1998 Annual Vegetation Report

1998 Annual Vegetation Report for the Rocky Flats Environmental Technology Site June 30, 1999

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Acronyms and Abbreviations

CDA	Colorado Department of Agriculture
CNHP	Colorado Natural Heritage Program
DOE	U.S. Department of Energy
GIS	Geographic Information System
GPS	Global Positioning System
K-H	Kaiser Hill Company, LLC
QA/QC	Quality Assurance and Quality Control
Site	Rocky Flats Environmental Technology Site

Executive Summary

This report summarizes the results of the vegetation monitoring that was conducted at the Rocky Flats Environmental Technology Site (Site) during 1998. 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. The goal of vegetation monitoring is to assess the status and quality of the plant communities on the Site, document any trends, and assess the effectiveness of various management techniques.

At an elevation of approximately 6000 feet, the Site contains a unique ecotonal mixture of mountain and prairie plant species resulting from the topography of the area and close proximity to the mountain front. The Buffer Zone, the area surrounding the Industrial Area, is one of the largest remaining undeveloped areas of its kind along the Colorado Piedmont. 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. 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, and Hops blue and Arogos skipper butterflies.

Vegetation monitoring is conducted at the Site using several methods to meet the monitoring objectives. During 1998 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, and quantitative assessments of the effectiveness of herbicide applications and potential associated impacts to the native plant communities.

Monitoring of the xeric tallgrass prairie during 1998 was conducted to evaluate the quality of the grassland and to document any changes in species composition at some of the permanent sampling locations. Monitoring continued to document the generally high quality of this rare plant community on the Site. Community-wide species richness inventories of the xeric tallgrass prairie documented the presence of 295 plant species in the community, including the continued presence of the relict tallgrass prairie species (big bluestem, little bluestem, indiangrass, switchgrass, prairie dropseed, and porcupine grass) characteristic of this rare community. Comparison of 1998 quantitative monitoring results for species richness and vegetation cover to previously collected data showed little change in the composition of the community. Most species showed fluctuations in cover, however, which are typical of annual responses to changes in local environmental

conditions. One species, little bluestem, which is one of the relict tallgrass species found on the grasslands on the Site, showed a decline in cover across all years. However, this decline is suspected to be a result of the 1994 late-summer drought, after which many of the observed plants had died. Another species, Porter's aster, seemed to be showing a cyclical response, having reached a peak in abundance in 1995 and then began to decline. For the most part, however, the composition of the prairie at the sites monitored was the same as in the past, with the same top three or four species providing most of the vegetation cover. Qualitative assessments of the xeric tallgrass prairie continued to document the threats facing this community, which include noxious weeds and dead plant litter buildup. These are discussed below.

Baseline monitoring was conducted at three large wetland complexes at the Site during 1998. The purpose of the monitoring was to provide quantitative species composition information for use in evaluating any future change in the wetland communities. The study documented a total of 95 vascular plant species at the wetland study locations. The dominant species in the wetland communities were Arctic rush, broadleaf cat-tail, and wooly sedge, all of which are common wetlands species in this region. A prairie cordgrass wetland community type was identified on the Site and is considered by the CNHP to be a critically imperiled community in the state of Colorado due to its rarity. Although only small patches of the community occur at the Site within the wetlands, the presence of this wetland type is further evidence of the uniqueness, health, and high quality of the ecological resources that have been preserved at the Site. Canada thistle, a noxious weed, was found at all three wetland complexes surveyed, but it was more abundant in the north Buffer Zone wetlands than at the Antelope Springs/Apple Orchard complex in the south Buffer Zone. Release of additional biological control agents could help control this species in the wetlands on the Site. In the long term however, the use of herbicides may also be necessary. The baseline information gathered at the wetlands in 1998 provides an additional tool for detecting change in the wetland communities and helping to preserve the integrity and quality of the Site's ecosystems.

During the 1998 field season, seven new records of vascular plant species were recorded for the Site, bringing the total number of plant species known to occur at Rocky Flats to 576. Unfortunately, one of the new records for 1998 was Russian knapweed, which is considered a noxious weed under Colorado statutes. The population was treated with an herbicide to begin immediate weed control and prevent its further spread at the Site. Herbicide treatments of the population will be continued in 1999 to eradicate the species from its only known location on the Site.

Monitoring continued during 1998 to determine the effect of applying the herbicide Tordon 22K on diffuse knapweed and native plant species on the xeric tallgrass prairie. Quantitative studies revealed that diffuse knapweed was significantly reduced in the treatment areas. Qualitative observations also showed no adult knapweed plants present in the treatment plot. There were, however, some impacts to other native plant species. Overall species diversity (a measure that combines species richness and abundance into a single measurement) declined and native forb abundance (cover) decreased in the treatment plot. In addition, cactus densities were also reduced by the herbicide. None of

these impacts however, were serious enough to warrant discontinuation of herbicide applications. In addition to controlling diffuse knapweed, results also showed an added benefit in that several other weed species including musk thistle, salsify, western ragweed, wild lettuce, and alyssum, were reduced in abundance as a result of the herbicide treatment. These Site data are in general agreement with studies conducted elsewhere that have shown similar effects on grassland communities after treatment with Tordon 22K. Those studies showed that long-term impacts to the native species were negligible and disappeared after a year or two. It is expected that similar results will be seen at the Site. Continued monitoring of the plots on the Site will assess the long-term effects, and will also determine how long the herbicide controls the diffuse knapweed before reapplication is necessary.

At the location of a 1996 grassland fire in the Buffer Zone where diffuse knapweed was present, monitoring was continued to evaluate whether a late-summer fire would affect diffuse knapweed densities. The third year of data showed that the increases in diffuse knapweed densities at the burned locations could not be attributed to the fire, because similar increases also occurred at control locations. However, the large increases shown in diffuse knapweed density at both the burned and unburned locations continue to underscore the need for aggressive control to prevent the further spread of diffuse knapweed across the Site.

Weed mapping continued to indicate that the most serious threat to the xeric tallgrass prairie and other plant communities on the Site is from noxious weeds. Diffuse knapweed is the most serious of these threats, now infesting approximately 45 percent of the Site. Although several hundred acres were treated with the herbicides Tordon 22K and Transline during 1997, weed mapping conducted in 1998 indicated that there was still an overall net increase in the number of acres infested by diffuse knapweed on the Site. Qualitative assessments of the herbicide treatment areas showed that the diffuse knapweed was effectively controlled where the ground equipment used for herbicide application was able to provide a continuous, even application of the herbicide. However, where uneven ground, obstacles, or steep slopes were present, the effectiveness of the applications was reduced because the ground vehicles had limited or no access to these areas, and hose or backpack application was required. Without an increase in the current level of effort, diffuse knapweed is likely to infest the entire Site within the next several years. Aerial application of herbicides would provide the most economical and effective control of large-scale weed problems.[1]

Another factor contributing to the degradation of the native plant communities on the is continued human disturbance. During 1998, field surveys identified two activities that have disturbed the soil surface at some locations, making these areas vulnerable to further noxious weed invasion. Where reduced blading of the main roads in the Buffer Zone has

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[1]An aerial herbicide application of Tordon 22K was conducted over 1500 acres at Rocky Flats in June 1999. The results and details of this effort will be reported in next years annual vegetation report.

been conducted to minimize the width of the roads, weed control and revegetation is now necessary to keep the weeds which have been established along the road edges from spreading into the surrounding grasslands. At locations near the gravel mining operations on the western edge of the Site, both old and new test pit disturbances are creating and have created weed islands, from which the weeds (especially diffuse knapweed) readily spread across the xeric tallgrass prairie. Weed control and revegetation are necessary along these disturbances and surrounding grasslands to reduce the weed problems at the Site.

Vegetation monitoring in 1998 continued to document the generally high quality of the native plant communities at the Site. However, the results also continued to underscore the serious issues that threaten the quality and long-term sustainability of the Site's ecological resources. These threats come primarily from weeds, disturbances, and plant litter build up, the latter of which has resulted from an absence of wildfires and/or grazing. Yet the data indicate that beneath the sometimes visually dominant weedy appearance, the native plant communities are still present. In fact, management actions such as weed control have been shown to improve the condition of the grasslands at the Site. Continued active management of these native communities is necessary if they are to survive over the long term, maintain their ecological value, and remain for the future. Through good stewardship and use of best management practices, the Site's current ecological resource management plan and weed control plan provide guidance for managing the resources in a sustainable manner. As stewards of the ecological resources at the Site, Kaiser-Hill and DOE are continually striving to preserve and maintain the heritage these unique resources represent for the future.

1998 Annual Vegetation Report

1. 1999 Annual Vegetation Report

1.1 Introduction

Rocky Flats Environmental Technology Site (Site) is a U.S. Department of Energy (DOE) facility located on the Colorado Piedmont east of the Front Range between Boulder and Golden, Colorado. The Site is located in Jefferson County, approximately 16 miles northwest of downtown Denver (Figure 1). In production from 1951 through 1989, the Site manufactured nuclear weapons components for the Cold War. Since shutdown, it has been classified as a Superfund site and is currently undergoing cleanup and closure. One of the DOE's goals has been to preserve the unique ecological resources found at the Site (K-H 1997a).

At an elevation of approximately 6000 feet, the Site contains a unique ecotonal mixture of mountain and prairie plant species resulting from the topography and close proximity to the mountain front. The Buffer Zone, the area surrounding the Industrial Area, is one of the largest remaining undeveloped areas of its kind along the Colorado Piedmont (approx. 5600 acres; K-H 1997b). A number of plant communities present at the Site have been identified as increasingly rare and unique by the Kaiser-Hill Company (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 (CNHP 1994; 1995). 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, and Hops blue and Arogos skipper butterflies (CNHP 1994; 1995).

The 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. The goal of vegetation monitoring is to assess the status and quality of the plant communities on the Site, document any trends, and assess the effectiveness of various management techniques. Ecological monitoring is an integral aspect of determining whether the management objectives and goals for the plant communities at the Site are being achieved (K-H 1997a, 1997b). Annual reports produced to synthesize and interpret the information provide the DOE with important and timely information necessary for wise stewardship and management of the Site's ecological resources.

This report summarizes the results of the vegetation monitoring conducted during 1998. Several monitoring techniques were used to evaluate the status and condition of the plant communities on the Site. General descriptions of the methods used are outlined in the following section, with summaries of the monitoring results presented in subsequent sections. Detailed technical reports for each of the specific monitoring activities conducted in 1998 are found in Appendix A.

1.2 Methods

Vegetation monitoring is conducted at the Site using several methods to meet the monitoring objectives. During 1998 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, and quantitative assessments of the effectiveness of herbicide applications and potential associated impacts to the native plant communities.

1.2.1 High-Value Vegetation Surveys

The goal of the high-value vegetation monitoring is to qualitatively assess the status and quality of the high-value plant communities (xeric tallgrass prairie, tall upland shrubland, selected wetlands, and Great Plains riparian woodland) on the Site and to document any changes in these areas. The high-value plant communities at the Site are those identified by K-H Ecology Group and the CNHP as containing significant or rare ecological resources at both the local and regional scale (K-H 1997b, 1997c; CNHP 1994, 1995).

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

- assess the species richness of the plant communities
- identify any rare plant populations
- 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 applications
- assess the impacts of disturbance on the plant communities
- provide a general assessment of the overall status and quality of the plant communities at the Site.

1.2.1.1 Species Richness Surveys

The xeric tallgrass prairie was monitored in 1998 as part of the rotating schedule for monitoring high-value vegetation communities on the Site. It was previously monitored in 1997, when all the high-value vegetation communities were monitored for the first time. Species richness was inventoried in each of the 12 xeric tallgrass prairie management units (Figure 2). Inventories were conducted by traversing each management unit twice during the growing season (in spring and late summer) and recording all vascular plant species observed. Attempts were made to visit, as completely as possible, all areas and microhabitats occurring within each management unit.

1.2.1.2 Weed Mapping Surveys

Sitewide weed mapping continued for selected species as a means of identifying high-priority treatment areas, monitoring the distribution of specific noxious weed species on the Site, and tracking the effectiveness of weed control at the Site. Weed mapping was conducted on foot during the high-value vegetation surveys in the xeric tallgrass prairie, and from a vehicle using binoculars for the remainder of the Site. Species were mapped during their respective flowering periods, when they were most visible. The species mapped included diffuse knapweed (*Centaurea diffusa*), musk thistle (*Carduus nutans*), dalmatian toadflax (*Linaria dalmatica*), and common mullein (*Verbascum thapsus*). These species had also been mapped sitewide in 1997. An additional four species, Russian knapweed (*Centaurea repens*), annual rye (*Secale cereale*), Scotch thistle (*Onopordum acanthium*), and jointed goatgrass (*Aegilops cylindrica*), were also mapped in 1998 due to their increasing infestation levels and concern over the aggressiveness of these species. Canada thistle (*Cirsium arvense*) was not mapped because it is common throughout most of the wetlands on the Site, and the wetlands map would therefore provide a good indication of the infested areas.

Infestation areas were classified in general density categories of high-, medium-, low-, and scattered-densities, based on a subjective interpretation of the extent, visual density, need for control, and aggressive nature of the species. In general, a high-density category indicated 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 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 in need of control. The scattered-density category was only used in a few cases and indicated a sporadic occurrence of the species. The noxious weed populations and distributions were drawn in the field on 44×34-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.

1.2.1.3 Photographic Documentation Surveys

No photographs were taken during the summer of 1998, because of the alternate year schedule in place. They will be taken again during the summer of 1999. However, the woody vegetation photographic documentation will continue in winter 1998. The areas of woody vegetation will be photographed from the permanent photo points established in 1997 to document the condition of the Great Plains riparian woodland and tall upland shrubland areas when the leaves are off the plants. Photographs will be taken in the same

compass directions from these photo points. Examples of these photographs will be presented in 1999 Annual Vegetation Report.

1.2.1.4 Qualitative Habitat Assessment and Rare Plant Surveys

Qualitative habitat assessments were made in each of the high-value vegetation community management units on the Site during 1998. Assessment objectives dealt primarily with habitat loss, threats to the plant community, weed issues, rare plant species, the health of dominant plant species in the community, and general community quality. Attempts were also made to revisit each of the locations where CNHP–listed plant species of special concern are known to occur. 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 during the 1997 field season. Locations were revisited in 1998 to confirm the continued presence of these species on the Site and to evaluate any concerns about them.

Further details on the qualitative methods used in 1998 are found in the document *High-Value Vegetation Survey Plan for the Rocky Flats Environmental Technology Site* (K-H 1997d) and *The Environmental Management Department Operating Procedures Manual* (DOE 1995).

1.2.2 Quantitative Vegetation Monitoring Techniques

The objectives of the quantitative vegetation monitoring are to assess plant community changes over time (i.e., trends) or changes in response to management actions (i.e., herbicide application). In 1998, quantitative vegetation monitoring was used for evaluating long-term trends on the xeric mixed grassland, providing a baseline of vegetation information at several wetland locations, evaluating the effects of herbicide applications on diffuse knapweed and native prairie species, and the effect of fire on diffuse knapweed.

Quantitative methods used to assess plant communities included:

- belt transects (species richness and woody plant and cactus density)
- point-intercept transects (foliar and basal cover)
- quadrats (species frequency and selected plant densities).

1.2.2.1 Belt Transects

Species richness was measured in a 2-m wide belt centered along each permanent 50-m transect. Every plant species rooted within the 100-m^2 area was recorded. In addition,

the densities of the woody plant stems and cactus species were counted for the 100-m^2 area and recorded. Species richness was sampled in both the spring and late summer, while woody plant and cactus density in the belt transects was only measured in the spring.

1.2.2.2 Point-Intercept Transects

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 types of hits were recorded. 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 the order of priority based on the protection from erosion each type of cover provided. A basal vegetation hit was 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 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. Cover was sampled in the late summer only, when plant growth was at its maximum.

1.2.2.3 Quadrats

Frequency information by species was gathered by randomly locating five, 1-m^2 quadrats along each transect and recording all species present in each plot. Density counts were made of selected weed species (which varied depending on the individual study) within each of the quadrats. Quadrats were sampled in both the spring and late summer.

For more detailed information on the quantitative methods used in 1998 for specific projects, refer to the technical reports in Appendix A or the *Environmental Monitoring Department Operating Procedures Manual* (DOE 1995) and the *High Value Vegetation Survey Plan for the Rocky Flats Environmental Technology Site* (K-H 1997d).

1.2.3 Data Analyses

All data were checked for quality assurance and quality control (QA/QC) prior to analysis, following previously accepted and applied steps for ecological data at the Site (K-H 1997e). Descriptive and graphical comparisons and summaries of the data were prepared for most data sets. Appropriate statistical analyses were also conducted on some data where feasible. Further details on the specific analyses conducted on particular data sets are found in the technical reports in Appendix A.

1.3 Results and Discussion

1.3.1 Xeric Tallgrass Prairie

The xeric tallgrass prairie is a rare and unique plant community at the Site (Figures 2 and 3). The large extent of this plant community found on the Site (approximately 1800 acres), combined with the land recently purchased by City of Boulder Open Space (1500 acres) to the west of the Site, is considered to be the largest remaining tract of this community in North America (CNHP, 1994, 1995). Monitoring was conducted on the Site's xeric tallgrass prairie during 1998 to document and assess the quality and health of the prairie community and assess any trends by comparison to past data.

Community-wide surveys on the xeric tallgrass prairie recorded a total of 295 plant species during 1998 (Table 1). The high number of different species indicates the high level of biodiversity found in this plant community on the Site. Compared to 1997, there was an increase of 21 species observed. Of the 295 species observed in 1998, 79 percent were native species, a decrease of 2 percent since 1997. These annual differences are not indicative of any trend on the prairie, but rather are typical of the differences that can be encountered in community-wide inventories. Normal annual variation in the abundance of difference species, observations of sole individuals of a given species, and slight differences in the routes traversed during surveys make this type of variation typical. Although the high percentage of native species is indicative of the high quality of the grassland, the 21 percent of non-native species on the grassland does suggest that there are weed concerns. While most non-native species on the grassland pose no significant threat, there are a few species which, due to their aggressive nature, can threaten the quality of the xeric tallgrass prairie. These species are discussed in the weeds section of the report (Section 1.3.5).

Quantitative monitoring at sites TR01, TR06, and TR12 in 1998 (Figure 4), showed that the xeric tallgrass prairie at the Site was typified by the presence of mountain muhly (*Muhlenbergia montana*), Porter's aster (*Aster porteri*), big bluestem (*Andropogon gerardii*; Figure 5), needle and thread grass (*Stipa comata*), and Canada bluegrass (*Poa compressa*; Table 2). Overall foliar vegetation cover was approximately 82 percent, which fell within the range of past measurements. Comparison to past monitoring results indicated that annual variation in vegetation cover for some individual species was noted. In examining cover values for the dominant species, big bluestem (Figure 5), a relict tallgrass prairie species, showed little change in cover from past years. Porter's aster, a native forb, showed a 10 percent decline in its cover amounts at some locations since it was last monitored in 1995. This may be indicative of a cyclic response, based on past data that seemed to show a steady increase over a previous three-year period. Needle and threadgrass and Canada bluegrass both showed only slight increases in cover. Mountain muhly, a native foothills grass, showed a considerable increase in cover at one location, but only a slight increase at another. Annual fluctuation of vegetation cover is common due to annual variations in the timing and availability of moisture and other environmental variables. Although some changes are apparent, the short-term length of the data sets preclude any definitive trend analyses due to the variability of the data and inherent "noise" which is characteristic of small data sets. However, the dominant

species from the past are still dominant today and there is no real evidence that there has been any shift in overall species composition.

Little bluestem (*Andropogon scoparius*; Figure 6), another relict tallgrass species, continued to show declines across the xeric tallgrass prairie. It has declined from almost 12 percent cover to 2 percent cover at one location and from 5 percent to 0 percent at another. Qualitative observations on the loss of little bluestem cover on the Site have been mentioned in the past (K-H 1997b), and quantitative measurements now confirm this observation. Originally, a large die-off of the species at these and other locations on the Site was noticed in 1995, the year following the late-summer drought of 1994. Little bluestem appeared to be particularly hard hit, and observations showed that many bunches had died. Only time will tell whether the species will recover at these sites. Qualitative observations at some other locations on the Site have shown, however, that the species was not as severely affected and appears to be doing fine at these locations. Thus, this may simply be an example of the dynamic nature of these native plant communities in response to environmental changes at different scales.

In general, the 1998 quantitative data suggest that the dominant species on the xeric tallgrass prairie appear to be doing well and the variations in annual cover are most likely part of the normal variability in response to environmental factors. The relict tallgrass prairie species (some of which occur infrequently at the Site) include big bluestem, little bluestem, indiangrass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*), switchgrass (*Panicum virgatum*), and porcupine grass (*Stipa spartea*), and were all observed in vegetative, flowering, and fruiting condition on the Site. Their continued presence is indicative of the uniqueness of the xeric tallgrass prairie at the Site.

The results also indicate that no major changes have occurred at the quantitative monitoring locations in the xeric tallgrass prairie since they were last monitored. The few changes that have been noted are subject to the short-term length of available data sets. This makes long-term interpretation difficult and precludes any meaningful trend analysis because of the difficulty in distinguishing natural variation "noise" from real trends. It must be remembered however, that the scale of the quantitative monitoring only evaluates the xeric tallgrass prairie at a few localized areas, compared to its overall extent on the Site. As a result, the scale at which this monitoring is conducted can overlook larger scale perturbations in the community that have not reached these monitoring sites. Therefore, the larger scale qualitative habitat assessments are more indicative of larger, widespread conditions on the prairie. The weed issues concerning the xeric tallgrass prairie are discussed in the weed section of the report. The detailed technical report for the xeric tallgrass prairie monitoring is in Appendix A.

1.3.2 Wetlands

Wetland monitoring was conducted in 1998 to provide baseline quantitative information for long-term monitoring at the Site. A total of 15 permanent transects were monitored at two of the largest wetlands in Rock Creek and at the Antelope Springs/Apple Orchard Seep wetlands in the Woman Creek drainage (Figure 7).

A total of 95 species were recorded at all three wetlands (Table 3). Species richness was highest at the Rock Creek Wetlands and lowest at Antelope Springs/Apple Orchard Seep wetlands. Native species accounted for 68–69 percent of all species present. This was similar to results found along streams on the Site in the past (71–74 percent; K-H 1997b). The high percentage of non-native species in the wetlands compared to other plant communities on the Site may be due to past grazing practices, higher use by wildlife, and because aquatic habitats tend to act as a good dispersal mechanism for seeds. No rare or imperiled plant species (as defined by the CNHP; CNHP 1997) were recorded at any of the wetland locations monitored.

Overall, the vegetation composition of these three large wetland areas was fairly similar. All three areas were dominated by arctic rush (*Juncus balticus*), a common species found in the wetlands of this region. One of two sedges—either wooly sedge (*Carex lanuginosa*) or Nebraska sedge (*Carex nebrascensis*), depending on site location—as well as cattails (*Typha latifolia*) provided the remainder of the dominant cover at all three wetlands (Table 4). Differences among the three wetlands appeared to depend on the drainage in which they were located. An analysis of the species richness similarity between the three wetlands revealed that the two Rock Creek wetlands were more similar to one another than to the Antelope Springs/Apple Orchard Seep wetlands. Total vegetation cover was also higher at the Rock Creek wetlands. These wetlands, besides having higher species richness, also had a higher diversity compared to Woman Creek, indicating that the higher quality wetlands are in the Rock Creek drainage, as they are more diverse and are not dominated by only one or two species. Photos of two of the wetland transects are shown in Figures 8 and 9.

Because this monitoring was conducted to provide a baseline of quantitative information on these wetlands, no trend analyses or comparisons with past data were possible. However, compared to the other plant communities monitored on the Site using the same methodology, the total species richness for the wetland community was lower than that previously observed in the xeric mixed grassland, mesic mixed grassland, and riparian communities[1] (K-H 1997b). Only the reclaimed grassland, a re-seeded agricultural field, had lower species richness. The percentage of native species in the wetland community (72 percent) was most similar to the riparian community, which would be expected because many of the same species are found in both communities (K-H 1997b). Overall vegetation cover in the wetlands was higher than that found at any of the other plant communities monitored from 1993 through 1995, with the exception of the 1995 mesic mixed grassland (K-H 1997b). This is typical of the high productivity of this type of wetland areas and suggests the overall good health of these wetlands on the Site.

Compared to other wetlands in the Boulder region, the classification of these large hillside seep wetlands best fits the description given by Cooper (1988) in a report on Boulder Valley wetlands. He describes it as an arctic rush (*Juncus balticus = J. arcticus*)

[1] The riparian community as used here refers to the EcMP classification system and data sets. It usually includes riparian woodland and some small, streamside wetland areas.

wetland community. Small inclusions of the cattail-duckweed (*Typha latifolia-Lemna minor*), Nebraska sedge, and prairie cordgrass (*Spartina pectinata*) communities are also present within these larger complexes at some locations. With the exception of the prairie cordgrass wetland type, most of these wetland types are common in the greater Boulder area (Cooper 1988). The prairie cordgrass wetland community (dominated by prairie cordgrass; Figure 10) however, is much more restricted now than in pre-settlement times (Cooper 1988). It was previously much more common along the floodplains of rivers and in sloughs and oxbows. As a result, this community is listed by the CNHP (CNHP 1997) as a plant community of concern, and it is considered to be a critically imperiled community in the state of Colorado due to its rarity. Although only small patches of the community occur at the Site within the wetlands, the presence of this wetland type is further evidence of the uniqueness, health, and high quality of the ecological resources that have been preserved at the Site.

The noxious weed Canada thistle was found throughout all three wetland sites studied, although it occurred less frequently and had less cover at the Antelope Springs/Apple Orchard Seep wetlands than at the Rock Creek wetlands. Canada thistle stem density in Rock Creek (site W1 = 13 plants/m^2; site W3 = 16 plants/m^2) was more than twice that in Woman Creek (site W2 = 6 plants/m^2). Canada thistle is listed on the state noxious weed list as one of the top ten weed species needing control in Colorado (CRS 1996). Additionally, Jefferson County has listed it as a priority for control within the county (Lile 1998). Landowners are responsible for controlling infestations of noxious weeds on their properties and preventing their spread to neighboring landowners.

Control of the Canada thistle in the wetlands on the Site is difficult because of the open water often present in these areas. Most recommended measures for controlling Canada thistle infestations are designed for dry land infestations, where mowing combined with herbicide treatment can provide effective treatment (Beck 1996). However, within the Site wetlands, mowing is not feasible due to the soft, uneven, and hummocky ground. Broad scale application of herbicides is not desirable or feasible either because 1) they are not designed for direct application to water sources, and 2) if they are approved for water application, they are non-selective and would affect all broadleaf forbs in the wetlands. Because none of these options is desirable, alternative solutions must be developed. In addition, repeated application over several years using any means is generally required for effective control of Canada thistle. Given these conditions, the following control methodology, using several methods, is suggested for controlling Canada thistle in the wetlands on the Site.

Two biocontrol insects are available from the Colorado Department of Agriculture (CDA) for control of Canada thistle (Beck 1996). *Ceutorhyncus litura* (crown boring weevil) and *Urophora cardui* (a gall-forming insect) both can stress populations of Canada thistle. *Ceutorhyncus litura* causes plants to be stressed and less vigorous. *Urophora cardui* stresses a plant by causing galls to develop on the plant. These galls, if formed near terminal growing points, prevent flowers from developing and setting seed. Neither insect is generally capable of totally controlling infestations, though using both in conjunction with other methods has proven effective in the past (Beck 1996). In 1997,

the CDA released two biocontrol insects on the Site to assist in the control of diffuse knapweed (*Centaurea diffusa*) and dalamatian toadflax (*Linaria dalmatica*), at no cost to the Site. The CDA should be encouraged to continue to use the Site as a testing ground for releases of the biocontrol insects for Canada thistle. This would provide additional control of this species on Site at little to no cost.

Another potential management action includes conducting prescribed burns in the wetlands. Although this may not directly reduce or control the Canada thistle, burning would reduce built-up dead plant litter and recycle nutrients, with the intent to invigorate the native plants in the wetlands. This would help the native species compete with the weeds. Application of approved herbicides is possible in the wetlands using a wick application method, where the herbicide is applied by hand to individual plants. Although more time and labor intensive, this could be done whether prescribed burns were conducted first or not. However, because the wetland vegetation is typically dense, prior removal of the dead plant material from the wetland would make wick application more effective, as Canada thistle plants and rosettes would be more visible and accessible for herbicide application. Wick applications of herbicides would have to be continued for several years to maintain good control. The detailed technical report for the wetland monitoring conducted in 1998 is located in Appendix A.

1.3.3 Rare Plants

Mapped locations of the plant species of concern, as listed by the CNHP, were revisited during the 1998 surveys. The known populations of mountain-loving sedge (Figure 11), forktip three-awn (Figure 12), and dwarf wild indigo (Figure 13) were all found again, and the plants were evaluated. All three species were observed in vegetative, flowering, and fruiting condition, and seemed to be doing well. Carrionflower greenbriar (Figure 14) was the only species where plants were not observed at some previously known population locations during 1998. However, it is often a difficult species to locate, and it is not known whether it comes up every year. Therefore, an attempt will be made to observe plants at these population locations again in 1999. At the locations where carrionflower greenbriar was observed, it was in vegetative, flowering, and fruiting condition, and appeared to be doing well.

1.3.4 Site Flora

As a result of the 1998 fieldwork, a total of seven 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 flora are:

Calamagrostis stricta (Timm.) Koel	Northern reedgrass
Sorbus scopulina Greene	Mountain ash

Centaurea repens L.	Russian knapweed[2]
Astragalus spathulatus Sheld.	Draba milk-vetch
Agropyron elongatum (Host) Beauv.	Tall wheatgrass
Chenopodium atrovirens Rydb.	Dark goosefoot
Solidago nana Nutt.	Low goldenrod

Of these species, none are rare or imperiled; however, the discovery of Russian knapweed (Figure 15) on the Site is cause for concern. It is listed as a noxious weed by the state of Colorado and property owners are required by law to control it. During 1998, the single population of Russian knapweed was treated with the herbicide Telar to control its spread.

With the addition of these new plant species, the Site flora now has 577 plants listed as occurring on the Site. The complete plant species list for Rocky Flats is presented in Appendix B.

1.3.5 Weeds

Currently the most serious threat to the native plant communities on the Site is from noxious weed infestations. Although many species of weeds exist in the plant communities on the Site, most are not especially problematic. However, under the Colorado Noxious Weed Act (CRS 1996), a number of particularly noxious weeds must be controlled by property owners to prevent their spread to surrounding lands. Some of these weeds pose a significant threat to the plant communities on the Site. During the 1998 monitoring, the impact of fire on diffuse knapweed was assessed (Figure 16) to ascertain the effectiveness of herbicide applications on diffuse knapweed and any associated impacts to native species, while mapping the distribution of various weed species on the Site. Results from the monitoring are discussed in the sections that follow. Detailed technical reports for the following monitoring summaries may be found in Appendix A.

1.3.5.1 Diffuse Knapweed Response to Fire

Diffuse knapweed 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 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 rangelands, disturbed sites, and even undisturbed plant communities, often becoming a dominant

[2] Listed as a noxious weed by the State of Colorado.

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 value, reduced grazing capacity, and less aesthetic and recreational value (Sheley et al. 1997, 1998).

The effect of fire on diffuse knapweed infestations is of particular concern to land managers because one of the most important tools for prairie management and restoration is fire. In 1996, an investigation was begun to evaluate the impact of fire on diffuse knapweed densities in the xeric tallgrass prairie, after a lightning-caused wildfire swept across the south Buffer Zone.

Results of three years of monitoring have shown that diffuse knapweed densities increased significantly in both the burned and unburned areas (Figures 17 and 18). The photographs in Figures 19 and 20 show a burned plot after the fire in 1996 and two years later in 1998, respectively. Because the unburned area also had a significant increase in diffuse knapweed, all indications show that in this particular case, the large increases in diffuse knapweed density observed two years after the fire were apparently not due to the fire. Rather, the potential for large increases in diffuse knapweed density is present with or without fire in disturbed and undisturbed native plant communities. Further investigation on how fire affects diffuse knapweed densities under other growing conditions are required to better determine whether these results are applicable elsewhere.

These data suggest therefore, that the use of fire as a resource management tool could potentially be conducted on the Site without significantly increasing the current diffuse knapweed problem. In fact, if fire was used in conjunction with herbicide applications, the potential for improving the effectiveness of herbicide applications is increased. The complete technical report on this study is found in Appendix A.

1.3.5.2 Diffuse Knapweed and Native Plants Response to Herbicide Application Study

In 1997, an investigation was begun to evaluate the effectiveness of herbicide applications using Tordon 22K on diffuse knapweed, and any resulting impacts that might occur on native species. The study was conducted northwest of the Industrial Area on the xeric tallgrass prairie using a control and treatment plot (Figure 21). Initial results have shown that the herbicide Tordon 22K was effective at controlling diffuse knapweed one year after spraying. Diffuse knapweed frequency was reduced significantly—by 60 percent—one year after the herbicide treatment (Figure 22). Results showed that the variability in the knapweed density data precluded attributing the loss of density in the treatment plot to the herbicide treatment alone. However, visual observations of the treatment plot revealed no adult knapweed plants present one year after treatment. In the control plot, adult knapweed plants were visually abundant, and knapweed frequency was not significantly changed. Continued monitoring of these plots will help determine how long the herbicide application controls the knapweed under site-specific conditions before re-application is necessary.

Although the observed effect on diffuse knapweed was desired, there was some impact to other species in the plant community. Four specific effects were observed:

- First, forbs other than diffuse knapweed were affected. In general, the overall abundance (cover) of forbs and their frequency of occurrence decreased. This decrease was not, however, to the point where the species were completely eliminated from the grassland. Associated with this, and most likely a result of the lowered competition from the forbs, the grasses in the community responded with increased vigor and showed some increase in the amount of total relative vegetation cover they provided in the community.

- Second, the herbicide treatment caused a loss of cactus density. The twistspine prickly pear cactus density was reduced by nearly 75 percent in the treatment plot.

- Third, species diversity (a measure combining species richness and abundance) declined significantly in the treatment plot, while remaining stable in the control plot (Figure 23). This suggests that the herbicide caused a few species to become more predominant, while others that had previously been more common, became less common.

- And fourth, overall species richness within the treated (i.e., herbicide applied) sampling plots declined initially. However, by the end of the second year, most of the initial decline had been recovered.

Data from the Site are consistent with the data from other studies which have also shown declines of species diversity and the loss of forb and weed cover after spraying with Tordon 22K, although the Site data does not show as dramatic an increase in graminoid cover. The long-term implications of these impacts to the plant community, and the time required for natural recovery at the Site, are uncertain. Rice and Toney (1996) however, who found similar decreases in forb cover due to herbicide treatments on a native prairie in Montana, reported that these responses were transitory, with forb values returning to pre-treatment levels after about three years. Rice et al. (1997) found that species diversity also declined after spraying with Tordon 22K, 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 Tordon 22K, 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 general conclusions from this study thus far are that diffuse knapweed was controlled in the areas sprayed, and that only a minimal impact to the native plant community was observed. Based on these results, the use of Tordon 22K should be continued for control of diffuse knapweed and resource management on the Site. Although some minor negative impacts were manifested initially, if the longer term responses at the Site are

similar to responses documented elsewhere, the prudent use of Tordon 22K can provide a valuable tool for assisting in the control of diffuse knapweed and management of the grasslands at the Site.

1.3.5.3 Weed Mapping

During 1997, a sitewide weed mapping program was begun for selected species as a means of identifying high-priority treatment areas, monitoring the distribution of specific noxious weed species on the Site, and tracking the effectiveness of weed control at the Site.

During 1998, several weed species were mapped. The weed distribution maps for diffuse knapweed (Figure 16), musk thistle (Figure 24), dalmatian toadflax (Figure 25), and mullein are shown in Figures 27 – 30, respectively. Four additional species—annual rye, Russian knapweed, Scotch thistle, and jointed goatgrass—were mapped in 1998 because of their aggressive nature and their recent appearance at various locations on the Site (Figure 26). The distributions of these species are shown in Figures 31 and 32. After being entered into the Site GIS, the overall extent of these species across the Site was estimated by species and by infestation level using the GIS coverage areas. Table 5 contains the estimated total acreage and acreage-by-density category for each of the species, based on these maps. The species with the greatest extent on the Site was diffuse knapweed, (covering nearly 2,913 acres), followed by dalmatian toadflax (1,934 acres), musk thistle (1,685 acres), and mullein (867 acres). The total acreage of the Site is approximately 6,485 acres (K-H 1997b). It should be noted that this acreage is only approximate and should not be interpreted as an exact area. These values are also representative of known locations for these species. It is possible that unmapped infestations are present.

Table 6 shows the change in infested acreage between the 1997 and 1998 mapped areas. The large increases in infestation acreage for dalmatian toadflax, musk thistle, and mullein are due in large part to the time of year in which mapping was conducted. During 1997, all weed mapping was conducted in late August to early September, when most of these species were no longer flowering. To better estimate the extent of these species in 1998, mapping was conducted for each species when it was in flower. Therefore, the increase in acreage shown for these species is an artifact of sampling. However, the more accurate mapping completed in 1998 reveals the substantial foothold that these weed species already have on the Site. If the distributions of all the different weed species are combined, it is apparent that most of the Site is infested and weed control is needed for one or more species. However, diffuse knapweed is by far the most aggressive species needing continued control on the Site.

During the 1997 calendar year, approximately 520 acres of diffuse knapweed were treated with Tordon 22K. Figure 33 shows the location of the areas treated and the pre-treatment density levels of diffuse knapweed at these locations. Figure 34 shows the same locations in 1998 during the growing season after the herbicide was applied. Many of the areas were totally clean (i.e., no diffuse knapweed present) during the growing

season after treatment. In other areas, the infestation density was reduced by one or two density levels.

Several factors may contribute to making the herbicide treatment more effective in some locations rather than in others. First, some areas may have been missed during treatment. Second, application methods vary in the evenness with which the herbicide is spread. At most of the large, clean locations shown on Figure 34, the herbicide treatments were applied using a truck-mounted boom that had a computer-regulated application rate regulated with the speed of the vehicle. This method was also used at the western-most location (mostly a scattered-density level; Figure 34), but this area is dotted with old fence posts and irrigation ditches that had to be avoided. As a result, maneuvering around obstacles left some areas untreated, allowing patches of diffuse knapweed to remain in the treated area. At the location northeast of the Industrial Area, the herbicide was applied with a hose or backpack equipment. As a result, the herbicide application was much less even, and more spots were missed. This would account for higher remaining density levels, even after application. Third, as previously mentioned, some error may be due to mapping inconsistencies.

Overall, the herbicide applications were generally effective on the diffuse knapweed, irregardless of whether the application was made in the spring or fall. However, qualitative observations made at the different treatment locations during 1998 showed that the herbicide affected the native species differently depending on the time of application. At locations treated in November to December 1997, the native spring, ephemeral forb species were hardest hit. Little to no flowering of the native spring wildflowers was observed during spring 1998 at any of the locations treated in late fall. However, at those locations where the herbicide application was conducted in June 1997, only a slight depression of the spring wildflower display was noticed in 1998, compared to adjacent untreated areas. Thus, the timing of the herbicide application may have an impact on the native forb community. Based on 1998 observations on the Site, a late fall application has a more significant impact on the spring-flowering native forbs than an early summer treatment. Observation of these areas will continue during 1999 to determine how long this effect lasts and to help determine when the most appropriate application time frame is for killing the weeds, while still protecting the native species.

On the positive side, not only was diffuse knapweed controlled at all treatment locations, but many other weedy forbs also were controlled or had reduced infestation levels as well. Qualitative observations showed that non-native species such as musk thistle, salsify (*Tragopogon dubius*), western ragweed (*Ambrosia psilostachya*), wild lettuce (*Scorzonera laciniata*), and alyssum (*Alyssum minus*) were all effectively controlled. Even common mullein was controlled at some locations. In addition, the graminoid species responded positively at all treatment locations, in both early summer and late fall. The reduced competition from both the native and weedy forbs allowed the graminoids to take advantage of the situation: their growth appeared more robust and more flowering was observed compared to adjacent untreated areas. Additionally, at one treatment location where a wildfire had crossed the pediment in March 1994, the warm-season graminiod species big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon*

scoparius), blue grama (*Bouteloua gracilis*), and side-oats grama (*Bouteloua curtipendula*) flowered profusely and were much taller than elsewhere on the Site. This suggests that combining prescribed burning with herbicide efforts could greatly improve the quality of the prairie community at the Site.

Currently the City of Boulder Mountain Parks is conducting trials using prescribed burning in conjunction with herbicide applications for controlling diffuse knapweed (Armstrong 1998, pers. comm.). Results are promising and the technique may be applicable to Site conditions. By burning diffuse knapweed infested areas, the surface litter is removed and knapweed seeds are allowed to germinate. Once the knapweed plants reach the rosette stage they are then treated with herbicide. Because the overtopping litter has been removed, more effective herbicide application is possible and the knapweed plants are killed. The herbicide then continues to work for several years without reapplication, and the recycled nutrients released by the fire allow the native species to improve in vigor and health. The native species gain a competitive edge by improving the plant community's resistance to re-infestation by the weeds.

The effectiveness of the herbicide Transline was also evaluated qualitatively in 1998 at locations where it was applied during the fall of 1997. Transline was applied in the Rock Creek drainage where diffuse knapweed was growing in proximity to wetlands or tall upland shrublands. Observations showed good control of diffuse knapweed in 1998. In most cases, the areas were completely clean, and at the locations where total effectiveness was not achieved, the infestation levels dropped by one or two density levels. At all the Transline application areas, there was little observed impact to the native forb and graminoid components of the plant communities.

Although the impacts to the native forb community were reduced with the Transline application, from an economic and pragmatic viewpoint, its use is less desirable because these areas will have to be retreated every one or two years. This herbicide is also considerably more expensive than Tordon 22K, which has a longer term residual effect where retreatment is needed only every 3–5 years. One of the goals of this monitoring effort is to determine more definitively what retreatment frequency will be required for effective longer-term control of diffuse knapweed under the conditions in the Buffer Zone.

Although diffuse knapweed infestations have been controlled at several treatment locations, significant hurdles must be overcome to achieve similar success across the entire Buffer Zone. For example, the extent of diffuse knapweed infestation is expanding at a faster rate than the current level of the control effort. The 1997 and 1998 diffuse knapweed mapping data show that even though approximately 520 acres of prairie were treated with herbicide during calendar year 1997, the extent of knapweed infestation on the Site still increased by nearly 380 acres in 1998. Even if the diffuse knapweed had been completely controlled on all 520 treated acres, there still would have been a net increase of nearly 150 acres of knapweed between 1997 and 1998, based on the maps.

Some of this discrepancy is attributable to the application methods. At some treatment locations it is not possible to achieve complete control, and therefore these areas retain some level of infestation and need further control. This is most apparent on the steeper hillside banks and obstacle-strewn areas where continuous, even application of the herbicide by conventional ground equipment is not possible. Thus, for example, in areas where the boom truck must be maneuvered around objects, or where hose or backpack application is necessary over large areas, spots are missed. At many of these locations, aerial spraying would provide a much more even distribution of the herbicide across the landscape, regardless of steep terrain or small surface irregularities such as rough ground or fence posts.

1.3.5.4 Disturbances

Another factor contributing to the degradation of the native plant communities on the Site is continued human disturbance. During 1998, field surveys identified two activities that have disturbed the soil surface at some locations, making these areas vulnerable to further noxious weed invasion. Blading of the main roads in the Buffer Zone is conducted annually to maintain the firebreak roads and provide mechanical weed control through constant disturbance. In 1996, however, the width of most Buffer Zone roads being bladed was reduced. The lack of constant disturbance along these road margins created the perfect habitat for many of the large weed infestations now present there. The presence and abundance of these species, combined with a lack of disturbance and/or herbicide treatment, has allowed more of these species to invade the prairie margins along the roads. It is apparent that herbicide applications are also necessary to control the weeds that are not being controlled by blading along the road margins. Revegetation, in conjunction with herbicide treatments along the road margins, would help to improve the condition of these areas and reduce the weed infestations.

A second problem was discovered on the far western edge of the Site near the gravel mining operations, where additional test pits had been dug on previously undisturbed portions of xeric tallgrass prairie. Although permissible under current mine permits, these disturbances create increasing weed control problems for the Site. It is crucial to prevent small areas of disturbance such as these from becoming weed infestation islands. Without weed control and revegetation, noxious weeds soon spread across previously weed-free areas. Throughout much of the area along the western edge of the Site, test pits were dug several years ago. These areas have now become covered with diffuse knapweed, which first established itself on the test pits and then spread across weed-free xeric tallgrass prairie.

Based on these results, improvements and modifications will continue to be made in the weed control program to address these concerns. As good stewards of the unique ecological resources at the Site, monitoring will continue to be used to evaluate the effectiveness of the management techniques employed and the condition of the plant communities on the Site.

1.4 Conclusions

Vegetation monitoring in 1998 continued to document the generally high quality of the native plant communities at the Site. The results, however, also continue to underscore the serious issues that threaten the quality and long-term sustainability of the Site's ecological resources. These threats come primarily from weeds, human disturbances, and plant litter build up, the latter of which has resulted from an absence of wildfires and grazing. Despite the above, the data indicate that beneath the sometimes visually dominant weedy appearance, the native plant communities are still present. Monitoring results also showed that management actions such as herbicide applications have been effective in controlling such species as diffuse knapweed and have improved the condition of the grasslands at the Site. Continued active management of these native communities will be necessary if they are to survive over the long term, maintain their ecological value, and remain for future generations to enjoy.

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1.6 Glossary

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

Biodiversity – The biological variation present at a given scale.

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).

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

Cover – Vegetation cover is a measure of abundance for individual plant species in a specified area.

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 – Those species which are 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.

Graminoids – Grasses, sedges, or rushes.

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

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

Species richness – The complete list 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 – that takes into account the total number of species present in each commmunity and the number in common between them.

Vascular plants – Plants that have xylem and phloem (i.e. conductive tissue) for movement of water, minerals, and nutrients internally. This excludes plants such as mosses, liverworts, and hornworts.

Wick application of herbicides – A method of applying herbicide by direct contact to individually selected individuals.

Figures

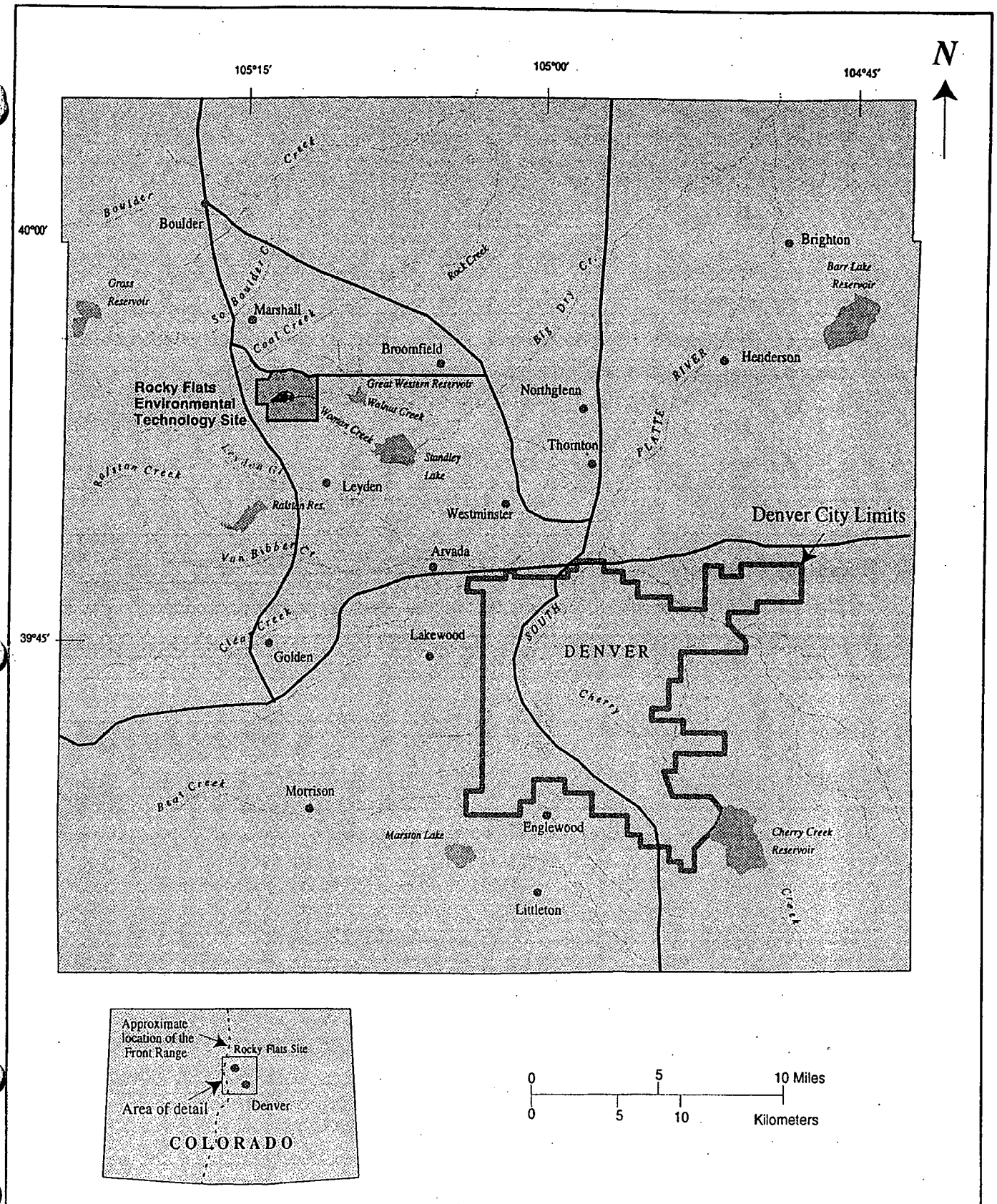
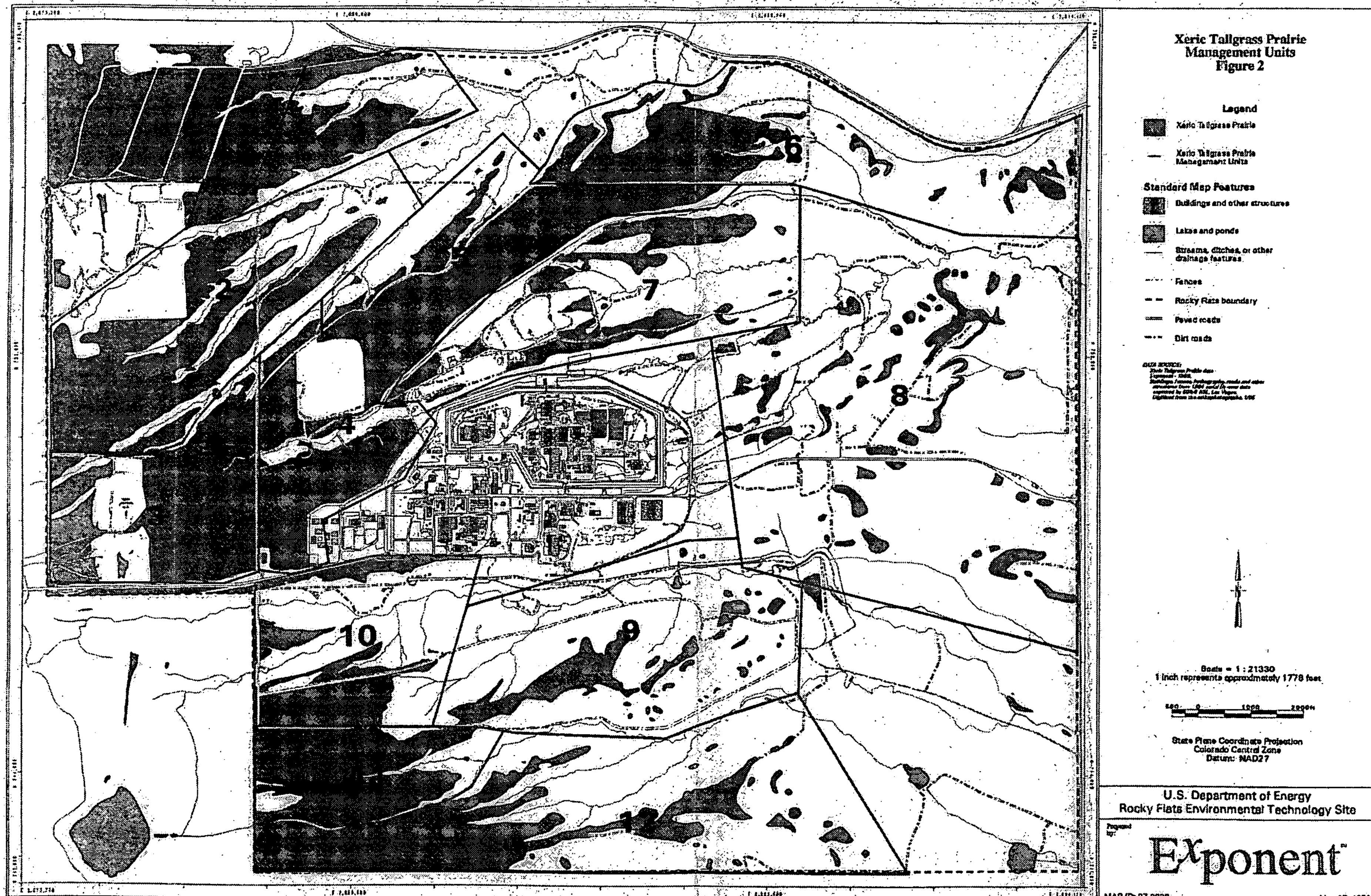


Figure 1

LOCATION OF THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE



Xeric Tallgrass Prairie Management Units
Figure 2

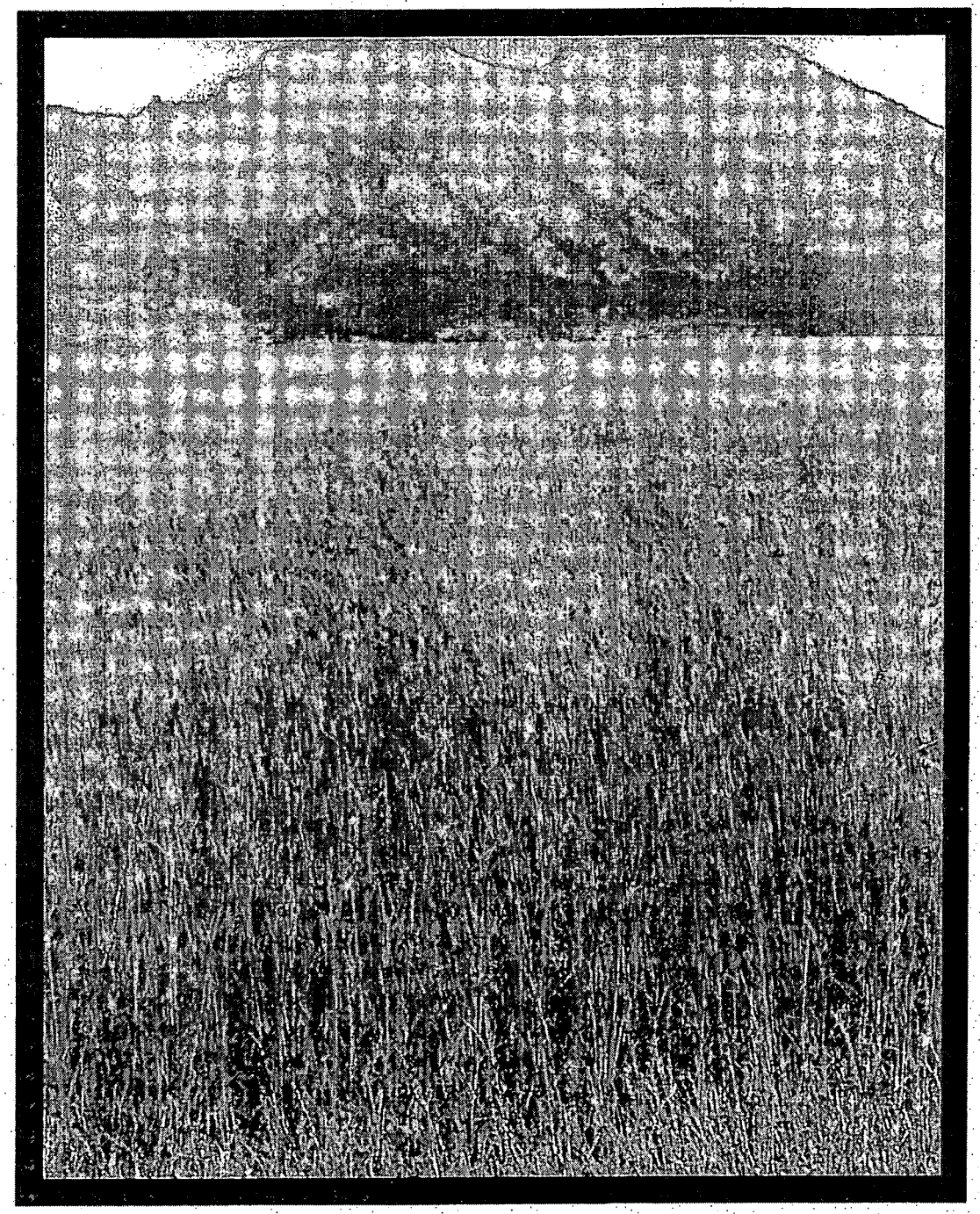
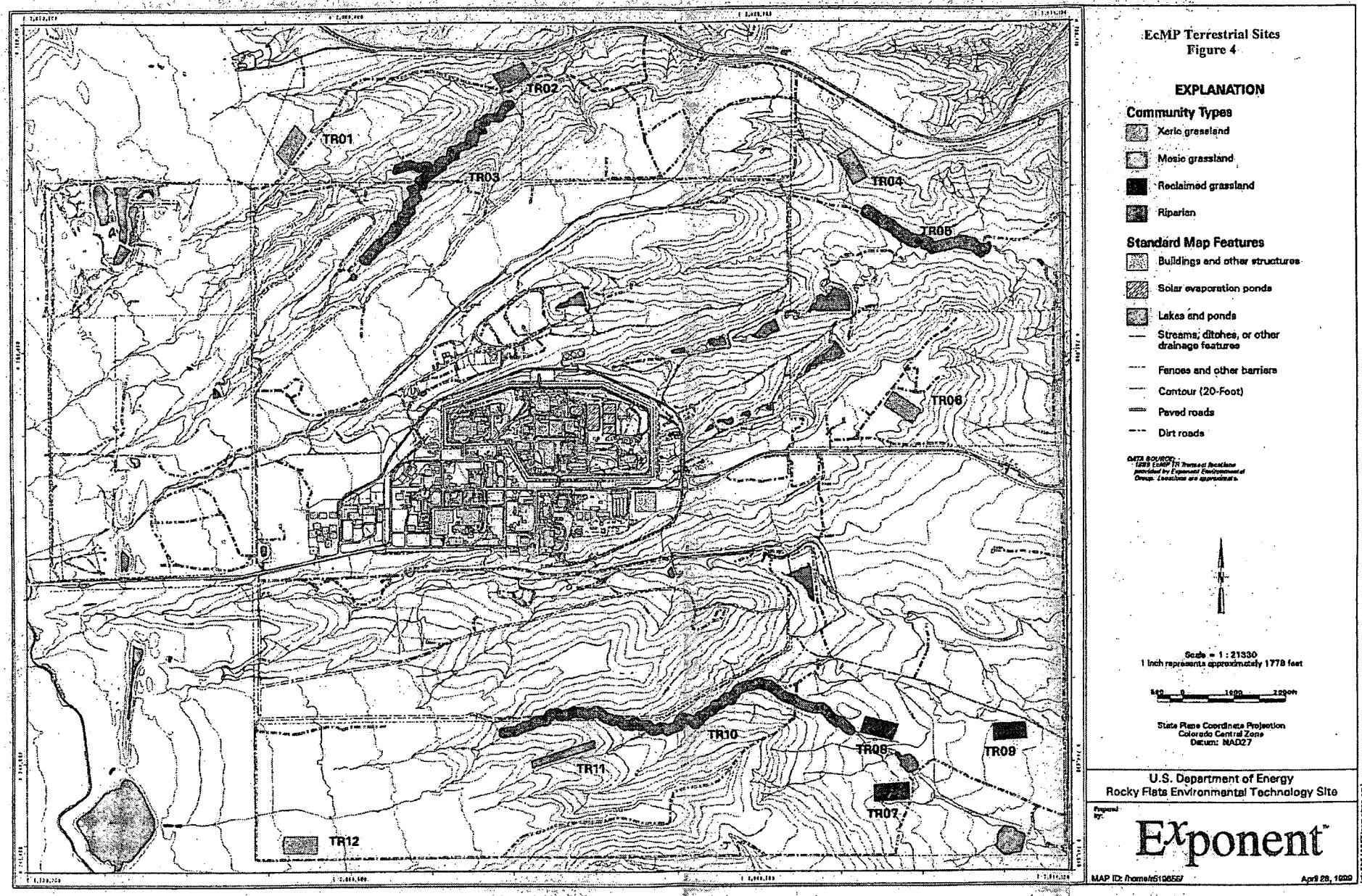


Figure 3. The xeric tallgrass prairie is a rare relict plant community and Rocky Flats contains one of the largest know remaining expanses of this community in North America. The orange grass in this photo is big bluestem in its autumn colors.



EcMP Terrestrial Sites
Figure 4

EXPLANATION

Community Types

- Xeric grassland
- Mesic grassland
- Reclaimed grassland
- Riparian

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
USFS TLMP TR Transect locations provided by Exponent Environmental Group. Locations are approximate.

Scale = 1 : 21330
1 inch represents approximately 1778 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

Prepared by:
Exponent™

MAP ID: /home/s519855/

April 28, 1999

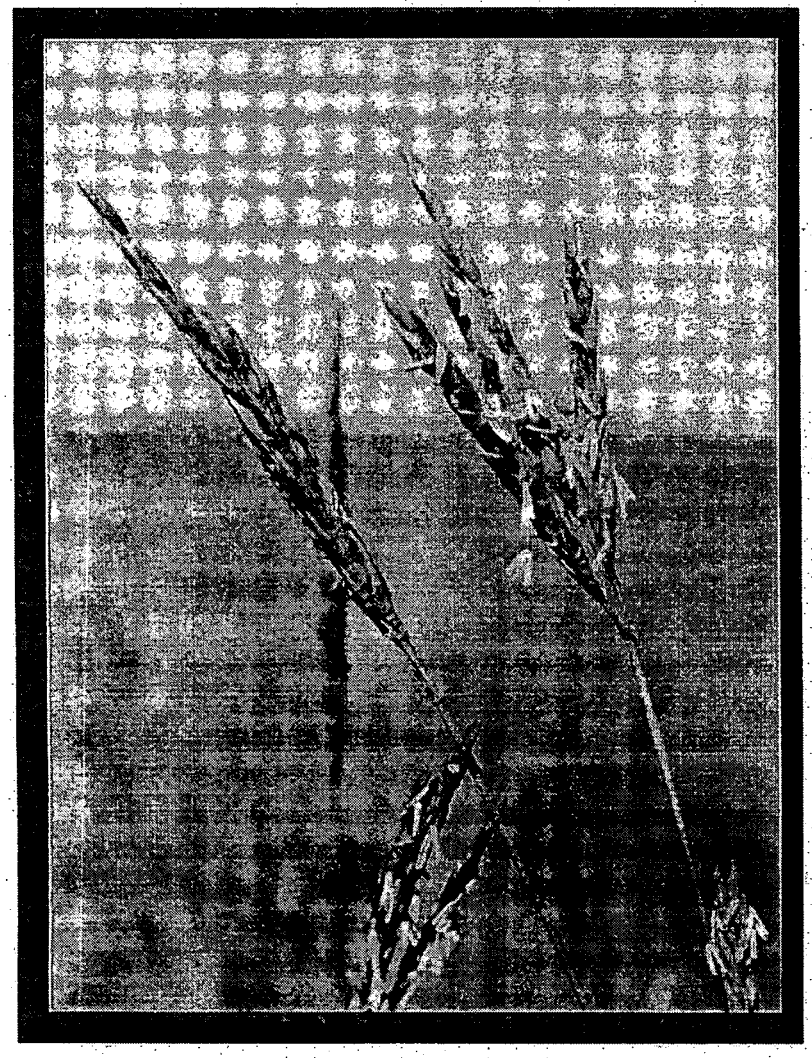


Figure 5. Big bluestem, commonly called turkeyfoot, is a relict xeric tallgrass prairie species.

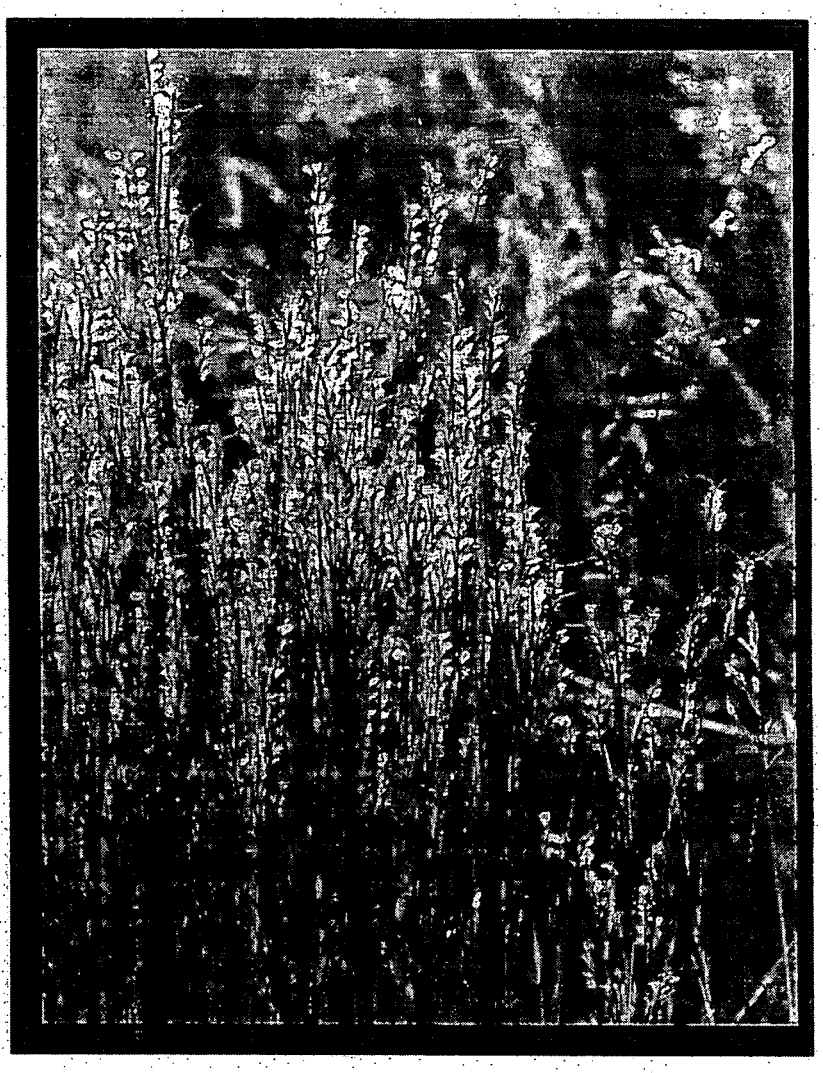
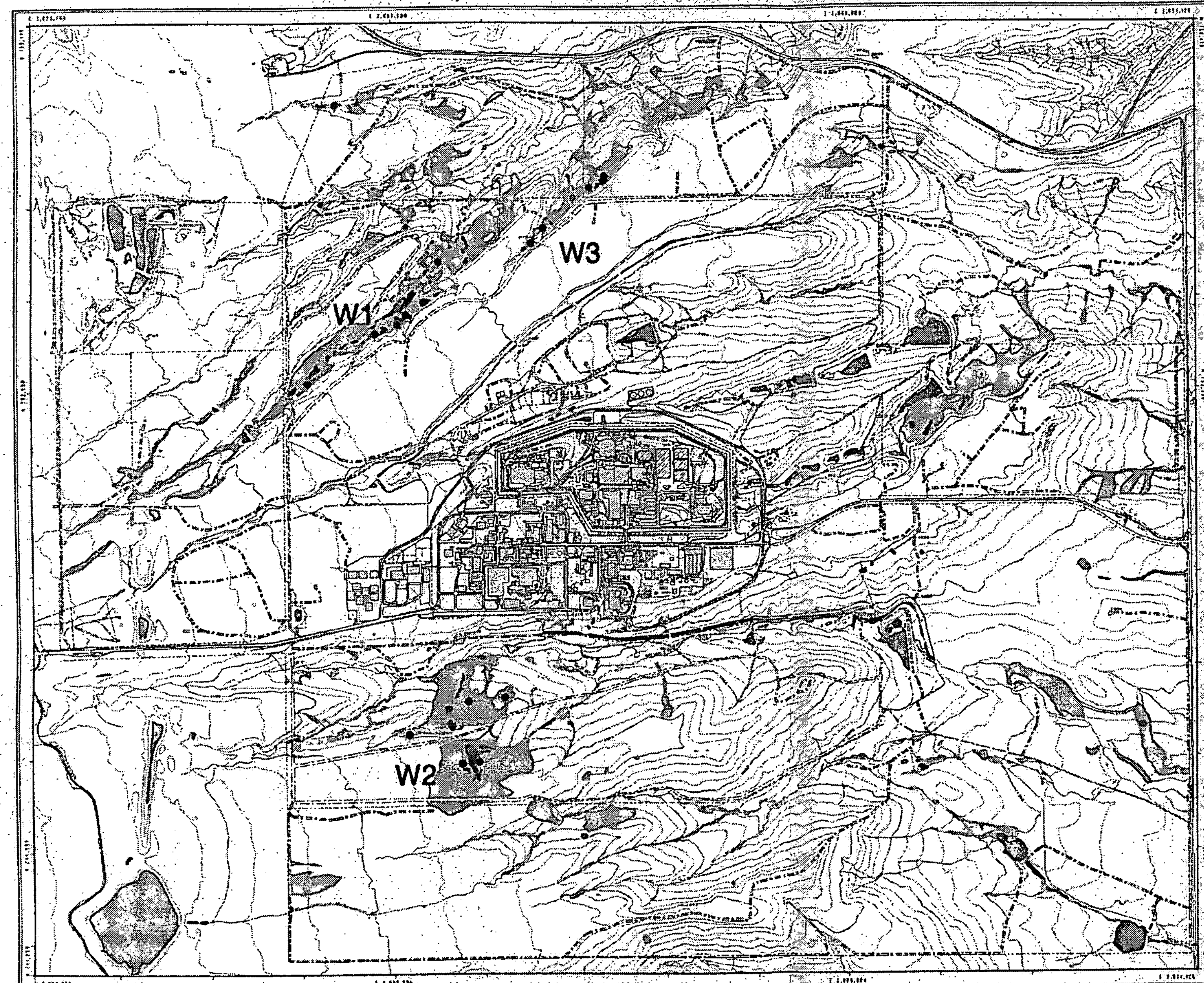


Figure 6. Little bluestem is another fairly common relict xeric tallgrass prairie species.



1998 Wetland Monitoring Transect Locations
Figure 7

MAP LEGEND

Standard Map Features

- Wet Meadow
- Short Marsh
- Tall Marsh
- Transect Starting Points
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 21330
1 inch represents approximately 1778 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

Prepared by:
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MAP ID: /home/r619655/

February 02, 1999

Figure 8. A typical wetland area in the Rock Creek drainage.

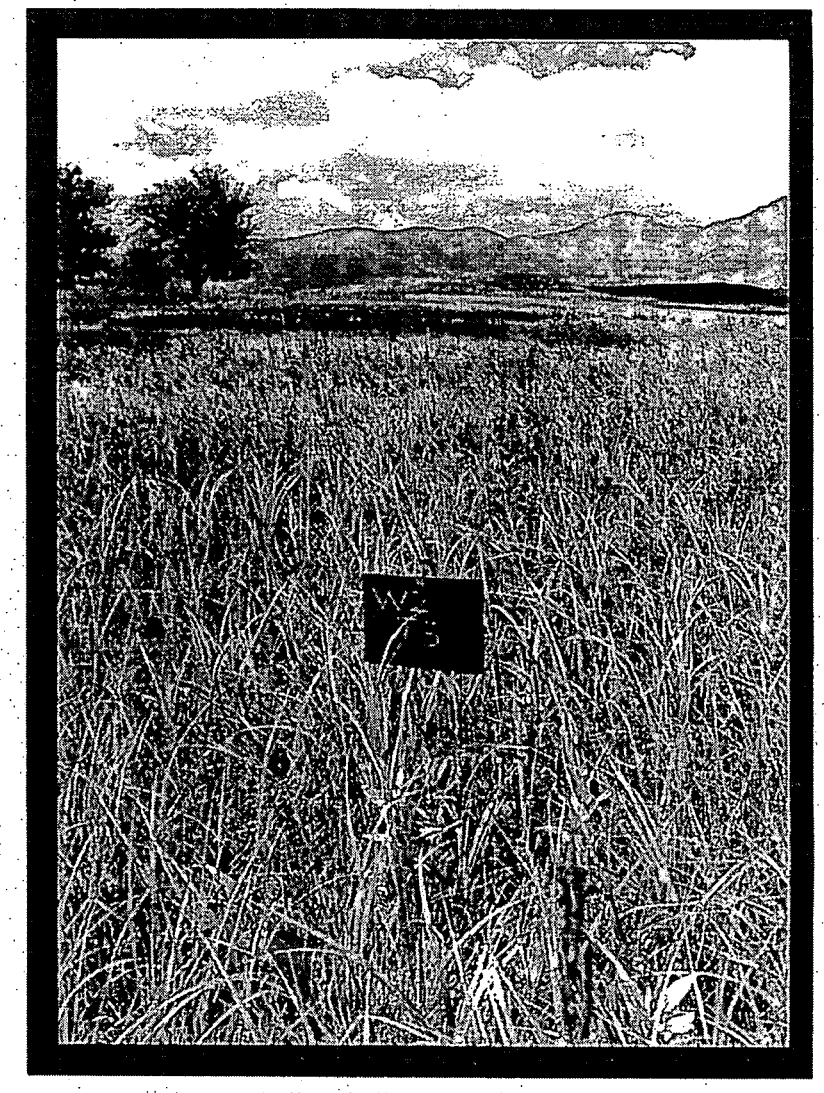


Figure 9. Prairie cordgrass dominated wetland type within the larger Apple Orchard Seep wetlands in Woman Creek.

Figure 10. Prairie cordgrass is a key species in the rare prairie cordgrass wetland type that occurs at the Site in small amounts.

Figure 11. Mountain-loving sedge is a rare dry grassland sedge that occurs along the north edge of many of the ridgetops at Rocky Flats.

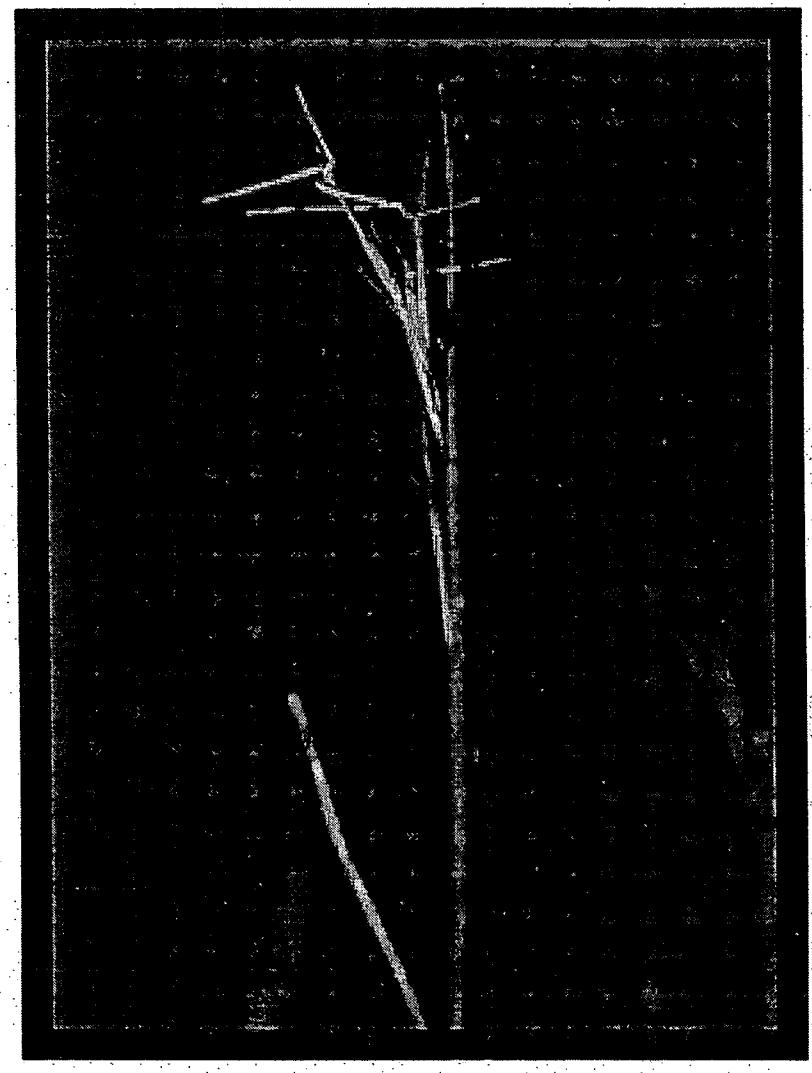


Figure 12. Fork-tip threeawn, so called because of the three bristle-like structures at the tip of each flower, is a rare plant on Site and in Colorado.

Figure13. Dwarf wild indigo, a rare species in Colorado, is a member of the pea family.

Figure 14. Carrion-flower greenbriar is a rare species that is found in the tall upland shrublands at Rocky Flats.

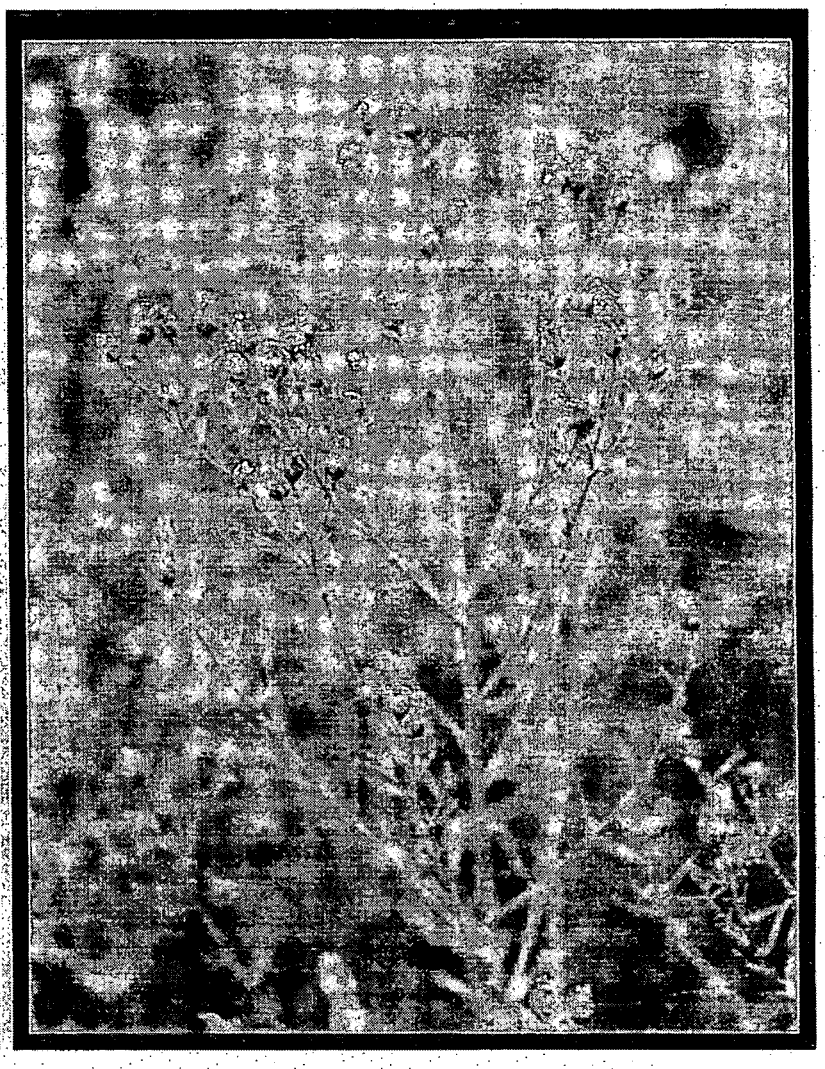


Figure 15. Russian Knapweed, a noxious weed, was discovered in a small patch on Site during 1998. It was also treated with herbicides to control its spread.

Figure 16. Diffuse knapweed, is an aggressive, noxious weed that has become a weed control problem across several hundred acres at Rocky Flats.

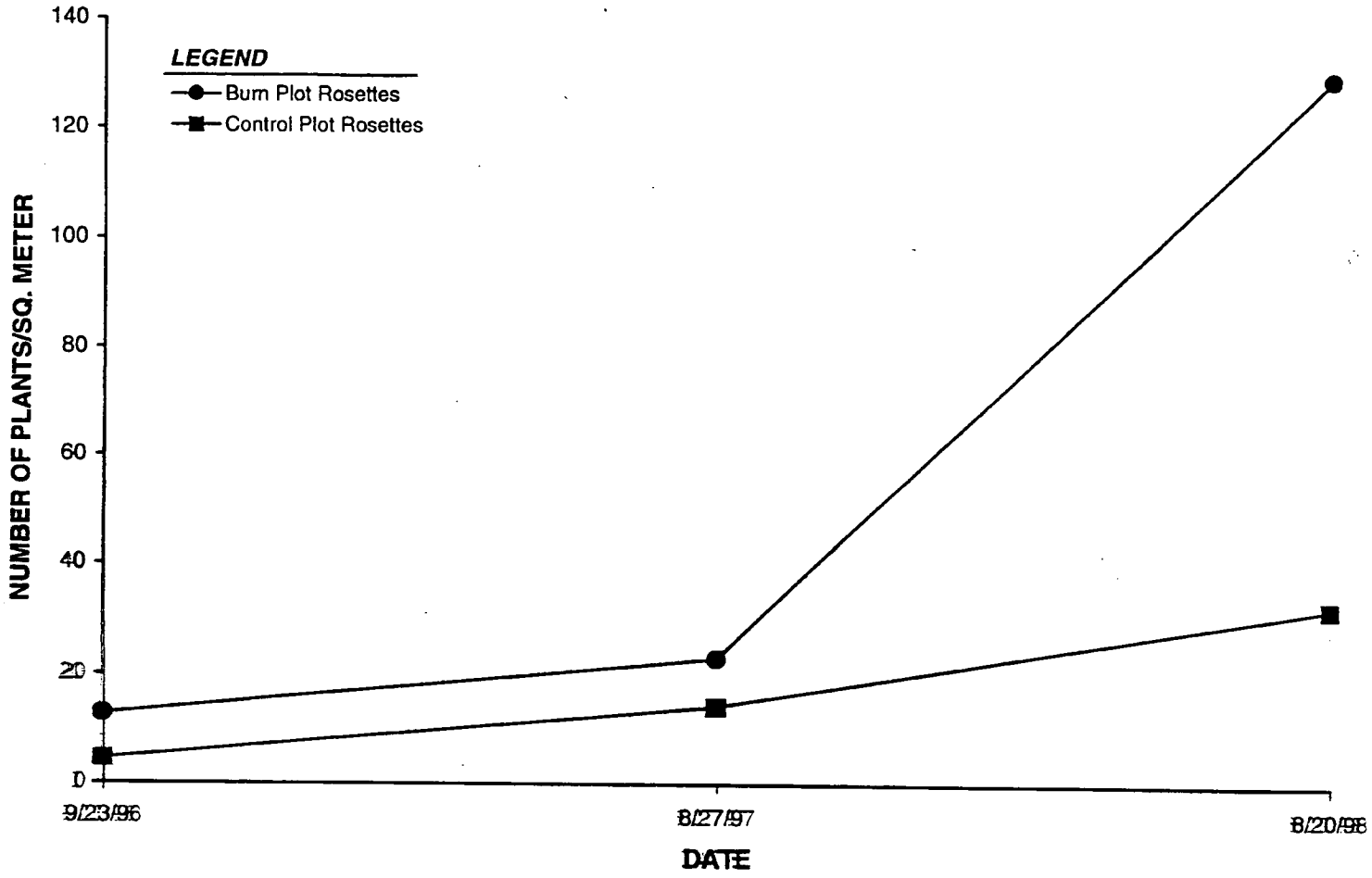


Figure 17. Diffuse knapweed rosette densities from 1996–1998.

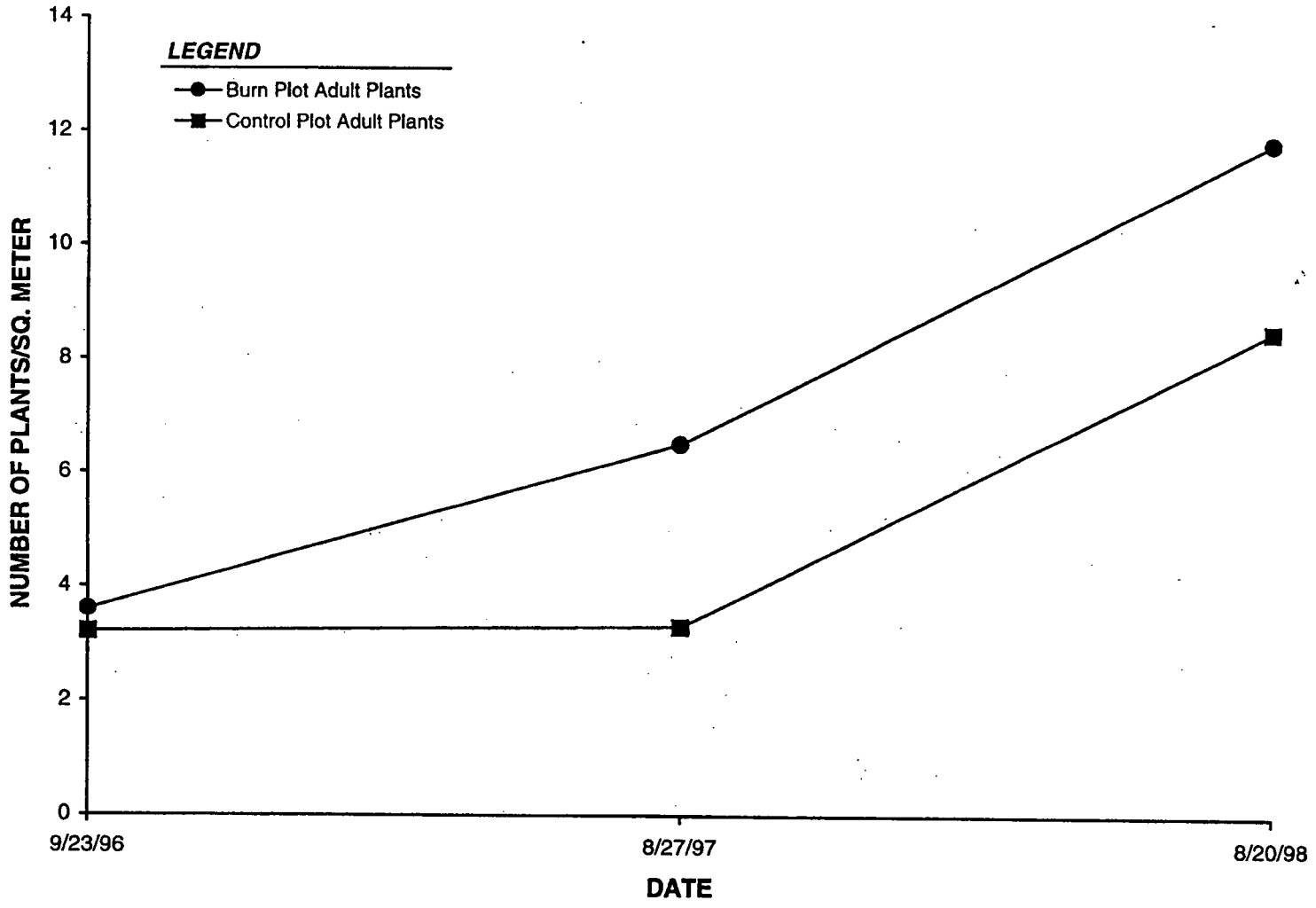


Figure 18. Diffuse knapweed adult plant densities from 1996–1998.

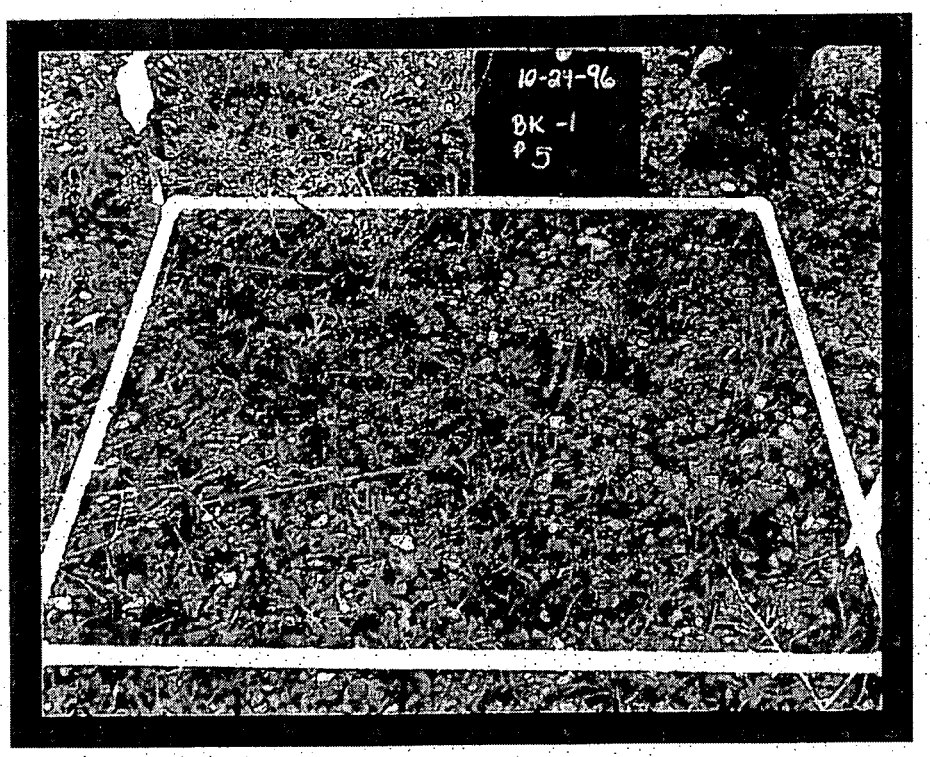


Figure 19. Diffuse knapweed plot after grassland fire in 1996.

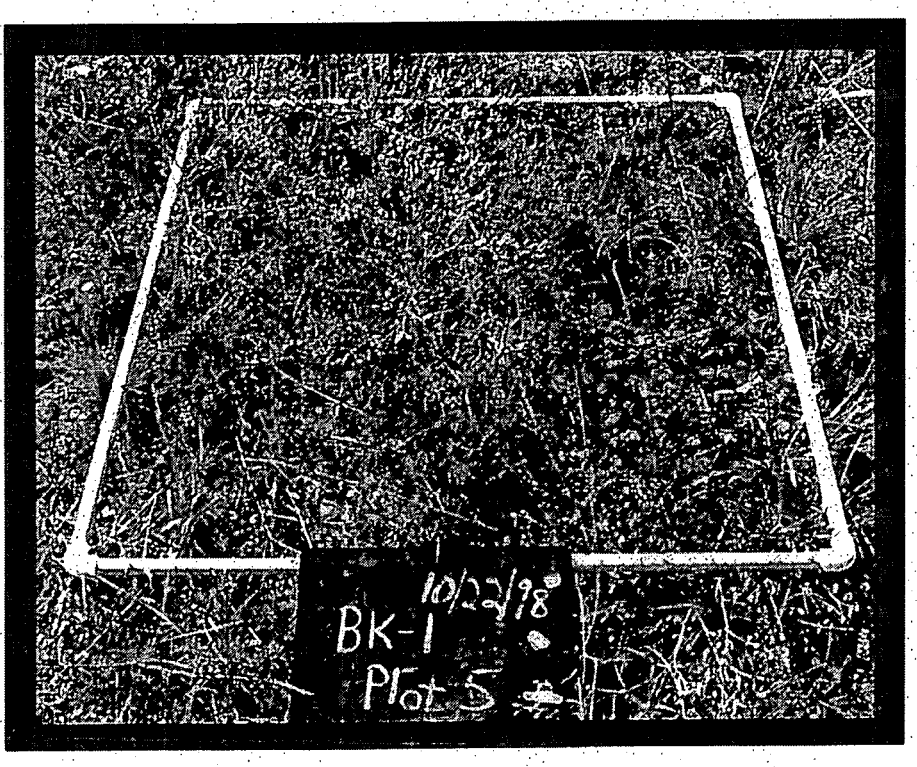
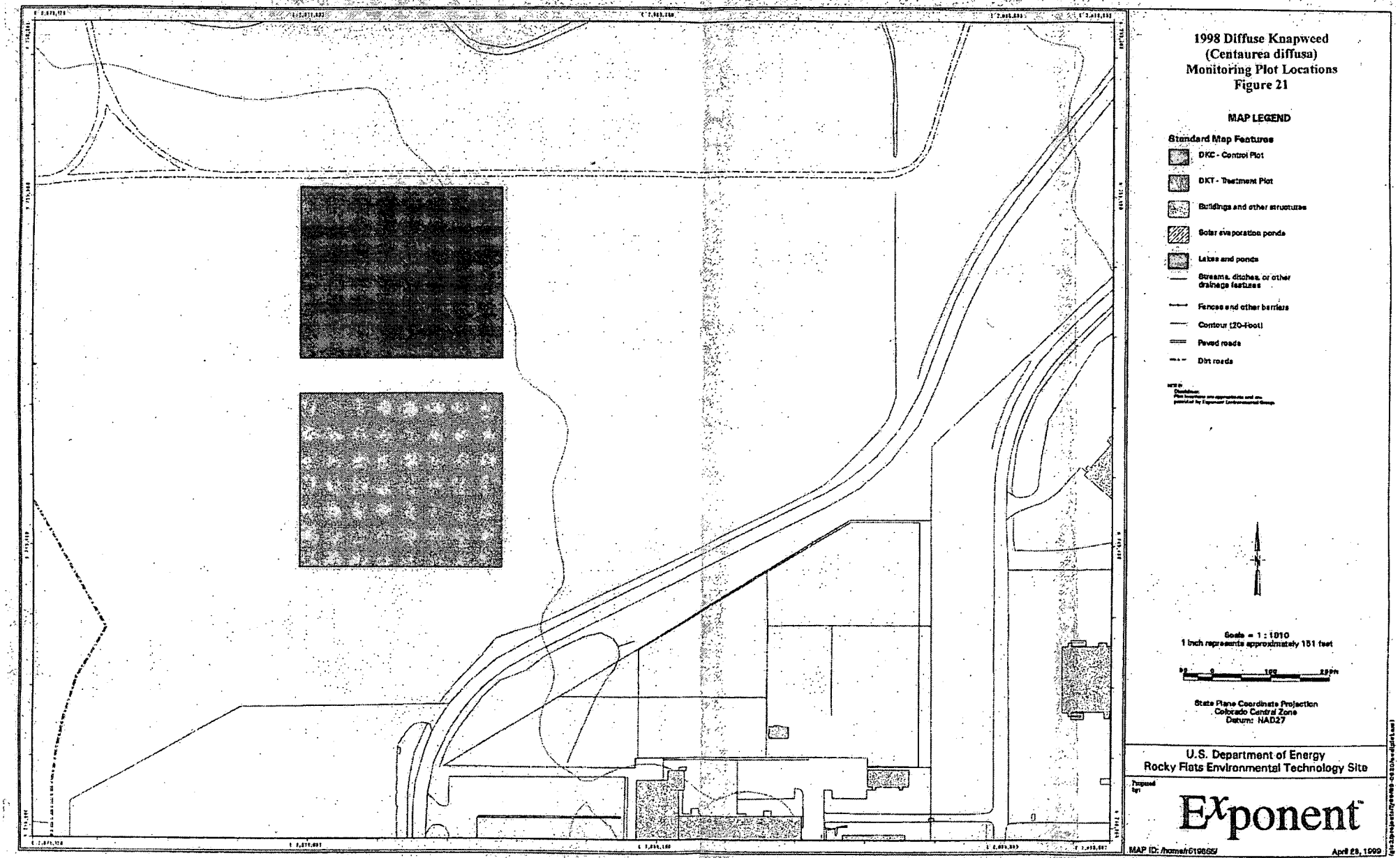


Figure 20. The same burned diffuse knapweed plot two years later in 1998.



1998 Diffuse Knapweed (Centaurea diffusa) Monitoring Plot Locations Figure 21

MAP LEGEND

Standard Map Features

- DKC - Control Plot
- DKT - Treatment Plot
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 1010
1 inch represents approximately 151 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

Prepared by:
Exponent

MAP ID: /home/r6/98655/

April 28, 1999

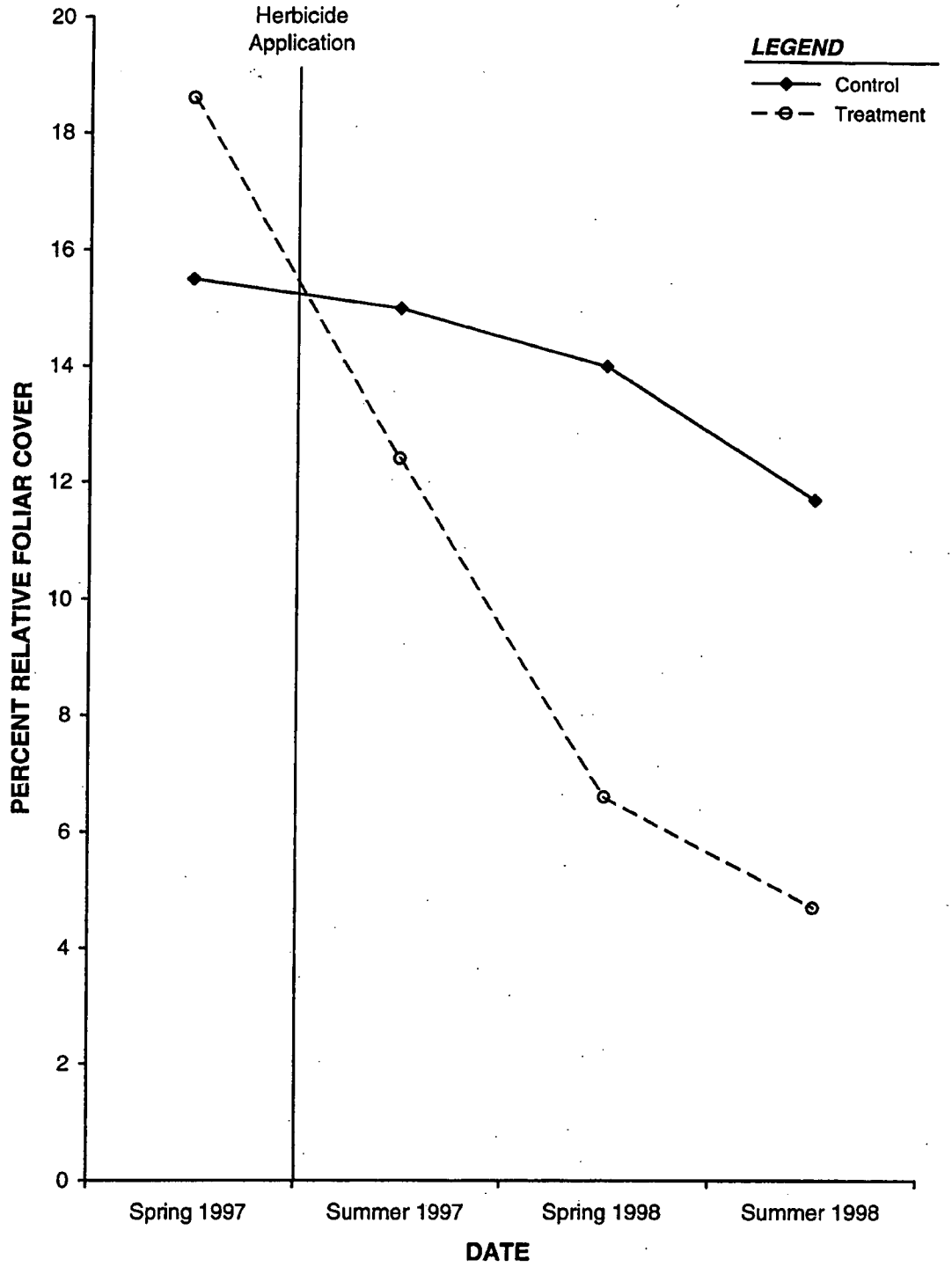


Figure 22. 1997 and 1998 diffuse knapweed monitoring control and treatment plot frequencies.

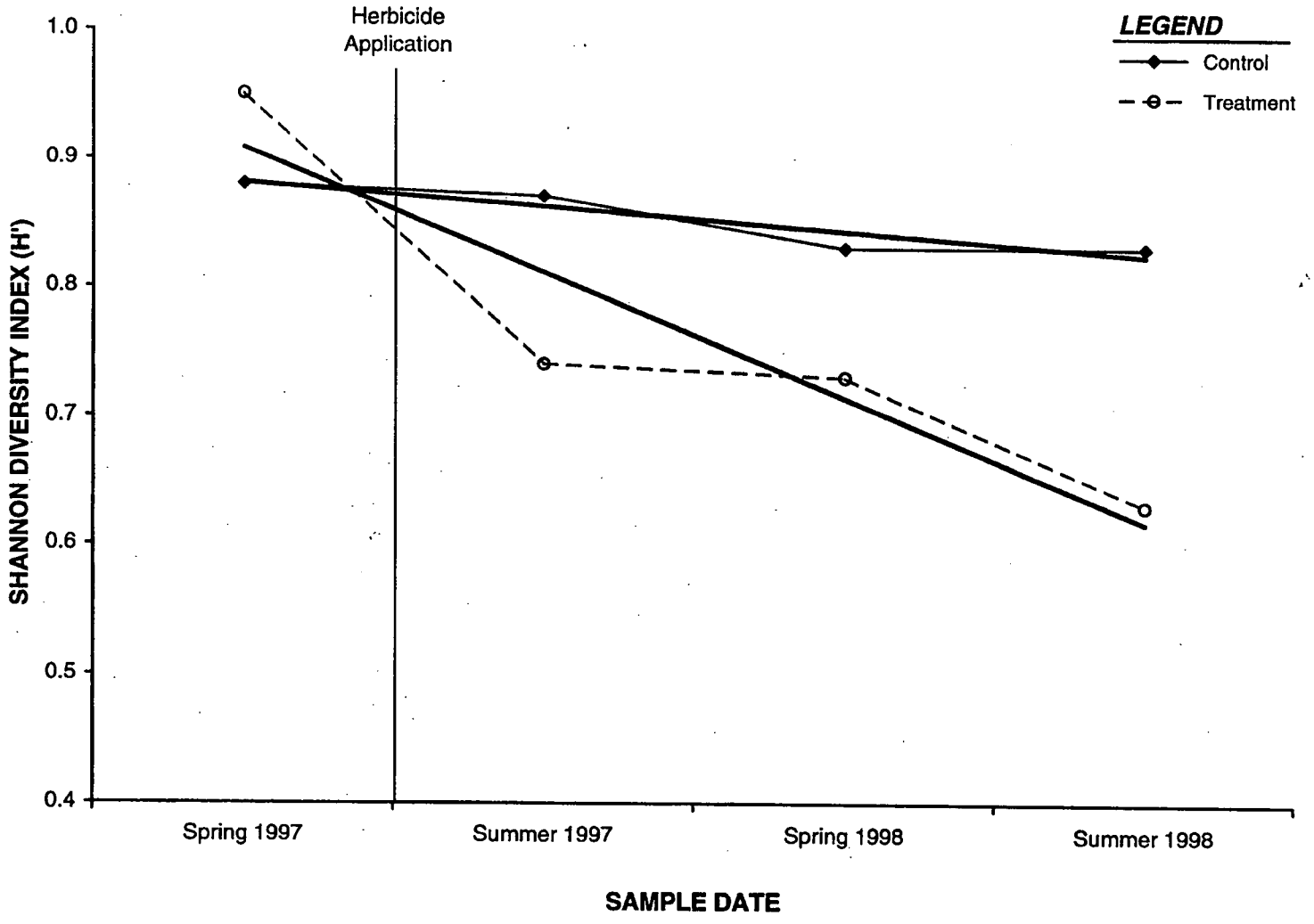


Figure 23. 1997 and 1998 diffuse knapweed monitoring plots Shannon-Weaver Diversity Indices.

Figure 24. Musk thistle, a member of the sunflower family, is a common weed in the southeastern Buffer Zone.

Figure 25. Dalamatian toadflax, although possessing beautiful flowers, is an noxious weed that is difficult to control.

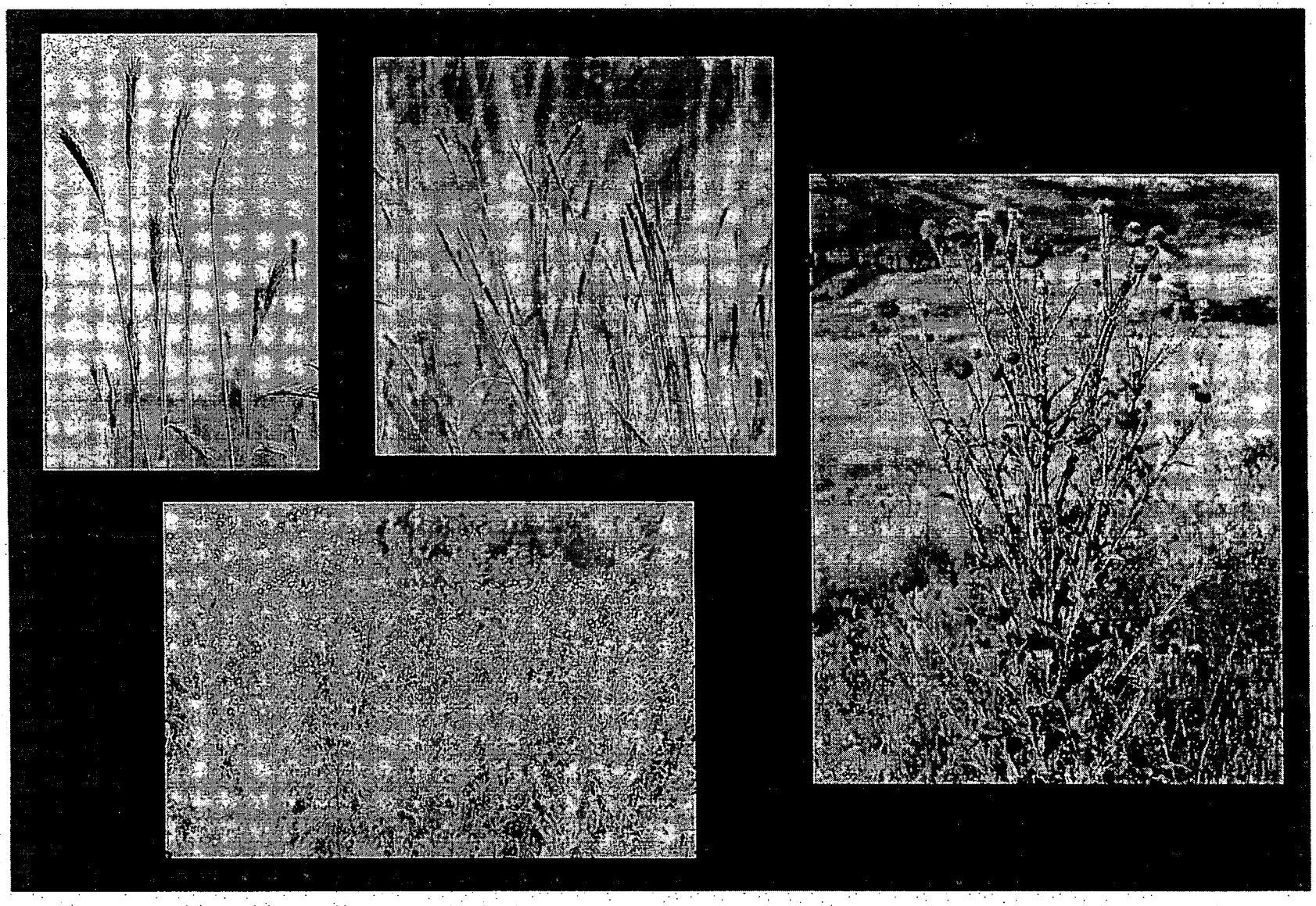
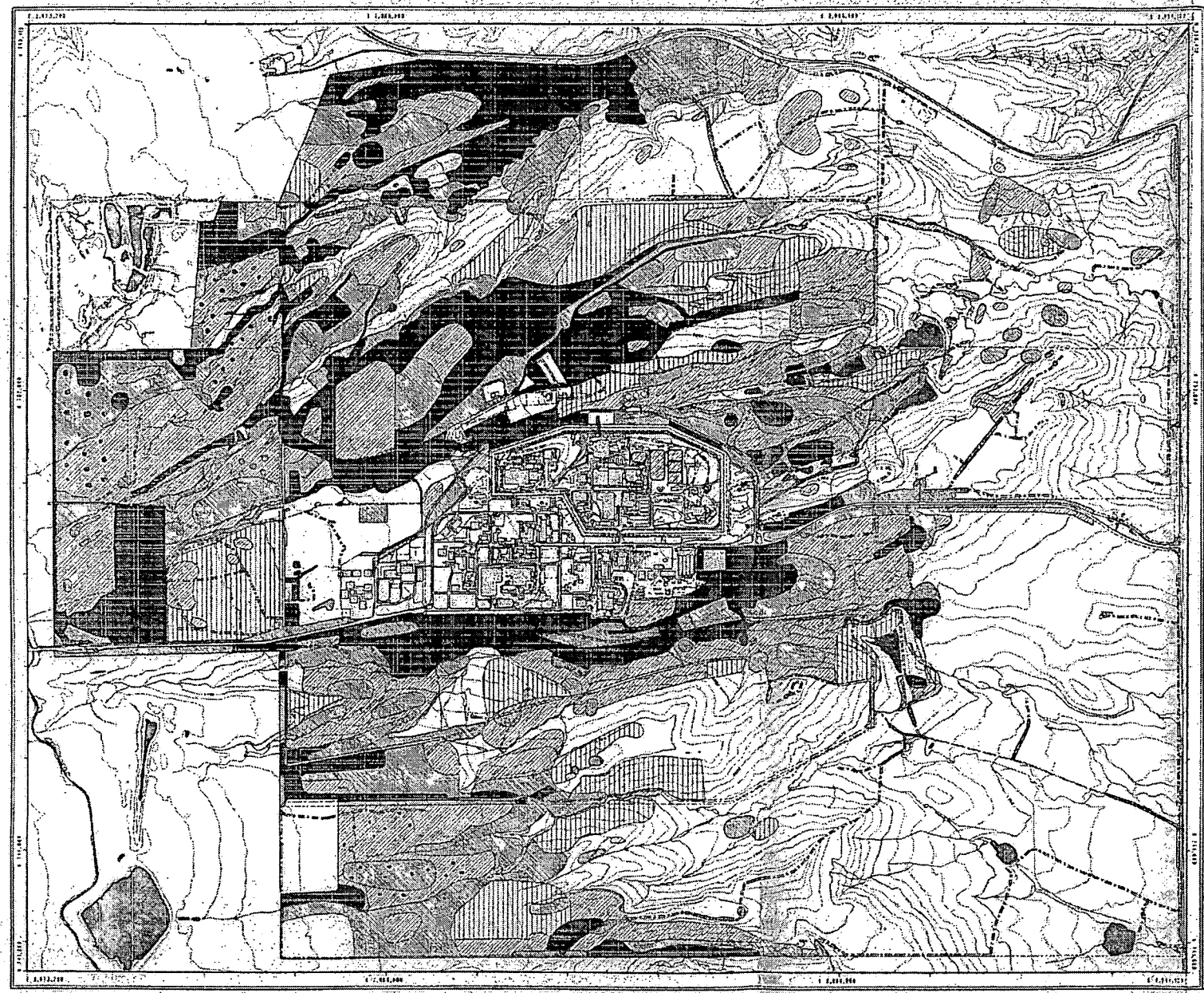


Figure 26. Clockwise from the upper left, annual rye, jointed goatgrass, Scotch thistle, and Russian knapweed, were mapped in 1998 because of their aggressive nature and their recent appearance at various locations on Site



1998 Diffuse Knapweed (Centaurea diffusa) Distribution Figure 27

MAP LEGEND

Standard Map Features

- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:

Scale = 1 : 21330
1 inch represents approximately 1778 feet

400 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

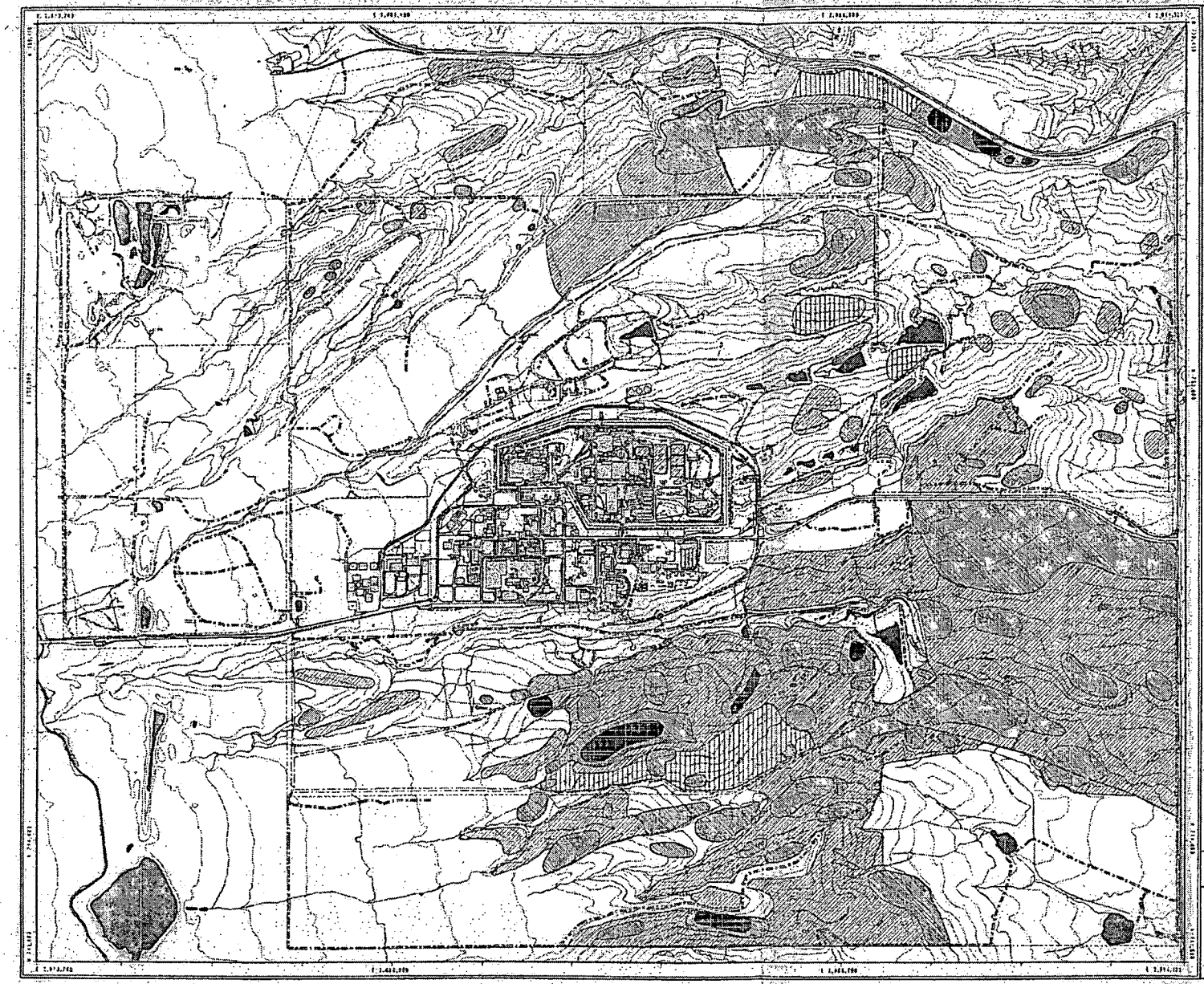
U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

Exponent

MAP ID: /home/rf/519655/

March 23, 1999



1998 Musk Thistle (Carduus nutans) Distribution Figure 28

MAP LEGEND

Standard Map Features

- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCES

Scale = 1 : 21330
1 inch represents approximately 1778 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

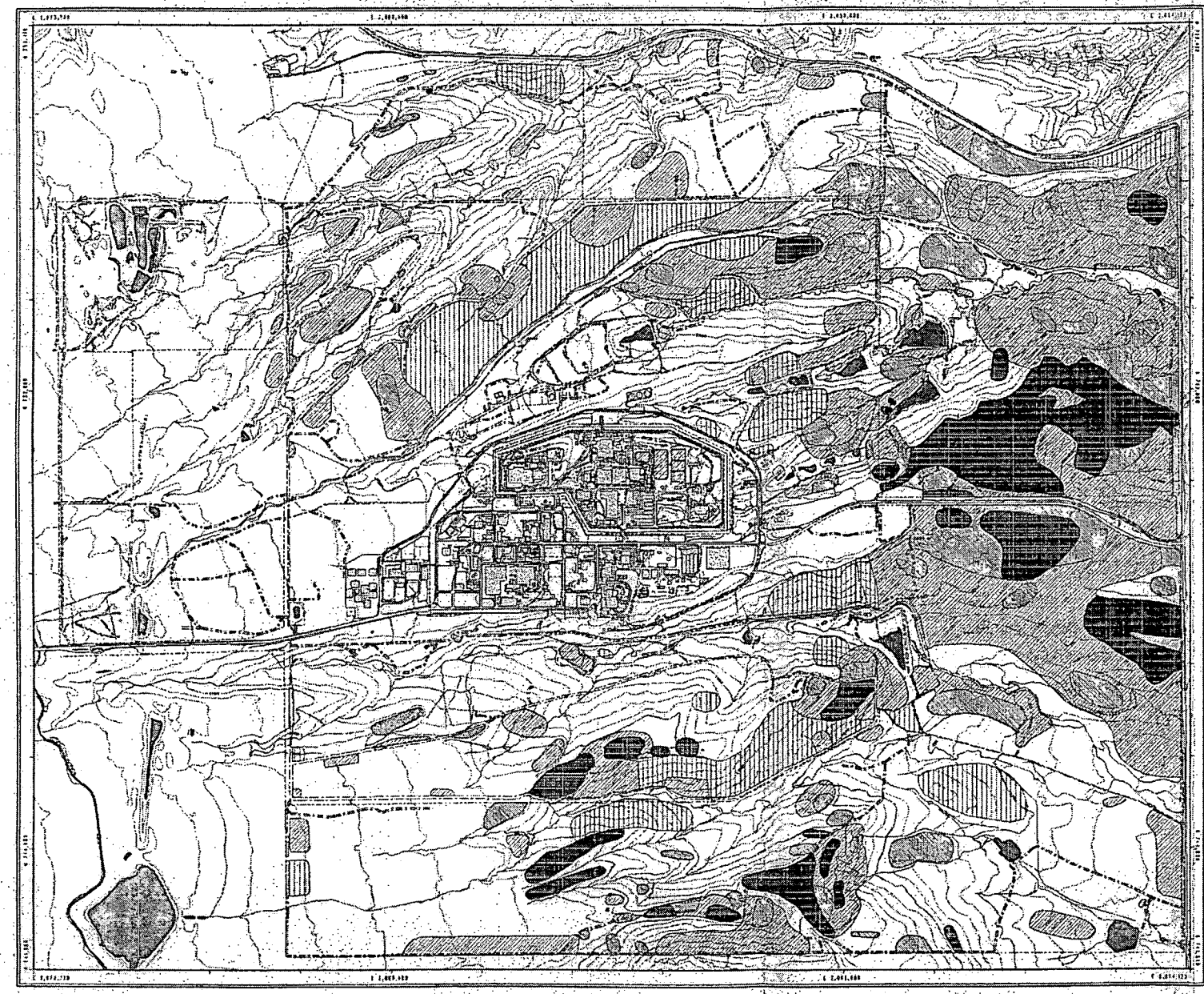
U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

Exponent

MAP ID: /home/rf19555/weedsmis/

March 23, 1999



1998 Dalmatian Toadflax (Linaria dalmatica) Distribution
Figure 29

MAP LEGEND

Standard Map Features

- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

BACK GROUND:
[illegible]

Scale = 1 : 21330
1 inch represents approximately 1778 feet

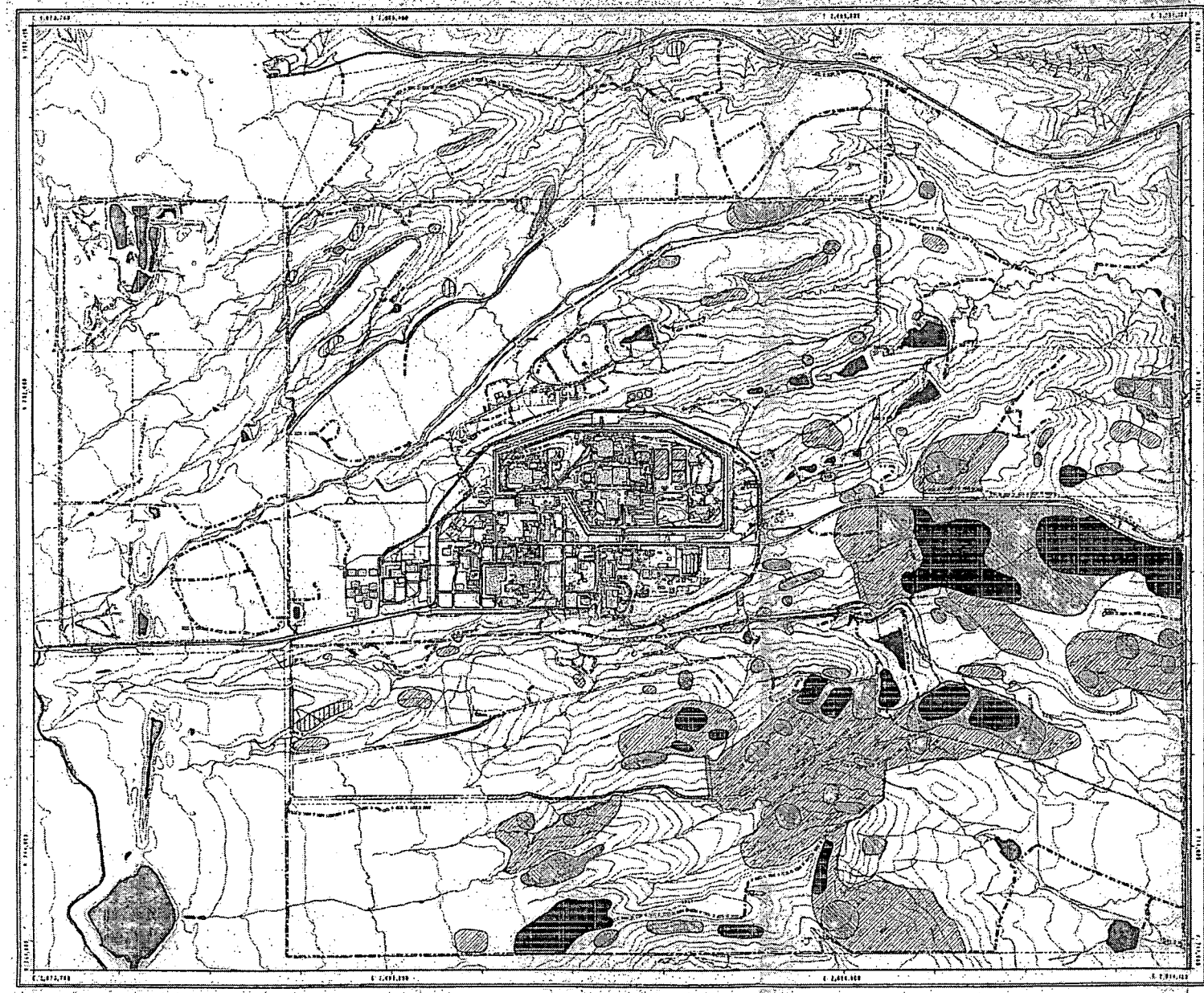
800 0 1600 2400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

Prepared by:
Exponent

MAP ID: /home/kl19655/ March 23, 1999



1998 Mullein (Verbascum thapsus) Distribution Figure 30

MAP LEGEND

Standard Map Features

- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:

Scale = 1 : 21330.
1 inch represents approximately 1778 feet

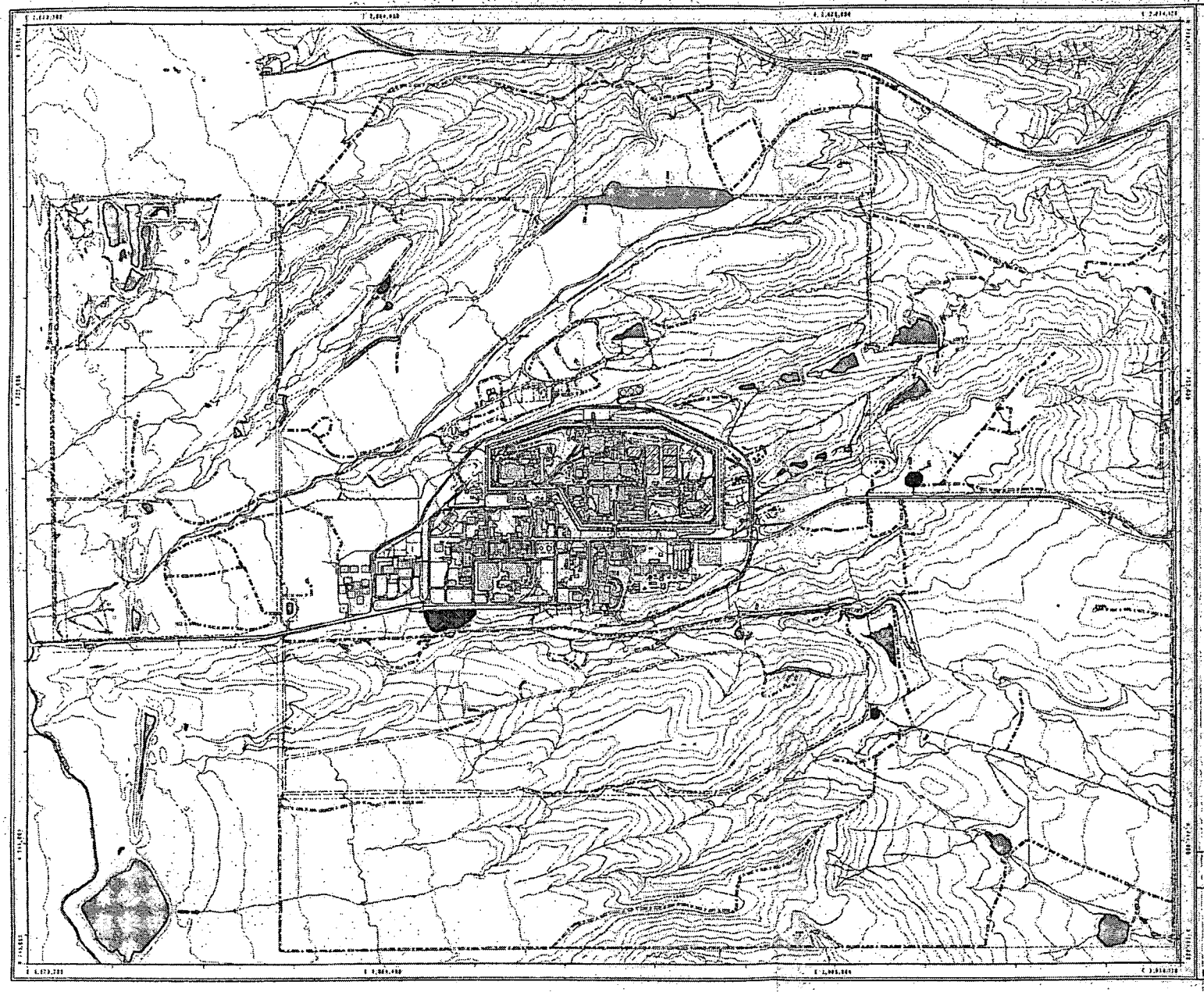
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

Prepared by:
Exponent

MAP ID: /home/s/519855/

March 23, 1999



1998 Scotch Thistle (Onopordum acanthium), Russian Knapweed (Centaurea repens), and Annual Rye (Secale cereale) Distribution
Figure 31

MAP LEGEND

Standard Map Features

- Scotch Thistle Infestations
- Russian Knapweed Infestations
- Annual Rye Infestations
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:

Scale = 1 : 21330
1 inch represents approximately 1778 feet

500 0 1000 2000ft

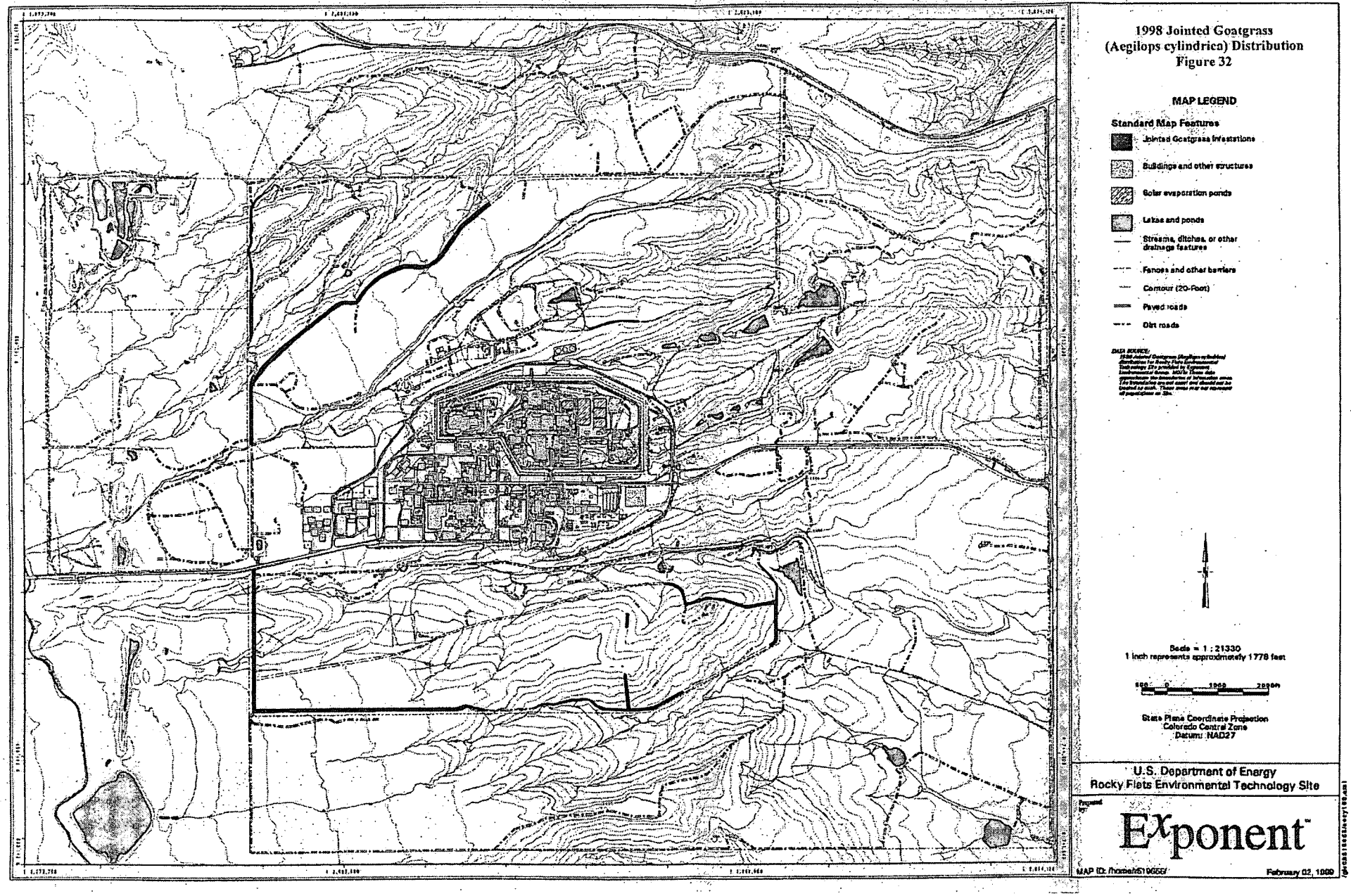
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

Exponent

MAP ID: /home/rf/519855/

February 02, 1999



1998 Jointed Goatgrass (Aegilops cylindrica) Distribution
Figure 32

MAP LEGEND

Standard Map Features

- Jointed Goatgrass infestations
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:

Scale = 1 : 21330
1 inch represents approximately 1778 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

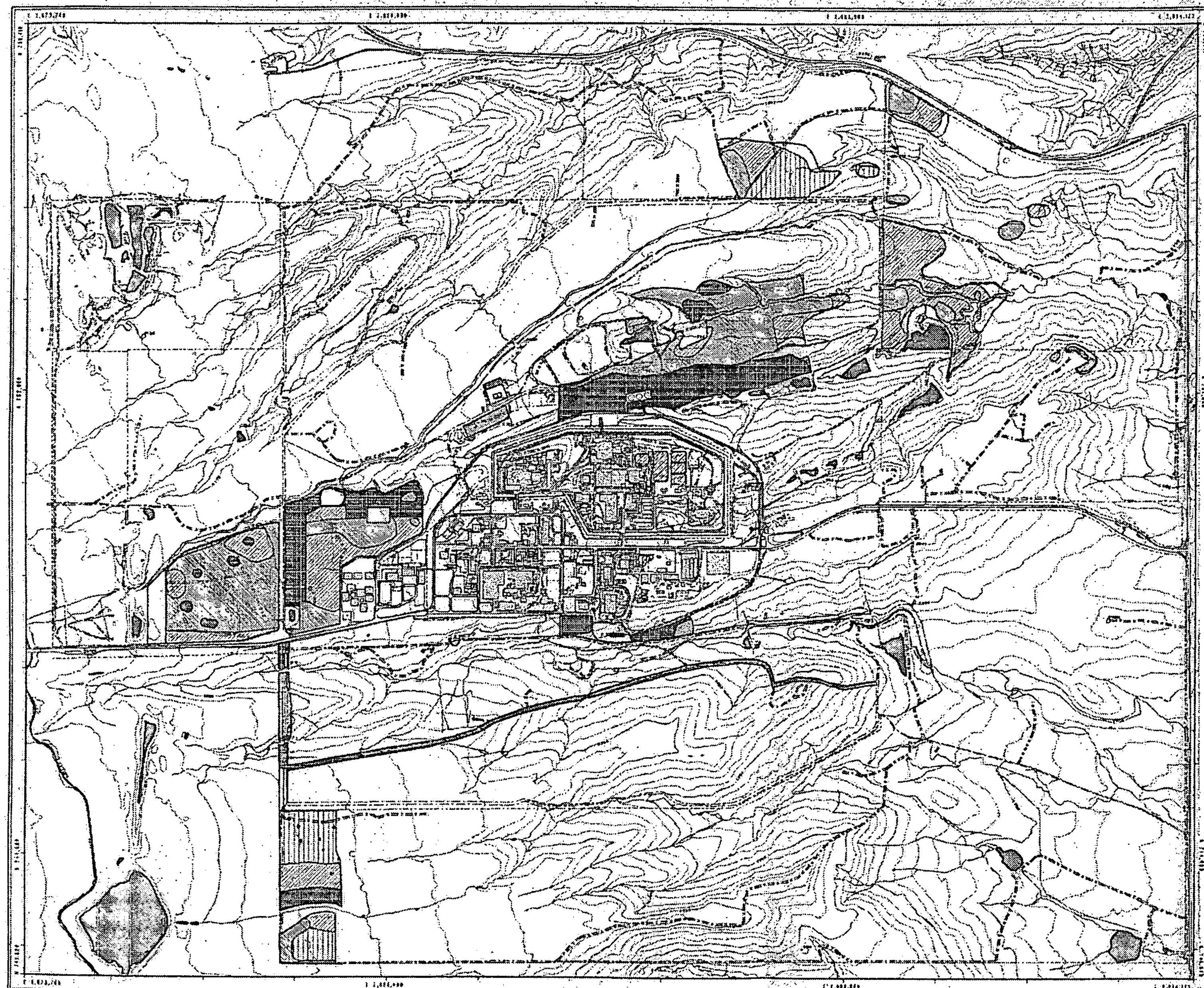
Prepared for:

Exponent

MAP ID: /home/sh519666/

February 02, 1999

1997 Diffuse Knapweed Density Levels At Treatment Locations Prior To Application Of Tordon 22K
Figure 33



MAP LEGEND

Standard Map Features

- Treatment Area Outline
- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:

Scale = 1 : 21330
1 inch represents approximately 1778 feet

500 0 1000 2000 ft

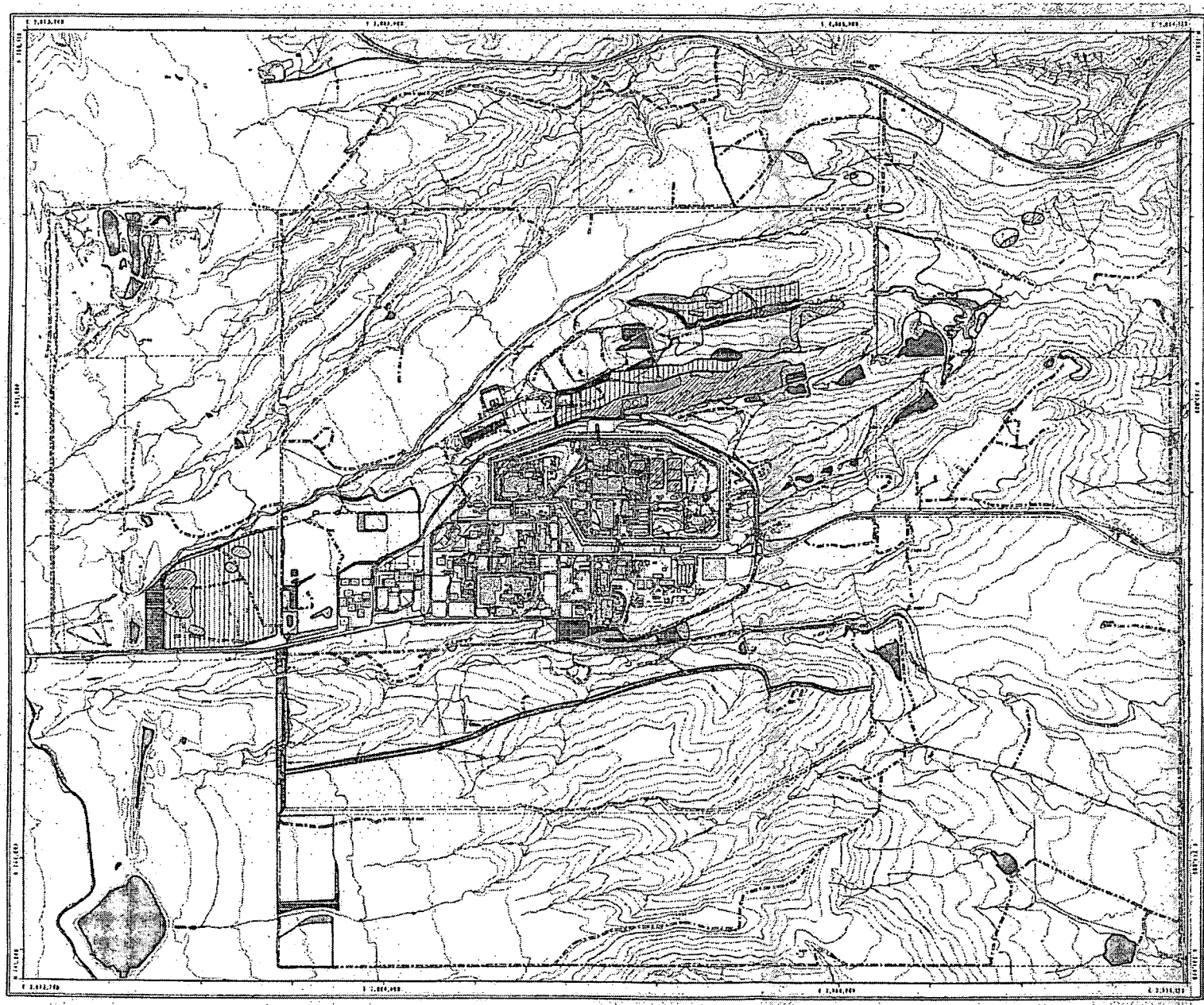
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

Prepared by:

Exponent™

MAP ID: /home/r5190557 March 23, 1999



1998 Diffuse Knapweed Density Levels At Treatment Locations After Application Of Tordon 22K
Figure 34

MAP LEGEND

Standard Map Features

- Treatment Area Outline
- High Density Areas
- Medium Density Areas
- Low Density Areas
- Scattered Density Areas
- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCES:
1998 Treatment Outline and Diffuse Knapweed Densities provided by Aspinall Environmental Group. Data only accommodate boundary and are correct only to provide a rough idea of distribution of knapweeds.

N

Scale = 1 : 21330
1 inch represents approximately 1778 feet

500 0 1000 2000 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

Prepared for:

Exponent

MAP ID: /home/rs1/965/

March 23, 1999

Tables

Table 1. 1997 and 1998 xeric tallgrass prairie species richness summary

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

Table 1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
ASTERACEAE	Scorzonera laciniata L.	SCLA1	N	X	X
ASTERACEAE	Senecio fendleri Gray	SEFE1	Y	X	X
ASTERACEAE	Senecio integerrimus Nutt.	SEIN1	Y	X	X
ASTERACEAE	Senecio plattensis Nutt.	SEPL1	Y	X	X
ASTERACEAE	Senecio spartioides T. & G.	SESP1	Y	X	X
ASTERACEAE	Senecio tridenticulatus Rydb.	SETR1	Y	X	
ASTERACEAE	Solidago missouriensis Nutt.	SOMI1	Y	X	X
ASTERACEAE	Solidago mollis Bart.	SOMO1	Y	X	X
ASTERACEAE	Solidago rigida L.	SORI1	Y	X	X
ASTERACEAE	Sonchus asper (L.) Hill	SOAS1	N	X	
ASTERACEAE	Taraxacum officinale Weber	TAOF1	N	X	X
ASTERACEAE	Thelesperma megapotanicum (Spreng.) O. Ktze.	THME1	Y	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
BERBERIDACEAE	Berberis repens Lindl.	BERE1	Y	X	
BORAGINACEAE	Cryptantha virgata (Porter) Payson	CRVI1	Y	X	X
BORAGINACEAE	Cynoglossum officinale L.	CYOF1	N	X	
BORAGINACEAE	Lappula redowskii (Hornem.) Greene	LARE1	Y	X	X
BORAGINACEAE	Lithospermum incisum Lehm.	LIIN1	Y	X	X
BORAGINACEAE	Mertensia lanceolata (Pursh.) A. DC.	MELA1	Y	X	X
BORAGINACEAE	Onosmodium molle Michx. var. occidentale (Mack.) Johnst.	ONMO1	Y	X	X
BORAGINACEAE	Plagiobothrys scouleri (H. & A.) I. M. Johnst.	PLSC1	Y	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
BRASSICACEAE	Arabis fendleri (S. Wats.) Greene var. fendleri	ARFE3	Y	X	X
BRASSICACEAE	Arabis glabra (L.) Bernh.	ARGL1	N	X	
BRASSICACEAE	Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins	ARHI1	Y	X	X
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	N	X	X
BRASSICACEAE	Camelina microcarpa Andrz. ex DC.	CAMI1	N	X	X
BRASSICACEAE	Descurainia pinnata (Walt.) Britt.	DEPI1	Y	X	X
BRASSICACEAE	Descurainia richardsonii (Sweet) Schultz	DERI1	Y		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
BRASSICACEAE	Erysimum capitatum (Nutt.) DC.	ERCA2	Y	X	X
BRASSICACEAE	Lepidium campestre (L.) R. Br.	LECA1	N	X	X
BRASSICACEAE	Lepidium densiflorum Schrad.	LEDE1	Y	X	X
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	LEMO1	Y	X	X
BRASSICACEAE	Sisymbrium altissimum L.	SIAL1	N	X	X
CACTACEAE	Coryphantha missouriensis (Sweet) Britt. & Rose	COMI1	Y	X	X
CACTACEAE	Echinocereus viridiflorus Engelm.	ECVI1	Y	X	X
CACTACEAE	Opuntia fragilis (Nutt.) Haw.	OPFR1	Y	X	X
CACTACEAE	Opuntia macrorhiza Engelm.	OPMA1	Y	X	X
CACTACEAE	Pediocactus simpsonii (Engelm.) Britt. & Rose	PESI1	Y	X	X
CAMPANULACEAE	Campanula rotundifolia L.	CARO1	Y	X	X
CAPRIFOLIACEAE	Symphoricarpos occidentalis Hook.	SYOC1	Y	X	X
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	ARFE2	Y	X	X
CARYOPHYLLACEAE	Cerastium arvense L.	CEAR1	Y	X	X
CARYOPHYLLACEAE	Paronychia jamesii T. & G.	PAJA1	Y	X	X
CARYOPHYLLACEAE	Silene antirrhina L.	SIAN1	Y	X	X
CARYOPHYLLACEAE	Silene drummondii Hook.	SIDR1	Y	X	X
CARYOPHYLLACEAE	Spergularia rubra (L.) K. Presl.	SPRU1	N	X	X
CARYOPHYLLACEAE	Vaccaria pyramidata Medic.	VAPY1	N	X	
CHENOPODIACEAE	Chenopodium album L.	CHAL1	N	X	
CHENOPODIACEAE	Chenopodium atrovirens Nutt.	CHAT1	Y	X	
CHENOPODIACEAE	Chenopodium leptophyllum Nutt. ex Moq.	CHLE2	Y	X	X
CHENOPODIACEAE	Salsola iberica Senn. & Pau.	SAIB1	N		X
CLUSIACEAE	Hypericum perforatum L.	HYPE1	N	X	X

Table 1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
COMMELINACEAE	Tradescantia occidentalis (Britt.) Smyth	TROC1	Y	X	X
CONVOLVULACEAE	Convolvulus arvensis L.	COAR1	N	X	X
CONVOLVULACEAE	Evolvulus nuttallianus R. & S.	EVNU1	Y	X	X
CRASSULACEAE	Sedum lanceolatum Torr.	SELA1	Y	X	X
CUPRESSACEAE	Juniperus communis L.	JUCO1	Y	X	X
CUPRESSACEAE	Juniperus scopulorum Sarg.	JUSC1	T	X	X
CYPERACEAE	Carex brevior (Dew.) Mack. ex Lunell.	CABR1	Y	X	
CYPERACEAE	Carex eleocharis Bailey	CAEL1	Y	X	X
CYPERACEAE	Carex filifolia Nutt.	CAFI1	Y		X
CYPERACEAE	Carex heliophila Mack.	CAHE1	Y	X	X
CYPERACEAE	Carex interior Bailey	CAIN1	Y		X
CYPERACEAE	Carex oreocharis Holm.	CAOR1	Y	X	X
CYPERACEAE	Carex praegracilis W. Boott.	CAPR1	Y		X
CYPERACEAE	Eleocharis compressa Sulliv.	ELCO1	Y	X	X
CYPERACEAE	Eleocharis macrostachya Britt.	ELMA1	Y	X	X
EUPHORBIACEAE	Euphorbia fendleri T. & G.	EUFE1	Y	X	X
EUPHORBIACEAE	Euphorbia robusta (Engelm.) Small	EURO1	Y	X	X
EUPHORBIACEAE	Euphorbia serpyllifolia Pers.	EUSE1	Y	X	
EUPHORBIACEAE	Euphorbia spathulata Lam.	EUSP1	Y	X	X
EUPHORBIACEAE	Tragia ramosa Nutt.	TRRA1	Y	X	X
FABACEAE	Amorpha fruticosa L.	AMFR1	Y	X	X
FABACEAE	Astragalus adsurgens Pall. var. robustior Hook.	ASAD1	Y	X	X
FABACEAE	Astragalus agrestis Dougl. ex G. Don	ASAG1	Y	X	X
FABACEAE	Astragalus crassicarpus Nutt.	ASCR1	Y	X	
FABACEAE	Astragalus drummondii Dougl. ex Hook.	ASDR1	Y	X	X
FABACEAE	Astragalus flexuosus (Hook.) G. Don	ASFL1	Y	X	X
FABACEAE	Astragalus shortianus Nutt. ex T.&G.	ASSH1	Y	X	X
FABACEAE	Astragalus spathulatus Sheld.	ASSP2	Y	X	
FABACEAE	Astragalus tridactylicus Gray	ASTR1	Y	X	X
FABACEAE	Dalea candida Michx. ex Willd. var. oligophylla (Torr.) Shinners.	DACA1	Y	X	X
FABACEAE	Dalea purpurea Vent	DAPU1	Y	X	X
FABACEAE	Glycyrrhiza lepidota Pursh.	GLLE1	Y	X	X
FABACEAE	Lupinus argenteus Pursh var. argenteus	LUAR1	Y	X	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
FABACEAE	Oxytropis lambertii Pursh.	OXLA1	Y	X	X
FABACEAE	Psoralea tenuiflora Pursh.	PSTE1	Y	X	X
FABACEAE	Robinia pseudo-acacia L.	ROPS1	N	X	X
FABACEAE	Thermopsis rhombifolia var. divaricarpa (Nels.) Isely	THRH1	Y	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
GENTIANACEAE	Swertia radiata (Kell.) O. Ktze.	SWRA1	Y	X	X
GERANIACEAE	Erodium cicutarium (L.) L'Her.	ERCI1	N	X	X
GERANIACEAE	Geranium caespitosum James ssp. caespitosum	GECA1	Y	X	X
GROSSULARIACEAE	Ribes aureum Pursh	RIAU1	Y	X	X
GROSSULARIACEAE	Ribes cereum Dougl.	RICE1	Y		X
HYDROPHYLLACEAE	Hydrophyllum fendleri (Gray) Heller	HYFE1	Y	X	
HYDROPHYLLACEAE	Phacelia heterophylla Pursh.	PHHE1	Y	X	X
IRIDACEAE	Iris missouriensis Nutt.	IRMI1	Y	X	X
IRIDACEAE	Sisyrinchium montanum Greene	SIMO1	Y	X	X
JUNCACEAE	Juncus balticus Willd.	JUBA1	Y	X	X
JUNCACEAE	Juncus dudleyi Wieg.	JUDU1	Y		X
JUNCACEAE	Juncus interior Wieg.	JUIN1	Y	X	X
JUNCACEAE	Juncus longistylis Torr.	JULO1	Y		X
LAMIACEAE	Hedeoma hispidum Pursh.	HEHI1	Y		X
LAMIACEAE	Marrubium vulgare L.	MAVU1	N	X	X
LAMIACEAE	Monarda fistulosa L. var. menthifolia (Grah.) Fern.	MOFI1	Y	X	X

Table 1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
LAMIACEAE	Nepeta cataria L.	NECA1	N	X	
LAMIACEAE	Prunella vulgaris L.	PRVU1	Y	X	
LAMIACEAE	Scutellaria brittonii Porter	SCBR1	Y	X	X
LILIACEAE	Allium cernuum Roth	ALCE1	Y	X	X
LILIACEAE	Allium geyeri S. Wats.	ALGE1	Y	X	X
LILIACEAE	Allium textile A. Nels. & Macbr.	ALTE1	Y	X	X
LILIACEAE	Calochortus gunnisonii S. Wats.	CAGU1	Y	X	X
LILIACEAE	Leucocrinum montanum Nutt.	LEMO2	Y	X	X
LILIACEAE	Zigadenus venenosus Wats. var. gramineus (Rydb.) Walsh ex Peck	ZIVE1	Y		X
LINACEAE	Linum perenne L. var. lewisii (Pursh.) Eat. & Wright	LIPE1	Y	X	X
MALVACEAE	Malva neglecta Wallr.	MANE1	N		X
MALVACEAE	Sphaeralcea coccinea (Pursh.) Rydb.	SPCO1	Y	X	X
NYCTAGINACEAE	Mirabilis hirsuta (Pursh.) MacM.	MIHI1	Y	X	X
NYCTAGINACEAE	Mirabilis linearis (Pursh.) Heimerl	MILI1	Y	X	X
ONAGRACEAE	Calylophus serrulatus (Nutt.) Raven	CASE2	Y	X	X
ONAGRACEAE	Epilobium paniculatum Nutt.	EPPA1	Y	X	
ONAGRACEAE	Gaura coccinea Pursh.	GACO1	Y	X	X
ONAGRACEAE	Oenothera howardii (A. Nels.) W. L. Wagner	OEHO1	Y	X	X
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	Y	X	X
OROBANCHACEAE	Orobanche fasciculata Nutt.	ORFA1	Y	X	X
OXALIDACEAE	Oxalis dillenii Jacq.	OXDI1	N	X	X
PAPAVERACEAE	Argemone polyanthemos (Fedde) G. Ownbey	ARPO1	Y	X	X
PINACEAE	Pinus ponderosa Laws	PIPO1	Y	X	X
PINACEAE	Pseudotsuga menziesii (Mirb.) Franco	PSME1	Y	X	X
PLANTAGINACE	Plantago lanceolata L.	PLLA1	N	X	X
PLANTAGINACE	Plantago patagonica Jacq.	PLPA1	Y	X	X
POACEAE	Aegilops cylindrica Host	AECY1	N	X	
POACEAE	Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	AGCA1	Y	X	X
POACEAE	Agropyron cristatum (L.) Gaertn.	AGCR1	N	X	X
POACEAE	Agropyron desertorum (Fisch.) Schult.	AGDE1	N	X	X
POACEAE	Agropyron elongatum (Host) Beauv.	AGEL1	N	X	
POACEAE	Agropyron griffithsii Scribn. & Smith	AGGR1	Y	X	X
POACEAE	Agropyron intermedium (Host) Beauv.	AGIN1	N	X	X
POACEAE	Agropyron smithii Rydb.	AGSM1	Y	X	X
POACEAE	Agrostis scabra Willd.	AGSC1	Y		X
POACEAE	Alopecurus geniculatus L.	ALGE2	Y		X
POACEAE	Andropogon gerardii Vitman	ANGE1	Y	X	X
POACEAE	Andropogon scoparius Michx.	ANSC1	Y	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
POACEAE	Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	Y	X	X
POACEAE	Bouteloua curtipendula (Michx.) Torr.	BOCU1	Y	X	X
POACEAE	Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	Y	X	X
POACEAE	Bouteloua hirsuta Lag	BOHI1	Y	X	X
POACEAE	Bromus inermis Leyss. ssp. inermis	BRIN1	N	X	X
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	N	X	X
POACEAE	Bromus tectorum L.	BRTE1	N	X	X
POACEAE	Buchloe dactyloides (Nutt.) Engelm.	BUDA1	Y	X	X
POACEAE	Dactylis glomerata L.	DAGL1	N	X	X
POACEAE	Danthonia spicata (L.) Beauv. ex R. & S.	DASP1	Y	X	X
POACEAE	Dichanthelium oligosanthes (Schultz) Gould var. scribnerianum (Nash) G	DIOL1	Y	X	X
POACEAE	Echinochloa crusgallii (L.) Beauv.	ECCR1	N	X	
POACEAE	Elymus canadensis L.	ELCA1	Y		X
POACEAE	Elymus juncea Fisch.	ELJU1	N		X
POACEAE	Festuca ovina L. var. rydbergii St. Yves	FEOV1	Y	X	X
POACEAE	Hordeum jubatum L.	HOJU1	Y	X	
POACEAE	Koeleria pyramidata (Lam.) Beauv.	KOPY1	Y	X	X
POACEAE	Lolium perenne L.	LOPE1	N		X
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	Y	X	X

Table 1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
POACEAE	Muhlenbergia wrightii Vasey	MUWR1	Y	X	
POACEAE	Oryzopsis hymenoides (R. & S.) Ricker	ORHY1	Y	X	X
POACEAE	Panicum capillare L.	PACA1	Y	X	
POACEAE	Panicum virgatum L.	PAVI1	Y	X	X
POACEAE	Phleum pratense L.	PHPR1	N	X	X
POACEAE	Poa bulbosa L.	POBU1	N	X	
POACEAE	Poa canbyi (Scribn.) Piper	POCA1	Y	X	X
POACEAE	Poa compressa L.	POCO1	N	X	X
POACEAE	Poa fendleriana (Steud.) Vasey	POFE1	Y	X	X
POACEAE	Poa pratensis L.	POPR1	N	X	X
POACEAE	Schedonnardus paniculatus (Nutt.) Trel.	SCPA2	N	X	
POACEAE	Secale cereale L.	SECE1	N	X	X
POACEAE	Setaria viridis (L.) Beauv.	SEVI1	N	X	X
POACEAE	Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	Y	X	X
POACEAE	Sorghastrum nutans (L.) Nash	SONU1	Y	X	X
POACEAE	Sporobolus asper (Michx.) Kunth	SPAS1	Y	X	X
POACEAE	Sporobolus cryptandrus (Torr.) A. Gray	SPCR1	Y	X	X
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	Y	X	X
POACEAE	Stipa comata Trin. & Rupr.	STCO1	Y	X	X
POACEAE	Stipa neomexicana (Thur.) Scribn.	STNE1	Y	X	
POACEAE	Stipa spartea Trinius	STSP1	Y	X	X
POACEAE	Stipa viridula Trin.	STVI1	Y	X	X
POACEAE	Triticum aestivum L.	TRAE1	N	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
POLEMONIACEAE	Navarretia minima Nutt.	NAMI1	N	X	X
POLYGONACEAE	Eriogonum alatum Torr.	ERAL1	Y	X	X
POLYGONACEAE	Eriogonum effusum Nutt.	EREF1	Y	X	X
POLYGONACEAE	Eriogonum umbellatum Torr.	ERUM1	Y	X	X
POLYGONACEAE	Polygonum arenastrum Jord. ex Bor.	POAR1	N	X	
POLYGONACEAE	Polygonum convolvulus L.	POCO2	N	X	X
POLYGONACEAE	Polygonum douglasii Greene	PODO1	Y	X	
POLYGONACEAE	Polygonum ramosissimum Michx.	PORA1	Y		X
POLYGONACEAE	Polygonum sawatchense Small	POSA1	Y	X	
POLYGONACEAE	Rumex acetosella L.	RUAC1	N	X	X
POLYGONACEAE	Rumex crispus L.	RUCR1	N	X	X
POLYGONACEAE	Rumex salicifolius Weinm. ssp. triangulivalvis Danser	RUSA1	Y	X	X
PORTULACACEAE	Claytonia rosea Rydb.	CLRO1	Y	X	
PORTULACACEAE	Talinum parviflorum Nutt.	TAPA1	Y	X	X
PRIMULACEAE	Androsace occidentalis Pursh.	ANOC1	Y	X	X
RANUNCULACEAE	Anemone patens L.	ANPA2	Y	X	X
RANUNCULACEAE	Clematis ligusticifolia Nutt.	CLLI1	Y		X
RANUNCULACEAE	Delphinium nuttalianum Pritz. ex Walpers	DENU1	Y	X	X
RANUNCULACEAE	Delphinium virescens Nutt. ssp. penardii (Huth) Ewan	DEVI1	Y	X	X
RANUNCULACEAE	Myosurus minimus L.	MYMI1	Y	X	X
ROSACEAE	Amelanchier alnifolia Nutt.	AMAL1	Y	X	X
ROSACEAE	Crataegus erythropoda Ashe	CRER1	Y	X	X
ROSACEAE	Geum macrophyllum Willd.	GEMA1	Y		X
ROSACEAE	Potentilla fissa Nutt.	POFI1	Y	X	X
ROSACEAE	Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc.	POGR1	Y	X	X
ROSACEAE	Potentilla hippiana Lehm.	POHI1	Y	X	X
ROSACEAE	Potentilla pensylvanica L.	POPE4	Y	X	X
ROSACEAE	Prunus pumila L. var. besseyi (Bailey) Gl.	PRPU1	Y	X	X
ROSACEAE	Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg.	PRVI1	Y	X	X
ROSACEAE	Rosa acicularis Lindl.	ROAC1	Y	X	
ROSACEAE	Rosa arkansana Porter	ROAR1	Y	X	X
ROSACEAE	Rosa woodsii Lindl.	ROWO1	Y	X	
RUBIACEAE	Galium aparine L.	GAAP1	Y	X	X
RUBIACEAE	Galium septentrionale Roemer & Schultes	GASE1	Y	X	

Table 1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
SALICACEAE	Populus deltoides Marsh. ssp. monilifera (Ait.) Eckenw.	PODE1	Y	X	X
SANTALACEAE	Comandra umbellata (L.) Nutt.	COUM1	Y	X	X
SAXIFRAGACEAE	Heuchera parvifolia Nutt. ex T.& G.	HEPA1	Y	X	X
SAXIFRAGACEAE	Saxifraga rhomoidea Greene	SARH1	Y	X	X
SCROPHULARIACEAE	Castilleja integra A. Gray	CAIN2	Y	X	X
SCROPHULARIACEAE	Castilleja sessiliflora Pursh.	CASE3	Y	X	X
SCROPHULARIACEAE	Collinsia parviflora Doug. ex Lindl.	COPA1	Y	X	X
SCROPHULARIACEAE	Linaria dalmatica (L.) Mill.	LIDA1	N	X	X
SCROPHULARIACEAE	Linaria vulgaris Hill	LIVU1	N		X
SCROPHULARIACEAE	Penstemon secundiflorus Benth.	PESE1	Y	X	X
SCROPHULARIACEAE	Penstemon strictus Bentham in De Candolle	PEST1	Y		X
SCROPHULARIACEAE	Penstemon virens Penn.	PEVI1	Y	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
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	N	X	X
SCROPHULARIACEAE	Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren	VEPE1	Y	X	X
SELAGINELLACEAE	Selaginella densa Rydb.	SEDE1	Y	X	X
SOLANACEAE	Physalis heterophylla Nees	PHHE2	Y	X	X
SOLANACEAE	Physalis virginiana P. Mill.	PHVI2	Y	X	X
SOLANACEAE	Solanum rostratum Dun.	SORO1	Y	X	
SOLANACEAE	Solanum triflorum Nutt.	SOTR1	Y		X
ULMACEAE	Ulmus pumila L.	ULPU1	N	X	X
VERBENACEAE	Lippia cuneifolia (Torr.) Steud.	LICU1	Y	X	X
VERBENACEAE	Verbena bracteata Lag. & Rodr.	VEBR1	Y	X	X
VIOLACEAE	Viola nuttallii Pursh.	VINU1	Y	X	X
	Total number of species			295	274
	Percent native species			79	81

Table 2. 1998 xeric mixed grassland foliar cover summary

Family	Scientific Name	Speccode	Native	TR01			TR06			TR12		
				Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover
APIACEAE	Lomatium orientale Coult. & Rose	LOOR1	Y							20	0.20	0.24
ASTERACEAE	Ambrosia psilostachya DC.	AMPS1	Y	20	0.20	0.25	20	1.00	1.17	40	0.40	0.48
ASTERACEAE	Antennaria parvifolia Nutt.	ANPA1	Y	20	0.20	0.25						
ASTERACEAE	Artemisia frigida Willd.	ARFR1	Y	20	0.20	0.25	20	0.20	0.23			
ASTERACEAE	Artemisia ludoviciana Nutt. var. ludoviciana	ARLU1	Y							40	0.80	0.97
ASTERACEAE	Aster porteri Gray	ASPO1	Y	100	11.80	14.53				80	1.20	1.45
ASTERACEAE	Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi	CANU1	N				20	0.20	0.23			
ASTERACEAE	Centaurea diffusa Lam.	CEDI1	N	20	0.20	0.25						
ASTERACEAE	Chrysopsis villosa Pursh.	CHVI1	Y	40	0.40	0.49						
ASTERACEAE	Helianthus pumilus Nutt.	HEPU1	Y				20	0.20	0.23			
ASTERACEAE	Lactuca serriola L.	LASE1	N							20	0.20	0.24
ASTERACEAE	Liatris punctata Hook.	LIPU1	Y	80	2.40	2.96				80	2.20	2.66
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	N				20	0.20	0.23			
BORAGINACEAE	Lithospermum incisum Lehm.	LIIN1	Y							20	0.20	0.24
BRASSICACEAE	Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	ALMI1	N	20	0.20	0.25	40	1.40	1.64	60	0.80	0.97
BRASSICACEAE	Descurainia pinnata (Walt.) Britt.	DEPI1	Y							20	0.20	0.24
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	LEMO1	Y	20	0.20	0.25						
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	ARFE2	Y	100	4.00	4.93				80	1.00	1.21
CARYOPHYLLACEAE	Paronychia jamesii T. & G.	PAJA1	Y	40	0.40	0.49						
CYPERACEAE	Carex filifolia Nutt.	CAFI1	Y				20	0.20	0.23			
CYPERACEAE	Carex heliophila Mack.	CAHE1	Y	80	5.80	7.14	60	1.60	1.87	100	4.00	4.83
EUPHORBIACEAE	Euphorbia robusta (Engelm.) Small	EURO1	Y							40	0.40	0.48
FABACEAE	Dalea purpurea Vent	DAPU1	Y	20	0.20	0.25						
FABACEAE	Oxytropis lambertii Pursh.	OXLA1	Y							20	0.20	0.24
FABACEAE	Psoralea tenuiflora Pursh.	PSTE1	Y	80	1.40	1.72				20	0.20	0.24
LINACEAE	Linum perenne L. var. lewisii (Pursh.) Eat. & Wright	LIPE1	Y				40	0.40	0.47			
ONAGRACEAE	Calylophus serrulatus (Nutt.) Raven	CASE2	Y	20	0.20	0.25						
POACEAE	Andropogon gerardii Vitman	ANGE1	Y	100	9.60	11.82	40	0.80	0.94	100	12.20	14.73
POACEAE	Andropogon scoparius Michx.	ANSC1	Y	80	1.40	1.72	40	0.40	0.47			
POACEAE	Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	Y	20	0.20	0.25	60	0.60	0.70			
POACEAE	Bouteloua curtipendula (Michx.) Torr.	BOCU1	Y	100	3.00	3.69	80	1.60	1.87	100	3.60	4.35
POACEAE	Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	Y	80	1.60	1.97	80	1.60	1.87	100	3.00	3.62
POACEAE	Bouteloua hirsuta Lag	BOHI1	Y	60	1.00	1.23				40	0.40	0.48
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	N	40	0.40	0.49	100	7.40	8.67	80	1.80	2.17
POACEAE	Bromus tectorum L.	BRTE1	N	20	0.40	0.49				20	0.80	0.97
POACEAE	Koeleria pyramidata (Lam.) Beauv.	KOPY1	Y	80	1.60	1.97				80	1.20	1.45
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	Y	80	14.80	18.23				100	2.20	2.66
POACEAE	Poa compressa L.	POCO1	N	80	6.60	8.13	60	4.20	4.92	100	6.20	7.49
POACEAE	Poa pratensis L.	POPR1	N	20	5.00	6.16	80	6.80	7.96	60	1.40	1.69
POACEAE	Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	Y	40	0.80	0.99	40	0.40	0.47	20	0.20	0.24

Table 2. (cont.)

Family	Scientific Name	Speccode	Native	TR01			TR06			TR12		
				Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover
POACEAE	Sorghastrum nutans (L.) Nash	SONU1	Y	80	1.20	1.48				40	1.60	1.93
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	Y	60	0.80	0.99						
POACEAE	Stipa comata Trin. & Rupr.	STCO1	Y	100	4.00	4.93	100	43.40	50.82	100	36.20	43.72
POACEAE	Stipa neomexicana (Thur.) Scribn.	STNE1	Y				20	3.60	4.22			
POLYGONACEAE	Eriogonum alatum Torr.	ERAL1	Y	40	0.40	0.49						
PORTULACACEAE	Talinum parviflorum Nutt.	TAPA1	Y	20	0.20	0.25						
SANTALACEAE	Comandra umbellata (L.) Nutt.	COUM1	Y	40	0.40	0.49						
SCROPHULARIACEAE	Linaria dalmatica (L.) Mill.	LIDA1	N				100	9.20	10.77			
	Total foliar cover				81.20	100.00		85.40	100.00		82.80	100.00
	Total native foliar cover				68.40	84.24		56.00	65.57		71.60	86.47

Note: Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible at a site (500).
Relative cover = Relative foliar cover is the number of hits on a species 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).

Table 3. 1998 wetlands species richness

Family	Scientific Name	Speccode	Native	Site		
				W1	W2	W3
ALISMATACEAE	Sagittaria latifolia Willd.	SALA1	Y			X
APIACEAE	Cicuta maculata L. var. angustifolia Hook.	CIMA1	Y	X		
ASCLEPIADACEAE	Asclepias incarnata L.	ASIN1	Y		X	X
ASCLEPIADACEAE	Asclepias speciosa Torr.	ASSP1	Y	X	X	X
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	Y	X	X	X
ASTERACEAE	Arnica fulgens Pursh.	ARFU1	Y	X		
ASTERACEAE	Arctium minus Bernh.	ARMI1	Y	X		
ASTERACEAE	Aster falcatus Lindl.	ASFA1	Y	X	X	
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	N	X	X	X
ASTERACEAE	Cirsium vulgare (Savi) Ten.	CIVU1	N	X	X	X
ASTERACEAE	Lactuca serriola L.	LASE1	N	X	X	X
ASTERACEAE	Sonchus asper (L.) Hill	SOAS1	N		X	
ASTERACEAE	Solidago missouriensis Nutt.	SOMI1	Y	X		
ASTERACEAE	Taraxacum officinale Weber	TAOF1	N	X	X	
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	N	X	X	X
BORAGINACEAE	Cynoglossum officinale L.	CYOF1	N		X	X
BORAGINACEAE	Onosmodium molle Michx. var. occidentale (Mack.) Johnst.	ONMO1	Y	X		
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	N	X		X
BRASSICACEAE	Nasturtium officinale R. Br.	NAOF1	N	X		X
BRASSICACEAE	Thlaspi arvense L.	THAR1	N	X	X	X
CANNABACEAE	Humulus lupulus L. var. lupuloides E. Small	HULU1	Y	X		
CAPRIFOLIACEAE	Symphoricarpos occidentalis Hook.	SYOC1	Y	X	X	X
CERATOPHYLLACEAE	Ceratophyllum demersum L.	CEDE1	Y			X
CLUSIACEAE	Hypericum perforatum L.	HYPE1	N	X	X	X
CYPERACEAE	Carex hystericina Muhl. ex Willd.	CAHY1	Y			X
CYPERACEAE	Carex interior Bailey	CAIN1	Y		X	X
CYPERACEAE	Carex lanuginosa Michx.	CALA1	Y	X	X	X
CYPERACEAE	Carex nebrascensis Dew.	CANE1	Y	X	X	X
CYPERACEAE	Carex praegracilis W. Boott.	CAPR1	Y		X	
CYPERACEAE	Carex scoparia Schkuhr. ex Willd.	CASC1	Y	X		
CYPERACEAE	Eleocharis macrostachya Britt.	ELMA1	Y	X	X	X
CYPERACEAE	Scirpus pallidus (Britt.) Fern	SCPA1	Y		X	
EQUISETACEAE	Equisetum laevigatum A. Br.	EQLA1	Y	X	X	
EUPHORBIACEAE	Euphorbia robusta (Engelm.) Small	EURO1	Y			X
FABACEAE	Amorpha fruticosa L.	AMFR1	Y	X		
FABACEAE	Dalea purpurea Vent	DAPU1	Y	X		
FABACEAE	Glycyrrhiza lepidota Pursh.	GLLE1	Y	X		
FABACEAE	Thermopsis rhombifolia var. divaricarpa (Nels.) Isely	THRH1	Y	X		
FABACEAE	Trifolium sp.	TRI1				X
IRIDACEAE	Iris missouriensis Nutt.	IRMI1	Y		X	
JUNCACEAE	Juncus balticus Willd.	JUBA1	Y	X	X	X
JUNCACEAE	Juncus dudleyi Wieg.	JUDU1	Y	X	X	X
JUNCACEAE	Juncus ensifolius Wikst. var. montanus (Englm.) C. L. Hitchc.	JUEN1	Y		X	X
JUNCACEAE	Juncus longistylis Torr.	JULO1	Y	X	X	X
JUNCACEAE	Juncus nodosus L.	JUNO1	Y		X	X
JUNCACEAE	Juncus torreyi Cov.	JUTO1	Y		X	
LAMIACEAE	Lycopus americanus Muhl. ex Barton	LYAM1	Y	X	X	X
LAMIACEAE	Mentha arvensis L.	MEAR1	Y	X	X	X
LAMIACEAE	Monarda fistulosa L. var. menthifolia (Grah.) Fern.	MOFI1	Y			X
LAMIACEAE	Nepeta cataria L.	NECA1	N	X		X
LAMIACEAE	Prunella vulgaris L.	PRVU1	Y	X	X	X
LEMNACEAE	Lemna minor L.	LEMI1	Y	X	X	X
LILIACEAE	Allium textile A. Nels. & Macbr.	ALTE1	Y	X		
LILIACEAE	Smilacina stellata (L.) Desf.	SMST1	Y	X		
LYTHRACEAE	Lythrum alatum Pursh.	LYAL1	Y		X	

Table 3. (cont.)

Family	Scientific Name	Speccode	Native	Site W1	Site W2	Site W3
ONAGRACEAE	Epilobium ciliatum Raf. ssp. glandulosum (Lehm.) Hock & Raven	EPCI1	Y	X	X	X
ONAGRACEAE	Epilobium paniculatum Nutt.	EPPA1	Y	X	X	X
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	Y	X	X	X
OXALIDACEAE	Oxalis dillenii Jacq.	OXDI1	N	X		X
POACEAE	Agropyron repens (L.) Beauv.	AGRE1	N	X	X	X
POACEAE	Agrostis scabra Willd.	AGSC1	Y	X	X	X
POACEAE	Agrostis stolonifera L.	AGST1	N	X	X	X
POACEAE	Bromus inermis Leyss. ssp. inermis	BRIN1	N	X		
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	N	X	X	X
POACEAE	Calamagrostis stricta (Timm.) Koel	CAST2	Y		X	
POACEAE	Glyceria striata (Lam.) Hitchc.	GLST1	Y	X	X	X
POACEAE	Hordeum jubatum L.	HOJU1	Y	X		X
POACEAE	Poa compressa L.	POCO1	N		X	
POACEAE	Poa palustris L.	POPA1	N	X	X	X
POACEAE	Poa pratensis L.	POPR1	N	X	X	X
POACEAE	Sphenopholis obtusata (Michx.) Scribn.	SPOB1	Y		X	X
POACEAE	Spartina pectinata Link	SPPE1	Y	X	X	X
POLYGONACEAE	Polygonum convolvulus L.	POCO2	N	X		X
POLYGONACEAE	Polygonum ramosissimum Michx.	PORA1	Y	X		X
POLYGONACEAE	Rumex crispus L.	RUCR1	N	X	X	X
POLYGONACEAE	Rumex obtusifolius L.	RUOB1	N	X		
PRIMULACEAE	Lysimachia ciliata L.	LYCI1	Y	X		
RANUNCULACEAE	Ranunculus macounii Britt.	RAMA1	Y	X		X
ROSACEAE	Geum aleppicum Jacq.	GEAL1	Y	X	X	X
ROSACEAE	Geum macrophyllum Willd.	GEMA1	Y	X	X	X
ROSACEAE	Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc.	POGR1	Y	X	X	
ROSACEAE	Potentilla norvegica L.	PONO1	Y	X		X
ROSACEAE	Rosa arkansana Porter	ROAR1	Y	X		X
RUBIACEAE	Galium aparine L.	GAAP1	Y	X		X
RUBIACEAE	Galium septentrionale Roemer & Schultes	GASE1	Y	X		
SCROPHULARIACEAE	Mimulus glabratus H. B. K. var. fremontii (Benth.) A. L. Grant	MIGL1	Y			X
SCROPHULARIACEAE	Scrophularia lanceolata Pursh.	SCLA2	Y	X		
SCROPHULARIACEAE	Veronica anagallis-aquatica L.	VEAN1	N	X		X
SCROPHULARIACEAE	Verbascum blattaria L.	VEBL1	N		X	
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	N	X		X
TYPHACEAE	Typha latifolia L.	TYLA1	Y	X	X	X
UNKNOWN	Unidentifiable species	UNKN		X		
URTICACEAE	Urtica dioica L. ssp. gracilis (Ait.) Seland.	URDI1	Y	X		X
VERBENACEAE	Verbena hastata L.	VEHA1	Y	X	X	X
VIOLACEAE	Viola sororia Willd.	VISO1	Y			X
	Total # species:			72	54	63
	Percent native species:			69	69	68

Wetland Indicator Species					
Facultative species	FAC		14	6	9
Facultative upland species	FACU		15	9	1
Facultative upland species - less frequently found in wetlands	FACU-		0	0	1
Facultative wetland species	FACW		12	12	10
Non-indicator species	NI		9	8	8
Obligate wetland species	OBL		14	15	19
Upland species	UPL		1	2	1
Total # species:			65	52	49

Table 4. 1998 wetland foliar cover data summary

Family	Scientific Name	Speccode	W1			W2			W3		
			Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover
ASCLEPIADACEAE	Asclepias incarnata L.	ASIN1							80	3.60	3.83
ASCLEPIADACEAE	Asclepias speciosa Torr.	ASSP1	40	1.40	1.48	20	0.20	0.23			
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	20	0.20	0.21						
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	80	5.40	5.71	40	3.40	3.86	100	5.20	5.53
ASTERACEAE	Lactuca serriola L.	LASE1							20	0.20	0.21
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	80	7.40	7.82				100	4.60	4.89
BRASSICACEAE	Nasturtium officinale R. Br.	NAOF1	20	0.80	0.85				20	3.20	3.40
CLUSIACEAE	Hypericum perforatum L.	HYPE1	20	1.40	1.48	20	0.20	0.23			
CYPERACEAE	Carex hystericina Muhl. ex Willd.	CAHY1							20	0.20	0.21
CYPERACEAE	Carex interior Bailey	CAIN1							40	0.40	0.43
CYPERACEAE	Carex lanuginosa Michx.	CALA1	60	7.60	8.03	80	6.00	6.82	20	0.40	0.43
CYPERACEAE	Carex nebrascensis Dew.	CANE1	80	3.00	3.17	80	5.00	5.68	100	6.00	6.38
CYPERACEAE	Carex praegracilis W. Boott.	CAPR1				60	1.60	1.82			
CYPERACEAE	Eleocharis macrostachya Britt.	ELMA1	20	0.80	0.85	20	0.80	0.91	80	2.80	2.98
FABACEAE	Thermopsis rhombifolia var. divaricarpa (Nels.) Isely	THRH1	40	1.20	1.27						
JUNCACEAE	Juncus balticus Willd.	JUBA1	100	37.80	39.96	100	45.20	51.36	100	37.40	39.79
JUNCACEAE	Juncus ensifolius Wikst. var. montanus (Englm.) C. L. Hitchc.	JUEN1				20	0.20	0.23	20	0.20	0.21
JUNCACEAE	Juncus longistylis Torr.	JULO1	40	2.20	2.33	40	3.80	4.32	60	1.60	1.70
JUNCACEAE	Juncus nodosus L.	JUNO1				20	0.40	0.45			
LAMIACEAE	Mentha arvensis L.	MEAR1	80	3.40	3.59				40	1.80	1.91
LAMIACEAE	Monarda fistulosa L. var. menthifolia (Grah.) Fern.	MOFI1							20	0.20	0.21
LAMIACEAE	Nepeta cataria L.	NECA1							20	0.20	0.21
LAMIACEAE	Prunella vulgaris L.	PRVU1				20	0.20	0.23			
LEMNACEAE	Lemna minor L.	LEMI1				20	0.20	0.23	40	0.40	0.43
LILIACEAE	Smilacina stellata (L.) Desf.	SMST1	20	0.20	0.21						
LYTHRACEAE	Lythrum alatum Pursh.	LYAL1				20	0.40	0.45			
ONAGRACEAE	Epilobium ciliatum Raf. ssp. glandulosum (Lehm.) Hock & Raven	EPCI1	60	1.20	1.27	20	0.20	0.23	40	0.40	0.43
ONAGRACEAE	Epilobium paniculatum Nutt.	EPPA1	40	0.60	0.63	20	0.40	0.45	80	1.40	1.49
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	20	0.20	0.21				40	0.80	0.85
POACEAE	Agropyron repens (L.) Beauv.	AGRE1	40	0.40	0.42	20	0.40	0.45			
POACEAE	Agrostis scabra Willd.	AGSC1	20	0.40	0.42				80	4.60	4.89
POACEAE	Agrostis stolonifera L.	AGST1	40	0.60	0.63				60	1.60	1.70
POACEAE	Calamagrostis stricta (Timm.) Koel	CAST2				20	1.60	1.82			
POACEAE	Glyceria striata (Lam.) Hitchc.	GLST1							20	1.20	1.28
POACEAE	Hordeum jubatum L.	HOJU1	20	0.20	0.21				20	0.20	0.21
POACEAE	Poa pratensis L.	POPR1	60	2.40	2.54	40	4.40	5.00	80	3.20	3.40
POACEAE	Spartina pectinata Link	SPPE1	20	1.80	1.90	40	5.00	5.68	40	1.40	1.49
POACEAE	Sphenopholis obtusata (Michx.) Scribn.	SPOB1							20	0.20	0.21

Table 4. (cont.)

Family	Scientific Name	Speccode	W1			W2			W3		
			Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover
POLYGONACEAE	Polygonum convolvulus L.	POCO2	20	0.40	0.42				20	0.40	0.43
POLYGONACEAE	Rumex crispus L.	RUCR1				20	0.20	0.23			
ROSACEAE	Geum aleppicum Jacq.	GEAL1	20	0.20	0.21	60	1.40	1.59	40	0.40	0.43
ROSACEAE	Geum macrophyllum Willd.	GEMA1	80	2.60	2.75	80	1.00	1.14	60	1.60	1.70
RUBIACEAE	Galium aparine L.	GAAP1	20	0.40	0.42				20	0.20	0.21
RUBIACEAE	Galium septentrionale Roemer & Schultes	GASE1	20	0.40	0.42						
SCROPHULARIACEAE	Scrophularia lanceolata Pursh.	SCLA2	20	0.20	0.21						
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	20	0.20	0.21						
SCROPHULARIACEAE	Veronica anagallis-aquatica L.	VEAN1							20	0.20	0.21
TYPHACEAE	Typha latifolia L.	TYLA1	60	8.80	9.30	40	5.80	6.59	40	7.20	7.66
URTICACEAE	Urtica dioica L. ssp. gracilis (Ait.) Seland.	URDI1							20	0.20	0.21
VERBENACEAE	Verbena hastata L.	VEHA1	20	0.60	0.63				20	0.20	0.21
VIOLACEAE	Viola sororia Willd.	VISO1							20	0.20	0.21
UNKNOWN	Unknown species	UNKN	20	0.20	0.21						
	Total cover			94.60	100.00		88.00	100.00		94.00	100.00
	Shannon-Weiner diversity index			1.03			0.84			1.07	

Note: Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible at a wetland (500).
Relative cover = Relative foliar cover is the number of hits on a species relative to the total number of all vegetative hits recorded per wetland (i.e., the percent of vegetative cover the species represented).
All cover values presented are means (n = 5).

Table 5. 1998 estimated weed infestation acreage summary

	1998 Acreage (Estimated)				
		Density Level			
Common Name	Site Total	High	Medium	Low	Scattered
Diffuse knapweed	2,913	761	778	987	388
Russian knapweed	1	NA	NA	NA	NA
Dalmatian toadflax	1,934	313	273	989	359
Musk thistle	1,685	32	515	1,035	102
Mullein	867	168	225	460	13
Jointed goatgrass	35	NA	NA	NA	NA
Annual rye	26	NA	NA	NA	NA
Scotch thistle	9	NA	NA	NA	NA

Note: NA - data not collected by density level

Table 6. Comparison of 1997 and 1998 weed infestation extents

Weed Species	Year	Site Total	Density Level			
			High	Medium	Low	Scattered
Diffuse knapweed	1997	2,678	696	893	658	431
	1998	2,913	761	778	987	388
Dalmatian toadflax	1997	422	135	205	82	0
	1998	1,934	313	273	989	359
Musk thistle	1997	474	2	270	202	0
	1998	1,685	32	515	1,035	102
Mullein	1997	575	117	238	203	17
	1998	867	168	225	460	13

Note: All values are estimated acreages.
See text for density level descriptions.

Appendix A

Technical Reports

Report 1	1998 High-Value Plant Community Survey
Report 2	Monitoring Summary for Diffuse Knapweed Control Study
Report 3	Effects of a Late-Summer Grassland Fire on Diffuse Knapweed Density
Report 4	1998 Wetland Monitoring Summary
Report 5	1998 Xeric Mixed Grassland Monitoring Summary

SPECIAL NOTE:

All the figures in the Technical Report sections are found in the main report section. They were not duplicated again for the Technical Reports in order to keep the electronic file size smaller. Please use the list below to find the appropriate figures in the Main Report Section.

Technical Report Figure #	=	Main Report Section Figure #
Figure 1-1		Figure 2
Figure 1-2		Figure 27
Figure 1-3		Figure 28
Figure 1-4		Figure 29
Figure 1-5		Figure 30
Figure 1-6		Figure 31
Figure 1-7		Figure 32
Figure 1-8		Figure 33
Figure 1-9		Figure 34
Figure 2-1		Figure 21
Figure 3-1		Figure 17
Figure 3-2		Figure 18
Figure 4-1		Figure 7
Figure 5-1		Figure 4

Report 1

1998 High-Value Plant Community Survey

1. 1998 High-Value Plant Community Survey

1.1 Introduction

The goal of the high-value vegetation monitoring is to qualitatively assess the status and quality of the high-value plant communities (xeric tallgrass prairie, tall upland shrubland, selected wetlands, and Great Plains riparian woodland) at the Rocky Flats Environmental Technology Site (Site) and to document any changes. The high-value plant communities at the Site are those 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 (K-H 1997a; CNHP 1994, 1995).

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

- assess species richness of the plant communities
- identify any rare plant populations
- 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 applications
- 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 was monitored in 1998. 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 occurring 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 on the Site, and tracking the effectiveness of weed control at the Site. Weed mapping was conducted on foot during the high-value vegetation surveys in the xeric tallgrass prairie, and from a vehicle using binoculars for the remainder of the Site. Species were mapped during their respective flowering periods, when they were most visible. The species mapped included diffuse knapweed (*Centaurea diffusa*), musk thistle (*Carduus nutans*), dalmatian toadflax (*Linaria dalmatica*), and common mullein (*Verbascum thapsus*). These species were also mapped in 1997. An additional four species, Russian knapweed (*Centaurea repens*), annual rye (*Secale cereale*), Scotch thistle (*Onopordum acanthium*), and jointed goatgrass (*Aegilops cylindrica*), were also mapped in 1998 due their increasing infestation levels and the aggressiveness of these species. Canada thistle (*Cirsium arvense*) was not mapped, because it is common throughout most of the wetlands on the Site, and therefore, the wetlands map would provide a good indication of the infested areas.

Infestation areas 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. In general, a high-density category indicated 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 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 in need of control. The scattered-density category was used only in a few cases and indicated a sporadic occurrence of the species. The rare plant and noxious weed populations and distributions were drawn in the field on 44×34-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.

1.2.3 Photographic Documentation

No photographs were taken at the permanent photo points during the summer of 1998 because of the switch to an alternate year schedule. Summer photographs will be taken again in the summer of 1999. Winter photographic documentation will be conducted in winter 1999, when the areas of woody vegetation will be photographed from the permanent photo points established in 1997 (K-H 1998). These photos will be used to document the condition of the Great Plains riparian woodland and tall upland shrubland areas when the leaves are off the plants. Photographs will be taken in the same compass directions from these photo points.

1.2.4 Qualitative Habitat Assessments

Qualitative habitat assessments were made in each of the high-value vegetation community management units on the Site during 1998. 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 each of the locations where CNHP–listed plant species of special concern are known to occur. 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 during the 1997 field season. Locations were revisited 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) and *The Environmental Management Department Operating Procedures Manual* (DOE 1994).

1.3 Results and Discussion

1.3.1 Site Flora

As a result of the 1998 fieldwork, a total of seven 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 flora are:

Calamagrostis stricta (Timm.) Koel	Northern reedgrass
Sorbus scopulina Greene	Mountain ash
Centaurea repens L.	Russian knapweed[1]
Astragalus spathulatus Sheld.	Draba milk-vetch
Agropyron elongatum (Host) Beauv.	Tall wheatgrass
Chenopodium atrovirens Rydb.	Dark goosefoot
Solidago nana Nutt.	Low goldenrod

Of these species, none are rare or imperiled; however, the discovery of Russian knapweed on the Site is cause for concern. It is listed as a noxious weed by the state of Colorado and property owners are required by law to control it. During 1998, the single population of Russian knapweed on the Site was treated with the herbicide Telar to control its spread.

[1] Listed as a noxious weed by the State of Colorado.

1.3.2 Xeric Tallgrass Prairie

A total of 295 plant species were recorded in the xeric tallgrass prairie at the Site during 1998 (Table 1-1). Of these, 79 percent were native species. This was an increase of 21 species, compared to the 1997 Site inventory, which found 274 species in the xeric tallgrass prairie. Four of these species were new to the Site species list (the last four in the list above). A Sorensen similarity index (Brower and Zar 1977) using presence/absence data from the two years yielded a value of 0.87, indicating a high floristic similarity between years, as would be expected. Examination of the species lists from both years (Table 1-1) shows no significant difference in the inventory results. The different species observed during the two 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.

Examination of the qualitative habitat assessment forms completed for the xeric tallgrass prairie management units revealed concerns similar to those reported last year (K-H 1998). The biggest management issue in the xeric tallgrass prairie, as well as the biggest threat, is weeds, especially diffuse knapweed. This species is found across much of the xeric tallgrass prairie and continues to spread. At many locations, other weed species—such as musk thistle, dalmatian toadflax, annual rye, common mullein, and numerous other less aggressive species—are also problems. The issue of weed control is discussed in greater detail later in this report.

Other management concerns for the xeric tallgrass prairie are related to plant litter buildup and human disturbance. At many locations, the bunch grasses are choked with dead plant material. In addition, the high accumulation of plant litter found on the prairie poses a wildfire concern. Prescribed burns would provide the best solution for this problem by removing the dead plant material (fuel) and recycling the nutrients to the grasses and forbs. This action would reduce the chance of catastrophic wildfire, and improve the health and vigor of the native plant species.

Continued human disturbance of the xeric tallgrass prairie is also a problem that is further degrading the quality of the prairie. Field surveys in 1998 identified two problems that disturbed the soil surface at certain locations in the xeric tallgrass prairie and will potentially open these locations to further noxious weed invasion, especially by diffuse knapweed. One of these problems is road maintenance in the Buffer Zone. Blading of the main roads in the Buffer Zone is conducted annually to maintain the firebreak roads and provide mechanical weed control through constant disturbance. In 1996, however, the width of most Buffer Zone roads that were bladed was reduced. The lack of constant disturbance along these road margins created the perfect habitat for many of the large weed infestations now present. The presence and abundance of these species, combined with a lack of disturbance and/or herbicide treatment, has allowed more of these species to invade the prairie margins along the roads. It is apparent that herbicide applications are also necessary to control the weeds that are not being controlled by blading along the road margins. Revegetation, in conjunction with herbicide treatments, would help to improve the condition of these areas and reduce the weed infestations along the road margins.

The second problem was discovered on the far western edge of the Site, near the gravel-mining operations, where additional test pits had been dug on previously undisturbed portions of xeric tallgrass prairie. Although permissible under current mine permits, these disturbances create increasing weed control problems for the Site. It is crucial to prevent small areas of disturbance such as these from becoming islands of weed infestation, which if left uncontrolled, can cause the spread of noxious weeds to previously weed-free areas. Much of the area on the western edge of the Site, where test pits were dug several years ago, is now covered with diffuse knapweed that established on the test pits and then spread across the once weed-free xeric tallgrass prairie.

1.3.3 Rare Plant Monitoring

Mapped locations of the plant species of concern, as listed by the CNHP, were revisited during the 1998 surveys. The known populations of mountain-loving sedge, forktip three-awn, and dwarf wild indigo were all found again, and the plants were evaluated. All three species were observed in vegetative, flowering, and fruiting condition, and seemed to be doing well. Carrionflower greenbriar was the only species where plants were not observed at some of the previously known population locations during 1998. However, it is often a difficult species to locate, and it is not known whether it comes up every year. Therefore, an attempt will be made to observe plants at these population locations again in 1999. At those locations where carrionflower greenbriar was observed, it was in vegetative, flowering, and fruiting condition, and appeared to be doing well.

1.3.4 Weeds

The 1998 weed distribution maps for diffuse knapweed, musk thistle, dalmatian toadflax, and mullein are shown in Figures 1-2 through 1-5, respectively. Four additional species—annual rye, Russian knapweed, Scotch thistle, and jointed goatgrass—were mapped in 1998 because of their aggressive nature and their recent appearance at various locations on the Site. The distributions of these species are shown in Figures 1-6 and 1-7. 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 using the GIS coverages. Table 1-2 contains the estimated total acreage and acreage-by-density category for each of the species, based on these maps. The species with the greatest extent on the Site was diffuse knapweed, covering nearly 2,913 acres, followed by dalmatian toadflax (1,934 acres), musk thistle (1,685 acres), and mullein (867 acres). The total acreage of the Site is approximately 6,485 acres (K-H 1997c). It should be noted that this acreage is only approximate and should not be interpreted as exact areas. These values are also representative of known locations for these species. It is possible that unmapped infestations are present as well.

Table 1-3 shows the change in infested acreage between the 1997 and 1998 mapped areas. The large increases in infestation acreages for dalmatian toadflax, musk thistle, and mullein are due in large part to the time of year in which mapping was conducted. During 1997, all weed mapping was conducted in late August to early September, when

most of these species were no longer flowering. To better estimate the extent of these species in 1998, mapping was conducted for each species when it was in flower. Therefore, the increase in acreage shown for these species is an artifact of sampling. However, the more accurate mapping completed in 1998 reveals the substantial foothold that these weed species already have on the Site. If the distributions of all the different weed species are combined, it is apparent that most of the Site is infested and weed control is needed for one or more species. However, diffuse knapweed is by far the most aggressive species needing continued control on the Site.

During the 1997 calendar year, approximately 520 acres of diffuse knapweed were treated with Tordon 22K. Figure 1-8 shows the location of the areas treated and the pre-treatment density levels of diffuse knapweed at these locations. Figure 1-9 shows the same locations in 1998 during the growing season after the herbicide was applied. Many of the areas were totally clean (i.e., no diffuse knapweed present) during the growing season after treatment. In other areas, the infestation density was reduced by one or two density levels.

Several factors may contribute to making the herbicide treatment more effective in some locations rather than in others. First, some areas may have been missed during treatment. Second, application methods vary in the evenness with which the herbicide is spread. At most of the large clean locations shown on Figure 1-9, the herbicide treatments were applied using a truck-mounted boom that had a computer-regulated application rate tied to the speed of the vehicle. This method was also used at the western-most location (mostly scattered-density level; Figure 1-9), but this area is dotted with old fence posts and irrigation ditches that had to be avoided. As a result, maneuvering around obstacles left some areas untreated, allowing patches of diffuse knapweed to remain in the treated area. At the locations northeast of the Industrial Area, the herbicide was applied with hose or backpack equipment. As a result, the herbicide application was much less even, and more spots were missed. This would account for higher remaining density levels, even after application. Third, as previously mentioned, some error may be due to mapping inconsistencies.

Overall, the herbicide applications were generally effective on the diffuse knapweed, irregardless of whether the application was made in the spring or fall. However, qualitative observations made at the different treatment locations during 1998 showed that the herbicide affected the native species differently depending on the time of application. At locations treated in November to December 1997, the native spring ephemeral forb species were hardest hit. Little to no flowering of the native spring wildflowers was observed during spring 1998 at any of the locations treated in late fall. However, at those locations where the herbicide application was made in June 1997, only a slight depression of the spring wildflower display was noticed in 1998, compared to adjacent untreated areas. Thus, the timing of the herbicide application may have a major impact on the native forb community. Based on 1998 observations on the Site, a late fall application has a more significant impact on the spring-flowering native forbs than an early summer treatment. Observation of these areas will continue during 1999 to

determine how long this effect lasts and to help determine when the most appropriate application timeframe is for killing the weeds and protecting the native species.

On the positive side, not only was diffuse knapweed controlled (albeit to varying extents) at all treatment locations, but many other weedy forbs also were controlled or had reduced infestation levels. Qualitative observations showed that non-native species such as musk thistle, salsify (*Tragopogon dubius*), western ragweed (*Ambrosia psilostachya*), wild lettuce (*Scorzonera laciniata*), and alyssum (*Alyssum minus*) were all effectively controlled. Even common mullein was controlled at some locations. In addition, qualitative observations showed that the graminoid species responded positively at all treatment locations, in both early summer and late fall. The reduced competition from both the native and weedy forbs allowed the graminoids to take advantage of the situation, as their growth appeared more robust and more flowering was observed as opposed to adjacent untreated areas. Additionally, at one treatment location where a wildfire had crossed the pediment in March 1994, the warm-season graminiod species big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), blue grama (*Bouteloua gracilis*), and side-oats grama (*Bouteloua curtipendula*) flowered profusely and were much taller than elsewhere on the Site. This suggests that combining prescribed burning with herbicide efforts could greatly improve the quality of the prairie community at the Site.

Currently the City of Boulder Mountain Parks is conducting trials using prescribed burning in conjunction with herbicide applications for control of diffuse knapweed (Armstrong 1998, pers. comm.). Results are promising thus far and the technique may be applicable to Site conditions. By burning diffuse knapweed infested areas, the surface litter is removed and knapweed seeds are allowed to germinate. Once the knapweed plants reach the rosette stage they are then treated with herbicide. Because the overtopping litter has been removed, herbicide application is much more effective and the knapweed plants are killed. The herbicide then continues to work for several years without reapplication, and the recycled nutrients released by the fire allow the native species to improve in vigor and health. The native species thus gain a competitive edge by improving the plant community's resistance to reinfestation by the weeds.

The effectiveness of the herbicide Transline was also qualitatively evaluated in 1998 at locations where it was applied during the fall of 1997 (Figure 5-6 in K-H 1998). Transline was applied in the Rock Creek drainage where diffuse knapweed was growing in proximity to wetlands and tall upland shrublands. Observations showed good control of diffuse knapweed in 1998. In most cases, the areas were completely clean, and at locations where total effectiveness was not achieved, the infestation levels dropped by one or two density levels. At all the Transline application areas, there was little observed impact to the native forb and graminoid components of the plant communities.

Although the impacts to the native forb community were fewer with the Transline herbicide, from an economic and pragmatic viewpoint, its use is less desirable because these areas will have to be retreated every one or two years, and it is considerably more expensive than Tordon 22K. With Tordon 22K, one of the benefits is the longer-term

residual effect: retreatment is needed only every 3–5 years. One of the goals of this monitoring effort is to determine more definitively what retreatment frequency will be required for effective longer-term control of diffuse knapweed under the conditions in the Buffer Zone.

Although diffuse knapweed infestations have been controlled at several treatment locations, significant hurdles must be overcome to achieve similar success across the entire Buffer Zone. Part of the problem is that the extent of the diffuse knapweed infestation is expanding at a faster rate than the current level of control effort. The 1997 and 1998 diffuse knapweed mapping data show that, even though approximately 520 acres of prairie were treated with herbicide during calendar year 1997, the extent of knapweed infestation on the Site still increased by nearly 380 acres in 1998. Even if the diffuse knapweed had been completely controlled on all 520 treated acres, there still would have been a net increase of nearly 150 acres of knapweed between 1997 and 1998, based on the maps.

Some of this discrepancy is attributable to the application methods. At some treatment locations, it is not possible to achieve complete control, so these areas retain some level of infestation and need further control. This is most apparent on the steeper hillside and obstacle-strewn areas where continuous, even application of the herbicide by conventional ground equipment is not possible. Thus, for example, in areas where the boom truck must be maneuvered around objects, or where hose or backpack application is necessary over large areas, spots are missed. At many of these locations, aerial spraying would provide a much more even distribution of the herbicide across the landscape, regardless of steep terrain or small surface irregularities such as rough ground or fence posts that may exist.

As improvements are made in the weed control program to address these concerns, monitoring will continue to evaluate the effectiveness of management actions and the overall condition of the high-value plant communities on Site.

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Table 1-1. 1997 and 1998 xeric tallgrass prairie species richness summary

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

Table 1-1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
ASTERACEAE	Scorzonera laciniata L.	SCLA1	N	X	X
ASTERACEAE	Senecio fendleri Gray	SEFE1	Y	X	X
ASTERACEAE	Senecio integerrimus Nutt.	SEIN1	Y	X	X
ASTERACEAE	Senecio plattensis Nutt.	SEPL1	Y	X	X
ASTERACEAE	Senecio spartioides T. & G.	SESP1	Y	X	X
ASTERACEAE	Senecio tridenticulatus Rydb.	SETR1	Y	X	
ASTERACEAE	Solidago missouriensis Nutt.	SOMI1	Y	X	X
ASTERACEAE	Solidago mollis Bart.	SOMO1	Y	X	X
ASTERACEAE	Solidago rigida L.	SORI1	Y	X	X
ASTERACEAE	Sonchus asper (L.) Hill	SOAS1	N	X	
ASTERACEAE	Taraxacum officinale Weber	TAOF1	N	X	X
ASTERACEAE	Thelesperma megapotanicum (Spreng.) O. Ktze.	THME1	Y	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
BERBERIDACEAE	Berberis repens Lindl.	BERE1	Y	X	
BORAGINACEAE	Cryptantha virgata (Porter) Payson	CRVI1	Y	X	X
BORAGINACEAE	Cynoglossum officinale L.	CYOF1	N	X	
BORAGINACEAE	Lappula redowskii (Hornem.) Greene	LARE1	Y	X	X
BORAGINACEAE	Lithospermum incisum Lehm.	LIIN1	Y	X	X
BORAGINACEAE	Mertensia lanceolata (Pursh.) A. DC.	MELA1	Y	X	X
BORAGINACEAE	Onosmodium molle Michx. var. occidentale (Mack.) Johnst.	ONMO1	Y	X	X
BORAGINACEAE	Plagiobothrys scouleri (H. & A.) I. M. Johnst.	PLSC1	Y	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
BRASSICACEAE	Arabis fendleri (S. Wats.) Greene var. fendleri	ARFE3	Y	X	X
BRASSICACEAE	Arabis glabra (L.) Bernh.	ARGL1	N	X	
BRASSICACEAE	Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins	ARHI1	Y	X	X
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	N	X	X
BRASSICACEAE	Camelina microcarpa Andrz. ex DC.	CAMI1	N	X	X
BRASSICACEAE	Descurainia pinnata (Walt.) Britt.	DEPI1	Y	X	X
BRASSICACEAE	Descurainia richardsonii (Sweet) Schultz	DERI1	Y		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
BRASSICACEAE	Erysimum capitatum (Nutt.) DC.	ERCA2	Y	X	X
BRASSICACEAE	Lepidium campestre (L.) R. Br.	LECA1	N	X	X
BRASSICACEAE	Lepidium densiflorum Schrad.	LEDE1	Y	X	X
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	LEMO1	Y	X	X
BRASSICACEAE	Sisymbrium altissimum L.	SIAL1	N	X	X
CACTACEAE	Coryphantha missouriensis (Sweet) Britt. & Rose	COMI1	Y	X	X
CACTACEAE	Echinocereus viridiflorus Engelm.	ECVI1	Y	X	X
CACTACEAE	Opuntia fragilis (Nutt.) Haw.	OPFR1	Y	X	X
CACTACEAE	Opuntia macrorhiza Engelm.	OPMA1	Y	X	X
CACTACEAE	Pediocactus simpsonii (Engelm.) Britt. & Rose	PESI1	Y	X	X
CAMPANULACEAE	Campanula rotundifolia L.	CARO1	Y	X	X
CAPRIFOLIACEAE	Symphoricarpos occidentalis Hook.	SYOC1	Y	X	X
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	ARFE2	Y	X	X
CARYOPHYLLACEAE	Cerastium arvense L.	CEAR1	Y	X	X
CARYOPHYLLACEAE	Paronychia jamesii T. & G.	PAJA1	Y	X	X
CARYOPHYLLACEAE	Silene antirrhina L.	SIAN1	Y	X	X
CARYOPHYLLACEAE	Silene drummondii Hook.	SIDR1	Y	X	X
CARYOPHYLLACEAE	Spergularia rubra (L.) K. Presl.	SPRU1	N	X	X
CARYOPHYLLACEAE	Vaccaria pyramidata Medic.	VAPY1	N	X	
CHENOPODIACEAE	Chenopodium album L.	CHAL1	N	X	
CHENOPODIACEAE	Chenopodium atrovirens Nutt.	CHAT1	Y	X	
CHENOPODIACEAE	Chenopodium leptophyllum Nutt. ex Moq.	CHLE2	Y	X	X
CHENOPODIACEAE	Salsola iberica Senn. & Pau.	SAIB1	N		X
CLUSIACEAE	Hypericum perforatum L.	HYPE1	N	X	X

Table 1-1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
COMMELINACEAE	Tradescantia occidentalis (Britt.) Smyth	TROC1	Y	X	X
CONVOLVULACEAE	Convolvulus arvensis L.	COAR1	N	X	X
CONVOLVULACEAE	Evolvulus nuttallianus R. & S.	EVNU1	Y	X	X
CRASSULACEAE	Sedum lanceolatum Torr.	SELA1	Y	X	X
CUPRESSACEAE	Juniperus communis L.	JUCO1	Y	X	X
CUPRESSACEAE	Juniperus scopulorum Sarg.	JUSC1	T	X	X
CYPERACEAE	Carex brevior (Dew.) Mack. ex Lunell.	CABR1	Y	X	
CYPERACEAE	Carex eleocharis Bailey	CAEL1	Y	X	X
CYPERACEAE	Carex filifolia Nutt.	CAFI1	Y		X
CYPERACEAE	Carex heliophila Mack.	CAHE1	Y	X	X
CYPERACEAE	Carex interior Bailey	CAIN1	Y		X
CYPERACEAE	Carex oreocharis Holm.	CAOR1	Y	X	X
CYPERACEAE	Carex praegracilis W. Boott.	CAPR1	Y		X
CYPERACEAE	Eleocharis compressa Sulliv.	ELCO1	Y	X	X
CYPERACEAE	Eleocharis macrostachya Britt.	ELMA1	Y	X	X
EUPHORBIACEAE	Euphorbia fendleri T. & G.	EUFE1	Y	X	X
EUPHORBIACEAE	Euphorbia robusta (Engelm.) Small	EURO1	Y	X	X
EUPHORBIACEAE	Euphorbia serpyllifolia Pers.	EUSE1	Y	X	
EUPHORBIACEAE	Euphorbia spathulata Lam.	EUSP1	Y	X	X
EUPHORBIACEAE	Tragia ramosa Nutt.	TRRA1	Y	X	X
FABACEAE	Amorpha fruticosa L.	AMFR1	Y	X	X
FABACEAE	Astragalus adsurgens Pall. var. robustior Hook.	ASAD1	Y	X	X
FABACEAE	Astragalus agrestis Dougl. ex G. Don	ASAG1	Y	X	X
FABACEAE	Astragalus crassicarpus Nutt.	ASCR1	Y	X	
FABACEAE	Astragalus drummondii Dougl. ex Hook.	ASDR1	Y	X	X
FABACEAE	Astragalus flexuosus (Hook.) G. Don	ASFL1	Y	X	X
FABACEAE	Astragalus shortianus Nutt. ex T.&G.	ASSH1	Y	X	X
FABACEAE	Astragalus spathulatus Sheld.	ASSP2	Y	X	
FABACEAE	Astragalus tridactylicus Gray	ASTR1	Y	X	X
FABACEAE	Dalea candida Michx. ex Willd. var. oligophylla (Torr.) Shinners.	DACA1	Y	X	X
FABACEAE	Dalea purpurea Vent	DAPU1	Y	X	X
FABACEAE	Glycyrrhiza lepidota Pursh.	GLLE1	Y	X	X
FABACEAE	Lupinus argenteus Pursh var. argenteus	LUAR1	Y	X	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
FABACEAE	Oxytropis lambertii Pursh.	OXLA1	Y	X	X
FABACEAE	Psoralea tenuiflora Pursh.	PSTE1	Y	X	X
FABACEAE	Robinia pseudo-acacia L.	ROPS1	N	X	X
FABACEAE	Thermopsis rhombifolia var. divaricarpa (Nels.) Isely	THRH1	Y	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
GENTIANACEAE	Swertia radiata (Kell.) O. Ktze.	SWRA1	Y	X	X
GERANIACEAE	Erodium cicutarium (L.) L'Her.	ERCI1	N	X	X
GERANIACEAE	Geranium caespitosum James ssp. caespitosum	GECA1	Y	X	X
GROSSULARIACEAE	Ribes aureum Pursh	RIAU1	Y	X	X
GROSSULARIACEAE	Ribes cereum Dougl.	RICE1	Y		X
HYDROPHYLLACEAE	Hydrophyllum fendleri (Gray) Heller	HYFE1	Y	X	
HYDROPHYLLACEAE	Phacelia heterophylla Pursh.	PHHE1	Y	X	X
IRIDACEAE	Iris missouriensis Nutt.	IRMI1	Y	X	X
IRIDACEAE	Sisyrinchium montanum Greene	SIMO1	Y	X	X
JUNCACEAE	Juncus balticus Willd.	JUBA1	Y	X	X
JUNCACEAE	Juncus dudleyi Wieg.	JUDU1	Y		X
JUNCACEAE	Juncus interior Wieg.	JUIN1	Y	X	X
JUNCACEAE	Juncus longistylis Torr.	JULO1	Y		X
LAMIACEAE	Hedeoma hispidum Pursh.	HEHI1	Y		X
LAMIACEAE	Marrubium vulgare L.	MAVU1	N	X	X
LAMIACEAE	Monarda fistulosa L. var. menthifolia (Grah.) Fern.	MOFI1	Y	X	X

Table 1-1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
LAMIACEAE	Nepeta cataria L.	NECA1	N	X	
LAMIACEAE	Prunella vulgaris L.	PRVU1	Y	X	
LAMIACEAE	Scutellaria brittonii Porter	SCBR1	Y	X	X
LILIACEAE	Allium cernuum Roth	ALCE1	Y	X	X
LILIACEAE	Allium geyeri S. Wats.	ALGE1	Y	X	X
LILIACEAE	Allium textile A. Nels. & Macbr.	ALTE1	Y	X	X
LILIACEAE	Calochortus gunnisonii S. Wats.	CAGU1	Y	X	X
LILIACEAE	Leucocrinum montanum Nutt.	LEMO2	Y	X	X
LILIACEAE	Zigadenus venenosus Wats. var. gramineus (Rydb.) Walsh ex Peck	ZIVE1	Y		X
LINACEAE	Linum perenne L. var. lewisii (Pursh.) Eat. & Wright	LIPE1	Y	X	X
MALVACEAE	Malva neglecta Wallr.	MANE1	N		X
MALVACEAE	Sphaeralcea coccinea (Pursh.) Rydb.	SPCO1	Y	X	X
NYCTAGINACEAE	Mirabilis hirsuta (Pursh.) MacM.	MIHI1	Y	X	X
NYCTAGINACEAE	Mirabilis linearis (Pursh.) Heimerl	MILI1	Y	X	X
ONAGRACEAE	Calylophus serrulatus (Nutt.) Raven	CASE2	Y	X	X
ONAGRACEAE	Epilobium paniculatum Nutt.	EPPA1	Y	X	
ONAGRACEAE	Gaura coccinea Pursh.	GACO1	Y	X	X
ONAGRACEAE	Oenothera howardii (A. Nels.) W. L. Wagner	OEHO1	Y	X	X
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	Y	X	X
OROBANCHACEAE	Orobanche fasciculata Nutt.	ORFA1	Y	X	X
OXALIDACEAE	Oxalis dillenii Jacq.	OXDI1	N	X	X
PAPAVERACEAE	Argemone polyanthemos (Fedde) G. Ownbey	ARPO1	Y	X	X
PINACEAE	Pinus ponderosa Laws	PIPO1	Y	X	X
PINACEAE	Pseudotsuga menziesii (Mirb.) Franco	PSME1	Y	X	X
PLANTAGINACE	Plantago lanceolata L.	PLLA1	N	X	X
PLANTAGINACE	Plantago patagonica Jacq.	PLPA1	Y	X	X
POACEAE	Aegilops cylindrica Host	AECY1	N	X	
POACEAE	Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	AGCA1	Y	X	X
POACEAE	Agropyron cristatum (L.) Gaertn.	AGCR1	N	X	X
POACEAE	Agropyron desertorum (Fisch.) Schult.	AGDE1	N	X	X
POACEAE	Agropyron elongatum (Host) Beauv.	AGEL1	N	X	
POACEAE	Agropyron griffithsii Scribn. & Smith	AGGR1	Y	X	X
POACEAE	Agropyron intermedium (Host) Beauv.	AGIN1	N	X	X
POACEAE	Agropyron smithii Rydb.	AGSM1	Y	X	X
POACEAE	Agrostis scabra Willd.	AGSC1	Y		X
POACEAE	Alopecurus geniculatus L.	ALGE2	Y		X
POACEAE	Andropogon gerardii Vitman	ANGE1	Y	X	X
POACEAE	Andropogon scoparius Michx.	ANSC1	Y	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
POACEAE	Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	Y	X	X
POACEAE	Bouteloua curtipendula (Michx.) Torr.	BOCU1	Y	X	X
POACEAE	Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	Y	X	X
POACEAE	Bouteloua hirsuta Lag	BOHI1	Y	X	X
POACEAE	Bromus inermis Leyss. ssp. inermis	BRIN1	N	X	X
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	N	X	X
POACEAE	Bromus tectorum L.	BRTE1	N	X	X
POACEAE	Buchloe dactyloides (Nutt.) Engelm.	BUDA1	Y	X	X
POACEAE	Dactylis glomerata L.	DAGL1	N	X	X
POACEAE	Danthonia spicata (L.) Beauv. ex R. & S.	DASP1	Y	X	X
POACEAE	Dichanthelium oligosanthes (Schultz) Gould var. scribnerianum (Nash) G	DIOL1	Y	X	X
POACEAE	Echinochloa crusgallii (L.) Beauv.	ECCR1	N	X	
POACEAE	Elymus canadensis L.	ELCA1	Y		X
POACEAE	Elymus juncea Fisch.	ELJU1	N		X
POACEAE	Festuca ovina L. var. rydbergii St. Yves	FEOV1	Y	X	X
POACEAE	Hordeum jubatum L.	HOJU1	Y	X	
POACEAE	Koeleria pyramidata (Lam.) Beauv.	KOPY1	Y	X	X
POACEAE	Lolium perenne L.	LOPE1	N		X
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	Y	X	X

Table 1-1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
POACEAE	Muhlenbergia wrightii Vasey	MUWR1	Y	X	
POACEAE	Oryzopsis hymenoides (R. & S.) Ricker	ORHY1	Y	X	X
POACEAE	Panicum capillare L.	PACA1	Y	X	
POACEAE	Panicum virgatum L.	PAVI1	Y	X	X
POACEAE	Phleum pratense L.	PHPR1	N	X	X
POACEAE	Poa bulbosa L.	POBU1	N	X	
POACEAE	Poa canbyi (Scribn.) Piper	POCA1	Y	X	X
POACEAE	Poa compressa L.	POCO1	N	X	X
POACEAE	Poa fendleriana (Steud.) Vasey	POFE1	Y	X	X
POACEAE	Poa pratensis L.	POPR1	N	X	X
POACEAE	Schedonnardus paniculatus (Nutt.) Trel.	SCPA2	N	X	
POACEAE	Secale cereale L.	SECE1	N	X	X
POACEAE	Setaria viridis (L.) Beauv.	SEVI1	N	X	X
POACEAE	Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	Y	X	X
POACEAE	Sorghastrum nutans (L.) Nash	SONU1	Y	X	X
POACEAE	Sporobolus asper (Michx.) Kunth	SPAS1	Y	X	X
POACEAE	Sporobolus cryptandrus (Torr.) A. Gray	SPCR1	Y	X	X
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	Y	X	X
POACEAE	Stipa comata Trin. & Rupr.	STCO1	Y	X	X
POACEAE	Stipa neomexicana (Thur.) Scribn.	STNE1	Y	X	
POACEAE	Stipa spartea Trinius	STSP1	Y	X	X
POACEAE	Stipa viridula Trin.	STVI1	Y	X	X
POACEAE	Triticum aestivum L.	TRAE1	N	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
POLEMONIACEAE	Navarretia minima Nutt.	NAMI1	N	X	X
POLYGONACEAE	Eriogonum alatum Torr.	ERAL1	Y	X	X
POLYGONACEAE	Eriogonum effusum Nutt.	EREF1	Y	X	X
POLYGONACEAE	Eriogonum umbellatum Torr.	ERUM1	Y	X	X
POLYGONACEAE	Polygonum arenastrum Jord. ex Bor.	POAR1	N	X	
POLYGONACEAE	Polygonum convolvulus L.	POCO2	N	X	X
POLYGONACEAE	Polygonum douglasii Greene	PODO1	Y	X	
POLYGONACEAE	Polygonum ramosissimum Michx.	PORA1	Y		X
POLYGONACEAE	Polygonum sawatchense Small	POSA1	Y	X	
POLYGONACEAE	Rumex acetosella L.	RUAC1	N	X	X
POLYGONACEAE	Rumex crispus L.	RUCR1	N	X	X
POLYGONACEAE	Rumex salicifolius Weinm. ssp. triangulivalvis Danser	RUSA1	Y	X	X
PORTULACACEAE	Claytonia rosea Rydb.	CLRO1	Y	X	
PORTULACACEAE	Talinum parviflorum Nutt.	TAPA1	Y	X	X
PRIMULACEAE	Androsace occidentalis Pursh.	ANOC1	Y	X	X
RANUNCULACEAE	Anemone patens L.	ANPA2	Y	X	X
RANUNCULACEAE	Clematis ligusticifolia Nutt.	CLLI1	Y		X
RANUNCULACEAE	Delphinium nuttalianum Pritz. ex Walpers	DENU1	Y	X	X
RANUNCULACEAE	Delphinium virescens Nutt. ssp. penardii (Huth) Ewan	DEVI1	Y	X	X
RANUNCULACEAE	Myosurus minimus L.	MYMI1	Y	X	X
ROSACEAE	Amelanchier alnifolia Nutt.	AMAL1	Y	X	X
ROSACEAE	Crataegus erythropoda Ashe	CRER1	Y	X	X
ROSACEAE	Geum macrophyllum Willd.	GEMA1	Y		X
ROSACEAE	Potentilla fissa Nutt.	POFI1	Y	X	X
ROSACEAE	Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc.	POGR1	Y	X	X
ROSACEAE	Potentilla hippiana Lehm.	POHI1	Y	X	X
ROSACEAE	Potentilla pensylvanica L.	POPE4	Y	X	X
ROSACEAE	Prunus pumila L. var. besseyi (Bailey) Gl.	PRPU1	Y	X	X
ROSACEAE	Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg.	PRVI1	Y	X	X
ROSACEAE	Rosa acicularis Lindl.	ROAC1	Y	X	
ROSACEAE	Rosa arkansana Porter	ROAR1	Y	X	X
ROSACEAE	Rosa woodsii Lindl.	ROWO1	Y	X	
RUBIACEAE	Galium aparine L.	GAAP1	Y	X	X
RUBIACEAE	Galium septentrionale Roemer & Schultes	GASE1	Y	X	

Table 1-1. (cont.)

Family	Scientific Name	Speccode	Native	1998	1997
SALICACEAE	Populus deltoides Marsh. ssp. monilifera (Ait.) Eckenw.	PODE1	Y	X	X
SANTALACEAE	Comandra umbellata (L.) Nutt.	COUM1	Y	X	X
SAXIFRAGACEAE	Heuchera parvifolia Nutt. ex T.& G.	HEPA1	Y	X	X
SAXIFRAGACEAE	Saxifraga rhomoidea Greene	SARH1	Y	X	X
SCROPHULARIACEAE	Castilleja integra A. Gray	CAIN2	Y	X	X
SCROPHULARIACEAE	Castilleja sessiliflora Pursh.	CASE3	Y	X	X
SCROPHULARIACEAE	Collinsia parviflora Doug. ex Lindl.	COPA1	Y	X	X
SCROPHULARIACEAE	Linaria dalmatica (L.) Mill.	LIDA1	N	X	X
SCROPHULARIACEAE	Linaria vulgaris Hill	LIVU1	N		X
SCROPHULARIACEAE	Penstemon secundiflorus Benth.	PESE1	Y	X	X
SCROPHULARIACEAE	Penstemon strictus Bentham in De Candolle	PEST1	Y		X
SCROPHULARIACEAE	Penstemon virens Penn.	PEVI1	Y	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
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	N	X	X
SCROPHULARIACEAE	Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren	VEPE1	Y	X	X
SELAGINELLACEAE	Selaginella densa Rydb.	SEDE1	Y	X	X
SOLANACEAE	Physalis heterophylla Nees	PHHE2	Y	X	X
SOLANACEAE	Physalis virginiana P. Mill.	PHVI2	Y	X	X
SOLANACEAE	Solanum rostratum Dun.	SORO1	Y	X	
SOLANACEAE	Solanum triflorum Nutt.	SOTR1	Y		X
ULMACEAE	Ulmus pumila L.	ULPU1	N	X	X
VERBENACEAE	Lippia cuneifolia (Torr.) Steud.	LICU1	Y	X	X
VERBENACEAE	Verbena bracteata Lag. & Rodr.	VEBR1	Y	X	X
VIOLACEAE	Viola nuttallii Pursh.	VINU1	Y	X	X
	Total number of species			295	274
	Percent native species			79	81

Table 1-2. 1998 estimated weed infestation acreage summary

	1998 Acreage (Estimated)				
		Density Level			
Common Name	Site Total	High	Medium	Low	Scattered
Diffuse knapweed	2,913	761	778	987	388
Russian knapweed	1	NA	NA	NA	NA
Dalmatian toadflax	1,934	313	273	989	359
Musk thistle	1,685	32	515	1,035	102
Mullein	867	168	225	460	13
Jointed goatgrass	35	NA	NA	NA	NA
Annual rye	26	NA	NA	NA	NA
Scotch thistle	9	NA	NA	NA	NA

Note: NA - data not collected by density level

Table 1-3. Comparison of 1997 and 1998 weed infestation extents

Weed Species	Year	Site Total	Density Level			
			High	Medium	Low	Scattered
Diffuse knapweed	1997	2,678	696	893	658	431
	1998	2,913	761	778	987	388
Dalmatian toadflax	1997	422	135	205	82	0
	1998	1,934	313	273	989	359
Musk thistle	1997	474	2	270	202	0
	1998	1,685	32	515	1,035	102
Mullein	1997	575	117	238	203	17
	1998	867	168	225	460	13

Note: All values are acreages.
See text for density level descriptions.

Report 2

Monitoring Summary for Diffuse Knapweed Control Study

2. Monitoring Summary for Diffuse Knapweed Control Study

2.1 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 (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 value, reduced grazing capacity, and less aesthetic and recreational value (Sheley et al. 1997, 1998).

Observations at the Site have shown that over the past seven years, the spread of diffuse knapweed has become epidemic. Weed mapping done in late summer 1997 showed that approximately 41 percent of the Site had some level of diffuse knapweed infestation (K-H 1998), and 1998 mapping revealed that the area in need of control was approximately 45 percent, even after weed control measures had been implemented over several hundred acres (see Section 1).

In 1997, a study was begun to evaluate the effectiveness of Tordon 22K (trademark of DowElanco; effective chemical compound is picloram) in controlling diffuse knapweed on the Site. Tordon 22K has been proven to be one of the more effective chemicals used to treat diffuse knapweed infestations, because it provides a multi-year residual effect that can prevent the species from germinating for several years after its application (Beck 1994). It has been used on the Site for the past several years, generally along roads and in localized areas of the Buffer Zone.

One of the areas currently affected at an increasing rate by diffuse knapweed is the Site's 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). Because of the importance of this plant community, a management concern has arisen as to what effect the spraying of Tordon 22K might have on the native species in the xeric tallgrass prairie. Thus, the purposes of this study were to assess the effectiveness of Tordon 22K in controlling diffuse knapweed and to identify any potential effects on desirable species in the xeric tallgrass prairie.

2.2 Study Site Location and Characteristics

The area selected for the study is north of the T130 trailer complex, west of the Industrial Area (Figure 2-1). 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 study site is large enough for placement of both control and treatment plots (each 60 × 65 m), and a large amount of diffuse knapweed was present where the two plots would be located.

2.3 Methods

Within 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 (Figure 2-2). 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, logistics and the required time frame only allowed for a single spring sampling prior to herbicide application. The first summer's data set would still be comparable to the second summer, however, because very little time would have passed since the herbicide application, and no major change would be observed until the following summer.

Sampling during 1997 was conducted June 16–19 and again from September 2–4. In 1998, sampling was conducted on June 17–19 and August 24–27. The treatment plot was sprayed with Tordon 22K, applied at a rate of 1 pint/acre, June 23–24, 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 still present.

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 densities of the woody plant stems and cactus species 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 types of hits were recorded.

- 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. A basal

vegetation hit was 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 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. Density stem counts for diffuse knapweed, St. John's-wort (*Hypericum perforatum*), and curly-top gumweed (*Grindelia squarrosa*) were also made using these same quadrats. No distinctions were made during counts for seedlings, rosettes, or adult plants. More detailed summaries of these specific methods are found in the *Environmental Monitoring Department Operating Procedures Manual* (DOE 1991) and the *High Value Vegetation Survey Plan for the Rocky Flats Environmental Technology Site* (K-H 1997).

Species richness data were summarized by generating a species list for the control plot and treatment plot for each sampling period. In addition, other species richness 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.

Statistical analysis on the results was conducted only when mean values were different enough to suggest a meaningful interpretation. Nonparametric tests were used for all analyses, because normality and variance requirements were not met. Comparisons between independent samples (i.e., the control and treatment plots) were done using Mann-Whitney U tests (Fowler and Cohen 1990). Dependent sample comparisons (i.e., within treatment over time) were done using Wilcoxon's test for matched pairs and Friedmans 2-way analysis of variance (ANOVA; Fowler and Cohen 1990; Sheskin 1997). Frequency analyses were done using a McNemar test (Sheskin 1997). The

difference between two regression lines was used to evaluate the differences in Shannon-Weaver diversity indices between the control and treatment plots over time (Fowler and Cohen 1990). For most results, descriptive comparisons were made between the control and treatment plots from the two years of data to examine potential changes over time—pre-treatment to post-treatment.

2.4 Results from 1997 and 1998

Compared to 1997, diffuse knapweed density declined significantly in 1998, in both the control and treatment plots, with the larger decrease occurring in the treatment plot (Wilcoxon's test for matched pairs; $T = 9.5$ and $T = 0$, respectively, $P < 0.05$; Table 2-1). Initial diffuse knapweed frequency in the control and treatment plots was 76 and 80 percent, respectively (Table 2-2, Figure 2-3). After herbicide application, diffuse knapweed frequency decreased by 60 percent in the treatment plot (McNemar test; $X^2 = 13.1$; Table 2-2, Figure 2-3) while remaining stable in the control plot.

A total of 98 species was recorded at the study plots during 1997 and 1998. Table 2-3 lists the species richness from each plot for each sampling session. The total number of species recorded in the control and treatment plots during each sampling period showed a seasonality effect (Table 2-4). Overall richness and the mean number of species per quadrat were higher in the spring and then showed a slight decline by late summer. However, after the herbicide application, the treatment plot had an overall richness loss of 12 species during the first summer, compared with only 3 lost in the control plot (Table 2-4). By the following year (spring and summer), however, the treatment plot had regained some of the lost species richness. The percent of native species increased slightly in both the control and treatment plots over the two-year period (Table 2-4). Species diversity (Shannon-Weaver Index) declined significantly in the treatment plot, while in the control plot, diversity remained stable (difference between two regression lines, $t = 2.776$, $df = 4$; Figure 2-4).

Basal vegetation cover and rock cover remained stable during both years in the control and treatment plots, while bare ground cover decreased by similar amounts in both plots (Table 2-4). The loss of bare ground cover was offset largely by similar increases in plant litter cover in both the control and treatment plots (Table 2-4). Cactus densities remained stable in the control plot during both years; however, in the treatment plot, the twistspine prickly pear density (*Opuntia macorhiza*) was especially hard hit by the herbicide treatment (Table 2-4). Twistspine prickly pear density declines were statistically significant, dropping from 1.09 plants/m^2 in summer 1997 to only 0.26 plants/m^2 in summer 1998 (Friedman 2-Way ANOVA by Ranks, $X^2 = 5$, $df = 1$; Table 2-4). Numerically, declines in the density of the hedgehog cactus (*Echinocereus viridiflora*) were also observed in the treatment plot, however they were not found to be statistically significant (Friedman 2-Way ANOVA by Ranks, $X^2 = 3.2$, $df = 1$; Table 2-4).

Foliar cover results, by species, for the control and treatment plots for each sampling session are presented in Table 2-5. Total foliar cover increased by similar amounts in

both the control and treatment plots over the two years, 17.4 and 15.2 percent, respectively (Table 2-5). Absolute native and non-native cover also showed parallel increases in both the control and treatment plots (Table 2-5). However, non-native cover increased by much larger amounts than native cover; most of this difference resulted from increases in the cover of the non-native graminoid, Canada bluegrass (*Poa compressa*; Table 2-5). Absolute forb cover was approximately the same in the control and treatment plots at the beginning of the study, 10.6 and 12.2 percent, respectively. Absolute forb cover remained stable in the control plot during the two years of monitoring (Table 2-5). In the treatment plot, however, absolute forb cover steadily declined after the herbicide treatment, decreasing from 12.2 to 3.8 percent (Table 2-5). Absolute graminoid cover increased in both the control and treatment plots over the same period, to 18 and 23.6 percent, respectively (Table 2-5). Cool-season graminoid species accounted for most of this increase, increasing by 15.2 and 18 percent in the control and treatment plots, respectively (Table 2-5). Warm-season grasses increased by only 2.8 and 5.6 percent in the control and treatment plots, respectively (Table 2-5). Examination of the data also showed seasonal shifts in cover amounts for many of these groupings. Often, the results from spring sampling would increase by late summer, then decrease the following spring and increase again by summer.

Change in species composition was evaluated by examining changes in the proportions of cover values for different species or groups of species. Relative forb and graminoid cover remained stable in the control plot over the two years, showing only a slight shift at the end of the second summer (Table 2-5). In the treatment plot, however, the proportions of forb to graminoid cover changed, indicating a shift in community structure (Table 2-5). Relative cover of forbs in the treatment plot declined steadily after the herbicide treatment (from 18.4 to 4.7 percent; Table 5), while graminoids increased (from 81.6 to 95.3 percent; Table 2-5). Evaluation of forb frequencies revealed no significant change in overall forb frequencies, nor in native or non-native forb frequencies. However, on a per species basis, diffuse knapweed, Fendler sandwort (*Arenaria fendleri*), and twistspine prickly pear, showed statistically significant declines in frequency (Table 2-2).

2.5 Discussion

This study examined the effect of Tordon 22K on diffuse knapweed and other species found in the xeric tallgrass prairie on the Site. The herbicide Tordon 22K was effective at controlling diffuse knapweed one year after spraying. Diffuse knapweed frequency was reduced significantly by treatment. Variability in the knapweed density data precluded attributing the loss of density in the treatment plot to the herbicide treatment alone. However, visual observations of the treatment plot revealed no adult knapweed plants present one year after treatment. In the control plot, adult knapweed plants were visually abundant, and knapweed frequency was not significantly changed. Continued monitoring of these plots will help determine how long the herbicide application controls the knapweed under site-specific conditions.

While the observed effect on diffuse knapweed was desired, there was some impact to other species in the plant community. Four specific effects were observed:

- First, forbs other than diffuse knapweed were affected. Overall forb cover decreased as a result of the herbicide treatment. Non-native forb cover was completely eliminated from the treatment plot, but a large decline in native forb cover also occurred. Although forb cover decreased, no significant loss of forb frequency occurred. This indicated that although there was a loss of forb cover, these species were not eliminated from the grassland. Associated with the loss of absolute and relative forb cover in the treatment plot was an increase in the amount of relative graminoid cover. The increase in relative graminoid cover in the treatment plot was attributable to the loss of relative forb cover. However, no actual increase in the amount of absolute graminoid cover (attributable to the herbicide application) was observed, because similar absolute graminoid cover increases were observed in both the control and treatment plots.

- Second, the herbicide treatment caused a loss of cactus density. The twistspine prickly pear cactus density was reduced by nearly 75 percent in the treatment plot.

- Third, species diversity declined significantly in the treatment plot, while remaining stable in the control plot.

- And fourth, overall plot species richness declined initially in the treatment plot. However, by the end of the second year, most of the initial decline had been recovered.

The long-term implications of these impacts to the plant community, and the time required for natural recovery at the Site, are uncertain.

Data from the Site are consistent with the data from other studies that have shown a decline of species diversity and a loss of forb and weed cover after spraying with Tordon 22K. The Site data does not show the corresponding large increase in graminoid cover that was observed at other locations, however. 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 Tordon 22K, 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 Tordon 22K, 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.

At the Site, although increases in overall graminoid cover (absolute graminoid cover) did occur in the treatment plot, they were not attributable to the herbicide treatments, because similar increases occurred in the control plot as well. The increases in relative graminoid cover are explained by the loss of relative forb cover: because this measure must add up to 100 percent, a change in one directly affects the other. Why increases in absolute graminoid cover were not shown in the Site treatment plot data is unknown. Perhaps biomass sampling would have been a more sensitive measure to use for evaluation. This method was used in some of the studies mentioned above, but time and personnel constraints prohibited its use in this study. General qualitative observations of the impact of the herbicide treatments at the study plots and other locations on the Site would suggest, however, that the graminoid species did respond positively to the herbicide treatment. At many locations, the vigor, robustness, and flowering of the graminoid species in sprayed areas was visually obvious and in stark contrast to adjacent unsprayed areas. So although the quantitative data do not indicate a measurable change in graminoid response, qualitative observations do suggest that the graminoid species responded favorably to the reduced competition from weeds and other forbs. (See Section 1 for more discussion of the qualitative effects of herbicide treatments on grasslands on the Site).

The general conclusions from this study thus far are that diffuse knapweed was controlled in the treatment plot, and that only minimal impact to the native plant community was observed. Based on these results, the use of Tordon 22K should be continued for control of diffuse knapweed and resource management on the Site. Although some minor negative impacts were manifested initially, if the longer-term responses at the Site are similar to responses documented elsewhere, the prudent use of Tordon 22K can provide a valuable tool for assisting in the control of diffuse knapweed and management of the grasslands at the Site.

2.6 References

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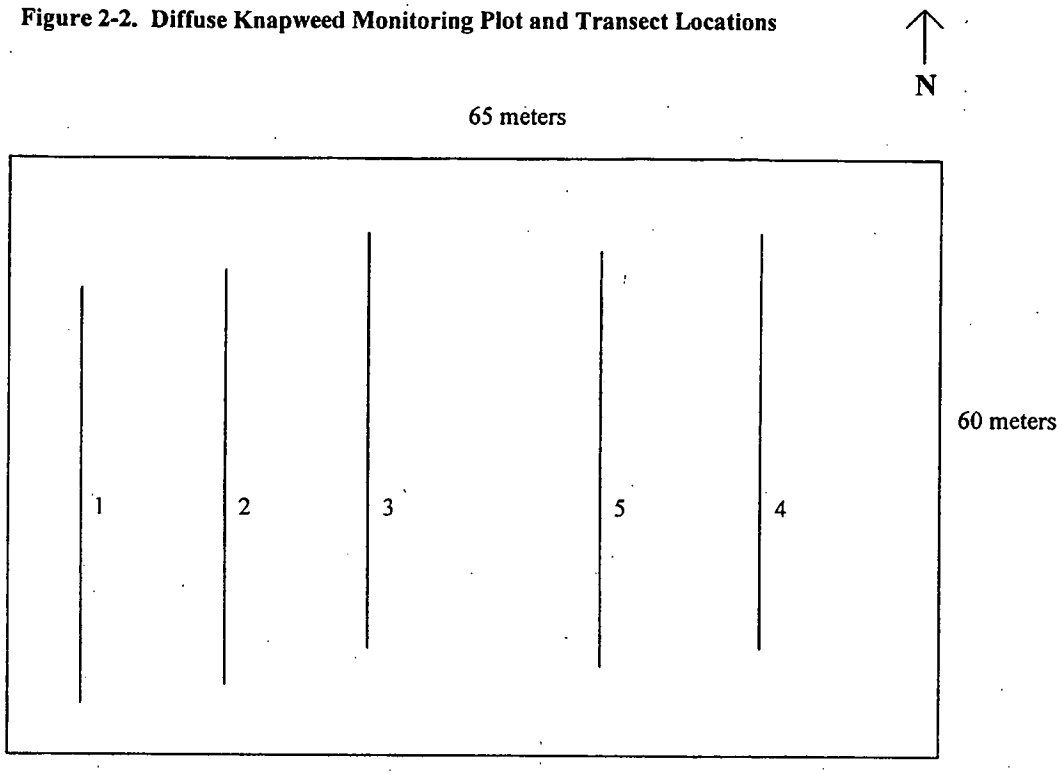
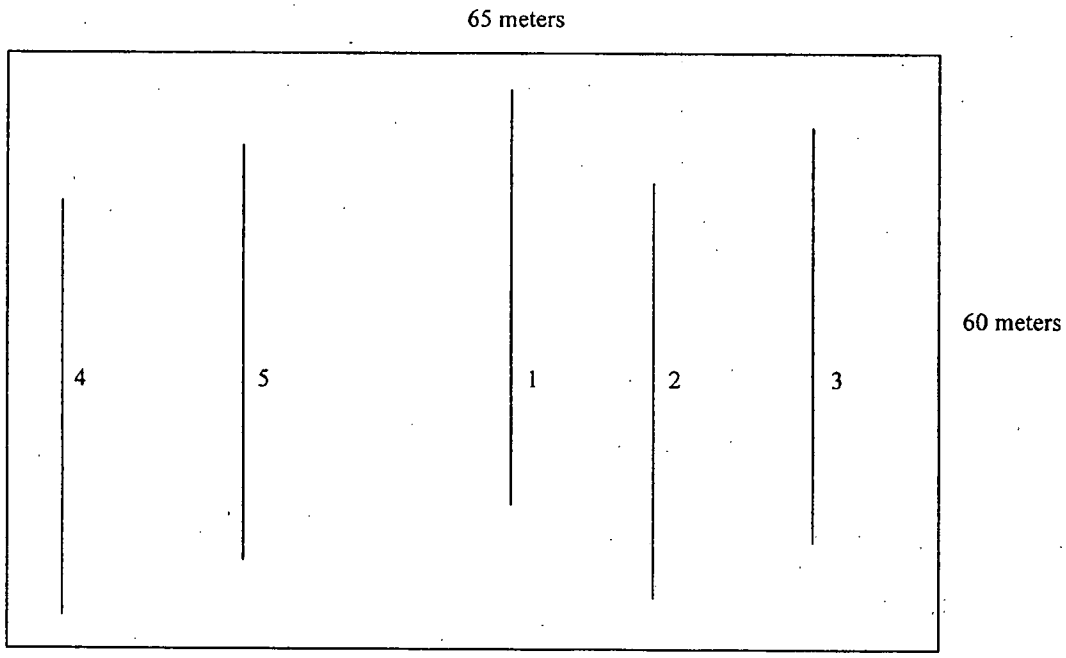
Figure 2-2. Diffuse Knapweed Monitoring Plot and Transect Locations



Control Plot - DKC



Treatment Plot - DKT

Table 2-1. 1997 and 1998 diffuse knapweed herbicide monitoring plot densities

	Control	Treatment
Spring 1997	5.56 [a]	22.96 [a]
Summer 1997	3.64	6.12
Spring 1998	14.52	2.24
Summer 1998	1.72 [b]	1.12 [c]

Note: Values are densities (# plants/m^2)
Different letters represent significant differences (P = 0.05).

Table 2-2. 1997–1998 diffuse knapweed herbicide monitoring plot plant frequency summary

Family	Scientific Name	Speccode	Form	Native	Cool/ Warm Season	Site DKC - Control				Site DKT - Treatment			
						Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998
APIACEAE	Lomatium orientale Coult. & Rose	LOOR1	F	Y		92		92	48	80	8	92	72
ASCLEPIADACEAE	Asclepias stenophylla A. Gray	ASST1	F	Y		8	4						
ASCLEPIADACEAE	Asclepias viridiflora Raf.	ASVI1	F	Y		8	12	8	8				
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	F	Y		8	8	8	4				
ASTERACEAE	Ambrosia psilostachya DC.	AMPS1	F	Y		72	68	64	68	32	32	12	16
ASTERACEAE	Arnica fulgens Pursh.	ARFU1	F	Y		36	16	40	28	16	12	16	12
ASTERACEAE	Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem.	ARCA1	F	Y						4	4	4	
ASTERACEAE	Artemisia ludoviciana Nutt. var. ludoviciana	ARLU1	F	Y		68	68	68	64	36	36	32	16
ASTERACEAE	Aster porteri Gray	ASPO1	F	Y		76	76	84	76	80	84	80	72
ASTERACEAE	Centaurea diffusa Lam.	CEDI1	F	N		76	76	76	60	80	60	52	20
ASTERACEAE	Chrysopsis fulcrata Greene	CHFU1	F	Y		8	8	8	4				
ASTERACEAE	Erigeron divergens T. & G.	ERDI1	F	Y						4			
ASTERACEAE	Erigeron flagellaris A. Gray	ERFL1	F	Y		4	4	4	4		4		
ASTERACEAE	Gaillardia aristata Pursh.	GAAR1	F	Y		12	4	8	4	8	4		4
ASTERACEAE	Grindelia squarrosa (Pursh.) Dun.	GRSQ1	F	Y		56	48	68	40	20	16	12	
ASTERACEAE	Lactuca serriola L.	LASE1	F	N		12	12	28	8	20	8		
ASTERACEAE	Liatris punctata Hook.	LIPU1	F	Y		16	20	20	28	20	20	28	20
ASTERACEAE	Microseris cuspidata (Pursh.) Sch. Bip.	MICU1	F	Y		4		8		4		4	
ASTERACEAE	Scorzonera laciniata L.	SCLA1	F	N						4	4		
ASTERACEAE	Senecio plattensis Nutt.	SEPL1	F	Y		8	4	4		24	12	20	4
ASTERACEAE	Solidago mollis Bart.	SOMO1	F	Y		24	24	28	28				
ASTERACEAE	Taraxacum officinale Weber	TAOF1	F	N						4			
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	F	N		8	16	44	32	12	8		4
BORAGINACEAE	Lithospermum incisum Lehm.	LIIN1	F	Y		4	4						
BORAGINACEAE	Mertensia lanceolata (Pursh.) A. DC.	MELA1	F	Y				4		4			
BRASSICACEAE	Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	ALMI1	F	N		28	20	12	16	4	4	16	4
BRASSICACEAE	Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins	ARHI1	F	Y						4			
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	F	N						4			
BRASSICACEAE	Camelina microcarpa Andrz. ex DC.	CAMI1	F	N		8							
BRASSICACEAE	Draba reptans (Lam.) Fern.	DRRE1	F	Y		16	4	4					4
BRASSICACEAE	Erysimum capitatum (Nutt.) DC.	ERCA2	F	Y		8	4	8		4			
BRASSICACEAE	Lepidium campestre (L.) R. Br.	LECA1	F	N			4	4	4	16	8	16	12
BRASSICACEAE	Lepidium densiflorum Schrad.	LEDE1	F	Y		4	4			12	8		
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	LEMO1	F	Y		8	8	12	16	12	16	12	12
CACTACEAE	Echinocereus viridiflorus Engelm.	ECVI1	C	Y		16	16	20	8	40	36	28	32
CACTACEAE	Opuntia macrorhiza Engelm.	OPMA1	C	Y		40	40	40	40	64	76	20	32
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	ARFE2	F	Y		32	44	20	44	52	40	28	28
CARYOPHYLLACEAE	Paronychia jamesii T. & G.	PAJA1	F	Y						12	12	4	4
CARYOPHYLLACEAE	Silene antirrhina L.	SIAN1	F	Y		8	8	4		4		28	
CLUSIACEAE	Hypericum perforatum L.	HYPE1	F	N		52	64	44	16	16	8	72	12
COMMELINACEAE	Tradescantia occidentalis (Britt.) Smyth	TROC1	F	Y						4		4	
CYPERACEAE	Carex heliophila Mack.	CAHE1	G	Y	C	64	72	72	68	32	40	52	40
FABACEAE	Dalea purpurea Vent	DAPU1	F	Y		8	4	8	8	12	12	8	12
FABACEAE	Psoralea tenuiflora Pursh.	PSTE1	F	Y		32	40	44	36	20	8	16	16
JUNCACEAE	Juncus interior Wieg.	JUIN1	G	Y			4		4				4
LILIACEAE	Allium textile A. Nels. & Macbr.	ALTE1	F	Y		20	4	8		36	12	24	12

Table 2-2. (cont.)

Family	Scientific Name	Speccode	Form	Native	Cool/ Warm Season	Site DKC - Control				Site DKT - Treatment			
						Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	F	Y				4					
OROBANCHACEAE	Orobanche fasciculata Nutt.	ORFA1	F	Y							4	4	4
POACEAE	Andropogon gerardii Vitman	ANGE1	G	Y	W	88	88	88	84	68	64	64	64
POACEAE	Andropogon scoparius Michx.	ANSC1	G	Y	W	28	28	20	24	20	40	20	20
POACEAE	Bouteloua curtipendula (Michx.) Torr.	BOCU1	G	Y	W	36	40	28	28	8	32	28	12
POACEAE	Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W		16	8	8	16	28	16	24
POACEAE	Bouteloua hirsuta Lag	BOHI1	G	Y	W	16	16	16	28	16			4
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	G	N	C			4	4	36	32	32	36
POACEAE	Bromus tectorum L.	BRTE1	G	N	C					8	4	12	8
POACEAE	Koeleria pyramidata (Lam.) Beauv.	KOPY1	G	Y	C	40	32	28	20	36	20	28	20
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	G	Y	W	100	100	96	100	96	96	92	92
POACEAE	Poa compressa L.	POCO1	G	N	C	92	100	100	100	96	96	100	100
POACEAE	Poa pratensis L.	POPR1	G	N	C	8	8	8	8			4	4
POACEAE	Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	G	Y	C	8	12						
POACEAE	Sorghastrum nutans (L.) Nash	SONU1	G	Y	W		4	4	4				4
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	G	Y	W	20	20	20	24				
POACEAE	Stipa comata Trin. & Rupr.	STCO1	G	Y	C				4				
POLEMONIACEAE	Collomia linearis Nutt.	COLI1	F	Y						4		4	4
POLYGONACEAE	Polygonum ramosissimum Michx.	PORA1	F	Y					8			4	8
POLYGONACEAE	Rumex crispus L.	RUCR1	F	N						4			
PORTULACACEAE	Talinum parviflorum Nutt.	TAPA1	F	Y			4	4					
SCROPHULARIACEAE	Penstemon virens Penn.	PEVI1	F	Y		4		4	4	16		28	12
SCROPHULARIACEAE	Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren	VEPE1	F	Y				4				72	32

Note: Frequency values are percentages (n = 25).

Table 2-3. 1997 and 1998 diffuse knapweed herbicide monitoring plot species richness summary

Family	Scientific Name	Speccode	Native	DKC - Control				DKT - Treatment			
				Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998
APIACEAE	Lomatium orientale Coult. & Rose	LOOR1	Y	X	X	X	X	X	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	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
ASTERACEAE	Antennaria parvifolia Nutt.	ANPA1	Y	X	X	X		X	X	X	X
ASTERACEAE	Arnica fulgens Pursh.	ARFU1	Y	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	
ASTERACEAE	Artemisia frigida Willd.	ARFR1	Y					X			
ASTERACEAE	Artemisia ludoviciana Nutt. var. ludoviciana	ARLU1	Y	X	X	X	X	X	X	X	X
ASTERACEAE	Aster porteri Gray	ASPO1	Y	X	X	X	X	X	X	X	X
ASTERACEAE	Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi	CANU1	N	X	X	X	X	X			
ASTERACEAE	Centaurea diffusa Lam.	CEDI1	N	X	X	X	X	X	X	X	X
ASTERACEAE	Chrysopsis fulcrata Greene	CHFU1	Y	X	X	X	X	X	X	X	X
ASTERACEAE	Chrysopsis villosa Pursh.	CHVI1	Y			X	X			X	X
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	N					X		X	
ASTERACEAE	Erigeron divergens T. & G.	ERDI1	Y				X	X	X		X
ASTERACEAE	Erigeron flagellaris A. Gray	ERFL1	Y	X	X	X	X	X	X	X	
ASTERACEAE	Gaillardia aristata Pursh.	GAAR1	Y	X	X	X	X	X	X	X	X
ASTERACEAE	Grindelia squarrosa (Pursh.) Dun.	GRSQ1	Y	X	X	X	X	X	X	X	X
ASTERACEAE	Lactuca serriola L.	LASE1	N	X	X	X	X	X	X		X
ASTERACEAE	Liatris punctata Hook.	LIPU1	Y	X	X	X	X	X	X	X	X
ASTERACEAE	Microseris cuspidata (Pursh.) Sch. Bip.	MICU1	Y	X		X		X		X	
ASTERACEAE	Scorzonera laciniata L.	SCLA1	N	X	X	X		X	X		
ASTERACEAE	Senecio plattensis Nutt.	SEPL1	Y	X	X	X	X	X	X	X	X
ASTERACEAE	Senecio spartioides T. & G.	SESP1	Y						X		X
ASTERACEAE	Solidago mollis Bart.	SOMO1	Y	X	X	X	X	X	X	X	X
ASTERACEAE	Solidago rigida L.	SORI1	Y		X	X	X				
ASTERACEAE	Taraxacum officinale Weber	TAOF1	N	X	X	X	X	X	X	X	X
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	N	X	X	X	X	X	X	X	X
BORAGINACEAE	Lithospermum incisum Lehm.	LIIN1	Y	X	X	X					
BORAGINACEAE	Mertensia lanceolata (Pursh.) A. DC.	MELA1	Y			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
BRASSICACEAE	Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins	ARHI1	Y			X	X	X	X		
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	N					X	X	X	
BRASSICACEAE	Camelina microcarpa Andrz. ex DC.	CAMI1	N	X	X	X	X	X		X	X
BRASSICACEAE	Draba reptans (Lam.) Fern.	DRRE1	Y	X	X	X					X
BRASSICACEAE	Erysimum capitatum (Nutt.) DC.	ERCA2	Y	X	X	X	X	X	X	X	X
BRASSICACEAE	Lepidium campestre (L.) R. Br.	LECA1	N	X	X	X	X	X	X	X	X
BRASSICACEAE	Lepidium densiflorum Schrad.	LEDE1	Y	X	X			X	X	X	X
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	LEMO1	Y	X	X	X	X	X	X	X	X
BRASSICACEAE	Sisymbrium altissimum L.	SIAL1	N	X	X					X	

Table 2-3. (cont.)

Family	Scientific Name	Speccode	Native	DKC - Control				DKT - Treatment			
				Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998
CACTACEAE	Coryphantha missouriensis (Sweet) Britt. & Rose	COMI1	Y	X				X			
CACTACEAE	Echinocereus viridiflorus Engelm.	ECVI1	Y	X	X	X	X	X	X	X	X
CACTACEAE	Opuntia macrorhiza Engelm.	OPMA1	Y	X	X	X	X	X	X	X	X
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	ARFE2	Y	X	X	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		X	X	X	X
CLUSIACEAE	Hypericum perforatum L.	HYPE1	N	X	X	X	X	X	X	X	X
COMMELINACEAE	Tradescantia occidentalis (Britt.) Smyth	TROC1	Y	X				X		X	X
CRASSULACEAE	Sedum lanceolatum Torr.	SELA1	Y					X	X	X	X
CYPERACEAE	Carex heliophila Mack.	CAHE1	Y	X	X	X	X	X	X	X	X
CYPERACEAE	Eleocharis compressa Sulliv.	ELCO1	Y	X	X	X	X	X	X	X	X
FABACEAE	Dalea purpurea Vent	DAPU1	Y	X	X	X	X	X	X	X	X
FABACEAE	Medicago lupulina L.	MELU1	N					X			
FABACEAE	Oxytropis lambertii Pursh.	OXLA1	Y	X							
FABACEAE	Psoralea tenuiflora Pursh.	PSTE1	Y	X	X	X	X	X	X	X	X
HYDROPHYLLACEAE	Phacelia heterophylla Pursh.	PHHE1	Y						X	X	X
JUNCACEAE	Juncus interior Wieg.	JUIN1	Y		X	X	X			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
LILIACEAE	Leucocrinum montanum Nutt.	LEMO2	Y	X		X					
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	Y	X	X	X	X				
OROBANCHACEAE	Orobanche fasciculata Nutt.	ORFA1	Y	X					X	X	X
PLANTAGINACE	Plantago lanceolata L.	PLLA1	N	X	X	X	X	X	X	X	X
PLANTAGINACE	Plantago patagonica Jacq.	PLPA1	Y					X			
POACEAE	Agropyron smithii Rydb.	AGSM1	Y	X						X	
POACEAE	Andropogon gerardii Vitman	ANGE1	Y	X	X	X	X	X	X	X	X
POACEAE	Andropogon scoparius Michx.	ANSC1	Y	X	X	X	X	X	X	X	X
POACEAE	Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	Y		X						
POACEAE	Bouteloua curtipendula (Michx.) Torr.	BOCU1	Y	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
POACEAE	Bouteloua hirsuta Lag	BOHI1	Y	X	X	X	X	X	X	X	X
POACEAE	Bromus inermis Leyss. ssp. inermis	BRIN1	N	X	X	X	X				
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	N	X	X	X	X	X	X	X	X
POACEAE	Bromus tectorum L.	BRTE1	N					X	X	X	X
POACEAE	Buchloe dactyloides (Nutt.) Engelm.	BUDA1	Y					X	X		X
POACEAE	Koeleria pyramidata (Lam.) Beauv.	KOPY1	Y	X	X	X	X	X	X	X	X
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	Y	X	X	X	X	X	X	X	X
POACEAE	Muhlenbergia wrightii Vasey	MUWR1	Y							X	X
POACEAE	Poa compressa L.	POCO1	N	X	X	X	X	X	X	X	X
POACEAE	Poa pratensis L.	POPR1	N	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
POACEAE	Sorghastrum nutans (L.) Nash	SONU1	Y		X	X	X		X	X	X
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	Y	X	X	X	X	X	X	X	X
POACEAE	Stipa comata Trin. & Rupr.	STCO1	Y				X			X	

Table 2-3. (cont.)

Family	Scientific Name	Speccode	Native	DKC - Control				DKT - Treatment			
				Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998
POLEMONIACEAE	Collomia linearis Nutt.	COLI1	Y					X		X	X
POLYGONACEAE	Eriogonum alatum Torr.	ERAL1	Y			X	X	X	X	X	X
POLYGONACEAE	Polygonum convolvulus L.	POCO2	N			X					
POLYGONACEAE	Polygonum ramosissimum Michx.	PORA1	Y			X	X			X	X
POLYGONACEAE	Rumex crispus L.	RUCR1	N					X		X	X
PORTULACACEAE	Talinum parviflorum Nutt.	TAPA1	Y		X	X	X	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				
SCROPHULARIACEAE	Penstemon virens Penn.	PEVI1	Y	X	X	X	X	X	X	X	X
SCROPHULARIACEAE	Verbascum blattaria L.	VEBL1	N	X	X	X	X				
SCROPHULARIACEAE	Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren	VEPE1	Y			X	X			X	X

Table 2-4. 1997 and 1998 diffuse knapweed herbicide monitoring plot data summary

	DKC - Control				DKT - Treatment			
Variables	Spring 97	Summer 97	Spring 98	Summer 98	Spring 97	Summer 97	Spring 98	Summer 98
Species Richness								
# plant families	18.0	18.0	19.0	18.0	20.0	17.0	21.0	20.0
# species	68.0	65.0	70.0	65.0	74.0	62.0	70.0	68.0
% natives	75.0	74.0	74.0	77.0	73.0	77.0	77.0	79.0
Mean # species/quadrat	13.8	12.8	14.0	12.1	12.2	10.1	11.9	9.1
Mean Percent Cover								
Total basal vegetation cover	10.8	8.0	11.2	9.2	10.8	10.2	10.2	8.8
Rock cover	12.8	12.0	10.2	10.8	19.8	17.4	18.2	17.2
Bare ground cover	11.6	4.0	3.0	2.2	9.0	5.4	2.6	3.0
Litter cover	64.8	76.0	75.6	77.8	60.4	67.0	69.0	71.0
Weed Densities (mean # stems/m^2)								
Diffuse knapweed	5.6	3.6	14.5	1.7	23.0	6.1	2.2	1.1
Curly-top gumweed	1.7	1.3	7.4	1.3	1.4	1.2	0.7	0.0
St. John's-wort	0.8	1.3	1.0	0.3	0.6	0.3	2.7	0.2
Weed Frequencies (%)								
Diffuse knapweed	76.0	76.0	76.0	60.0	80.0	60.0	52.0	20.0
Curly-top gumweed	56.0	48.0	68.0	40.0	20.0	16.0	12.0	0.0
St. John's-wort	52.0	64.0	44.0	16.0	16.0	8.0	72.0	12.0
Cactus Densities (mean # stems/m^2)								
Twistspine prickly pear cactus	0.62	0.65	0.54	0.65	0.79	1.09	0.24	0.26
Hedgehog cactus	0.06	0.05	0.05	0.06	0.20	0.22	0.14	0.13

Table 2-5. 1997 and 1998 diffuse knapweed herbicide monitoring plot foliar cover data summary

Scientific Name	Speccode	Form	Native	Cool/ Warm Season	Site DKC - Control											
					Frequency (%)				Absolute Foliar Cover (%)				Relative Foliar Cover (%)			
					Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998
Centaurea diffusa Lam.	CEDI1	F	N		100	100	40	80	2.6	4.8	0.4	1.0	3.8	6.1	0.5	1.2
Tragopogon dubius Scop.	TRDU1	F	N		40	20	60		0.4	0.2	0.6		0.6	0.3	0.8	
Lepidium campestre (L.) R. Br.	LECA1	F	N		20	20	20	20	0.4	0.2	0.2	0.2	0.6	0.3	0.3	0.2
Plantago lanceolata L.	PLLA1	F	N													
Camelina microcarpa Andrz. ex DC.	CAMI1	F	N					20				0.2				0.2
Hypericum perforatum L.	HYPE1	F	N			20				0.2				0.3		
Aster porteri Gray	ASPO1	F	Y		100	100	100	100	2.6	2.0	5.4	4.6	3.8	2.5	7.1	5.4
Ambrosia psilostachya DC.	AMPS1	F	Y		60	60	100	80	1.2	0.6	1.2	1.4	1.8	0.8	1.6	1.6
Artemisia ludoviciana Nutt. var. ludoviciana	ARLU1	F	Y		100	20	40	40	1.0	0.2	0.6	0.4	1.5	0.3	0.8	0.5
Psoralea tenuiflora Pursh.	PSTE1	F	Y		40	80	40	80	0.8	1.4	0.8	1.6	1.2	1.8	1.1	1.9
Grindelia squarrosa (Pursh.) Dun.	GRSQ1	F	Y		40	80		20	0.4	1.2		0.2	0.6	1.5		0.2
Arenaria fendleri A. Gray	ARFE2	F	Y		40	20		40	0.4	0.2		0.4	0.6	0.3		0.5
Silene antirrhina L.	SIAN1	F	Y		20				0.2				0.3			
Liatris punctata Hook.	LIPU1	F	Y		20				0.2				0.3			
Arnica fulgens Pursh.	ARFU1	F	Y		20		20		0.2		0.2		0.3		0.3	
Asclepias stenophylla A. Gray	ASST1	F	Y		20	20			0.2	0.2			0.3	0.3		
Lesquerella montana (A. Gray) Wats.	LEMO1	F	Y													
Solidago mollis Bart.	SOMO1	F	Y													
Senecio plattensis Nutt.	SEPL1	F	Y													
Penstemon virens Penn.	PEVI1	F	Y													
Erigeron flagellaris A. Gray	ERFL1	F	Y			20	20			0.2	0.2			0.3	0.3	
Lomatium orientale Coult. & Rose	LOOR1	F	Y				60				0.8				1.1	
Lepidium densiflorum Schrad.	LEDE1	F	Y													
Gaillardia aristata Pursh.	GAAR1	F	Y			20				0.2				0.3		
Allium textile A. Nels. & Macbr.	ALTE1	F	Y													
Dalea purpurea Vent	DAPU1	F	Y			20	20			0.2	0.2			0.3	0.3	
Poa compressa L.	POCO1	G	N	C	100	100	100	100	17.2	20.8	25.4	31.8	25.2	26.4	33.5	37.1
Poa pratensis L.	POPR1	G	N	C	20	40	40	20	0.4	0.6	0.8	0.2	0.6	0.8	1.1	0.2
Bromus japonicus Thunb. ex Murr.	BRJA1	G	N	C												
Bromus tectorum L.	BRTE1	G	N	C												
Carex heliophila Mack.	CAHE1	G	Y	C	60	100	80	80	0.6	1.6	2.0	2.0	0.9	2.0	2.6	2.3
Eleocharis compressa Sulliv.	ELCO1	G	Y	C	20		20		0.4		0.2		0.6		0.3	
Koeleria pyramidata (Lam.) Beauv.	KOPY1	G	Y	C	40	20	20	20	0.4	0.2	0.2	0.2	0.6	0.3	0.3	0.2
Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	G	Y	C		20				0.2				0.3		
Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	G	Y	W	100	100	100	100	23.2	24.4	23.2	22.2	34.0	31.0	30.6	25.9
Andropogon gerardii Vitman	ANGE1	G	Y	W	100	100	100	100	8.6	11.0	7.2	12.2	12.6	14.0	9.5	14.3
Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	G	Y	W	100	100	100	100	5.6	6.2	4.8	6.0	8.2	7.9	6.3	7.0
Bouteloua curtipendula (Michx.) Torr.	BOCU1	G	Y	W	40	80	40	80	0.4	1.8	1.0	0.8	0.6	2.3	1.3	0.9
Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W	20			20	0.4			0.2	0.6			0.2
Andropogon scoparius Michx.	ANSC1	G	Y	W	20	20	20		0.4	0.2	0.2		0.6	0.3	0.3	
Bouteloua hirsuta Lag	BOHI1	G	Y	W			20				0.2				0.3	

Table 2-5. (cont.)

Scientific Name	Speccode	Form	Native	Cool/ Warm Season	Site DKT - Treatment											
					Frequency (%)				Absolute Foliar Cover (%)				Relative Foliar Cover (%)			
					Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998	Spring 1997	Summer 1997	Spring 1998	Summer 1998
Total foliar cover									66.4	71.0	75.4	81.6	100.0	100.0	100.0	100.0
Total forb cover									12.2	8.8	5.0	3.8	18.4	12.4	6.6	4.7
Total native forb cover									7.0	3.8	5.0	3.8	10.5	5.4	6.6	4.7
Total non-native forb cover									5.2	5.0	0.0	0.0	7.8	7.0	0.0	0.0
Total graminoid cover									54.2	62.2	70.4	77.8	81.6	87.6	93.4	95.3
Total native cover									44.8	50.8	47.0	47.2	67.5	71.5	62.3	57.8
Total non-native cover									21.6	20.2	28.4	34.4	32.5	28.5	37.7	42.2
Total warm season graminoid cover									36.8	45.6	41.2	42.4	55.4	64.2	54.6	52.0
Total cool season graminoid cover									17.4	16.6	29.2	35.4	26.2	23.4	38.7	43.4

Note: Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible at a site (500).
Relative cover = Relative foliar cover is the number of hits on a species 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).

Report 3

Effects of a Late-Summer Grassland Fire on Diffuse Knapweed Density

3. Effects of a Late-Summer Grassland Fire on Diffuse Knapweed Density

3.1 Introduction

Diffuse knapweed is listed as a noxious weed under Colorado State law (CRS 1996) and as a result must be controlled by property owners. Prescribed burns have been proposed as a possible component of a comprehensive program to manage the ecological resources of the Site. However, diffuse knapweed is a species adapted to disturbance regimes, and concern has been expressed that a fire disturbance might actually promote the spread of the species (Sheley et al. 1998). A natural fire in 1996 provided an opportunity to evaluate the effects of a burn on an area of diffuse knapweed infestation.

On September 2, 1996, lightning caused a wildfire that swept across approximately 105 acres of grassland in the Buffer Zone south of the Industrial Area at Rocky Flats Environmental Technology Site (Site). Observations the next day suggested that the fire was a fast-moving, cool fire. While most of the litter and much of the live biomass had been removed, diffuse knapweed (*Centaurea diffusa*) was not consumed and remained standing. The adult plants had only been scorched at the base, leaving current-year stalks still standing, and rosettes that were present before the fire had only their leaf tips scorched. As a result, it was possible to determine pre-burn stem densities.

This study was designed to examine the effects of the late summer grassland fire on the stem densities of diffuse knapweed. The hypothesis being tested was:

> H_o = There would be no difference in the pre-burn and post-burn stem density of diffuse knapweed (post-burn being two years after the fire).

3.2 Methods

The study was designed using both unburned (control) and burned (treatment) plots where diffuse knapweed was present in visually similar amounts. Where possible, the control and treatment plots were selected adjacent to each other across the edge of the fire line. This was possible for only a portion of the diffuse knapweed control plot. The remainder of the control plot was located across a gravel road where the fire had burned up to the road edge. The plant community was the same, however. The soil type present at the study location is Flatirons very cobbly sandy loam (SCS 1980).

Ten replicate, square-shaped 1-m^2 quadrats were located randomly in each of the unburned and burned plots. Each quadrat location was staked with rebar at one corner, and quadrats were oriented using a compass so that the edges were aligned N-S and E-W. The staked corner position for each quadrat was recorded, so the quadrat could be

relocated accurately for future sampling. Stem densities were counted and recorded for each quadrat. Both adult plants (stalks) and rosettes were counted, and their numbers were summed for the total stem density per quadrat. All three values were recorded for each quadrat. Adult plants were defined as all plants that had bolted. Rosette counts included both seedling and rosette growth forms. Sampling was conducted in late summer 1996, 1997, and 1998.

Data were entered and quality checked prior to analysis. Data were summarized using the 10 quadrats sampled for each plot ($n = 10$). Pre- and post-burn stem-density analyses between the control and treatment plots were conducted using a Mann-Whitney U test ($P = 0.05$, two-tailed test; Fowler and Cohen, 1990). Analyses of between-year differences in stem densities within treatment types were conducted using Wilcoxon's test for matched pairs ($P = 0.05$, two-tailed test; Fowler and Cohen, 1990). Both tests are ranking tests that compare the medians of the samples. Statistical analyses used only the 1996 and 1998 data.

3.3 Results

The results for the unburned and burned sites are shown in Table 3-1 and Figures 3-1 and 3-2. Diffuse knapweed rosette densities increased significantly in both the unburned and burned plots from 1996 to 1998 ($P = 0.05$; Table 3-1 and Figure 3-1). Although rosette density was higher in the burned plot than in the unburned plot for each of the three years, the difference in rosette density was not statistically significant in 1996 or 1998 ($P = 0.05$; 1997 not analyzed; Table 3-1 and Figure 3-1). The number of adult plants also increased in both the unburned plot and burned plot from 1996 to 1998, with the burned plot having the higher density during each year (Table 3-1 and Figure 3-2). Although there was a statistically significant increase in the density of adult plants in the burned plot over this time, the difference between plots was not statistically significant in either 1996 or 1998 ($P = 0.05$; 1997 not analyzed; Table 3-1 and Figure 3-2).

The number of rosettes in the unburned and burned plots increased by factors of 7 and 10, respectively, over the two-year period (Table 3-1 and Figure 3-1). The number of adult plants increased by factors of 2.7 and 3.3 in the unburned and burned plots, respectively, for the same two years (Table 3-1 and Figure 3-2). From 1996 to 1997, the number of diffuse knapweed rosettes increased by factors of approximately 3 and 2, respectively, for the unburned and burned plots (Table 3-1 and Figure 3-1). At the same time, the number of adult plants doubled in the burned plots while remaining the same in the unburned plots (Table 3-1 and Figure 3-2). The number of adult plants nearly doubled again from 1997 to 1998 in the burned plots, while nearly tripling in the unburned plots during the same time period (Table 3-1 and Figure 3-2).

3.4 Discussion

The diffuse knapweed response in the unburned and burned plots were generally parallel, with both the rosette and adult plant life stages showing increased densities over time.

The fact that diffuse knapweed rosette densities increased significantly in both the unburned and burned plots from 1996 to 1998, combined with the lack of a statistically significant difference ($P = 0.05$) in the rosette densities between the unburned and burned plots in 1996 and again in 1998, suggests that the late-summer grassland fire had a negligible impact on the rosette density of diffuse knapweed. The data, however, do illustrate how rapidly diffuse knapweed can increase in an infested area, and that the potential for large increases in diffuse knapweed density are present with or without fire in otherwise undisturbed native plant communities..

The effect of fire on diffuse knapweed infestations is a concern of land managers, because one of the most important tools for prairie management and restoration is fire. Results elsewhere on diffuse knapweed and spotted knapweed have shown that fire does not control these species, because the fires have not been hot enough to affect seed germination (Sheley et al. 1998). Spotted knapweed infestations have been shown to actually increase after prescribed burns (Sheley et al. 1998). However, the present study revealed significant increases in knapweed density in both the burned and unburned plots, indicating that diffuse knapweed populations will increase in an infested area whether it is burned or not. Therefore, the concern that using fire as a component of a comprehensive land management program will result in knapweed infestations beyond what would occur naturally is not justified, based on the results of this investigation.

Examined from a different point of view, the use of prescribed burns in conjunction with herbicide applications could potentially improve the effectiveness of these applications in controlling diffuse knapweed. In Montana's Lolo National Forest, prescribed burns in combination with aerial herbicide applications have been successful in controlling spotted knapweed infestations on steep mountain grasslands (Henry 1998). Locally, the City of Boulder Mountain Parks is conducting trials using prescribed burns followed by herbicide applications to control diffuse knapweed (Armstrong 1998, pers. comm.). Results of their trials appear promising and could potentially be used on the Site, in addition to current weed control methods.

As new management techniques are developed, these best management techniques will be pursued to control diffuse knapweed more effectively on the Site.

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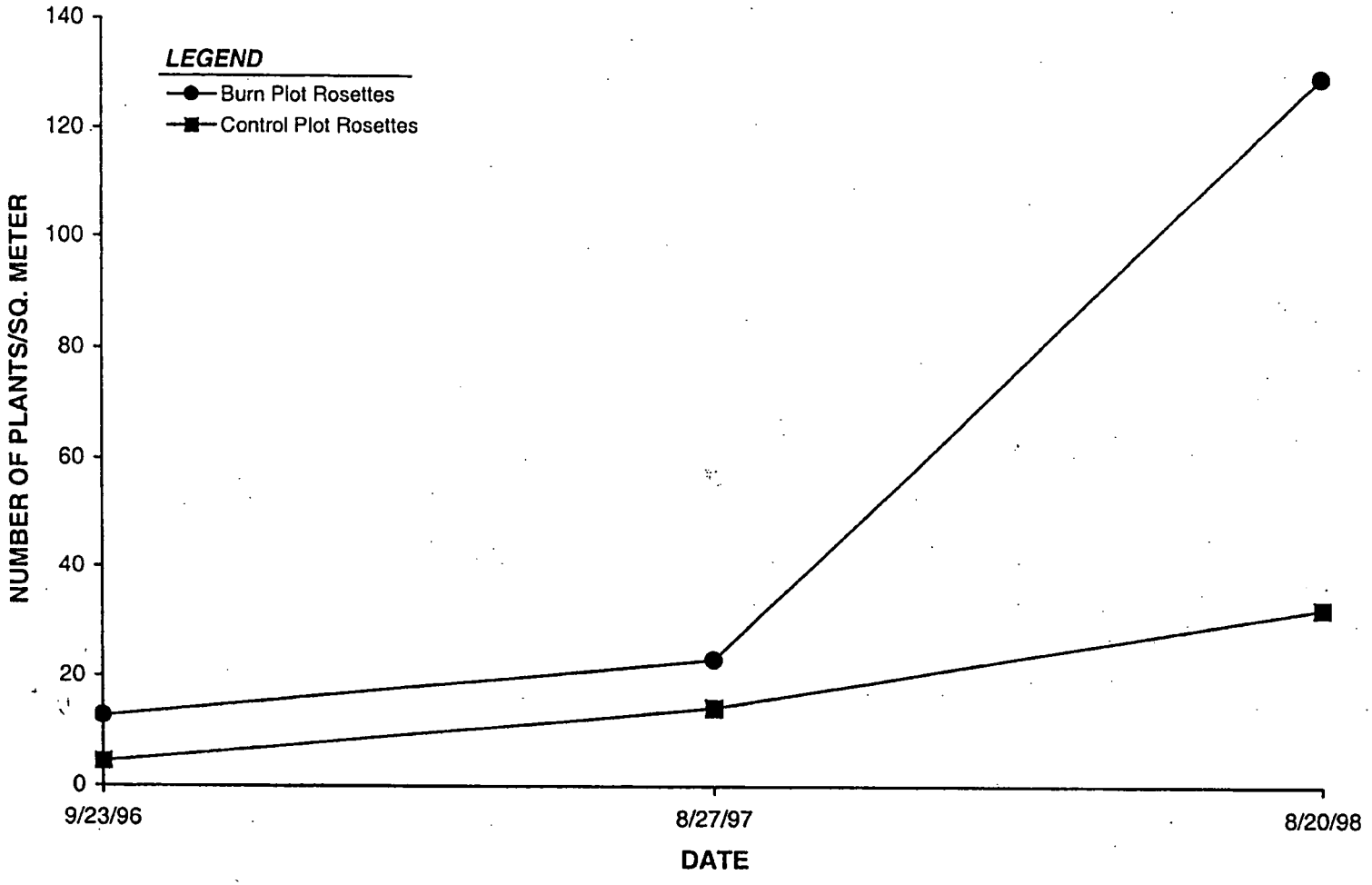

Figure 3-1. Diffuse knapweed rosette densities from 1996–1998.

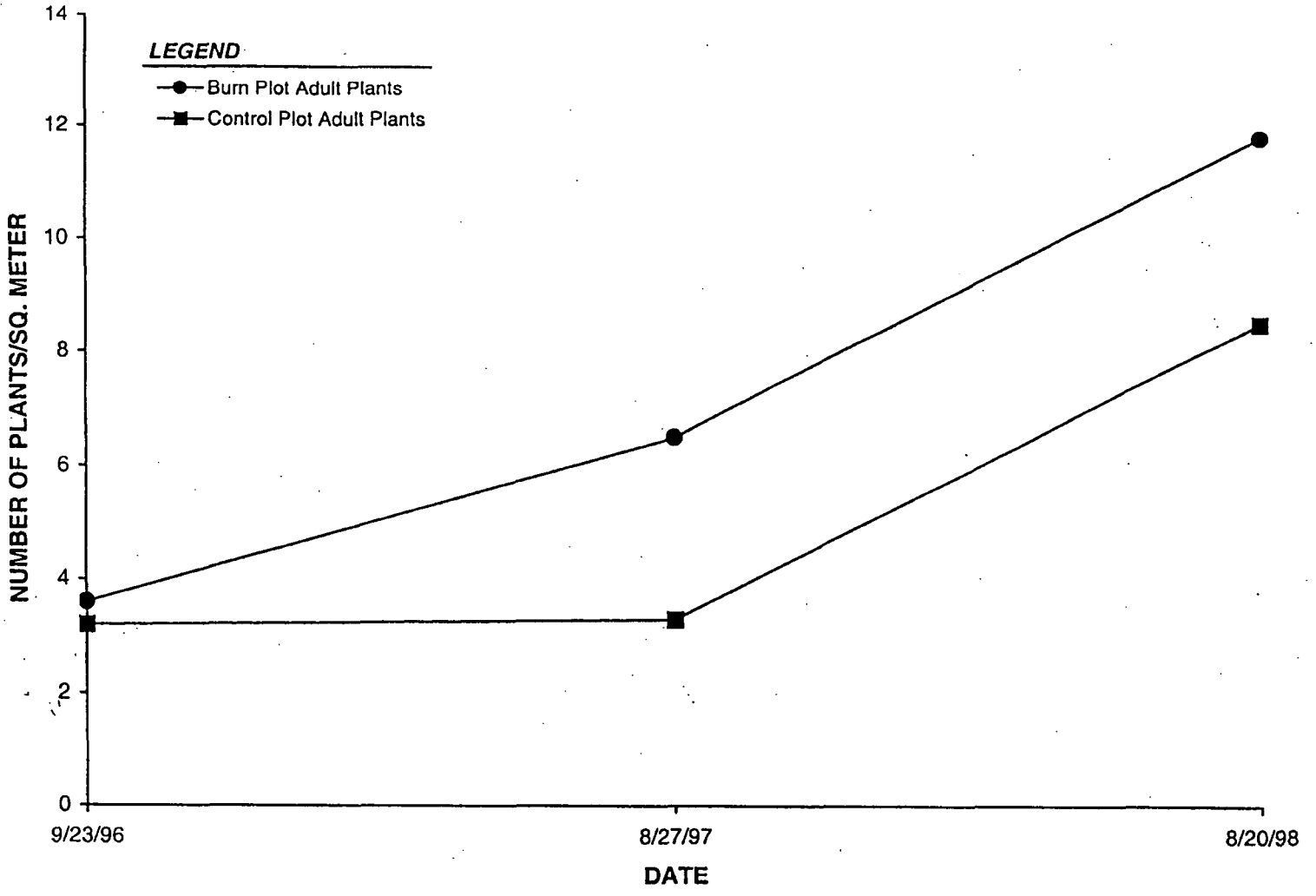

Figure 3-2. Diffuse knapweed adult plant densities from 1996–1998.

Table 3-1. 1996–1998 *Centaurea diffusa* densities in control and burn plots

		Plant Density (mean # of plants/sq. meter)		
Sampsite	Data	9/23/96	8/27/97	8/20/98
Burn plot	Rosettes	12.8	23	129.3
Control plot	Rosettes	4.5	14.3	32.4
Burn plot	Mature plants	3.6	6.5	11.8
Control plot	Mature plants	3.2	3.3	8.5
Burn plot	Total # plants	16.4	29.5	141.1
Control plot	Total # plants	7.7	17.6	40.9

Report 4

1998 Wetland Monitoring Summary

4. 1998 Wetland Monitoring Summary

4.1 Introduction

Monitoring is an integral part of determining whether the management objectives and goals for the high-value plant communities at Rocky Flats Environmental Technology Site (Site) are being achieved (IMP 1997; 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 might go undetected through the use of broader-scale qualitative monitoring techniques.

Wetlands are an integral part of the overall Site ecosystem. Their numerous functions include providing habitat for many plants and animals, storing and releasing water, maintaining water quality, and controlling erosion (COE 1994). In 1994, the U.S. Army Corps of Engineers (COE) conducted a wetlands inventory that identified more than 1,000 wetlands on the Site, covering 191 acres (COE 1994). The Site vegetation map, updated in 1996 using a broader definition of wetlands areas, identified approximately 407 acres of wetlands on the Site. The broader definition used for the 1996 map allowed inclusion of wet meadow areas.

At present, the only quantitative baseline data available for wetlands on the Site is from a few scattered localities where sampling was conducted during the baseline inventory study in 1991 (DOE 1992). The COE inventory in 1994 delineated wetlands on the Site, but gathered only qualitative vegetation data (COE 1994). During 1997, as part of the high-value vegetation community monitoring, species richness was inventoried in three of the largest wetland areas on the Site (K-H 1997c), documenting 260 species of vascular plants in these wetlands (K-H 1998). In the 1998 study, 15 permanently marked transects were located in the wetlands that had been qualitatively surveyed in 1997, to provide quantitative long-term monitoring data for the wetland community (Figure 4-1). Monitoring was conducted using the same methods as were used for other quantitative vegetation monitoring on the Site, allowing compatibility with and comparability to other Site data. The purpose of this monitoring was to provide quantitative baseline information at permanent wetland locations that could be used to assess and document future changes in these communities.

The following questions were proposed for the 1998 monitoring, to provide baseline information on the species composition in the wetland communities on the Site:

1. What is the baseline species richness at these wetland locations?
2. What is the baseline foliar cover (total and individual species) at these wetland locations?

3. What is the baseline percent of total native foliar cover at these wetland locations?

4. What is the baseline woody plant densities at these wetland locations?

5. What is the baseline frequency of occurrence of individual species at these wetland locations?

6. How does the species richness and foliar cover information from the wetlands compare to that of the other plant communities on the Site?

4.2 Methods

4.2.1 Study Site Information

The areas selected for this study were two large wetlands located in Rock Creek and the Antelope Springs/Apple Orchard wetland in Woman Creek (Figure 4-1). These areas were chosen for two primary reasons: they are the largest wetlands on the Site, and a floristic inventory was conducted in each of these areas in 1997. The COE (1994) study that delineated the Site wetlands described these areas as a wetland mosaic, with water regimes varying from temporary to saturated, and vegetation types ranging from wet meadow to marsh. It described these hillside wetlands as seep-fed, usually with multiple discharge points located just at or below the pediment surface.

4.2.2 Field Work and Data Analysis

Monitoring was conducted at 15 transects located in the wetlands shown in Figure 4-1. Five 50-m transects were located randomly in each of the wetland areas designated as W1, W2, and W3. Transects were located using the Site's GIS. A baseline was positioned along an edge of the wetland, and randomly generated x and y coordinates were used to mark the 0-m end of the transects on maps. In the field, the 0-m ends of the transects were located on the ground, and the direction of each transect was determined using randomly generated aspects. Adjustments were made as necessary, however, so that each transect remained entirely within the boundaries of the wetland (minimum distance from edge of wetland = 1 m). Tall marsh and short marsh classifications were used as the definition for wetland vegetation for the purposes of this study. A minimum of 3 m was maintained between transects, and no transects overlapped.

The following data were recorded for each transect: species richness, foliar cover, frequency, and Canada thistle and woody plant densities. Each transect was also documented with a photograph looking down the length of the transect. Sampling was conducted only once during the summer (July 13–17, 1998) to prevent trampling and damage to the wetland vegetation along the transects.

- Species richness was determined in a 2-m-wide belt centered along the length of each 50-m transect. All plant species rooted within the

100-m^2 belt were recorded. In addition, the densities of the woody plant stems and cactus species were counted and recorded for each 100-m^2 area.

- Foliar cover was estimated using a point-intercept method along each 50-m transect. A 2-m-long rod, with a 6-mm diameter, was dropped vertically at 50-cm intervals along the transect to record a total of 100 intercept points. Foliar vegetation hits (defined as any portion of a plant touching the rod above the ground surface) were recorded 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 the right-hand side (starting from the 0-m end) of each transect and recording all species present in each plot.

- Density counts of Canada thistle (*Cirsium arvense*) were made using a ¼-m^2 quadrat placed in the bottom left-hand corner of each 1-m^2 quadrat. The density values made from the smaller quadrats were then multiplied by 4 to provide a 1-m^2 density value. A single photograph of each transect was taken during the sampling session to visually document the condition of the transect. The photograph was taken from the 0-m end of the transect and looked down the length of the transect toward the 50-m endpoint.

More detailed descriptions of these specific methods are found in the *Environmental Monitoring Department Operating Procedures Manual* (DOE 1995) and the *High Value Vegetation Survey Plan for the Rocky Flats Environmental Technology Site* (K-H 1997a).

Species richness data were summarized by generating a species list for each wetland area. A Sorensen coefficient of similarity index (Brower and Zar 1977) was used to evaluate the species richness similarity among the wetlands. In addition, other species richness variables were calculated from the species lists. 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 possible five transects sampled in each wetland. Absolute foliar cover was the percentage of the number of hits on a species out of the total number of hits possible at a wetland (500). Relative foliar cover was the number of hits a species had relative to the total number of all vegetative hits recorded per wetland (i.e., the percent of vegetative cover represented by the species). Both absolute and relative foliar cover values are means. Frequency based on quadrats (n = 25 per wetland) was defined as the number of quadrats in which a species was recorded, divided by 25 (the total number of quadrats possible) and then multiplied by 100. Density count data were summarized as the mean number of stems per square meter. No statistical analysis of the data was conducted because these data are baseline values, which will be compared with future sampling results.

4.3 Results

Total species richness recorded across all three sites was 95 species. Species richness was highest at site W1 (72 species) and lowest at W2 (54 species; Table 4-1). The highest number of species per 1-m^2 quadrat was found at site W3 (10.0 species), followed by W1 (8.9 species) and W2 (5.8 species). The percentage of native species was essentially the same at all three sites (68–69 percent; Table 4-1). Sorted by U.S. Fish and Wildlife Service (USFWS) wetland indicator types, obligate wetland species made up the largest number of species at each site (Table 4-1). Of the species recorded at the three sites, none is considered rare or imperiled by the Colorado Natural Heritage Program (CNHP 1997). The Sorensen similarity index showed the greatest similarity (based on species presence/absence) between sites W1 and W3 (0.73). The lowest similarity was between sites W1 and W2 (0.62). Similarity between W2 and W3 was 0.70.

Total absolute foliar cover was essentially equal at sites W1 and W3, with 94.6 and 94 percent, respectively (Table 4-2). Site W2 had only slightly less absolute foliar cover, at 88 percent (Table 4-2). Relative foliar cover was dominated at all sites by Arctic rush (*Juncus balticus*; mean across all three sites = 43.7 percent; Table 4-2). Broad-leaved cattails (*Typha latifolia*) provided the second largest amount of relative foliar cover at sites W1 and W3 (9.3 and 7.7 percent, respectively; Table 4-2). At W2, woolly sedge (*Carex lanuginosa*) provided the second highest amount of relative foliar cover (6.8 percent; Table 4-2). The dominant noxious weed found at all three wetland sites was Canada thistle (*Cirsium arvense*), which averaged 5 percent relative foliar cover across all three sites (Table 4-2). Other species that provided greater than 4 percent relative foliar cover at any of the sites included yellowrocket wintercress (*Barbarea vulgaris*), Nebraska sedge (*Carex nebrascensis*), longstyle rush (*Juncus longistylis*), rough bent (*Agrostis scabra*), Kentucky bluegrass (*Poa pratensis*), and prairie cordgrass (*Spartina pectinata*; Table 4-2). Ninety percent of the foliar cover at W2 came from native species, whereas at sites W1 and W3, only 80 percent of the cover was from native species. Shannon-Weaver diversity indices were calculated for all three sites based on cover data (Table 4-2). Sites W3 (1.07) and W1 (1.03) had the highest diversity, and W2 had the lowest (0.84).

Yellowrocket wintercress had the highest frequency of any recorded species, with frequencies of 100 percent and 92 percent at sites W1 and W3, respectively (Table 4-3). However, it did not occur in any of the quadrats at site W2 (Table 4-3). Arctic rush (mean frequency = 77 percent) and Canada thistle (mean frequency = 75 percent) were the next most common species encountered across all three wetland sites (Table 4-3).

Snowberry (*Symphoricarpos occidentalis*) had the highest woody stem densities of any woody species at all three sites, but was less than 2 stems/m^2 at all sites (Table 4-4). The noxious weed Canada thistle was found at the highest densities at sites W1 and W3, with plant densities of 13 and 16 plants/m^2, respectively (Table 4-5). At W2, the Canada thistle density was only 6 plants/m^2 (Table 4-5).

4.4 Discussion

Overall, the vegetation composition of these three large wetland areas was fairly similar. All three areas were dominated by arctic rush. One of two sedges—either wooly sedge or Nebraska sedge, depending on site location—and cattails provided the remainder of the dominant cover. Differences among the three wetland sites appeared to depend the drainage in which they were located. Sites W1 and W3, in Rock Creek, appeared more similar to one another than to W2, which was located in Woman Creek. Higher total site species richness, number of species/m^2, total absolute foliar cover, and greater diversity were found at the Rock Creek wetlands. The highest Sorensen similarity index (based on species presence/absence) occurred between the two Rock Creek sites. Data from 1997 species richness inventories of the entire wetland complexes where the transects for this study were located also revealed similar results (K-H 1997c). These data showed that the highest species richness was found at the W1 wetland complex (188 species), and although the lowest species richness occurred at W3 (178 species; W2 had 180 species), the highest similarity occurred between the Rock Creek wetlands (Sorensen coefficient of similarity = 0.80; K-H 1997c).

Compared to the other plant communities monitored on the Site using the same methodology, the total species richness for the wetland community was lower than that observed in the xeric mixed grassland, mesic mixed grassland, and riparian communities[2] (K-H 1997d). Only the reclaimed grassland had lower species richness. The percentage of native species in the wetland community (overall = 72 percent) was most similar to the riparian community, which would be expected because many of the same species are found in both communities (K-H 1997d). Total foliar cover in the wetlands (92.2 percent) was higher than that found at any of the other plant communities monitored from 1993 through 1995, with the exception of the 1995 mesic mixed grassland (K-H 1997d).

Based on the results of this study, the classification of these large hillside seep wetlands best fits that described by Cooper (1988), in a report on Boulder Valley wetlands, as an arctic rush (*Juncus balticus = J. arcticus*) wetland community. Small inclusions of the cattail-duckweed (*Typha latifolia-Lemna minor*), Nebraska sedge, and prairie cordgrass (*Spartina pectinata*) communities are also present within these larger complexes at some locations. With the exception of the prairie cordgrass wetland type, none of these wetland types are uncommon in the greater Boulder area (Cooper 1988). The prairie cordgrass wetland community however, as Cooper (1988) mentions, is more restricted now than in presettlement times. It was previously much more common along the floodplains of rivers and in sloughs and oxbows. As a result, this community is listed by the Colorado Natural Heritage Program (CNHP 1997) as a plant community of concern. It is considered to be a critically imperiled community in the state of Colorado due to its rarity. Although only small patches of the community occur at the Site within the

[2] The riparian community as used here refers to the EcMP classification system and data sets. It usually included riparian woodland and some small streamside wetland areas.

wetlands, the presence of this wetland type is further evidence of the uniqueness, health, and high quality of the ecological resources, which have been preserved at the Site.

In describing the wetlands of the Boulder valley, Cooper describes the arctic rush community as "occupying seasonally wet meadows." This classification is described as an herbaceous wetland with mineral soils and fresh water. It is dominated by arctic rush, but often has a variety of associated species. He also mentions that this wetland classification usually has a long grazing history and that arctic rush is considered to be an "increaser,"[3] because it is not considered very palatable by cattle. This latter information raises some interesting questions that relate past land use to the current species composition found in Site wetlands. Prior to DOE acquisition in the early 1950s, the entire area of the Site was rangeland that had probably been grazed for at least a century or more (total time frame hypothesized). Considering that arctic rush is an "increaser" with grazing pressure, it would have been increasing in cover for some time in the wetlands on the Site. This could help explain the dominance of arctic rush not only in these wetlands, but many others on the Site. With the relief of grazing pressure from most of these wetlands for nearly 50 years (part of the W3 wetland has not been grazed for only 25 years), it could be assumed that the dominance of arctic rush may be decreasing. The question could also be raised as to whether these wetlands are reverting back to a pre-grazing composition. In other words, as the dominance of arctic rush in the community decreases, are other species migrating back into the community and surviving? Given the prevalence of exotic weed species, especially Canada thistle, it is unknown whether a truly pre-grazing composition could ever be achieved.

A qualitative comparison of the Site 1998 wetland data with information from wetlands on City of Boulder Open Space properties to the north and west of the Site reveals similarities (D'Amico 1998, pers. comm.). Although most of the Open Space wetlands are not large hillside seep wetlands—most are riparian or pond-edge wetlands—the species found at these locations are either present in the 1998 site wetland inventory lists or from the species inventories conducted in wetlands on the Site in 1997. Because of differences in methods, and because the Open Space information was qualitative, no detailed comparisons of species richness or cover were possible. However, the dominant species listed for the Open Space wetlands are also dominant in places on the Site as well. One apparent difference in the Open Space data was the lack of Canada thistle at most localities. Out of 10 wetlands for which data was obtained, Canada thistle was only listed in the species lists for three locations. Whether this is reality or a consequence of the qualitative assessment used to gather the data is not known. If true, it is interesting that these wetlands have not been infested.

On the Site, the noxious weed Canada thistle was found throughout all three wetland sites studied, although it occurred less frequently and had less cover at W2 than at W1 and W3. Canada thistle stem density in Rock Creek (W1 = 13 plants/m^2; W3 16 plants/m^2)

[3] An increaser is defined as a species that increases in dominance because the grazing animals selectively eat other species (i.e., decreasing their abundance), giving the "increaser" species a competitive advantage.

was more than twice that in Woman Creek (W2 = 6 plants/m^2). Canada thistle is listed on the state noxious weed list as one of the top ten weed species needing control in Colorado (CRS 1996). Additionally, it has been listed by Jefferson County as a priority for control within the county (Lyle 1998). Landowners are responsible for controlling infestations of noxious weeds on their properties and preventing their spread to neighboring landowners.

Control of the Canada thistle in the wetlands on the Site is made difficult because of the open water often present in these areas. Most recommended measures for controlling Canada thistle infestations are designed for dryland infestations, where mowing combined with herbicide treatment can provide effective treatment (Beck 1996). However, within Site wetlands, mowing is not feasible due to the soft, uneven, hummocky ground. Herbicides are not safe to apply at a broad scale because either 1) they are not designed for direct application to water sources, or 2) if they are approved for water application, they are non-selective and would affect all broadleaf forbs in the wetlands. Because none of these options is desirable, alternative solutions must be developed. In addition, repeated application over several years using any means is generally required for effective control of Canada thistle.

Given these conditions, the following control methodology is suggested for controlling Canada thistle in the wetlands on the Site. Two biocontrol insects are available from the Colorado Department of Agriculture (CDA) for control of Canada thistle (Beck 1996). *Ceutorhyncus litura* (crown boring weevil) and *Urophora cardui* (a gall-forming insect) both can stress populations of Canada thistle. *Ceutorhyncus litura* causes plants to be stressed and less vigorous. *Urophora cardui* stresses a plant by causing galls to develop on the plant, which if formed near terminal growing points, prevents flowers from developing and setting seed. Neither is generally capable of totally controlling infestations, but using both in conjunction with other methods has proven effective (Beck 1996). In 1997, the CDA released two biocontrol insects on the Site to assist in the control of diffuse knapweed (*Centaurea diffusa*) and dalamatian toadflax (*Linaria dalmatica*), at no cost to the Site. The CDA should be encouraged to continue to use the Site as a testing ground for releases of the biocontrol insects for Canada thistle. This would provide additional control of this species on Site at little to no cost.

Other potential actions include conducting controlled burns in the wetlands. Although this may not directly reduce or control the Canada thistle, burning would reduce built-up dead plant litter and recycle nutrients, the intent being to invigorate the native plants in the wetlands. This would help the native species to compete with the weeds. Application of approved herbicides is possible in the wetlands using a wick application method, where the herbicide is applied by hand to individual plants. Although more time and labor intensive, this could be done whether controlled burns were conducted first or not. However, because the wetland vegetation is typically dense, removal of the dead plant material from the wetland first would make wick application more effective, as Canada thistle plants and rosettes would be more visible and accessible for herbicide application. Wick applications of herbicides would have to be continued for several years to maintain good control.

4.5 References

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Table 4-1. 1998 wetlands species richness

Family	Scientific Name	Speccode	Native	Site		
				W1	W2	W3
ALISMATACEAE	Sagittaria latifolia Willd.	SALA1	Y			X
APIACEAE	Cicuta maculata L. var. angustifolia Hook.	CIMA1	Y	X		
ASCLEPIADACEAE	Asclepias incarnata L.	ASIN1	Y		X	X
ASCLEPIADACEAE	Asclepias speciosa Torr.	ASSP1	Y	X	X	X
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	Y	X	X	X
ASTERACEAE	Arnica fulgens Pursh.	ARFU1	Y	X		
ASTERACEAE	Arctium minus Bernh.	ARMI1	Y	X		
ASTERACEAE	Aster falcatus Lindl.	ASFA1	Y	X	X	
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	N	X	X	X
ASTERACEAE	Cirsium vulgare (Savi) Ten.	CIVU1	N	X	X	X
ASTERACEAE	Lactuca serriola L.	LASE1	N	X	X	X
ASTERACEAE	Sonchus asper (L.) Hill	SOAS1	N		X	
ASTERACEAE	Solidago missouriensis Nutt.	SOMI1	Y	X		
ASTERACEAE	Taraxacum officinale Weber	TAOF1	N	X	X	
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	N	X	X	X
BORAGINACEAE	Cynoglossum officinale L.	CYOF1	N		X	X
BORAGINACEAE	Onosmodium molle Michx. var. occidentale (Mack.) Johnst.	ONMO1	Y	X		
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	N	X		X
BRASSICACEAE	Nasturtium officinale R. Br.	NAOF1	N	X		X
BRASSICACEAE	Thlaspi arvense L.	THAR1	N	X	X	X
CANNABACEAE	Humulus lupulus L. var. lupuloides E. Small	HULU1	Y	X		
CAPRIFOLIACEAE	Symphoricarpos occidentalis Hook.	SYOC1	Y	X	X	X
CERATOPHYLLACEAE	Ceratophyllum demersum L.	CEDE1	Y			X
CLUSIACEAE	Hypericum perforatum L.	HYPE1	N	X	X	X
CYPERACEAE	Carex hystericina Muhl. ex Willd.	CAHY1	Y			X
CYPERACEAE	Carex interior Bailey	CAIN1	Y		X	X
CYPERACEAE	Carex lanuginosa Michx.	CALA1	Y	X	X	X
CYPERACEAE	Carex nebrascensis Dew.	CANE1	Y	X	X	X
CYPERACEAE	Carex praegracilis W. Boott.	CAPR1	Y		X	
CYPERACEAE	Carex scoparia Schkuhr. ex Willd.	CASC1	Y	X		
CYPERACEAE	Eleocharis macrostachya Britt.	ELMA1	Y	X	X	X
CYPERACEAE	Scirpus pallidus (Britt.) Fern	SCPA1	Y		X	
EQUISETACEAE	Equisetum laevigatum A. Br.	EQLA1	Y	X	X	
EUPHORBIACEAE	Euphorbia robusta (Engelm.) Small	EURO1	Y			X
FABACEAE	Amorpha fruticosa L.	AMFR1	Y	X		
FABACEAE	Dalea purpurea Vent	DAPU1	Y	X		
FABACEAE	Glycyrrhiza lepidota Pursh.	GLLE1	Y	X		
FABACEAE	Thermopsis rhombifolia var. divaricarpa (Nels.) Isely	THRH1	Y	X		
FABACEAE	Trifolium sp.	TRI1				X
IRIDACEAE	Iris missouriensis Nutt.	IRMI1	Y		X	
JUNCACEAE	Juncus balticus Willd.	JUBA1	Y	X	X	X
JUNCACEAE	Juncus dudleyi Wieg.	JUDU1	Y	X	X	X
JUNCACEAE	Juncus ensifolius Wikst. var. montanus (Englm.) C. L. Hitchc.	JUEN1	Y		X	X
JUNCACEAE	Juncus longistylis Torr.	JULO1	Y	X	X	X
JUNCACEAE	Juncus nodosus L.	JUNO1	Y		X	X
JUNCACEAE	Juncus torreyi Cov.	JUTO1	Y		X	
LAMIACEAE	Lycopus americanus Muhl. ex Barton	LYAM1	Y	X	X	X
LAMIACEAE	Mentha arvensis L.	MEAR1	Y	X	X	X
LAMIACEAE	Monarda fistulosa L. var. menthifolia (Grah.) Fern.	MOFI1	Y			X
LAMIACEAE	Nepeta cataria L.	NECA1	N	X		X
LAMIACEAE	Prunella vulgaris L.	PRVU1	Y	X	X	X
LEMNACEAE	Lemna minor L.	LEMI1	Y	X	X	X
LILIACEAE	Allium textile A. Nels. & Macbr.	ALTE1	Y	X		
LILIACEAE	Smilacina stellata (L.) Desf.	SMST1	Y	X		
LYTHRACEAE	Lythrum alatum Pursh.	LYAL1	Y		X	

Table 4-1. (cont.)

Family	Scientific Name	Speccode	Native	Site		
				W1	W2	W3
ONAGRACEAE	Epilobium ciliatum Raf. ssp. glandulosum (Lehm.) Hock & Raven	EPCI1	Y	X	X	X
ONAGRACEAE	Epilobium paniculatum Nutt.	EPPA1	Y	X	X	X
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	Y	X	X	X
OXALIDACEAE	Oxalis dillenii Jacq.	OXDI1	N	X		X
POACEAE	Agropyron repens (L.) Beauv.	AGRE1	N	X	X	X
POACEAE	Agrostis scabra Willd.	AGSC1	Y	X	X	X
POACEAE	Agrostis stolonifera L.	AGST1	N	X	X	X
POACEAE	Bromus inermis Leyss. ssp. inermis	BRIN1	N	X		
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	N	X	X	X
POACEAE	Calamagrostis stricta (Timm.) Koel	CAST2	Y		X	
POACEAE	Glyceria striata (Lam.) Hitchc.	GLST1	Y	X	X	X
POACEAE	Hordeum jubatum L.	HOJU1	Y	X		X
POACEAE	Poa compressa L.	POCO1	N		X	
POACEAE	Poa palustris L.	POPA1	N	X	X	X
POACEAE	Poa pratensis L.	POPR1	N	X	X	X
POACEAE	Sphenopholis obtusata (Michx.) Scribn.	SPOB1	Y		X	X
POACEAE	Spartina pectinata Link	SPPE1	Y	X	X	X
POLYGONACEAE	Polygonum convolvulus L.	POCO2	N	X		X
POLYGONACEAE	Polygonum ramosissimum Michx.	PORA1	Y	X		X
POLYGONACEAE	Rumex crispus L.	RUCR1	N	X	X	X
POLYGONACEAE	Rumex obtusifolius L.	RUOB1	N	X		
PRIMULACEAE	Lysimachia ciliata L.	LYCI1	Y	X		
RANUNCULACEAE	Ranunculus macounii Britt.	RAMA1	Y	X		X
ROSACEAE	Geum aleppicum Jacq.	GEAL1	Y	X	X	X
ROSACEAE	Geum macrophyllum Willd.	GEMA1	Y	X	X	X
ROSACEAE	Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc.	POGR1	Y	X	X	
ROSACEAE	Potentilla norvegica L.	PONO1	Y	X		X
ROSACEAE	Rosa arkansana Porter	ROAR1	Y	X		X
RUBIACEAE	Galium aparine L.	GAAP1	Y	X		X
RUBIACEAE	Galium septentrionale Roemer & Schultes	GASE1	Y	X		
SCROPHULARIACEAE	Mimulus glabratus H. B. K. var. fremontii (Benth.) A. L. Grant	MIGL1	Y			X
SCROPHULARIACEAE	Scrophularia lanceolata Pursh.	SCLA2	Y	X		
SCROPHULARIACEAE	Veronica anagallis-aquatica L.	VEAN1	N	X		X
SCROPHULARIACEAE	Verbascum blattaria L.	VEBL1	N		X	
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	N	X		X
TYPHACEAE	Typha latifolia L.	TYLA1	Y	X	X	X
UNKNOWN	Unidentifiable species	UNKN		X		
URTICACEAE	Urtica dioica L. ssp. gracilis (Ait.) Seland.	URDI1	Y	X		X
VERBENACEAE	Verbena hastata L.	VEHA1	Y	X	X	X
VIOLACEAE	Viola sororia Willd.	VISO1	Y			X
		Total # species:		72	54	63
		Percent native species:		69	69	68

Wetland Indicator Species					
Facultative species	FAC		14	6	9
Facultative upland species	FACU		15	9	1
Facultative upland species - less frequently found in wetlands	FACU-		0	0	1
Facultative wetland species	FACW		12	12	10
Non-indicator species	NI		9	8	8
Obligate wetland species	OBL		14	15	19
Upland species	UPL		1	2	1
	Total # species:		65	52	49

Table 4-2. 1998 wetland foliar cover data summary

Family	Scientific Name	Speccode	W1			W2			W3		
			Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover
ASCLEPIADACEAE	Asclepias incarnata L.	ASIN1							80	3.60	3.83
ASCLEPIADACEAE	Asclepias speciosa Torr.	ASSP1	40	1.40	1.48	20	0.20	0.23			
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	20	0.20	0.21						
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	80	5.40	5.71	40	3.40	3.86	100	5.20	5.53
ASTERACEAE	Lactuca serriola L.	LASE1							20	0.20	0.21
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	80	7.40	7.82				100	4.60	4.89
BRASSICACEAE	Nasturtium officinale R. Br.	NAOF1	20	0.80	0.85				20	3.20	3.40
CLUSIACEAE	Hypericum perforatum L.	HYPE1	20	1.40	1.48	20	0.20	0.23			
CYPERACEAE	Carex hystericina Muhl. ex Willd.	CAHY1							20	0.20	0.21
CYPERACEAE	Carex interior Bailey	CAIN1							40	0.40	0.43
CYPERACEAE	Carex lanuginosa Michx.	CALA1	60	7.60	8.03	80	6.00	6.82	20	0.40	0.43
CYPERACEAE	Carex nebrascensis Dew.	CANE1	80	3.00	3.17	80	5.00	5.68	100	6.00	6.38
CYPERACEAE	Carex praegracilis W. Boott.	CAPR1				60	1.60	1.82			
CYPERACEAE	Eleocharis macrostachya Britt.	ELMA1	20	0.80	0.85	20	0.80	0.91	80	2.80	2.98
FABACEAE	Thermopsis rhombifolia var. divaricarpa (Nels.) Isely	THRH1	40	1.20	1.27						
JUNCACEAE	Juncus balticus Willd.	JUBA1	100	37.80	39.96	100	45.20	51.36	100	37.40	39.79
JUNCACEAE	Juncus ensifolius Wikst. var. montanus (Englm.) C. L. Hitchc.	JUEN1				20	0.20	0.23	20	0.20	0.21
JUNCACEAE	Juncus longistylis Torr.	JULO1	40	2.20	2.33	40	3.80	4.32	60	1.60	1.70
JUNCACEAE	Juncus nodosus L.	JUNO1				20	0.40	0.45			
LAMIACEAE	Mentha arvensis L.	MEAR1	80	3.40	3.59				40	1.80	1.91
LAMIACEAE	Monarda fistulosa L. var. menthifolia (Grah.) Fern.	MOFI1							20	0.20	0.21
LAMIACEAE	Nepeta cataria L.	NECA1							20	0.20	0.21
LAMIACEAE	Prunella vulgaris L.	PRVU1				20	0.20	0.23			
LEMNACEAE	Lemna minor L.	LEMI1				20	0.20	0.23	40	0.40	0.43
LILIACEAE	Smilacina stellata (L.) Desf.	SMST1	20	0.20	0.21						
LYTHRACEAE	Lythrum alatum Pursh.	LYAL1				20	0.40	0.45			
ONAGRACEAE	Epilobium ciliatum Raf. ssp. glandulosum (Lehm.) Hock & Raven	EPCI1	60	1.20	1.27	20	0.20	0.23	40	0.40	0.43
ONAGRACEAE	Epilobium paniculatum Nutt.	EPPA1	40	0.60	0.63	20	0.40	0.45	80	1.40	1.49
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	20	0.20	0.21				40	0.80	0.85
POACEAE	Agropyron repens (L.) Beauv.	AGRE1	40	0.40	0.42	20	0.40	0.45			
POACEAE	Agrostis scabra Willd.	AGSC1	20	0.40	0.42				80	4.60	4.89
POACEAE	Agrostis stolonifera L.	AGST1	40	0.60	0.63				60	1.60	1.70
POACEAE	Calamagrostis stricta (Timm.) Koel	CAST2				20	1.60	1.82			
POACEAE	Glyceria striata (Lam.) Hitchc.	GLST1							20	1.20	1.28
POACEAE	Hordeum jubatum L.	HOJU1	20	0.20	0.21				20	0.20	0.21
POACEAE	Poa pratensis L.	POPR1	60	2.40	2.54	40	4.40	5.00	80	3.20	3.40
POACEAE	Spartina pectinata Link	SPPE1	20	1.80	1.90	40	5.00	5.68	40	1.40	1.49
POACEAE	Sphenopholis obtusata (Michx.) Scribn.	SPOB1							20	0.20	0.21

Table 4-2. (cont.)

Family	Scientific Name	Speccode	W1			W2			W3		
			Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover
POLYGONACEAE	Polygonum convolvulus L.	POCO2	20	0.40	0.42				20	0.40	0.43
POLYGONACEAE	Rumex crispus L.	RUCR1				20	0.20	0.23			
ROSACEAE	Geum aleppicum Jacq.	GEAL1	20	0.20	0.21	60	1.40	1.59	40	0.40	0.43
ROSACEAE	Geum macrophyllum Willd.	GEMA1	80	2.60	2.75	80	1.00	1.14	60	1.60	1.70
RUBIACEAE	Galium aparine L.	GAAP1	20	0.40	0.42				20	0.20	0.21
RUBIACEAE	Galium septentrionale Roemer & Schultes	GASE1	20	0.40	0.42						
SCROPHULARIACEAE	Scrophularia lanceolata Pursh.	SCLA2	20	0.20	0.21						
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	20	0.20	0.21						
SCROPHULARIACEAE	Veronica anagallis-aquatica L.	VEAN1							20	0.20	0.21
TYPHACEAE	Typha latifolia L.	TYLA1	60	8.80	9.30	40	5.80	6.59	40	7.20	7.66
URTICACEAE	Urtica dioica L. ssp. gracilis (Ait.) Seland.	URDI1							20	0.20	0.21
VERBENACEAE	Verbena hastata L.	VEHA1	20	0.60	0.63				20	0.20	0.21
VIOLACEAE	Viola sororia Willd.	VISO1							20	0.20	0.21
UNKNOWN	Unknown species	UNKN	20	0.20	0.21						
	Total cover			94.60	100.00		88.00	100.00		94.00	100.00
	Shannon-Weiner diversity index			1.03			0.84			1.07	

Note: Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible at a wetland (500).
Relative cover = Relative foliar cover is the number of hits on a species relative to the total number of all vegetative hits recorded per wetland (i.e., the percent of vegetative cover the species represented).
All cover values presented are means (n = 5).

Table 4-3. 1998 wetland species frequency data summary

Family	Scientific Name	Speccode	Native	Site		
				W1 Frequency	W2 Frequency	W3 Frequency
APIACEAE	Cicuta maculata L. var. angustifolia Hook.	CIMA1	Y	4		
ASCLEPIADACEAE	Asclepias incarnata L.	ASIN1	Y			32
ASCLEPIADACEAE	Asclepias speciosa Torr.	ASSP1	Y	8	4	
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	Y	20	4	4
ASTERACEAE	Arnica fulgens Pursh.	ARFU1	Y	4		
ASTERACEAE	Aster falcatus Lindl.	ASFA1	Y	12		
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	N	80	56	88
ASTERACEAE	Cirsium vulgare (Savi) Ten.	CIVU1	N	12		8
ASTERACEAE	Lactuca serriola L.	LASE1	N	4		16
ASTERACEAE	Taraxacum officinale Weber	TAOF1	N	12		
BORAGINACEAE	Cynoglossum officinale L.	CYOF1	N		4	
BORAGINACEAE	Onosmodium molle Michx. var. occidentale (Mack.) Johnst.	ONMO1	Y	4		
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	N	100		92
BRASSICACEAE	Nasturtium officinale R. Br.	NAOF1	N	4		16
BRASSICACEAE	Thlaspi arvense L.	THAR1	N	12		
CAPRIFOLIACEAE	Symphoricarpos occidentalis Hook.	SYOC1	Y	12	32	20
CLUSIACEAE	Hypericum perforatum L.	HYPE1	N	16	4	12
CYPERACEAE	Carex interior Bailey	CAIN1	Y			4
CYPERACEAE	Carex lanuginosa Michx.	CALA1	Y	20	20	
CYPERACEAE	Carex nebrascensis Dew.	CANE1	Y	20	24	20
CYPERACEAE	Carex praegracilis W. Boott.	CAPR1	Y		4	
CYPERACEAE	Carex scoparia Schkuhr. ex Willd.	CASC1	Y	4		
CYPERACEAE	Eleocharis macrostachya Britt.	ELMA1	Y	4	8	16
FABACEAE	Trifolium sp.	TRI1				4
JUNCACEAE	Juncus balticus Willd.	JUBA1	Y	72	84	76
JUNCACEAE	Juncus dudleyi Wieg.	JUDU1	Y	4		
JUNCACEAE	Juncus ensifolius Wikst. var. montanus (Englm.) C. L. Hitchc.	JUEN1	Y			4
JUNCACEAE	Juncus longistylis Torr.	JULO1	Y	8	32	36
JUNCACEAE	Juncus nodosus L.	JUNO1	Y			8
LAMIACEAE	Lycopus americanus Muhl. ex Barton	LYAM1	Y	4		28
LAMIACEAE	Mentha arvensis L.	MEAR1	Y	68	20	44
LAMIACEAE	Monarda fistulosa L. var. menthifolia (Grah.) Fern.	MOFI1	Y			4
LAMIACEAE	Nepeta cataria L.	NECA1	N	4		4
LAMIACEAE	Prunella vulgaris L.	PRVU1	Y	4	4	
LEMNACEAE	Lemna minor L.	LEMI1	Y	4	12	12
LYTHRACEAE	Lythrum alatum Pursh.	LYAL1	Y		20	
ONAGRACEAE	Epilobium ciliatum Raf. ssp. glandulosum (Lehm.) Hock & Raven	EPCI1	Y	44	36	36
ONAGRACEAE	Epilobium paniculatum Nutt.	EPPA1	Y	40	20	56
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	Y	24	20	16

Table 4-3. (cont.)

Family	Scientific Name	Speccode	Native	Site		
				W1 Frequency	W2 Frequency	W3 Frequency
OXALIDACEAE	Oxalis dillenii Jacq.	OXDI1	N	8		
POACEAE	Agropyron repens (L.) Beauv.	AGRE1	N	4	12	
POACEAE	Agrostis scabra Willd.	AGSC1	Y	16		40
POACEAE	Agrostis stolonifera L.	AGST1	N	8		24
POACEAE	Calamagrostis stricta (Timm.) Koel	CAST2	Y		8	
POACEAE	Glyceria striata (Lam.) Hitchc.	GLST1	Y			8
POACEAE	Hordeum jubatum L.	HOJU1	Y	4		4
POACEAE	Poa palustris L.	POPA1	N		8	
POACEAE	Poa pratensis L.	POPR1	N	32	24	44
POACEAE	Spartina pectinata Link	SPPE1	Y	8	12	4
POACEAE	Sphenopholis obtusata (Michx.) Scribn.	SPOB1	Y			4
POLYGONACEAE	Polygonum convolvulus L.	POCO2	N	4		4
POLYGONACEAE	Polygonum ramosissimum Michx.	PORA1	Y	4		
POLYGONACEAE	Rumex crispus L.	RUCR1	N	4	4	
RANUNCULACEAE	Ranunculus macounii Britt.	RAMA1	Y	4		
ROSACEAE	Geum aleppicum Jacq.	GEAL1	Y	12	36	8
ROSACEAE	Geum macrophyllum Willd.	GEMA1	Y	60	40	56
ROSACEAE	Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc.	POGR1	Y	4		
ROSACEAE	Potentilla norvegica L.	PONO1	Y	4		
ROSACEAE	Rosa arkansana Porter	ROAR1	Y			4
RUBIACEAE	Galium aparine L.	GAAP1	Y	32		56
RUBIACEAE	Galium septentrionale Roemer & Schultes	GASE1	Y	8		
SCROPHULARIACEAE	Scrophularia lanceolata Pursh.	SCLA2	Y	16		
SCROPHULARIACEAE	Veronica anagallis-aquatica L.	VEAN1	N			16
TYPHACEAE	Typha latifolia L.	TYLA1	Y	24	16	32
URTICACEAE	Urtica dioica L. ssp. gracilis (Ait.) Seland.	URDI1	Y			8
VERBENACEAE	Verbena hastata L.	VEHA1	Y	4	8	8
VIOLACEAE	Viola sororia Willd.	VISO1	Y			24

Table 4-4. 1998 wetland shrub densities

	Site		
Scientific Name	W1	W2	W3
Amorpha fruticosa L.	0.002	0.000	0.000
Rosa arkansana Porter	0.046	0.000	0.064
Symphoricarpos occidentalis Hook.	0.844	1.850	0.822

Note: Values are # stems/sq. meter.

Table 4-5. 1998 wetland Canada thistle (Cirsium arvense) densities

Site	Density (# plants/m^2)
W1	12.96
W2	5.76
W3	16.00

Report 5

1998 Xeric Mixed Grassland Monitoring Summary

5. 1998 Xeric Mixed Grassland Monitoring Summary

5.1 Purpose

Monitoring is an integral part of determining whether the management objectives and goals for the high-value plant communities at Rocky Flats Environmental Technology Site (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 go undetected through the use of broader scale qualitative monitoring techniques.

During 1998, three permanent monitoring sites (TR01, TR06, and TR12) in the xeric mixed grassland community that had been set out and monitored in 1993, 1994, and 1995 (Figure 5-1; DOE 1995a, K-H 1997c) were monitored again to reassess and document any change. Originally, all three sites were classified as xeric mixed grassland. After the 1996 vegetation mapping effort, sites TR01 and TR12 were reclassified as part of the xeric tallgrass prairie community, and TR06 was reclassified as part of the xeric needle and threadgrass community, to better reflect the actual community composition of the xeric mixed grassland (K-H 1997c). These sites were last monitored in the summer of 1995. The purpose of this year's monitoring was to re-evaluate the health of the plant communities at these locations and document any change.

5.2 Background Information

The plant communities monitored 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 classification followed the plant community classification that had been outlined in the baseline study (DOE 1992), which identified xeric (xeric mixed grassland), mesic (mesic mixed grassland), and hydric (riparian community) communities at the Site. Since the last time these sites were monitored in 1995, some weed control efforts had been conducted at some locations. In June 1997, TR12 was sprayed with Tordon 22K to control the noxious weed diffuse knapweed (*Centaurea diffusa*), and in August 1997, one of the transects at TR06 had a biological control agent released to help control another weed, dalmatian toadflax (*Linaria dalmatica*), which is abundant at that location.

5.3 Methods

During 1998, the xeric sites, TR01, TR06, and TR12 (Figure 5-1), were monitored for species richness, cover, and frequency. The sampling methods and procedures used at these sites during 1998 were the same as those used in 1993–1995, and are described in the *Ecological Monitoring Program, Final Program Plan* (DOE 1993) and the

Environmental Management Operating Procedures Manual, Volume V, Ecology, 5-51200-OPS-EE (DOE 1995b). An additional measure for species frequency was added to the sampling in 1998 to provide additional quantitative information (described below).

A total of fifteen 50-m transects (five at each site) were monitored in 1998. Transects were sampled in the spring and late summer. Species richness and frequency were monitored during both sampling sessions, and 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 densities of the woody plant stems and cactus species were counted and recorded for the 100-m^2 area. Basal cover and foliar cover were estimated using a point-intercept method along each 50-m transect. A 2-m-long rod, with a 6-mm diameter, was dropped vertically at 50-cm intervals along the transect to record a total of 100 intercept points.

Two types of hits were recorded. 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 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 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 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 of each transect was taken during the late summer sampling session to visually document the condition of the transect. Photographs were taken from the 0-m end of the transect near the permanent marker, looking toward the 50-m endpoint.

Species richness data were summarized by generating a species list for each site. To make the 1998 data compatible with the way past data sets had been analyzed, belt-transect data and point-intercept data were combined to provide overall species richness for analysis. Other species richness variables were calculated from the species lists and used for comparison. 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) the species represented). Both absolute and relative foliar cover values presented are means. 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 were made between the 1993–1995 and 1998 data sets to examine potential changes over time. No statistical analyses were conducted because of the variability in the data and the short-term nature of the data sets.

5.4 Results

A total of 122 species were recorded at all three sites monitored in 1998. The number of species found at each site varied from 81 to 84, with the site TR01 having the lowest and TR12 the highest (Table 5-1). The percentage of native species found across all sites combined was 84 percent, with individual sites ranging from 81 to 86 percent (Table 5-1). A Sorensen similarity index using species presence/absence data revealed the highest similarity between TR01 and TR12 (0.79). Comparisons between TR06 and TR01, and TR06 and TR12, were lower, at 0.63 and 0.67, respectively.

Cactus density was highest at site TR12 (1.16 plants/m^2), followed by TR01 (0.68 plants/m^2) and TR06 (0.11 plants/m^2). Spanish bayonet (*Yucca glauca*), was the only woody plant of any abundance to occur at any of the sites, and it was only found at TR06 (0.27 plants/m^2).

Basal vegetation cover averaged 7–8 percent at all three sites (Table 5-2). Other ground cover classifications, in descending order of importance at all sites, came from litter, rock, and bare ground (Table 5-2). Total foliar cover was similar at all sites, ranging from 81 to 85 percent (Table 5-2). The percentage of cover coming from native vegetation, however, was highest at sites TR01 (84 percent) and TR12 (87 percent; Table 5-2). Native cover was much lower at TR06 (66 percent; Table 5-2). Examined by cool-season vs. warm-season graminoid species, TR01 was the only site dominated by warm-season grasses (41 percent; Table 5-2). Site TR06 was dominated by cool-season graminoid species (80 percent), with warm-season graminoid species constituting only 5 percent of the total vegetation cover (Table 5-2). Site TR12 was intermediate, with cool- and warm-season grasses constituting 63 and 28 percent of the total vegetation cover, respectively (Table 5-2). Site TR01 was dominated by mountain muhly (*Muhlenbergia montana*), Porter's aster (*Aster porteri*), and big bluestem (*Andropogon gerardii*; Table 5-3). At site TR06, the dominant species were needle and thread grass (*Stipa comata*), dalmatian toadflax (*Linaria dalmatica*), and Japanese brome (*Bromus japonicus*; Table 5-3). Site TR12 had foliar cover dominated by needle and thread grass, big bluestem, and Canada bluegrass (*Poa compressa*; Table 5-3). Species frequency results are presented for the first time for both spring and summer sampling sessions in Table 5-4. Different sites had differing frequencies for the various species, and this information will be most useful for comparisons to future monitoring to determine whether there have been any changes.

5.5 Discussion

The permanent transects at sites TR01, TR06, and TR12 were monitored during 1998, and the data were compared to those from 1993–1995. No major changes were observed

for most of the endpoints considered (Table 5-2). In general, most of the measured variables in 1998 were intermediate in comparison to past measured variables, indicating the natural variability inherent in the grassland ecosystem, although some of the variability is likely due to sampling bias as well. For example, the apparent losses of basal vegetation cover in 1998 (which were offset by large increases in litter cover) are most likely due to differences in field technicians' interpretations of basal vegetation and litter hits (Table 5-2).

No important changes were noted with respect to species richness or total foliar cover at any of the sites since they were last monitored. Previously, a loss of relative native cover at these sites had been shown in the data (from 1993–1995; K-H 1997c) and was an issue of concern. The 1998 data showed that this apparent trend may be starting to reverse at sites TR06 and TR12. At TR01, however, native cover continues to decline (Table 5-3). Most of the non-native cover at TR01 in 1998 was from the cool-season graminiod species, Canada bluegrass and Kentucky bluegrass (*Poa pratensis*), both of which showed increased relative foliar cover amounts since 1995 (Table 5-3). Although the decline in overall non-native cover observed at TR01 since 1995 was minimal (2.6 percent), the continuing loss of native foliar cover at this site warrants further observation in future years when these sites are monitored again.

Relative foliar cover values were examined for all species at each site for 1993, 1994, 1995, and 1998, to determine whether any large or consistent changes in relative cover had occurred. A few individual species showed some apparent change worthy of noting. One of the more important species on the xeric tallgrass prairie that has been losing cover over the past few years is little bluestem (*Andropogon scoparius*), one of the relict tallgrass prairie species (Table 5-5). Little bluestem showed steady declines in relative cover at both TR01 and TR12 over the past several years, declining from almost 12 percent to 2 percent at TR01 and 5 percent to 0 percent at TR12 (Table 5-5). Qualitative observations on the loss of little bluestem cover on the Site have been mentioned in the past (K-H 1997c), and now the quantitative measurements confirm this observation. Originally, a large die-off of the species at these and other locations on the Site was noticed in 1995, the year following the late-summer drought of 1994. Little bluestem was particularly hard hit, and observations showed that many of the bunches died. Only time will tell whether the species will recover at these sites. Qualitative observations at some other locations on the Site have shown, however, that the species was apparently not as severely affected and appears to be doing fine. So this may simply be an example of the dynamic nature of these native plant communities in response to environmental changes at different scales.

During 1998, at TR01, mountain muhly cover increased dramatically from past measurements (Table 5-5). Porters' aster at TR01 lost over 10 percent of its relative foliar cover since 1995, when it had a bumper-crop year and was abundant across the prairie (Table 5-5). Whether the large fluctuations in these two species indicate a species composition shift or just natural variability is not certain, however, because the time frames represented by the data sets are too short to separate natural variability, or "noise," from real trends. Data sets of more than 10 years might begin to show some of the

annual variation that could be expected. The apparent increase of Japanese brome (cheatgrass) at TR06 is also of concern, because this site already has the most non-native composition of the three sites (Table 5-5). This warrants continued observation as well.

Site TR12 was treated with the herbicide Tordon 22K in June 1997 to help control diffuse knapweed, which had begun to seriously infest the site. Using 1993–1995 data as baseline information and sites TR01 and TR06 as controls, a few changes have occurred, likely attributable to the herbicide application. The percent of native foliar cover at TR12 rose by 10 percent from 1995 to 1998, compared to continued loss of native cover at TR01 and only a 3 percent increase at TR06 (Table 5-2). Forb cover also decreased by over 20 percent at TR12, compared to 10 percent declines at TR01 and TR06 for the same time period (Table 5-2). These responses are similar to those observed at the diffuse knapweed herbicide monitoring plots for 1998 (see Section 3 in this Annual Report).

Examination of data from the transect at TR06, where biological control agents were released in 1997, showed no observable effect on the cover of dalamatian toadflax. Qualitative visual observations in the area where the agents were released also did not show any noticeable impact on the species. It may take several years for the biological control agents to increase to levels that can cause noticeable impacts on dalamatian toadflax.

In general, the 1998 monitoring data showed that no major changes have occurred at these sites since they were last monitored. The few changes that were noted are subject to the short-term nature of the available data sets, making it difficult to distinguish natural variability "noise" from real trends. However, these data, combined with qualitative assessments of the resources, continue to suggest that proactive management of the grassland communities on the Site is necessary to maintain the quality and health of these communities, and to preserve these resources for future generations. For example, if site TR12 had not been treated with herbicide to control the diffuse knapweed infestation—which qualitative assessments had indicated was a problem during the years since the last quantitative monitoring at the site—the results might have been quite different. Currently, the most significant threat to the grassland communities on the Site is from noxious weeds. The buildup of dead plant litter in the communities, resulting from a lack of fire and grazing, is also a significant problem. As good stewards of the ecological resources at the Site, the implementation of prescribed burns and continued use of various weed control methods (potentially including aerial herbicide application) will provide essential tools for proper management of these resources.

5.6 References

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Table 5-1. 1998 xeric mixed grassland species richness

Family	Scientific Name	Speccode	Native	TR01	TR06	TR12
AGAVACEAE	Yucca glauca Nutt.	YUGL1	Y		X	
ANACARDIACEAE	Rhus aromatica Ait. var. trilobata (Nutt.) A. Gray	RHAR1	Y	X		
APIACEAE	Lomatium orientale Coult. & Rose	LOOR1	Y	X	X	X
ASCLEPIADACEAE	Asclepias viridiflora Raf.	ASVI1	Y	X		X
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	Y	X		X
ASTERACEAE	Ambrosia psilostachya DC.	AMPS1	Y	X	X	X
ASTERACEAE	Antennaria parvifolia Nutt.	ANPA1	Y	X		X
ASTERACEAE	Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem.	ARCA1	Y		X	
ASTERACEAE	Artemisia dracunculus L.	ARDR1	Y		X	
ASTERACEAE	Artemisia frigida Willd.	ARFR1	Y	X	X	X
ASTERACEAE	Artemisia ludoviciana Nutt. var. ludoviciana	ARLU1	Y	X	X	X
ASTERACEAE	Aster falcatus Lindl.	ASFA1	Y	X		
ASTERACEAE	Aster porteri Gray	ASPO1	Y	X		X
ASTERACEAE	Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi	CANU1	N		X	
ASTERACEAE	Centaurea diffusa Lam.	CEDI1	N	X		X
ASTERACEAE	Chrysopsis fulcrata Greene	CHFU1	Y	X		X
ASTERACEAE	Chrysopsis villosa Pursh.	CHVI1	Y	X	X	X
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	N		X	
ASTERACEAE	Cirsium undulatum (Nutt.) Spreng.	CIUN1	Y	X	X	
ASTERACEAE	Erigeron canus A. Gray	ERCA1	Y		X	
ASTERACEAE	Erigeron divergens T. & G.	ERDI1	Y	X	X	X
ASTERACEAE	Erigeron flagellaris A. Gray	ERFL1	Y			X
ASTERACEAE	Gaillardia aristata Pursh.	GAAR1	Y	X		X
ASTERACEAE	Gutierrezia sarothrae (Pursh.) Britt. & Rusby	GUSA1	Y			X
ASTERACEAE	Helianthus pumilus Nutt.	HEPU1	Y	X	X	
ASTERACEAE	Lactuca serriola L.	LASE1	N	X	X	X
ASTERACEAE	Liatris punctata Hook.	LIPU1	Y	X	X	X
ASTERACEAE	Microseris cuspidata (Pursh.) Sch. Bip.	MICU1	Y	X	X	X
ASTERACEAE	Ratibida columnifera (Nutt.) Woot. & Standl.	RACO1	Y	X		X
ASTERACEAE	Scorzonera laciniata L.	SCLA1	N		X	X
ASTERACEAE	Senecio plattensis Nutt.	SEPL1	Y	X	X	X
ASTERACEAE	Senecio spartioides T. & G.	SESP1	Y			X
ASTERACEAE	Solidago mollis Bart.	SOMO1	Y	X		X
ASTERACEAE	Taraxacum officinale Weber	TAOF1	N		X	X
ASTERACEAE	Thelesperma megapotanicum (Spreng.) O. Ktze.	THME1	Y		X	
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	N	X	X	X
BORAGINACEAE	Lithospermum incisum Lehm.	LIIN1	Y		X	X
BORAGINACEAE	Mertensia lanceolata (Pursh.) A. DC.	MELA1	Y	X		
BORAGINACEAE	Onosmodium molle Michx. var. occidentale (Mack.) Johnst.	ONMO1	Y		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
BRASSICACEAE	Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins	ARHI1	Y	X		
BRASSICACEAE	Camelina microcarpa Andrz. ex DC.	CAMI1	N	X	X	X
BRASSICACEAE	Descurainia pinnata (Walt.) Britt.	DEPI1	Y		X	X
BRASSICACEAE	Descurainia richardsonii (Sweet) Schultz	DERI1	Y		X	
BRASSICACEAE	Lepidium densiflorum Schrad.	LEDE1	Y			X
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	LEMO1	Y	X	X	X
BRASSICACEAE	Sisymbrium altissimum L.	SIAL1	N		X	
CACTACEAE	Coryphantha missouriensis (Sweet) Britt. & Rose	COMI1	Y	X	X	X
CACTACEAE	Echinocereus viridiflorus Engelm.	ECVI1	Y	X	X	X
CACTACEAE	Pediocactus simpsonii (Engelm.) Britt. & Rose	PESI1	Y		X	
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	ARFE2	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
CHENOPODIACEAE	Chenopodium leptophyllum Nutt. ex Moq.	CHLE2	Y		X	X
CLUSIACEAE	Hypericum perforatum L.	HYPE1	N	X	X	X
COMMELINACEAE	Tradescantia occidentalis (Britt.) Smyth	TROC1	Y	X	X	
CONVOLVULACEAE	Convolvulus arvensis L.	COAR1	N		X	
CONVOLVULACEAE	Evolvulus nuttallianus R. & S.	EVNU1	Y			X
CRASSULACEAE	Sedum lanceolatum Torr.	SELA1	Y	X		
CYPERACEAE	Carex eleocharis Bailey	CAEL1	Y		X	
CYPERACEAE	Carex filifolia Nutt.	CAFI1	Y		X	
CYPERACEAE	Carex heliophila Mack.	CAHE1	Y	X	X	X
EUPHORBIACEAE	Euphorbia robusta (Engelm.) Small	EURO1	Y			X
FABACEAE	Astragalus agrestis Dougl. ex G. Don	ASAG1	Y	X	X	
FABACEAE	Astragalus flexuosus (Hook.) G. Don	ASFL1	Y		X	

Table 5-1. (cont.)

Family	Scientific Name	Speccode	Native	TR01	TR06	TR12
FABACEAE	Astragalus shortianus Nutt. ex T.&G.	ASSH1	Y	X	X	X
FABACEAE	Dalea purpurea Vent	DAPU1	Y	X	X	X
FABACEAE	Oxytropis lambertii Pursh.	OXLA1	Y	X	X	X
FABACEAE	Psoralea tenuiflora Pursh.	PSTE1	Y	X	X	X
GERANIACEAE	Erodium cicutarium (L.) L'Her.	ERCI1	N			X
HYDROPHYLLACEAE	Phacelia heterophylla Pursh.	PHHE1	Y		X	X
JUNCACEAE	Juncus interior Wieg.	JUIN1	Y	X		X
LILIACEAE	Allium textile A. Nels. & Macbr.	ALTE1	Y	X	X	X
LILIACEAE	Leucocrinum montanum Nutt.	LEMO2	Y		X	X
LINACEAE	Linum perenne L. var. lewisii (Pursh.) Eat. & Wright	LIPE1	Y		X	
NYCTAGINACEAE	Mirabilis linearis (Pursh.) Heimerl	MILI1	Y	X	X	X
ONAGRACEAE	Calylophus serrulatus (Nutt.) Raven	CASE2	Y	X		X
ONAGRACEAE	Gaura coccinea Pursh.	GACO1	Y		X	
OROBANCHACEAE	Orobanche fasciculata Nutt.	ORFA1	Y	X		X
POACEAE	Agropyron smithii Rydb.	AGSM1	Y	X	X	
POACEAE	Andropogon gerardii Vitman	ANGE1	Y	X	X	X
POACEAE	Andropogon scoparius Michx.	ANSC1	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 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	Koeleria pyramidata (Lam.) Beauv.	KOPY1	Y	X	X	X
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	Y	X		X
POACEAE	Poa compressa L.	POCO1	N	X	X	X
POACEAE	Poa pratensis L.	POPR1	N	X	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
POACEAE	Sporobolus cryptandrus (Torr.) A. Gray	SPCR1	Y	X	X	X
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	Y	X		
POACEAE	Stipa comata Trin. & Rupr.	STCO1	Y	X	X	X
POACEAE	Stipa neomexicana (Thur.) Scribn.	STNE1	Y		X	
POLEMONIACEAE	Ipomopsis spicata (Nutt.) V. Grant ssp. spicata	IPSP1	Y	X		
POLYGONACEAE	Eriogonum alatum Torr.	ERAL1	Y	X	X	X
PORTULACACEAE	Talinum parviflorum Nutt.	TAPA1	Y	X		
RANUNCULACEAE	Delphinium nuttalianum Pritz. ex Walpers	DENU1	Y			X
ROSACEAE	Potentilla fissa Nutt.	POFI1	Y	X		X
ROSACEAE	Potentilla hippiana Lehm.	POHI1	Y	X		
SANTALACEAE	Comandra umbellata (L.) Nutt.	COUM1	Y	X	X	X
SCROPHULARIACEAE	Castilleja sessiliflora Pursh.	CASE3	Y	X		X
SCROPHULARIACEAE	Linaria dalmatica (L.) Mill.	LIDA1	N		X	X
SCROPHULARIACEAE	Penstemon secundiflorus Benth.	PESE1	Y		X	
SCROPHULARIACEAE	Penstemon virens Penn.	PEVI1	Y	X		X
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	N		X	
SOLANACEAE	Solanum triflorum Nutt.	SOTR1	Y			X
VIOLACEAE	Viola nuttallii Pursh.	VINU1	Y	X	X	X
BRASSICACEAE	Draba reptans (Lam.) Fern.	DRRE1	Y		X	X
ASTERACEAE	Helianthus rigidus (Cass.) Desf. ssp. subrhomboideus (Rydb.) Heiser	HERI1	Y	X		
BRASSICACEAE	Erysimum capitatum (Nutt.) DC.	ERCA2	Y	X	X	X
CACTACEAE	Opuntia macrorhiza Engelm.	OPMA1	Y	X	X	X
FABACEAE	Astragalus tridactylicus Gray	ASTR1	Y		X	
ONAGRACEAE	Oenothera howardii (A. Nels.) W. L. Wagner	OEHO1	Y		X	
ASTERACEAE	Solidago nana Nutt.	SONA1	Y			X

Species Richness Summary	Entire Community	TR01	TR06	TR12
Total # of species	122	81	83	84
Percent native species	84	86	81	83
Total # of families	35	26	23	28
Total # of monocots	28	23	24	21
Total # of dicots	94	58	59	63
Ratio monocots/dicots	0.3	0.4	0.41	0.33
Total # of forbs	92	56	58	62
Total # of graminoids	24	21	20	19
Total # of cactus	4	3	4	3
Total # of shrubs	2	1	1	0

Table 5-2. 1993–1998 xeric mixed grassland vegetation measurement comparisons

	TR01				TR06				TR12			
Data	1993	1994	1995	1998	1993	1994	1995	1998	1993	1994	1995	1998
# Species	76	88	90	81	68	89	98	83	68	91	83	84
% Native species	87	84	86	86	72	80	80	81	81	84	81	83
Total foliar cover	71.4	81.2	84.6	81.2	76.4	89.4	92.4	85.4	80.2	90.4	89.2	82.8
Total native cover	91.3	88.2	86.8	84.2	79.8	73.8	62.6	65.6	92.8	87.8	76.2	86.5
Cool-season graminoid cover	24.1	27.3	30.3	30.5	78.5	80.5	69.5	79.5	51.6	55.1	49.6	62.6
Warm-season graminoid cover	40.9	37.7	30.7	41.1	5.5	5.1	5.8	5.2	27.9	21.2	20.4	27.8
Forb cover	35	35	39	28.3	15.7	14.3	24.7	15	20.4	23	30	9.7
Basal vegetation cover		19.2	15.8	7.8		21.6	16.2	7.2		17.2	15	7.2
Litter cover		57	51.2	68.6		73.4	74.2	88		65.4	57.4	72.8
Rock cover		21.6	23.8	19.8		3.4	5.4	3.8		16.8	19.8	15.6
Bare ground cover		2.2	9.2	3.8		1.6	4.2	1		0.6	7.8	4.4

Note: Cover values are mean percentages (n = 5).

Table 5-3. 1998 xeric mixed grassland foliar cover summary

Family	Scientific Name	Speccode	Native	TR01			TR06			TR12		
				Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover
APIACEAE	Lomatium orientale Coult. & Rose	LOOR1	Y							20	0.20	0.24
ASTERACEAE	Ambrosia psilostachya DC.	AMPS1	Y	20	0.20	0.25	20	1.00	1.17	40	0.40	0.48
ASTERACEAE	Antennaria parvifolia Nutt.	ANPA1	Y	20	0.20	0.25						
ASTERACEAE	Artemisia frigida Willd.	ARFR1	Y	20	0.20	0.25	20	0.20	0.23			
ASTERACEAE	Artemisia ludoviciana Nutt. var. ludoviciana	ARLU1	Y							40	0.80	0.97
ASTERACEAE	Aster porteri Gray	ASPO1	Y	100	11.80	14.53				80	1.20	1.45
ASTERACEAE	Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi	CANU1	N				20	0.20	0.23			
ASTERACEAE	Centaurea diffusa Lam.	CEDI1	N	20	0.20	0.25						
ASTERACEAE	Chrysopsis villosa Pursh.	CHVI1	Y	40	0.40	0.49						
ASTERACEAE	Helianthus pumilus Nutt.	HEPU1	Y				20	0.20	0.23			
ASTERACEAE	Lactuca serriola L.	LASE1	N							20	0.20	0.24
ASTERACEAE	Liatris punctata Hook.	LIPU1	Y	80	2.40	2.96				80	2.20	2.66
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	N				20	0.20	0.23			
BORAGINACEAE	Lithospermum incisum Lehm.	LIIN1	Y							20	0.20	0.24
BRASSICACEAE	Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	ALMI1	N	20	0.20	0.25	40	1.40	1.64	60	0.80	0.97
BRASSICACEAE	Descurainia pinnata (Walt.) Britt.	DEPI1	Y							20	0.20	0.24
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	LEMO1	Y	20	0.20	0.25						
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	ARFE2	Y	100	4.00	4.93				80	1.00	1.21
CARYOPHYLLACEAE	Paronychia jamesii T. & G.	PAJA1	Y	40	0.40	0.49						
CYPERACEAE	Carex filifolia Nutt.	CAFI1	Y				20	0.20	0.23			
CYPERACEAE	Carex heliophila Mack.	CAHE1	Y	80	5.80	7.14	60	1.60	1.87	100	4.00	4.83
EUPHORBIACEAE	Euphorbia robusta (Engelm.) Small	EURO1	Y							40	0.40	0.48
FABACEAE	Dalea purpurea Vent	DAPU1	Y	20	0.20	0.25						
FABACEAE	Oxytropis lambertii Pursh.	OXLA1	Y							20	0.20	0.24
FABACEAE	Psoralea tenuiflora Pursh.	PSTE1	Y	80	1.40	1.72				20	0.20	0.24
LINACEAE	Linum perenne L. var. lewisii (Pursh.) Eat. & Wright	LIPE1	Y				40	0.40	0.47			
ONAGRACEAE	Calylophus serrulatus (Nutt.) Raven	CASE2	Y	20	0.20	0.25						
POACEAE	Andropogon gerardii Vitman	ANGE1	Y	100	9.60	11.82	40	0.80	0.94	100	12.20	14.73
POACEAE	Andropogon scoparius Michx.	ANSC1	Y	80	1.40	1.72	40	0.40	0.47			
POACEAE	Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	Y	20	0.20	0.25	60	0.60	0.70			
POACEAE	Bouteloua curtipendula (Michx.) Torr.	BOCU1	Y	100	3.00	3.69	80	1.60	1.87	100	3.60	4.35
POACEAE	Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	Y	80	1.60	1.97	80	1.60	1.87	100	3.00	3.62
POACEAE	Bouteloua hirsuta Lag	BOHI1	Y	60	1.00	1.23				40	0.40	0.48
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	N	40	0.40	0.49	100	7.40	8.67	80	1.80	2.17
POACEAE	Bromus tectorum L.	BRTE1	N	20	0.40	0.49				20	0.80	0.97
POACEAE	Koeleria pyramidata (Lam.) Beauv.	KOPY1	Y	80	1.60	1.97				80	1.20	1.45
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	Y	80	14.80	18.23				100	2.20	2.66
POACEAE	Poa compressa L.	POCO1	N	80	6.60	8.13	60	4.20	4.92	100	6.20	7.49
POACEAE	Poa pratensis L.	POPR1	N	20	5.00	6.16	80	6.80	7.96	60	1.40	1.69
POACEAE	Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	Y	40	0.80	0.99	40	0.40	0.47	20	0.20	0.24

Table 5-3. (Cont.)

Family	Scientific Name	Speccode	Native	TR01			TR06			TR12		
				Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover	Frequency	Absolute Cover	Relative Cover
POACEAE	Sorghastrum nutans (L.) Nash	SONU1	Y	80	1.20	1.48				40	1.60	1.93
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	Y	60	0.80	0.99						
POACEAE	Stipa comata Trin. & Rupr.	STCO1	Y	100	4.00	4.93	100	43.40	50.82	100	36.20	43.72
POACEAE	Stipa neomexicana (Thur.) Scribn.	STNE1	Y				20	3.60	4.22			
POLYGONACEAE	Eriogonum alatum Torr.	ERAL1	Y	40	0.40	0.49						
PORTULACACEAE	Talinum parviflorum Nutt.	TAPA1	Y	20	0.20	0.25						
SANTALACEAE	Comandra umbellata (L.) Nutt.	COUM1	Y	40	0.40	0.49						
SCROPHULARIACEAE	Linaria dalmatica (L.) Mill.	LIDA1	N				100	9.20	10.77			
	Total foliar cover				81.20	100.00		85.40	100.00		82.80	100.00
	Total native foliar cover				68.40	84.24		56.00	65.57		71.60	86.47

Note: Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible at a site (500).
Relative cover = Relative foliar cover is the number of hits on a species 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).

Table 5-4. 1998 xeric mixed grassland site plant frequencies

Family	Scientific Name	Native	Speccode	TR01		TR06		TR12	
				Spring	Summer	Spring	Summer	Spring	Summer
AGAVACEAE	Yucca glauca Nutt.	Y	YUGL1			20	12		
APIACEAE	Lomatium orientale Coult. & Rose	Y	LOOR1	92	28	72	4	100	48
ASCLEPIADACEAE	Asclepias viridiflora Raf.	Y	ASVI1	4	4			4	4
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	Y	ACMI1	4	4				
ASTERACEAE	Ambrosia psilostachya DC.	Y	AMPS1	28	16	12	12	24	28
ASTERACEAE	Antennaria parvifolia Nutt.	Y	ANPA1	4	4			4	4
ASTERACEAE	Artemisia frigida Willd.	Y	ARFR1	16	16	20	20	8	4
ASTERACEAE	Artemisia ludoviciana Nutt. var. ludoviciana	Y	ARLU1			8		16	12
ASTERACEAE	Aster falcatus Lindl.	Y	ASFA1	4	4				
ASTERACEAE	Aster porteri Gray	Y	ASPO1	88	88			40	44
ASTERACEAE	Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi	N	CANU1			24	16		
ASTERACEAE	Centaurea diffusa Lam.	N	CEDI1	16	4			4	8
ASTERACEAE	Chrysopsis fulcrata Greene	Y	CHFU1	8	8				
ASTERACEAE	Chrysopsis villosa Pursh.	Y	CHVI1	64	52			28	32
ASTERACEAE	Cirsium arvense (L.) Scop.	N	CIAR1			8	8		
ASTERACEAE	Cirsium undulatum (Nutt.) Spreng.	Y	CIUN1			8	4		
ASTERACEAE	Erigeron flagellaris A. Gray	Y	ERFL1					20	
ASTERACEAE	Gaillardia aristata Pursh.	Y	GAAR1	28	16			12	4
ASTERACEAE	Helianthus pumilus Nutt.	Y	HEPU1	4	4	4	4		
ASTERACEAE	Lactuca serriola L.	N	LASE1			52	28		
ASTERACEAE	Liatris punctata Hook.	Y	LIPU1	76	72		4	68	76
ASTERACEAE	Microseris cuspidata (Pursh.) Sch. Bip.	Y	MICU1	8				12	
ASTERACEAE	Scorzonera laciniata L.	N	SCLA1			8			4
ASTERACEAE	Senecio plattensis Nutt.	Y	SEPL1	40	20				
ASTERACEAE	Senecio spartioides T. & G.	Y	SESP1					8	8
ASTERACEAE	Solidago mollis Bart.	Y	SOMO1	4	4				
ASTERACEAE	Taraxacum officinale Weber	N	TAOF1			12	4	8	
ASTERACEAE	Tragopogon dubius Scop.	N	TRDU1	20	20	68	40	8	12
BORAGINACEAE	Lithospermum incisum Lehm.	Y	LIIN1				12		4
BORAGINACEAE	Mertensia lanceolata (Pursh.) A. DC.	Y	MELA1	4					
BRASSICACEAE	Alyssum alyssoides (L.) L.	N	ALAL1	12	4				
BRASSICACEAE	Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	N	ALMI1	20	16	36	40	80	72
BRASSICACEAE	Camelina microcarpa Andrz. ex DC.	N	CAMI1		4	76	24	44	24
BRASSICACEAE	Descurainia pinnata (Walt.) Britt.	Y	DEPI1			16			
BRASSICACEAE	Draba reptans (Lam.) Fern.	Y	DRRE1	16		8		28	12
BRASSICACEAE	Erysimum capitatum (Nutt.) DC.	Y	ERCA2	40	20	12	4		4
BRASSICACEAE	Lepidium densiflorum Schrad.	Y	LEDE1					4	4
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	Y	LEMO1	68	56	32	20	44	36
BRASSICACEAE	Sisymbrium altissimum L.	N	SIAL1			4			
CACTACEAE	Echinocereus viridiflorus Engelm.	Y	ECVI1	40	52		4	60	52
CACTACEAE	Opuntia macrorhiza Engelm.	Y	OPMA1	28	20	12	12	32	36

Table 5-4. (cont.)

Family	Scientific Name	Native	Speccode	TR01		TR06		TR12	
				Spring	Summer	Spring	Summer	Spring	Summer
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	Y	ARFE2	76	80		4	72	72
CARYOPHYLLACEAE	Paronychia jamesii T. & G.	Y	PAJA1	48	52			8	8
CARYOPHYLLACEAE	Silene antirrhina L.	Y	SIAN1	12					
CARYOPHYLLACEAE	Silene drummondii Hook.	Y	SIDR1	4	4			4	4
CLUSIACEAE	Hypericum perforatum L.	N	HYPE1	4	40				4
COMMELINACEAE	Tradescantia occidentalis (Britt.) Smyth	Y	TROC1	4		8			
CYPERACEAE	Carex filifolia Nutt.	Y	CAFI1			8	4		
CYPERACEAE	Carex heliophila Mack.	Y	CAHE1	84	92	28	32	100	100
FABACEAE	Astragalus agrestis Dougl. ex G. Don	Y	ASAG1	4	4				
FABACEAE	Astragalus shortianus Nutt. ex T.&G.	Y	ASSH1			4			
FABACEAE	Astragalus tridactylicus Gray	Y	ASTR1				4		
FABACEAE	Dalea purpurea Vent	Y	DAPU1	16	16	4	4	4	
FABACEAE	Psoralea tenuiflora Pursh.	Y	PSTE1	60	56	12	8	48	44
JUNCACEAE	Juncus interior Wieg.	Y	JUIN1						4
LILIACEAE	Allium textile A. Nels. & Macbr.	Y	ALTE1	20		12		28	20
LILIACEAE	Leucocrinum montanum Nutt.	Y	LEMO2			4			
LINACEAE	Linum perenne L. var. lewisii (Pursh.) Eat. & Wright	Y	LIPE1			48	32		
NYCTAGINACEAE	Mirabilis linearis (Pursh.) Heimerl	Y	MILI1		4				12
ONAGRACEAE	Gaura coccinea Pursh.	Y	GACO1			4			
OROBANCHACEAE	Orobanche fasciculata Nutt.	Y	ORFA1	4				32	
POACEAE	Agropyron smithii Rydb.	Y	AGSM1		4	4			
POACEAE	Andropogon gerardii Vitman	Y	ANGE1	68	76	8	4	60	60
POACEAE	Andropogon scoparius Michx.	Y	ANSC1	60	68	4	4		4
POACEAE	Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	Y	ARLO1		4	8	12		16
POACEAE	Bouteloua curtipendula (Michx.) Torr.	Y	BOCU1	52	60	60	72	60	84
POACEAE	Bouteloua gracilis (H. B. K.) Lag ex Griffiths	Y	BOGR1	52	68	44	72	64	84
POACEAE	Bouteloua hirsuta Lag	Y	BOHI1	40	68		12	36	28
POACEAE	Bromus japonicus Thunb. ex Murr.	N	BRJA1	20	8	68	60	40	52
POACEAE	Bromus tectorum L.	N	BRTE1	8	4			4	8
POACEAE	Buchloe dactyloides (Nutt.) Engelm.	Y	BUDA1	8				16	24
POACEAE	Koeleria pyramidata (Lam.) Beauv.	Y	KOPY1	76	76	16	12	56	48
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	Y	MUMO1	60	64			4	8
POACEAE	Poa compressa L.	N	POCO1	36	36	20	16	36	44
POACEAE	Poa pratensis L.	N	POPR1	28	24	32	28	20	16
POACEAE	Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	Y	SIHY1	48	44	8	4		
POACEAE	Sorghastrum nutans (L.) Nash	Y	SONU1	4	12			4	8
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	Y	SPHE1	16	16				
POACEAE	Stipa comata Trin. & Rupr.	Y	STCO1	24	32	88	92	100	100
POACEAE	Stipa neomexicana (Thur.) Scribn.	Y	STNE1			20	20		
POLYGONACEAE	Eriogonum alatum Torr.	Y	ERAL1	68	68		4	4	4
PORTULACACEAE	Talinum parviflorum Nutt.	Y	TAPA1	24	32				

Table 5-4. (cont.)

Family	Scientific Name	Native	Speccode	TR01		TR06		TR12	
				Spring	Summer	Spring	Summer	Spring	Summer
ROSACEAE	Potentilla fissa Nutt.	Y	POFI1	4	4				
ROSACEAE	Potentilla hippiana Lehm.	Y	POHI1	8	8				
SANTALACEAE	Comandra umbellata (L.) Nutt.	Y	COUM1	28	28				
SCROPHULARIACEAE	Castilleja sessiliflora Pursh.	Y	CASE3	12	4				
SCROPHULARIACEAE	Linaria dalmatica (L.) Mill.	N	LIDA1			100	100	12	
SCROPHULARIACEAE	Penstemon secundiflorus Benth.	Y	PESE1			4			
SCROPHULARIACEAE	Penstemon virens Penn.	Y	PEVI1	8					
SOLANACEAE	Solanum triflorum Nutt.	Y	SOTR1					4	
VIOLACEAE	Viola nuttallii Pursh.	Y	VINU1	16		48		56	

Note: All values are percentages based on n = 25.

Table 5-5. Plant species with large or consistent increases or declines in relative foliar cover (1993–1998)

Station/Scientific Name	Speccode	1993	1994	1995	1998	Change
TR01						
Andropogon scoparius	ANSC1	11.76	10.34	5.44	1.72	-10.04
Muhlenbergia montana	MUMO1	9.80	8.37	8.75	18.23	8.42
Aster porteri	ASPO1	3.92	10.34	25.06	14.53	10.61
TR06						
Bromus japonicus	BRJA1	0.79	2.46	6.06	8.67	7.88
TR12						
Andropogon scoparius	ANSC1	5.49	2.88	0.90	0.00	-5.49
Arenaria fendleri	ARFE2	5.24	6.19	2.47	1.21	-4.03
Psorelea tenuiflora	PSTE1	4.24	2.43	1.57	0.24	-4.00

Note: Cover values are all mean percentages (n = 5).

Appendix B

Rocky Flats Plant List

Plant Species Known to Occur at Rocky Flats Environmental Technology Site, May 1999

Family	Scientific Name	Speccode	Common Name
ACERACEAE	Acer glabrum Torr.	ACGL1	Mountain Maple
ACERACEAE	Acer negundo L. var. interius (Britt.) Sarg.	ACNE1	Box-elder
AGAVACEAE	Yucca glauca Nutt.	YUGL1	Yucca
ALISMATACEAE	Alisma trivale Pursh	ALTR1	American Water Plantain
ALISMATACEAE	Sagittaria latifolia Willd.	SALA1	Common Arrowhead
AMARANTHACEAE	Amaranthus albus L.	AMAL2	Tumbleweed
AMARANTHACEAE	Amaranthus retroflexus L.	AMRE1	Rough Pigweed
ANACARDIACEAE	Rhus aromatica Ait. var. trilobata (Nutt.) A. Gray	RHAR1	Fragrant Sumac
ANACARDIACEAE	Toxicodendron rydbergii (Small) Greene	TORY1	Poison Ivy
APIACEAE	Cicuta maculata L. var. angustifolia Hook.	CIMA1	Water Hemlock
APIACEAE	Conium maculatum L.	COMA1	Poison Hemlock
APIACEAE	Daucus carota L.	DACA2	Wild Carrot
APIACEAE	Harbouria trachypleura (Gray) C. & R.	HATR1	Whiskbroom Parsley
APIACEAE	Heracleum sphondylium L. ssp. montanum (Schleich.) Briq.	HESP1	Cow Parsnip
APIACEAE	Ligusticum porteri C. & R.	LIPO1	Porter's Lovage
APIACEAE	Lomatium orientale Coult. & Rose	LOOR1	Wild Parsley
APIACEAE	Musineon divaricatum (Pursh.) Nutt. var. hookeri T. & G.	MUDI1	Musineon
APIACEAE	Osmorhiza chiliensis H. & A.	OSCH1	Sweet Cicely
APIACEAE	Osmorhiza longistylis (Torr.) DC var. longistylis	OSLO1	Anise Root
APOCYNACEAE	Apocynum androsaemifolium L.	APAN1	Spreading Dogbane
APOCYNACEAE	Apocynum cannabinum L.	APCA1	Hemp Dogbane
ASCLEPIADACEAE	Asclepias incarnata L.	ASIN1	Swamp Milkweed
ASCLEPIADACEAE	Asclepias pumila (Gray) Vail	ASPU1	Plains Milkweed
ASCLEPIADACEAE	Asclepias speciosa Torr.	ASSP1	Showy Milkweed
ASCLEPIADACEAE	Asclepias stenophylla A. Gray	ASST1	Narrow-leaved Milkweed
ASCLEPIADACEAE	Asclepias viridiflora Raf.	ASVI1	Green Milkweed
ASTERACEAE	Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	Yarrow
ASTERACEAE	Agoseris glauca (Pursh.) Dietr.	AGGL1	False Dandelion
ASTERACEAE	Ambrosia artemisiifolia L.	AMAR1	Common Ragweed
ASTERACEAE	Ambrosia psilostachya DC.	AMPS1	Western Ragweed
ASTERACEAE	Ambrosia trifida L.	AMTR1	Giant Ragweed
ASTERACEAE	Antennaria microphylla Rydb.	ANMI1	Pink Pussytoes
ASTERACEAE	Antennaria parvifolia Nutt.	ANPA1	Pussytoes
ASTERACEAE	Anthemis cotula L.	ANCO1	Dog Fennel
ASTERACEAE	Arctium minus Bernh.	ARMI1	Burdock
ASTERACEAE	Arnica fulgens Pursh.	ARFU1	Arnica
ASTERACEAE	Artemisia campestris L. ssp. caudata (Michx.) Hall & Clem.	ARCA1	Western Sagewort
ASTERACEAE	Artemisia dracunculus L.	ARDR1	Silky Wormwood
ASTERACEAE	Artemisia frigida Willd.	ARFR1	Silver Sage
ASTERACEAE	Artemisia ludoviciana Nutt. var. ludoviciana	ARLU1	White Sage
ASTERACEAE	Aster falcatus Lindl.	ASFA1	Aster
ASTERACEAE	Aster fendleri A. Gray	ASFE1	Fendler's Aster
ASTERACEAE	Aster hesperius A. Gray var. hersperius	ASHE1	Panicled Aster
ASTERACEAE	Aster laevis L. var. geyeri A. Gray	ASLA1	Smooth Blue Aster
ASTERACEAE	Aster porteri Gray	ASPO1	Aster
ASTERACEAE	Bidens cernua L.	BICE1	Nodding Beggarticks
ASTERACEAE	Bidens frondosa L.	BIFR1	Beggar-ticks
ASTERACEAE	Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi	CANU1	Musk Thistle
ASTERACEAE	Centaurea diffusa Lam.	CEDI1	Diffuse Knapweed
ASTERACEAE	Centaurea repens L.	CERE1	Russian Knapweed
ASTERACEAE	Chrysanthemum leucanthemum L.	CHLE1	Ox-eye Daisy
ASTERACEAE	Chrysopsis fulcrata Greene	CHFU1	Golden Aster
ASTERACEAE	Chrysopsis villosa Pursh.	CHVI1	Golden Aster
ASTERACEAE	Chrysothamnus nauseosus (Pall.) Britt. ssp. graveolens (Nutt.) Piper	CHNA1	Greenplume Rabbitbrush
ASTERACEAE	Chrysothamnus nauseosus (Pall.) Britt. ssp. nauseosus	CHNA2	Rubber Rabbitbrush
ASTERACEAE	Cichorium intybus L.	CIIN1	Common Chicory
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	Canada Thistle
ASTERACEAE	Cirsium flodmanni (Rydb.) Arthur	CIFL1	Flodman's Thistle
ASTERACEAE	Cirsium ochrocentrum A. Gray	CIOC1	Yellow Spine Thistle
ASTERACEAE	Cirsium undulatum (Nutt.) Spreng.	CIUN1	Wavyleaf Thistle
ASTERACEAE	Cirsium vulgare (Savi) Ten.	CIVU1	Bull Thistle
ASTERACEAE	Conyza canadensis (L.) Cronq.	COCA1	Horseweed
ASTERACEAE	Crepis occidentalis Nutt.	CROC1	Hawksbeard
ASTERACEAE	Crepis runcinata (James) T. & G.	CRRU1	Hawksbeard
ASTERACEAE	Dyssodia papposa (Vent) Hitchc.	DYPA1	Fetid Marigold

Plant Species Known to Occur at Rocky Flats Environmental Technology Site, May 1999 (cont.)

Family	Scientific Name	Speccode	Common Name
ASTERACEAE	Erigeron canus A. Gray	ERCA1	Fleabane
ASTERACEAE	Erigeron compositus Pursh var. dicoideus A. Gray	ERCO1	
ASTERACEAE	Erigeron divergens T. & G.	ERDI1	Fleabane
ASTERACEAE	Erigeron flagellaris A. Gray	ERFL1	Fleabane
ASTERACEAE	Erigeron pumilus Nutt.	ERPU1	Fleabane
ASTERACEAE	Erigeron speciosa (Lindl.) DC. var. macranthus (Nutt.) Cronq.	ERSP1	Oregon Fleabane
ASTERACEAE	Erigeron strigosus Muhl. ex Willd.	ERST1	Daisy Fleabane
ASTERACEAE	Erigeron vetensis Rydb.	ERVE1	LaVeta Fleabane
ASTERACEAE	Gaillardia aristata Pursh.	GAAR1	Blanket Flower
ASTERACEAE	Gnapthalium chilense Spreng.	GNCH1	Cotton-batting
ASTERACEAE	Grindelia squarrosa (Pursh.) Dun.	GRSQ1	Curly-top Gumweed
ASTERACEAE	Gutierrezia sarothrae (Pursh.) Britt. & Rusby	GUSA1	Snakeweed
ASTERACEAE	Happlopappus spinulosus (Pursh) DC.	HASP1	Cutleaf Ironplant
ASTERACEAE	Helianthus annuus L.	HEAN1	Common Sunflower
ASTERACEAE	Helianthus ciliaris DC.	HECI1	Texas Blue Weed
ASTERACEAE	Helianthus maximilianii Schrad.	HEMA1	Maximilian Sunflower
ASTERACEAE	Helianthus nuttallii T. & G.	HENU1	Nuttall's Sunflower
ASTERACEAE	Helianthus petiolaris Nutt.	HEPE1	Plains Sunflower
ASTERACEAE	Helianthus pumilus Nutt.	HEPU1	Sunflower
ASTERACEAE	Helianthus rigidus (Cass.) Desf. ssp. subrhomboideus (Rydb.) Heiser	HERI1	Stiff Sunflower
ASTERACEAE	Heliomeris multiflora Nuttall	HEMU1	Showy Goldeneye
ASTERACEAE	Hymenopappus filifolius Hook. var. cinereus (Rydb.) I. M. Johnst.	HYFI1	Hymenopappus
ASTERACEAE	Iva axillaris Pursh.	IVAX1	Poverty Weed
ASTERACEAE	Iva xanthifolia Nutt.	IVXA1	Marsh Elder
ASTERACEAE	Kuhnia chlorolepis Woot. & Standl.	KUCH1	False Boneset
ASTERACEAE	Kuhnia eupatorioides L.	KUEU1	False Boneset
ASTERACEAE	Lactuca oblongifolia Nutt.	LAOB1	Blue Lettuce
ASTERACEAE	Lactuca serriola L.	LASE1	Prickly Lettuce
ASTERACEAE	Leucelene ericoides (Torr.) Greene	LEER1	White Aster
ASTERACEAE	Liatris punctata Hook.	LIPU1	Blazing Star
ASTERACEAE	Machaeranthera bigelovii (Gray) Greene	MABI1	Bigelovi's Tansy Aster
ASTERACEAE	Machaeranthera canescens (Pursh) A. Gray	MACA1	Hoary Aster
ASTERACEAE	Microseris cuspidata (Pursh.) Sch. Bip.	MICU1	False Dandelion
ASTERACEAE	Onopordum acanthium L.	ONAC1	Scotch Thistle
ASTERACEAE	Picradeniopsis oppositifolia (Nutt.) Rydb.	PIOP1	Picradeniopsis
ASTERACEAE	Ratibida columnifera (Nutt.) Woot. & Standl.	RACO1	Prairie Coneflower
ASTERACEAE	Rudbeckia ampla Nelson	RUAM1	Goldenglow
ASTERACEAE	Scorzonera laciniata L.	SCLA1	False Salsify
ASTERACEAE	Senecio fendleri Gray	SEFE1	Groundsel
ASTERACEAE	Senecio integerrimus Nutt.	SEIN1	Groundsel
ASTERACEAE	Senecio plattensis Nutt.	SEPL1	Prairie Ragwort
ASTERACEAE	Senecio spartioides T. & G.	SESP1	Groundsel
ASTERACEAE	Senecio tridenticulatus Rydb.	SETR1	Groundsel
ASTERACEAE	Solidago canadensis L.	SOCA1	Canada Goldenrod
ASTERACEAE	Solidago gigantea Ait.	SOGI1	Late Goldenrod
ASTERACEAE	Solidago missouriensis Nutt.	SOMI1	Prairie Goldenrod
ASTERACEAE	Solidago mollis Bart.	SOMO1	Soft Goldenrod
ASTERACEAE	Solidago nana Nutt.	SONA1	Low Goldenrod
ASTERACEAE	Solidago rigida L.	SORI1	Rigid Goldenrod
ASTERACEAE	Sonchus arvensis L. ssp. uglinosus (Bieb.) Nyman	SOAR2	Field Sow Thistle
ASTERACEAE	Sonchus asper (L.) Hill	SOAS1	Prickly Sow Thistle
ASTERACEAE	Stephanomeria pauciflora (Torr.) A. Nels.	STPA1	Wire Lettuce
ASTERACEAE	Taraxacum laevigatum (Willd.) DC.	TALA1	Red Seeded Dandelion
ASTERACEAE	Taraxacum officinale Weber	TAOF1	Dandelion
ASTERACEAE	Thelesperma megapotanicum (Spreng.) O. Ktze.	THME1	Greenthread
ASTERACEAE	Townsendia grandiflora (Nutt.)	TOGR1	Easter Daisy
ASTERACEAE	Townsendia hookeri Beaman	TOHO1	Easter Daisy
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	Goat's Beard
ASTERACEAE	Tragopogon porrifolius L.	TRPO1	Salsify
ASTERACEAE	Xanthium strumarium L.	XAST1	Cocklebur
BERBERIDACEAE	Berberis repens Lindl.	BERE1	Oregon Grape
BETULACEAE	Alnus incana (L.) Moench ssp. tenuifolia (Nuttall) Breitung	ALIN1	Alder
BETULACEAE	Betula occidentalis Hook.	BEOC1	Water Birch
BORAGINACEAE	Asperugo procumbens L.	ASPR1	Madwort
BORAGINACEAE	Cryptantha virgata (Porter) Payson	CRVI1	Miners Candle

Plant Species Known to Occur at Rocky Flats Environmental Technology Site, May 1999 (cont.)

Family	Scientific Name	Speccode	Common Name
BORAGINACEAE	Cynoglossum officinale L.	CYOF1	Hound's Tongue
BORAGINACEAE	Hackelia floribunda (Lehm.) I. M. Johnst.	HAFL1	Large-flowered Stickseed
BORAGINACEAE	Lappula redowskii (Hornem.) Greene	LARE1	Stickseed
BORAGINACEAE	Lithospermum incisum Lehm.	LIIN1	Puccoon
BORAGINACEAE	Lithospermum multiflorum Torr.	LIMU1	
BORAGINACEAE	Mertensia lanceolata (Pursh.) A. DC.	MELA1	Bluebells
BORAGINACEAE	Onosmodium molle Michx. var. occidentale (Mack.) Johnst.	ONMO1	False Gromwell
BORAGINACEAE	Plagiobothrys scouleri (H. & A.) I. M. Johnst.	PLSC1	Popcorn Flower
BRASSICACEAE	Alyssum alyssoides (L.) L.	ALAL1	Pale Alyssum
BRASSICACEAE	Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	ALMI1	Alyssum
BRASSICACEAE	Arabis fendleri (S. Wats.) Greene var. fendleri	ARFE3	Rock Cress
BRASSICACEAE	Arabis glabra (L.) Bernh.	ARGL1	Tower Mustard
BRASSICACEAE	Arabis hirsuta (L.) Scop. var. pynocarpa (Hopkins) Rollins	ARHI1	Rock Cress
BRASSICACEAE	Barbarea vulgaris R. Br.	BAVU1	Yellowrocket Wintercress
BRASSICACEAE	Camelina microcarpa Andrz. ex DC.	CAMI1	Small-seeded False Flax
BRASSICACEAE	Capsella bursa-pastoris (L.) Medic.	CABU1	Shepherd's Purse
BRASSICACEAE	Cardaria chalepensis (L.) Hand-Mazz	CACH1	Lens-padded Hoary Cress
BRASSICACEAE	Cardaria draba (L.) Desv.	CADR1	Hoary Cress
BRASSICACEAE	Chorispora tenella (Pall.) DC.	CHTE1	Blue Mustard
BRASSICACEAE	Conringia orientalis (L.) Dum.	COOR1	Hare's-ear Mustard
BRASSICACEAE	Descurainia pinnata (Walt.) Britt.	DEPI1	Tansy Mustard
BRASSICACEAE	Descurainia richardsonii (Sweet) Schultz	DERI1	Tansy Mustard
BRASSICACEAE	Descurainia sophia (L.) Webb ex Prantl.	DESO1	Flixweed
BRASSICACEAE	Draba nemorosa L.	DRNE1	Yellow Whitlowort
BRASSICACEAE	Draba reptans (Lam.) Fern.	DRRE1	White Whitlowort
BRASSICACEAE	Erysimum capitatum (Nutt.) DC.	ERCA2	Western Wallflower
BRASSICACEAE	Erysimum repandum L.	ERRE1	Bushy Wallflower
BRASSICACEAE	Hesperis matronalis L.	HEMA2	Dame's Rocket
BRASSICACEAE	Lepidium campestre (L.) R. Br.	LECA1	Field Peppergrass
BRASSICACEAE	Lepidium densiflorum Schrad.	LEDE1	Peppergrass
BRASSICACEAE	Lesquerella montana (A. Gray) Wats.	LEMO1	Bladderpod
BRASSICACEAE	Nasturtium officinale R. Br.	NAOF1	Watercress
BRASSICACEAE	Physaria vitulifera Rydb.	PHVI1	Double Bladder-pod
BRASSICACEAE	Rorippa palustris (L.) Bess. ssp. hispida (Desv.) Jonsell	ROPA1	Bog Yellow Cress
BRASSICACEAE	Sisymbrium altissimum L.	SIAL1	Tumbling Mustard
BRASSICACEAE	Thlaspi arvense L.	THAR1	Field Penny Cress
CACTACEAE	Coryphantha missouriensis (Sweet) Britt. & Rose	COMI1	Nipple Cactus
CACTACEAE	Echinocereus viridiflorus Engelm.	ECVI1	Hedgehog Cactus
CACTACEAE	Opuntia fragilis (Nutt.) Haw.	OPFR1	Little Prickly Pear
CACTACEAE	Opuntia macrorhiza Engelm.	OPMA1	Twistspine Prickly Pear
CACTACEAE	Opuntia polyacantha Haw.	OPPO1	Plains Prickly Pear
CACTACEAE	Pediocactus simpsonii (Engelm.) Britt. & Rose	PESI1	Nipple Cactus
CALLITRICHACEAE	Callitriche verna L.	CAVE1	Water Starwort
CAMPANULACEAE	Campanula rotundifolia L.	CARO1	Harebell
CAMPANULACEAE	Lobelia siphilitica L. var. ludoviciana A. DC.	LOSI1	Great Lobelia
CAMPANULACEAE	Triodanis leptocarpa (Nutt.) Nieuw.	TRLE1	Venus' Looking Glass
CANNABACEAE	Humulus lupulus L. var. lupuloides E. Small	HULU1	Common Hops
CAPPERACEAE	Polansia dodecandra (L.) DC. ssp. trachysperma (T. & G.) Iltis	PODO2	Clammy-weed
CAPRIFOLIACEAE	Symphoricarpos occidentalis Hook.	SYOC1	Western Snowberry
CAPRIFOLIACEAE	Symphoricarpos oreophilus Gray	SYOR1	Snowberry
CAPRIFOLIACEAE	Viburnum opulus L. var. americanum Ait	VIOP1	Highbush Cranberry
CARYOPHYLLACEAE	Arenaria fendleri A. Gray	ARFE2	Fendler's Sandwort
CARYOPHYLLACEAE	Cerastium arvense L.	CEAR1	Prairie Chickweed
CARYOPHYLLACEAE	Cerastium brachypodum (Engelm. ex A. Gray) Robins.	CEBR1	Short-stalked Chickweed
CARYOPHYLLACEAE	Cerastium vulgatum L.	CEVU1	Common Mouse-Ear
CARYOPHYLLACEAE	Conosilene conica (L.) Fourreau ssp. conoidea (L.) Love & Kjellqvist	COCO1	Community Campion
CARYOPHYLLACEAE	Paronychia jamesii T. & G.	PAJA1	James' Nailwort
CARYOPHYLLACEAE	Saponaria officinalis L.	SAOF1	Bouncing Bet
CARYOPHYLLACEAE	Silene antirrhina L.	SIAN1	Sleepy Catchfly
CARYOPHYLLACEAE	Silene drummondii Hook.	SIDR1	Campion
CARYOPHYLLACEAE	Silene pratensis (Raf.)Godr. & Gren	SIPR1	White Campion
CARYOPHYLLACEAE	Spergularia rubra (L.) K. Presl.	SPRU1	Sand Spurry
CARYOPHYLLACEAE	Stellaria longifolia Muhl. ex Willd.	STLO1	Long-leaved Stitchwort
CARYOPHYLLACEAE	Vaccaria pyramidata Medic.	VAPY1	Cow Cockle
CERATOPHYLLACEAE	Ceratophyllum demersum L.	CEDE1	Coontail

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Family	Scientific Name	Speccode	Common Name
CHENOPODIACEAE	Atriplex canescens (Pursh.) Nutt.	ATCA1	Four-winged Saltbush
CHENOPODIACEAE	Chenopodium album L.	CHAL1	Lamb's Quarters
CHENOPODIACEAE	Chenopodium atrovirens Nutt.	CHAT1	Dark Goosefoot
CHENOPODIACEAE	Chenopodium berlandieri Moq.	CHBE1	Pitseed Goosefoot
CHENOPODIACEAE	Chenopodium botrys L.	CHBO1	Jerusalem Oak
CHENOPODIACEAE	Chenopodium dessicatum A. Nels.	CHDE1	Desert goosefoot
CHENOPODIACEAE	Chenopodium fremontii S. Wats.	CHFR1	Fremont Goosefoot
CHENOPODIACEAE	Chenopodium leptophyllum Nutt. ex Moq.	CHLE2	Goosefoot
CHENOPODIACEAE	Chenopodium overi Aellen	CHOV1	Overi's Goosefoot
CHENOPODIACEAE	Kochia scoparia (L.) Schrad.	KOSC1	Kochia
CHENOPODIACEAE	Salsola iberica Senn. & Pau.	SAIB1	Russian-Thistle
CLUSIACEAE	Hypericum majus (A. Gray) Britt.	HYMA1	Greater St. John's-wort
CLUSIACEAE	Hypericum perforatum L.	HYPE1	Common St. John's-wort
COMMELINACEAE	Tradescantia occidentalis (Britt.) Smyth	TROC1	Spiderwort
CONVOLVULACEAE	Calystegia macouni (Greene) Brummitt	CAMA1	Hedge Bindweed
CONVOLVULACEAE	Convolvulus arvensis L.	COAR1	Field Bindweed
CONVOLVULACEAE	Evolvulus nuttallianus R. & S.	EVNU1	Evolvulus
CRASSULACEAE	Sedum lanceolatum Torr.	SELA1	Stonecrop
CUPRESSACEAE	Juniperus communis L.	JUCO1	Common Juniper
CUPRESSACEAE	Juniperus scopulorum Sarg.	JUSC1	Rocky Mountain Juniper
CUSCUTACEAE	Cuscuta approximata Bab.	CUAP1	Dodder
CYPERACEAE	Carex athrostachya Olney	CAAT1	Sedge
CYPERACEAE	Carex aurea Nutt.	CAAU1	Sedge
CYPERACEAE	Carex bebbii (Bailey) Fern	CABE1	Sedge
CYPERACEAE	Carex brevior (Dew.) Mack. ex Lunell.	CABR1	Sedge
CYPERACEAE	Carex douglasii F. Boott.	CADO1	Sedge
CYPERACEAE	Carex eleocharis Bailey	CAEL1	Sedge
CYPERACEAE	Carex emoryi Dew.	CAEM1	Sedge
CYPERACEAE	Carex filifolia Nutt.	CAFI1	Sedge
CYPERACEAE	Carex heliophila Mack.	CAHE1	Sedge
CYPERACEAE	Carex hystericina Muhl. ex Willd.	CAHY1	Sedge
CYPERACEAE	Carex interior Bailey	CAIN1	Sedge
CYPERACEAE	Carex lanuginosa Michx.	CALA1	Sedge
CYPERACEAE	Carex nebrascensis Dew.	CANE1	Sedge
CYPERACEAE	Carex oreocharis Holm.	CAOR1	Sedge
CYPERACEAE	Carex praegracilis W. Boott.	CAPR1	Sedge
CYPERACEAE	Carex rostrata Stokes ex Willd.	CARO2	Sedge
CYPERACEAE	Carex scoparia Schkuhr. ex Willd.	CASC1	Sedge
CYPERACEAE	Carex simulata Mack.	CASI1	Sedge
CYPERACEAE	Carex stipata Muhl.	CAST1	Sedge
CYPERACEAE	Carex vulpinoidea Michx.	CAVU1	Fox Sedge
CYPERACEAE	Eleocharis acicularis (L.) R. & S.	ELAC1	Spikerush
CYPERACEAE	Eleocharis compressa Sulliv.	ELCO1	Spikerush
CYPERACEAE	Eleocharis macrostachya Britt.	ELMA1	Spikerush
CYPERACEAE	Eleocharis parvula Link ex Boff. & Fingerbr. var. anachaeta (Torr.) Svens.	ELPA1	Spikerush
CYPERACEAE	Scirpus acutus Muhl.	SCAC1	Bulrush
CYPERACEAE	Scirpus pallidus (Britt.) Fern	SCPA1	Bulrush
CYPERACEAE	Scirpus pungens Vahl	SCPU1	Pungent Bulrush
CYPERACEAE	Scirpus validus Vahl.	SCVA1	Bulrush
ELAEAGNACEAE	Elaeagnus angustifolia L.	ELAN1	Russian Olive
EQUISETACEAE	Equisetum arvense L.	EQAR1	Field Horsetail
EQUISETACEAE	Equisetum laevigatum A. Br.	EQLA1	Smooth Horsetail
EQUISETACEAE	Equisetum variegatum Schleich.	EQVA1	Variegated Scouring Rush
EUPHORBIACEAE	Euphorbia dentata Michx.	EUDE1	Toothed Spurge
EUPHORBIACEAE	Euphorbia fendleri T. & G.	EUFE1	Fendler's Euphorbia
EUPHORBIACEAE	Euphorbia marginata Pursh.	EUMA1	Snow-on-the-Mountain
EUPHORBIACEAE	Euphorbia robusta (Engelm.) Small	EURO1	Spurge
EUPHORBIACEAE	Euphorbia serpyllifolia Pers.	EUSE1	Thyme-leaved Spurge
EUPHORBIACEAE	Euphorbia spathulata Lam.	EUSP1	Spurge
EUPHORBIACEAE	Tragia ramosa Nutt.	TRRA1	Noseburn
FABACEAE	Amorpha fruticosa L.	AMFR1	False Indigo
FABACEAE	Amorpha nana Nutt.	AMNA1	Dwarf Wild Indigo
FABACEAE	Astragalus adsurgens Pall. var. robustior Hook.	ASAD1	Standing Milkvetch
FABACEAE	Astragalus agrestis Dougl. ex G. Don	ASAG1	Field Milkvetch
FABACEAE	Astragalus bisulcatus (Hook.) A. Gray	ASBI1	Two-grooved Vetch

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Family	Scientific Name	Speccode	Common Name
FABACEAE	Astragalus canadensis L.	ASCA1	Canada Milk-vetch
FABACEAE	Astragalus crassicarpus Nutt.	ASCR1	Ground-plum
FABACEAE	Astragalus drummondii Dougl. ex Hook.	ASDR1	Drummond Milkvetch
FABACEAE	Astragalus flexuosus (Hook.) G. Don	ASFL1	Pliant Milkvetch
FABACEAE	Astragalus parryi Gray	ASPA1	Parry's Milkvetch
FABACEAE	Astragalus shortianus Nutt. ex T.&G.	ASSH1	Short's Milkvetch
FABACEAE	Astragalus spathulatus Sheld.	ASSP2	Draba Milk-Vetch
FABACEAE	Astragalus tridactylicus Gray	ASTR1	Foothill Milkvetch
FABACEAE	Dalea candida Michx. ex Willd. var. oligophylla (Torr.) Shinners.	DACA1	White Prairie Clover
FABACEAE	Dalea purpurea Vent	DAPU1	Purple Prairie Clover
FABACEAE	Glycyrrhiza lepidota Pursh.	GLLE1	Wild Licorice
FABACEAE	Lathyrus eucosmus Butters and St. John	LAEU1	Purple Peavine
FABACEAE	Lotus corniculatus L.	LOCO1	Birdfoot Trefoil
FABACEAE	Lupinus argenteus Pursh ssp. ingratus (Greene) Harmon	LUAR2	
FABACEAE	Lupinus argenteus Pursh var. argenteus	LUAR1	Silvery Lupine
FABACEAE	Medicago lupulina L.	MELU1	Black Medick
FABACEAE	Medicago sativa L. ssp. sativa	MESA1	Alfalfa
FABACEAE	Melilotus alba Medic.	MEAL1	White Sweetclover
FABACEAE	Melilotus officinalis (L.) Pall.	MEOF1	Yellow Sweetclover
FABACEAE	Oxytropis lambertii Pursh.	OXLA1	Purple Locoweed
FABACEAE	Psoralea tenuiflora Pursh.	PSTE1	Wild Alfala
FABACEAE	Robinia pseudo-acacia L.	ROPS1	Black Locust
FABACEAE	Thermopsis rhombifolia var. divaricarpa (Nels.) Isely	THRH1	Golden Banner
FABACEAE	Trifolium hybridum L.	TRHY1	Alsike Clover
FABACEAE	Trifolium pratense L.	TRPR1	Red Clover
FABACEAE	Vicia americana Muhl. ex Willd.	VIAM1	American Vetch
FUMARIACEAE	Fumaria vaillentii Lois	FUVA1	Fumitory
GENTIANACEAE	Gentiana affinis Griseb.	GEAF1	Northern Gentian
GENTIANACEAE	Swertia radiata (Kell.) O. Ktze.	SWRA1	Green Gentian
GERANIACEAE	Erodium cicutarium (L.) L'Her.	ERCI1	Filaria
GERANIACEAE	Geranium caespitosum James ssp. caespitosum	GECA1	Common Wild Geranium
GROSSULARIACEAE	Ribes aureum Pursh	RIAU1	Golden Currant
GROSSULARIACEAE	Ribes cereum Dougl.	RICE1	Western Red Currant
HALORAGACEAE	Myriophyllum exalbescens Fern.	MYEX1	American Milfoil
HYDROPHYLLACEAE	Hydrophyllum fendleri (Gray) Heller	HYFE1	Waterleaf
HYDROPHYLLACEAE	Phacelia heterophylla Pursh.	PHHE1	Scorpionweed
IRIDACEAE	Iris missouriensis Nutt.	IRMI1	Western Blue Flag
IRIDACEAE	Sisyrinchium montanum Greene	SIMO1	Blue-eyed Grass
JUNCACEAE	Juncus articulatus L.	JUAR1	Articulate Rush
JUNCACEAE	Juncus balticus Willd.	JUBA1	Baltic Rush
JUNCACEAE	Juncus bufonius L.	JUBU1	Toad Rush
JUNCACEAE	Juncus dudleyi Wieg.	JUDU1	Dudley Rush
JUNCACEAE	Juncus ensifolius Wikst. var. montanus (Englm.) C. L. Hitchc.	JUEN1	Rush
JUNCACEAE	Juncus interior Wieg.	JUIN1	Inland Rush
JUNCACEAE	Juncus longistylis Torr.	JULO1	Rush
JUNCACEAE	Juncus nodosus L.	JUNO1	Knotted Rush
JUNCACEAE	Juncus torreyi Cov.	JUTO1	Torrey's Rush
JUNCACEAE	Juncus tracyi Rydb.	JUTR1	Tracy Rush
LAMIACEAE	Dracocephalum parviflorum Nutt.	DRPA1	Dragonhead
LAMIACEAE	Hedeoma hispidum Pursh.	HEHI1	Rough False Pennyroyal
LAMIACEAE	Lycopus americanus Muhl. ex Barton	LYAM1	American Bugleweed
LAMIACEAE	Marrubium vulgare L.	MAVU1	Common Horehound
LAMIACEAE	Mentha arvensis L.	MEAR1	Field Mint
LAMIACEAE	Monarda fistulosa L. var. menthifolia (Grah.) Fern.	MOFI1	Wild Bergamot
LAMIACEAE	Monarda pectinata Nutt.	MOPE1	Spotted Bee-Balm
LAMIACEAE	Nepeta cataria L.	NECA1	Catnip
LAMIACEAE	Prunella vulgaris L.	PRVU1	Selfheal
LAMIACEAE	Salvia reflexa Hornem.	SARE1	Lance-leaved Sage
LAMIACEAE	Scutellaria brittonii Porter	SCBR1	Britton's Skullcap
LAMIACEAE	Stachys palustris L. ssp. pilosa (Nutt.) Epling	STPA2	Hedge Nettle
LEMNACEAE	Lemna minor L.	LEMI1	Duckweed
LILIACEAE	Allium cernuum Roth	ALCE1	Wild Onion
LILIACEAE	Allium geyeri S. Wats.	ALGE1	Geyer's Onion
LILIACEAE	Allium textile A. Nels. & Macbr.	ALTE1	Wild White Onion
LILIACEAE	Asparagus officinalis L.	ASOF1	Asparagus

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Family	Scientific Name	Speccode	Common Name
LILIACEAE	Calochortus gunnisonii S. Wats.	CAGU1	Sego Lily
LILIACEAE	Leucocrinum montanum Nutt.	LEMO2	Mountain Lily
LILIACEAE	Smilacina stellata (L.) Desf.	SMST1	Spikenard
LILIACEAE	Zigadenus venenosus Wats. var. gramineus (Rydb.) Walsh ex Peck	ZIVE1	Death Camass
LINACEAE	Linum perenne L. var. lewisii (Pursh.) Eat. & Wright	LIPE1	Blue Flax
LINACEAE	Linum pratense (Nort.) Small	LIPR1	Norton's Flax
LYTHRACEAE	Ammania robusta Herr & Regel.	AMRO1	Robust Toothcup
LYTHRACEAE	Lythrum alatum Pursh.	LYAL1	Winged Loosestrife
MALVACEAE	Malva neglecta Wallr.	MANE1	Common Mallow
MALVACEAE	Sidalcea candida Gray	SICA1	White Checkermallow
MALVACEAE	Sidalcea neomexicana Gray	SINE1	New Mexico Checkmallow
MALVACEAE	Sphaeralcea coccinea (Pursh.) Rydb.	SPCO1	Red False Mallow
NYCTAGINACEAE	Mirabilis hirsuta (Pursh.) MacM.	MIHI1	Hairy Four-O'Clock
NYCTAGINACEAE	Mirabilis linearis (Pursh.) Heimerl	MILI1	Narrowleaf Four O'Clock
NYCTAGINACEAE	Mirabilis nyctaginea (Michx.) MacM.	MINY1	Wild Four-O'Clock
ONAGRACEAE	Calylophus serrulatus (Nutt.) Raven	CASE2	Plains Yellow Primrose
ONAGRACEAE	Epilobium ciliatum Raf. ssp. glandulosum (Lehm.) Hock & Raven	EPCI1	Willow Herb
ONAGRACEAE	Epilobium paniculatum Nutt.	EPPA1	Willow Herb
ONAGRACEAE	Gaura coccinea Pursh.	GACO1	Scarlet Gaura
ONAGRACEAE	Gaura parviflora Dougl.	GAPA1	Velvety Gaura
ONAGRACEAE	Oenothera flava (A. Nels.) Garrett	OEFL1	Evening Primrose
ONAGRACEAE	Oenothera howardii (A. Nels.) W. L. Wagner	OEHO1	Yellow Stemless Evening Pr
ONAGRACEAE	Oenothera villosa Thunb. ssp. strigosa (Rydb.) Dietrich & Raven	OEVI1	Common Evening Primrose
ORCHIDACEAE	Habenaria hyperborea (L.) R. Br.	HAHY1	Northern Green Orchid
OROBANCHACEAE	Orobanche fasciculata Nutt.	ORFA1	Broomrape
OXALIDACEAE	Oxalis dillenii Jacq.	OXDI1	Gray-Green Wood Sorrel
PAPAVERACEAE	Argemone polyanthemos (Fedde) G. Ownbey	ARPO1	Prickly Poppy
PINACEAE	Picea pungens Engelm.	PIPU1	Blue Spruce
PINACEAE	Pinus ponderosa Laws	PIPO1	Ponderosa Pine
PINACEAE	Pseudotsuga menziesii (Mirb.) Franco	PSME1	Douglas-Fir
PLANTAGINACE	Plantago lanceolata L.	PLLA1	English Plantain
PLANTAGINACE	Plantago major L.	PLMA1	Common Plantain
PLANTAGINACE	Plantago patagonica Jacq.	PLPA1	Patagonian Plantain
POACEAE	Aegilops cylindrica Host	AECY1	Jointed Goatgrass
POACEAE	Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	AGCA1	Slender Wheatgrass
POACEAE	Agropyron cristatum (L.) Gaertn.	AGCR1	Crested Wheatgrass
POACEAE	Agropyron dasystachyum (Hook.) Scribn.	AGDA1	
POACEAE	Agropyron desertorum (Fisch.) Schult.	AGDE1	Crested Wheatgrass
POACEAE	Agropyron elongatum (Host) Beauv.	AGEL1	Tall Wheatgrass
POACEAE	Agropyron griffithsii Scribn. & Smith	AGGR1	
POACEAE	Agropyron intermedium (Host) Beauv.	AGIN1	Intermediate Wheatgrass
POACEAE	Agropyron repens (L.) Beauv.	AGRE1	Quackgrass
POACEAE	Agropyron smithii Rydb.	AGSM1	Western Wheatgrass
POACEAE	Agropyron spicatum (Pursh) Scribn. and Sm.	AGSP1	Bluebunch Wheatgrass
POACEAE	Agrostis scabra Willd.	AGSC1	Ticklegrass
POACEAE	Agrostis stolonifera L.	AGST1	Redtop
POACEAE	Alopecurus geniculatus L.	ALGE2	Marsh Foxtail
POACEAE	Andropogon gerardii Vitman`	ANGE1	Big Bluestem
POACEAE	Andropogon scoparius Michx.	ANSC1	Little Bluestem
POACEAE	Apera interrupta (L.) Beauvois	APIN1	Italian Windgrass
POACEAE	Aristida basiramea Engelm. ex Vasey var. basiramea	ARBA1	Forktip Threeawn
POACEAE	Aristida purpurea Nutt. var. longiseta (Steud.) Vasey	ARFE1	Fendler Threeawn
POACEAE	Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	Red Threeawn
POACEAE	Avena fatua var. sativa (L.) Hausskn.	AVFA1	Cultivated Oats
POACEAE	Bouteloua curtipendula (Michx.) Torr.	BOCU1	Side-oats Grama
POACEAE	Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	Blue Grama
POACEAE	Bouteloua hirsuta Lag	BOHI1	Hairy Grama
POACEAE	Bromus briziformis F. & M.	BRBR1	Rattlesnake Grass
POACEAE	Bromus inermis Leyss. ssp. inermis	BRIN1	Smooth Brome
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	Japanese Brome
POACEAE	Bromus tectorum L.	BRTE1	Downy Brome
POACEAE	Buchloe dactyloides (Nutt.) Engelm.	BUDA1	Buffalo-grass
POACEAE	Calamagrostis stricta (Timm.) Koel	CAST2	Northern Reedgrass
POACEAE	Cenchrus longispinus (Hack.) Fern	CELO1	Field Sandbur
POACEAE	Ceratochloa marginata (Nees ex Stued.) Jackson	CEMA1	Rescuegrass

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Family	Scientific Name	Speccode	Common Name
POACEAE	Dactylis glomerata L.	DAGL1	Orchardgrass
POACEAE	Danthonia spicata (L.) Beauv. ex R. & S.	DASP1	Poverty Oatgrass
POACEAE	Dichanthelium linearifolium (Scribn.) Gould	DILI1	Slimleaf Dichanthelium
POACEAE	Dichanthelium oligosanthes (Schultz) Gould var. scribnerianum (Nash) G	DIOL1	Scribner Dichanthelium
POACEAE	Digitaria sanguinalis (L.) Scop.	DISA1	Hairy Crabgrass
POACEAE	Echinochloa crusgallii (L.) Beauv.	ECCR1	Barnyard Grass
POACEAE	Elymus canadensis L.	ELCA1	Canada Wild Rye
POACEAE	Elymus juncea Fisch.	ELJU1	Russian Wild Rye
POACEAE	Eragrostis cilianensis (All.) E. Mosher	ERCI2	Stinkgrass
POACEAE	Eragrostis curvula (Schrad.) Nees	ERCU1	Weeping Lovegrass
POACEAE	Eragrostis pilosa (L.) Beauv.	ERPI1	India Lovegrass
POACEAE	Festuca octoflora Walt.	FEOC1	Six-weeks Fescue
POACEAE	Festuca ovina L. var. rydbergii St. Yves	FEOV1	Sheep's Fescue
POACEAE	Festuca pratensis Huds.	FEPR1	Meadow Fescue
POACEAE	Glyceria grandis S. Wats. ex A. Gray	GLGR1	Tall Mannagrass
POACEAE	Glyceria striata (Lam.) Hitchc.	GLST1	Fowl Mannagrass
POACEAE	Hordeum brachyantherum Nevski	HOBR1	Meadow Barley
POACEAE	Hordeum jubatum L.	HOJU1	Foxtail Barley
POACEAE	Koeleria pyramidata (Lam.) Beauv.	KOPY1	Junegrass
POACEAE	Leersia oryzoides (L.) Sw.	LEOR1	Rice Cutgrass
POACEAE	Lolium perenne L.	LOPE1	Ryegrass
POACEAE	Muhlenbergia asperifolia (Nees. & Mey.) Parodi	MUAS1	Scratchgrass
POACEAE	Muhlenbergia filiformis (Thurb.) Rydb.	MUFI1	Muhly
POACEAE	Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	Mountain Muhly
POACEAE	Muhlenbergia racemosa (Michx.) B. S. P.	MURA1	Marsh Muhly
POACEAE	Muhlenbergia wrightii Vasey	MUWR1	Spike Muhly
POACEAE	Oryzopsis hymenoides (R. & S.) Ricker	ORHY1	Indian Ricegrass
POACEAE	Panicum capillare L.	PACA1	Witchgrass
POACEAE	Panicum virgatum L.	PAVI1	Switchgrass
POACEAE	Phalaris arundinacea L.	PHAR1	Reed Canarygrass
POACEAE	Phleum pratense L.	PHPR1	Timothy
POACEAE	Phragmites australis (Cav.) Trin. ex Steud.	PHAU1	Common Reed
POACEAE	Poa bulbosa L.	POBU1	Bulbous Bluegrass
POACEAE	Poa canbyi (Scribn.) Piper	POCA1	Canby's Bluegrass
POACEAE	Poa compressa L.	POCO1	Canada Bluegrass
POACEAE	Poa fendleriana (Steud.) Vasey	POFE1	Muttongrass
POACEAE	Poa palustris L.	POPA1	Fowl Bluegrass
POACEAE	Poa pratensis L.	POPR1	Kentucky Bluegrass
POACEAE	Polypogon monspeliensis (L.) Desf.	POMO1	Rabbitfoot Grass
POACEAE	Schedonnardus paniculatus (Nutt.) Trel.	SCPA2	Tumblegrass
POACEAE	Secale cereale L.	SECE1	Rye
POACEAE	Setaria viridis (L.) Beauv.	SEVI1	Green Foxtail
POACEAE	Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	Squirreltail
POACEAE	Sorghastrum nutans (L.) Nash	SONU1	Indian-grass
POACEAE	Spartina pectinata Link	SPPE1	Prairie Cordgrass
POACEAE	Sphenopholis obtusata (Michx.) Scribn.	SPOB1	Prairie Wedgegrass
POACEAE	Sporobolus asper (Michx.) Kunth	SPAS1	Rough Dropseed
POACEAE	Sporobolus cryptandrus (Torr.) A. Gray	SPCR1	Sand Dropseed
POACEAE	Sporobolus heterolepis (A. Gray) A. Gray	SPHE1	Prairie Dropseed
POACEAE	Sporobolus neglectus Nash	SPNE1	Poverty Grass
POACEAE	Stipa comata Trin. & Rupr.	STCO1	Needle-and-thread
POACEAE	Stipa neomexicana (Thur.) Scribn.	STNE1	New Mexico Feather Grass
POACEAE	Stipa spartea Trinius	STSP1	Porcupine-grass
POACEAE	Stipa viridula Trin.	STVI1	Green Needlegrass
POACEAE	Triticum aestivum L.	TRAE1	Wheat
POACEAE	X Agrohordeum macounii (Vasey) Lepage	AGMA1	
POLEMONIACEAE	Collomia linearis Nutt.	COLI1	Collomia
POLEMONIACEAE	Gilia opthalmoides Brand. ssp. clokeyi (Mason) A. & V. Grant	GIOP1	Gilia
POLEMONIACEAE	Ipomopsis spicata (Nutt.) V. Grant ssp. spicata	IPSP1	Spike Gilia
POLEMONIACEAE	Microsteris gracilis (Hook.) Greene	MIGR1	
POLEMONIACEAE	Navarretia minima Nutt.	NAMI1	Navarretia
POLYGONACEAE	Eriogonum alatum Torr.	ERAL1	Winged Eriogonum
POLYGONACEAE	Eriogonum effusum Nutt.	EREF1	Spreading Wild Buckwheat
POLYGONACEAE	Eriogonum jamesii Benth.	ERJA1	James' Wild Buckwheat
POLYGONACEAE	Eriogonum umbellatum Torr.	ERUM1	Sulphur Flower

Plant Species Known to Occur at Rocky Flats Environmental Technology Site, May 1999 (cont.)

Family	Scientific Name	Speccode	Common Name
POLYGONACEAE	Polygonum arenastrum Jord. ex Bor.	POAR1	Knotweed
POLYGONACEAE	Polygonum convolvulus L.C394	POCO2	Wild Buckwheat
POLYGONACEAE	Polygonum douglasii Greene	PODO1	Knotweed
POLYGONACEAE	Polygonum hydropiper L.	POHY1	Water Pepper
POLYGONACEAE	Polygonum lapathifolium L.	POLA1	Pale Smartweed
POLYGONACEAE	Polygonum pensylvanicum L.	POPE1	Pennsylvania Smartweed
POLYGONACEAE	Polygonum persicaria L.	POPE2	Lady's Thumb
POLYGONACEAE	Polygonum ramosissimum Michx.	PORA1	Knotweed
POLYGONACEAE	Polygonum sawatchense Small	POSA1	Knotweed
POLYGONACEAE	Rumex acetosella L.	RUAC1	Sheep Sorrel
POLYGONACEAE	Rumex crispus L.	RUCR1	Curly Dock
POLYGONACEAE	Rumex maritimus L.	RUMA1	Golden Dock
POLYGONACEAE	Rumex obtusifolius L.	RUOB1	Bitter Dock
POLYGONACEAE	Rumex salicifolius Weinm. ssp. triangulivalvis Danser	RUSA1	Willow Dock
POLYPODIACEAE	Cystopteris fragilis (L.) Bernh.	CYFR1	Fragile Fern
PORTULACACEAE	Claytonia rosea Rydb.	CLRO1	Spring Beauty
PORTULACACEAE	Portulaca oleracea L.	POOL1	Common Purslane
PORTULACACEAE	Talinum parviflorum Nutt.	TAPA1	Prairie Fameflower
POTAMOGETONACEAE	Potamogeton foliosus Raf.	POFO1	Leafy Pondweed
POTAMOGETONACEAE	Potamogeton natans L.	PONA1	Floatingleaf Pondweed
PRIMULACEAE	Androsace occidentalis Pursh.	ANOC1	Western Rock Jasmine
PRIMULACEAE	Dodecatheon pulchellum (Raf.) Merrill	DOPU1	Shooting Star
PRIMULACEAE	Lysimachia ciliata L.	LYCI1	Fringed Loostrife
RANUNCULACEAE	Anemone cylindrica A. Gray	ANCY1	Candle Anemone
RANUNCULACEAE	Anemone patens L.	ANPA2	Pasque-flower
RANUNCULACEAE	Clematis hirsutissima Pursh	CLHI1	Hairy Clematis
RANUNCULACEAE	Clematis ligusticifolia Nutt.	CLLI1	Western Clematis
RANUNCULACEAE	Delphinium nuttalianum Pritz. ex Walpers	DENU1	Blue Larkspur
RANUNCULACEAE	Delphinium virescens Nutt. ssp. penardii (Huth) Ewan	DEVI1	Prairie Larkspur
RANUNCULACEAE	Myosurus minimus L.	MYMI1	Mousetail
RANUNCULACEAE	Ranunculus macounii Britt.	RAMA1	Macoun's Buttercup
RANUNCULACEAE	Ranunculus scleratus L.	RASC1	Cursed Crowfoot
RANUNCULACEAE	Ranunculus trichophyllus Chaix	RATR1	Hairy Leaf Buttercup
RANUNCULACEAE	Thalictrum dasycarpum Fisch. & Ave-Lall	THDA1	Purple Meadow Rue
RHAMNACEAE	Ceanothus herbaceus Raf. var. pubescens (T. & G.)	CEHE1	New Jersey Tea
ROSACEAE	Agrimonia striata Michx.	AGST2	Striate Agrimony
ROSACEAE	Amelanchier alnifolia Nutt.	AMAL1	Saskatoon Service-berry
ROSACEAE	Crataegus erythropoda Ashe	CRER1	Hawthorne
ROSACEAE	Crataegus succulenta Link var. occidentalis (Britton) E. J. Palm.	CRSU1	Hawthorn
ROSACEAE	Geum aleppicum Jacq.	GEAL1	Yellow Avens
ROSACEAE	Geum macrophyllum Willd.	GEMA1	Large-leaved Avens
ROSACEAE	Physocarpus monogynus (Torr.) Coult.	PHMO1	Mountain Ninebark
ROSACEAE	Physocarpus opulifolius (L.) Raf.	PHOP1	Ninebark
ROSACEAE	Potentilla arguta Pursh	POAR2	Tall Cinquefoil
ROSACEAE	Potentilla fissa Nutt.	POFI1	Cinquefoil
ROSACEAE	Potentilla gracilis Dougl. ex Hook. var. glabrata (Lehm.) C. L. Hitchc.	POGR1	Cinquefoil
ROSACEAE	Potentilla hippiana Lehm.	POHI1	Wooly Cinquefoil
ROSACEAE	Potentilla norvegica L.	PONO1	Norwegian Cinquefoil
ROSACEAE	Potentilla paradoxa Nutt.	POPA2	Bushy Cinquefoil
ROSACEAE	Potentilla pensylvanica L.	POPE4	Cinquefoil
ROSACEAE	Potentilla pulcherrima x hippiana	POPU1	Hybrid Cinquefoil
ROSACEAE	Potentilla rivalis Nutt.	PORI1	Cinquefoil
ROSACEAE	Prunus americana Marsh.	PRAM1	Wild Plum
ROSACEAE	Prunus pumila L. var. besseyi (Bailey) Gl.	PRPU1	Sand Cherry
ROSACEAE	Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg.	PRVI1	Chokecherry
ROSACEAE	Pyrus malus L.	PYMA1	Apple
ROSACEAE	Rosa acicularis Lindl.	ROAC1	Prickly Wild Rose
ROSACEAE	Rosa arkansana Porter	ROAR1	Prairie Wild Rose
ROSACEAE	Rosa woodsii Lindl.	ROWO1	Western Wild Rose
ROSACEAE	Rubus deliciosus Torr.	RUDE1	Boulder Raspberry
ROSACEAE	Rubus idaeus L. ssp. sachalinensis (Levl.) Focke var. sachalinensis	RUID1	Raspberry
ROSACEAE	Sanguisorba minor Scop.	SAMI1	Burnet
ROSACEAE	Sorbus scopulina Greene	SOSC1	Mountain Ash
RUBIACEAE	Galium aparine L.	GAAP1	Catchweed Bedstraw
RUBIACEAE	Galium septentrionale Roemer & Schultes	GASE1	Northern Bedstraw

Plant Species Known to Occur at Rocky Flats Environmental Technology Site, May 1999 (cont.)

Family	Scientific Name	Speccode	Common Name
SALICACEAE	Populus alba L.	POAL1	Silver Poplar
SALICACEAE	Populus angustifolia James	POAN3	Narrow-leaved Cottonwood
SALICACEAE	Populus deltoides Marsh. ssp. monilifera (Ait.) Eckenw.	PODE1	Plains Cottonwood
SALICACEAE	Populus x acuminata Rydb.	POAC1	Lanceleaf Cottonwood
SALICACEAE	Salix amygdaloides Anderss.	SAAM1	Peach-leaf Willow
SALICACEAE	Salix exigua Nutt. ssp. exigua	SAEX2	Coyote Willow
SALICACEAE	Salix exigua Nutt. ssp. interior (Rowlee) Cronq.	SAEX1	Sandbar Willow
SALICACEAE	Salix fragilis L.	SAFR1	Crack Willow
SALICACEAE	Salix irrorata Andersson	SAIR1	
SALICACEAE	Salix lutea Nutt.	SALU1	Yellow Willow
SANTALACEAE	Comandra umbellata (L.) Nutt.	COUM1	Bastard Toadflax
SAXIFRAGACEAE	Heuchera parvifolia Nutt. ex T.& G.	HEPA1	Alumroot
SAXIFRAGACEAE	Saxifraga rhomoidea Greene	SARH1	Diamondleaf Saxifrage
SCROPHULARIACEAE	Castilleja integra A. Gray	CAIN2	Orange Paintbrush
SCROPHULARIACEAE	Castilleja sessiliflora Pursh.	CASE3	Downy Paintbrush
SCROPHULARIACEAE	Collinsia parviflora Doug. ex Lindl.	COPA1	Blue Lips
SCROPHULARIACEAE	Gratiola neglecta Torr.	GRNE1	Hedge Hyssop
SCROPHULARIACEAE	Linaria dalmatica (L.) Mill.	LIDA1	Toadflax
SCROPHULARIACEAE	Linaria vulgaris Hill	LIVU1	Butter-and-eggs
SCROPHULARIACEAE	Mimulus floribundus Dougl. ex Lindl.	MIFL1	Monkey Flower
SCROPHULARIACEAE	Mimulus glabratus H. B. K. var. fremontii (Benth.) A. L. Grant	MIGL1	Roundleaf Monkey-flower
SCROPHULARIACEAE	Penstemon albidus Nutt.	PEAL1	White Beardtongue
SCROPHULARIACEAE	Penstemon secundiflorus Benth.	PESE1	Penstemon
SCROPHULARIACEAE	Penstemon strictus Bentham in De Candolle	PEST1	Rocky Mountain Penstemon
SCROPHULARIACEAE	Penstemon virens Penn.	PEVI1	Slender Penstemon
SCROPHULARIACEAE	Penstemon virgatus Gray ssp. asa-grayi Crosswhite	PEVI2	Penstemon
SCROPHULARIACEAE	Scrophularia lanceolata Pursh.	SCLA2	Figwort
SCROPHULARIACEAE	Verbascum blattaria L.	VEBL1	Moth Mullein
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	Common Mullein
SCROPHULARIACEAE	Veronica americana (Raf.) Schwein. ex Benth.	VEAM1	Brooklime Speedwell
SCROPHULARIACEAE	Veronica anagallis-aquatica L.	VEAN1	Water Speedwell
SCROPHULARIACEAE	Veronica catentata Penn.	VECA1	Catenate Ironweed
SCROPHULARIACEAE	Veronica peregrina L. var. xalapensis (H. B. K.) St. John & Warren	VEPE1	Purslane Speedwell
SELAGINELLACEAE	Selaginella densa Rydb.	SEDE1	Spikemoss
SMILACACEAE	Smilax herbacea L. var. lasioneura (Small) Rydb..	SMHE1	Carrion Flower
SOLANACEAE	Physalis heterophylla Nees	PHHE2	Clammy Ground cherry
SOLANACEAE	Physalis virginiana P. Mill.	PHVI2	Virginia Ground Cherry
SOLANACEAE	Quincula lobata (Torr.) Raf.	QULO1	Purple Ground Cherry
SOLANACEAE	Solanum rostratum Dun.	SORO1	Buffalo Bur
SOLANACEAE	Solanum triflorum Nutt.	SOTR1	Cut-leaved Nightshade
TAMARICACEAE	Tamarix ramosissima Ledeb.	TARA1	Salt Cedar
TYPHACEAE	Typha angustifolia L.	TYAN1	Narrow-leaved Cattail
TYPHACEAE	Typha latifolia L.	TYLA1	Common Cattail
ULMACEAE	Ulmus pumila L.	ULPU1	Siberian Elm
URTICACEAE	Parietaria pensylvanica Muhl. ex Willd.	PAPE1	Pennsylvania Pellitory
URTICACEAE	Urtica dioica L. ssp. gracilis (Ait.) Seland.	URDI1	Stinging Nettle
VERBENACEAE	Lippia cuneifolia (Torr.) Steud.	LICU1	Fog-fruit
VERBENACEAE	Verbena bracteata Lag. & Rodr.	VEBR1	Prostrate Vervain
VERBENACEAE	Verbena hastata L.	VEHA1	Blue Vervain
VIOLACEAE	Hybanthus verticillatus (Ort.) Baill.	HYVE1	Nodding Green Violet
VIOLACEAE	Viola nuttallii Pursh.	VINU1	Yellow Prairie Violet
VIOLACEAE	Viola rydbergii Greene	VIRY1	Rydberg's Violet
VIOLACEAE	Viola scopulorum (Gray) Greene	VISC1	Colorado Violet
VIOLACEAE	Viola sororia Willd.	VISO1	Northern Bog Violet
VITACEAE	Vitis riparia Michx.	VIRI1	River-bank Grape
ZYGOPHYLLACEAE	Tribulus terrestris L.	TRTE1	Puncture Vine