heterophylla Nees | PHHE2 | Y | X | | | | | X | | | | | X | | | | |
| SOLANACEAE | Solanum triflorum Nutt. | SOTR1 | Y | | | | | | | | | | | | | | X | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VIOLACEAE | Viola nuttallii Pursh. | VINU1 | Y | | X | X | X | X | | X | X | X | X | | X | X | X | X |
| VIOLACEAE | Viola sororia Willd. | VINE1 | Y | | | | | | | | | | | | | X | | |
| | Total Number of Species | | | 76 | 88 | 90 | 81 | 82 | 68 | 89 | 98 | 83 | 81 | 68 | 91 | 83 | 84 | 85 |
| | Percent Native | | | 87 | 84 | 86 | 86 | 80 | 72 | 80 | 80 | 81 | 80 | 81 | 84 | 81 | 83 | 81 |

**Table 2-2. Xeric Mixed Grassland Woody Stem and Cactus Density Summary (1993-2001)**

| | Cactus Density (plants/sq. meter) | | | | | Woody Stem Density (stems/sq. meter) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | **1993** | **1994** | **1995** | **1998** | **2001** | **1993** | **1994** | **1995** | **1998** | **2001** |
| TR01 | 0.52 | 0.79 | 1.72 | 0.68 | 0.24 | 0.004 | 0.002 | 0.002 | 0.004 | 0.010 |
| TR06 | 0.19 | 0.21 | 0.24 | 0.11 | 0.14 | 0.160 | 0.110 | 0.240 | 0.268 | 0.318 |
| TR12 | 1.09 | 0.95 | 1.21 | 1.16 | 0.24 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Site values are based on n=5.

| | Opuntia macorhiza Density (plants/sq. meter) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Site** | **1993** | **1994** | **1995** | **1998** | **1999** | **2000** | **2001** |
| TR01 | 0.15 | 0.25 | 0.24 | 0.14 | 0.16 | 0.07 | 0.02 |
| TR06 | 0.12 | 0.12 | 0.12 | 0.06 | NA | NA | 0.05 |
| TR12 | 0.53 | 0.47 | 0.48 | 0.58 | NA | NA | 0.08 |

Site values are based on n=5.

| | Echinocereus viridiflorus Density (plants/sq. meter) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Site** | **1993** | **1994** | **1995** | **1998** | **1999** | **2000** | **2001** |
| TR01 | 0.37 | 0.53 | 1.41 | 0.53 | 0.59 | 0.29 | 0.22 |
| TR06 | 0.07 | 0.07 | 0.12 | 0.05 | NA | NA | 0.09 |
| TR12 | 0.56 | 0.48 | 0.73 | 0.57 | NA | NA | 0.16 |

Site values are based on n=5.

Table 2-3. 1993-2001 Xeric Mixed Grassland Foliar Cover Summary

| | | | | | TR01 | | | | | | | | | | | | | | TR06 | | | | | | | | | | TR12 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Absolute Cover (%) | | | | | | | Relative Cover (%) | | | | | | | Absolute Cover (%) | | | | | Relative Cover (%) | | | | | Absolute Cover (%) | | | | | Relative Cover (%) | | | | |
| Scientific Name | Speccode | Growth Form | Native | Cool/Warm Season | 1993 | 1994 | 1995 | 1998 | 1999 | 2000 | 2001 | 1993 | 1994 | 1995 | 1998 | 1999 | 2000 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 |
| Yucca glauca Nutt. | YUGL1 | S | Y | | | | | | | | | | | | | | | | 0.2 | | | | | 0.3 | | | | | | | | | | | | | | |
| Echinocereus viridiflorus Engelm. | ECVI1 | C | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | |
| Opuntia macrorhiza Engelm. | OPHU1 | C | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.4 | | | | | 0.4 | | | |
| Lepidium sp. | LEP1 | F | N | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | |
| Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | F | N | | 0.2 | 1.6 | 0.4 | 0.2 | | 0.2 | | 0.3 | 2.0 | 0.5 | 0.2 | | 0.3 | | | 1.4 | 1.2 | 1.4 | 1.0 | | 1.6 | 1.3 | 1.6 | 1.2 | 0.6 | 5.0 | 11.2 | 0.8 | 1.4 | 0.7 | 5.5 | 12.6 | 1.0 | 1.7 |
| Camelina microcarpa Andrz. ex DC. | CAMI1 | F | N | | | | | | | | | | | | | | | | | 0.8 | 4.6 | | 2.8 | | 0.9 | 5.0 | | 3.3 | 0.8 | 1.0 | 1.8 | | | 1.0 | 1.1 | 2.0 | | |
| Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | CANU1 | F | N | | | | | | | | | | | | | | | | 1.0 | 0.2 | 0.4 | 0.2 | | 1.3 | 0.2 | 0.4 | 0.2 | | | | | | | | | | | |
| Centaurea diffusa Lam. | CEDI1 | F | N | | | | | 0.2 | | | 0.4 | | | | 0.2 | | | 0.5 | | | | | | | | | | | | | 0.2 | | 0.2 | | | 0.2 | | 0.2 |
| Cirsium arvense (L.) Scop. | CIAR1 | F | N | | | | | | | | | | | | | | | | 0.2 | | | | | 0.3 | | | | | | | | | | | | | | |
| Hypericum perforatum L. | HYPE1 | F | N | | 0.2 | 0.6 | 0.2 | | | | | 0.3 | 0.7 | 0.2 | | | | | | | | | | | | | | | 0.2 | | 0.2 | | | 0.2 | | 0.2 | | |
| Lactuca serriola L. | LASE1 | F | N | | | | | | | | 0.2 | | | | | | | 0.2 | | | 0.2 | | | | | 0.2 | | | | | | 0.2 | 0.2 | | | | 0.2 | 0.2 |
| Linaria dalmatica (L.) Mill. | LIDA1 | F | N | | | | | | | | 0.2 | | | | | | | 0.2 | 7.0 | 7.2 | 11.0 | 9.2 | 4.0 | 9.2 | 8.1 | 11.9 | 10.8 | 4.8 | 0.8 | 1.0 | 0.4 | | | 1.0 | 1.1 | 0.4 | | |
| Scorzonera laciniata L. | SCLA1 | F | N | | | | | | | | | | | | | | | | | 0.4 | | | | | 0.4 | | | | | | 0.2 | | 0.2 | | | 0.2 | | 0.2 |
| Sisymbrium altissimum L. | SIAL1 | F | N | | | | | | | | 0.4 | | | | | | | 0.5 | | 0.6 | 1.8 | | 0.4 | | 0.7 | 1.9 | | 0.5 | | 0.2 | | | | | 0.2 | | | |
| Tragopogon dubius Scop. | TRDU1 | F | N | | 0.2 | | 0.4 | | | | | 0.3 | | 0.5 | | | | | 0.2 | | 0.8 | 0.2 | | 0.3 | | 0.9 | 0.2 | | 0.2 | 0.2 | 0.6 | | 0.4 | 0.2 | 0.2 | 0.7 | | 0.5 |
| Verbascum thapsus L. | VETH1 | F | N | | | | | | | | | | | | | | | | 0.2 | 0.2 | 0.2 | | | 0.3 | 0.2 | 0.2 | | | | | | | | | | | | |
| Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | | |
| Allium textile A. Nels. & Macbr. | ALTE1 | F | Y | | | 0.2 | | | | | | | 0.2 | | | | | | | | 0.2 | | | | | 0.2 | | | | | | | | | | | | |
| Ambrosia psilostachya DC. | AMPS1 | F | Y | | 0.2 | | 0.2 | 0.2 | | | 0.2 | 0.3 | | 0.2 | 0.2 | | | 0.2 | 0.4 | | | 1.0 | | 0.5 | | | 1.2 | | 0.4 | 0.2 | 0.6 | 0.4 | | 0.5 | 0.2 | 0.7 | 0.5 | |
| Antennaria microphylla Rydb. | ANMI1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | |
| Antennaria parvifolia Nutt. | ANPA1 | F | Y | | | | | 0.2 | | | | | | | 0.2 | | | | | | | | | | | | | | | | | | | | | | | |
| Arenaria fendleri A. Gray | ARFE2 | F | Y | | 6.4 | 5.4 | 2.8 | 4.0 | 0.4 | 0.4 | 0.6 | 9.0 | 6.7 | 3.3 | 4.9 | 0.5 | 0.5 | 0.7 | | | | | | | | | | | 4.2 | 5.6 | 2.2 | 1.0 | 0.2 | 5.2 | 6.2 | 2.5 | 1.2 | 0.2 |
| Artemisia frigida Willd. | ARFR1 | F | Y | | | 0.2 | | 0.2 | | | | | 0.2 | | 0.2 | | | | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | | | | | | | | | | |
| Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | F | Y | | | | | | | | 0.2 | | | | | | | 0.2 | 0.2 | | | | | 0.3 | | | | | 0.4 | | 1.2 | 0.8 | 1.0 | 0.5 | | 1.3 | 1.0 | 1.2 |
| Asclepias viridiflora Raf. | ASVI1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | | |
| Aster porteri Gray | ASPO1 | F | Y | | 2.8 | 8.4 | 21.2 | 11.8 | 0.6 | | | 3.9 | 10.3 | 25.1 | 14.5 | 0.8 | | | | | | | | | | | | | 0.8 | 0.4 | 3.2 | 1.2 | 0.2 | 1.0 | 0.4 | 3.6 | 1.4 | 0.2 |
| Calylophus serrulatus (Nutt.) Raven | CASE2 | F | Y | | | | 0.2 | 0.2 | | | | | | 0.2 | 0.2 | | | | | | | | | | | | | | 0.6 | 0.4 | 0.2 | | | 0.7 | 0.4 | 0.2 | | |
| Chrysopsis fulcrata Greene | CHFU1 | F | Y | | 0.2 | 0.8 | 0.2 | | | | | 0.3 | 1.0 | 0.2 | | | | | | | | | | | | | | | | 0.4 | | | | | 0.4 | | | |
| Chrysopsis villosa Pursh. | CHVI1 | F | Y | | 4.2 | 3.4 | 2.0 | 0.4 | 0.4 | | | 5.9 | 4.2 | 2.4 | 0.5 | 0.5 | | | | 0.2 | | | | | 0.2 | | | | 1.6 | 0.8 | 0.4 | | 0.4 | 2.0 | 0.9 | 0.4 | | 0.5 |
| Comandra umbellata (L.) Nutt. | COUM1 | F | Y | | | | | 0.4 | | | | | | | 0.5 | | | | | | | | | | | | | | | | | | | | | | | |
| Dalea purpurea Vent | DAPU1 | F | Y | | 0.6 | | | 0.2 | | | | 0.8 | | | 0.2 | | | | | | | | | | | | | | | | | | | | | | | |
| Descurainia pinnata (Walt.) Britt. | DEPI1 | F | Y | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | | 0.2 | | | | | 0.2 | |
| Descurainia richardsonii (Sweet) Schultz | DERI1 | F | Y | | | | | | | | | | | | | | | | | | 0.4 | | | | | 0.4 | | | | | | | | | | | | |
| Draba reptans (Lam.) Fern. | DRRE1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 |
| Erigeron flagellaris A. Gray | ERFL1 | F | Y | | | | | | | | | | | | | | | | 0.2 | | | | | 0.3 | | | | | | | 0.4 | | 0.4 | | | 0.4 | | 0.5 |
| Eriogonum alatum Torr. | ERAL1 | F | Y | | 0.6 | 0.6 | | 0.4 | | | 0.2 | 0.8 | 0.7 | | 0.5 | | | 0.2 | | 0.2 | | | | | 0.2 | | | | | | | | | | | | | |
| Erysimum capitatum (Nutt.) DC. | ERAS1 | F | Y | | 0.2 | 0.2 | | | | | | 0.3 | 0.2 | | | | | | 0.2 | 0.6 | | | | 0.3 | 0.7 | | | | | | | | | | | | | |
| Euphorbia robusta (Engelm.) Small | EURO1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | 0.2 | 0.4 | 0.6 | | 0.2 | 0.2 | 0.5 | 0.7 |
| Gaillardia aristata Pursh. | GAAR1 | F | Y | | | | | | | | 0.2 | | | | | | | 0.2 | | | | | | | | | | | | | | | | | | | | |
| Helianthus pumilus Nutt. | HEPU1 | F | Y | | | | | | | | | | | | | | | | 0.2 | | | 0.2 | | 0.3 | | | 0.2 | | | | | | | | | | | |
| Ipomopsis spicata (Nutt.) V. Grant ssp. spicata | IPSP1 | F | Y | | | | | | | | 0.2 | | | | | | | 0.2 | | | | | | | | | | | | | | | | | | | | |
| Lepidium densiflorum Schrad. | LEDE1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 |
| Lesquerella montana (A. Gray) Wats. | LEMO1 | F | Y | | | 0.4 | 0.4 | 0.2 | | 0.2 | 1.0 | | 0.5 | 0.5 | 0.2 | | 0.3 | 1.2 | | 0.2 | | | | | 0.2 | | | | | | | | | | | | | |
| Liatris punctata Hook. | LIPU1 | F | Y | | 5.4 | 3.6 | 2.0 | 2.4 | 3.0 | 3.2 | 5.6 | 7.6 | 4.4 | 2.4 | 3.0 | 4.0 | 4.4 | 6.8 | | | | | | | | | | | 1.4 | 2.8 | 2.2 | 2.2 | 2.4 | 1.7 | 3.1 | 2.5 | 2.7 | 2.9 |
| Linum perenne L. var. lewisii (Pursh.) Eat. & Wright | LIPE1 | F | Y | | | | | | | | | | | | | | | | 0.6 | 0.2 | 0.6 | 0.4 | | 0.8 | 0.2 | 0.6 | 0.5 | | | | | | | | | | | |
| Lithospermum incisum Lehm. | LIIN1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | 0.2 | | | | 0.2 | 0.2 |
| Lomatium orientale Coult. & Rose | LOOR1 | F | Y | | | 0.2 | | | | | | | 0.2 | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | |
| Mertensia lanceolata (Pursh.) A. DC. | MELA1 | F | Y | | | | 0.2 | | | | | | | 0.2 | | | | | | | | | | | | | | | | | | | | | | | | |
| Mirabilis linearis (Pursh.) Heimerl | MILI1 | F | Y | | | | | | | | | | | | | | | | 0.2 | 0.2 | | | | 0.3 | 0.2 | | | | 0.2 | | | | | 0.2 | | | | |
| Oenothera coronopifolia T. & G. | OECO1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | | |
| Oxytropis lambertii Pursh. | OXLA1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | |
| Paronychia jamesii T. & G. | PAJA1 | F | Y | | 0.4 | 0.2 | 0.6 | 0.4 | | 0.2 | 0.6 | 0.6 | 0.2 | 0.7 | 0.5 | | 0.3 | 0.7 | | | | | | | | | | | | | | | | | | | | |
| Penstemon virens Penn. | PEVI1 | F | Y | | | | | | 0.2 | | | | | | | 0.3 | | | | | | | | | | | | | | | | | | | | | | |
| Phacelia heterophylla Pursh. | PHHE1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | 0.2 | 0.2 | | | | 0.2 |
| Potentilla fissa Nutt. | POFI1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | |
| Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc. | POGR1 | F | Y | | 0.2 | | | | | | | 0.3 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Potentilla hippiana Lehm. | POHI1 | F | Y | | 0.2 | 0.2 | 0.2 | | | | | 0.3 | 0.2 | 0.2 | | | | | | | | | | | | | | | | | | | | | | | | |
| Psoralea tenuiflora Pursh. | PSTE1 | F | Y | | 3.0 | 2.4 | 2.0 | 1.4 | 0.6 | 0.6 | 1.2 | 4.2 | 3.0 | 2.4 | 1.7 | 0.8 | 0.8 | 1.5 | 1.2 | 0.2 | 1.0 | | 1.2 | 1.6 | 0.2 | 1.1 | | 1.4 | 3.4 | 2.2 | 1.4 | 0.2 | 0.8 | 4.2 | 2.4 | 1.6 | 0.2 | 1.0 |
| Senecio spartioides T. & G. | SESP1 | F | Y | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.4 | | | | | 0.5 |
| Silene antirrhina L. | SIAN1 | F | Y | | | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | | | | | | | | |
| Talinum parviflorum Nutt. | TAPA1 | F | Y | | | | | 0.2 | | | | | | | 0.2 | | | | | | | | | | | | | | | | | | | | | | | |
| Thelesperma megapotanicum (Spreng.) O. Ktze. | THME1 | F | Y | | | | | | | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | | | | | | | | | | |
| Bromus inermis Leyss. ssp. inermis | BRIN1 | G | N | C | | | | | | | | | | | | | | | | | | | 0.4 | | | | | 0.5 | | | | | | | | | | |
| Bromus japonicus Thunb. ex Murr. | BRJA1 | G | N | C | | | 0.8 | 0.4 | 0.6 | | | | | 0.9 | 0.5 | 0.8 | | | 0.6 | 2.2 | 5.6 | 7.4 | 10.4 | 0.8 | 2.5 | 6.1 | 8.7 | 12.4 | | 0.2 | 1.0 | 1.8 | 2.4 | | 0.2 | 1.1 | 2.2 | 2.9 |
| Bromus tectorum L. | BRTE1 | G | N | C | | 0.2 | 0.4 | 0.4 | 0.8 | 0.4 | 0.4 | | 0.2 | 0.5 | 0.5 | 1.1 | 0.5 | 0.5 | | 0.4 | 0.2 | | 0.4 | | 0.4 | 0.2 | | 0.5 | | | | 0.8 | 3.4 | | | | 1.0 | 4.1 |
| Poa compressa L. | POCO1 | G | N | C | 3.6 | 3.6 | 7.6 | 6.6 | 7.4 | 5.4 | 8.4 | 5.0 | 4.4 | 9.0 | 8.1 | 9.8 | 7.4 | 10.2 | 2.8 | 4.8 | 5.8 | 4.2 | 4.4 | 3.7 | 5.4 | 6.3 | 4.9 | 5.3 | 3.0 | 2.2 | 5.2 | 6.2 | 6.0 | 3.7 | 2.4 | 5.8 | 7.5 | 7.2 |
| Poa pratensis L. | POPR1 | G | N | C | 2.0 | 3.6 | 1.4 | 5.0 | 6.0 | 6.2 | 3.4 | 2.8 | 4.4 | 1.7 | 6.2 | 7.9 | 8.4 | 4.1 | 3.4 | 5.2 | 2.8 | 6.8 | 7.4 | 4.5 | 5.8 | 3.0 | 8.0 | 8.9 | 0.2 | 1.0 | 0.4 | 1.4 | 2.8 | 0.2 | 1.1 | 0.4 | 1.7 | 3.3 |
| Agropyron smithii Rydb. | AGSM1 | G | Y | C | | | | | | | | | | | | | | | 0.6 | 0.2 | 0.6 | | 0.2 | 0.8 | 0.2 | 0.6 | | 0.2 | | | | | | | | | | |

Table 2-3. (cont.)

| | | | | | TR01 | | | | | | | | | | | | | | TR06 | | | | | | | | | | TR12 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Absolute Cover (%) | | | | | | | Relative Cover (%) | | | | | | | Absolute Cover (%) | | | | | Relative Cover (%) | | | | | Absolute Cover (%) | | | | | Relative Cover (%) | | | | |
| Scientific Name | Speccode | Growth Form | Native | Cool/Warm Season | 1993 | 1994 | 1995 | 1998 | 1999 | 2000 | 2001 | 1993 | 1994 | 1995 | 1998 | 1999 | 2000 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 | 1993 | 1994 | 1995 | 1998 | 2001 |
| Aristida purpurea Nutt. var. longiseta (Steud.) Vasey | ARFE1 | G | Y | C | | | | | | | | | | | | | | | 0.2 | 0.6 | | | | 0.3 | 0.7 | | | | | | | | | | | | | |
| Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | G | Y | C | 1.0 | 0.4 | 0.8 | 0.2 | 0.8 | 0.6 | 1.0 | 1.4 | 0.5 | 0.9 | 0.2 | 1.1 | 0.8 | 1.2 | 1.2 | | 0.6 | 0.6 | 0.8 | 1.6 | | 0.6 | 0.7 | 1.0 | 0.8 | 0.8 | 1.0 | | 0.2 | 1.0 | 0.9 | 1.1 | | 0.2 |
| Carex eleocharis Bailey | CAEL1 | G | Y | C | 5.2 | | | | | | | 7.3 | | | | | | | 3.2 | | | | | 4.2 | | | | | 7.4 | | | | | 9.2 | | | | |
| Carex filifolia Nutt. | CAFI1 | G | Y | C | | | | | | | | | | | | | | | | 0.4 | 0.2 | 0.2 | | | 0.4 | 0.2 | 0.2 | | | | | | | | | | | |
| Carex heliophila Mack. | CAHE1 | G | Y | C | | 5.2 | 5.0 | 5.8 | 4.2 | 4.8 | 4.4 | | 6.4 | 5.9 | 7.1 | 5.5 | 6.5 | 5.3 | | 2.2 | 2.8 | 1.6 | 0.6 | | 2.5 | 3.0 | 1.9 | 0.7 | | 9.4 | 5.0 | 4.0 | 7.8 | | 10.4 | 5.6 | 4.8 | 9.3 |
| Koeleria pyramidata (Lam.) Beauv. | KOPY1 | G | Y | C | 3.2 | 3.6 | 1.6 | 1.6 | 5.8 | 5.6 | 3.8 | 4.5 | 4.4 | 1.9 | 2.0 | 7.7 | 7.6 | 4.6 | 1.0 | 0.2 | | | | 1.3 | 0.2 | | | | 2.0 | 0.4 | 0.6 | 1.2 | 2.0 | 2.5 | 0.4 | 0.7 | 1.4 | 2.4 |
| Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | G | Y | C | | 0.2 | 0.6 | 0.8 | | 0.2 | 0.6 | | 0.2 | 0.7 | 1.0 | | 0.3 | 0.7 | | | | 0.4 | | | | | 0.5 | | | 0.2 | | 0.2 | | | 0.2 | | 0.2 | |
| Stipa comata Trin. & Rupr. | STCO1 | G | Y | C | 1.2 | 5.2 | 7.4 | 4.0 | 5.0 | 5.0 | 8.8 | 1.7 | 6.4 | 8.7 | 4.9 | 6.6 | 6.8 | 10.7 | 47.0 | 55.8 | 45.6 | 43.4 | 38.2 | 61.5 | 62.4 | 49.4 | 50.8 | 45.7 | 28.0 | 35.6 | 31.0 | 36.2 | 22.6 | 34.9 | 39.4 | 34.8 | 43.7 | 27.0 |
| Stipa neomexicana (Thur.) Scribn. | STNE1 | G | Y | C | | | | | | | | | | | | | | | | | | 3.6 | 5.2 | | | | 4.2 | 6.2 | | | | | | | | | | |
| Stipa viridula Trin. | STVI1 | G | Y | C | 1.0 | 0.2 | | | | | | 1.4 | 0.2 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Andropogon gerardii Vitman | ANGE1 | G | Y | W | 11.0 | 9.4 | 9.0 | 9.6 | 16.4 | 13.4 | 13.8 | 15.4 | 11.6 | 10.6 | 11.8 | 21.6 | 18.3 | 16.7 | 0.6 | 0.8 | 1.0 | 0.8 | 0.8 | 0.8 | 0.9 | 1.1 | 0.9 | 1.0 | 11.8 | 10.2 | 11.8 | 12.2 | 14.2 | 14.7 | 11.3 | 13.2 | 14.7 | 17.0 |
| Andropogon scoparius Michx. | ANSC1 | G | Y | W | 8.4 | 8.4 | 4.6 | 1.4 | 2.4 | 1.2 | 1.8 | 11.8 | 10.3 | 5.4 | 1.7 | 3.2 | 1.6 | 2.2 | 0.6 | 0.8 | 1.4 | 0.4 | 0.8 | 0.8 | 0.9 | 1.5 | 0.5 | 1.0 | 4.4 | 2.6 | 0.8 | | 0.4 | 5.5 | 2.9 | 0.9 | | 0.5 |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | G | Y | W | 0.4 | 2.2 | 2.2 | 3.0 | 5.2 | 4.4 | 4.0 | 0.6 | 2.7 | 2.6 | 3.7 | 6.9 | 6.0 | 4.8 | 1.0 | 0.6 | 1.2 | 1.6 | 2.8 | 1.3 | 0.7 | 1.3 | 1.9 | 3.3 | 2.2 | 2.0 | 2.0 | 3.6 | 4.8 | 2.7 | 2.2 | 2.2 | 4.3 | 5.7 |
| Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | G | Y | W | 0.4 | 1.4 | 0.6 | 1.6 | 2.6 | 3.0 | 3.0 | 0.6 | 1.7 | 0.7 | 2.0 | 3.4 | 4.1 | 3.6 | 1.2 | 2.4 | 1.8 | 1.6 | 1.0 | 1.6 | 2.7 | 1.9 | 1.9 | 1.2 | 1.2 | 1.4 | 1.0 | 3.0 | 2.4 | 1.5 | 1.5 | 1.1 | 3.6 | 2.9 |
| Bouteloua hirsuta Lag | BOHI1 | G | Y | W | 0.4 | 1.4 | 0.2 | 1.0 | 1.4 | 1.4 | 0.8 | 0.6 | 1.7 | 0.2 | 1.2 | 1.8 | 1.9 | 1.0 | 0.8 | | | | 0.2 | 1.0 | | | | 0.2 | 0.2 | 0.4 | 0.8 | 0.4 | 1.0 | 0.2 | 0.4 | 0.9 | 0.5 | 1.2 |
| Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | G | Y | W | | | | | | | | | | | | | | | | | | | | | | | | | 0.2 | 0.2 | | | 0.2 | 0.2 | 0.2 | | | 0.2 |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | G | Y | W | 7.0 | 6.8 | 7.4 | 14.8 | 8.8 | 13.8 | 14.0 | 9.8 | 8.4 | 8.7 | 18.2 | 11.6 | 18.8 | 16.9 | | | | | | | | | | | 1.2 | 2.0 | 0.6 | 2.2 | 2.6 | 1.5 | 2.2 | 0.7 | 2.7 | 3.1 |
| Muhlenbergia torreyi (Kunth) Hitchc. ex Bush | MUTO1 | G | Y | W | 0.6 | | | | | | | 0.8 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sorghastrum nutans (L.) Nash | SONU1 | G | Y | W | 1.0 | 0.4 | 1.0 | 1.2 | 2.0 | 1.8 | 1.8 | 1.4 | 0.5 | 1.2 | 1.5 | 2.6 | 2.5 | 2.2 | | | | | | | | | | | 1.2 | 0.2 | 1.2 | 1.6 | 1.2 | 1.5 | 0.2 | 1.3 | 1.9 | 1.4 |
| Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | G | Y | W | | 0.6 | 1.0 | 0.8 | 1.2 | 1.4 | 1.4 | | 0.7 | 1.2 | 1.0 | 1.6 | 1.9 | 1.7 | | | | | | | | | | | | 0.2 | | | | | 0.2 | | | |
| Total foliar cover | | | | | 71.4 | 81.2 | 84.6 | 81.2 | 75.8 | 73.4 | 82.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 76.4 | 89.4 | 92.4 | 85.4 | 83.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 80.2 | 90.4 | 89.2 | 82.8 | 83.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Total forb cover | | | | | 25.0 | 28.4 | 33.0 | 23.0 | 5.2 | 4.8 | 11.2 | 35.0 | 35.0 | 39.0 | 28.3 | 6.9 | 6.5 | 13.6 | 12.0 | 12.8 | 22.8 | 12.8 | 10.0 | 15.7 | 14.3 | 24.7 | 15.0 | 12.0 | 16.4 | 20.8 | 26.8 | 8.0 | 9.6 | 20.4 | 23.0 | 30.0 | 9.7 | 11.5 |
| Total native forb cover | | | | | 24.4 | 26.2 | 32.0 | 22.6 | 5.2 | 4.6 | 10.0 | 34.2 | 32.3 | 37.8 | 27.8 | 6.9 | 6.3 | 12.1 | 3.4 | 2.0 | 2.6 | 1.8 | 1.8 | 4.5 | 2.2 | 2.8 | 2.1 | 2.2 | 13.6 | 13.2 | 12.2 | 7.0 | 7.2 | 17.0 | 14.6 | 13.7 | 8.5 | 8.6 |
| Total non-native forb cover | | | | | 0.6 | 2.2 | 1.0 | 0.4 | 0.0 | 0.2 | 1.2 | 0.8 | 2.7 | 1.2 | 0.5 | 0.0 | 0.3 | 1.5 | 8.6 | 10.8 | 20.2 | 11.0 | 8.2 | 11.3 | 12.1 | 21.9 | 12.9 | 9.8 | 2.6 | 7.6 | 14.6 | 1.0 | 2.4 | 3.2 | 8.4 | 16.4 | 1.2 | 2.9 |
| Total graminoid cover | | | | | 46.4 | 52.8 | 51.6 | 58.2 | 70.6 | 68.6 | 71.4 | 65.0 | 65.0 | 61.0 | 71.7 | 93.1 | 93.5 | 86.4 | 64.2 | 76.6 | 69.6 | 72.6 | 73.6 | 84.0 | 85.7 | 75.3 | 85.0 | 88.0 | 63.8 | 69.0 | 62.4 | 74.8 | 74.0 | 79.6 | 76.3 | 70.0 | 90.3 | 88.5 |
| Total native graminoid cover | | | | | 40.8 | 45.4 | 41.4 | 45.8 | 55.8 | 56.6 | 59.2 | 57.1 | 55.9 | 48.9 | 56.4 | 73.6 | 77.1 | 71.7 | 57.4 | 64.0 | 55.2 | 54.2 | 50.6 | 75.1 | 71.6 | 59.7 | 63.5 | 60.5 | 60.6 | 65.6 | 55.8 | 64.6 | 59.4 | 75.6 | 72.6 | 62.6 | 78.0 | 71.1 |
| Total non-native graminoid cover | | | | | 5.6 | 7.4 | 10.2 | 12.4 | 14.8 | 12.0 | 12.2 | 7.8 | 9.1 | 12.1 | 15.3 | 19.5 | 16.3 | 14.8 | 6.8 | 12.6 | 14.4 | 18.4 | 23.0 | 8.9 | 14.1 | 15.6 | 21.5 | 27.5 | 3.2 | 3.4 | 6.6 | 10.2 | 14.6 | 4.0 | 3.8 | 7.4 | 12.3 | 17.5 |
| Total native cover | | | | | 65.2 | 71.6 | 73.4 | 68.4 | 61.0 | 61.2 | 69.2 | 91.3 | 88.2 | 86.8 | 84.2 | 80.5 | 83.4 | 83.8 | 61.0 | 66.0 | 57.8 | 56.0 | 52.4 | 79.8 | 73.8 | 62.6 | 65.6 | 62.7 | 74.4 | 79.4 | 68.0 | 71.6 | 66.6 | 92.8 | 87.8 | 76.2 | 86.5 | 79.7 |
| Total non-native cover | | | | | 6.2 | 9.6 | 11.2 | 12.8 | 14.8 | 12.2 | 13.4 | 8.7 | 11.8 | 13.2 | 15.8 | 19.5 | 16.6 | 16.2 | 15.4 | 23.4 | 34.6 | 29.4 | 31.2 | 20.2 | 26.2 | 37.4 | 34.4 | 37.3 | 5.8 | 11.0 | 21.2 | 11.2 | 17.0 | 7.2 | 12.2 | 23.8 | 13.5 | 20.3 |
| Total warm-season graminoid cover | | | | | 29.2 | 30.6 | 26.0 | 33.4 | 40.0 | 40.4 | 40.6 | 40.9 | 37.7 | 30.7 | 41.1 | 52.8 | 55.0 | 49.2 | 4.2 | 4.6 | 5.4 | 4.4 | 5.6 | 5.5 | 5.1 | 5.8 | 5.2 | 6.7 | 22.4 | 19.2 | 18.2 | 23.0 | 26.8 | 27.9 | 21.2 | 20.4 | 27.8 | 32.1 |
| Total cool-season graminoid cover | | | | | 17.2 | 22.2 | 25.6 | 24.8 | 30.6 | 28.2 | 30.8 | 24.1 | 27.3 | 30.3 | 30.5 | 40.4 | 38.4 | 37.3 | 60.0 | 72.0 | 64.2 | 68.2 | 68.0 | 78.5 | 80.5 | 69.5 | 79.9 | 81.3 | 41.4 | 49.8 | 44.2 | 51.8 | 47.2 | 51.6 | 55.1 | 49.6 | 62.6 | 56.5 |

Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible (500).
Relative cover = Relative foliar cover was the number of hits a species had relative to the total number of all vegetative hits recorded per site (i.e., the percent of vegetative cover the species represented).
All cover values presented are means (n = 5).
Native categories: Y = Native, N = Non-Native
Form categories: C = Cactus, F = Forb, G = Graminoid, S = Shrub
Cool/Warm Season categories: C = Cool season species, W = Warm season species

**Table 2-4. 1998-2001 Xeric Mixed Grassland Species Frequency Summary**

| | | | | TR01 | | | | | | | TR06 | | | | TR12 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Spring | Summer | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer |
| Family | Scientific Name | Speccode | Native | 1998 | 1998 | 1999 | 2000 | 2000 | 2001 | 2001 | 1998 | 1998 | 2001 | 2001 | 1998 | 1998 | 2001 | 2001 |
| AGAVACEAE | Yucca glauca Nutt. | YUGL1 | Y | | | | | | | | 20 | 12 | 12 | 12 | | | | |
| APIACEAE | Lomatium orientale Coult. & Rose | LOOR1 | Y | 92 | 28 | 12 | 8 | | 32 | | 72 | 4 | 32 | | 100 | 48 | 60 | |
| ASCLEPIADACEAE | Asclepias viridiflora Raf. | ASVI1 | Y | 4 | 4 | 4 | 4 | 4 | | 4 | | | | | 4 | 4 | | |
| ASTERACEAE | Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | Y | 4 | 4 | 4 | | | | | | | | | | | | |
| ASTERACEAE | Ambrosia psilostachya DC. | AMPS1 | Y | 28 | 16 | | | | 8 | | 12 | 12 | | 4 | 24 | 28 | 16 | 12 |
| ASTERACEAE | Antennaria parvifolia Nutt. | ANPA1 | Y | 4 | 4 | | | | | | | | | | 4 | 4 | | |
| ASTERACEAE | Artemisia dracunculus L. | ARDR1 | Y | | | | | | | | | | | 4 | | | | |
| ASTERACEAE | Artemisia frigida Willd. | ARFR1 | Y | 16 | 16 | 4 | | | | | 20 | 20 | 4 | | 8 | 4 | 4 | 8 |
| ASTERACEAE | Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | Y | | | | 4 | 4 | | 4 | 8 | | | | 16 | 12 | 12 | 12 |
| ASTERACEAE | Aster falcatus Lindl. | ASFA1 | Y | 4 | 4 | | | | | | | | | | | | | |
| ASTERACEAE | Aster porteri Gray | ASPO1 | Y | 88 | 88 | 44 | | | 12 | 4 | | | | | 40 | 44 | 16 | 12 |
| ASTERACEAE | Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | CANU1 | N | | | | | | | | 24 | 16 | 16 | 20 | | | | |
| ASTERACEAE | Centaurea diffusa Lam. | CEDI1 | N | 16 | 4 | | | | | 4 | | | | | 4 | 8 | 16 | 32 |
| ASTERACEAE | Chrysopsis fulcrata Greene | CHFU1 | Y | 8 | 8 | 4 | 4 | 4 | 12 | 4 | | | | | | | | |
| ASTERACEAE | Chrysopsis villosa Pursh. | CHVI1 | Y | 64 | 52 | 32 | 8 | 4 | | 8 | | | | | 28 | 32 | 4 | 4 |
| ASTERACEAE | Cirsium arvense (L.) Scop. | CIAR1 | N | | | | | | | | 8 | 8 | | | | | | |
| ASTERACEAE | Cirsium undulatum (Nutt.) Spreng. | CIUN1 | Y | | | | | | | | 8 | 4 | | | | | | |
| ASTERACEAE | Conyza canadensis (L.) Cronq. | COCA1 | Y | | | | | | | 4 | | | | | | | 8 | 32 |
| ASTERACEAE | Erigeron canus A. Gray | ERCA1 | Y | | | | | | 4 | | | | | | | | | |
| ASTERACEAE | Erigeron divergens T. & G. | ERDI1 | Y | | | | | | | | | | | | | | 16 | 4 |
| ASTERACEAE | Erigeron flagellaris A. Gray | ERFL1 | Y | | | | | | | | | | | | 20 | | | 24 |
| ASTERACEAE | Gaillardia aristata Pursh. | GAAR1 | Y | 28 | 16 | 4 | 16 | 20 | 24 | 20 | | | | | 12 | 4 | 8 | 8 |
| ASTERACEAE | Helianthus pumilus Nutt. | HEPU1 | Y | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | | |
| ASTERACEAE | Lactuca serriola L. | LASE1 | N | | | | | | 4 | 8 | 52 | 28 | 4 | 4 | | | 16 | 20 |
| ASTERACEAE | Liatris punctata Hook. | LIPU1 | Y | 76 | 72 | 76 | 84 | 84 | 72 | 80 | | 4 | | | 68 | 76 | 52 | 72 |
| ASTERACEAE | Microseris cuspidata (Pursh.) Sch. Bip. | MICU1 | Y | 8 | | | | | | | | | | | 12 | | | |
| ASTERACEAE | Scorzonera laciniata L. | SCLA1 | N | | | | | | | | 8 | | 4 | | | 4 | 4 | 4 |
| ASTERACEAE | Senecio plattensis Nutt. | SEPL1 | Y | 40 | 20 | 4 | 8 | 4 | 12 | | | | | | | | | |
| ASTERACEAE | Senecio spartioides T. & G. | SESP1 | Y | | | | | | | | | | | | 8 | 8 | 8 | 8 |
| ASTERACEAE | Solidago mollis Bart. | SOMO1 | Y | 4 | 4 | | | | | | | | | | | | | |
| ASTERACEAE | Taraxacum officinale Weber | TAOF1 | N | | | | | | 4 | | 12 | 4 | | | 8 | | 4 | |
| ASTERACEAE | Tragopogon dubius Scop. | TRDU1 | N | 20 | 20 | | | | 20 | 20 | 68 | 40 | | 8 | 8 | 12 | 24 | 24 |
| BORAGINACEAE | Lappula redowskii (Hornem.) Greene | LARE1 | Y | | | | | | 8 | | | | 12 | | | | 16 | |
| BORAGINACEAE | Lithospermum incisum Lehm. | LIIN1 | Y | | | | | | | | | 12 | | 8 | | 4 | | |
| BORAGINACEAE | Mertensia lanceolata (Pursh.) A. DC. | MELA1 | Y | 4 | | | | | | | | | | | | | | |
| BRASSICACEAE | Alyssum alyssoides (L.) L. | ALAL1 | N | 12 | 4 | | | 4 | | | | | | | | | | |
| BRASSICACEAE | Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | N | 20 | 16 | 12 | 16 | 8 | 16 | 12 | 36 | 40 | 52 | 36 | 80 | 72 | 56 | 52 |
| BRASSICACEAE | Camelina microcarpa Andrz. ex DC. | CAMI1 | N | | 4 | | | | 4 | 4 | 76 | 24 | 64 | 56 | 44 | 24 | 56 | 36 |
| BRASSICACEAE | Descurainia pinnata (Walt.) Britt. | DEPI1 | Y | | | | | | 12 | | 16 | | 56 | | | | 56 | 24 |
| BRASSICACEAE | Draba reptans (Lam.) Fern. | DRRE1 | Y | 16 | | | 36 | 4 | 76 | 4 | 8 | | 52 | 12 | 28 | 12 | 64 | 12 |
| BRASSICACEAE | Erysimum capitatum (Nutt.) DC. | ERCA2 | Y | 40 | 20 | 8 | 16 | 8 | 52 | 44 | 12 | 4 | 28 | 32 | | 4 | | |
| BRASSICACEAE | Lepidium densiflorum Schrad. | LEDE1 | Y | | | | | | | | | | | | 4 | 4 | 24 | 20 |
| BRASSICACEAE | Lesquerella montana (A. Gray) Wats. | LEMO1 | Y | 68 | 56 | 44 | 60 | 48 | 92 | 84 | 32 | 20 | 40 | 28 | 44 | 36 | 52 | 40 |
| BRASSICACEAE | Sisymbrium altissimum L. | SIAL1 | N | | | | | | 24 | 8 | 4 | | 8 | 12 | | | | |
| CACTACEAE | Coryphantha missouriensis (Sweet) Britt. & Rose | COMI1 | Y | | | | | | | | | | 4 | | | | | |
| CACTACEAE | Echinocereus viridiflorus Engelm. | ECVI1 | Y | 40 | 52 | 48 | 40 | 36 | 28 | 36 | | 4 | 4 | 4 | 60 | 52 | 28 | 36 |
| CACTACEAE | Opuntia macrorhiza Engelm. | OPMA1 | Y | 28 | 20 | 16 | 8 | 8 | | 4 | 12 | 12 | 8 | | 32 | 36 | 8 | 8 |
| CARYOPHYLLACEAE | Arenaria fendleri A. Gray | ARFE2 | Y | 76 | 80 | 32 | 32 | 20 | 24 | 20 | | 4 | | | 72 | 72 | 36 | 48 |
| CARYOPHYLLACEAE | Paronychia jamesii T. & G. | PAJA1 | Y | 48 | 52 | 32 | 40 | 36 | 32 | 40 | | | | | 8 | 8 | 4 | 4 |
| CARYOPHYLLACEAE | Silene antirrhina L. | SIAN1 | Y | 12 | | | | | 28 | 20 | | | | | | | 8 | 8 |
| CARYOPHYLLACEAE | Silene drummondii Hook. | SIDR1 | Y | 4 | 4 | | | | | | | | | | 4 | 4 | | |
| CHENOPODIACEAE | Chenopodium leptophyllum Nutt. ex Moq. | CHLE2 | Y | | | | | | 4 | 4 | | | | | | | | |
| CLUSIACEAE | Hypericum perforatum L. | HYPE1 | N | 4 | 40 | | | | 40 | 28 | | | | | | 4 | 40 | 16 |
| COMMELINACEAE | Tradescantia occidentalis (Britt.) Smyth | TROC1 | Y | 4 | | | | | | | 8 | | 16 | | | | | |
| CYPERACEAE | Carex filifolia Nutt. | CAFI1 | Y | | | | | | | | 8 | 4 | 8 | 8 | | | | |

Table 2-4. (cont.)

| | | | | TR01 | | | | | | | TR06 | | | | TR12 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Spring | Summer | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer | Spring | Summer |
| **Family** | **Scientific Name** | **Speccode** | **Native** | **1998** | **1998** | **1999** | **2000** | **2000** | **2001** | **2001** | **1998** | **1998** | **2001** | **2001** | **1998** | **1998** | **2001** | **2001** |
| CYPERACEAE | Carex heliophila Mack. | CAHE1 | Y | 84 | 92 | 96 | 96 | 96 | 92 | 92 | 28 | 32 | 32 | 24 | 100 | 100 | 100 | 92 |
| EUPHORBIACEAE | Euphorbia robusta (Engelm.) Small | EURO1 | Y | | | | | | | | | | | | | | 4 | |
| FABACEAE | Astragalus agrestis Dougl. ex G. Don | ASAG1 | Y | 4 | 4 | | | | | | | | | | | | | |
| FABACEAE | Astragalus shortianus Nutt. ex T.&G. | ASSH1 | Y | | | | | | | | 4 | | | | | | | |
| FABACEAE | Astragalus tridactylicus Gray | ASTR1 | Y | | | | | | | | | 4 | | | | | | |
| FABACEAE | Dalea purpurea Vent | DAPU1 | Y | 16 | 16 | 16 | 12 | 12 | 4 | 8 | 4 | 4 | 4 | 4 | 4 | | | |
| FABACEAE | Psoralea tenuiflora Pursh. | PSTE1 | Y | 60 | 56 | 28 | 64 | 60 | 16 | 68 | 12 | 8 | 4 | 12 | 48 | 44 | 4 | 36 |
| GERANIACEAE | Erodium cicutarium (L.) L'Her. | ERCI1 | N | | | | | | 4 | 4 | | | | | | | 4 | |
| HYDROPHYLLACEAE | Phacelia heterophylla Pursh. | PHHE1 | Y | | | | | | | | | | | | | | 4 | 4 |
| JUNCACEAE | Juncus interior Wieg. | JUIN1 | Y | | | | | | | | | | | | | 4 | | |
| LILIACEAE | Allium textile A. Nels. & Macbr. | ALTE1 | Y | 20 | | 8 | | | 20 | 4 | 12 | | 20 | | 28 | 20 | 8 | |
| LILIACEAE | Leucocrinum montanum Nutt. | LEMO2 | Y | | | | | | | | 4 | | 4 | | | | | |
| LINACEAE | Linum perenne L. var. lewisii (Pursh.) Eat. & Wright | LIPE1 | Y | | | | | | | | 48 | 32 | 48 | 28 | | | | 4 |
| NYCTAGINACEAE | Mirabilis linearis (Pursh.) Heimerl | MILI1 | Y | | 4 | | | | | 8 | | | | | | 12 | | 4 |
| ONAGRACEAE | Gaura coccinea Pursh. | GACO1 | Y | | | | | | | | 4 | | 4 | | | | | |
| OROBANCHACEAE | Orobanche fasciculata Nutt. | ORFA1 | Y | 4 | | | | | | | | | | | 32 | | 4 | |
| POACEAE | Agropyron smithii Rydb. | AGSM1 | Y | | 4 | | | | | | 4 | | | | | | | |
| POACEAE | Andropogon gerardii Vitman | ANGE1 | Y | 68 | 76 | 76 | 80 | 72 | 64 | 80 | 8 | 4 | 4 | 8 | 60 | 60 | 68 | 60 |
| POACEAE | Andropogon scoparius Michx. | ANSC1 | Y | 60 | 68 | 64 | 64 | 56 | 44 | 56 | 4 | 4 | 8 | 4 | | 4 | | 8 |
| POACEAE | Aristida purpurea Nutt. var. longiseta (Steud.) Vasey | ARFE1 | Y | | | | | | 4 | | | | | | | | | |
| POACEAE | Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | Y | | 4 | 20 | 12 | 20 | 16 | 20 | 8 | 12 | 12 | 16 | | 16 | 8 | 16 |
| POACEAE | Bouteloua curtipendula (Michx.) Torr. | BOCU1 | Y | 52 | 60 | 72 | 76 | 56 | 68 | 60 | 60 | 72 | 76 | 76 | 60 | 84 | 64 | 76 |
| POACEAE | Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | Y | 52 | 68 | 80 | 60 | 64 | 60 | 60 | 44 | 72 | 60 | 88 | 64 | 84 | 60 | 88 |
| POACEAE | Bouteloua hirsuta Lag | BOHI1 | Y | 40 | 68 | 60 | 72 | 68 | 32 | 68 | | 12 | 8 | 16 | 36 | 28 | 36 | 32 |
| POACEAE | Bromus inermis Leyss. ssp. inermis | BRIN1 | N | | | | | | | | | | | 4 | | | | |
| POACEAE | Bromus japonicus Thunb. ex Murr. | BRJA1 | N | 20 | 8 | 8 | | | 4 | | 68 | 60 | 72 | 80 | 40 | 52 | 36 | 44 |
| POACEAE | Bromus tectorum L. | BRTE1 | N | 8 | 4 | 4 | 4 | 4 | 4 | 8 | | | 20 | 8 | 4 | 8 | 16 | 16 |
| POACEAE | Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | Y | 8 | | 4 | 8 | 4 | | | | | | | 16 | 24 | 20 | 16 |
| POACEAE | Koeleria pyramidata (Lam.) Beauv. | KOPY1 | Y | 76 | 76 | 76 | 88 | 80 | 72 | 76 | 16 | 12 | 8 | 20 | 56 | 48 | 36 | 32 |
| POACEAE | Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | Y | 60 | 64 | 68 | 68 | 72 | 68 | 68 | | | | | 4 | 8 | 8 | 8 |
| POACEAE | Poa compressa L. | POCO1 | N | 36 | 36 | 44 | 40 | 40 | 44 | 44 | 20 | 16 | 32 | 24 | 36 | 44 | 48 | 48 |
| POACEAE | Poa pratensis L. | POPR1 | N | 28 | 24 | 36 | 32 | 32 | 32 | 32 | 32 | 28 | 44 | 36 | 20 | 16 | 28 | 24 |
| POACEAE | Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | Y | 48 | 44 | 20 | 48 | 24 | 40 | 20 | 8 | 4 | 8 | 8 | | | | 4 |
| POACEAE | Sorghastrum nutans (L.) Nash | SONU1 | Y | 4 | 12 | 8 | 12 | 8 | 4 | 8 | | | | | 4 | 8 | 4 | 8 |
| POACEAE | Sporobolus asper (Michx.) Kunth | SPAS1 | Y | | | | | | | | | | | 4 | | | | |
| POACEAE | Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | Y | 16 | 16 | 16 | 16 | 16 | 16 | 20 | | | | | | | | |
| POACEAE | Stipa comata Trin. & Rupr. | STCO1 | Y | 24 | 32 | 36 | 48 | 40 | 28 | 48 | 88 | 92 | 100 | 92 | 100 | 100 | 96 | 96 |
| POACEAE | Stipa neomexicana (Thur.) Scribn. | STNE1 | Y | | | | | | | | 20 | 20 | 20 | 20 | | | | |
| POLYGONACEAE | Eriogonum alatum Torr. | ERAL1 | Y | 68 | 68 | 36 | 16 | 16 | 16 | 16 | | 4 | | 4 | 4 | 4 | | |
| PORTULACACEAE | Talinum parviflorum Nutt. | TAPA1 | Y | 24 | 32 | 8 | 12 | 20 | 20 | 16 | | | | | | | | |
| PRIMULACEAE | Androsace occidentalis Pursh. | ANOC1 | Y | | | | | | | | | | 4 | | | | 4 | |
| ROSACEAE | Potentilla fissa Nutt. | POFI1 | Y | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | | | | | | |
| ROSACEAE | Potentilla hippiana Lehm. | POHI1 | Y | 8 | 8 | 4 | 4 | 4 | 4 | | | | | | | | | |
| SANTALACEAE | Comandra umbellata (L.) Nutt. | COUM1 | Y | 28 | 28 | 12 | 28 | 32 | 20 | 16 | | | | | | | | |
| SCROPHULARIACEAE | Castilleja sessiliflora Pursh. | CASE3 | Y | 12 | 4 | 4 | 4 | 4 | 4 | 4 | | | | | | | | |
| SCROPHULARIACEAE | Linaria dalmatica (L.) Mill. | LIDA1 | N | | | | | | | | 100 | 100 | 80 | 88 | 12 | | 4 | 8 |
| SCROPHULARIACEAE | Penstemon secundiflorus Benth. | PESE1 | Y | | | | | | | | 4 | | 4 | 4 | | | | |
| SCROPHULARIACEAE | Penstemon virens Penn. | PEVI1 | Y | 8 | | 12 | 8 | | 8 | 4 | | | | | | | | |
| SOLANACEAE | Solanum triflorum Nutt. | SOTR1 | Y | | | | | | | | | | | | 4 | | | |
| VIOLACEAE | Viola nuttallii Pursh. | VINU1 | Y | 16 | | | | | 4 | | 48 | | 20 | | 56 | | 16 | |

Table 2-5. Species Cover Change From 1998 To 2001

| TR01 | TR06 | TR12 |
|---|---|---|
| **Increasers** | **Increasers** | **Increasers** |
| Muhlenbergia montana | Bromus japonicus | Andropogon gerardii |
| Poa compressa | Poa pratensis | Bouteloua curtipendula |
| | | Poa compressa |
| **Decreasers** | | **Decreasers** |
| Andropogon scoparius | | Andropogon scoparius |
| Arenaria fendleri | | Arenaria fendleri |
| Chrysopsis villosa | | Psorelea tenuiflora |
| **H-L-H pattern** | | **H-L-H pattern** |
| Andropogon gerardii | | Carex heliophila |
| Koleria pyrimidata | | |
| Liatris punctata | | |
| **L-H-L pattern** | **L-H-L pattern** | **L-H-L pattern** |
| Aster porteri | Camelina microcarpa | Alyssum minus |
| Bouteloua curtipendula | Linaria dalmatica | Aster porteri |
| Poa pratensis | Poa compressa | Stipa comata |
| | Stipa comata | |

Based on n=5. Minimum of 3% minimum-maximum change of absolute cover during study period.

Table 4-1. 1997-2000 Diffuse Knapweed Herbicide Monitoring Data Summary

| | Spring97 | Summer97 | Spring98 | Summer98 | Spring99 | Summer99 | Spring00 | Summer00 | Spring01 | Summer01 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species Richness Variables** | | | | | | | | | | |
| # species | | | | | | | | | | |
| DKC - Control | 68 | 65 | 70 | 65 | 67 | 58 | 64 | 59 | 69 | 68 |
| DKT - Treatment | 74 | 62 | 70 | 68 | 72 | 73 | 71 | 69 | 81 | 73 |
| % natives | | | | | | | | | | |
| DKC - Control | 75 | 74 | 74 | 77 | 76 | 76 | 78 | 81 | 75 | 75 |
| DKT - Treatment | 73 | 77 | 77 | 79 | 75 | 76 | 75 | 75 | 75 | 75 |
| mean # species/quadrat | | | | | | | | | | |
| DKC - Control | 13.8 | 12.8 | 14.0 | 12.1 | 14.0 | 11.4 | 12.9 | 11.6 | 14.1 | 12.4 |
| DKT - Treatment | 12.2 | 10.1 | 11.9 | 9.1 | 12.3 | 10.3 | 10.2 | 9.1 | 11.8 | 10.4 |
| | | | | | | | | | | |
| **Shannon-Weaver Diversity Index** | | | | | | | | | | |
| DKC - Control | 0.79 | 0.81 | 0.76 | 0.73 | 0.78 | 0.79 | 0.82 | 0.84 | 0.85 | 0.83 |
| DKT - Treatment | 0.83 | 0.66 | 0.63 | 0.56 | 0.64 | 0.67 | 0.69 | 0.64 | 0.73 | 0.71 |
| | | | | | | | | | | |
| **Diffuse Knapweed Density (mean # stems/m2)** | | | | | | | | | | |
| DKC - Control | 5.6 | 3.6 | 14.5 | 1.7 | 26.1 | 6.2 | 5.6 | 7.1 | 16.4 | 7.2 |
| DKT - Treatment | 23.0 | 6.1 | 2.2 | 1.1 | 1.7 | 1.4 | 1.8 | 1.9 | 41.4 | 15.0 |
| | | | | | | | | | | |
| **Diffuse Knapweed Frequency (%)** | | | | | | | | | | |
| DKC - Control | 76 | 76 | 76 | 60 | 96 | 64 | 68 | 64 | 80 | 76 |
| DKT - Treatment | 80 | 60 | 52 | 20 | 44 | 44 | 44 | 48 | 72 | 56 |
| | | | | | | | | | | |
| **Cactus Densities (mean # stems/m2)** | | | | | | | | | | |
| Twistspine prickly pear cactus | | | | | | | | | | |
| DKC - Control | 0.62 | | 0.54 | | 0.71 | | 0.65 | | 0.61 | |
| DKT - Treatment | 0.79 | | 0.24 | | 0.10 | | 0.07 | | 0.04 | |
| Hedgehog cactus | | | | | | | | | | |
| DKC - Control | 0.06 | | 0.05 | | 0.08 | | 0.04 | | 0.40 | |
| DKT - Treatment | 0.20 | | 0.14 | | 0.09 | | 0.06 | | 0.01 | |

Table 4-2. 1997-2001 Control and Treatment Species Richness Summary

| | | | | Control | | | | | | | | | | Treatment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Family | Scientific Name | Speccode | Native | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 |
| APIACEAE | Lomatium orientale Coult. & Rose | LOOR1 | Y | X | X | X | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASCLEPIADACEAE | Asclepias stenophylla A. Gray | ASST1 | Y | X | X | X | X | X | X | X | X | X | X | X | | | X | X | X | X | X | X | X |
| ASCLEPIADACEAE | Asclepias viridiflora Raf. | ASVI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Ambrosia psilostachya DC. | AMPS1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Antennaria parvifolia Nutt. | ANPA1 | Y | X | X | X | | X | X | | | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Arnica fulgens Pursh. | ARFU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | ARCA1 | Y | X | X | | X | | | X | X | X | X | X | X | X | | | | | | X | X |
| ASTERACEAE | Artemisia frigida Willd. | ARFR1 | Y | | | | | | | | | | | X | | | | | | | | | |
| ASTERACEAE | Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Aster porteri Gray | ASPO1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | CANU1 | N | X | X | X | X | | | | | | | X | | | | | X | X | X | X | X |
| ASTERACEAE | Centaurea diffusa Lam. | CEDI1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Chrysopsis fulcrata Greene | CHFU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Chrysopsis villosa Pursh. | CHVI1 | Y | | | X | X | | | X | | | | | | X | X | | | | | | |
| ASTERACEAE | Cirsium arvense (L.) Scop. | CIAR1 | N | | | | | | | | | | X | X | | X | | X | | | | | |
| ASTERACEAE | Conyza canadensis (L.) Cronq. | COCA1 | Y | | | | | | | | | | | | | | | | X | | X | | X |
| ASTERACEAE | Erigeron divergens T. & G. | ERDI1 | Y | | | | X | X | | X | | X | X | X | X | | X | X | | X | X | X | |
| ASTERACEAE | Erigeron flagellaris A. Gray | ERFL1 | Y | X | X | X | X | | X | | X | | X | X | X | X | | | | | X | | X |
| ASTERACEAE | Gaillardia aristata Pursh. | GAAR1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Lactuca serriola L. | LASE1 | N | X | X | X | X | X | X | | | X | X | X | X | | X | X | X | X | X | X | X |
| ASTERACEAE | Liatris punctata Hook. | LIPU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Microseris cuspidata (Pursh.) Sch. Bip. | MICU1 | Y | X | | X | | X | | | | X | | X | | X | | X | | X | | X | |
| ASTERACEAE | Scorzonera laciniata L. | SCLA1 | N | X | X | X | | X | | X | | X | X | X | X | | | | | | X | X | X |
| ASTERACEAE | Senecio plattensis Nutt. | SEPL1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Senecio spartioides T. & G. | SESP1 | Y | | | | | | | | | | | | X | | X | X | X | X | X | X | X |
| ASTERACEAE | Solidago mollis Bart. | SOMO1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | X | X | X | X | X |
| ASTERACEAE | Solidago rigida L. | SORI1 | Y | | X | X | X | X | X | X | X | | | | | | | | | | | | |
| ASTERACEAE | Sonchus arvensis L. ssp. arvensis L. | SOAR1 | N | | | | | | | | | | | | | | | | | X | X | | |
| ASTERACEAE | Taraxacum officinale Weber | TAOF1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ASTERACEAE | Tragopogon dubius Scop. | TRDU1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BORAGINACEAE | Lappula redowskii (Hornem.) Greene | LARE1 | Y | | | | | | | | | | | | | | | | | | | X | X |
| BORAGINACEAE | Lithospermum incisum Lehm. | LIIN1 | Y | X | X | X | | X | | X | X | | X | | | | | | | | | | |
| BORAGINACEAE | Mertensia lanceolata (Pursh.) A. DC. | MELA1 | Y | | | X | | X | | | X | | | X | | | | | | | | | |
| BRASSICACEAE | Alyssum alyssoides (L.) L. | ALAL1 | N | | | X | | | | | | X | | X | | | | | | | | | |
| BRASSICACEAE | Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BRASSICACEAE | Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | ARHI1 | Y | | | X | X | | | | | | | X | X | | | X | X | X | X | X | X |
| BRASSICACEAE | Barbarea vulgaris R. Br. | BAVU1 | N | | | | | | | | | | | X | X | X | | X | X | X | X | X | X |
| BRASSICACEAE | Camelina microcarpa Andrz. ex DC. | CAMI1 | N | X | X | X | X | X | X | | | X | X | X | | X | X | X | X | X | | X | X |
| BRASSICACEAE | Draba reptans (Lam.) Fern. | DRRE1 | Y | X | X | X | | X | | | | X | X | | | | X | | | | | X | |
| BRASSICACEAE | Erysimum capitatum (Nutt.) DC. | ERCA2 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BRASSICACEAE | Lepidium campestre (L.) R. Br. | LECA1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BRASSICACEAE | Lepidium densiflorum Schrad. | LEDE1 | Y | X | X | | | | | | | | | X | X | X | X | | X | X | | X | X |
| BRASSICACEAE | Lesquerella montana (A. Gray) Wats. | LEMO1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BRASSICACEAE | Sisymbrium altissimum L. | SIAL1 | N | X | X | | | | | | | X | | | | X | | X | X | | | X | X |
| BRASSICACEAE | Thlaspi arvense L. | THAR1 | N | | | | | | | | | | X | | | | | | | | | | |
| CACTACEAE | Coryphantha missouriensis (Sweet) Britt. & Rose | COMI1 | Y | X | | | | X | | | | | | X | | | | | | | | X | |
| CACTACEAE | Echinocereus viridiflorus Engelm. | ECVI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CACTACEAE | Opuntia macrorhiza Engelm. | OPMA1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CAMPANULACEAE | Triodanis perfoliata (L.) Nieuw. | TRPE1 | Y | | | | | | | | | | | | | | | | | | | X | |
| CARYOPHYLLACEAE | Arenaria fendleri A. Gray | ARFE2 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CARYOPHYLLACEAE | Paronychia jamesii T. & G. | PAJA1 | Y | X | | | X | | | X | | X | X | X | X | X | X | X | X | X | X | X | X |
| CARYOPHYLLACEAE | Silene antirrhina L. | SIAN1 | Y | X | X | X | | X | | X | | X | X | X | X | X | X | X | X | X | X | X | X |
| CLUSIACEAE | Hypericum perforatum L. | HYPE1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| COMMELINACEAE | Tradescantia occidentalis (Britt.) Smyth | TROC1 | Y | X | | | | | | | | | | X | | X | X | X | X | X | | X | X |
| CRASSULACEAE | Sedum lanceolatum Torr. | SELA1 | Y | | | | | | | | | | | X | X | X | X | X | X | X | X | X | X |
| CYPERACEAE | Carex heliophila Mack. | CAHE1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CYPERACEAE | Eleocharis compressa Sulliv. | ELCO1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| FABACEAE | Dalea purpurea Vent | DAPU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| FABACEAE | Medicago lupulina L. | MELU1 | N | | | | | | | | | | | X | | | | | | | | | |
| FABACEAE | Oxytropis lambertii Pursh. | OXLA1 | Y | X | | | | | X | | | X | | | | | | | | | | | |
| FABACEAE | Psoralea tenuiflora Pursh. | PSTE1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| HYDROPHYLLACEAE | Phacelia heterophylla Pursh. | PHHE1 | Y | | | | | | | | | | | | X | X | X | X | X | X | X | X | X |
| JUNCACEAE | Juncus interior Wieg. | JUIN1 | Y | | X | X | X | X | X | X | X | X | X | | | X | X | X | X | | X | X | X |
| LAMIACEAE | Hedeoma hispidum Pursh. | HEHI1 | Y | | | | | | | | | | | | | X | | | | X | | X | X |
| LILIACEAE | Allium textile A. Nels. & Macbr. | ALTE1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | X | |
| LILIACEAE | Leucocrinum montanum Nutt. | LEMO2 | Y | X | | X | | X | | | | X | | | | | | | | | | | |
| NYCTAGINACEAE | Mirabilis linearis (Pursh.) Heimerl | MILI1 | Y | | | | | | | | X | | | | | | | | | | | | |
| ONAGRACEAE | Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven | OEVI1 | Y | X | X | X | X | X | X | X | X | X | X | | | | | X | X | X | X | X | X |
| OROBANCHACEAE | Orobanche fasciculata Nutt. | ORFA1 | Y | X | | | | X | | X | | X | X | | X | X | X | X | | X | X | X | |
| PLANTAGINACE | Plantago lanceolata L. | PLLA1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

Table 4-2. (cont.)

| Family | Scientific Name | Speccode | Native | Control | | | | | | | | | | Treatment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 |
| PLANTAGINACE | Plantago patagonica Jacq. | PLPA1 | Y | | | | | | | | | | | X | | | | | | | | | |
| POACEAE | Agropyron smithii Rydb. | AGSM1 | Y | X | | | | | | | X | | | | | X | | X | | | | | |
| POACEAE | Andropogon gerardii Vitman | ANGE1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Andropogon scoparius Michx. | ANSC1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | Y | | X | | | | X | X | X | X | X | | | | | | X | | X | | X |
| POACEAE | Bouteloua curtipendula (Michx.) Torr. | BOCU1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Bouteloua hirsuta Lag | BOHI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Bromus inermis Leyss. ssp. inermis | BRIN1 | N | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | |
| POACEAE | Bromus japonicus Thunb. ex Murr. | BRJA1 | N | X | X | X | X | X | X | X | | | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Bromus tectorum L. | BRTE1 | N | | | | | | | | | X | | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | Y | | | | | | | | | | | X | X | | X | X | X | X | X | | |
| POACEAE | Koeleria pyramidata (Lam.) Beauv. | KOPY1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Muhlenbergia wrightii Vasey | MUWR1 | Y | | | | | | | X | | | X | | | X | X | X | | X | X | X | |
| POACEAE | Panicum capillare L. | PACA1 | Y | | | | | | | | | | | | | | | | X | | | | |
| POACEAE | Poa compressa L. | POCO1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Poa pratensis L. | POPR1 | N | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | Y | X | X | | X | X | X | X | X | X | X | X | X | | X | X | X | X | X | X | X |
| POACEAE | Sorghastrum nutans (L.) Nash | SONU1 | Y | | X | X | X | | X | X | X | X | X | | X | X | X | | X | X | X | X | X |
| POACEAE | Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| POACEAE | Stipa comata Trin. & Rupr. | STCO1 | Y | | | | X | | X | | | X | X | | | X | | | | | | | |
| POLEMONIACEAE | Collomia linearis Nutt. | COLI1 | Y | | | | | | | | | | | X | | X | X | X | X | | | X | X |
| POLYGONACEAE | Eriogonum alatum Torr. | ERAL1 | Y | | | X | X | | | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| POLYGONACEAE | Polygonum arenastrum Jord. ex Bor. | POAR1 | N | | | | | | | | | | | | | | | X | | | | | |
| POLYGONACEAE | Polygonum convolvulus L. | POCO2 | N | | | X | | | | | | | | | | | | | | | | | |
| POLYGONACEAE | Polygonum ramosissimum Michx. | PORA1 | Y | | | X | X | | | | | | | | | X | X | X | X | | | | |
| POLYGONACEAE | Rumex crispus L. | RUCR1 | N | | | | | | | | | | | X | | X | X | X | X | X | | X | |
| PORTULACACEAE | Talinum parviflorum Nutt. | TAPA1 | Y | | X | X | X | X | X | X | X | X | | X | | | | X | X | X | X | X | X |
| RANUNCULACEAE | Delphinium nuttalianum Pritz. ex Walpers | DENU1 | Y | | | | | | | | | | | | | | | | | | | X | |
| ROSACEAE | Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc. | POGR1 | Y | | | | | | | | | | | X | | | | | | | | | |
| ROSACEAE | Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg. | PRVI1 | Y | X | X | X | X | X | X | X | X | X | X | | | | | | | | | | |
| SCROPHULARIACEAE | Linaria dalmatica (L.) Mill. | LIDA1 | N | | | | | X | | X | | X | X | | | | | | | X | X | X | X |
| SCROPHULARIACEAE | Penstemon virens Penn. | PEVI1 | Y | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| SCROPHULARIACEAE | Verbascum blattaria L. | VEBL1 | N | X | X | X | X | X | X | X | X | | | | | | | | | | | | |
| SCROPHULARIACEAE | Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | Y | | | X | X | X | | | | | | | | X | X | X | X | | | X | X |
| VIOLACEAE | Viola nuttallii Pursh. | VINU1 | Y | | | | | X | | | | X | | | | | | | | | | | |
| | Unknown species | UNKN | | | | | | | | | | | | | | | | | X | | | X | |

**Table 4-3. 1997-2001 Diffuse Knapweed Monitoring Study Species Frequency Summary**

| | | | CONTROL FREQUENCY (%) | | | | | | | | | | TREATMENT FREQUENCY (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scientific Name | Speccode | Native | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 |
| Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | Y | 8 | 8 | 8 | 4 | 8 | 4 | 4 | 4 | 4 | 4 | | | | | | | 4 | | | 4 |
| Allium textile A. Nels. & Macbr. | ALTE1 | Y | 20 | 4 | 8 | | 8 | | | | 20 | 16 | 36 | 12 | 24 | 12 | 28 | 16 | | | 12 | |
| Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | N | 28 | 20 | 12 | 16 | 20 | 8 | 4 | 4 | 8 | 4 | 4 | 4 | 16 | 4 | 8 | 4 | 4 | 4 | 4 | 4 |
| Ambrosia psilostachya DC. | AMPS1 | Y | 72 | 68 | 64 | 68 | 64 | 60 | 60 | 64 | 76 | 72 | 32 | 32 | 12 | 16 | 16 | 12 | 28 | 28 | 36 | 32 |
| Andropogon gerardii Vitman | ANGE1 | Y | 88 | 88 | 88 | 84 | 88 | 92 | 84 | 84 | 76 | 84 | 68 | 64 | 64 | 64 | 64 | 68 | 64 | 60 | 56 | 64 |
| Andropogon scoparius Michx. | ANSC1 | Y | 28 | 28 | 20 | 24 | 16 | 36 | 48 | 52 | 24 | 36 | 20 | 40 | 20 | 20 | 20 | 28 | 28 | 32 | 16 | 32 |
| Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | ARHI1 | Y | | | | | | | | | | | 4 | | | | 4 | 4 | 4 | 4 | | |
| Arenaria fendleri A. Gray | ARFE2 | Y | 32 | 44 | 20 | 44 | 32 | 36 | 32 | 36 | 36 | 24 | 52 | 40 | 28 | 28 | 28 | 24 | 28 | 16 | 28 | 28 |
| Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | Y | | | | | | | | 4 | 4 | 8 | | | | | | | | | | |
| Arnica fulgens Pursh. | ARFU1 | Y | 36 | 16 | 40 | 28 | 40 | 12 | 32 | 8 | 40 | 28 | 16 | 12 | 16 | 12 | 20 | 8 | 20 | 8 | 20 | 20 |
| Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | ARCA1 | Y | | | | | | | | | | | 4 | 4 | 4 | | | | | | | |
| Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | Y | 68 | 68 | 68 | 64 | 68 | 64 | 68 | 68 | 88 | 64 | 36 | 36 | 32 | 16 | 24 | 16 | 20 | 16 | 20 | 20 |
| Asclepias stenophylla A. Gray | ASST1 | Y | 8 | 4 | | | 4 | 4 | | 4 | 8 | 12 | | | | | | | | | | |
| Asclepias viridiflora Raf. | ASVI1 | Y | 8 | 12 | 8 | 8 | 12 | 12 | 8 | 8 | 4 | 4 | | | | | | | | | | |
| Aster porteri Gray | ASPO1 | Y | 76 | 76 | 84 | 76 | 76 | 76 | 52 | 40 | 52 | 44 | 80 | 84 | 80 | 72 | 80 | 72 | 44 | 48 | 56 | 56 |
| Barbarea vulgaris R. Br. | BAVU1 | N | | | | | | | | | | | 4 | | | | | | | | | |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | Y | 36 | 40 | 28 | 28 | 40 | 40 | 60 | 44 | 48 | 52 | 8 | 32 | 28 | 12 | 24 | 32 | 20 | 36 | 28 | 24 |
| Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | Y | | 16 | 8 | 8 | 8 | 20 | 28 | 24 | 24 | 32 | 16 | 28 | 16 | 24 | 36 | 48 | 36 | 48 | 36 | 44 |
| Bouteloua hirsuta Lag | BOHI1 | Y | 16 | 16 | 16 | 28 | 16 | 20 | 24 | 28 | 20 | 24 | 16 | | | 4 | 8 | 20 | 12 | 12 | 8 | 4 |
| Bromus japonicus Thunb. ex Murr. | BRJA1 | N | | | 4 | 4 | 4 | | | | | | 36 | 32 | 32 | 36 | 40 | 24 | 24 | 12 | 44 | 36 |
| Bromus tectorum L. | BRTE1 | N | | | | | | | | | | | 8 | 4 | 12 | 8 | | 12 | 12 | 8 | 12 | 8 |
| Camelina microcarpa Andrz. ex DC. | CAMI1 | N | 8 | | | | 8 | 4 | | | 12 | | | | | | 4 | | | | | |
| Carex heliophila Mack. | CAHE1 | Y | 64 | 72 | 72 | 68 | 56 | 60 | 68 | 76 | 72 | 64 | 32 | 40 | 52 | 40 | 36 | 28 | 36 | 36 | 28 | 32 |
| Centaurea diffusa Lam. | CEDI1 | N | 76 | 76 | 76 | 60 | 96 | 64 | 68 | 64 | 80 | 76 | 80 | 60 | 52 | 20 | 44 | 44 | 44 | 48 | 72 | 56 |
| Chrysopsis fulcrata Greene | CHFU1 | Y | 8 | 8 | 8 | 4 | 4 | 4 | 4 | 8 | 4 | 4 | | | | | 4 | 4 | 4 | | | |
| Collomia linearis Nutt. | COLI1 | Y | | | | | | | | | | | 4 | | 4 | 4 | 4 | 4 | | | 4 | 4 |
| Dalea purpurea Vent | DAPU1 | Y | 8 | 4 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 12 | 12 | 8 | 12 | 12 | 12 | 16 | 16 | 12 | 12 |
| Draba reptans (Lam.) Fern. | DRRE1 | Y | 16 | 4 | 4 | | 12 | | | | 32 | | | | | 4 | | | | | 8 | |
| Echinocereus viridiflorus Engelm. | ECVI1 | Y | 16 | 16 | 20 | 8 | 8 | 4 | 4 | 12 | 4 | 4 | 40 | 36 | 28 | 32 | 28 | 24 | 20 | 20 | 8 | 16 |
| Erigeron divergens T. & G. | ERDI1 | Y | | | | | 4 | | 4 | | 4 | | 4 | | | | | | 4 | | 4 | |
| Erigeron flagellaris A. Gray | ERFL1 | Y | 4 | 4 | 4 | 4 | | 4 | | 4 | | 4 | | 4 | | | | | | 4 | | 4 |
| Erysimum capitatum (Nutt.) DC. | ERCA2 | Y | 8 | 4 | 8 | | 4 | | | | 8 | | 4 | | | | 8 | 8 | 12 | 4 | 12 | 8 |
| Gaillardia aristata Pursh. | GAAR1 | Y | 12 | 4 | 8 | 4 | 12 | 8 | 4 | 8 | 8 | 4 | 8 | 4 | | 4 | 4 | 4 | 4 | 8 | 4 | 4 |
| Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | Y | 56 | 48 | 68 | 40 | 40 | 32 | 32 | 20 | 8 | 12 | 20 | 16 | 12 | | 12 | 4 | 4 | 4 | 8 | 8 |
| Hypericum perforatum L. | HYPE1 | N | 52 | 64 | 44 | 16 | 24 | 16 | 20 | 28 | 28 | 36 | 16 | 8 | 72 | 12 | 36 | 24 | 20 | 36 | 12 | 20 |
| Juncus interior Wieg. | JUIN1 | Y | | 4 | | 4 | | 4 | | 4 | | 4 | | | | 4 | | | | | | |
| Koeleria pyramidata (Lam.) Beauv. | KOPY1 | Y | 40 | 32 | 28 | 20 | 28 | 24 | 40 | 24 | 36 | 20 | 36 | 20 | 28 | 20 | 20 | 32 | 24 | 24 | 24 | 20 |
| Lactuca serriola L. | LASE1 | N | 12 | 12 | 28 | 8 | 20 | 4 | | | 4 | | 20 | 8 | | | 28 | 16 | 4 | | 28 | 16 |
| Lappula redowskii (Hornem.) Greene | LARE1 | Y | | | | | | | | | | | | | | | | | | | 4 | |
| Lepidium campestre (L.) R. Br. | LECA1 | N | | 4 | 4 | 4 | 12 | 8 | 4 | | 32 | 20 | 16 | 8 | 16 | 12 | 20 | 12 | 4 | | 28 | 28 |
| Lepidium densiflorum Schrad. | LEDE1 | Y | 4 | 4 | | | | | | | | | 12 | 8 | | | | | | | 20 | 4 |
| Lesquerella montana (A. Gray) Wats. | LEMO1 | Y | 8 | 8 | 12 | 16 | 28 | 16 | 12 | 12 | 16 | 20 | 12 | 16 | 12 | 12 | 20 | 20 | 12 | 12 | 12 | 12 |
| Liatris punctata Hook. | LIPU1 | Y | 16 | 20 | 20 | 28 | 24 | 24 | 16 | 24 | 16 | 16 | 20 | 20 | 28 | 20 | 28 | 24 | 28 | 16 | 16 | 16 |
| Lithospermum incisum Lehm. | LIIN1 | Y | 4 | 4 | | | | | | 4 | | | | | | | | | | | | |
| Lomatium orientale Coult. & Rose | LOOR1 | Y | 92 | | 92 | 48 | 100 | | 96 | 4 | 96 | 32 | 80 | 8 | 92 | 72 | 92 | 24 | 88 | 16 | 84 | 52 |
| Mertensia lanceolata (Pursh.) A. DC. | MELA1 | Y | | | 4 | | | | | | | | 4 | | | | | | | | | |
| Microseris cuspidata (Pursh.) Sch. Bip. | MICU1 | Y | 4 | | 8 | | 4 | | | | 12 | | 4 | | 4 | | 8 | | | | 12 | |
| Mirabilis linearis (Pursh.) Heimerl | MILI1 | Y | | | | | | | | 4 | | | | | | | | | | | | |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | Y | 100 | 100 | 96 | 100 | 96 | 100 | 100 | 100 | 88 | 96 | 96 | 96 | 92 | 92 | 96 | 100 | 96 | 96 | 100 | 100 |
| Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven | OEVI1 | Y | | | 4 | | | | | | | | | | | | 4 | 4 | 4 | 4 | | |
| Opuntia macrorhiza Engelm. | OPMA1 | Y | 40 | 40 | 40 | 40 | 36 | 32 | 48 | 44 | 40 | 44 | 64 | 76 | 20 | 32 | 24 | 28 | 16 | 20 | 12 | 20 |
| Orobanche fasciculata Nutt. | ORFA1 | Y | | | | | 4 | | 12 | | 12 | 4 | | 4 | 4 | 4 | 20 | | 40 | 12 | | |
| Paronychia jamesii T. & G. | PAJA1 | Y | | | | | | | | | | 4 | 12 | 12 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Penstemon virens Penn. | PEVI1 | Y | 4 | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 16 | | 28 | 12 | 28 | 24 | 20 | 16 | 20 | 16 |
| Poa compressa L. | POCO1 | N | 92 | 100 | 100 | 100 | 100 | 96 | 100 | 100 | 100 | 100 | 96 | 96 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 96 |
| Poa pratensis L. | POPR1 | N | 8 | 8 | 8 | 8 | 4 | 4 | 8 | 8 | 8 | 4 | | | 4 | 4 | 8 | 4 | | | | |
| Polygonum ramosissimum Michx. | PORA1 | Y | | | | 8 | | | | | | | | | 4 | 8 | 8 | 4 | | | | |
| Psoralea tenuiflora Pursh. | PSTE1 | Y | 32 | 40 | 44 | 36 | 36 | 44 | 44 | 36 | 24 | 28 | 20 | 8 | 16 | 16 | 12 | 16 | 20 | 20 | 20 | 16 |
| Rumex crispus L. | RUCR1 | N | | | | | | | | | | | 4 | | | | | | | | | |
| Scorzonera laciniata L. | SCLA1 | N | | | | | | | | | | | 4 | 4 | | | | | | | | |
| Senecio plattensis Nutt. | SEPL1 | Y | 8 | 4 | 4 | | 16 | 4 | 4 | 8 | 8 | 4 | 24 | 12 | 20 | 4 | 12 | 4 | 4 | 4 | 8 | 4 |
| Senecio spartioides T. & G. | SESP1 | Y | | | | | | | | | | | | | | | | | | | | 4 |
| Silene antirrhina L. | SIAN1 | Y | 8 | 8 | 4 | | 12 | | 8 | | 20 | 16 | 4 | | 28 | | 24 | 8 | 12 | 4 | 48 | 28 |
| Sisymbrium altissimum L. | SIAL1 | N | | | | | | | | | 4 | | | | | | | | | | | |
| Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | Y | 8 | 12 | | | 8 | 12 | | | | 4 | | | | | | 4 | 4 | 4 | | |
| Solidago mollis Bart. | SOMO1 | Y | 24 | 24 | 28 | 28 | 28 | 24 | 28 | 24 | 28 | 32 | | | | | | | | | | |
| Sorghastrum nutans (L.) Nash | SONU1 | Y | | 4 | 4 | 4 | | 4 | 4 | 4 | 4 | 4 | | | | 4 | | 4 | | 4 | 4 | 4 |
| Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | Y | 20 | 20 | 20 | 24 | 20 | 20 | 20 | 20 | 20 | 20 | | | | | | | | | | |
| Stipa comata Trin. & Rupr. | STCO1 | Y | | | | 4 | | 4 | | | 8 | 4 | | | | | | | | | | |
| Talinum parviflorum Nutt. | TAPA1 | Y | | 4 | 4 | | 8 | 4 | 4 | | 4 | | | | | | 12 | 28 | 4 | 20 | 16 | 20 |
| Taraxacum officinale Weber | TAOF1 | N | | | | | | | | | | | 4 | | | | | | | | 8 | 4 |
| Tradescantia occidentalis (Britt.) Smyth | TROC1 | Y | | | | | | | | | | | 4 | | 4 | | 4 | 4 | 4 | | 4 | 4 |
| Tragopogon dubius Scop. | TRDU1 | N | 8 | 16 | 44 | 32 | 32 | 20 | 24 | 32 | 40 | 44 | 12 | 8 | | 4 | 8 | 4 | 20 | 28 | 40 | 36 |
| Triodanis perfoliata (L.) Nieuw. | TRPE1 | Y | | | | | | | | | | | | | | | | | | | 4 | |
| Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | Y | | | 4 | | | | | | | | | | 72 | 32 | 60 | 16 | | | 20 | |
| Viola nuttallii Pursh. | VINU1 | Y | | | | | | | | | 4 | | | | | | | | | | | |
| Unknown species | UNKN | | | | | | | | | | | | | | | | | 4 | | | | |

Frequency based on n=25.

**Table 4-4. 1997-2001 Diffuse Knapweed Monitoring Study Species Frequency Changes Summary**

| Scientific Name | Speccode | Native | Frequency Changes (%) Control Change | Treatment Change | Control vs. Treatment Change |
|---|---|---|---|---|---|
| Opuntia macrorhiza Engelm. | OPMA1 | Y | 0 | -52 | -52 |
| Arenaria fendleri A. Gray | ARFE2 | Y | 4 | -24 | -28 |
| Allium textile A. Nels. & Macbr. | ALTE1 | Y | 0 | -24 | -24 |
| Echinocereus viridiflorus Engelm. | ECVI1 | Y | -12 | -32 | -20 |
| Lepidium campestre (L.) R. Br. | LECA1 | N | 32 | 12 | -20 |
| Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | Y | 0 | -16 | -16 |
| Senecio plattensis Nutt. | SEPL1 | Y | 0 | -16 | -16 |
| Bouteloua hirsuta Lag | BOHI1 | Y | 4 | -8 | -12 |
| Carex heliophila Mack. | CAHE1 | Y | 8 | -4 | -12 |
| Centaurea diffusa Lam. | CEDI1 | N | 4 | -8 | -12 |
| Orobanche fasciculata Nutt. | ORFA1 | Y | 12 | 0 | -12 |
| Lepidium densiflorum Schrad. | LEDE1 | Y | -4 | 8 | 12 |
| Talinum parviflorum Nutt. | TAPA1 | Y | 4 | 16 | 12 |
| Lactuca serriola L. | LASE1 | N | -8 | 8 | 16 |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | Y | -12 | 4 | 16 |
| Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | N | -20 | 0 | 20 |
| Hypericum perforatum L. | HYPE1 | N | -24 | -4 | 20 |
| Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | Y | 0 | 20 | 20 |
| Silene antirrhina L. | SIAN1 | Y | 12 | 44 | 32 |
| Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | Y | -48 | -12 | 36 |

Frequency based on n=25.

Values are based on Spring 1997 vs. Spring 2001 comparisons.

Table 4-5. 1997-2001 Diffuse Knapweed Monitoring Study Foliar Cover Summary - Control Plot

| | | | | | Frequency (%) | | | | | | | | | | Absolute Cover (%) | | | | | | | | | | Relative Cover (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scientific Name | Speccode | Growth Form | Native | Cool/ Warm Season | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 |
| Camelina microcarpa Andrz. ex DC. | CAMI1 | F | N | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.2 | | | | | | |
| Centaurea diffusa Lam. | CEDI1 | F | N | | 100 | 100 | 40 | 80 | 40 | 60 | 100 | 100 | 100 | 100 | 2.6 | 4.8 | 0.4 | 1.0 | 0.6 | 2.0 | 3.2 | 4.8 | 5.2 | 5.8 | 3.8 | 6.1 | 0.5 | 1.2 | 0.9 | 2.4 | 4.8 | 6.6 | 7.6 | 6.9 |
| Hypericum perforatum L. | HYPE1 | F | N | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | | | | | | | | |
| Lepidium campestre (L.) R. Br. | LECA1 | F | N | | 20 | 20 | 20 | 20 | | 40 | | | 20 | 20 | 0.4 | 0.2 | 0.2 | 0.2 | | 0.2 | | | 0.2 | 0.2 | 0.6 | 0.3 | 0.3 | 0.2 | | 0.2 | | | 0.3 | 0.2 |
| Tragopogon dubius Scop. | TRDU1 | F | N | | 40 | 20 | 80 | | 40 | 20 | 60 | 40 | 20 | | 0.4 | 0.2 | 0.6 | | 0.2 | 0.2 | 0.6 | 0.6 | 0.2 | | 0.6 | 0.3 | 0.8 | | 0.3 | 0.2 | 0.9 | 1.1 | 0.3 | |
| Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | F | Y | | | | | | | | 20 | | 20 | | | | | | | | 0.2 | | 0.2 | | | | | | | | 0.3 | | 0.3 | |
| Ambrosia psilostachya DC. | AMPS1 | F | Y | | 60 | 60 | 100 | 80 | 80 | 60 | 40 | 100 | 80 | 80 | 1.2 | 0.6 | 1.2 | 1.4 | 1.8 | 1.4 | 1.0 | 2.4 | 1.2 | 3.2 | 1.8 | 0.8 | 1.6 | 1.6 | 2.8 | 1.7 | 1.5 | 3.3 | 1.7 | 3.8 |
| Arenaria fendleri A. Gray | ARFE2 | F | Y | | 40 | 20 | | 40 | 20 | 40 | 40 | | 40 | | 0.4 | 0.2 | | 0.4 | 0.6 | 0.4 | 0.6 | | 0.6 | | 0.6 | 0.3 | | 0.5 | 0.9 | 0.5 | 0.9 | | 0.9 | |
| Arnica fulgens Pursh. | ARFU1 | F | Y | | 20 | | 20 | | | 20 | | | 20 | | 0.2 | | 0.2 | | | 0.2 | | | 0.2 | | 0.3 | | 0.3 | | | 0.2 | | | 0.3 | |
| Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | F | Y | | 100 | 20 | 40 | 40 | 40 | 40 | 40 | 60 | 40 | 60 | 1.0 | 0.2 | 0.8 | 0.4 | 0.6 | 0.4 | 0.6 | 1.2 | 0.8 | 1.0 | 1.5 | 0.3 | 0.8 | 0.5 | 0.9 | 0.5 | 0.9 | 1.6 | 0.9 | 1.2 |
| Asclepias stenophylla A. Gray | ASST1 | F | Y | | 20 | 20 | | | | 40 | 20 | | | | 0.2 | 0.2 | | | | 0.4 | 0.2 | | | | 0.3 | 0.3 | | | | 0.5 | 0.3 | | | |
| Asclepias viridiflora Raf. | ASVI1 | F | Y | | | | | | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | |
| Aster porteri Gray | ASPO1 | F | Y | | 100 | 100 | 100 | 100 | 100 | 100 | 20 | 40 | 40 | 80 | 2.6 | 2.0 | 5.4 | 4.6 | 4.6 | 5.6 | 0.4 | 0.6 | 0.4 | 1.0 | 3.8 | 2.5 | 7.1 | 5.4 | 7.1 | 6.7 | 0.6 | 0.8 | 0.6 | 1.2 |
| Chrysopsis fulcrata Greene | CHFU1 | F | Y | | | | | | | | 20 | 20 | 20 | | | | | | | | 0.2 | 0.2 | 0.2 | | | | | | | | 0.3 | 0.3 | 0.3 | |
| Dalea purpurea Vent | DAPU1 | F | Y | | | 20 | 20 | | 20 | 20 | | | | | | 0.2 | 0.2 | | 0.2 | 0.2 | | | | | | 0.3 | 0.3 | | 0.3 | 0.2 | | | | |
| Draba reptans (Lam.) Fern. | DRRE1 | F | Y | | | | | | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | |
| Erigeron divergens T. & G. | ERDI1 | F | Y | | | | | | 40 | | | | | | | | | | 0.4 | | | | | | | | | | 0.6 | | | | | |
| Erigeron flagellaris A. Gray | ERFL1 | F | Y | | | 20 | 20 | | | | | | | | | 0.2 | 0.2 | | | | | | | | | 0.3 | 0.3 | | | | | | | |
| Gaillardia aristata Pursh. | GAAR1 | F | Y | | | 20 | | | 20 | | | | 20 | | | 0.2 | | | 0.2 | | | | 0.2 | | | 0.3 | | | 0.3 | | | | 0.3 | |
| Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | F | Y | | 40 | 80 | | 20 | | | 20 | | | | 0.4 | 1.2 | | 0.2 | | | 0.2 | | | | 0.6 | 1.5 | | 0.2 | | | 0.3 | | | |
| Liatris punctata Hook. | LIPU1 | F | Y | | 20 | | | | | | | 40 | | | 0.2 | | | | | | | 0.4 | | | 0.3 | | | | | | | 0.5 | | |
| Lomatium orientale Coult. & Rose | LOOR1 | F | Y | | | | 60 | | 40 | | 40 | | 100 | | | | 0.8 | | 0.4 | | 0.6 | | 1.8 | | | | 1.1 | | 0.6 | | 0.9 | | 2.6 | |
| Penstemon virens Penn. | PEVI1 | F | Y | | | | | | | | | | 20 | 20 | | | | | | | | | 0.2 | 0.2 | | | | | | | | | 0.3 | 0.2 |
| Psoralea tenuiflora Pursh. | PSTE1 | F | Y | | 40 | 80 | 40 | 80 | 20 | 100 | 80 | 100 | 60 | 100 | 0.8 | 1.4 | 0.8 | 1.6 | 0.2 | 1.4 | 1.4 | 2.6 | 1.2 | 3.0 | 1.2 | 1.8 | 1.1 | 1.9 | 0.3 | 1.7 | 2.1 | 3.6 | 1.7 | 3.6 |
| Silene antirrhina L. | SIAN1 | F | Y | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | | | | | | | | | |
| Solidago mollis Bart. | SOMO1 | F | Y | | | | | | | | | | | 60 | | | | | | | | | | 0.6 | | | | | | | | | | 0.7 |
| Poa compressa L. | POCO1 | G | N | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 17.2 | 20.8 | 25.4 | 31.8 | 19.2 | 24.2 | 19.6 | 11.8 | 20.4 | 26.6 | 25.2 | 26.4 | 33.5 | 37.1 | 29.5 | 28.9 | 29.6 | 16.1 | 29.7 | 31.7 |
| Poa pratensis L. | POPR1 | G | N | C | 20 | 40 | 40 | 20 | | | | 40 | 60 | 20 | 0.4 | 0.6 | 0.8 | 0.2 | | | | 0.4 | 1.0 | 0.2 | 0.6 | 0.8 | 1.1 | 0.2 | | | | 0.5 | 1.5 | 0.2 |
| Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | G | Y | C | | | | | | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.2 |
| Carex heliophila Mack. | CAHE1 | G | Y | C | 60 | 100 | 80 | 80 | 60 | 60 | 80 | 80 | 100 | 100 | 0.6 | 1.6 | 2.0 | 2.0 | 2.0 | 1.2 | 1.6 | 2.0 | 1.4 | 2.0 | 0.9 | 2.0 | 2.6 | 2.3 | 3.1 | 1.4 | 2.4 | 2.7 | 2.0 | 2.4 |
| Eleocharis compressa Sulliv. | ELCO1 | G | Y | C | 20 | | 20 | | | 20 | | 20 | | 20 | 0.4 | | 0.2 | | | 0.2 | | 0.2 | | 0.2 | 0.6 | | 0.3 | | | 0.2 | | 0.3 | | 0.2 |
| Koeleria pyramidata (Lam.) Beauv. | KOPY1 | G | Y | C | 40 | 20 | 20 | 20 | 40 | 40 | 20 | | 60 | 20 | 0.4 | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.2 | | 0.8 | 0.2 | 0.6 | 0.3 | 0.3 | 0.2 | 0.6 | 0.5 | 0.3 | | 1.2 | 0.2 |
| Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | G | Y | C | | 20 | | | 20 | | | | | | | 0.2 | | | 0.2 | | | | | | | 0.3 | | | 0.3 | | | | | |
| Andropogon gerardii Vitman | ANGE1 | G | Y | W | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 8.6 | 11.0 | 7.2 | 12.2 | 6.6 | 12.0 | 8.8 | 14.2 | 3.8 | 11.0 | 12.6 | 14.0 | 9.5 | 14.3 | 10.2 | 14.4 | 13.3 | 19.4 | 5.5 | 13.1 |
| Andropogon scoparius Michx. | ANSC1 | G | Y | W | 20 | 20 | 20 | | | 60 | 80 | 40 | 60 | 60 | 0.4 | 0.2 | 0.2 | | | 0.6 | 1.2 | 0.8 | 0.8 | 0.6 | 0.6 | 0.3 | 0.3 | | | 0.7 | 1.8 | 1.1 | 1.2 | 0.7 |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | G | Y | W | 40 | 80 | 40 | 80 | 40 | 60 | 60 | 40 | 60 | 80 | 0.4 | 1.8 | 1.0 | 0.8 | 1.2 | 2.0 | 1.4 | 1.0 | 1.6 | 1.6 | 0.6 | 2.3 | 1.3 | 0.9 | 1.8 | 2.4 | 2.1 | 1.4 | 2.3 | 1.9 |
| Bouteloua gracilis (H. B. K.) Lag.ex Griffiths | BOGR1 | G | Y | W | 20 | | | 20 | 20 | 20 | 60 | 60 | 40 | | 0.4 | | | 0.2 | 0.2 | 0.4 | 0.4 | 0.8 | 0.6 | | 0.6 | | | 0.2 | 0.3 | 0.5 | 0.6 | 1.1 | 0.9 | |
| Bouteloua hirsuta Lag. | BOHI1 | G | Y | W | | | 20 | | 20 | 40 | 40 | | | 20 | | | 0.2 | | 0.2 | 0.4 | 0.4 | | | 0.2 | | | 0.3 | | 0.3 | 0.5 | 0.6 | | | 0.2 |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | G | Y | W | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 23.2 | 24.4 | 23.2 | 22.2 | 19.6 | 23.4 | 18.4 | 22.6 | 20.8 | 20.6 | 34.0 | 31.0 | 30.6 | 25.9 | 30.2 | 28.0 | 27.8 | 30.9 | 30.2 | 24.6 |
| Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | G | Y | W | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 5.6 | 6.2 | 4.8 | 6.0 | 5.6 | 6.4 | 5.0 | 6.4 | 4.8 | 5.4 | 8.2 | 7.9 | 6.3 | 7.0 | 8.6 | 7.7 | 7.6 | 8.7 | 7.0 | 6.4 |
| Total foliar cover | | | | | | | | | | | | | | | 68.2 | 78.8 | 75.8 | 85.6 | 65.0 | 83.6 | 66.2 | 73.2 | 68.8 | 83.8 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Total forb cover | | | | | | | | | | | | | | | 10.6 | 11.8 | 10.6 | 10.0 | 9.8 | 12.4 | 9.2 | 13.0 | 12.8 | 15.0 | 15.5 | 15.0 | 14.0 | 11.7 | 15.1 | 14.8 | 13.9 | 17.8 | 18.6 | 17.9 |
| Total native forb cover | | | | | | | | | | | | | | | 7.2 | 6.4 | 9.4 | 8.6 | 9.0 | 10.0 | 5.4 | 7.4 | 7.2 | 9.0 | 10.6 | 8.1 | 12.4 | 10.0 | 13.8 | 12.0 | 8.2 | 10.1 | 10.5 | 10.7 |
| Total non-native forb cover | | | | | | | | | | | | | | | 3.4 | 5.4 | 1.2 | 1.4 | 0.8 | 2.4 | 3.8 | 5.6 | 5.6 | 6.0 | 5.0 | 6.9 | 1.6 | 1.6 | 1.2 | 2.9 | 5.7 | 7.7 | 8.1 | 7.2 |
| Total graminoid cover | | | | | | | | | | | | | | | 57.6 | 67.0 | 65.2 | 75.6 | 55.2 | 71.2 | 57.0 | 60.2 | 56.0 | 68.8 | 84.5 | 85.0 | 86.0 | 88.3 | 84.9 | 85.2 | 86.1 | 82.2 | 81.4 | 82.1 |
| Total native graminoid cover | | | | | | | | | | | | | | | 40.0 | 45.6 | 39.0 | 43.6 | 36.0 | 47.0 | 37.4 | 48.0 | 34.6 | 42.0 | 58.7 | 57.9 | 51.5 | 50.9 | 55.4 | 56.2 | 56.5 | 65.6 | 50.3 | 50.1 |
| Total non-native graminoid cover | | | | | | | | | | | | | | | 17.6 | 21.4 | 26.2 | 32.0 | 19.2 | 24.2 | 19.6 | 12.2 | 21.4 | 26.8 | 25.8 | 27.2 | 34.6 | 37.4 | 29.5 | 28.9 | 29.6 | 16.7 | 31.1 | 32.0 |
| Total native cover | | | | | | | | | | | | | | | 47.2 | 52.0 | 48.4 | 52.2 | 45.0 | 57.0 | 42.8 | 55.4 | 41.8 | 51.0 | 69.2 | 66.0 | 63.9 | 61.0 | 69.2 | 68.2 | 64.7 | 75.7 | 60.8 | 60.9 |
| Total non-native cover | | | | | | | | | | | | | | | 21.0 | 26.8 | 27.4 | 33.4 | 20.0 | 26.6 | 23.4 | 17.8 | 27.0 | 32.8 | 30.8 | 34.0 | 36.1 | 39.0 | 30.8 | 31.8 | 35.3 | 24.3 | 39.2 | 39.1 |
| Total warm-season graminoid cover | | | | | | | | | | | | | | | 38.6 | 43.6 | 36.6 | 41.4 | 33.4 | 45.2 | 35.6 | 45.8 | 32.4 | 39.4 | 56.6 | 55.3 | 48.3 | 48.4 | 51.4 | 54.1 | 53.8 | 62.6 | 47.1 | 47.0 |
| Total cool-season graminoid cover | | | | | | | | | | | | | | | 19.0 | 23.4 | 28.6 | 34.2 | 21.8 | 26.0 | 21.4 | 14.4 | 23.6 | 29.4 | 27.9 | 29.7 | 37.7 | 40.0 | 33.5 | 31.1 | 32.3 | 19.7 | 34.3 | 35.1 |

Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible (500).
Relative cover = Relative foliar cover was the number of hits a species had relative to the total number of all vegetative hits recorded per site (i.e., the percent of vegetative cover the species represented).
All cover values presented are means (n = 5).
Native categories: Y = Native, N = Non-Native
Form categories: C = Cactus, F = Forb, G = Graminoid
Cool/Warm Season categories: C = Cool season species, W = Warm season species

**Table 4-6. 1997-2001 Diffuse Knapweed Monitoring Study Foliar Cover Summary - Treatment Plot**

| | | | | | Frequency (%) | | | | | | | | | | Absolute Cover (%) | | | | | | | | | | Relative Cover (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scientific Name | Speccode | Growth Form | Native | Cool/ Warm Season | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 | Spring 1997 | Summer 1997 | Spring 1998 | Summer 1998 | Spring 1999 | Summer 1999 | Spring 2000 | Summer 2000 | Spring 2001 | Summer 2001 |
| Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | F | N | | | | | | 20 | 20 | 20 | | 20 | 20 | | | | | 0.2 | 0.2 | 0.2 | | 0.2 | 0.2 | | | | | 0.3 | 0.3 | 0.3 | | 0.3 | 0.2 |
| Centaurea diffusa Lam. | CEDI1 | F | N | | 100 | 100 | | | | 20 | 40 | 60 | 20 | 60 | 4.4 | 4.8 | | | | 0.6 | 0.4 | 1.2 | 0.8 | 1.2 | 6.6 | 6.8 | | | | 0.8 | 0.6 | 1.7 | 1.1 | 1.4 |
| Hypericum perforatum L. | HYPE1 | F | N | | 20 | 20 | | | | | 20 | 20 | | | 0.2 | 0.2 | | | | | 0.2 | 0.2 | | | 0.3 | 0.3 | | | | | 0.3 | 0.3 | | |
| Lactuca serriola L. | LASE1 | F | N | | | | | | | 20 | | | 40 | 20 | | | | | | 0.2 | | | 0.4 | 0.2 | | | | | | 0.3 | | | 0.5 | 0.2 |
| Lepidium campestre (L.) R. Br. | LECA1 | F | N | | 20 | | | | | | | | 20 | 20 | 0.2 | | | | | | | | 0.2 | 0.2 | 0.3 | | | | | | | | 0.3 | 0.2 |
| Plantago lanceolata L. | PLLA1 | F | N | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | | | | | | | | | |
| Tragopogon dubius Scop. | TRDU1 | F | N | | 20 | | | | | 40 | 40 | 20 | 60 | 40 | 0.2 | | | | | 0.4 | 0.4 | 0.2 | 0.6 | 0.6 | 0.3 | | | | | 0.5 | 0.6 | 0.3 | 0.8 | 0.7 |
| Allium textile A. Nels. & Macbr. | ALTE1 | F | Y | | 20 | 20 | 20 | | | | | | | | 0.2 | 0.2 | 0.2 | | | | | | | | 0.3 | 0.3 | 0.3 | | | | | | | |
| Ambrosia psilostachya DC. | AMPS1 | F | Y | | 80 | | | | | 20 | 40 | 60 | 60 | 80 | 1.6 | | | | | 0.2 | 0.6 | 1.0 | 0.6 | 1.6 | 2.4 | | | | | 0.3 | 1.0 | 1.4 | 0.8 | 2.2 |
| Arenaria fendleri A. Gray | ARFE2 | F | Y | | 20 | | | | | | | | 20 | 20 | 0.4 | | | | | | | | 0.2 | 0.2 | 0.6 | | | | | | | | 0.3 | 0.2 |
| Arnica fulgens Pursh. | ARFU1 | F | Y | | 60 | 20 | 20 | 40 | 40 | | 20 | | 60 | 40 | 0.6 | 0.2 | 0.4 | 0.4 | 0.8 | | 0.6 | | 0.6 | 0.4 | 0.9 | 0.3 | 0.5 | 0.5 | 1.3 | | 1.0 | | 0.8 | 0.5 |
| Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | F | Y | | 20 | 60 | | 60 | | 60 | 40 | 20 | 20 | 20 | 0.4 | 1.0 | | 0.6 | | 0.6 | 0.6 | 0.2 | 0.2 | 0.2 | 0.6 | 1.4 | | 0.7 | | 0.8 | 1.0 | 0.3 | 0.3 | 0.2 |
| Asclepias stenophylla A. Gray | ASST1 | F | Y | | 20 | | | 20 | | | | | | | 0.2 | | | 0.2 | | | | | | | 0.3 | | | 0.2 | | | | | | |
| Aster porteri Gray | ASPO1 | F | Y | | 80 | 100 | 60 | 60 | 60 | 80 | 20 | 40 | 40 | 20 | 2.0 | 2.0 | 1.8 | 2.6 | 2.6 | 3.2 | 0.6 | 0.4 | 0.8 | 0.2 | 3.0 | 2.8 | 2.4 | 3.2 | 4.1 | 4.0 | 1.0 | 0.6 | 1.1 | 0.2 |
| Collomia linearis Nutt. | COLI1 | F | Y | | | | | | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | |
| Dalea purpurea Vent | DAPU1 | F | Y | | | 20 | 20 | | | | 20 | | 20 | | | 0.2 | 0.2 | | | | 0.2 | | 0.2 | | | 0.3 | 0.3 | | | | 0.3 | | 0.3 | |
| Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | F | Y | | 60 | 20 | 20 | | 20 | | 20 | 20 | | | 0.6 | 0.2 | 0.2 | | 0.2 | | 0.4 | 0.2 | | | 0.9 | 0.3 | 0.3 | | 0.3 | | 0.6 | 0.3 | | |
| Lepidium densiflorum Schrad. | LEDE1 | F | Y | | | | | | | | | | 40 | | | | | | | | | | 0.4 | | | | | | | | | | 0.5 | |
| Lesquerella montana (A. Gray) Wats. | LEMO1 | F | Y | | | | | | | 20 | 40 | | 20 | | | | | | | 0.2 | 0.4 | | 0.2 | | | | | | | 0.3 | 0.6 | | 0.3 | |
| Liatris punctata Hook. | LIPU1 | F | Y | | 20 | | 20 | | | 40 | 60 | 40 | 40 | 20 | 0.2 | | 0.2 | | | 0.6 | 0.8 | 0.4 | 1.0 | 0.2 | 0.3 | | 0.3 | | | 0.8 | 1.3 | 0.6 | 1.4 | 0.2 |
| Lomatium orientale Coult. & Rose | LOOR1 | F | Y | | 60 | | 80 | | 80 | | 40 | | 60 | | 0.8 | | 1.6 | | 1.2 | | 0.4 | | 1.4 | | 1.2 | | 2.1 | | 1.9 | | 0.6 | | 1.9 | |
| Penstemon virens Penn. | PEVI1 | F | Y | | | | 20 | | | | | 20 | | | | | 0.2 | | | | | 0.2 | | | | | 0.3 | | | | | 0.3 | | |
| Psoralea tenuiflora Pursh. | PSTE1 | F | Y | | | | | | | | | | 20 | 40 | | | | | | | | | 0.2 | 0.4 | | | | | | | | | 0.3 | 0.5 |
| Senecio plattensis Nutt. | SEPL1 | F | Y | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | | | | | | | |
| Senecio spartioides T. & G. | SESP1 | F | Y | | | | | | | 20 | 20 | 20 | 20 | | | | | | | 0.2 | 0.4 | 0.4 | 0.2 | | | | | | | 0.3 | 0.6 | 0.6 | 0.3 | |
| Silene antirrhina L. | SIAN1 | F | Y | | | | | | | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.2 |
| Talinum parviflorum Nutt. | TAPA1 | F | Y | | | | | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | | |
| Tradescantia occidentalis (Britt.) Smyth | TROC1 | F | Y | | | | | | 20 | | | | | | | | | | 0.4 | | | | | | | | | | 0.6 | | | | | |
| Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | F | Y | | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.3 | | | | | |
| Bromus japonicus Thunb. ex Murr. | BRJA1 | G | N | C | 60 | 80 | 40 | 60 | 40 | 40 | 20 | | 60 | 20 | 2.2 | 2.4 | 2.0 | 2.2 | 1.2 | 0.8 | 0.2 | | 0.6 | 0.2 | 3.3 | 3.4 | 2.7 | 2.7 | 1.9 | 1.0 | 0.3 | | 0.8 | 0.2 |
| Bromus tectorum L. | BRTE1 | G | N | C | 20 | | 40 | 40 | | 20 | | | 20 | | 1.8 | | 1.2 | 0.6 | | 0.6 | | | 0.2 | | 2.7 | | 1.6 | 0.7 | | 0.8 | | | 0.3 | |
| Poa compressa L. | POCO1 | G | N | C | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 12.2 | 12.4 | 25.0 | 31.6 | 23.8 | 22.8 | 20.4 | 13.0 | 23.0 | 25.2 | 18.4 | 17.5 | 33.2 | 38.7 | 37.9 | 28.6 | 32.6 | 18.8 | 31.4 | 30.3 |
| Poa pratensis L. | POPR1 | G | N | C | 20 | 20 | 20 | | | | | 20 | 20 | | 0.2 | 0.4 | 0.2 | | | | | 0.2 | 0.2 | | 0.3 | 0.6 | 0.3 | | | | | 0.3 | 0.3 | |
| Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | G | Y | C | | | | | | | | | | 20 | | | | | | | | | | 0.2 | | | | | | | | | | 0.2 |
| Carex heliophila Mack. | CAHE1 | G | Y | C | 60 | 40 | 60 | 40 | 40 | 40 | 20 | 60 | 80 | 60 | 0.8 | 1.2 | 0.8 | 0.8 | 0.6 | 0.8 | 1.0 | 2.0 | 2.6 | 2.2 | 1.2 | 1.7 | 1.1 | 1.0 | 1.0 | 1.0 | 1.6 | 2.9 | 3.6 | 2.6 |
| Koeleria pyramidata (Lam.) Beauv. | KOPY1 | G | Y | C | 40 | 20 | | | 20 | | 20 | | 40 | 20 | 0.2 | 0.2 | | | 0.2 | | 0.2 | | 0.4 | 0.2 | 0.3 | 0.3 | | | 0.3 | | 0.3 | | 0.5 | 0.2 |
| Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | G | Y | C | | | | 20 | | 20 | | | | 40 | | | | 0.2 | | 0.2 | | | | 0.4 | | | | 0.2 | | 0.3 | | | | 0.5 |
| Andropogon gerardii Vitman | ANGE1 | G | Y | W | 80 | 100 | 80 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 5.0 | 8.2 | 5.4 | 7.8 | 4.6 | 10.2 | 5.4 | 9.4 | 5.4 | 11.2 | 7.5 | 11.5 | 7.2 | 9.6 | 7.3 | 12.6 | 8.6 | 13.6 | 7.4 | 13.5 |
| Andropogon scoparius Michx. | ANSC1 | G | Y | W | 80 | 60 | 80 | 60 | 40 | 40 | 60 | 80 | 40 | 80 | 1.6 | 1.0 | 1.0 | 1.0 | 0.6 | 1.4 | 1.8 | 1.2 | 1.4 | 3.0 | 2.4 | 1.4 | 1.3 | 1.2 | 1.3 | 1.8 | 2.9 | 1.7 | 1.9 | 3.6 |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | G | Y | W | 60 | 40 | 60 | 20 | 60 | 80 | 40 | 80 | 60 | 60 | 0.8 | 0.4 | 1.4 | 0.2 | 1.6 | 2.0 | 0.6 | 2.4 | 1.0 | 2.2 | 1.2 | 0.6 | 1.9 | 0.2 | 2.5 | 2.5 | 1.0 | 3.5 | 1.4 | 2.6 |
| Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | G | Y | W | 40 | 20 | 80 | | | 80 | 60 | 40 | 40 | 40 | 0.6 | 0.2 | 1.2 | | | 0.8 | 1.0 | 1.2 | 0.6 | 1.2 | 0.9 | 0.3 | 1.6 | | | 1.0 | 1.6 | 1.7 | 0.8 | 1.4 |
| Bouteloua hirsuta Lag | BOHI1 | G | Y | W | 80 | | | 20 | 40 | | 80 | 20 | | 20 | 0.8 | | | 0.2 | 0.6 | | 1.0 | 0.2 | | 0.2 | 1.2 | | | 0.2 | 1.0 | | 1.6 | 0.3 | | 0.2 |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | G | Y | W | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 26.4 | 35.2 | 31.6 | 32.6 | 23.0 | 32.6 | 24.2 | 34.4 | 29.0 | 30.4 | 39.8 | 49.6 | 41.9 | 40.0 | 36.6 | 40.9 | 38.7 | 49.7 | 39.6 | 36.5 |
| Sorghastrum nutans (L.) Nash | SONU1 | G | Y | W | | | | | | 20 | 20 | | | 20 | | | | | | 0.2 | 0.2 | | | 0.2 | | | | | | 0.3 | 0.3 | | | 0.2 |
| Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | G | Y | W | 60 | 20 | 40 | 40 | 40 | 40 | 20 | 40 | 20 | 40 | 1.6 | 0.6 | 0.6 | 0.6 | 0.6 | 1.0 | 0.4 | 0.6 | 0.4 | 0.4 | 2.4 | 0.8 | 0.8 | 0.7 | 1.3 | 1.3 | 0.6 | 0.9 | 0.5 | 0.5 |
| Total foliar cover | | | | | | | | | | | | | | | 66.4 | 71.0 | 75.4 | 81.6 | 62.8 | 79.8 | 62.6 | 69.2 | 73.2 | 83.2 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Total forb cover | | | | | | | | | | | | | | | 12.2 | 8.8 | 5.0 | 3.8 | 5.6 | 6.4 | 6.2 | 4.6 | 8.4 | 6.0 | 18.4 | 12.4 | 6.6 | 4.7 | 8.9 | 8.0 | 9.9 | 6.6 | 11.5 | 7.2 |
| Total native forb cover | | | | | | | | | | | | | | | 7.0 | 3.8 | 5.0 | 3.8 | 5.4 | 5.0 | 5.0 | 3.0 | 6.2 | 3.6 | 10.5 | 5.4 | 6.6 | 4.7 | 8.6 | 6.3 | 8.0 | 4.3 | 8.5 | 4.3 |
| Total non-native forb cover | | | | | | | | | | | | | | | 5.2 | 5.0 | 0.0 | 0.0 | 0.2 | 1.4 | 1.2 | 1.6 | 2.2 | 2.4 | 7.8 | 7.0 | 0.0 | 0.0 | 0.3 | 1.8 | 1.9 | 2.3 | 3.0 | 2.9 |
| Total graminoid cover | | | | | | | | | | | | | | | 54.2 | 62.2 | 70.4 | 77.8 | 57.2 | 73.4 | 56.4 | 64.6 | 64.8 | 77.2 | 81.6 | 87.6 | 93.4 | 95.3 | 91.1 | 92.0 | 90.1 | 93.4 | 88.5 | 92.8 |
| Total native graminoid cover | | | | | | | | | | | | | | | 37.8 | 47.0 | 42.0 | 43.4 | 32.2 | 49.2 | 35.8 | 51.4 | 40.8 | 51.8 | 56.9 | 66.2 | 55.7 | 53.2 | 51.3 | 61.7 | 57.2 | 74.3 | 55.7 | 62.3 |
| Total non-native graminoid cover | | | | | | | | | | | | | | | 16.4 | 15.2 | 28.4 | 34.4 | 25.0 | 24.2 | 20.6 | 13.2 | 24.0 | 25.4 | 24.7 | 21.4 | 37.7 | 42.2 | 39.8 | 30.3 | 32.9 | 19.1 | 32.8 | 30.5 |
| Total native cover | | | | | | | | | | | | | | | 44.8 | 50.6 | 47.0 | 47.2 | 37.6 | 54.2 | 40.8 | 54.4 | 47.0 | 55.4 | 67.5 | 71.5 | 62.3 | 57.8 | 59.9 | 67.9 | 65.2 | 78.6 | 64.2 | 66.6 |
| Total non-native cover | | | | | | | | | | | | | | | 21.6 | 20.2 | 28.4 | 34.4 | 25.2 | 25.6 | 21.8 | 14.6 | 26.2 | 27.8 | 32.5 | 28.5 | 37.7 | 42.2 | 40.1 | 32.1 | 34.8 | 21.4 | 35.8 | 33.4 |
| Total warm-season graminoid cover | | | | | | | | | | | | | | | 36.8 | 45.6 | 41.2 | 42.4 | 31.4 | 48.2 | 34.6 | 49.4 | 37.8 | 48.8 | 55.4 | 64.2 | 54.6 | 52.0 | 50.0 | 60.4 | 55.3 | 71.4 | 51.6 | 58.7 |
| Total cool-season graminoid cover | | | | | | | | | | | | | | | 17.4 | 16.6 | 29.2 | 35.4 | 25.8 | 25.2 | 21.8 | 15.2 | 27.0 | 28.4 | 26.2 | 23.4 | 38.7 | 43.4 | 41.1 | 31.6 | 34.8 | 22.0 | 36.9 | 34.1 |

Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible (500).
Relative cover = Relative foliar cover was the number of hits a species had relative to the total number of all vegetative hits recorded per site (i.e., the percent of vegetative cover the species represented).
All cover values presented are means (n = 5).
Native categories: Y = Native, N = Non-Native
Form categories: C = Cactus, F = Forb, G = Graminoid
Cool/Warm Season categories: C = Cool season species, W = Warm season species

**Table 5-1. Cover Class System**

| Cover Class | Visually Estimated Cover Range | Midpoint |
|---|---|---|
| 1 | <5% | 2.50% |
| 2 | 5-25% | 15.00% |
| 3 | 26-50% | 37.50% |
| 4 | 51-75% | 62.50% |
| 5 | >76% | 87.50% |

**Table 6-1. 2001 *Larinus minutus* Release Numbers By Location**

| SAMPSITE | # Insects Released |
|---|---|
| LM1 | 250 |
| LM2 | 125 |
| LM3 | 100 |
| LM4 | 85 |
| LM5 | 125 |
| LM6 | 1500 |
| Total | 2185 |

**Table 6-2. 2001 Diffuse Knapweed Biocontrol Release Location Monitoring Summary**

| SAMPSITE | Cover (%) | Stem Density (plants/sq. m) |
|---|---|---|
| LM1 | 33.5 | 15.8 |
| LM2 | 19.4 | 14.5 |
| LM3 | 21.6 | 4.4 |
| LM4 | 26.1 | 9.5 |
| LM5 | 6.3 | 1.1 |
| Mean (5 sites combined) | 21.4 | 9.1 |

**Table 7-1. Diffuse Knapweed Location Marking Identifiers**

| SiteID | Paint Color | Flag Color | # of Plant Marked |
|---|---|---|---|
| A | Red | Pink | 88 |
| B | Orange | Orange | 69 |
| C | Blue | Green | 80 |

**Table 7-2. Diffuse Knapweed Movement Summary By Date**

| Site | Original number of marked plants October 2000 | November 2000 | January 2001 | March 2001 | April 2001 |
|---|---|---|---|---|---|
| Site A | 88 | 3/3 | 31/35 | 35/40 | 40/45 |
| Site B | 69 | 9/13 | 26/38 | 28/41 | 36/52 |
| Site C | 80 | 9/11 | 45/56 | 48/60 | 56/70 |
| Mean (all plots) | 237 | 21/9 | 102/43 | 111/47 | 132/56 |
| % Movement between time periods (all plots) | NA | 9 | 34 | 4 | 9 |

x/y = # of plants blown away/%of plants blown away

**Table 7-3. Diffuse Knapweed Movement Summary**

| | Distance Moved (meters [feet]) | |
|---|---|---|
| **Site** | **Mean** | **Maximum** |
| Plot A | 389 (1276) | 1209 (3965) |
| Plot B | 458 (1501) | 1120 (3676) |
| Plot C | 334 (1096) | 1480 (4857) |
| All Sites | 399 (1310) | 1480 (4857) |

**Table 7-4. Estimates of Diffuse Knapweed Movement at Rocky Flats**

| | |
|---|---|
| 2000 Data<br>Initial Assumptions | |
| Total acres of high and medium categories of diffuse knapweed<br>(Based on the 2000 Site-wide weed mapping effort. Used only high and medium categories since these are quite dense infestations. In the low and scattered categories plants are more spread out.) | 1041 acres |
| Adult diffuse knapweed density in high and medium categories<br>(Used a conservative estimate of 1 plant/ $m^2$. This area was previously mapped as high and medium categories. It has had from 4 to 7 plants/$m^2$ each of the last 4 summers based on quantative studies. I have chosen to use a conservative estimate of 1 adult plant/ $m^2$ for this estimation.) | 1 plant/$m^2$ |
| Total number of square meters per acre | 4047 $m^2$/acre |
| Total number of plants in high and medium categories in 2000<br>(Based on above assumptions.) | 4,212,927 plants |
| Estimate of the number of plants that blew away in winter 2000-2001<br>(Based on 56% of plants observed to have moved on Site during this study) | 2,359,239 plants |
| Average distance moved by plants in winter 2000-2001 | 399 m (1310 feet) |
| Maximum distance moved by plants in winter 2000-2001 | 1480 m (4857 feet) |

2000 source data (K-H 2001).

**Table 8-1. Small Mammal Mound Species Richness Summary**

| Plot Type | Total # Species | Percent Native | Mean # Species | Shannon-Weaver Diversity Index |
|---|---|---|---|---|
| TA | 61 | 74 | 10.7 | 1.075 |
| TI | 58 | 76 | 13.1 | 1.095 |
| TN | 69 | 72 | 13.6 | 1.224 |
| UA | 75 | 69 | 15 | 1.277 |
| UI | 62 | 76 | 14.9 | 1.128 |
| UN | 73 | 71 | 16.6 | 1.274 |

TA = treated active mound, TI = treated intermound, TN = treated not active mound
UA = untreated active mound, UI = untreated intermound, UN = untreated not active mound

**Table 8-2. Sorensen Coefficient of Similarity Summary**

| Comparison | Similarity Coefficient |
|---|---|
| UI - UA | 0.66 |
| UI - UN | 0.73 |
| UI - TA | 0.60 |
| UI - TI | 0.83 |
| UI - TN | 0.75 |

TA = treated active mound, TI = treated intermound, TN = treated not active mound
UA = untreated active mound, UI = untreated intermound, UN = untreated not active mound

**Table 8-3. Small Mammal Mound Species Frequency and Cover Summary**

| Scientific Name | Speccode | Growth Form | Native | Cool/Warm Season | Frequency (%) | | | | | | Relative Cover (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | TA | TI | TN | UA | UI | UN | TA | TI | TN | UA | UI | UN |
| Coryphantha missouriensis (Sweet) Britt. & Rose | COMI1 | C | Y | | 3.3 | | | | | | 0.1 | | | | | |
| Echinocereus viridiflorus Engelm. | ECVI1 | C | Y | | 10.0 | 10.0 | 10.0 | 20.0 | 16.7 | 13.3 | 0.2 | 0.3 | 0.2 | 0.4 | 0.4 | 0.2 |
| Opuntia macrorhiza Engelm. | OPMA1 | C | Y | | 30.0 | 30.0 | 43.3 | 80.0 | 50.0 | 56.7 | 0.7 | 0.7 | 1.1 | 1.8 | 1.2 | 1.1 |
| Alyssum alyssoides (L.) L. | ALAL1 | F | N | | | | | | | 3.3 | | | | | | 0.1 |
| Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | F | N | | 16.7 | | 10.0 | 33.3 | 3.3 | 20.0 | 1.3 | | 1.0 | 1.1 | 0.1 | 0.7 |
| Arabis glabra (L.) Bernh. | ARGL1 | F | N | | | | | 3.3 | | | | | | 0.1 | | |
| Camelina microcarpa Andrz. ex DC. | CAMI1 | F | N | | 16.7 | 3.3 | 40.0 | 16.7 | 10.0 | 23.3 | 0.4 | 0.1 | 0.9 | 0.4 | 0.2 | 0.5 |
| Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | CANU1 | F | N | | | | | 10.0 | | 3.3 | | | | 0.2 | | 0.1 |
| Centaurea diffusa Lam. | CEDI1 | F | N | | 33.3 | 16.7 | 30.0 | 86.7 | 33.3 | 90.0 | 0.9 | 0.4 | 1.0 | 11.5 | 0.8 | 18.5 |
| Cirsium arvense (L.) Scop. | CIAR1 | F | N | | 13.3 | | 6.7 | 20.0 | | 6.7 | 0.7 | | 0.1 | 0.4 | | 0.1 |
| Cirsium vulgare (Savi) Ten. | CIVU1 | F | N | | | | 3.3 | | | | | | 0.1 | | | |
| Convolvulus arvensis L. | COAR1 | F | N | | 3.3 | 3.3 | 6.7 | | | 10.0 | 0.1 | 0.1 | 0.6 | | | 0.2 |
| Cynoglossum officinale L. | CYOF1 | F | N | | | | | 3.3 | | | | | | 0.1 | | |
| Erodium cicutarium (L.) L'Her. | ERCI1 | F | N | | | | 3.3 | 3.3 | | 10.0 | | | 0.1 | 0.1 | | 0.2 |
| Hypericum perforatum L. | HYPE1 | F | N | | | 10.0 | | 6.7 | 16.7 | 6.7 | | 0.3 | | 0.1 | 0.4 | 0.1 |
| Lactuca serriola L. | LASE1 | F | N | | 30.0 | 6.7 | 23.3 | 66.7 | 20.0 | 76.7 | 0.6 | 0.2 | 0.8 | 2.8 | 0.5 | 2.7 |
| Lepidium campestre (L.) R. Br. | LECA1 | F | N | | | | 3.3 | 3.3 | 3.3 | | | | 0.5 | 0.1 | 0.1 | |
| Linaria dalmatica (L.) Mill. | LIDA1 | F | N | | 16.7 | | 23.3 | 46.7 | 13.3 | 63.3 | 0.8 | | 0.5 | 1.9 | 0.3 | 2.7 |
| Rumex acetosella L. | RUAC1 | F | N | | | 3.3 | | | | | | 0.1 | | | | |
| Rumex crispus L. | RUCR1 | F | N | | | | | 6.7 | | 3.3 | | | | 0.2 | | 0.1 |
| Scorzonera laciniata L. | SCLA1 | F | N | | | | | 3.3 | | 13.3 | | | | 0.1 | | 0.3 |
| Sisymbrium altissimum L. | SIAL1 | F | N | | 23.3 | 3.3 | 16.7 | 10.0 | | | 1.1 | 0.1 | 0.4 | 0.2 | | |
| Taraxacum officinale Weber | TAOF1 | F | N | | | 3.3 | 3.3 | 13.3 | 3.3 | 26.7 | | 0.1 | 0.1 | 0.3 | 0.1 | 0.6 |
| Tragopogon dubius Scop. | TRDU1 | F | N | | 33.3 | 13.3 | 30.0 | 40.0 | 26.7 | 53.3 | 0.7 | 0.3 | 0.7 | 0.9 | 0.6 | 1.1 |
| Verbascum blattaria L. | VEBL1 | F | N | | 3.3 | 3.3 | 6.7 | 6.7 | 3.3 | 3.3 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 |
| Verbascum thapsus L. | VETH1 | F | N | | | | 6.7 | 13.3 | 3.3 | 3.3 | | | 0.5 | 0.7 | 0.1 | 0.1 |
| Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | F | Y | | | | 3.3 | | 3.3 | | | | 0.1 | | 0.1 | |
| Allium textile A. Nels. & Macbr. | ALTE1 | F | Y | | | 6.7 | 6.7 | 3.3 | 13.3 | 10.0 | | 0.1 | 0.1 | 0.1 | 0.3 | 0.2 |
| Ambrosia psilostachya DC. | AMPS1 | F | Y | | 13.3 | 30.0 | 23.3 | 46.7 | 43.3 | 56.7 | 0.8 | 0.7 | 0.5 | 1.4 | 1.7 | 1.1 |
| Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | ARHI1 | F | Y | | | 16.7 | 3.3 | | 16.7 | 6.7 | | 0.4 | 0.1 | | 0.4 | 0.2 |
| Arenaria fendleri A. Gray | ARFE2 | F | Y | | | 33.3 | 26.7 | | 60.0 | 6.7 | | 0.8 | 0.6 | | 1.4 | 0.1 |
| Arnica fulgens Pursh. | ARFU1 | F | Y | | | | | | 3.3 | | | | | | 0.1 | |
| Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | ARCA1 | F | Y | | | | | 10.0 | | 13.3 | | | | 0.2 | | 0.3 |
| Artemisia dracunculus L. | ARDR1 | F | Y | | 3.3 | | | 6.7 | | 3.3 | 0.1 | | | 0.1 | | 0.1 |
| Artemisia frigida Willd. | ARFR1 | F | Y | | 3.3 | | 6.7 | 23.3 | | 30.0 | 0.1 | | 0.1 | 0.9 | | 0.9 |
| Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | F | Y | | 13.3 | 6.7 | 10.0 | 20.0 | 26.7 | 10.0 | 1.1 | 0.2 | 0.2 | 0.9 | 1.3 | 0.5 |
| Asclepias speciosa Torr. | ASSP1 | F | Y | | 6.7 | 3.3 | | 3.3 | | | 0.6 | 0.1 | | 0.4 | | |
| Aster falcatus Lindl. | ASFA1 | F | Y | | | | | | 3.3 | | | | | | 0.1 | |
| Aster porteri Gray | ASPO1 | F | Y | | | 13.3 | | 3.3 | 3.3 | 10.0 | | 0.3 | | 0.1 | 0.1 | 0.2 |
| Astragalus agrestis Dougl. ex G. Don | ASAG1 | F | Y | | | | 3.3 | | 6.7 | | | | 0.1 | | 0.2 | |
| Castilleja sessiliflora Pursh. | CASE3 | F | Y | | | | | | | 3.3 | | | | | | 0.1 |
| Chenopodium leptophyllum Nutt. ex Moq. | CHLE2 | F | Y | | 6.7 | | | 10.0 | | | 0.1 | | | 0.2 | | |
| Chrysopsis fulcrata Greene | CHFU1 | F | Y | | | 3.3 | | | 3.3 | 3.3 | | 0.1 | | | 0.1 | 0.1 |
| Chrysopsis villosa Pursh. | CHVI1 | F | Y | | | | 3.3 | 10.0 | | 16.7 | | | 0.9 | 0.2 | | 0.4 |
| Cirsium undulatum (Nutt.) Spreng. | CIUN1 | F | Y | | | | | 3.3 | | | | | | 0.1 | | |
| Conyza canadensis (L.) Cronq. | COCA1 | F | Y | | | 6.7 | 16.7 | 6.7 | 6.7 | | | 0.1 | 0.4 | 0.1 | 0.2 | |
| Dalea candida Michx. ex Willd. var. oligophylla (Torr.) Shinners. | DACA1 | F | Y | | | | | | | 6.7 | | | | | | 0.1 |
| Dalea purpurea Vent | DAPU1 | F | Y | | 13.3 | 13.3 | 30.0 | 20.0 | 16.7 | 26.7 | 0.3 | 0.3 | 0.7 | 0.5 | 0.4 | 0.6 |

Table 8-3. (cont.)

| Scientific Name | Speccode | Growth Form | Native | Cool/Warm Season | Frequency | | | | | | Relative Cover | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | TA | TI | TN | UA | UI | UN | TA | TI | TN | UA | UI | UN |
| Delphinium nuttalianum Pritz. ex Walpers | DENU1 | F | Y | | | | | | | 3.3 | | | | | | 0.1 |
| Descurainia pinnata (Walt.) Britt. | DEPI1 | F | Y | | 3.3 | | 6.7 | 3.3 | | | 0.4 | | 0.1 | 0.1 | | |
| Draba reptans (Lam.) Fern. | DRRE1 | F | Y | | 3.3 | 20.0 | 6.7 | 3.3 | 13.3 | 6.7 | 0.1 | 0.5 | 0.2 | 0.1 | 0.3 | 0.1 |
| Erigeron divergens T. & G. | ERDI1 | F | Y | | 3.3 | | 3.3 | 6.7 | | 20.0 | 0.1 | | 0.1 | 0.2 | | 0.4 |
| Eriogonum alatum Torr. | ERAL1 | F | Y | | | 3.3 | 10.0 | 3.3 | 10.0 | 10.0 | | 0.1 | 0.2 | 0.1 | 0.2 | 0.2 |
| Erysimum capitatum (Nutt.) DC. | ERCA2 | F | Y | | | 3.3 | 3.3 | 6.7 | 13.3 | 3.3 | | 0.1 | 0.1 | 0.1 | 0.3 | 0.1 |
| Evolvulus nuttallianus R. & S. | EVNU1 | F | Y | | | | 3.3 | | | | | | 0.1 | | | |
| Gaillardia aristata Pursh. | GAAR1 | F | Y | | 10.0 | 16.7 | 13.3 | 13.3 | 33.3 | 6.7 | 0.2 | 0.4 | 0.3 | 0.3 | 0.7 | 0.2 |
| Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | F | Y | | | 6.7 | 3.3 | 6.7 | 3.3 | 3.3 | | 0.2 | 0.1 | 0.2 | 0.1 | 0.1 |
| Helianthus petiolaris Nutt. | HEPE1 | F | Y | | 6.7 | | | | | | 0.2 | | | | | |
| Lappula redowskii (Hornem.) Greene | LARE1 | F | Y | | | | 3.3 | 3.3 | | | | | 0.1 | 0.1 | | |
| Lepidium densiflorum Schrad. | LEDE1 | F | Y | | 13.3 | | | | | 3.3 | 0.3 | | | | | 0.1 |
| Lesquerella montana (A. Gray) Wats. | LEMO1 | F | Y | | 3.3 | 33.3 | 20.0 | 13.3 | 20.0 | 10.0 | 0.1 | 0.8 | 0.5 | 0.3 | 0.5 | 0.2 |
| Liatris punctata Hook. | LIPU1 | F | Y | | 6.7 | 40.0 | 23.3 | | 46.7 | 20.0 | 0.1 | 1.3 | 0.5 | | 1.0 | 0.4 |
| Lithospermum incisum Lehm. | LIIN1 | F | Y | | | | | 3.3 | | | | | | 0.1 | | |
| Lomatium orientale Coult. & Rose | LOOR1 | F | Y | | 6.7 | 23.3 | 10.0 | | 20.0 | 36.7 | 0.2 | 0.5 | 0.2 | | 0.5 | 0.7 |
| Mertensia lanceolata (Pursh.) A. DC. | MELA1 | F | Y | | 3.3 | | | 3.3 | | | 0.0 | | | 0.1 | | |
| Microseris cuspidata (Pursh.) Sch. Bip. | MICU1 | F | Y | | | | 3.3 | | | | | | 0.1 | | | |
| Mirabilis linearis (Pursh.) Heimerl | MILI1 | F | Y | | 3.3 | | 3.3 | 3.3 | | | 0.1 | | 0.1 | 0.1 | | |
| Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven | OEVI1 | F | Y | | 6.7 | 6.7 | 10.0 | 6.7 | 3.3 | | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | |
| Orobanche fasciculata Nutt. | ORFA1 | F | Y | | | | | | | 10.0 | | | | | | 0.2 |
| Oxytropis lambertii Pursh. | OXLA1 | F | Y | | | | | | | 3.3 | | | | | | 0.1 |
| Paronychia jamesii T. & G. | PAJA1 | F | Y | | | 6.7 | | | 10.0 | 3.3 | | 0.2 | | | 0.2 | 0.1 |
| Penstemon virens Penn. | PEVI1 | F | Y | | 13.3 | 6.7 | 16.7 | 16.7 | | 23.3 | 0.3 | 0.1 | 0.4 | 0.4 | | 0.5 |
| Phacelia heterophylla Pursh. | PHHE1 | F | Y | | 3.3 | | | 3.3 | | | 0.0 | | | 0.1 | | |
| Physalis virginiana P. Mill. | PHVI2 | F | Y | | 3.3 | | 6.7 | 13.3 | | | 0.1 | | 0.5 | 0.6 | | |
| Plantago patagonica Jacq. | PLPA1 | F | Y | | | | 13.3 | 6.7 | | 6.7 | | | 0.3 | 0.1 | | 0.2 |
| Polygonum ramosissimum Michx. | PORA1 | F | Y | | 3.3 | 10.0 | 3.3 | 6.7 | | | 0.1 | 0.2 | 0.1 | 0.2 | | |
| Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc. | POGR1 | F | Y | | | 3.3 | | | | | | 0.1 | | | | |
| Potentilla hippiana Lehm. | POHI1 | F | Y | | 3.3 | 10.0 | 3.3 | | 3.3 | | 0.5 | 1.5 | 0.1 | | 0.5 | |
| Potentilla pensylvanica L. | POPE4 | F | Y | | | | | 3.3 | | | | | | 0.1 | | |
| Psoralea tenuiflora Pursh. | PSTE1 | F | Y | | 50.0 | 43.3 | 60.0 | 53.3 | 43.3 | 70.0 | 1.1 | 1.1 | 1.9 | 2.3 | 1.3 | 2.1 |
| Ratibida columnifera (Nutt.) Woot. & Standl. | RACO1 | F | Y | | | | 10.0 | 13.3 | 3.3 | 13.3 | | | 0.2 | 0.3 | 0.1 | 0.3 |
| Senecio plattensis Nutt. | SEPL1 | F | Y | | 3.3 | | | 6.7 | 3.3 | 3.3 | 0.1 | | | 0.2 | 0.1 | 0.1 |
| Senecio spartioides T. & G. | SESP1 | F | Y | | | | 6.7 | 6.7 | | 3.3 | | | 0.1 | 0.1 | | 0.1 |
| Silene antirrhina L. | SIAN1 | F | Y | | 36.7 | 10.0 | 60.0 | 53.3 | 6.7 | 50.0 | 0.8 | 0.2 | 1.4 | 1.2 | 0.2 | 1.0 |
| Silene drummondii Hook. | SIDR1 | F | Y | | 3.3 | 3.3 | 10.0 | | | | 0.1 | 0.1 | 0.2 | | | |
| Solidago mollis Bart. | SOMO1 | F | Y | | | | | | 6.7 | | | | | | 0.2 | |
| Talinum parviflorum Nutt. | TAPA1 | F | Y | | | 3.3 | | | 6.7 | | | 0.1 | | | 0.1 | |
| Tradescantia occidentalis (Britt.) Smyth | TROC1 | F | Y | | 3.3 | | | | | | 0.1 | | | | | |
| Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | F | Y | | | 13.3 | | | 3.3 | | | 0.3 | | | 0.1 | |
| Viola nuttallii Pursh. | VINU1 | F | Y | | | | | 3.3 | | 3.3 | | | | 0.1 | | 0.1 |
| Aegilops cylindrica Host | AECY1 | G | N | C | 3.3 | | | | | | 0.1 | | | | | |
| Bromus inermis Leyss. ssp. inermis | BRIN1 | G | N | C | 3.3 | | | | | | 0.5 | | | | | |
| Bromus japonicus Thunb. ex Murr. | BRJA1 | G | N | C | 6.7 | 26.7 | 33.3 | 46.7 | 30.0 | 63.3 | 0.1 | 0.6 | 1.1 | 1.3 | 0.7 | 1.3 |
| Bromus tectorum L. | BRTE1 | G | N | C | 90.0 | 13.3 | 73.3 | 93.3 | 13.3 | 90.0 | 35.5 | 0.3 | 13.4 | 22.8 | 0.3 | 14.3 |
| Poa compressa L. | POCO1 | G | N | C | 46.7 | 93.3 | 86.7 | 56.7 | 96.7 | 70.0 | 8.3 | 37.3 | 28.1 | 7.9 | 39.2 | 13.2 |

Table 8-3. (cont.)

| Scientific Name | Speccode | Growth Form | Native | Cool/Warm Season | Frequency | | | | | | Relative Cover | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | TA | TI | TN | UA | UI | UN | TA | TI | TN | UA | UI | UN |
| Poa pratensis L. | POPR1 | G | N | C | 73.3 | 60.0 | 60.0 | 70.0 | 76.7 | 63.3 | 17.4 | 11.1 | 8.4 | 9.2 | 12.2 | 8.0 |
| Agropyron smithii Rydb. | AGSM1 | G | Y | C | 6.7 | | 6.7 | 10.0 | | 6.7 | 0.9 | | 1.2 | 1.0 | | 0.5 |
| Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | G | Y | C | 10.0 | 13.3 | 13.3 | 13.3 | 30.0 | 13.3 | 0.2 | 0.3 | 0.3 | 0.3 | 1.4 | 0.3 |
| Carex heliophila Mack. | CAHE1 | G | Y | C | 73.3 | 70.0 | 70.0 | 73.3 | 60.0 | 83.3 | 4.6 | 1.7 | 3.5 | 11.7 | 1.3 | 8.0 |
| Juncus interior Wieg. | JUIN1 | G | Y | C | | 23.3 | | | 13.3 | 3.3 | | 0.6 | | | 0.3 | 0.1 |
| Koeleria pyramidata (Lam.) Beauv. | KOPY1 | G | Y | C | 20.0 | 70.0 | 33.3 | 10.0 | 80.0 | 30.0 | 0.4 | 2.1 | 0.8 | 0.2 | 2.9 | 0.7 |
| Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | G | Y | C | 36.7 | 33.3 | 33.3 | 36.7 | 26.7 | 16.7 | 0.8 | 0.8 | 1.2 | 1.2 | 0.6 | 0.7 |
| Stipa comata Trin. & Rupr. | STCO1 | G | Y | C | 66.7 | 33.3 | 76.7 | 63.3 | 46.7 | 76.7 | 8.5 | 3.2 | 12.7 | 5.1 | 2.8 | 7.1 |
| Andropogon gerardii Vitman | ANGE1 | G | Y | W | 30.0 | 66.7 | 20.0 | 13.3 | 83.3 | 13.3 | 3.0 | 10.6 | 2.1 | 0.6 | 8.0 | 1.0 |
| Andropogon scoparius Michx. | ANSC1 | G | Y | W | 3.3 | 36.7 | 13.3 | 10.0 | 36.7 | 10.0 | 0.1 | 0.9 | 0.3 | 0.2 | 0.9 | 0.2 |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | G | Y | W | 53.3 | 53.3 | 56.7 | 23.3 | 63.3 | 46.7 | 2.4 | 1.3 | 3.9 | 1.1 | 2.2 | 2.1 |
| Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | G | Y | W | 40.0 | 56.7 | 46.7 | 40.0 | 60.0 | 40.0 | 0.9 | 1.4 | 1.6 | 0.9 | 1.4 | 0.8 |
| Bouteloua hirsuta Lag | BOHI1 | G | Y | W | 6.7 | 43.3 | 16.7 | 16.7 | 20.0 | 23.3 | 0.1 | 1.1 | 1.2 | 0.3 | 0.5 | 0.5 |
| Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | G | Y | W | | | | | 10.0 | | | | | | 0.3 | |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | G | Y | W | | 70.0 | 3.3 | | 46.7 | | | 8.9 | 0.1 | | 5.3 | |
| Sorghastrum nutans (L.) Nash | SONU1 | G | Y | W | 6.7 | 43.3 | | 3.3 | 36.7 | 3.3 | 0.9 | 4.1 | | 0.1 | 2.4 | 0.1 |
| Sporobolus asper (Michx.) Kunth | SPAS1 | G | Y | W | 6.7 | | | | | 3.3 | 0.1 | | | | | 0.1 |
| Total foliar cover | | | | | | | | | | | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Total forb cover | | | | | | | | | | | 14.39 | 12.66 | 19.04 | 33.78 | 15.75 | 39.75 |
| Total native forb cover | | | | | | | | | | | 7.81 | 11.08 | 11.62 | 12.42 | 12.62 | 11.74 |
| Total non-native forb cover | | | | | | | | | | | 6.57 | 1.58 | 7.42 | 21.36 | 3.12 | 28.01 |
| Total graminoid cover | | | | | | | | | | | 84.69 | 86.34 | 79.68 | 63.94 | 82.64 | 58.88 |
| Total native graminoid cover | | | | | | | | | | | 22.89 | 36.99 | 28.75 | 22.78 | 30.25 | 22.11 |
| Total non-native graminoid cover | | | | | | | | | | | 61.80 | 49.36 | 50.92 | 41.16 | 52.39 | 36.77 |
| Total native cover | | | | | | | | | | | 31.62 | 49.06 | 41.66 | 37.48 | 44.49 | 35.22 |
| Total non-native cover | | | | | | | | | | | 68.38 | 50.94 | 58.34 | 62.52 | 55.51 | 64.78 |
| Total warm-season graminoid cover | | | | | | | | | | | 7.48 | 28.29 | 9.13 | 3.28 | 20.97 | 4.82 |
| Total cool-season graminoid cover | | | | | | | | | | | 77.21 | 58.05 | 70.54 | 60.67 | 61.67 | 54.06 |
| Total cactus cover | | | | | | | | | | | 0.93 | 1.00 | 1.28 | 2.28 | 1.62 | 1.37 |

Frequency = The percentage of plots a species occurred in (n = 30).
Relative cover = Relative foliar cover is the cover a species had relative to the total cover of all vegetation (i.e., the percent of vegetative cover the species represented).
All cover values presented are means (n = 30).
Native categories: Y = Native, N = Non-Native
Form categories: C = Cactus, F = Forb, G = Graminoid
Cool/Warm Season categories: C = Cool season species, W = Warm season species
TA = treated active, TI = treated intermound, TN = treated not active, UA = untreated active, UI = untreated intermound, UN = untreated not active.

**Table 8-4. Small Mammal Mound Dominant Species by Mound Classification**

**UN - Untreated Non-Active Mounds**

| Scientific Name | Speccode | Relative Cover |
|---|---|---|
| Centaurea diffusa Lam. | CEDI1 | 18.5 |
| Bromus tectorum L. | BRTE1 | 14.3 |
| Poa compressa L. | POCO1 | 13.2 |
| Poa pratensis L. | POPR1 | 8.0 |

**UI - Untreated Intermound Areas**

| Scientific Name | Speccode | Relative Cover |
|---|---|---|
| Poa compressa L. | POCO1 | 39.2 |
| Poa pratensis L. | POPR1 | 12.2 |
| Andropogon gerardii Vitman | ANGE1 | 8.0 |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | 5.3 |

**UA - Untreated Active Mounds**

| Scientific Name | Speccode | Relative Cover |
|---|---|---|
| Bromus tectorum L. | BRTE1 | 22.8 |
| Carex heliophila Mack. | CAHE1 | 11.7 |
| Centaurea diffusa Lam. | CEDI1 | 11.5 |
| Poa pratensis L. | POPR1 | 9.2 |

**TN - Treated Non-Active Mounds**

| Scientific Name | Speccode | Relative Cover |
|---|---|---|
| Poa compressa L. | POCO1 | 28.1 |
| Bromus tectorum L. | BRTE1 | 13.4 |
| Stipa comata Trin. & Rupr. | STCO1 | 12.7 |
| Poa pratensis L. | POPR1 | 8.4 |

**TI - Treated Intermound Areas**

| Scientific Name | Speccode | Relative Cover |
|---|---|---|
| Poa compressa L. | POCO1 | 37.3 |
| Poa pratensis L. | POPR1 | 11.1 |
| Andropogon gerardii Vitman | ANGE1 | 10.6 |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | 8.9 |

**TA - Treated Active Mounds**

| Scientific Name | Speccode | Relative Cover |
|---|---|---|
| Bromus tectorum L. | BRTE1 | 35.5 |
| Poa pratensis L. | POPR1 | 17.4 |
| Stipa comata Trin. & Rupr. | STCO1 | 8.5 |
| Poa compressa L. | POCO1 | 8.3 |

**Table 8-5. Small Mammal Mound Study Species Affinities For Disturbed And Undisturbed Areas**

**Species with Affinities for Undisturbed Areas**

| Scientific Name | Speccode | Growth Form | Native | Cool/Warm Season |
|---|---|---|---|---|
| Andropogon gerardii Vitman | ANGE1 | G | Y | W |
| Andropogon scoparius Michx. | ANSC1 | G | Y | W |
| Arenaria fendleri A. Gray | ARFE2 | F | Y | |
| Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | G | Y | C |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | G | Y | W |
| Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | G | Y | W |
| Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | G | Y | W |
| Gaillardia aristata Pursh. | GAAR1 | F | Y | |
| Hypericum perforatum L. | HYPE1 | F | N | |
| Juncus interior Wieg. | JUIN1 | G | Y | C |
| Koeleria pyramidata (Lam.) Beauv. | KOPY1 | G | Y | C |
| Liatris punctata Hook. | LIPU1 | F | Y | |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | G | Y | W |
| Poa compressa L. | POCO1 | G | N | C |
| Sorghastrum nutans (L.) Nash | SONU1 | G | Y | W |

**Species with Affinities for Disturbed Areas**

| Scientific Name | Speccode | Growth Form | Native | Cool/Warm Season |
|---|---|---|---|---|
| Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | F | N | |
| Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | ARCA1 | F | Y | |
| Artemisia frigida Willd. | ARFR1 | F | Y | |
| Bromus japonicus Thunb. ex Murr. | BRJA1 | G | N | C |
| Bromus tectorum L. | BRTE1 | G | N | C |
| Carex heliophila Mack. | CAHE1 | G | Y | C |
| Centaurea diffusa Lam. | CEDI1 | F | N | |
| Chrysopsis villosa Pursh. | CHVI1 | F | Y | |
| Lactuca serriola L. | LASE1 | F | N | |
| Linaria dalmatica (L.) Mill. | LIDA1 | F | N | |
| Penstemon virens Penn. | PEVI1 | F | Y | |
| Psoralea tenuiflora Pursh. | PSTE1 | F | Y | |
| Ratibida columnifera (Nutt.) Woot. & Standl. | RACO1 | F | Y | |
| Silene antirrhina L. | SIAN1 | F | Y | |
| Stipa comata Trin. & Rupr. | STCO1 | G | Y | C |
| Taraxacum officinale Weber | TAOF1 | F | N | |
| Tragopogon dubius Scop. | TRDU1 | F | N | |

Native categories: Y = Native, N = Non-Native
Form categories: C = Cactus, F = Forb, G = Graminoid
Cool/Warm Season categories: C = Cool season species, W = Warm season species

**Table 9-1. Seed Mix for Landfill Cover**

| Scientific Name | Common Name | Application Rate (PLS lbs/ac) |
|---|---|---|
| *Agropyron smithii* | Western Wheatgrass | 12.0 |
| *Bouteloua gracilis* | Blue Grama Grass | 8.0 |
| *Buchloe dactlyoides* | Buffalo Grass | 8.0 |
| *Andropogon gerardii* | Big Bluestem | 8.0 |
| *Bouteloua curtipendula* | Side-Oats Grama Grass | 8.0 |
| *Andropogon scoparius* | Little Bluestem | 8.0 |
| *Linum perenne* | Blue Flax | 4.0 |
| Total PLS per acre application | | 56.0 |

PLS = pure live seed

**Table 9-2. 2001 Landfill Revegetation Cover Summary**

| Scientific Name | Speccode | Growth Form | Native | Cool/ Warm Season | Frequency | Percent Absolute Cover | Percent Relative Cover |
|---|---|---|---|---|---|---|---|
| Centaurea diffusa Lam. | CEDI1 | F | N | | 40 | 1.2 | 1.7 |
| Dyssodia papposa (Vent) Hitchc. | DYPA1 | F | N | | 20 | 0.2 | 0.3 |
| Melilotus alba Medic. | MEAL1 | F | N | | 20 | 0.2 | 0.3 |
| Melilotus officinalis (L.) Pall. | MEOF1 | F | N | | 60 | 1.8 | 2.5 |
| Plantago lanceolata L. | PLLA1 | F | N | | 20 | 0.2 | 0.3 |
| Ambrosia psilostachya DC. | AMPS1 | F | Y | | 100 | 1.4 | 2.0 |
| Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | F | Y | | 40 | 0.6 | 0.8 |
| Helianthus annuus L. | HEAN1 | F | Y | | 40 | 0.4 | 0.6 |
| Bromus japonicus Thunb. ex Murr. | BRJA1 | G | N | C | 20 | 1.2 | 1.7 |
| Bromus tectorum L. | BRTE1 | G | N | C | 60 | 1.6 | 2.2 |
| Dactylis glomerata L. | DAGL1 | G | N | C | 20 | 0.2 | 0.3 |
| Schedonnardus paniculatus (Nutt.) Trel. | SCPA2 | G | N | C | 20 | 0.4 | 0.6 |
| Echinochloa crusgallii (L.) Beauv. | ECCR1 | G | N | W | 20 | 0.2 | 0.3 |
| Setaria viridis (L.) Beauv. | SEVI1 | G | N | W | 40 | 0.8 | 1.1 |
| Agropyron smithii Rydb. | AGSM1 | G | Y | C | 100 | 9 | 12.6 |
| Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | G | Y | C | 20 | 0.2 | 0.3 |
| Andropogon gerardii Vitman | ANGE1 | G | Y | W | 60 | 1 | 1.4 |
| Andropogon scoparius Michx. | ANSC1 | G | Y | W | 40 | 0.4 | 0.6 |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | G | Y | W | 100 | 6 | 8.4 |
| Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | G | Y | W | 100 | 33.2 | 46.6 |
| Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | G | Y | W | 100 | 7 | 9.8 |
| Panicum capillare L. | PACA1 | G | Y | W | 40 | 0.8 | 1.1 |
| Panicum virgatum L. | PAVI1 | G | Y | W | 40 | 0.4 | 0.6 |
| Sporobolus asper (Michx.) Kunth | SPAS1 | G | Y | W | 40 | 1.4 | 2.0 |
| Sporobolus neglectus Nash | SPNE1 | G | Y | W | 40 | 1.4 | 2.0 |
| Total foliar cover | | | | | | 71.2 | 100.0 |
| Total forb cover | | | | | | 6 | 8.4 |
| Total native forb cover | | | | | | 2.4 | 3.4 |
| Total non-native forb cover | | | | | | 3.6 | 5.1 |
| Total graminoid cover | | | | | | 65.2 | 91.6 |
| Total native graminoid cover | | | | | | 60.8 | 85.4 |
| Total non-native graminoid cover | | | | | | 4.4 | 6.2 |
| Total native cover | | | | | | 63.2 | 88.8 |
| Total non-native cover | | | | | | 8 | 11.2 |
| Total warm-season graminoid cover | | | | | | 52.6 | 73.9 |
| Total cool-season graminoid cover | | | | | | 12.6 | 17.7 |

Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible (500).
Relative cover = Relative foliar cover was the number of hits a species had relative to the total number of all vegetative hits recorded per site (i.e., the percent of vegetative cover the species represented).
All cover values presented are means (n = 5).
Native categories: Y = Native, N = Non-Native
Form categories: C = Cactus, F = Forb, G = Graminoid
Cool/Warm Season categories: C = Cool season species, W = Warm season species

**Table 9-3. Reference Root Depths**

| Common Name | Max. Depth (in feet) | Working Depth (in feet) | Lateral Spread (in feet) |
|---|---|---|---|
| | | | |
| Little Bluestem | 3.5-8.0 | 3.0-6.7 | 1.2-3.0 |
| Blue Grama | 2.3-4.3 | 1.7-3.6 | 0.3-2.1 |
| Buffalo Grass | 4.5-7.2 | 3.0-5.0 | 0.8-1.7 |
| Big Bluestem | 9.3 | 5 | 0.7-1.2 |
| Side-Oats Grama | 5.5 | 4.0-4.5 | 0.7-1.5 |

Information source: Weaver, J.E. 1920. Root development in the grassland formation: A correlation of the root systems of native vegetation and crop plants. Carnegie Institution of Washington. Washington, DC.
Note: These data represent the range of values found for these species under varying soil and other environmental conditions.

**Table 10-1. 1999-2001 Prescibed Burn Species Richness Summary**

| | | | | Unburned | | | Burned | | |
|---|---|---|---|---|---|---|---|---|---|
| **Family** | **Scientific Name** | **Speccode** | **Native** | **1999** | **2000** | **2001** | **1999** | **2000** | **2001** |
| ANACARDIACEAE | Rhus aromatica Ait. var. trilobata (Nutt.) A. Gray | RHAR1 | Y | X | X | X | | | |
| APIACEAE | Lomatium orientale Coult. & Rose | LOOR1 | Y | X | | X | X | | X |
| ASCLEPIADACEAE | Asclepias speciosa Torr. | ASSP1 | Y | | | | X | X | X |
| ASCLEPIADACEAE | Asclepias stenophylla A. Gray | ASST1 | Y | X | X | X | X | X | X |
| ASCLEPIADACEAE | Asclepias viridiflora Raf. | ASVI1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | Y | X | X | X | | | |
| ASTERACEAE | Ambrosia psilostachya DC. | AMPS1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Antennaria parvifolia Nutt. | ANPA1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | ARCA1 | Y | | | X | X | X | X |
| ASTERACEAE | Artemisia frigida Willd. | ARFR1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Aster porteri Gray | ASPO1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | CANU1 | N | | | | | X | X |
| ASTERACEAE | Centaurea diffusa Lam. | CEDI1 | N | X | X | X | X | X | X |
| ASTERACEAE | Chrysopsis fulcrata Greene | CHFU1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Chrysopsis villosa Pursh. | CHVI1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Cirsium undulatum (Nutt.) Spreng. | CIUN1 | Y | | | | X | X | X |
| ASTERACEAE | Conyza canadensis (L.) Cronq. | COCA1 | Y | | | X | | X | X |
| ASTERACEAE | Erigeron divergens T. & G. | ERDI1 | Y | X | | | X | X | X |
| ASTERACEAE | Erigeron flagellaris A. Gray | ERFL1 | Y | | | X | | X | X |
| ASTERACEAE | Gaillardia aristata Pursh. | GAAR1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | Y | | X | X | X | X | X |
| ASTERACEAE | Helianthus annuus L. | HEAN1 | Y | | | | | X | |
| ASTERACEAE | Helianthus pumilus Nutt. | HEPU1 | Y | X | X | X | | | |
| ASTERACEAE | Helianthus rigidus (Cass.) Desf. ssp. subrhomboideus (Rydb.) Heiser | HERI1 | Y | X | X | X | | | |
| ASTERACEAE | Lactuca serriola L. | LASE1 | N | | X | X | X | X | X |
| ASTERACEAE | Liatris punctata Hook. | LIPU1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Ratibida columnifera (Nutt.) Woot. & Standl. | RACO1 | Y | | | | | X | X |
| ASTERACEAE | Senecio plattensis Nutt. | SEPL1 | Y | X | X | X | X | X | X |
| ASTERACEAE | Senecio spartioides T. & G. | SESP1 | Y | | | X | X | X | X |
| ASTERACEAE | Solidago mollis Bart. | SOMO1 | Y | X | X | X | X | | |
| ASTERACEAE | Taraxacum officinale Weber | TAOF1 | N | | X | X | X | X | X |
| ASTERACEAE | Tragopogon dubius Scop. | TRDU1 | N | X | X | X | X | X | X |
| BORAGINACEAE | Cryptantha virgata (Porter) Payson | CRVI1 | Y | | | | X | X | |
| BORAGINACEAE | Lithospermum incisum Lehm. | LIIN1 | Y | | | | X | X | X |
| BRASSICACEAE | Alyssum alyssoides (L.) L. | ALAL1 | N | | X | | | | |
| BRASSICACEAE | Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | N | X | X | X | X | X | X |
| BRASSICACEAE | Arabis fendleri (S. Wats.) Greene var. fendleri | ARFE3 | Y | | X | | | | |
| BRASSICACEAE | Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | ARHI1 | Y | X | X | X | X | X | X |
| BRASSICACEAE | Camelina microcarpa Andrz. ex DC. | CAMI1 | N | | | X | | | X |
| BRASSICACEAE | Descurainia pinnata (Walt.) Britt. | DEPI1 | Y | | | | | | X |
| BRASSICACEAE | Draba reptans (Lam.) Fern. | DRRE1 | Y | | X | X | | | X |
| BRASSICACEAE | Erysimum capitatum (Nutt.) DC. | ERCA2 | Y | X | X | X | X | X | X |
| BRASSICACEAE | Lepidium densiflorum Schrad. | LEDE1 | Y | | X | X | | X | |
| BRASSICACEAE | Lesquerella montana (A. Gray) Wats. | LEMO1 | Y | X | X | X | X | X | X |
| BRASSICACEAE | Sisymbrium altissimum L. | SIAL1 | N | | | X | | | X |
| CACTACEAE | Echinocereus viridiflorus Engelm. | ECVI1 | Y | X | X | X | X | X | X |
| CACTACEAE | Opuntia macrorhiza Engelm. | OPMA1 | Y | X | X | X | X | X | X |
| CARYOPHYLLACEAE | Arenaria fendleri A. Gray | ARFE2 | Y | X | X | X | X | X | X |
| CARYOPHYLLACEAE | Paronychia jamesii T. & G. | PAJA1 | Y | X | X | X | X | X | X |
| CARYOPHYLLACEAE | Silene antirrhina L. | SIAN1 | Y | | | X | | X | X |
| CARYOPHYLLACEAE | Silene drummondii Hook. | SIDR1 | Y | X | X | X | | | |
| CHENOPODIACEAE | Chenopodium leptophyllum Nutt. ex Moq. | CHLE2 | Y | | | X | | | X |
| CHENOPODIACEAE | Kochia scoparia (L.) Schrad. | KOSC1 | N | | X | X | | | |
| CHENOPODIACEAE | Salsola iberica Senn. & Pau. | SAIB1 | N | | X | X | | | |
| CLUSIACEAE | Hypericum perforatum L. | HYPE1 | N | X | X | X | X | X | X |
| CONVOLVULACEAE | Convolvulus arvensis L. | COAR1 | N | | | | | X | X |
| CYPERACEAE | Carex eleocharis Bailey | CAEL1 | Y | | | | | | X |
| CYPERACEAE | Carex heliophila Mack. | CAHE1 | Y | X | X | X | X | X | X |
| EUPHORBIACEAE | Euphorbia robusta (Engelm.) Small | EURO1 | Y | | | | X | X | X |
| FABACEAE | Astragalus agrestis Dougl. ex G. Don | ASAG1 | Y | | X | X | X | X | X |
| FABACEAE | Dalea purpurea Vent | DAPU1 | Y | X | X | X | X | X | X |
| FABACEAE | Melilotus alba Medic. | MEAL1 | N | | | | | | X |
| FABACEAE | Melilotus officinalis (L.) Pall. | MEOF1 | N | | | | | X | |
| FABACEAE | Psoralea tenuiflora Pursh. | PSTE1 | Y | X | X | X | X | X | X |
| GERANIACEAE | Erodium cicutarium (L.) L'Her. | ERCI1 | N | | | X | X | X | |
| HYDROPHYLLACEAE | Phacelia heterophylla Pursh. | PHHE1 | Y | | | X | | | X |

**Table 10-1. (cont.)**

| Family | Scientific Name | Speccode | Native | Unburned 1999 | Unburned 2000 | Unburned 2001 | Burned 1999 | Burned 2000 | Burned 2001 |
|---|---|---|---|---|---|---|---|---|---|
| JUNCACEAE | Juncus interior Wieg. | JUIN1 | Y | X | X | X | X | X | X |
| LILIACEAE | Allium textile A. Nels. & Macbr. | ALTE1 | Y | X | X | X | X | | X |
| NYCTAGINACEAE | Mirabilis linearis (Pursh.) Heimerl | MILI1 | Y | X | X | X | X | X | X |
| ONAGRACEAE | Calylophus serrulatus (Nutt.) Raven | CASE2 | Y | X | | X | | | |
| OROBANCHACEAE | Orobanche fasciculata Nutt. | ORFA1 | Y | X | | | | | X |
| PLANTAGINACE | Plantago lanceolata L. | PLLA1 | N | | | | X | X | X |
| POACEAE | Aegilops cylindrica Host | AECY1 | N | | | | X | | |
| POACEAE | Agropyron smithii Rydb. | AGSM1 | Y | | | X | X | X | X |
| POACEAE | Andropogon gerardii Vitman | ANGE1 | Y | X | X | X | X | X | X |
| POACEAE | Andropogon scoparius Michx. | ANSC1 | Y | X | X | X | X | X | X |
| POACEAE | Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | Y | X | X | X | X | X | X |
| POACEAE | Bouteloua curtipendula (Michx.) Torr. | BOCU1 | Y | X | X | X | X | X | X |
| POACEAE | Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | Y | X | X | X | X | X | X |
| POACEAE | Bouteloua hirsuta Lag | BOHI1 | Y | X | X | X | X | X | X |
| POACEAE | Bromus japonicus Thunb. ex Murr. | BRJA1 | N | X | X | X | X | X | X |
| POACEAE | Bromus tectorum L. | BRTE1 | N | X | X | X | X | X | X |
| POACEAE | Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | Y | X | X | X | | X | X |
| POACEAE | Festuca octoflora Walt. | FEOC1 | Y | | | X | | | |
| POACEAE | Koeleria pyramidata (Lam.) Beauv. | KOPY1 | Y | X | X | X | X | X | X |
| POACEAE | Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | Y | X | X | X | X | X | X |
| POACEAE | Muhlenbergia wrightii Vasey | MUWR1 | Y | X | X | | | | X |
| POACEAE | Panicum capillare L. | PACA1 | Y | | | | X | X | |
| POACEAE | Poa compressa L. | POCO1 | N | X | X | X | X | X | X |
| POACEAE | Poa pratensis L. | POPR1 | N | X | X | X | X | X | X |
| POACEAE | Setaria viridis (L.) Beauv. | SEVI1 | N | | | | X | X | |
| POACEAE | Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | Y | X | X | X | X | X | X |
| POACEAE | Sorghastrum nutans (L.) Nash | SONU1 | Y | X | X | X | X | X | X |
| POACEAE | Sporobolus asper (Michx.) Kunth | SPAS1 | Y | | | | X | X | X |
| POACEAE | Sporobolus cryptandrus (Torr.) A. Gray | SPCR1 | Y | | | | X | X | X |
| POACEAE | Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | Y | X | X | X | X | X | X |
| POACEAE | Stipa comata Trin. & Rupr. | STCO1 | Y | X | X | X | X | X | X |
| POLEMONIACEAE | Ipomopsis spicata (Nutt.) V. Grant ssp. spicata | IPSP1 | Y | X | X | X | | | |
| POLYGONACEAE | Eriogonum alatum Torr. | ERAL1 | Y | X | X | X | X | X | X |
| POLYGONACEAE | Polygonum ramosissimum Michx. | PORA1 | Y | | | X | | | |
| PORTULACACEAE | Talinum parviflorum Nutt. | TAPA1 | Y | X | X | X | X | X | X |
| ROSACEAE | Potentilla fissa Nutt. | POFI1 | Y | X | X | X | | | |
| ROSACEAE | Potentilla hippiana Lehm. | POHI1 | Y | X | X | X | | | |
| SANTALACEAE | Comandra umbellata (L.) Nutt. | COUM1 | Y | X | X | X | | | X |
| SCROPHULARIACEAE | Castilleja sessiliflora Pursh. | CASE3 | Y | X | X | X | X | | |
| SCROPHULARIACEAE | Linaria dalmatica (L.) Mill. | LIDA1 | N | X | X | X | X | X | X |
| SCROPHULARIACEAE | Penstemon virens Penn. | PEVI1 | Y | X | X | X | X | X | X |
| SCROPHULARIACEAE | Verbascum thapsus L. | VETH1 | N | | | | X | X | X |
| SCROPHULARIACEAE | Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | Y | | | | | | X |
| SELAGINELLACEAE | Selaginella densa Rydb. | SEDE1 | Y | | | | | X | |
| | Total Species Richness | | | 66 | 72 | 84 | 73 | 79 | 85 |
| | Percent Native Species | | | 86 | 81 | 81 | 78 | 77 | 79 |
| | Mean # Species/Quadrat (1 sq. meter) | | | 12.7 | 12.0 | 13.0 | 10.6 | 10.7 | 12.9 |

**Table 10-2. Pre- and Post-Burn Cactus Densities**

| | | Density (plants/m$^2$) | | |
|---|---|---|---|---|
| **Scientific Name** | **Site** | **1999** | **2000** | **2001** |
| Opuntia macorhiza | Unburned | 0.254a | 0.1b | 0.039b |
| | Burned | 0.98a | 0.37b | 0.107b |
| Echinocereus viridiflorus | Unburned | 0.44a | 0.31a | 0.16a |
| | Burned | 0.55a | 0.74a | 0.25b |

Sample size (n=10)

Means within the same treatment having the same letter are not significantly different from the 1999 data (P > 0.05)

**Table 10-3. 1999-2001 Prescibed Burn Control (Unburned Area) Foliar Cover Summary**

| Scientific Name | Speccode | Growth | Native | Cool/Warm | Frequency 1999 | Frequency 2000 | Frequency 2001 | Absolute Cover 1999 | Absolute Cover 2000 | Absolute Cover 2001 | Relative Cover 1999 | Relative Cover 2000 | Relative Cover 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | F | N | | | 10 | | | 0.1 | | | 0.1 | |
| Centaurea diffusa Lam. | CEDI1 | F | N | | | | 20 | | | 0.2 | | | 0.2 |
| Lactuca serriola L. | LASE1 | F | N | | | | 10 | | | 0.1 | | | 0.1 |
| Linaria dalmatica (L.) Mill. | LIDA1 | F | N | | 30 | 20 | 30 | 0.4 | 0.2 | 0.6 | 0.5 | 0.3 | 0.7 |
| Sisymbrium altissimum L. | SIAL1 | F | N | | | | 20 | | | 0.2 | | | 0.2 |
| Tragopogon dubius Scop. | TRDU1 | F | N | | | | 10 | | | 0.1 | | | 0.1 |
| Ambrosia psilostachya DC. | AMPS1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Arenaria fendleri A. Gray | ARFE2 | F | Y | | 20 | 30 | 50 | 0.2 | 0.4 | 0.5 | 0.3 | 0.5 | 0.6 |
| Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | ARHI1 | F | Y | | 10 | | | 0.1 | | | 0.1 | | |
| Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Aster porteri Gray | ASPO1 | F | Y | | 10 | | 10 | 0.3 | | 0.1 | 0.4 | | 0.1 |
| Chrysopsis villosa Pursh. | CHVI1 | F | Y | | 20 | | | 0.2 | | | 0.3 | | |
| Eriogonum alatum Torr. | ERAL1 | F | Y | | 10 | | 20 | 0.2 | | 0.2 | 0.3 | | 0.2 |
| Gaillardia aristata Pursh. | GAAR1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Ipomopsis spicata (Nutt.) V. Grant ssp. spicata | IPSP1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Lesquerella montana (A. Gray) Wats. | LEMO1 | F | Y | | | 10 | 30 | | 0.1 | 0.5 | | 0.1 | 0.6 |
| Liatris punctata Hook. | LIPU1 | F | Y | | 80 | 90 | 100 | 2.2 | 2.3 | 3.7 | 2.8 | 3.0 | 4.3 |
| Lomatium orientale Coult. & Rose | LOOR1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Paronychia jamesii T. & G. | PAJA1 | F | Y | | | 10 | 40 | | 0.1 | 0.4 | | 0.1 | 0.5 |
| Penstemon virens Penn. | PEVI1 | F | Y | | 10 | | | 0.1 | | | 0.1 | | |
| Psoralea tenuiflora Pursh. | PSTE1 | F | Y | | 40 | 30 | 80 | 0.5 | 0.4 | 1.1 | 0.6 | 0.5 | 1.3 |
| Silene antirrhina L. | SIAN1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Solidago mollis Bart. | SOMO1 | F | Y | | 10 | | | 0.1 | | | 0.1 | | |
| Bromus japonicus Thunb. ex Murr. | BRJA1 | G | N | C | 30 | | | 0.4 | | | 0.5 | | |
| Bromus tectorum L. | BRTE1 | G | N | C | 20 | 20 | 20 | 0.5 | 0.5 | 0.3 | 0.6 | 0.7 | 0.4 |
| Poa compressa L. | POCO1 | G | N | C | 90 | 100 | 100 | 10.2 | 7.5 | 12.8 | 12.9 | 9.8 | 15.0 |
| Poa pratensis L. | POPR1 | G | N | C | 80 | 70 | 80 | 5.8 | 5.6 | 7.2 | 7.3 | 7.3 | 8.5 |
| Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holm | ARLO1 | G | Y | C | 60 | 20 | 40 | 0.9 | 0.3 | 0.6 | 1.1 | 0.4 | 0.7 |
| Carex heliophila Mack. | CAHE1 | G | Y | C | 90 | 100 | 100 | 4.9 | 5.3 | 4.6 | 6.2 | 6.9 | 5.4 |
| Juncus interior Wieg. | JUIN1 | G | Y | C | 10 | | | 0.1 | | | 0.1 | | |
| Koeleria pyramidata (Lam.) Beauv. | KOPY1 | G | Y | C | 100 | 90 | 80 | 4.0 | 3.9 | 2.6 | 5.1 | 5.1 | 3.1 |
| Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | G | Y | C | | 30 | 60 | | 0.4 | 0.6 | | 0.5 | 0.7 |
| Stipa comata Trin. & Rupr. | STCO1 | G | Y | C | 80 | 90 | 90 | 4.3 | 5.0 | 7.3 | 5.4 | 6.5 | 8.6 |
| Andropogon gerardii Vitman | ANGE1 | G | Y | W | 100 | 100 | 100 | 14.3 | 13.4 | 11.6 | 18.1 | 17.4 | 13.6 |
| Andropogon scoparius Michx. | ANSC1 | G | Y | W | 60 | 50 | 70 | 1.8 | 0.9 | 1.1 | 2.3 | 1.2 | 1.3 |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | G | Y | W | 80 | 90 | 80 | 3.0 | 3.3 | 2.5 | 3.8 | 4.3 | 2.9 |
| Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | G | Y | W | 90 | 100 | 100 | 2.5 | 2.7 | 2.5 | 3.2 | 3.5 | 2.9 |
| Bouteloua hirsuta Lag | BOHI1 | G | Y | W | 40 | 80 | 40 | 0.8 | 1.1 | 0.9 | 1.0 | 1.4 | 1.1 |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | G | Y | W | 90 | 90 | 90 | 18.5 | 20.3 | 19.0 | 23.4 | 26.4 | 22.3 |
| Sorghastrum nutans (L.) Nash | SONU1 | G | Y | W | 80 | 70 | 90 | 2.3 | 2.3 | 2.5 | 2.9 | 3.0 | 2.9 |
| Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | G | Y | W | 30 | 30 | 40 | 0.6 | 0.7 | 0.7 | 0.8 | 0.9 | 0.8 |
| Total foliar cover | | | | | | | | 79.2 | 76.8 | 85.1 | 100.0 | 100.0 | 100.0 |
| Total forb cover | | | | | | | | 4.3 | 3.6 | 8.3 | 5.4 | 4.7 | 9.8 |
| Total native forb cover | | | | | | | | 3.9 | 3.3 | 7.1 | 4.9 | 4.3 | 8.3 |
| Total non-native forb cover | | | | | | | | 0.4 | 0.3 | 1.2 | 0.5 | 0.4 | 1.4 |
| Total graminoid cover | | | | | | | | 74.9 | 73.2 | 76.8 | 94.6 | 95.3 | 90.2 |
| Total native graminoid cover | | | | | | | | 58.0 | 59.6 | 56.5 | 73.2 | 77.6 | 66.4 |
| Total non-native graminoid cover | | | | | | | | 16.9 | 13.6 | 20.3 | 21.3 | 17.7 | 23.9 |
| Total warm-season graminoid cover | | | | | | | | 43.8 | 44.7 | 40.8 | 55.3 | 58.2 | 47.9 |
| Total cool-season graminoid cover | | | | | | | | 31.1 | 28.5 | 36.0 | 39.3 | 37.1 | 42.3 |
| Total native cover | | | | | | | | 61.9 | 62.9 | 63.6 | 78.2 | 81.9 | 74.7 |
| Total non-native cover | | | | | | | | 17.3 | 13.9 | 21.5 | 21.8 | 18.1 | 25.3 |

Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible (1000).

Relative cover = Relative foliar cover was the number of hits a species had relative to the total number of all vegetative hits recorded per site (i.e., the percent of vegetative cover the species represented).

All cover values presented are means (n = 10).

Native categories: Y = Native, N = Non-Native

Form categories: C = Cactus, F = Forb, G = Graminoid

Cool/Warm Season categories: C = Cool season species, W = Warm season species

**Table 10-4. 1999-2001 Prescibed Burn Treatment (Burned Area) Foliar Cover Summary**

| Scientific Name | Speccode | Growth | Native | Cool/Warm Season | Frequency 1999 | Frequency 2000 | Frequency 2001 | Absolute Cover 1999 | Absolute Cover 2000 | Absolute Cover 2001 | Relative Cover 1999 | Relative Cover 2000 | Relative Cover 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | F | N | | 10 | | 20 | 0.1 | | 0.3 | 0.1 | | 0.4 |
| Centaurea diffusa Lam. | CEDI1 | F | N | | 10 | 30 | 20 | 0.1 | 0.3 | 0.4 | 0.1 | 0.4 | 0.5 |
| Hypericum perforatum L. | HYPE1 | F | N | | | | 10 | | | 0.1 | | | 0.1 |
| Lactuca serriola L. | LASE1 | F | N | | | | 10 | | | 0.1 | | | 0.1 |
| Linaria dalmatica (L.) Mill. | LIDA1 | F | N | | 10 | 10 | 10 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Verbascum thapsus L. | VETH1 | F | N | | | 10 | 10 | | 0.1 | 0.1 | | 0.1 | 0.1 |
| Ambrosia psilostachya DC. | AMPS1 | F | Y | | | | 20 | | | 0.2 | | | 0.2 |
| Arenaria fendleri A. Gray | ARFE2 | F | Y | | 10 | | 30 | 0.1 | | 0.2 | 0.1 | | 0.2 |
| Artemisia frigida Willd. | ARFR1 | F | Y | | 10 | | | 0.1 | | | 0.1 | | |
| Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | F | Y | | 10 | 30 | 50 | 0.1 | 0.4 | 0.6 | 0.1 | 0.5 | 0.7 |
| Aster porteri Gray | ASPO1 | F | Y | | | | 20 | | | 0.2 | | | 0.2 |
| Asclepias viridiflora Raf. | ASVI1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Chrysopsis fulcrata Greene | CHFU1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Chrysopsis villosa Pursh. | CHVI1 | F | Y | | 10 | | | 0.1 | | | 0.1 | | |
| Cirsium undulatum (Nutt.) Spreng. | CIUN1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Eriogonum alatum Torr. | ERAL1 | F | Y | | | | 10 | | | 0.1 | | | 0.1 |
| Erigeron flagellaris A. Gray | ERFL1 | F | Y | | | | 10 | | | 0.2 | | | 0.2 |
| Lesquerella montana (A. Gray) Wats. | LEMO1 | F | Y | | | | 40 | | | 0.9 | | | 1.1 |
| Liatris punctata Hook. | LIPU1 | F | Y | | 80 | 90 | 80 | 1.6 | 2.2 | 1.9 | 2.1 | 2.9 | 2.3 |
| Penstemon virens Penn. | PEVI1 | F | Y | | 10 | | | 0.1 | | | 0.1 | | |
| Psoralea tenuiflora Pursh. | PSTE1 | F | Y | | 20 | 50 | 60 | 0.3 | 0.6 | 0.8 | 0.4 | 0.8 | 1.0 |
| Silene antirrhina L. | SIAN1 | F | Y | | | | 20 | | | 0.2 | | | 0.2 |
| Aegilops cylindrica Host | AECY1 | G | N | C | 10 | | | 0.1 | | | 0.1 | | |
| Bromus japonicus Thunb. ex Murr. | BRJA1 | G | N | C | 40 | | 10 | 0.9 | | 0.1 | 1.2 | | 0.1 |
| Bromus tectorum L. | BRTE1 | G | N | C | 10 | 20 | 20 | 0.3 | 0.5 | 0.4 | 0.4 | 0.7 | 0.5 |
| Poa compressa L. | POCO1 | G | N | C | 100 | 100 | 100 | 23.3 | 17.6 | 24.1 | 30.2 | 23.6 | 28.7 |
| Poa pratensis L. | POPR1 | G | N | C | 100 | 90 | 90 | 7.7 | 5.9 | 6.0 | 10.0 | 7.9 | 7.2 |
| Agropyron smithii Rydb. | AGSM1 | G | Y | C | | | 10 | | | 0.1 | | | 0.1 |
| Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holm | ARLO1 | G | Y | C | 20 | 30 | 40 | 0.2 | 0.3 | 0.4 | 0.3 | 0.4 | 0.5 |
| Carex heliophila Mack. | CAHE1 | G | Y | C | 90 | 90 | 90 | 3.3 | 2.9 | 2.3 | 4.3 | 3.9 | 2.7 |
| Koeleria pyramidata (Lam.) Beauv. | KOPY1 | G | Y | C | 60 | 50 | 80 | 0.8 | 0.8 | 1.2 | 1.0 | 1.1 | 1.4 |
| Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | G | Y | C | | 20 | | | 0.2 | | | 0.3 | |
| Stipa comata Trin. & Rupr. | STCO1 | G | Y | C | 80 | 90 | 90 | 4.1 | 5.6 | 5.7 | 5.3 | 7.5 | 6.8 |
| Andropogon gerardii Vitman | ANGE1 | G | Y | W | 100 | 100 | 100 | 14.4 | 17.4 | 16.6 | 18.7 | 23.3 | 19.8 |
| Andropogon scoparius Michx. | ANSC1 | G | Y | W | 70 | 80 | 80 | 1.8 | 2.0 | 1.9 | 2.3 | 2.7 | 2.3 |
| Bouteloua curtipendula (Michx.) Torr. | BOCU1 | G | Y | W | 40 | 90 | 80 | 1.0 | 2.3 | 1.8 | 1.3 | 3.1 | 2.1 |
| Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | G | Y | W | 80 | 90 | 60 | 1.3 | 1.9 | 1.1 | 1.7 | 2.5 | 1.3 |
| Bouteloua hirsuta Lag | BOHI1 | G | Y | W | 30 | 10 | 30 | 0.3 | 0.1 | 0.3 | 0.4 | 0.1 | 0.4 |
| Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | G | Y | W | 100 | 100 | 100 | 13.2 | 11.8 | 13.4 | 17.1 | 15.8 | 16.0 |
| Sorghastrum nutans (L.) Nash | SONU1 | G | Y | W | 50 | 50 | 60 | 1.6 | 1.5 | 1.7 | 2.1 | 2.0 | 2.0 |
| Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | G | Y | W | 10 | 10 | 10 | 0.2 | 0.1 | 0.1 | 0.3 | 0.1 | 0.1 |
| Total foliar cover | | | | | | | | 77.2 | 74.6 | 83.9 | 100.0 | 100.0 | 100.0 |
| Total forb cover | | | | | | | | 2.7 | 3.7 | 6.7 | 3.5 | 5.0 | 8.0 |
| Total native forb cover | | | | | | | | 2.4 | 3.2 | 5.6 | 3.1 | 4.3 | 6.7 |
| Total non-native forb cover | | | | | | | | 0.3 | 0.5 | 1.1 | 0.4 | 0.7 | 1.3 |
| Total graminoid cover | | | | | | | | 74.5 | 70.9 | 77.2 | 96.5 | 95.0 | 92.0 |
| Total native graminoid cover | | | | | | | | 42.2 | 46.9 | 46.6 | 54.7 | 62.9 | 55.5 |
| Total non-native graminoid cover | | | | | | | | 32.3 | 24.0 | 30.6 | 41.8 | 32.2 | 36.5 |
| Total warm-season graminoid cover | | | | | | | | 33.8 | 37.1 | 36.9 | 43.8 | 49.7 | 44.0 |
| Total cool-season graminoid cover | | | | | | | | 40.7 | 33.8 | 40.3 | 52.7 | 45.3 | 48.0 |
| Total native cover | | | | | | | | 44.6 | 50.1 | 52.2 | 57.8 | 67.2 | 62.2 |
| Total non-native cover | | | | | | | | 32.6 | 24.5 | 31.7 | 42.2 | 32.8 | 37.8 |

Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible (1000).

Relative cover = Relative foliar cover was the number of hits a species had relative to the total number of all vegetative hits recorded per site (i.e., the percent of vegetative cover the species represented).

All cover values presented are means (n = 10).

Native categories: Y = Native, N = Non-Native

Form categories: C = Cactus, F = Forb, G = Graminoid

Cool/Warm Season categories: C = Cool season species, W = Warm season species

**Table 10-5. 1999-2001 Prescibed Burn Species Frequency Summary**

| | | | | Unburned | | | Burned | | |
|---|---|---|---|---|---|---|---|---|---|
| **Family** | **Scientific Name** | **Speccode** | **Native** | **1999** | **2000** | **2001** | **1999** | **2000** | **2001** |
| APIACEAE | Lomatium orientale Coult. & Rose | LOOR1 | Y | 16 | | 2 | 16 | | 4 |
| ASCLEPIADACEAE | Asclepias stenophylla A. Gray | ASST1 | Y | | | | | 2 | |
| ASCLEPIADACEAE | Asclepias viridiflora Raf. | ASVI1 | Y | 2 | 2 | 2 | | | |
| ASTERACEAE | Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | ACMI1 | Y | 6 | 4 | 4 | | | |
| ASTERACEAE | Ambrosia psilostachya DC. | AMPS1 | Y | 2 | 2 | 6 | 8 | 10 | 36 |
| ASTERACEAE | Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | ARCA1 | Y | | | | 2 | | 16 |
| ASTERACEAE | Artemisia frigida Willd. | ARFR1 | Y | 6 | 2 | | 8 | 4 | 8 |
| ASTERACEAE | Artemisia ludoviciana Nutt. var. ludoviciana | ARLU1 | Y | 4 | 8 | 8 | 26 | 24 | 30 |
| ASTERACEAE | Aster porteri Gray | ASPO1 | Y | 30 | 2 | 10 | 10 | 6 | 18 |
| ASTERACEAE | Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | CANU1 | N | | | | | 2 | 4 |
| ASTERACEAE | Centaurea diffusa Lam. | CEDI1 | N | | 2 | 8 | 6 | 16 | 22 |
| ASTERACEAE | Chrysopsis fulcrata Greene | CHFU1 | Y | 8 | 8 | 10 | 2 | 2 | 2 |
| ASTERACEAE | Chrysopsis villosa Pursh. | CHVI1 | Y | 26 | 12 | 12 | 2 | | |
| ASTERACEAE | Cirsium undulatum (Nutt.) Spreng. | CIUN1 | Y | | | | 2 | 2 | 2 |
| ASTERACEAE | Conyza canadensis (L.) Cronq. | COCA1 | Y | | | 2 | | 2 | 14 |
| ASTERACEAE | Erigeron divergens T. & G. | ERDI1 | Y | | | | 4 | | 6 |
| ASTERACEAE | Erigeron flagellaris A. Gray | ERFL1 | Y | | | 2 | | 6 | 26 |
| ASTERACEAE | Gaillardia aristata Pursh. | GAAR1 | Y | 8 | 18 | 18 | 12 | 8 | 12 |
| ASTERACEAE | Grindelia squarrosa (Pursh.) Dun. | GRSQ1 | Y | | | | 8 | 8 | 24 |
| ASTERACEAE | Helianthus pumilus Nutt. | HEPU1 | Y | 2 | 2 | 2 | | | |
| ASTERACEAE | Lactuca serriola L. | LASE1 | N | | | 4 | | 2 | 20 |
| ASTERACEAE | Liatris punctata Hook. | LIPU1 | Y | 82 | 86 | 80 | 52 | 60 | 58 |
| ASTERACEAE | Ratibida columnifera (Nutt.) Woot. & Standl. | RACO1 | Y | | | | | | 2 |
| ASTERACEAE | Senecio plattensis Nutt. | SEPL1 | Y | 6 | 6 | 2 | 4 | 4 | 4 |
| ASTERACEAE | Solidago mollis Bart. | SOMO1 | Y | 6 | 6 | 6 | | | |
| ASTERACEAE | Taraxacum officinale Weber | TAOF1 | N | | | 2 | 2 | 10 | 4 |
| ASTERACEAE | Tragopogon dubius Scop. | TRDU1 | N | | 2 | 16 | 2 | 10 | 12 |
| BORAGINACEAE | Lithospermum incisum Lehm. | LIIN1 | Y | | | | | | 2 |
| BRASSICACEAE | Alyssum alyssoides (L.) L. | ALAL1 | N | | 2 | | | | |
| BRASSICACEAE | Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | ALMI1 | N | 8 | 4 | 6 | 18 | | 12 |
| BRASSICACEAE | Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | ARHI1 | Y | 8 | 4 | 8 | 8 | 2 | 2 |
| BRASSICACEAE | Camelina microcarpa Andrz. ex DC. | CAMI1 | N | | | 2 | | | |
| BRASSICACEAE | Draba reptans (Lam.) Fern. | DRRE1 | Y | | 2 | 2 | | | 16 |
| BRASSICACEAE | Erysimum capitatum (Nutt.) DC. | ERCA2 | Y | 4 | 4 | 22 | 4 | 2 | 32 |
| BRASSICACEAE | Lesquerella montana (A. Gray) Wats. | LEMO1 | Y | 34 | 48 | 66 | 54 | 80 | 74 |
| BRASSICACEAE | Sisymbrium altissimum L. | SIAL1 | N | | | 4 | | | 2 |
| CACTACEAE | Echinocereus viridiflorus Engelm. | ECVI1 | Y | 46 | 34 | 30 | 48 | 46 | 40 |
| CACTACEAE | Opuntia macrorhiza Engelm. | OPMA1 | Y | 28 | 12 | 8 | 58 | 36 | 26 |
| CARYOPHYLLACEAE | Arenaria fendleri A. Gray | ARFE2 | Y | 32 | 22 | 20 | 14 | 10 | 14 |
| CARYOPHYLLACEAE | Paronychia jamesii T. & G. | PAJA1 | Y | 22 | 20 | 24 | 4 | | 2 |
| CARYOPHYLLACEAE | Silene antirrhina L. | SIAN1 | Y | | | 26 | | 2 | 34 |
| CHENOPODIACEAE | Chenopodium leptophyllum Nutt. ex Moq. | CHLE2 | Y | | | 2 | | | |
| CLUSIACEAE | Hypericum perforatum L. | HYPE1 | N | 4 | 6 | 26 | 2 | 2 | 14 |
| CYPERACEAE | Carex eleocharis Bailey | CAEL1 | Y | | | | | | 2 |
| CYPERACEAE | Carex heliophila Mack. | CAHE1 | Y | 94 | 96 | 90 | 84 | 82 | 78 |
| FABACEAE | Astragalus agrestis Dougl. ex G. Don | ASAG1 | Y | | | | 4 | 4 | 4 |
| FABACEAE | Dalea purpurea Vent | DAPU1 | Y | 10 | 10 | 6 | 4 | 6 | 4 |
| FABACEAE | Psoralea tenuiflora Pursh. | PSTE1 | Y | 26 | 40 | 44 | 18 | 20 | 18 |
| GERANIACEAE | Erodium cicutarium (L.) L'Her. | ERCI1 | N | | | 2 | | | |
| JUNCACEAE | Juncus interior Wieg. | JUIN1 | Y | 4 | 4 | 4 | 8 | 2 | 4 |
| LILIACEAE | Allium textile A. Nels. & Macbr. | ALTE1 | Y | 4 | | 12 | | | |
| NYCTAGINACEAE | Mirabilis linearis (Pursh.) Heimerl | MILI1 | Y | | | 4 | | | |
| OROBANCHACEAE | Orobanche fasciculata Nutt. | ORFA1 | Y | | | | | | 2 |
| POACEAE | Agropyron smithii Rydb. | AGSM1 | Y | | | | 2 | 2 | 2 |
| POACEAE | Andropogon gerardii Vitman | ANGE1 | Y | 64 | 64 | 66 | 76 | 76 | 78 |
| POACEAE | Andropogon scoparius Michx. | ANSC1 | Y | 56 | 54 | 44 | 38 | 40 | 38 |
| POACEAE | Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | ARLO1 | Y | 14 | 12 | 12 | 4 | 14 | 8 |
| POACEAE | Bouteloua curtipendula (Michx.) Torr. | BOCU1 | Y | 74 | 66 | 62 | 44 | 50 | 46 |
| POACEAE | Bouteloua gracilis (H. B. K.) Lag ex Griffiths | BOGR1 | Y | 78 | 60 | 62 | 58 | 68 | 44 |
| POACEAE | Bouteloua hirsuta Lag | BOHI1 | Y | 52 | 60 | 48 | 18 | 30 | 18 |
| POACEAE | Bromus japonicus Thunb. ex Murr. | BRJA1 | N | 4 | | | 14 | 2 | 8 |
| POACEAE | Bromus tectorum L. | BRTE1 | N | 2 | 2 | 8 | 4 | 4 | 8 |

**Table 10-5. (cont.)**

| Family | Scientific Name | Speccode | Native | Unburned 1999 | Unburned 2000 | Unburned 2001 | Burned 1999 | Burned 2000 | Burned 2001 |
|---|---|---|---|---|---|---|---|---|---|
| POACEAE | Buchloe dactyloides (Nutt.) Engelm. | BUDA1 | Y | 2 | 2 | | | | |
| POACEAE | Koeleria pyramidata (Lam.) Beauv. | KOPY1 | Y | 62 | 74 | 72 | 28 | 32 | 46 |
| POACEAE | Muhlenbergia montana (Nutt.) Hitchc. | MUMO1 | Y | 76 | 78 | 78 | 76 | 64 | 64 |
| POACEAE | Poa compressa L. | POCO1 | N | 56 | 52 | 52 | 84 | 88 | 82 |
| POACEAE | Poa pratensis L. | POPR1 | N | 38 | 38 | 36 | 48 | 50 | 48 |
| POACEAE | Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | SIHY1 | Y | 18 | 22 | 22 | | 6 | 6 |
| POACEAE | Sorghastrum nutans (L.) Nash | SONU1 | Y | 24 | 22 | 20 | | | |
| POACEAE | Sporobolus heterolepis (A. Gray) A. Gray | SPHE1 | Y | 8 | 8 | 10 | | | |
| POACEAE | Stipa comata Trin. & Rupr. | STCO1 | Y | 34 | 42 | 48 | 50 | 58 | 66 |
| POLYGONACEAE | Eriogonum alatum Torr. | ERAL1 | Y | 38 | 22 | 20 | 12 | 10 | 8 |
| PORTULACACEAE | Talinum parviflorum Nutt. | TAPA1 | Y | 4 | 10 | 8 | | | |
| ROSACEAE | Potentilla fissa Nutt. | POFI1 | Y | 2 | 2 | 2 | | | |
| ROSACEAE | Potentilla hippiana Lehm. | POHI1 | Y | 2 | 2 | | | | |
| SANTALACEAE | Comandra umbellata (L.) Nutt. | COUM1 | Y | 6 | 16 | 8 | | | 2 |
| SCROPHULARIACEAE | Castilleja sessiliflora Pursh. | CASE3 | Y | 2 | 2 | 2 | | | |
| SCROPHULARIACEAE | Linaria dalmatica (L.) Mill. | LIDA1 | N | 14 | 14 | 14 | 2 | 2 | 4 |
| SCROPHULARIACEAE | Penstemon virens Penn. | PEVI1 | Y | 8 | 2 | 4 | 2 | 4 | 2 |
| SCROPHULARIACEAE | Verbascum thapsus L. | VETH1 | N | | | | 2 | | |
| SCROPHULARIACEAE | Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | VEPE1 | Y | | | | | | 2 |

## Appendices

**Located on CD Rom**

# Appendix B

## 2001 Vascular Plants Species List for the Rocky Flats Environmental Technology Site

As of 2001, there are currently 600 species of vascular plants that have been documented as occurring at Rocky Flats. Voucher specimens are maintained in the Site's herbarium. The Site herbarium was donated in December 2001 to the herbarium at the University of Colorado - Boulder in order to make the plant collection more accessible to the public and other researchers. Plant nomenclature follows that of GPFA (1986), Weber (1976), and Weber (1990), in that order of determination.

GPFA. 1986. Flora of the Great Plains, 2nd printing with 1991 supplement. Great Plains Flora Association. University Press of Kansas, Lawrence, KS. 1402 p.

Weber, W.A. 1976. Rocky Mountain flora. Colorado Associated University Press, Boulder, CO.

Weber, W.A. 1990. Colorado flora: Eastern Slope. University Press of Colorado, Niwot, CO.

| Family | Scientific Name | Com |
|---|---|---|
| ACERACEAE | Acer glabrum Torr. | Mountain M |
| ACERACEAE | Acer negundo L. var. interius (Britt.) Sarg. | Box-elder |
| AGAVACEAE | Yucca glauca Nutt. | Yucca |
| ALISMATACEAE | Alisma trivale Pursh | American W |
| ALISMATACEAE | Sagittaria latifolia Willd. | Common A |
| AMARANTHACEAE | Amaranthus albus L. | Tumblewee |
| AMARANTHACEAE | Amaranthus retroflexus L. | Rough Pigw |
| ANACARDIACEAE | Rhus aromatica Ait. var. trilobata (Nutt.) A. Gray | Fragrant Su |
| ANACARDIACEAE | Toxicodendron rydbergii (Small) Greene | Poison Ivy |
| APIACEAE | Berula erecta (Huds.) Cov. var. incisum | Water Pars |
| APIACEAE | Cicuta maculata L. var. angustifolia Hook. | Water Hem |
| APIACEAE | Conium maculatum L. | Poison Hen |
| APIACEAE | Daucus carota L. | Wild Carrot |
| APIACEAE | Harbouria trachypleura (Gray) C. & R. | Whiskbroon |
| APIACEAE | Heracleum sphondylium L. ssp. montanum (Schleich.) Briq. | Cow Parsni |
| APIACEAE | Ligusticum porteri C. & R. | Porter's Lov |
| APIACEAE | Lomatium orientale Coult. & Rose | Wild Parsle |
| APIACEAE | Musineon divaricatum (Pursh.) Nutt. var. hookeri T. & G. | Musineon |
| APIACEAE | Osmorhiza chiliensis H. & A. | Sweet Cice |
| APIACEAE | Osmorhiza longistylis (Torr.) DC var. longistylis | Anise Root |
| APOCYNACEAE | Apocynum androsaemifolium L. | Spreading [ |
| APOCYNACEAE | Apocynum cannabinum L. | Hemp Dogt |
| ASCLEPIADACEAE | Asclepias incarnata L. | Swamp Mill |
| ASCLEPIADACEAE | Asclepias pumila (Gray) Vail | Plains Milkv |
| ASCLEPIADACEAE | Asclepias speciosa Torr. | Showy Milk |

| | | |
|---|---|---|
| ASCLEPIADACEAE | Asclepias stenophylla A. Gray | Narrow-lea\ |
| ASCLEPIADACEAE | Asclepias viridiflora Raf. | Green Milkv |
| ASTERACEAE | Achillea millefolium L. ssp. lanulosa (Nutt.) Piper | Yarrow |
| ASTERACEAE | Agoseris glauca (Pursh.) Dietr. | False Dand |
| ASTERACEAE | Ambrosia artemisiifolia L. | Common R: |
| ASTERACEAE | Ambrosia psilostachya DC. | Western Ra |
| ASTERACEAE | Ambrosia trifida L. | Giant Ragw |
| ASTERACEAE | Antennaria microphylla Rydb. | Pink Pussyt |
| ASTERACEAE | Antennaria parvifolia Nutt. | Pussytoes |
| ASTERACEAE | Anthemis cotula L. | Dog Fennel |
| ASTERACEAE | Arctium minus Bernh. | Burdock |
| ASTERACEAE | Arnica fulgens Pursh. | Arnica |
| ASTERACEAE | Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem. | Western Sa |
| ASTERACEAE | Artemisia dracunculus L. | Silky Worm' |
| ASTERACEAE | Artemisia frigida Willd. | Silver Sage |
| ASTERACEAE | Artemisia ludoviciana Nutt. var. ludoviciana | White Sage |
| ASTERACEAE | Aster campestris Nutt. | Meadow As |
| ASTERACEAE | Aster falcatus Lindl. | Aster |
| ASTERACEAE | Aster fendleri A. Gray | Fendler's A: |
| ASTERACEAE | Aster hesperius A. Gray var. hersperius | Panicled As |
| ASTERACEAE | Aster laevis L. var. geyeri A. Gray | Smooth Blu |
| ASTERACEAE | Aster porteri Gray | Aster |
| ASTERACEAE | Bidens cernua L. | Nodding Be |
| ASTERACEAE | Bidens frondosa L. | Beggar-tick |
| ASTERACEAE | Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi | Musk Thistl |
| ASTERACEAE | Centaurea diffusa Lam. | Diffuse Kna |
| ASTERACEAE | Centaurea repens L. | Russian Kn |
| ASTERACEAE | Chrysanthemum leucanthemum L. | Ox-eye Dai: |
| ASTERACEAE | Chrysopsis fulcrata Greene | Golden Aste |
| ASTERACEAE | Chrysopsis villosa Pursh. | Golden Aste |
| ASTERACEAE | Chrysothamnus nauseosus (Pall.) Britt. ssp. graveolens (Nutt.) Piper | Greenplume |
| ASTERACEAE | Chrysothamnus nauseosus (Pall.) Britt. ssp. nauseosus | Rubber Rab |
| ASTERACEAE | Cichorium intybus L. | Common C |
| ASTERACEAE | Cirsium arvense (L.) Scop. | Canada Thi |
| ASTERACEAE | Cirsium flodmanni (Rydb.) Arthur | Flodman's |
| ASTERACEAE | Cirsium ochrocentrum A. Gray | Yellow Spin |
| ASTERACEAE | Cirsium undulatum (Nutt.) Spreng. | Wavyleaf Tl |
| ASTERACEAE | Cirsium vulgare (Savi) Ten. | Bull Thistle |
| ASTERACEAE | Conyza canadensis (L.) Cronq. | Horseweed |
| ASTERACEAE | Crepis occidentalis Nutt. | Hawksbear |
| ASTERACEAE | Crepis runcinata (James) T. & G. | Hawksbear |

| | | |
|---|---|---|
| ASTERACEAE | Dyssodia papposa (Vent) Hitchc. | Fetid Marig |
| ASTERACEAE | Erigeron canus A. Gray | Fleabane |
| ASTERACEAE | Erigeron compositus Pursh var. dicoideus A. Gray | |
| ASTERACEAE | Erigeron divergens T. & G. | Fleabane |
| ASTERACEAE | Erigeron flagellaris A. Gray | Fleabane |
| ASTERACEAE | Erigeron pumilus Nutt. | Fleabane |
| ASTERACEAE | Erigeron speciosa (Lindl.) DC. var. macranthus (Nutt.) Cronq. | Oregon Fle |
| ASTERACEAE | Erigeron strigosus Muhl. ex Willd. | Daisy Fleab |
| ASTERACEAE | Erigeron vetensis Rydb. | LaVeta Flea |
| ASTERACEAE | Gaillardia aristata Pursh. | Blanket Flo |
| ASTERACEAE | Gnapthalium chilense Spreng. | Cotton-batti |
| ASTERACEAE | Grindelia squarrosa (Pursh.) Dun. | Curly-top G |
| ASTERACEAE | Gutierrezia sarothrae (Pursh.) Britt. & Rusby | Snakeweed |
| ASTERACEAE | Happlopappus spinulosus (Pursh) DC. | Cutleaf Iron |
| ASTERACEAE | Helianthus annuus L. | Common S |
| ASTERACEAE | Helianthus ciliaris DC. | Texas Blue |
| ASTERACEAE | Helianthus maximilianii Schrad. | Maximilian |
| ASTERACEAE | Helianthus nuttallii T. & G. | Nuttall's Su |
| ASTERACEAE | Helianthus petiolaris Nutt. | Plains Sunf |
| ASTERACEAE | Helianthus pumilus Nutt. | Sunflower |
| ASTERACEAE | Helianthus rigidus (Cass.) Desf. ssp. subrhomboideus (Rydb.) Heiser | Stiff Sunflo |
| ASTERACEAE | Heliomeris multiflora Nuttall | Showy Gol |
| ASTERACEAE | Hymenopappus filifolius Hook. var. cinereus (Rydb.) I. M. Johnst. | Hymenopap |
| ASTERACEAE | Iva axillaris Pursh. | Poverty We |
| ASTERACEAE | Iva xanthifolia Nutt. | Marsh Elde |
| ASTERACEAE | Kuhnia chlorolepis Woot. & Standl. | False Bone |
| ASTERACEAE | Kuhnia eupatorioides L. | False Bone |
| ASTERACEAE | Lactuca oblongifolia Nutt. | Blue Lettuc |
| ASTERACEAE | Lactuca serriola L. | Prickly Lett |
| ASTERACEAE | Leucelene ericoides (Torr.) Greene | White Aster |
| ASTERACEAE | Liatris punctata Hook. | Blazing Sta |
| ASTERACEAE | Lygodesmia juncea (Pursh.) Hook. | Skeleton-w |
| ASTERACEAE | Machaeranthera bigelovii (Gray) Greene | Bigelovi's T |
| ASTERACEAE | Machaeranthera canescens (Pursh) A. Gray | Hoary Aste |
| ASTERACEAE | Microseris cuspidata (Pursh.) Sch. Bip. | False Dand |
| ASTERACEAE | Onopordum acanthium L. | Scotch This |
| ASTERACEAE | Picradeniopsis oppositifolia (Nutt.) Rydb. | Picradeniop |
| ASTERACEAE | Ratibida columnifera (Nutt.) Woot. & Standl. | Prairie Con |
| ASTERACEAE | Rudbeckia ampla Nelson | Goldenglow |
| ASTERACEAE | Scorzonera laciniata L. | False Salsif |
| ASTERACEAE | Senecio fendleri Gray | Groundsel |
| | | |

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|---|---|---|
| ASTERACEAE | Senecio integerrimus Nutt. | Groundsel |
| ASTERACEAE | Senecio plattensis Nutt. | Prairie Rag |
| ASTERACEAE | Senecio spartioides T. & G. | Groundsel |
| ASTERACEAE | Senecio tridenticulatus Rydb. | Groundsel |
| ASTERACEAE | Solidago canadensis L. | Canada Go |
| ASTERACEAE | Solidago gigantea Ait. | Late Golder |
| ASTERACEAE | Solidago missouriensis Nutt. | Prairie Gold |
| ASTERACEAE | Solidago mollis Bart. | Soft Golden |
| ASTERACEAE | Solidago nana Nutt. | Low Golder |
| ASTERACEAE | Solidago rigida L. | Rigid Golde |
| ASTERACEAE | Sonchus arvensis L. ssp. uglinosus (Bieb.) Nyman | Field Sow T |
| ASTERACEAE | Sonchus asper (L.) Hill | Prickly Sow |
| ASTERACEAE | Stephanomeria pauciflora (Torr.) A. Nels. | Wire Lettuc |
| ASTERACEAE | Taraxacum laevigatum (Willd.) DC. | Red Seede |
| ASTERACEAE | Taraxacum officinale Weber | Dandelion |
| ASTERACEAE | Thelesperma megapotanicum (Spreng.) O. Ktze. | Greenthrea |
| ASTERACEAE | Townsendia grandiflora (Nutt.) | Easter Dais |
| ASTERACEAE | Townsendia hookeri Beaman | Easter Dais |
| ASTERACEAE | Tragopogon dubius Scop. | Goat's Bear |
| ASTERACEAE | Tragopogon porrifolius L. | Salsify |
| ASTERACEAE | Xanthium strumarium L. | Cocklebur |
| BERBERIDACEAE | Berberis repens Lindl. | Oregon Gra |
| BETULACEAE | Alnus incana (L.) Moench ssp. tenuifolia (Nuttall) Breitung | Alder |
| BETULACEAE | Betula occidentalis Hook. | Water Birch |
| BORAGINACEAE | Asperugo procumbens L. | Madwort |
| BORAGINACEAE | Cryptantha virgata (Porter) Payson | Miners Can |
| BORAGINACEAE | Cynoglossum officinale L. | Hound's To |
| BORAGINACEAE | Hackelia floribunda (Lehm.) I. M. Johnst. | Large-flowe |
| BORAGINACEAE | Lappula redowskii (Hornem.) Greene | Stickseed |
| BORAGINACEAE | Lithospermum incisum Lehm. | Puccoon |
| BORAGINACEAE | Lithospermum multiflorum Torr. | |
| BORAGINACEAE | Mertensia lanceolata (Pursh.) A. DC. | Bluebells |
| BORAGINACEAE | Onosmodium molle Michx. var. occidentale (Mack.) Johnst. | False Grom |
| BORAGINACEAE | Plagiobothrys scouleri (H. & A.) I. M. Johnst. | Popcorn Flc |
| BRASSICACEAE | Alyssum alyssoides (L.) L. | Pale Alyssu |
| BRASSICACEAE | Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley | Alyssum |
| BRASSICACEAE | Arabis fendleri (S. Wats.) Greene var. fendleri | Rock Cress |
| BRASSICACEAE | Arabis glabra (L.) Bernh. | Tower Must |
| BRASSICACEAE | Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins | Rock Cress |
| BRASSICACEAE | Barbarea vulgaris R. Br. | Yellowrocke |
| BRASSICACEAE | Camelina microcarpa Andrz. ex DC. | Small-seed |

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|---|---|---|
| BRASSICACEAE | Capsella bursa-pastoris (L.) Medic. | Shepherd's |
| BRASSICACEAE | Cardaria chalepensis (L.) Hand-Mazz | Lens-padde |
| BRASSICACEAE | Cardaria draba (L.) Desv. | Hoary Cres: |
| BRASSICACEAE | Chorispora tenella (Pall.) DC. | Blue Mustai |
| BRASSICACEAE | Conringia orientalis (L.) Dum. | Hare's-ear I |
| BRASSICACEAE | Descurainia pinnata (Walt.) Britt. | Tansy Must |
| BRASSICACEAE | Descurainia richardsonii (Sweet) Schultz | Tansy Must |
| BRASSICACEAE | Descurainia sophia (L.) Webb ex Prantl. | Flixweed |
| BRASSICACEAE | Draba nemorosa L. | Yellow Whit |
| BRASSICACEAE | Draba reptans (Lam.) Fern. | White Whitl |
| BRASSICACEAE | Erysimum capitatum (Nutt.) DC. | Western Wa |
| BRASSICACEAE | Erysimum repandum L. | Bushy Wallf |
| BRASSICACEAE | Hesperis matronalis L. | Dame's Roc |
| BRASSICACEAE | Lepidium campestre (L.) R. Br. | Field Peppe |
| BRASSICACEAE | Lepidium densiflorum Schrad. | Peppergras |
| BRASSICACEAE | Lesquerella montana (A. Gray) Wats. | Bladderpod |
| BRASSICACEAE | Nasturtium officinale R. Br. | Watercress |
| BRASSICACEAE | Physaria vitulifera Rydb. | Double Blac |
| BRASSICACEAE | Rorippa palustris (L.) Bess. ssp. hispida (Desv.) Jonsell | Bog Yellow |
| BRASSICACEAE | Sisymbrium altissimum L. | Tumbling M |
| BRASSICACEAE | Thlaspi arvense L. | Field Penny |
| CACTACEAE | Coryphantha missouriensis (Sweet) Britt. & Rose | Nipple Cact |
| CACTACEAE | Echinocereus viridiflorus Engelm. | Hedgehog ( |
| CACTACEAE | Opuntia fragilis (Nutt.) Haw. | Little Prickly |
| CACTACEAE | Opuntia macrorhiza Engelm. | Twistspine I |
| CACTACEAE | Opuntia polyacantha Haw. | Plains Prick |
| CACTACEAE | Pediocactus simpsonii (Engelm.) Britt. & Rose | Nipple Cact |
| CALLITRICHACEAE | Callitriche verna L. | Water Starv |
| CAMPANULACEAE | Campanula rotundifolia L. | Harebell |
| CAMPANULACEAE | Lobelia siphilitica L. var. ludoviciana A. DC. | Great Lobel |
| CAMPANULACEAE | Triodanis leptocarpa (Nutt.) Nieuw. | Venus' Lool |
| CAMPANULACEAE | Triodanis perfoliata (L.) Nieuw. | Venus Look |
| CANNABACEAE | Humulus lupulus L. var. lupuloides E. Small | Common H |
| CAPPARACEAE | Cleome serrulata Pursh. | Rocky Mou |
| CAPPARACEAE | Polansia dodecandra (L.) DC. ssp. trachysperma (T. & G.) Iltis | Clammy-we |
| CAPRIFOLIACEAE | Symphoricarpos occidentalis Hook. | Western Sn |
| CAPRIFOLIACEAE | Symphoricarpos oreophilus Gray | Snowberry |
| CAPRIFOLIACEAE | Viburnum opulus L. var. americanum Ait | Highbush C |
| CARYOPHYLLACEAE | Arenaria fendleri A. Gray | Fendler's Sa |
| CARYOPHYLLACEAE | Cerastium arvense L. | Prairie Chic |
| CARYOPHYLLACEAE | Cerastium brachypodum (Engelm. ex A. Gray) Robins. | Short-stalke |
| | | |

| | | |
|---|---|---|
| CARYOPHYLLACEAE | Cerastium vulgatum L. | Common M |
| CARYOPHYLLACEAE | Conosilene conica (L.) Fourreau ssp. conoidea (L.) Love & Kjellqvist | Community |
| CARYOPHYLLACEAE | Paronychia jamesii T. & G. | James' Nail |
| CARYOPHYLLACEAE | Saponaria officinalis L. | Bouncing B |
| CARYOPHYLLACEAE | Silene antirrhina L. | Sleepy Cat |
| CARYOPHYLLACEAE | Silene drummondii Hook. | Campion |
| CARYOPHYLLACEAE | Silene pratensis (Raf.)Godr. & Gren | White Cam |
| CARYOPHYLLACEAE | Spergularia rubra (L.) K. Presl. | Sand Spurr |
| CARYOPHYLLACEAE | Stellaria longifolia Muhl. ex Willd. | Long-leave |
| CARYOPHYLLACEAE | Vaccaria pyramidata Medic. | Cow Cockle |
| CERATOPHYLLACEAE | Ceratophyllum demersum L. | Coontail |
| CHENOPODIACEAE | Atriplex canescens (Pursh.) Nutt. | Four-winge |
| CHENOPODIACEAE | Chenopodium album L. | Lamb's Qua |
| CHENOPODIACEAE | Chenopodium atrovirens Nutt. | Dark Goose |
| CHENOPODIACEAE | Chenopodium berlandieri Moq. | Pitseed Go |
| CHENOPODIACEAE | Chenopodium botrys L. | Jerusalem ( |
| CHENOPODIACEAE | Chenopodium dessicatum A. Nels. | Desert goos |
| CHENOPODIACEAE | Chenopodium fremontii S. Wats. | Fremont Gc |
| CHENOPODIACEAE | Chenopodium leptophyllum Nutt. ex Moq. | Goosefoot |
| CHENOPODIACEAE | Chenopodium overi Aellen | Overi's Goc |
| CHENOPODIACEAE | Kochia scoparia (L.) Schrad. | Kochia |
| CHENOPODIACEAE | Salsola iberica Senn. & Pau. | Russian-Th |
| CLUSIACEAE | Hypericum majus (A. Gray) Britt. | Greater St. |
| CLUSIACEAE | Hypericum perforatum L. | Common St |
| COMMELINACEAE | Tradescantia occidentalis (Britt.) Smyth | Spiderwort |
| CONVOLVULACEAE | Calystegia macouni (Greene) Brummitt | Hedge Bind |
| CONVOLVULACEAE | Calystegia sepium (L.) R. Br. ssp. angulata Brummitt | Hedge Bind |
| CONVOLVULACEAE | Convolvulus arvensis L. | Field Bindw |
| CONVOLVULACEAE | Evolvulus nuttallianus R. & S. | Evolvulus |
| CRASSULACEAE | Sedum lanceolatum Torr. | Stonecrop |
| CUPRESSACEAE | Juniperus communis L. | Common Ju |
| CUPRESSACEAE | Juniperus scopulorum Sarg. | Rocky Mou |
| CUSCUTACEAE | Cuscuta approximata Bab. | Dodder |
| CYPERACEAE | Carex athrostachya Olney | Sedge |
| CYPERACEAE | Carex aurea Nutt. | Sedge |
| CYPERACEAE | Carex bebbii (Bailey) Fern | Sedge |
| CYPERACEAE | Carex brevior (Dew.) Mack. ex Lunell. | Sedge |
| CYPERACEAE | Carex douglasii F. Boott. | Sedge |
| CYPERACEAE | Carex eleocharis Bailey | Sedge |
| CYPERACEAE | Carex emoryi Dew. | Sedge |
| CYPERACEAE | Carex filifolia Nutt. | Sedge |

| | | |
|---|---|---|
| CYPERACEAE | Carex heliophila Mack. | Sedge |
| CYPERACEAE | Carex hystericina Muhl. ex Willd. | Sedge |
| CYPERACEAE | Carex interior Bailey | Sedge |
| CYPERACEAE | Carex lanuginosa Michx. | Sedge |
| CYPERACEAE | Carex nebrascensis Dew. | Sedge |
| CYPERACEAE | Carex oreocharis Holm. | Sedge |
| CYPERACEAE | Carex praegracilis W. Boott. | Sedge |
| CYPERACEAE | Carex rostrata Stokes ex Willd. | Sedge |
| CYPERACEAE | Carex scoparia Schkuhr. ex Willd. | Sedge |
| CYPERACEAE | Carex simulata Mack. | Sedge |
| CYPERACEAE | Carex stipata Muhl. | Sedge |
| CYPERACEAE | Carex vulpinoidea Michx. | Fox Sedge |
| CYPERACEAE | Cyperus acuminatus Torr. & Hook. | Taperleaf F |
| CYPERACEAE | Eleocharis acicularis (L.) R. & S. | Spikerush |
| CYPERACEAE | Eleocharis compressa Sulliv. | Spikerush |
| CYPERACEAE | Eleocharis macrostachya Britt. | Spikerush |
| CYPERACEAE | Eleocharis obtusa (Willd.) J.A. Schult. | Blunt Spike |
| CYPERACEAE | Eleocharis parvula Link ex Boff. & Fingerbr. var. anachaeta (Torr.) Svens. | Spikerush |
| CYPERACEAE | Scirpus acutus Muhl. | Bulrush |
| CYPERACEAE | Scirpus pallidus (Britt.) Fern | Bulrush |
| CYPERACEAE | Scirpus pungens Vahl | Pungent Bu |
| CYPERACEAE | Scirpus validus Vahl. | Bulrush |
| ELAEAGNACEAE | Elaeagnus angustifolia L. | Russian Oli |
| EQUISETACEAE | Equisetum arvense L. | Field Horse |
| EQUISETACEAE | Equisetum laevigatum A. Br. | Smooth Hoı |
| EQUISETACEAE | Equisetum variegatum Schleich. | Variegated |
| EUPHORBIACEAE | Euphorbia dentata Michx. | Toothed Sp |
| EUPHORBIACEAE | Euphorbia fendleri T. & G. | Fendler's Eı |
| EUPHORBIACEAE | Euphorbia marginata Pursh. | Snow-on-th |
| EUPHORBIACEAE | Euphorbia robusta (Engelm.) Small | Spurge |
| EUPHORBIACEAE | Euphorbia serpyllifolia Pers. | Thyme-leav |
| EUPHORBIACEAE | Euphorbia spathulata Lam. | Spurge |
| EUPHORBIACEAE | Tragia ramosa Nutt. | Noseburn |
| FABACEAE | Amorpha fruticosa L. | False Indigo |
| FABACEAE | Amorpha nana Nutt. | Dwarf Wild |
| FABACEAE | Astragalus adsurgens Pall. var. robustior Hook. | Standing M |
| FABACEAE | Astragalus agrestis Dougl. ex G. Don | Field Milkve |
| FABACEAE | Astragalus bisulcatus (Hook.) A. Gray | Two-groove |
| FABACEAE | Astragalus canadensis L. | Canada Mil |
| FABACEAE | Astragalus crassicarpus Nutt. | Ground-pluı |
| FABACEAE | Astragalus drummondii Dougl. ex Hook. | Drummond |
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| FABACEAE | Astragalus flexuosus (Hook.) G. Don | Pliant Milkv |
| FABACEAE | Astragalus lotiflorus Hook. | Lotus Milk-\ |
| FABACEAE | Astragalus parryi Gray | Parry's Milk |
| FABACEAE | Astragalus shortianus Nutt. ex T.&G. | Short's Milk |
| FABACEAE | Astragalus spathulatus Sheld. | Draba Milk- |
| FABACEAE | Astragalus tridactylicus Gray | Foothill Milk |
| FABACEAE | Coronilla varia L. | Crown Vetc |
| FABACEAE | Dalea candida Michx. ex Willd. var. oligophylla (Torr.) Shinners. | White Prairi |
| FABACEAE | Dalea purpurea Vent | Purple Prai |
| FABACEAE | Glycyrrhiza lepidota Pursh. | Wild Licoric |
| FABACEAE | Lathyrus eucosmus Butters and St. John | Purple Pea |
| FABACEAE | Lotus corniculatus L. | Birdfoot Tre |
| FABACEAE | Lupinus argenteus Pursh ssp. ingratus (Greene) Harmon | |
| FABACEAE | Lupinus argenteus Pursh var. argenteus | Silvery Lupi |
| FABACEAE | Medicago lupulina L. | Black Medic |
| FABACEAE | Medicago sativa L. ssp. sativa | Alfalfa |
| FABACEAE | Melilotus alba Medic. | White Swee |
| FABACEAE | Melilotus officinalis (L.) Pall. | Yellow Swe |
| FABACEAE | Oxytropis lambertii Pursh. | Purple Locc |
| FABACEAE | Psoralea tenuiflora Pursh. | Wild Alfala |
| FABACEAE | Robinia pseudo-acacia L. | Black Locus |
| FABACEAE | Thermopsis rhombifolia var. divaricarpa (Nels.) Isely | Golden Ban |
| FABACEAE | Trifolium hybridum L. | Alsike Clove |
| FABACEAE | Trifolium pratense L. | Red Clover |
| FABACEAE | Trifolium repens L. | White Clove |
| FABACEAE | Vicia americana Muhl. ex Willd. | American V |
| FUMARIACEAE | Fumaria vaillentii Lois | Fumitory |
| GENTIANACEAE | Gentiana affinis Griseb. | Northern Ge |
| GENTIANACEAE | Swertia radiata (Kell.) O. Ktze. | Green Gent |
| GERANIACEAE | Erodium cicutarium (L.) L'Her. | Filaria |
| GERANIACEAE | Geranium caespitosum James ssp. caespitosum | Common W |
| GROSSULARIACEAE | Ribes aureum Pursh | Golden Cur |
| GROSSULARIACEAE | Ribes cereum Dougl. | Western Re |
| GROSSULARIACEAE | Ribes inerme Rydb. | Common G |
| HALORAGACEAE | Myriophyllum exalbescens Fern. | American M |
| HYDROPHYLLACEAE | Hydrophyllum fendleri (Gray) Heller | Waterleaf |
| HYDROPHYLLACEAE | Phacelia heterophylla Pursh. | Scorpionwe |
| IRIDACEAE | Iris missouriensis Nutt. | Western Blu |
| IRIDACEAE | Sisyrinchium montanum Greene | Blue-eyed ( |
| JUNCACEAE | Juncus articulatus L. | Articulate R |
| JUNCACEAE | Juncus balticus Willd. | Baltic Rush |

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| JUNCACEAE | Juncus bufonius L. | Toad Rush |
| JUNCACEAE | Juncus dudleyi Wieg. | Dudley Rus |
| JUNCACEAE | Juncus ensifolius Wikst. var. montanus (Englm.) C. L. Hitchc. | Rush |
| JUNCACEAE | Juncus interior Wieg. | Inland Rush |
| JUNCACEAE | Juncus longistylis Torr. | Rush |
| JUNCACEAE | Juncus nodosus L. | Knotted Ru: |
| JUNCACEAE | Juncus torreyi Cov. | Torrey's Ru |
| JUNCACEAE | Juncus tracyi Rydb. | Tracy Rush |
| LAMIACEAE | Dracocephalum parviflorum Nutt. | Dragonhea |
| LAMIACEAE | Hedeoma hispidum Pursh. | Rough Fals |
| LAMIACEAE | Lycopus americanus Muhl. ex Barton | American B |
| LAMIACEAE | Lycopus asper Greene | Rough Bugl |
| LAMIACEAE | Marrubium vulgare L. | Common H |
| LAMIACEAE | Mentha arvensis L. | Field Mint |
| LAMIACEAE | Monarda fistulosa L. var. menthifolia (Grah.) Fern. | Wild Bergar |
| LAMIACEAE | Monarda pectinata Nutt. | Spotted Be |
| LAMIACEAE | Nepeta cataria L. | Catnip |
| LAMIACEAE | Prunella vulgaris L. | Selfheal |
| LAMIACEAE | Salvia reflexa Hornem. | Lance-leave |
| LAMIACEAE | Scutellaria brittonii Porter | Britton's Sk |
| LAMIACEAE | Stachys palustris L. ssp. pilosa (Nutt.) Epling | Hedge Nett |
| LEMNACEAE | Lemna minor L. | Duckweed |
| LILIACEAE | Allium cernuum Roth | Wild Onion |
| LILIACEAE | Allium geyeri S. Wats. | Geyer's Oni |
| LILIACEAE | Allium textile A. Nels. & Macbr. | Wild White |
| LILIACEAE | Asparagus officinalis L. | Asparagus |
| LILIACEAE | Calochortus gunnisonii S. Wats. | Sego Lily |
| LILIACEAE | Leucocrinum montanum Nutt. | Mountain Li |
| LILIACEAE | Smilacina stellata (L.) Desf. | Spikenard |
| LILIACEAE | Zigadenus venenosus Wats. var. gramineus (Rydb.) Walsh ex Peck | Death Cam |
| LINACEAE | Linum perenne L. var. lewisii (Pursh.) Eat. & Wright | Blue Flax |
| LINACEAE | Linum pratense (Nort.) Small | Norton's Fla |
| LYTHRACEAE | Ammania robusta Herr & Regel. | Robust Too |
| LYTHRACEAE | Lythrum alatum Pursh. | Winged Loc |
| MALVACEAE | Malva neglecta Wallr. | Common M |
| MALVACEAE | Sidalcea candida Gray | White Chec |
| MALVACEAE | Sidalcea neomexicana Gray | New Mexic |
| MALVACEAE | Sphaeralcea coccinea (Pursh.) Rydb. | Red False |
| NYCTAGINACEAE | Mirabilis hirsuta (Pursh.) MacM. | Hairy Four- |
| NYCTAGINACEAE | Mirabilis linearis (Pursh.) Heimerl | Narrowleaf |
| NYCTAGINACEAE | Mirabilis nyctaginea (Michx.) MacM. | Wild Four-O |

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| ONAGRACEAE | Calylophus serrulatus (Nutt.) Raven | Plains Yello |
| ONAGRACEAE | Epilobium ciliatum Raf. ssp. glandulosum (Lehm.) Hock & Raven | Willow Herb |
| ONAGRACEAE | Epilobium paniculatum Nutt. | Willow Herb |
| ONAGRACEAE | Gaura coccinea Pursh. | Scarlet Gau |
| ONAGRACEAE | Gaura parviflora Dougl. | Velvety Gau |
| ONAGRACEAE | Oenothera flava (A. Nels.) Garrett | Evening Pri |
| ONAGRACEAE | Oenothera howardii (A. Nels.) W. L. Wagner | Yellow Sten |
| ONAGRACEAE | Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven | Common E |
| ORCHIDACEAE | Habenaria hyperborea (L.) R. Br. | Northern Gr |
| OROBANCHACEAE | Orobanche fasciculata Nutt. | Broomrape |
| OXALIDACEAE | Oxalis dillenii Jacq. | Gray-Green |
| PAPAVERACEAE | Argemone polyanthemos (Fedde) G. Ownbey | Prickly Popp |
| PINACEAE | Picea pungens Engelm. | Blue Spruce |
| PINACEAE | Pinus ponderosa Laws | Ponderosa |
| PINACEAE | Pseudotsuga menziesii (Mirb.) Franco | Douglas-Fir |
| PLANTAGINACE | Plantago lanceolata L. | English Plan |
| PLANTAGINACE | Plantago major L. | Common Pl |
| PLANTAGINACE | Plantago patagonica Jacq. | Patagonian |
| POACEAE | Aegilops cylindrica Host | Jointed Goa |
| POACEAE | Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc. | Slender Wh |
| POACEAE | Agropyron cristatum (L.) Gaertn. | Crested Wh |
| POACEAE | Agropyron dasystachyum (Hook.) Scribn. | |
| POACEAE | Agropyron desertorum (Fisch.) Schult. | Crested Wh |
| POACEAE | Agropyron elongatum (Host) Beauv. | Tall Wheatg |
| POACEAE | Agropyron griffithsii Scribn. & Smith | |
| POACEAE | Agropyron intermedium (Host) Beauv. | Intermediate |
| POACEAE | Agropyron repens (L.) Beauv. | Quackgrass |
| POACEAE | Agropyron smithii Rydb. | Western Wh |
| POACEAE | Agropyron spicatum (Pursh) Scribn. and Sm. | Bluebunch |
| POACEAE | Agrostis scabra Willd. | Ticklegrass |
| POACEAE | Agrostis stolonifera L. | Redtop |
| POACEAE | Alopecurus geniculatus L. | Marsh Foxta |
| POACEAE | Andropogon gerardii Vitman | Big Blueste |
| POACEAE | Andropogon saccharoides Sw. var. torreyanus (Steud.) Hack. | Silver Blues |
| POACEAE | Andropogon scoparius Michx. | Little Bluest |
| POACEAE | Apera interrupta (L.) Beauvois | Italian Wind |
| POACEAE | Aristida basiramea Engelm. ex Vasey var. basiramea | Forktip Thre |
| POACEAE | Aristida purpurea Nutt. var. longiseta (Steud.) Vasey | Fendler Thr |
| POACEAE | Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr | Red Threea |
| POACEAE | Avena fatua var. sativa (L.) Hausskn. | Cultivated C |
| POACEAE | Bouteloua curtipendula (Michx.) Torr. | Side-oats G |

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| POACEAE | Bouteloua gracilis (H. B. K.) Lag ex Griffiths | Blue Grama |
| POACEAE | Bouteloua hirsuta Lag | Hairy Gram |
| POACEAE | Bromus briziformis F. & M. | Rattlesnake |
| POACEAE | Bromus inermis Leyss. ssp. inermis | Smooth Brc |
| POACEAE | Bromus japonicus Thunb. ex Murr. | Japanese B |
| POACEAE | Bromus tectorum L. | Downy Bror |
| POACEAE | Buchloe dactyloides (Nutt.) Engelm. | Buffalo-gras |
| POACEAE | Calamagrostis stricta (Timm.) Koel | Northern Re |
| POACEAE | Cenchrus longispinus (Hack.) Fern | Field Sandb |
| POACEAE | Ceratochloa marginata (Nees ex Stued.) Jackson | Rescuegras |
| POACEAE | Dactylis glomerata L. | Orchardgra |
| POACEAE | Danthonia spicata (L.) Beauv. ex R. & S. | Poverty Oat |
| POACEAE | Dichanthelium linearifolium (Scribn.) Gould | Slimleaf Dic |
| POACEAE | Dichanthelium oligosanthes (Schultz) Gould var. scribnerianum (Nash) G | Scribner Di |
| POACEAE | Digitaria sanguinalis (L.) Scop. | Hairy Crabg |
| POACEAE | Echinochloa crusgallii (L.) Beauv. | Barnyard G |
| POACEAE | Elymus canadensis L. | Canada Wil |
| POACEAE | Elymus juncea Fisch. | Russian Wi |
| POACEAE | Eragrostis cilianensis (All.) E. Mosher | Stinkgrass |
| POACEAE | Eragrostis curvula (Schrad.) Nees | Weeping Lc |
| POACEAE | Eragrostis minor Host | Little Loveg |
| POACEAE | Eragrostis pilosa (L.) Beauv. | India Loveg |
| POACEAE | Eragrostis trichodes (Nutt.) Wood | Sand Loveg |
| POACEAE | Festuca octoflora Walt. | Six-weeks F |
| POACEAE | Festuca ovina L. var. rydbergii St. Yves | Sheep's Fe |
| POACEAE | Festuca pratensis Huds. | Meadow Fe |
| POACEAE | Glyceria grandis S. Wats. ex A. Gray | Tall Manna |
| POACEAE | Glyceria striata (Lam.) Hitchc. | Fowl Manna |
| POACEAE | Hordeum brachyantherum Nevski | Meadow Ba |
| POACEAE | Hordeum jubatum L. | Foxtail Barl |
| POACEAE | Koeleria pyramidata (Lam.) Beauv. | Junegrass |
| POACEAE | Leersia oryzoides (L.) Sw. | Rice Cutgra |
| POACEAE | Lolium perenne L. var. aristatum Willd. | Italian Ryeg |
| POACEAE | Lolium perenne L. var. perenne | Perennial R |
| POACEAE | Lycurus phleoides H.B.K. | Wolftail |
| POACEAE | Muhlenbergia asperifolia (Nees. & Mey.) Parodi | Scratchgras |
| POACEAE | Muhlenbergia filiformis (Thurb.) Rydb. | Muhly |
| POACEAE | Muhlenbergia montana (Nutt.) Hitchc. | Mountain M |
| POACEAE | Muhlenbergia racemosa (Michx.) B. S. P. | Marsh Muhl |
| POACEAE | Muhlenbergia wrightii Vasey | Spike Muhly |
| POACEAE | Oryzopsis hymenoides (R. & S.) Ricker | Indian Rice |
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| POACEAE | Panicum capillare L. | Witchgrass |
| POACEAE | Panicum dichotomiflorum Michx. | Fall Panicu |
| POACEAE | Panicum virgatum L. | Switchgrass |
| POACEAE | Phalaris arundinacea L. | Reed Cana |
| POACEAE | Phleum pratense L. | Timothy |
| POACEAE | Phragmites australis (Cav.) Trin. ex Steud. | Common R |
| POACEAE | Poa bulbosa L. | Bulbous Blu |
| POACEAE | Poa canbyi (Scribn.) Piper | Canby's Blu |
| POACEAE | Poa compressa L. | Canada Blu |
| POACEAE | Poa fendleriana (Steud.) Vasey | Muttongrass |
| POACEAE | Poa juncifolia Scribn. | Alkali Blueg |
| POACEAE | Poa palustris L. | Fowl Bluegr |
| POACEAE | Poa pratensis L. | Kentucky B |
| POACEAE | Polypogon monspeliensis (L.) Desf. | Rabbitfoot ( |
| POACEAE | Schedonnardus paniculatus (Nutt.) Trel. | Tumblegras |
| POACEAE | Secale cereale L. | Rye |
| POACEAE | Setaria viridis (L.) Beauv. | Green Foxta |
| POACEAE | Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc. | Squirreltail |
| POACEAE | Sorghastrum nutans (L.) Nash | Indian-grass |
| POACEAE | Spartina pectinata Link | Prairie Corc |
| POACEAE | Sphenopholis obtusata (Michx.) Scribn. | Prairie Wed |
| POACEAE | Sporobolus asper (Michx.) Kunth | Rough Drop |
| POACEAE | Sporobolus cryptandrus (Torr.) A. Gray | Sand Drops |
| POACEAE | Sporobolus heterolepis (A. Gray) A. Gray | Prairie Drop |
| POACEAE | Sporobolus neglectus Nash | Poverty Gra |
| POACEAE | Stipa comata Trin. & Rupr. | Needle-and |
| POACEAE | Stipa neomexicana (Thur.) Scribn. | New Mexico |
| POACEAE | Stipa robusta (Vasey) Scribn. | Sleepy Gras |
| POACEAE | Stipa spartea Trinius | Porcupine-g |
| POACEAE | Stipa viridula Trin. | Green Need |
| POACEAE | Triticum aestivum L. | Wheat |
| POACEAE | X Agrohordeum macounii (Vasey) Lepage | |
| POLEMONIACEAE | Collomia linearis Nutt. | Collomia |
| POLEMONIACEAE | Gilia opthalmoides Brand. ssp. clokeyi (Mason) A. & V. Grant | Gilia |
| POLEMONIACEAE | Ipomopsis spicata (Nutt.) V. Grant ssp. spicata | Spike Gilia |
| POLEMONIACEAE | Microsteris gracilis (Hook.) Greene | |
| POLEMONIACEAE | Navarretia minima Nutt. | Navarretia |
| POLYGONACEAE | Eriogonum alatum Torr. | Winged Eric |
| POLYGONACEAE | Eriogonum effusum Nutt. | Spreading \ |
| POLYGONACEAE | Eriogonum jamesii Benth. | James' Wilc |
| POLYGONACEAE | Eriogonum umbellatum Torr. | Sulphur Flo |
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| POLYGONACEAE | Polygonum arenastrum Jord. ex Bor. | Knotweed |
| POLYGONACEAE | Polygonum convolvulus L. | Wild Buckw |
| POLYGONACEAE | Polygonum douglasii Greene | Knotweed |
| POLYGONACEAE | Polygonum hydropiper L. | Water Pepp |
| POLYGONACEAE | Polygonum lapathifolium L. | Pale Smartv |
| POLYGONACEAE | Polygonum pensylvanicum L. | Pennsylvan |
| POLYGONACEAE | Polygonum persicaria L. | Lady's Thur |
| POLYGONACEAE | Polygonum ramosissimum Michx. | Knotweed |
| POLYGONACEAE | Polygonum sawatchense Small | Knotweed |
| POLYGONACEAE | Rumex acetosella L. | Sheep Sorr |
| POLYGONACEAE | Rumex crispus L. | Curly Dock |
| POLYGONACEAE | Rumex maritimus L. | Golden Doc |
| POLYGONACEAE | Rumex obtusifolius L. | Bitter Dock |
| POLYGONACEAE | Rumex salicifolius Weinm. ssp. triangulivalvis Danser | Willow Docl |
| POLYPODIACEAE | Cystopteris fragilis (L.) Bernh. | Fragile Ferr |
| PORTULACACEAE | Claytonia rosea Rydb. | Spring Beau |
| PORTULACACEAE | Portulaca oleracea L. | Common Pı |
| PORTULACACEAE | Talinum parviflorum Nutt. | Prairie Fam |
| POTAMOGETONACEAE | Potamogeton foliosus Raf. | Leafy Pond' |
| POTAMOGETONACEAE | Potamogeton natans L. | Floatingleaf |
| PRIMULACEAE | Androsace occidentalis Pursh. | Western Rc |
| PRIMULACEAE | Dodecatheon pulchellum (Raf.) Merrill | Shooting St |
| PRIMULACEAE | Lysimachia ciliata L. | Fringed Loc |
| RANUNCULACEAE | Anemone cylindrica A. Gray | Candle Ane |
| RANUNCULACEAE | Anemone patens L. | Pasque-flov |
| RANUNCULACEAE | Clematis hirsutissima Pursh | Hairy Clema |
| RANUNCULACEAE | Clematis ligusticifolia Nutt. | Western Cle |
| RANUNCULACEAE | Delphinium nuttalianum Pritz. ex Walpers | Blue Larksp |
| RANUNCULACEAE | Delphinium virescens Nutt. ssp. penardii (Huth) Ewan | Prairie Lark |
| RANUNCULACEAE | Myosurus minimus L. | Mousetail |
| RANUNCULACEAE | Ranunculus macounii Britt. | Macoun's B |
| RANUNCULACEAE | Ranunculus scleratus L. | Cursed Cro |
| RANUNCULACEAE | Ranunculus trichophyllus Chaix | Hairy Leaf E |
| RANUNCULACEAE | Thalictrum dasycarpum Fisch. & Ave-Lall | Purple Mea |
| RHAMNACEAE | Ceanothus fendleri A. Gray | Buckbrush |
| RHAMNACEAE | Ceanothus herbaceus Raf. var. pubescens (T. & G.) | New Jersey |
| ROSACEAE | Agrimonia striata Michx. | Striate Agri |
| ROSACEAE | Amelanchier alnifolia Nutt. | Saskatoon : |
| ROSACEAE | Crataegus erythropoda Ashe | Hawthorne |
| ROSACEAE | Crataegus succulenta Link var. occidentalis (Britton) E. J. Palm. | Hawthorn |
| ROSACEAE | Geum aleppicum Jacq. | Yellow Aver |

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| ROSACEAE | Geum macrophyllum Willd. | Large-leave |
| ROSACEAE | Physocarpus monogynus (Torr.) Coult. | Mountain N |
| ROSACEAE | Physocarpus opulifolius (L.) Raf. | Ninebark |
| ROSACEAE | Potentilla arguta Pursh | Tall Cinque |
| ROSACEAE | Potentilla fissa Nutt. | Cinquefoil |
| ROSACEAE | Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc. | Cinquefoil |
| ROSACEAE | Potentilla hippiana Lehm. | Wooly Cinq |
| ROSACEAE | Potentilla norvegica L. | Norwegian |
| ROSACEAE | Potentilla paradoxa Nutt. | Bushy Cinq |
| ROSACEAE | Potentilla pensylvanica L. | Cinquefoil |
| ROSACEAE | Potentilla pulcherrima x hippiana | Hybrid Cinq |
| ROSACEAE | Potentilla rivalis Nutt. | Cinquefoil |
| ROSACEAE | Prunus americana Marsh. | Wild Plum |
| ROSACEAE | Prunus pumila L. var. besseyi (Bailey) Gl. | Sand Cherr |
| ROSACEAE | Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg. | Chokecherr |
| ROSACEAE | Pyrus malus L. | Apple |
| ROSACEAE | Rosa acicularis Lindl. | Prickly Wild |
| ROSACEAE | Rosa arkansana Porter | Prairie Wild |
| ROSACEAE | Rosa woodsii Lindl. | Western Wi |
| ROSACEAE | Rubus deliciosus Torr. | Boulder Ra: |
| ROSACEAE | Rubus idaeus L. ssp. sachalinensis (Levl.) Focke var. sachalinensis | Raspberry |
| ROSACEAE | Sanguisorba minor Scop. | Burnet |
| ROSACEAE | Sorbus scopulina Greene | Mountain A: |
| RUBIACEAE | Galium aparine L. | Catchweed |
| RUBIACEAE | Galium septentrionale Roemer & Schultes | Northern Be |
| SALICACEAE | Populus alba L. | Silver Popla |
| SALICACEAE | Populus angustifolia James | Narrow-leav |
| SALICACEAE | Populus deltoides Marsh. ssp. monilifera (Ait.) Eckenw. | Plains Cottc |
| SALICACEAE | Populus x acuminata Rydb. | Lanceleaf C |
| SALICACEAE | Salix amygdaloides Anderss. | Peach-leaf |
| SALICACEAE | Salix exigua Nutt. ssp. exigua | Coyote Will |
| SALICACEAE | Salix exigua Nutt. ssp. interior (Rowlee) Cronq. | Sandbar Wi |
| SALICACEAE | Salix fragilis L. | Crack Willo |
| SALICACEAE | Salix irrorata Andersson | |
| SALICACEAE | Salix lutea Nutt. | Yellow Willc |
| SANTALACEAE | Comandra umbellata (L.) Nutt. | Bastard To: |
| SAXIFRAGACEAE | Heuchera parvifolia Nutt. ex T.& G. | Alumroot |
| SAXIFRAGACEAE | Saxifraga rhomoidea Greene | Diamondlea |
| SCROPHULARIACEAE | Castilleja integra A. Gray | Orange Pai |
| SCROPHULARIACEAE | Castilleja sessiliflora Pursh. | Downy Pair |
| SCROPHULARIACEAE | Collinsia parviflora Doug. ex Lindl. | Blue Lips |

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| SCROPHULARIACEAE | Gratiola neglecta Torr. | Hedge Hys: |
| SCROPHULARIACEAE | Limosella aquatica L. | Mudwort |
| SCROPHULARIACEAE | Linaria dalmatica (L.) Mill. | Toadflax |
| SCROPHULARIACEAE | Linaria vulgaris Hill | Butter-and- |
| SCROPHULARIACEAE | Mimulus floribundus Dougl. ex Lindl. | Monkey Flo |
| SCROPHULARIACEAE | Mimulus glabratus H. B. K. var. fremontii (Benth.) A. L. Grant | Roundleaf I |
| SCROPHULARIACEAE | Penstemon albidus Nutt. | White Bear |
| SCROPHULARIACEAE | Penstemon secundiflorus Benth. | Penstemon |
| SCROPHULARIACEAE | Penstemon strictus Bentham in De Candolle | Rocky Mou |
| SCROPHULARIACEAE | Penstemon virens Penn. | Slender Pe |
| SCROPHULARIACEAE | Penstemon virgatus Gray ssp. asa-grayi Crosswhite | Penstemon |
| SCROPHULARIACEAE | Scrophularia lanceolata Pursh. | Figwort |
| SCROPHULARIACEAE | Verbascum blattaria L. | Moth Mullei |
| SCROPHULARIACEAE | Verbascum thapsus L. | Common M |
| SCROPHULARIACEAE | Veronica americana (Raf.) Schwein. ex Benth. | Brooklime S |
| SCROPHULARIACEAE | Veronica anagallis-aquatica L. | Water Spee |
| SCROPHULARIACEAE | Veronica catentata Penn. | Catenate Ir |
| SCROPHULARIACEAE | Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren | Purslane S |
| SELAGINELLACEAE | Selaginella densa Rydb. | Spikemoss |
| SMILACACEAE | Smilax herbacea L. var. lasioneura (Small) Rydb.. | Carrion Flo |
| SOLANACEAE | Physalis heterophylla Nees | Clammy Gr |
| SOLANACEAE | Physalis pumila Nutt. ssp. Hispida (Waterfall) Hinton | Prairie Gro |
| SOLANACEAE | Physalis virginiana P. Mill. | Virginia Gro |
| SOLANACEAE | Quincula lobata (Torr.) Raf. | Purple Gro |
| SOLANACEAE | Solanum rostratum Dun. | Buffalo Bur |
| SOLANACEAE | Solanum triflorum Nutt. | Cut-leaved |
| TAMARICACEAE | Tamarix ramosissima Ledeb. | Salt Cedar |
| TYPHACEAE | Typha angustifolia L. | Narrow-lea |
| TYPHACEAE | Typha latifolia L. | Common C |
| ULMACEAE | Ulmus pumila L. | Siberian Elr |
| URTICACEAE | Parietaria pensylvanica Muhl. ex Willd. | Pennsylvan |
| URTICACEAE | Urtica dioica L. ssp. gracilis (Ait.) Seland. | Stinging Ne |
| VERBENACEAE | Lippia cuneifolia (Torr.) Steud. | Fog-fruit |
| VERBENACEAE | Verbena bracteata Lag. & Rodr. | Prostrate V |
| VERBENACEAE | Verbena hastata L. | Blue Vervai |
| VIOLACEAE | Hybanthus verticillatus (Ort.) Baill. | Nodding Gr |
| VIOLACEAE | Viola nuttallii Pursh. | Yellow Prai |
| VIOLACEAE | Viola rydbergii Greene | Rydberg's \ |
| VIOLACEAE | Viola scopulorum (Gray) Greene | Colorado Vi |
| VIOLACEAE | Viola sororia Willd. | Northern Bo |
| VITACEAE | Vitis riparia Michx. | River-bank |
| | | |

| | | |
|---|---|---|
| ZYGOPHYLLACEAE | Tribulus terrestris L. | Puncture Vi |

# Appendix C

# Rocky Flats Environmental Technology Site

## Photographic Monitoring Results (1997-2001)

As part of the ongoing ecological monitoring at the Rocky Flats Environmental Technology Site (Site), permanent photo points were set in place in 1997 to provide a visual baseline of the current conditions of the various plant communities at the Site at that time. In 1999, 2000, and 2001, photographs were retaken at these locations and examined to evaluate any changes in the plant communities. By clicking on one of the images below you can link to a map that shows the locations of the permanent photo points at the Site. To view side by side comparisons of one of the sets of photographs taken at that location in 1997, 1999, 2000, and 2001, click on that photo point.

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# Appendix D

## Photo Monitoring Results from Project Disturbances and Revegetation /Restoration Activities in the Buffer Zone at Rocky Flats Environmental Technology Site

In 1999, remediation projects disturbed several acres of native and previously reclaimed grassland at Rocky Flats. Revegetation was a required activity at the conclusion of each project. The links below will take you to maps and photographs showing the locations and extent of the restoration efforts undertaken to restore these areas with native plant species. Monitoring efforts continued to document the recovery during 2000 and 2001. Photographs taken at photo points during 2001 have been added to the web pages to provide a time-series of the recovery at these project locations. Click on the links below to view the various projects.

McKay Ditch Project

Solar Ponds and Tanks Pipeline Projects

T-1 Trench and East Trenches Projects

South Buffer Zone Road Revegetation Project

Large Map Showing All 1999 Projects (Linked to Projects)

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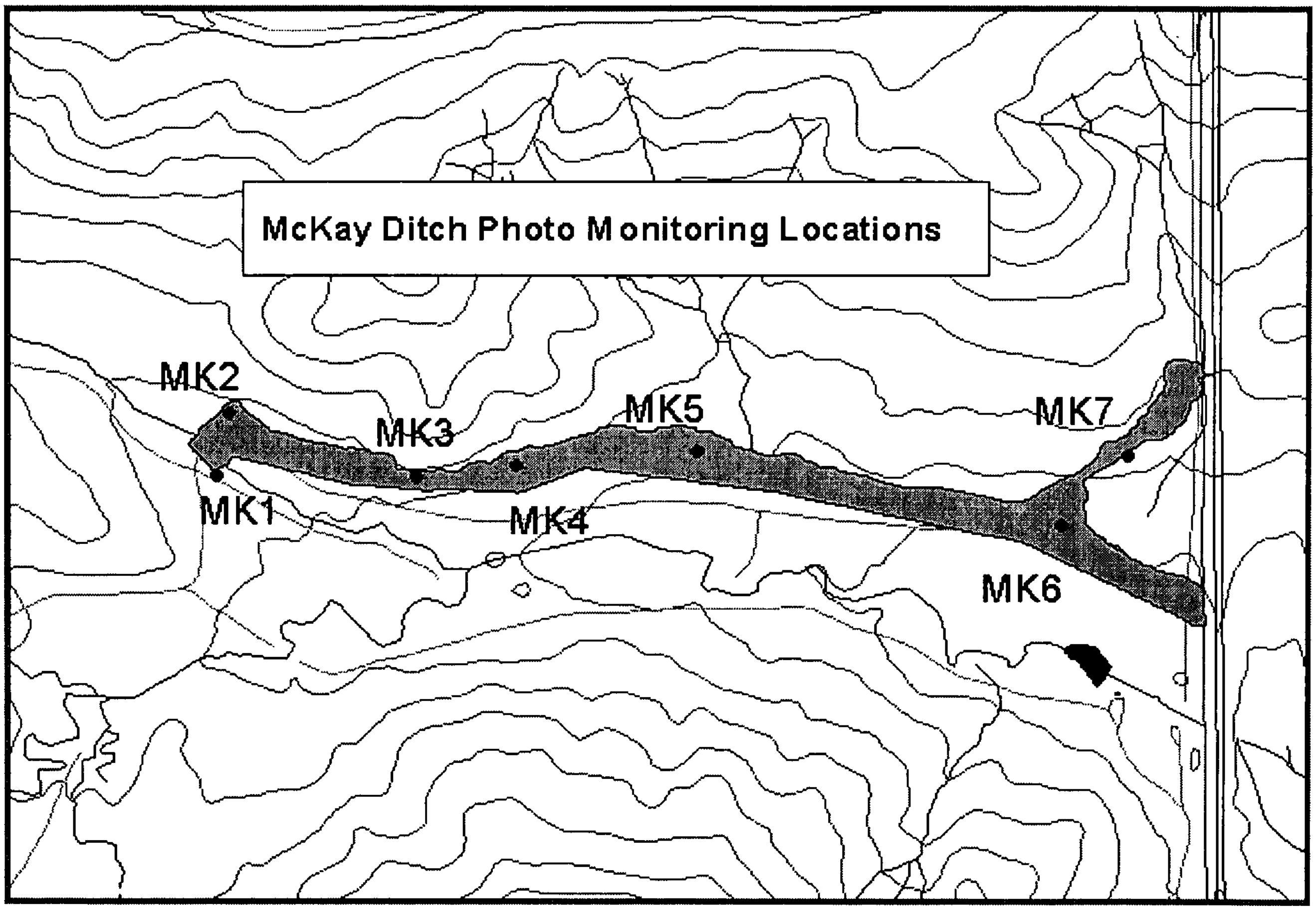
# McKay Ditch Restoration/Revegetation Photo Monitoring Project

### Rocky Flats Environmental Technology Site, Ecology Group

During 1999, a water diversion pipeline was buried across a portion of the northeast Buffer Zone at the Rocky Flats Environmental Technology Site (Site). It was decided that photo monitoring would be an appropriate design to visually document the progression of the restoration/revegetation effort for Site managers and ecologists. The monitoring plan used both photo point and photo quadrats to document changes of the landscape views and ground's surface. To see currently available photographs of the restoration effort click on the photo locations on the project map below. The seed mix used for the restoration is available by clicking here.

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