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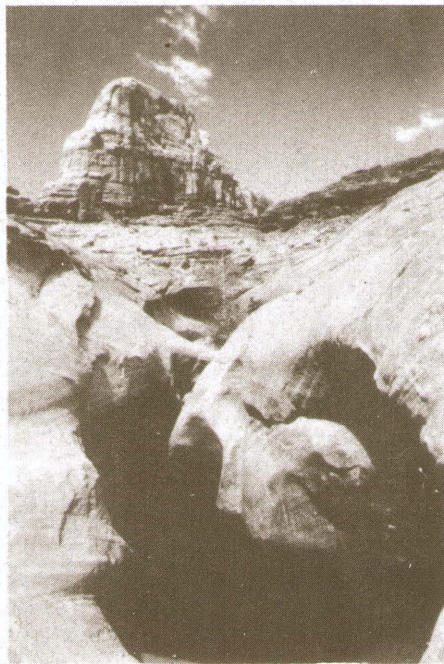
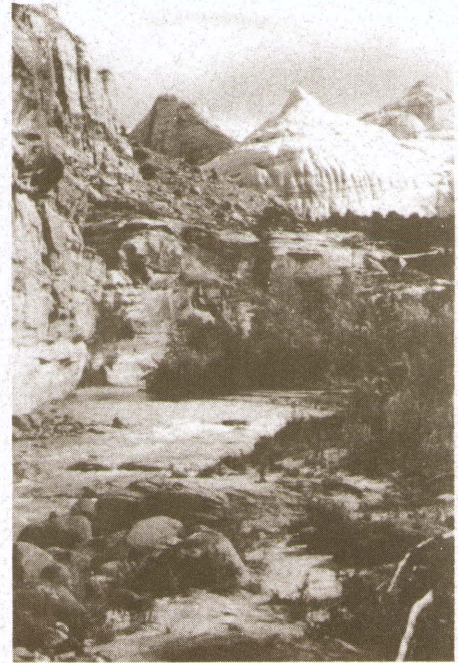
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## Vascular Flora and Vegetation of Capitol Reef National Park, Utah

Kenneth D. Heil, J. Mark Porter, Rich Fleming,  
and William H. Romme



Technical Report NPS/NAUCARE/NRTR-93/01



National Park Service

U.S. Department of the Interior



Cooperative Park Studies Unit

at Northern Arizona University





**National Park Service  
Cooperative Park Studies Unit  
Northern Arizona University**

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## Vascular Flora and Vegetation of Capitol Reef National Park, Utah

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Technical Report NPS/NAUCARE/NRTR-93/01

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Capitol Reef National Park was established in 1971 as a 241,000 acre park in the heart of the Colorado Plateau. The law creating the park called for the immediate phase-out of livestock grazing. In 1982, controversy surrounding the required phase-out precipitated the passage of a second law which called for an extension of grazing activities. This law also called for the establishment of a comprehensive grazing research program, initially overseen by the National Academy of Sciences, to determine the effects of the activity on the park's natural and cultural resources. By 1991, with NPS funding, the Division of Resource Management and science at Capitol Reef National Park eventually shepherded to completion 11 separate studies as part of this effort. This document is the first report to be published as part of this grazing research series.

Norman R. Henderson  
Chief, Resource Management and Science  
Capitol Reef National Park



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## Abstract

Capitol Reef National Park (CARE) is a 98000-ha (242000-ac) reserve located in southern Utah, USA. It contains outstanding examples of the rugged topography, flora, fauna, and vegetation of this portion of the Colorado Plateau. In this study, we collected and documented the vascular flora, with special attention on taxa of concern (endangered or threatened or candidates for listing), classified the plant communities in the park, and described the distribution and patterns of plant communities in relation to gradients of elevation, geologic substrate, and grazing intensity.

We documented 759 vascular plant species in CARE, representing 352 genera and 86 families. CARE supports at least 36 taxa that are listed as endangered or threatened. This is one of the greatest concentrations in the region of plant taxa of special concern. The high plant diversity in CARE reflects the great range of habitats present and the geographic location at the intersection of several biogeographic regions.

We identified 34 plant community types within the park. Distribution of communities is controlled primarily by gradients in elevation and geologic substrate. Dry, hot areas at the lowest elevations support various upland

shrub, grassland, and badlands communities; sandstones at low elevations and a variety of substrates at middle elevations support several kinds of pinyon-juniper communities; and cool, moist sites at high elevations are covered by woodland communities dominated by conifers or aspen. Riparian areas at all elevations support woodlands and wetlands. Unusual and rare plant communities in CARE include the bristlecone pine-cushion plant community and the dogwood-spruce riparian woodland at high elevations; and hanging gardens, waterpockets, and the hornbeam-boxelder-oak woodland at low elevations.

Past grazing by livestock has altered the composition and structure of many grassland and riparian communities in CARE. It may require many decades of grazing protection and possibly active intervention to restore these communities to their presettlement condition. Recovery of community structure probably will be more rapid in riparian areas than in more arid grasslands, but restoration of original species composition may be slow in both kinds of areas. Establishment during the 20th century of exotic plants, e.g., tamarix and cheatgrass, has permanently changed the composition of many plant communities in CARE.

## Introduction

Capitol Reef National Park (CARE) is a 98,000-ha (242,000-acre) reserve located in southern Utah, USA (Figure 1). Established as a National Monument in 1937 and expanded as a National Park to its present size in 1971, it contains outstanding examples of the rugged topography, spectacular geology, and unusual fauna and flora that characterize the Colorado Plateau physiographic province (Fenneman 1931). The major feature of the park is the Waterpocket Fold, a large monocline that extends some 160 km (100 miles) from near the Colorado River in the south to the flanks of Thousand Lakes Mountain in the north, and

encompasses geologic strata representing a vast geologic time period from the Paleozoic Era to the present (Smith et al. 1963). Numerous streams have cut through the fold, exposing the rock layers and creating a spectacularly rugged landscape.

Although Capitol Reef's geology has been mapped and described in some detail (Smith et al. 1963, Billingsley et al. 1987), the flora (plant taxa present) and vegetation (plant communities) previously have been relatively little studied. The great diversity in geology and topography, the gradient in elevation (1180-2670 m [3900-8800 ft]), and the park's



strategic biogeographic location near the intersection of several major floristic regions, have resulted in a remarkable diversity of plant taxa and communities within the park's borders, including numerous endemic and rare taxa (Welsh and Chatterley 1985). The purpose of this study was to inventory, map, describe, and assess the flora and vegetation of Capitol Reef National Park.

**Previous Work: Floristics**

Capitol Reef National Park lies in a portion of the Colorado Plateau that has been relatively poorly explored botanically. Previous floristic studies have been conducted in the general region, including the San Rafael Swell (Harris, 1980), Henry Mountains (Stan-

ton 1931 [cited in Everitt 1970], Neese 1981), Uinta Basin (Goodrich and Neese 1986), San Francisco Peaks (Rominger and Paulik 1983), Natural Bridges National Monument (Welsh and Moore 1968), Arches National Park (Harrison et al. 1964), Canyonlands National Park (Loope 1977, Welsh 1970), Glen Canyon National Recreation Area (Tuhy and MacMahon 1988), and Grand Canyon National Park (Phillips et al. 1989). Within Capitol Reef itself, Susan Meyer conducted a preliminary inventory in 1981-1982 and identified over 500 plant taxa, but acknowledged that her inventory was not exhaustive.

With the passage of the Endangered Species Act in 1973, the protection of rare and endemic plant species has increasingly become

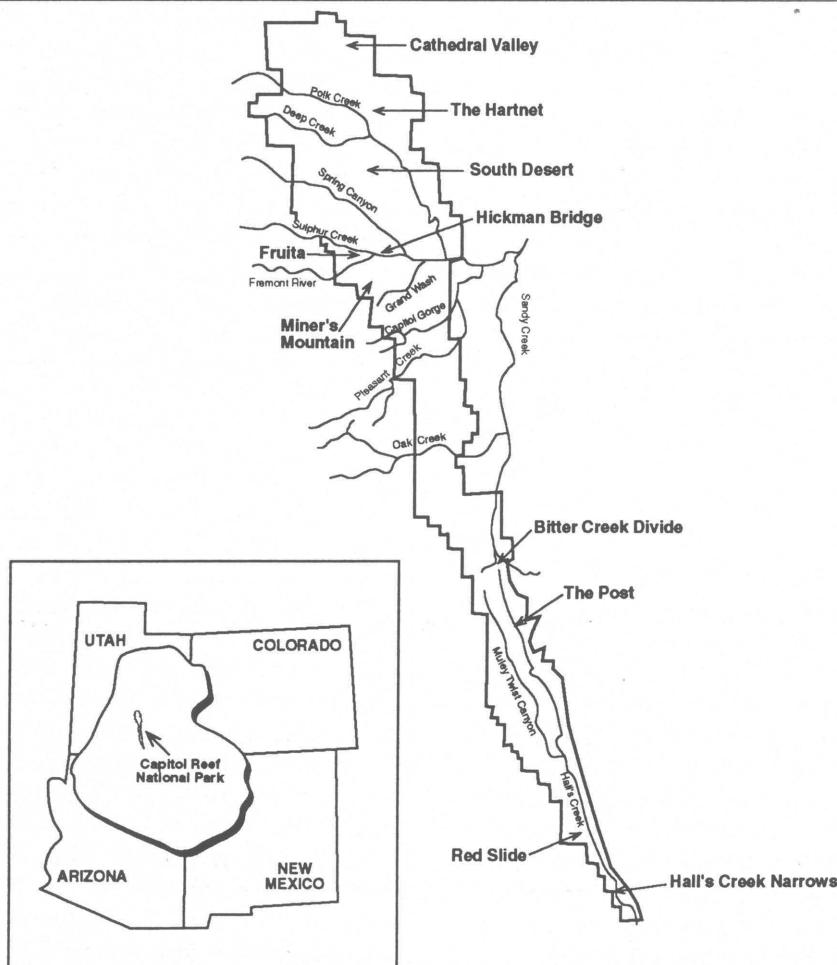


Figure 1. Detailed map of Capitol Reef National Park with inset of location map of Capitol Reef National Park within the Colorado Plateau Physiographic Region.



a management concern in national parks and other kinds of nature reserves. Thus, one important objective of our research was to conduct a systematic inventory of rare plant taxa in CARE (Bratton and White 1980, White and Bratton 1980). Although no inventories of rare plants in the park as a whole have previously been completed, occasional collections and studies of local areas have been made. In particular, Susan Meyer and Keith Harrison provided several records of rare plant species in CARE. Additionally, Pamela Camp and Alice Lindahl conducted a survey of the flora, vegetation and rare plant species of the Hall Creek drainage (Figure 1), including lands both in and out of CARE, from The Post southward to Lake Powell (Camp 1978). Camp documented 12 rare plant species, 8 of which are endemic to the Colorado Plateau but are not on federal lists of endangered or threatened species.

Further documentation of rare plant taxa has come from field reports of the U. S. Fish and Wildlife Service, Endangered Species Office botanist (e.g., Anderson 1985). Prior to the initiation of this project, 17 taxa were recorded from CARE (Table 1) that were included in the Review of Plant Taxa for Listing as Endangered or Threatened Species, by the U. S. Fish and Wildlife Service (Federal Register (F.R.) 50[188]:39526-39584). These records usually take the form of voucher specimens in herbaria (e.g., BYU) or documentation in the literature (e.g., Welsh and Chatterly 1985).

The U. S. Fish and Wildlife Service (USFWS) has classified rare plant species according to potential vulnerability, utilizing alpha-numeric codes to denote the status of the plants. See Table 1 for a summary of the USFWS status codes as used throughout this report. These status assessments are based on information currently available to USFWS, and they are subject to change.

These previous studies indicated the floristic richness of Capitol Reef and the concentration of rare plant taxa within the park, but none were comprehensive surveys. Therefore, our study was initiated in part to provide the baseline information on park flora and vegetation necessary for park management and future research.

### Previous Work: Vegetation

No detailed classifications or analyses of the vegetation of the park as a whole have been made, although some portions of the vegetation have been studied. The vegetation of CARE has been classified and mapped at a coarse scale based on aerial photographs, with nine vegetation types identified (e.g., woodlands, grasslands, badlands), and this information is contained within the park's geographical information system (GIS). Barth and McCullough (1988) analyzed the effects of current and historic livestock grazing on riparian vegetation in CARE, and Welsh (1988) described the riparian vegetation along the Fremont River in the context of an assessment of a proposed water development upstream. Fisher et al. (1991) and Cole (1991) have reconstructed changes in grassland and woodland vegetation that occurred during the last several centuries to millenia. Vegetation research in progress in CARE includes studies of the effects of soil microphytic crusts on erosion (West 1990 and personal communication) and of plant community dynamics in waterpockets (N. Henderson, personal communication).

Vegetation classifications have been developed for other units of the National Park system on the Colorado Plateau, including Canyonlands National Park (Loope 1977), Glen Canyon National Recreation Area (Tuhy and MacMahon 1988), Grand Canyon National Park (Phillips et al. 1989), and Zion National Park (K. Harper, personal communication). Everitt (1970) classified and mapped the vegetation of a portion of the Henry Mountains near CARE, and Singh and West (1971) classified the *Atriplex*-dominated plant communities near Green River, Utah. The USDA Soil Conservation Service (SCS) classified rangeland plant communities of a large area in southern Utah, including portions of CARE. Coniferous forest habitat types and aspen community types of southern Utah were identified by Youngblood and Mauk (1985) and by Mueggler and Campbell (1986), respectively. An excellent overview of semi-desert and woodland vegetation in this region is provided by West (1988).



**Table 1.** List of plant species which appear on federal lists of threatened, endangered, candidate species, and species no longer candidates for listing from Capitol Reef National Park. Federal status is indicated in parentheses, following the scientific name (see footnote for explanation of status codes). New records of plant species of concern are marked with an asterisk (\*).

<i>Cycladenia humilis</i> var. <i>jonesii</i>	(E)	Near Deer Point
<i>Echinocereus triglochidiatus</i> var. <i>inermis</i>	(E)*	Paradise Flats
<i>Erigeron maguirei</i> var. <i>maguirei</i>	(E)*	Upper Deep Creek
<i>Sclerocactus wrightiae</i>	(E)	Cathedral Valley
<i>Townsendia aprica</i>	(T)	South Desert Overlook
<i>Gilia caespitosa</i>	(1)	Grand Wash; Near Hickman Bridge
<i>Pediocactus winkleri</i>	(1)	The Hartnet
<i>Schoenocrambe barnebyi</i>	(1)*	Along Sulfur Creek
<i>Spiranthes diluvialis</i>	(1)*	Along Fremont River
<i>Cymopterus beckii</i>	(2)	Near Hickman Bridge
<i>Dalea flavescens</i> var. <i>epica</i>	(2)*	Near The Post
<i>Erigeron maguirei</i> var. <i>harrisonii</i>	(2)	Near Hickman Bridge
<i>Habenaria zothecina</i>	(2)*	Halls Narrows
<i>Hymenoxys depressa</i>	(2)*	Waterpocket Fold along Deep Creek
<i>Thelesperma subnuda</i> var. <i>alpina</i>	(2)*	Upper Deep Creek
<i>Asclepias ruthiae</i>	(3c)	South Desert
<i>Astragalus barnebyi</i>	(3c)	Along the Caineville Road
<i>Astragalus chamaeluce</i> var. <i>laccoliticus</i>	*=	Near The Post
<i>Astragalus consobrinus</i>	(3c)	South Desert Overlook
<i>Astragalus harrisonii</i>	(3c)	Near Hickman Bridge
<i>Astragalus malacoides</i>	(3c)	The Purple Hills; Circle Cliffs
<i>Astragalus pardalinus</i>	(3c)*	Cathedral Valley
<i>Astragalus woodruffii</i>	(3c)*	Fremont River, east entrance
<i>Castilleja scabrida</i>	(3c)	Near Hickman Bridge
<i>Chamaechenactis scaposa</i>	(3c)	The Upper Hartnet
<i>Cryptantha johnstonii</i>	(3c)*	The Hartnet
<i>Erigeron abajoensis</i>	(3c)*	Upper Deep Creek
<i>Eriogonum corymbosum revealianum</i>	(3c)*	Upper Deep Creek
<i>Eriogonum tumulosum</i>	(3c)*	The Hartnet
<i>Geranium marginale</i>	(3c)*	Upper Deep Creek
<i>Lomatium junceum</i>	(3c)	Near Bitter Creek Divide
<i>Nama retorsum</i>	(3c)	Near Hickman Bridge
<i>Parthenium ligulatum</i>	(3c)	The Upper Hartnet
<i>Peteria thompsonii</i>	(3c)*	Cathedral Valley
<i>Physaria acutifolia</i> var. <i>purpurea</i>	(3c)*	Upper Deep Creek
<i>Xylorhiza confertifolia</i>	(3c)*	Top of Burr Trail

= *Astragalus chamaeluce* currently has a 3c status; however var. *laccoliticus* has not been assessed for potential threats, and because it represents a small fraction of the distribution of *Astragalus chamaeluce*, it is possible that it may be listed as a candidate.

The U. S. Fish and Wildlife Service (USFWS) has classified rare plant species according to potential vulnerability, utilizing alpha-numeric codes to denote the status of the plants. Those used in this report are defined as follows:

E- Taxa listed as endangered;

T- Taxa listed as threatened;

1- Taxa for which the USFWS has on file substantial information on biological vulnerability and threats to support the listing of these taxa as endangered or threatened species;

2- Taxa for which information now in possession of the USFWS indicates the possible appropriateness for the listing of these taxa as endangered or threatened species, but for which substantial information on biological vulnerability and threats is not currently available;

3- Taxa are no longer being considered for listing as endangered or threatened species, (3c) because they have proven to be more abundant or widespread than was previously believed and /or are not subject to any identifiable threat.

These codes are used throughout this report. It should be noted, however, that these status assessments are based on information currently available to USFWS, and they are subject to change.

### Location

Capitol Reef National Park lies in Wayne, Garfield, Sevier, and Emery Counties, Utah (Figure 1). The highest elevation (2670 m [8800 ft]) is in the northwestern end of the park, and the lowest elevation (1180 m [3900 ft]) is at the southern tip. The Bitter Creek Divide appears to represent an important biogeographic boundary: to the south a low desert type of vegetation predominates, whereas to the north pinyon/juniper and high desert plant communities are more characteristic. At Fruita are irrigated orchards and meadows. The Waterpocket Fold contains many deep, stream-cut canyons and nearly vertical rock walls. Runoff from north of the Bitter Creek Divide eventually flows into the Fremont River; south of the Bitter Creek Divide, most runoff flows into Halls Creek and eventually to Lake Powell.

Many portions of CARE are remote and difficult to reach. State Highway 24 crosses CARE from east to west in the northern third of the park. A scenic drive provides access to areas along the west side of the Waterpocket Fold south of Fruita. An unimproved dirt road runs through the Cathedral Valley (Middle Desert) region in the north, and another dirt road follows the Waterpocket Fold south to "The Post" and then exits the park. A four wheel drive road provides access to the Upper Deep Creek region. The remainder of the park is accessible only by foot. Nearly 31 miles of trails provide some access to remote portions of the park, but many areas are far from any trails, and the extremely steep and rugged topography makes much of the Waterpocket Fold inaccessible or nearly so.

The inaccessibility of most of the park area is a major reason why its flora has not yet been adequately documented. Accessible and well collected areas in the park include: Fruita, Fremont River Valley, Upper Deep Creek, Cathedral Valley, Lower Halls Creek, Hickman Bridge Overlook area, Capitol Gorge, Chimney Rock area, Deer Point, Cohab/Frying Pan Canyons, Spring Canyon, Pleasant Creek, Sulphur Creek, Grand Wash, and The Hartnet. One major objective in our research was to inventory the more remote and poorly collected portions of the park as thoroughly as possible.

### Geology

The geology of Capitol Reef National Park is complex (Smith et al. 1963, Billingsley et al. 1987). The oldest rocks are Permian in age and are found only in the deepest canyons along the western side of the park. Mesa Verde sandstone of Cretaceous age, the youngest sedimentary formation in the park aside from Quaternary deposits, occurs along the eastern boundary. Volcanic activity occurred in the nearby areas of Boulder and Thousand Lake Mountains at approximately 20 million years ago (Barnes 1978). Basaltic boulders were later carried by glacial melt water down the mountains and are now scattered throughout much of the park. As the Colorado Plateau was gradually uplifted, the Waterpocket Fold was created; this prominent structure forms an eastward tilted bend that runs from Thousand Lake Mountain nearly 160 km (100 mi) to Lake Powell (Olson and Olson 1986).

Billingsley et al. (1987) identified 34 distinct geological units within Capitol Reef National Park and adjacent areas. These units range from bedrock deposits of sandstone, limestone, shale, and mudstone; to intrusive and extrusive igneous rocks; to Quaternary deposits of aeolian, alluvial, and colluvial origin. The variety of habitats created by these different geologic substrates has a profound effect on the distribution of plant species and communities, as is described below.

### Climate

The climate of Capitol Reef National Park varies seasonally and with elevation, but few instrumental weather data are available for this area. Records taken from 1948-1986 at CARE headquarters in Fruita (1670 m [5500 ft]) indicate a mean annual precipitation of 18 cm (7.2 in), with 30% falling in July and August. Annual precipitation is estimated to be about 12.5 cm (5 in) at the lowest elevations along Halls Creek, and about 30 cm (12 in) at the highest elevations in upper Deep Creek. An important reason for the generally low precipitation throughout CARE is the location of the Waterpocket Fold within an apparent rain shadow of the high Aquarius Plateau lying to the west (Everitt 1970).

The seasonal distribution of precipitation is bimodal in this region, with peaks in winter and late summer (Everitt 1970). Much of the rainfall during July and August comes as sudden cloudbursts which can cause devastating floods along desert washes (Woolley 1947). Winter precipitation generally is more gentle and prolonged; a larger fraction of this water percolates into the soil and supports plant growth the following summer.

At the lower elevations, maximum temperatures in the summer frequently exceed 38 degrees C (100 degrees F) (Smith et al. 1963). Summer temperatures at higher elevations in the park are more moderate (Park Service data). Winter temperatures throughout the park are typically cool to cold, with freezing temperatures sometimes lasting several days. Freezing can occur as late as May or as early as September. Park records indicate an average January minimum at Fruita of -8 C (18 F) and an average July maximum of 33 C (92 F).

West (1983a, 1983b; Charley and West 1975) has constructed climate diagrams for several stations in southern Utah which have generally similar climatic conditions as those of CARE. These analyses show that in the lower elevations, potential evapotranspiration exceeds precipitation throughout most of the

growing season, indicating severe and sustained drought stress for plants. High soil temperatures also create severe conditions for plant growth: Wein and West (1972) measured soil surface temperatures >60 degrees C in July at a semi-desert site near Cisco, Utah. Such temperatures exceed the recognized upper limit of tolerance for most plant tissues. Early spring probably is the only time when moisture and temperature conditions are consistently favorable for plant growth at low elevations in CARE. The climate diagrams indicate that higher elevations also have a pronounced precipitation deficit in early summer, but late summer "monsoon" showers may provide sufficient moisture to match evaporative demands, at least in some years.

#### Specific Objectives

1. To complete an annotated list of vascular plant species in Capitol Reef National Park, identifying special status, general location, abundance, habitat, geology, special use information, and elevation.
2. To develop a plant community classification system by use of multivariate analysis.
3. To describe major vegetation patterns by means of direct gradient analysis, and to assess some of the effects of livestock grazing on grassland and riparian plant communities.

## Methods

### Inventory of Vascular Plants

To develop a complete vascular plant flora for the park, it was necessary to systematically inventory all of the kinds of habitats present at various times during the growing season. This was accomplished by establishing a series of transects extending from east to west across the park. The transects were located at intervals of one to several kilometers, depending on accessibility and variability of habitats within specific areas. Additional transects were established to reach special habitats not included in the east-west transects, and in the final year of field

work we located several sampling points in areas between the transects to sample the full range of environmental gradients within the park.

We walked each of these transects at least once early and late in the growing season, sampled the plant communities at each place where substrate, elevation, or topography changed substantially, and collected voucher specimens of the vascular plants. In this way we inventoried the vascular flora over the entire range of elevations, geologic substrates, and topographic features represented in the park,



throughout the growing season (April - October) during three years (1986, 1987, 1988). Voucher specimens were deposited in the herbaria at Brigham Young University (BYU), San Juan College (SJNM), and Capitol Reef National Park.

#### **Inventory of Threatened and Endangered Taxa**

Prior to field investigations, we reviewed the taxa listed by the USFWS as threatened, endangered and/or sensitive plant species (F.R. 50[188]:39526-39584) to compile a list of those taxa which were known from or near the park (Welsh and Chatterly 1985, Welsh 1978, Welsh et al. 1975, Welsh and Thorn 1978). This initial list included species which were documented from the park as well as species reported near enough that there was a potential that they may occur in the park. We also used the herbarium at Brigham Young University to locate previously documented populations of species on the USFWS list which were known to be in or near the park. The herbarium also provided information regarding blooming and fruiting periods of each species.

We then visited known localities of threatened, endangered and/or sensitive plant species during the respective blooming periods to become familiar with both reproductive and vegetative characteristics of the plants. During these visits, we took photographs and characterized the habitat (elevation, substrate, topographic position, slope, aspect, associated species). This habitat information helped us to recognize similar areas along our sampling transects (described in the previous section) where previously unreported populations of rare plants might be located.

We searched for rare plants along our sampling transects (described above) throughout the three field seasons of 1986, 1987, and 1988. Wherever threatened, endangered and/or sensitive plant species were encountered, we recorded the location on USGS topographic maps, habitat characteristics, number of plants, any apparent or potential threats, and areal extent of the population.

#### **Habitat Relationships of Rare Plants**

The possible affinity of each rare plant taxon for a particular geologic substrate(s) was

examined in two ways. First, we constructed a matrix of correlations between presence/absence of a given taxon and geologic substrate, based on our field inventory data. (At each site where we found a population of rare plants, we recorded the geologic substrate and other habitat information.) Secondly, we ordinated the same data by means of principal component analysis (Gauch 1981). Ordination is a multivariate technique of indirect gradient analysis that reveals the relative similarity and dissimilarity among sampling units, in this case geologic formations.

#### **Field Sampling of Community Composition**

Because of the large study area, the rugged and often barely accessible terrain, and the diversity of species and habitats present, we adopted a rapid field sampling technique emphasizing semi-quantitative, releve information (Mueller-Dombois and Ellenberg 1974). With this approach we sacrificed some precision and accuracy in our measurements, but it was the only feasible way to sample the vegetation of the entire park within a reasonable time frame. It did provide adequate data for construction of a broad-scale classification and analysis of plant communities over the entire park. Future studies of finer-scale patterns within some of the community types that we have identified may be more appropriately conducted using more intensive quadrat or transect sampling techniques.

We sampled a total of 344 stands during the field seasons (April-October) of 1986, 1987, and 1988. Stands were located along the sampling transects that we established to inventory the vascular flora (described above). Before going into the field, we selected the general locations where we wished to sample by studying USGS topographical maps and geology maps (Billingsley et al. 1987) and identifying areas that would represent the entire range of variation in elevation and geologic substrate within CARE. When we reached one of these general areas in the field, we then selected a representative portion of it, established a sample stand, and recorded its exact position on a 15-minute topographic map. Each stand was an area of approximately 100 square meters (usually about 10m x 10m)

within which the environment and the vegetation appeared more or less homogeneous. Stand borders were not staked or measured precisely, but were selected visually before sampling began.

In each stand we first recorded all vascular plant species present. Then, we visually estimated the proportion of total plant biomass contributed by each species using five categories: 1-5%, 6-25%, 26-50%, 51-75%, and 76-100%. (The releve method commonly employs estimates of percent ground cover of each species, but we based our sampling on percent of total biomass present in order to better capture the dominance of the large trees and shrubs in sites where these growth forms were present.) We also noted species growing in the general area but not present within the borders of the stand. Finally, we recorded slope, aspect, elevation, geological substrate, topographic position, and other general information for each stand. Recent grazing intensity was estimated visually on the basis of livestock scat and tracks, and categorized as none, light, moderate, or heavy. Any other kinds of disturbance, e.g., recent fire, also were noted.

### Community Classification

The species abundance data were subjected to cluster analysis using TWINSPLAN (Cornell Ecology Programs, Gauch 1981) on the VAX computer at Fort Lewis College. This is a hierarchical, polythetic, divisive method of classification. The program produced 30 clusters after 7 divisions. Next we evaluated the floristic composition and environmental characteristics of the individual stands within each cluster. Most of the clusters represented more or less distinctive and easily recognizable species assemblages, and these were then regarded as community types in our classification. We combined some clusters to produce a single community type because of their apparent physiognomic and floristic similarity. We also divided some clusters into more than one community type because of differences in dominant species, growth forms, or environmental conditions that were conspicuous in the field even though they did not have a strong effect in the clustering process. Our

intent was not to produce a purely objective community classification, but to create a practical classification composed of a reasonable number of types that are easily recognizable in the field and can be used by managers and future researchers. The final result was our classification system containing 34 community types (see Results section).

### Gradient Analysis of the Vegetation

To unravel the effects of environmental variation and disturbance on the composition of the vegetation, we employed direct gradient analysis. Because our community composition data assigned each plant species to an abundance class (i.e., 1-5% or 6-25%, etc.) we could not directly compare the actual abundance of each species or group of species among different stands. Instead, we used three modified gradient analysis techniques for comparison.

First, for some analyses, e.g., total percent cover of grasses in grasslands along gradients of elevation, soil type, and grazing intensity, we calculated a minimum total grass cover for each stand. This was accomplished by taking the minimum value of the abundance class for each grass species, summing these values, and then determining into which abundance class the sum fit. For example, if a stand contained two species with abundance class 2 plus two species with abundance class 3, the sum of minimum values would be  $1+1+6+6=14$ . A value of 14 falls within abundance class 3, so the minimum total cover of grass species within this stand would be abundance class 3. Although this approach was conservative and insensitive to subtle differences among stands, it did reveal several large differences in vegetation composition that could be explained in terms of environmental gradients and/or disturbance history.

Our second technique of direct gradient analysis was to determine the proportion of sampled stands that fell into each of several categories of interest. For example, we calculated the percent of pinyon-juniper stands in which pinyon had a higher abundance rank than juniper, in which juniper had a higher rank than pinyon, and in which their abundance ranks were equal. Again,

this method was insensitive to subtle differences, but it did reveal major trends.

Finally, we plotted locations of stands representing each community type along axes of elevation and relative soil moisture (a function of substrate) to depict the distribution of plant communities along the two major controlling gradients in the park, viz., elevation and substrate.

### Vegetation Mapping

A vegetation map was produced using the park's geographical information system (GIS).

The gradient analysis of the vegetation revealed strong correlations between community types and combinations of elevation, geologic substrate, slope, aspect, and topographic position. Therefore, Boolean analysis program was used to identify all locations within the park where each particular combination of environmental conditions occur; these areas then were classified as the appropriate community type within a new map of vegetation. See Romme et al. (1993) for details on producing the vegetation map.

## Results

### Vascular Flora

To date, 759 species in 352 genera and 86 families are known from Capitol Reef National Park, based on our inventory as well as previous studies. The total number of specific and infraspecific taxa is 806. We found 316 previously unreported taxa in the park. The largest plant families were the Gramineae and Compositae, with 105 and 155 taxa respectively. In contrast, several families were represented by only one species (e.g., Selaginellaceae, Cannabinaceae, Lentibulariaceae, and Commelinaceae).

An annotated checklist of vascular plants is provided in Appendix I. This list includes information on general distribution, elevational range, and plant community(s) for each taxon listed. Nomenclature follows Welsh et al. (1987) for the most part, though in some instances Cronquist et al. (1972, 1977, 1984) was followed. A total of 432 new plant specimens were deposited in CARE's herbarium.

### Threatened and Endangered Taxa

New distributional records produced by our inventory indicate that an additional 19 taxa included in the Review of Plant Taxa for Listing as Endangered or Threatened Species, by the U. S. Fish and Wildlife Service (Federal Register 50[188]:39526-39584; F. R. 55[35]:6184-6229) are found in CARE (Table 1). This brings to 36 the total number of species in CARE

currently listed with the USFWS. Although this is a sizable number of taxa, it represents only about 4.6% of the park's total vascular flora.

Four of these taxa have been designated as endangered species. Two of the endangered taxa, *Echinocereus triglochidiatus* var. *inermis* and *Cycladenia humilis* var. *jonesii*, are known from single localities in CARE; however, they are also known from a few populations quite distant from the park in Utah and Colorado. The remaining two, *Sclerocactus wrightiae*, and *Erigeron maguirei* var. *maguirei*, while local and restricted in distribution within the park, are represented by numerous occurrences within CARE.

One species, *Townsendia aprica*, is classified as threatened. We found it to be somewhat more common than prior accounts indicated, with populations scattered from Upper Cathedral Valley to the Hartnet, at Upper Deep Creek, and overlooking the Fremont River near Miners Mountain. Aside from these populations in CARE, the only other known locations are north of the park in the San Rafael Swell.

In addition to the officially listed endangered and threatened taxa, ten other taxa in CARE are federal candidates, of which four are classified as Category 1 taxa and should be officially listed as either endangered or threatened within the near future. These four



include *Gilia caespitosa*, *Pediocactus winkleri*, *Spiranthes diluvialis*, and *Schoenocranbe barnebyi*. Finally, 21 additional taxa are classified as 3C.

### Habitats of Rare Plant Species

We found several key locations in CARE (Figure 1) that contained large concentrations of rare plant taxa, including upper Deep Creek (8 taxa), the Hartnet area (6 taxa), the Hickman Bridge area (6 taxa), Deep Creek in the Water-pocket Fold (5 taxa), and Miners Mountain (5 taxa). The southern portion of the park, south of Bitter Creek Divide, apparently supports fewer taxa of concern than an equivalent area in the northern part of the park (Table 2).

To further examine this pattern in rare plant distribution, we examined two arbitrarily selected sets of seven areas on the map, each area comprising two square miles. All of the areas in one set were located north of the Bitter Creek Divide, and all in the other set were located south of the Divide. We found a significant difference ( $\alpha < 0.05$ ) between the number of rare plants within comparable areas north and south of Bitter Creek Divide (Figure 2).

Of the 36 taxa of concern, only 14 are apparently restricted to a single geological formation (Table 3). Seven of these 14 are associated with Quaternary formations, either alluvial, colluvial, pediment, or eolian deposits. However, certain groups of petrologically similar geologic formations tend to support similar assemblages of rare plants. Table 4 shows the correlations of geologic formations based on the occurrence of rare plants on these formations. High correlations occur between Navajo, Kayenta and Wingate formations. This indicates that those taxa of concern associated with any one of these predominantly sandstone formations (e.g., Navajo) are likely to be found on the other two as well (e.g., Kayenta and Wingate). Significant correlations also exist between the Summer-ville and Entrada Formations, which contain mostly clays, mudstones, and siltstones in CARE.

These relationships among geologic substrates also were demonstrated in the principle component analysis (PCA) ordination. Figure 3 shows the first three principle

components, which represent approximately 50% of the variance in the data. Habitats underlain by the Kayenta, Wingate, Navajo, Kaibab, and Cutler Formations — all of which produce relatively coarse textured soils — support similar taxa of rare plants. Habitats underlain by the finer textured Mancos, Curtis, Entrada, Summerville, and Moenkopi Formations support a different group of rare plant taxa. The Quaternary geologic substrates were isolated in the ordination space, indicating that they were floristically dissimilar from either the coarse-textured or the fine-textured groups. This probably is because several rare plant taxa are found exclusively on Quaternary alluvial deposits, and also because several species from both of the other major groups are found on Quaternary alluvium as well. The rare plants from the Chinle, Morrison, and Carmel Formations were not strongly associated with those of any other formations.

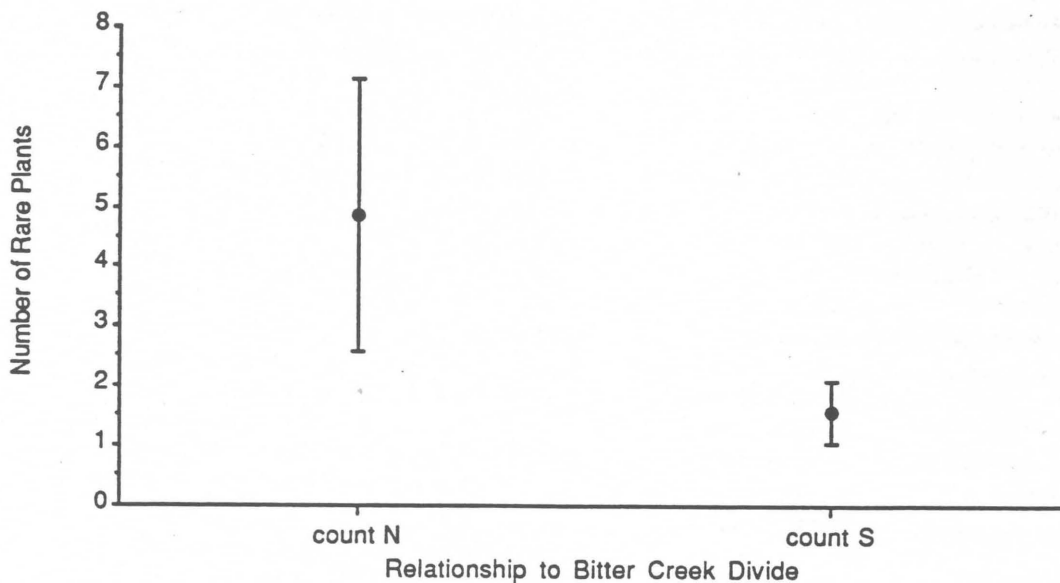
### Plant Community Classification

We identified 34 plant community types within the park, plus several phases within some community types (Table 5). The vegetation in CARE appears to be a continuum rather than a series of discrete units, except where underlying physical factors, such as soil texture or moisture, change abruptly. Continuously varying vegetation still can be classified, but it must be recognized that some of our distinctions are more or less arbitrary.

We define a community as a more or less unique and repeated assemblage of plant species occupying sites characterized by a more or less unique combination of elevation and soil texture conditions. A phase is a recognizable subunit of a community type, characterized by a somewhat unusual assemblage of species and occupying a portion of the usual habitat for that community type with no recognizably unique environmental conditions. Phases may reflect subtle, unrecognized patterns in underlying environmental gradients; or unique historical events of dispersal, establishment, or disturbance; or both. They cannot be mapped reliably, but they contribute to the park's biological diversity, and so are included in this classification. Romme et al. (1993) provide a dichotomous

**Table 2.** Key locations of endangered, threatened and other plants of concern in Capitol Reef National Park (see Table 1 for a list of these species and a summary of their status according to the U.S. Fish and Wildlife Service). Each location represents an area of approximately two square miles and the number of rare species found therein. Many individual species are found in more than one location. The division of the park into northern (N) and southern (S) regions coincides with a natural divide (Bitter Creek Divide) but is otherwise arbitrary.

Location	Number of Species	North or South
Miners Mountain	5	N
Upper Deep Creek	8	N
Deep Creek on the Fold	5	N
The Hartnett	6	N
Cathedral Valley	3	N
Paradise Flats	1	N
Hickman Bridge	6	N
4 mi. S of Bitter Creek Divide	2	S
Halls Narrows	1	S
Below Burr Trail	2	S
The Post	2	S
Red Slide	1	S
Wagon Box Mesa	1	S
Top of Burr Trail	2	S



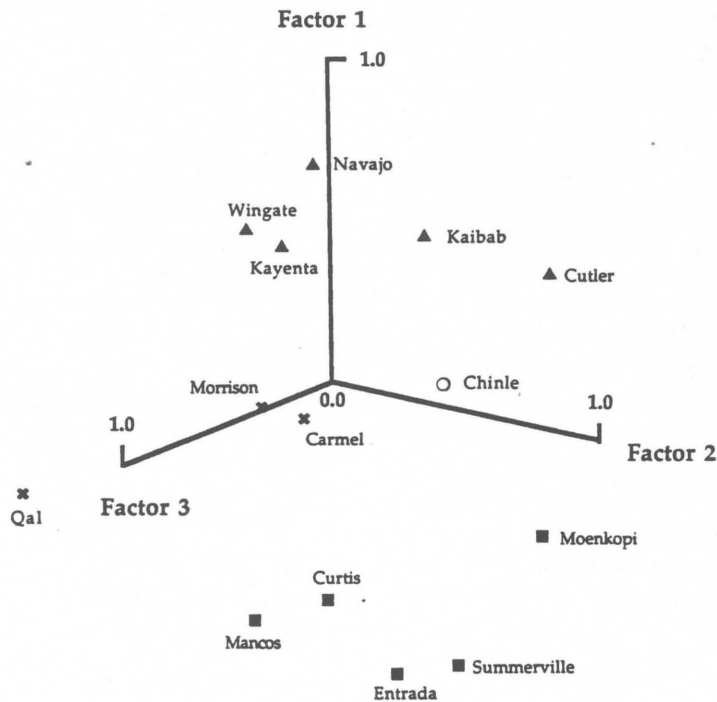
**Figure 2.** Relative abundance of rare plant taxa north and south of the Bitter Creek Divide in Capitol Reef National Park. Vertical lines are  $\pm 1$  standard deviation.

**Table 3.** Geologic substrates associated with species which appear on federal lists of threatened, endangered, candidate species and species no longer candidates for listing. The asterisk indicates the geologic formation on which the species is most often associated (if any), when it is found on multiple substrates.

<i>Cycladenia humilis</i> var. <i>jonesii</i>	(E)	Chinle
<i>Echinocereus triglochidiatus</i> var. <i>inermis</i>	(E)	Qal
<i>Erigeron maguirei</i> var. <i>maguirei</i>	(E)	Navajo, Cutler
<i>Sclerocactus wrightiae</i>	(E)	Entrada, Mancos*, Summerville, Qal
<i>Townsendia aprica</i>	(T)	Cutler, Entrada, Moenkopi, Summerville
<i>Gilia caespitosa</i>	(1)	Kayenta, Navajo*, Carmel
<i>Pediocactus winkleri</i>	(1)	Summerville*, Entrada, Carmel
<i>Schoenrambe barnebyi</i>	(1)	Moenkopi*, Chinle, Cutler
<i>Spiranthes diluvialis</i>	(1)	Qal
<i>Cymopterus beckii</i>	(2)	Navajo, Kayenta, Wingate, Cutler
<i>Dalea flavescens</i> var. <i>epica</i>	(2)	Qal
<i>Erigeron maguirei</i> var. <i>harrisonii</i>	(2)	Kayenta, Navajo
<i>Habenaria zothecina</i>	(2)	Qal
<i>Hymenoxys depressa</i>	(2)	Entrada, Summerville, Curtis, Mancos
<i>Thelesperma subnuda</i> var. <i>alpina</i>	(2)	Carmel
<i>Asclepias ruthiae</i>	(3c)	Entrada, Qal
<i>Astragalus barnebyi</i>	(3c)	Morrison
<i>Astragalus chamaeluce</i> var. <i>laccoliticus</i>	(*)	Mancos*, Qal
<i>Astragalus consobrinus</i>	(3c)	Kayenta, Entrada, Moenkopi, Summerville, Qal
<i>Astragalus harrisonii</i>	(3c)	Kayenta, Navajo, Wingate, Qal
<i>Astragalus malacoides</i>	(3c)	Mancos, Moenkopi, Qal
<i>Astragalus pardalinus</i>	(3c)	Entrada*, Qal
<i>Astragalus woodruffii</i>	(3c)	Entrada, Summerville, Qal
<i>Castilleja scabrida</i>	(3c)	Kayenta, Navajo, Wingate, Qal
<i>Chamaecharis scaposa</i>	(3c)	Entrada, Moenkopi
<i>Cryptantha johnstonii</i>	(3c)	Carmel
<i>Erigeron abajoensis</i>	(3c)	Navajo*, Cutler
<i>Eriogonum corymbosum revealianum</i>	(3c)	Carmel, Qal
<i>Eriogonum tumulosum</i>	(3c)	Moenkopi, Summerville
<i>Geranium marginale</i>	(3c)	Qal
<i>Lomatium junceum</i>	(3c)	Moenkopi
<i>Nama retorsum</i>	(3c)	Qal
<i>Parthenium ligulatum</i>	(3c)	Entrada, Moenkopi, Summerville
<i>Peteria thompsonii</i>	(3c)	Entrada, Qal
<i>Physaria acutifolia</i> var. <i>purpurea</i>	(3c)	Carmel
<i>Xylorhiza confertifolia</i>	(3c)	Chinle

**Table 4.** Matrix of correlations among geologic formations in relation to the presence of rare plants (those on federal lists; see Table 1) at CARE.

	Morri- son	Curtis	Kaibab	Chinle	Win- gate	Mancos	Cutler	Carmel	Kay- enta	Navajo	Moen-Summer- kopi ville	En- trada	Qal	
Curtis	-0.028	1.000												
Kaibab	-0.040	-0.040	1.000											
Chinle	-0.050	-0.050	-0.071	1.000										
Wingate	-0.050	-0.050	0.367	-0.088	1.000									
Mancos	-0.058	0.497	-0.083	-0.103	-0.103	1.000								
Cutler	-0.066	-0.066	0.605	0.172	0.172	-0.138	1.000							
Carmel	-0.073	-0.073	-0.105	-0.131	-0.131	-0.153	-0.174	1.000						
Kayenta	-0.073	-0.073	0.219	-0.131	0.675	-0.153	0.041	0.005	1.000					
Navajo	-0.081	-0.081	0.495	-0.143	0.615	-0.168	0.415	-0.025	0.724	1.000				
Moenkopi	-0.088	-0.088	-0.126	0.085	-0.156	0.029	0.176	-0.231	-0.053	-0.254	1.000			
Summerville	-0.088	0.317	-0.126	-0.156	-0.156	0.240	-0.016	-0.053	-0.053	-0.254	0.362	1.000		
Entrada	-0.108	0.256	-0.155	-0.193	-0.193	0.154	-0.084	-0.126	-0.126	-0.314	0.233	0.664	1.000	
Qal	-0.154	-0.154	-0.220	-0.274	0.124	0.203	-0.364	-0.258	-0.111	-0.168	-0.352	-0.221	-0.006	1.000



**Figure 3.** Principal component ordination (PCA) of stands containing rare plant taxa in relation to geologic substrate in Capitol Reef National Park. Factor 1 represents 22.7% of the variance, factor 2 represents 14.8%, and factor 3 represents 13.0% of the variance. Substrates producing coarse textured soils are depicted with a triangle; those with fine textured soils are depicted with a square. Substrates depicted with an "x" or a circle produce a variety of soil textures, and are largely uncorrelated with the three axes.



**Table 5.** Summary of community types and phases in Capitol Reef National Park. See text for definitions of community types and phases, and Appendix I for more detailed descriptions.

A. Badlands Communities	D3a. Cushion Plant Phase
A1. Bentonite Badlands Community	D3b. Galleta Phase
A2. Hopsage Badlands Community	D3c. Pygmy Sagebrush Phase
A3. Mat Saltbush Community	D4. Pinyon-Juniper-Tall Shrub Community
A3a. Shrub Phase	D5. Dwarf Mountain-Mahogany Slickrock Community
A3b. Grassland Phase	
A3c. Buckwheat Phase	
A4. Gypsum Badlands Community	
B. Grassland Communities	E. Upland Forest and Woodland Communities
B1. Shadscale-Grassland Community	E1. Bristlecone Pine-Cushion Plant Community
B2. Eolian Grassland Community	E2. Ponderosa Pine-Bitterbrush Woodland Community
B3. Mixed Grassland Community	E2a. Mountain-Mahogany Phase
	E3. Ponderosa Pine-Manzanita Woodland Community
C. Upland Shrub Communities	E4. Mesic Montane Woodland Community
C1. Eolian Shrub Community	E5. Aspen Woodland Community
C1a. Blackbrush-Mormon Tea Phase	
C1b. Sand Sagebrush Phase	
C2. Blackbrush-Rabbitbrush Community	F. Riparian and Wetland Communities
C3. Intermittent Riparian Shrub Community	F1. Cottonwood-Rabbitbrush Woodland Community
C3a. Greasewood-Rabbitbrush Phase	F2. Waterpocket Community
C3b. Fourwing Saltbush-Rabbitbrush Phase	F3. Cottonwood-Willow Riparian Woodland Community
C3c. Big Sagebrush Phase	F3a. Reed Phase
C4. Low Shrub Community	F3b. Baltic Rush Phase
C5. Dry Canyonbottom Shrub Community	F4. Alder-Birch Riparian Community
C6. Mesic Canyonbottom Shrub Community	F5. Dogwood-Spruce Riparian Woodland Community
C7. Sagebrush-Bitterbrush Community	F6. Hanging Garden Community
D. Pinyon-Juniper Woodland Communities	F7. Hornbeam-Box Elder-Oak Woodland Community
D1. Pinyon-Juniper-Grass Community	F8. Cultivated Orchards and Settlements
D2. Juniper-Mormon Tea Community	F9. Perennial Wetland Community
D3. Pinyon-Juniper-Low Shrub Community	

key for identification of plant communities in CARE, plus a detailed description of each community type and phase, in terms of species composition, associated environmental conditions, and major responses to disturbances.

The community classification that we produced is a synthesis of the objective results of the cluster analysis and our more intuitive field experience with the park's vegetation. In general, the clusters produced by the objective analysis coincided nicely with the vegetation units that we perceived in the field. Several clusters that were very distinct in the objective analysis appeared far less distinct in the field, and so they were combined with other, similar-appearing groups in the final classification. The cluster analysis also drew attention to a few

distinct assemblages of species that we had not previously recognized in the field, but that were quite apparent when we looked for them.

#### Gradient Analysis of the Vegetation

The major abiotic variables controlling the distribution and composition of plant communities in CARE are elevation and geologic substrate. Disturbance by livestock grazing, both past and present, also modifies the vegetation. We analyzed each of these factors separately, and then looked for interactions among them, as presented below.

#### Elevational Patterns

We examined vegetational changes along an elevational gradient within our sample

stands classified as pinyon-juniper woodland and as grassland communities. All community-types varied with elevation, but these were the communities for which we had an adequate sample size to uncover the details of the patterns. We aggregated all six of the pinyon-juniper types (i.e., pinyon-juniper-grass, juniper-Mormon tea, juniper-saltbush, pinyon-juniper-low shrub, pinyon-juniper-tall shrub, and dwarf mountain mahogany slickrock communities) for this analysis; and similarly aggregated all three grassland types (i.e., shadscale grassland, eolian grassland, and mixed grassland communities).

The relative abundance of *Pinus edulis* and *Juniperus osteosperma* varied with elevation (Figure 4). Generally, juniper was dominant in stands at lower elevations, especially those below 1700 m (5600 feet), and pinyon was dominant in stands at the highest elevations, especially above 2120 m (7000 feet). Between 1700-2120 m, there was a mixture of dominance patterns, reflecting the influence of other

variables, e.g., substrate (see below). These results are consistent with those reported elsewhere in the southwestern USA (Woodin and Lindsey 1954, Tueller et al. 1979, Pieper and Lymbery 1987).

The minimum total grass cover in grassland communities generally increased with elevation (Figure 5). For this analysis we examined only ungrazed and lightly grazed stands, since grazing also influences grass cover (see below). The progressively greater cover of graminoid species with increasing elevation is probably due to the increasing quantity and reliability of precipitation at higher elevations.

#### Substrate Patterns

Geologic substrate had an important influence on the relative abundance of *Pinus edulis* and *Juniperus osteosperma* in pinyon-juniper woodlands located between 1700-2120 m (Figure 6). Generally, juniper was more

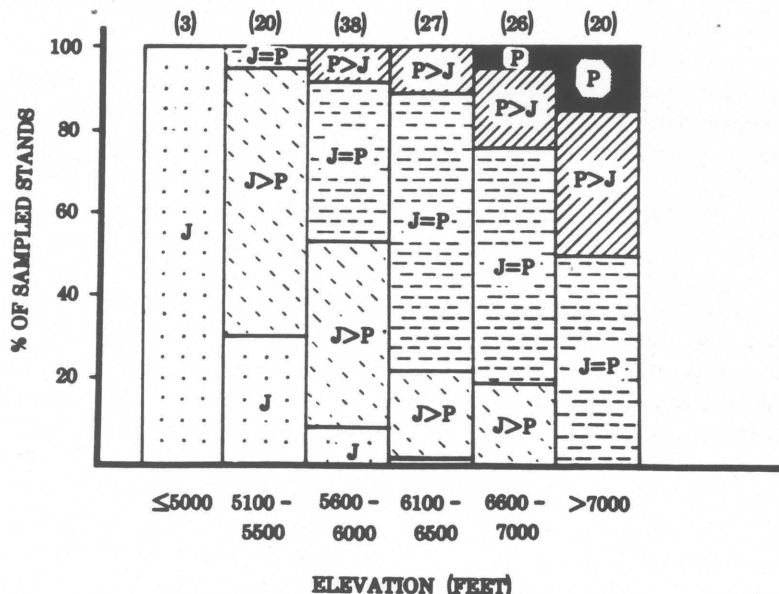
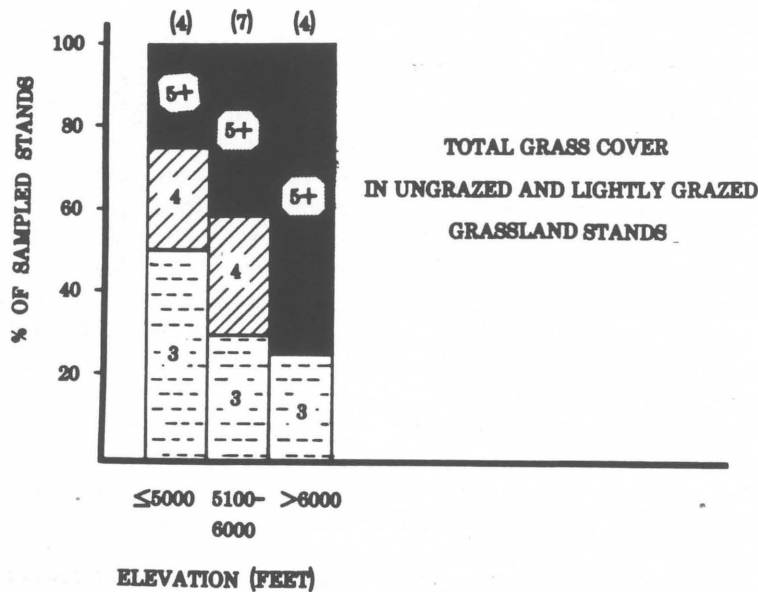


Figure 4. Compositional patterns in pinyon-juniper woodlands in relation to elevation in Capitol Reef National Park. "J" indicates that juniper (*Juniperus osteosperma*) is the only one of the two species present; "J>P" indicates that juniper is more abundant than pinyon (*Pinus edulis*); "J=P" indicates that pinyon and juniper are roughly equal in abundance; "P>J" indicates that pinyon is more abundant than juniper; and "P" indicates that pinyon is the only one of the two species present. The numbers in parentheses at the top represent the number of sampled stands in each elevational class.



**Figure 5.** Patterns in minimum total grass cover within grassland stands along an elevational gradient in Capitol Reef National Park. "3" depicts plant cover class 3 (26-50%) in our releve samples; "4" depicts cover class 4 (51-75%); and "5" depicts cover class 5 (76-100%). The numbers in parentheses at the top are the number of sampled stands in each elevation class. This analysis was restricted to ungrazed and lightly grazed stands only.

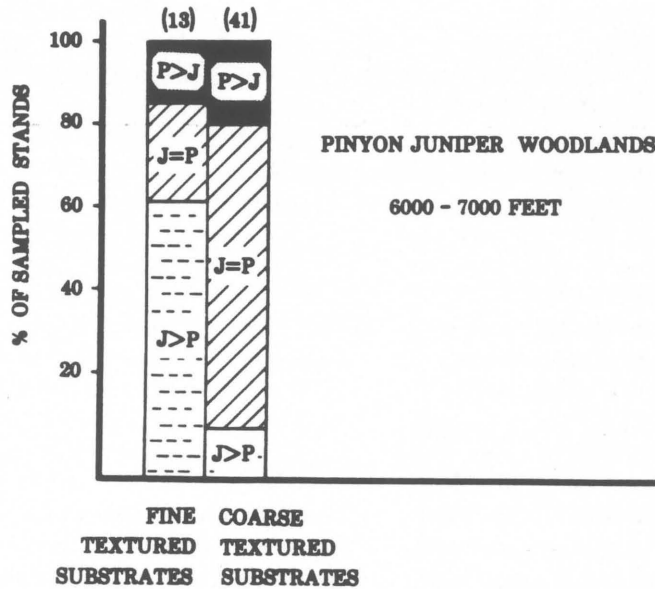
abundant than pinyon on fine-textured substrates (clays, siltstones, mudstones), whereas the two species were roughly equal or pinyon was dominant on coarse-textured substrates (sandstones, colluvium). This pattern is consistent with the elevational pattern reported above, in that drought stress is generally greater both at lower elevations and in finer textured soils. These results indicate that juniper has greater drought tolerance than pinyon. Everitt (1970:91) reported that the lower elevational limit of pinyon-juniper vegetation in the Henry Mountains several km east of CARE was dependant on geological substrate: the lower limit was approximately 1515 m (5000 ft) on coarse-textured soils developing from indurated sandstones, approximately 1820 m (6000 ft) in shallow gravels overlying porphyry, and approximately 2120 m (7000 ft) on fine-textured soils developing from Mancos shales.

Geologic substrate also influenced minimum total grass cover in grassland communi-

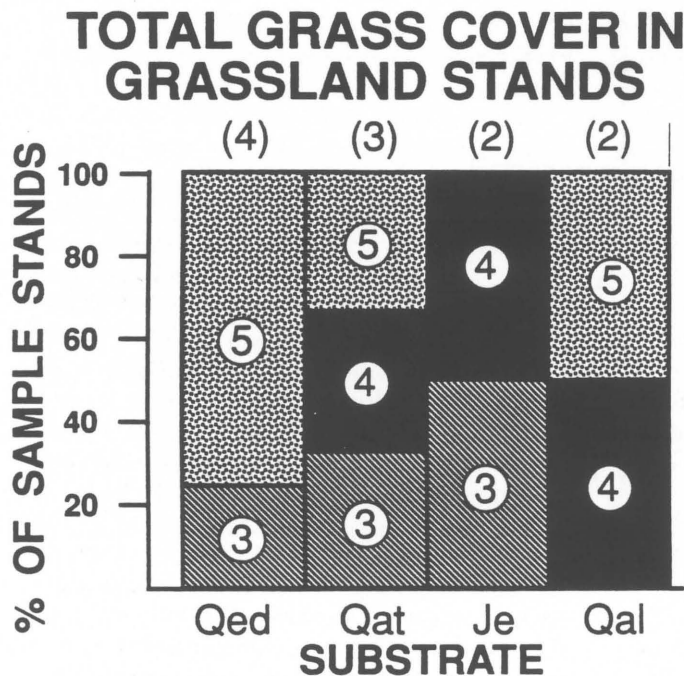
ties (Figure 7). This analysis was done only with ungrazed and lightly grazed stands to eliminate grazing interactions. Relatively sandy soils developing in eolian and alluvial substrates generally supported a higher cover of graminoids than finer textured soils developing in terrace gravel deposits and Entrada sandstone. This may be because sandy soils most effectively retain the moisture from intermittent summer rain showers within the upper portion of the soil profile where most of the roots of the grasses are located.

#### Community Patterns

We examined patterns in species richness by calculating the mean, standard deviation, and range in number of species listed for each stand classified within a particular community type or phase. There was a surprising similarity in richness among many community types; mean number of species per stand was between 20 and 30 in 21 of the 36 community types and phases (Figure 8). The richest

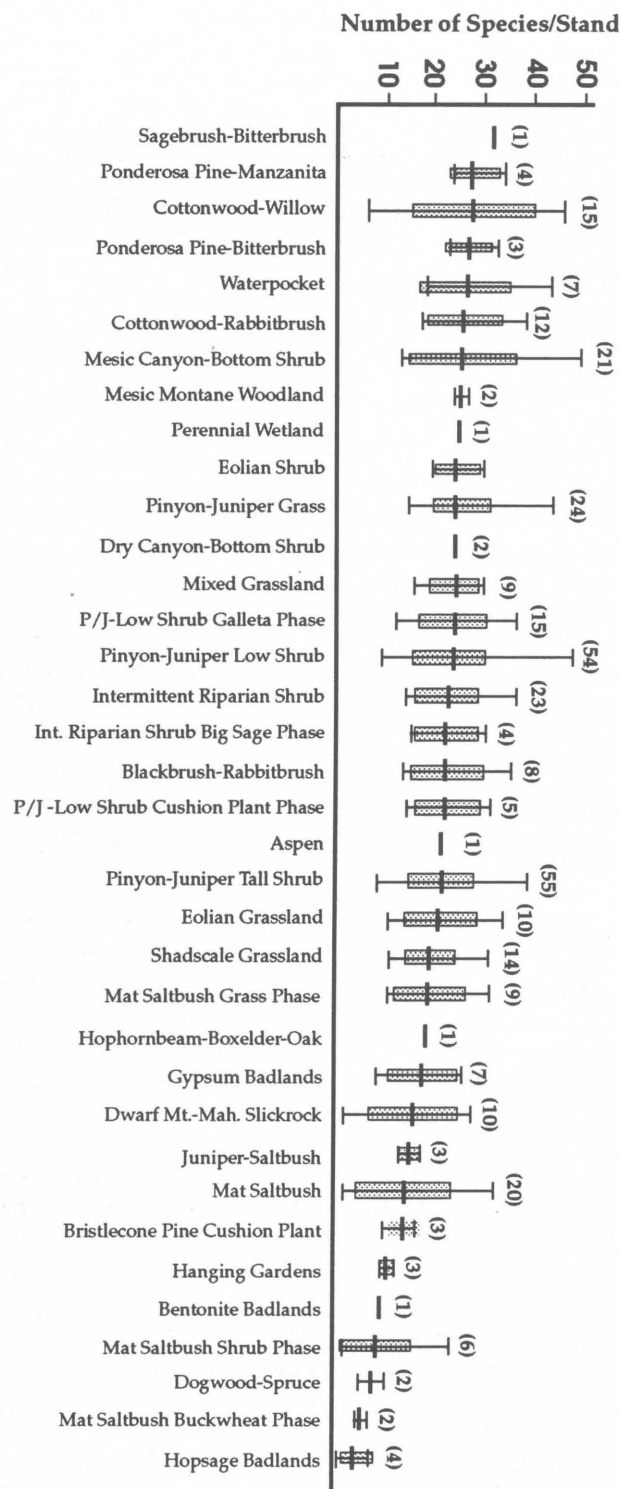


**Figure 6.** Compositional patterns in pinyon-juniper woodlands in relation to geologic substrate in Capitol Reef National Park. "J" indicates that juniper (*Juniperus osteosperma*) is the only one of the two species present; "J>P" indicates that juniper is more abundant than pinyon (*Pinus edulis*); "J=P" indicates that pinyon and juniper are roughly equal in abundance; "P>J" indicates that pinyon is more abundant than juniper; and "P" indicates that pinyon is the only one of the two species present. The numbers in parentheses at the top represent the number of sampled stands in each elevational class. This analysis was restricted to stands at 6000-7000 feet (1820-2120 m), which is the elevational zone where pinyon and juniper are roughly equal in abundance.



**Figure 7.** Patterns in minimum total grass cover in relation to geologic substrate in grassland stands in Capitol Reef National Park. "3" depicts plant cover class 3 (26-50%) in our releve samples; "4" depicts cover class 4 (51-75%); and "5" depicts cover class 5 (76-100%). The numbers in parentheses at the top are the number of sampled stands in each elevation class. This analysis was restricted to ungrazed and lightly grazed stands only. Qed=Quaternary eolian deposits; Qat=Quaternary terrace gravel deposits; Je=Entrada formation; Qal=Quaternary alluvium.





**Figure 8.** Patterns in species richness among plant community types in Capitol Reef National Park. Horizontal lines represent the mean and range, and shaded areas represent one standard deviation, of the number of vascular plant species recorded in our releve plots of approximately 100 square meters area. Numbers in parentheses indicate the number of sampled stands within each community type.

communities included the ponderosa pine types, various riparian types, and pinyon-juniper woodland types. Generally, richness was higher in those communities subjected to less drought stress, i.e., those at higher elevations or in well watered habitats at low elevations. Lowest richness generally was found in the various badlands community types which are subjected to regular and severe drought stress, sometimes in combination with high soil temperatures and salinity.

There were some apparent exceptions to the generalizations in the previous paragraph. Hanging gardens and the dogwood-spruce community—both located in habitats with a perennial water supply—were among the least rich communities; and the highest mean richness was in the xeric-appearing sagebrush-bitterbrush community. These seemingly disparate results may be simply an artifact of small sample size. Alternatively, they may reflect other unrecognized processes that influence richness and community structure.

The relatively high richness in the pinyon-juniper types was somewhat surprising, since these communities occupy only an intermediate position in the elevational moisture gradient. However, pinyon-juniper woodlands usually are found in habitats characterized by deep, coarse textured soils or shallow soils over fractured bedrock, e.g., in sandstones and colluvium. These kinds of soils provide deep soil moisture which can be reached by the roots of woody shrubs and trees, thus ameliorating the adverse effects of relatively low total precipitation (Everitt 1970, Loope 1977). Thus, pinyon-juniper woodlands in CARE actually can be viewed as occupying comparatively mesic habitats.

The various community types and phases differed greatly in the degree to which they have been affected by past and present livestock grazing (Figure 9). Generally, the most affected communities were those characterized by gentle topography, easy accessibility, and lower elevations. The most heavily grazed community types include the various grassland communities, and both intermittent and perennial riparian communities at low elevations. The communities least affected by grazing were those characterized by steep and rocky habitats, lack of accessibility, or very little palatable vegetation.

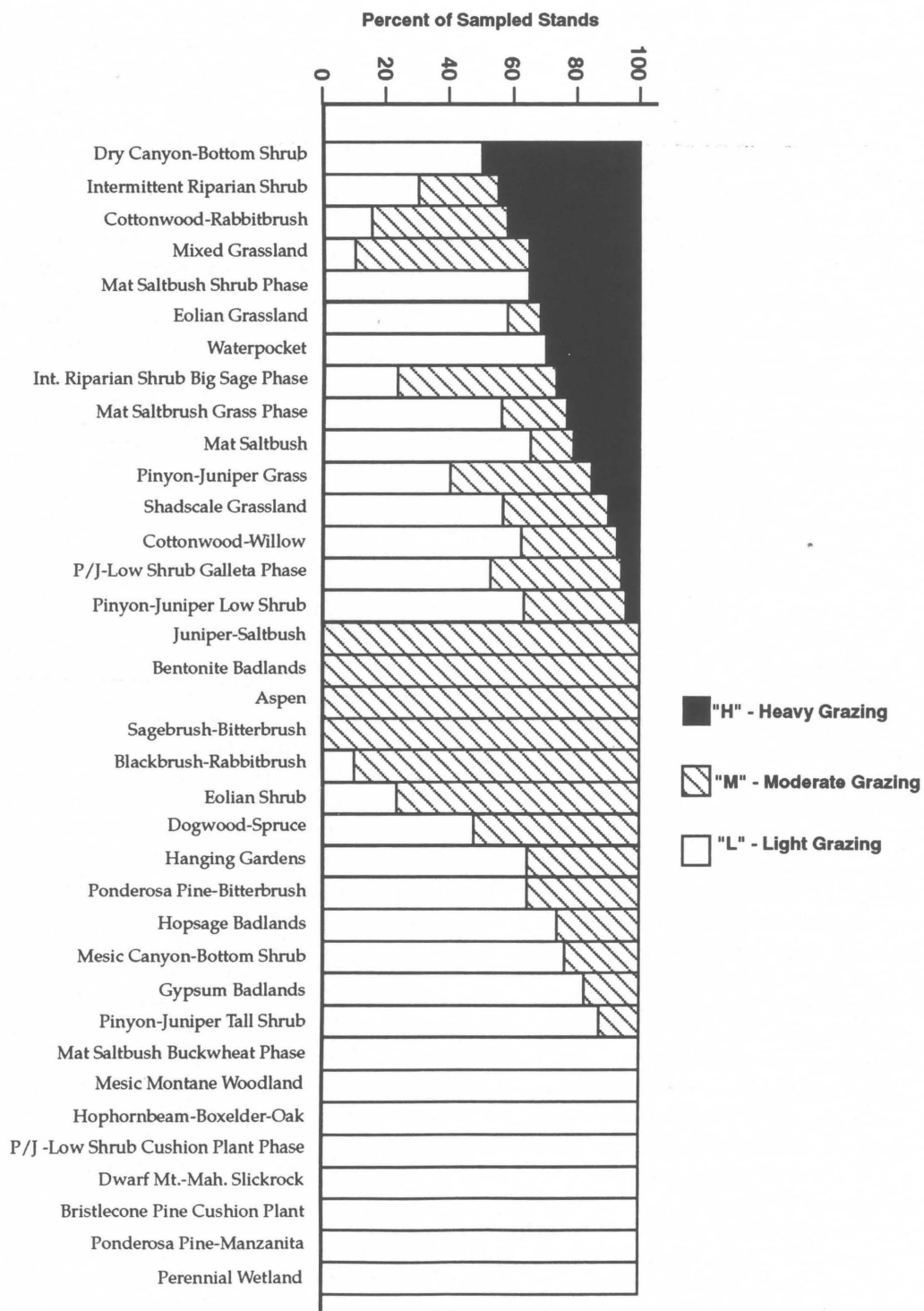
### Effects of Livestock Grazing

The influence of gradients in elevation and geologic substrate, described above, interacts with the effects of livestock grazing to produce some complex patterns in the vegetation of CARE. For example, minimum total grass cover generally increased with elevation in ungrazed and lightly grazed grasslands (Figure 5), but the opposite pattern was seen in moderate to heavily grazed stands (Figure 10). The explanation for this shift is unknown (in fact, it may be merely an artifact of small sample size).

Richness, i.e., total number of species per stand, did not show any consistent pattern with either elevation or grazing intensity in grassland communities (Figure 11). One would expect heavy and prolonged grazing to eliminate the most palatable species in a community, but they may be replaced by other species tolerant of grazing, such that the total number of species remains unchanged. Figure 12 shows the relative abundance of grazing intolerant species ("decreasers") and grazing tolerant species (native "increasers" plus exotic "invaders") in the grassland communities. Grazing tolerance was determined from the literature (Table 6). The minimum total cover of grazing tolerant species was generally greater than that of intolerant species even in lightly grazed stands, but the dominance of "increasers" and "invaders" became even greater with increasing grazing intensity (Figure 12).

We also examined the presence or absence of two preferred forage species that are very sensitive to grazing pressure, the shrub *Ceratoides lanata* and the grass *Stipa comata*, in relation to grazing intensity in grassland communities. Approximately half of even the lightly and moderately grazed stands, and three fourths of the heavily grazed stands, lacked both species (Figure 13).

Grazing has modified the structure of lower-elevation riparian plant communities as well as grasslands in CARE (also see Barth and McCullough 1988). Figure 14 shows the relative abundance of grazing tolerant vs intolerant species in waterpocket communities subject to either light or heavy grazing pressure. Grazing intolerant species were equal or greater in abundance than tolerant species in



**Figure 9.** Patterns in grazing intensity among plant community types in Capitol Reef National Park. "H" depicts heavy grazing; "M" depicts moderate grazing; and "L" depicts light or absence of grazing. These are subjective estimates of grazing intensity, made at each sampling site. The numbers at the top indicate the number of sampled stands in each community type.

Vascular Flora and Vegetation  
of Capitol Reef National Park, Utah

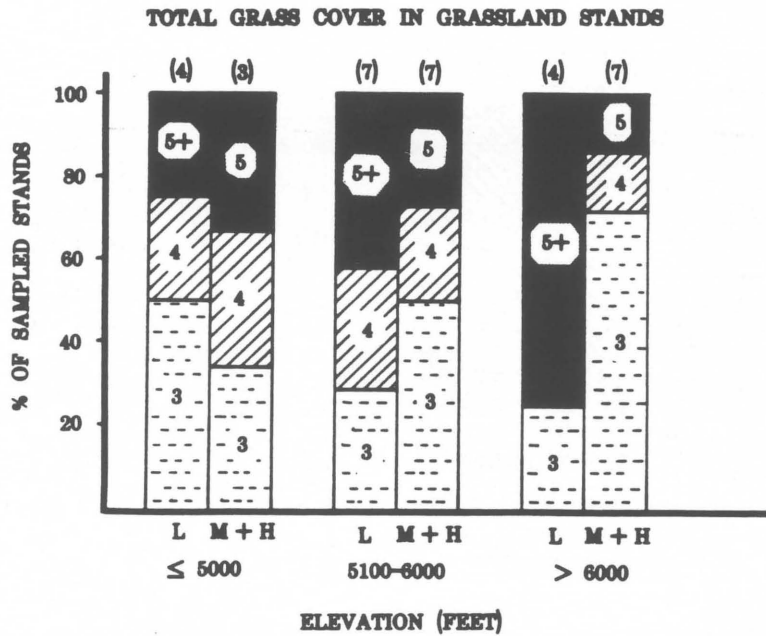


Figure 10. Patterns in minimum total grass cover in relation to elevation and grazing intensity in grassland stands in Capitol Reef National Park. "3" depicts plant cover class 3 (26-50%) in our releve samples; "4" depicts cover class 4 (51-75%); and "5" depicts cover class 5 (76-100%). The numbers in parentheses at the top are the number of sampled stands in each elevation/grazing class.

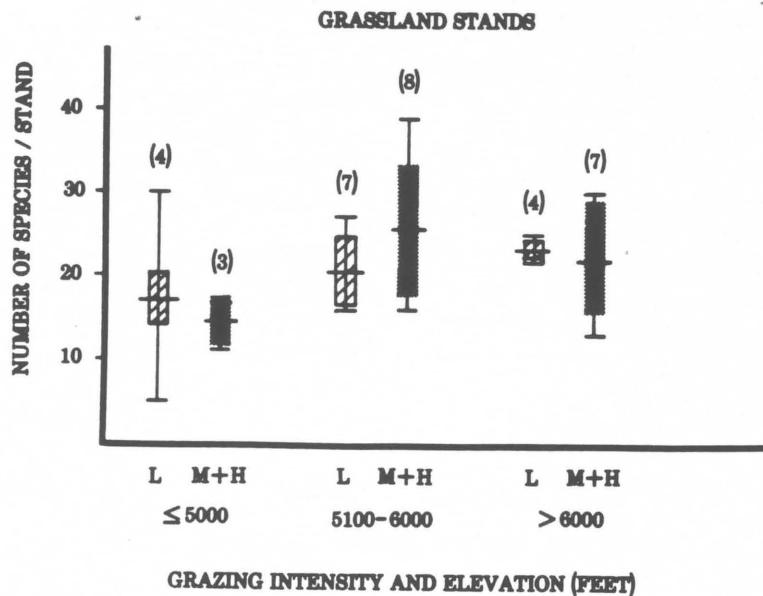
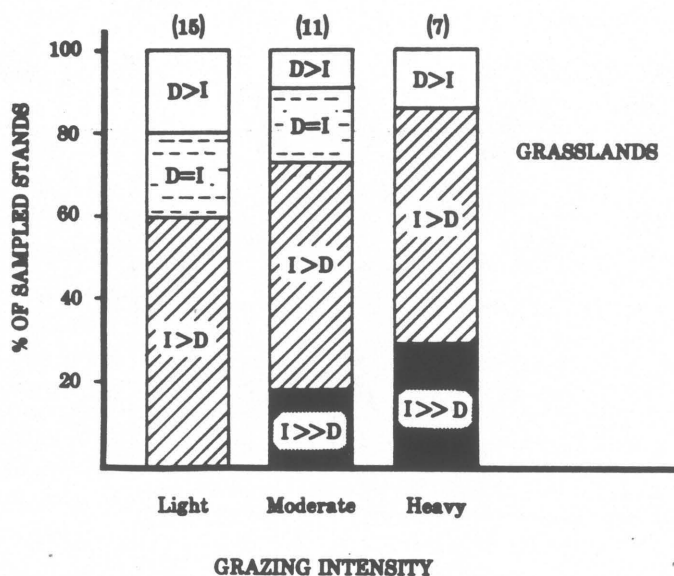


Figure 11. Patterns in species richness of grassland stands in Capitol Reef National Park. Horizontal lines represent the mean and range, and shaded areas represent one standard deviation, of the number of vascular plant species recorded in our releve plots of approximately 100 square meters area. "H" depicts heavy grazing; "M" depicts moderate grazing; and "L" depicts light or absence of grazing. These are subjective estimates of grazing intensity, made at each sampling site. Numbers in parentheses indicate the number of sampled stands within each elevation/grazing class.





**Figure 12.** Patterns in relative abundance of increaser (grazing tolerant) and decreaser (grazing intolerant) species (see Table 6) in relation to grazing intensity in grassland stands in Capitol Reef National Park. "D>I" indicates that decreaser species are more abundant (greater total cover) than increaser species; "D=I" indicates that decrease and increaser species are roughly equal in abundance; "I>D" indicates that increasers are more abundant than decrease; and "I>>D" indicates that increasers are far more abundant than decrease. Numbers in parentheses at the top indicate the number of sampled stands in each grazing class. Grazing classes are based on subjective estimates of grazing intensity at each sampling site.

all five of the lightly grazed stands; but in the two heavily grazed stands, tolerant species were more abundant than intolerant in one stand, and the two classes were equal in the other. Interestingly, we found no moderately grazed waterpockets; all were either lightly grazed (perhaps ungrazed) or heavily grazed. This probably is because the waterpockets are such favorable habitats for livestock that they graze heavily in all waterpockets that they can reach.

Grazing and other disturbances have created numerous opportunities in CARE for exotic species to become established. Many of these are undesirable weedy species (Table 6). Exotic species comprised an average of 7% of the flora in grassland stands located below 5000 ft in CARE, but were smaller components of the flora at higher elevations (Figure 15).

#### Overall Vegetation Patterns in CARE

Figure 16 summarizes the major patterns in the distribution of plant communities in CARE. The two most important controlling

variables are elevation and soil characteristics. Elevation is a complex gradient incorporating changes in both temperature and precipitation. Generally, temperatures decrease and precipitation increases with increasing elevation.

The soil gradient in Figure 16 represents primarily a gradient in water availability. The most mesic soils are those with a perennial water supply. The next most mesic soils are either coarse-textured (e.g., colluvium) or overlie deeply fractured bedrock (e.g., some sandstones); both of these conditions provide deep water supplies that can be tapped by woody species having deep roots (Everitt 1970, Loope 1977). The most xeric soils are either very shallow and developing over impenetrable bedrock (e.g., some sandstones), or of very fine texture such that precipitation tends to run off rather than infiltrate (e.g., clays and silts).

It is evident from Figure 16 that several community types in CARE are largely restricted to a single soil or rock type, even

**Table 6.** Summary of individual species responses to livestock grazing in southern Utah. Numbers in parentheses indicate the references which are listed at the bottom of the table. Species with an asterisk (\*) have been classified as both increasers and decreasers, depending upon specific site and grazing conditions. Invaders are non-native species (mostly of Eurasian origin).

**Decreasers under Grazing Pressure**

**Shrubs:**

*Artemisia biglovii* (1)  
*Artemisia spinescens* (1,2)  
*Atriplex canescens* (1,4)  
*Atriplex cuneata* (1,4) \*  
*Ceratoides lanata* (1,4)  
*Ephedra torreyana* (1)  
*Eriogonum microthecum* (1)  
*Kochia americana* (1,2)  
*Salix* spp. (1)

**Forbs:**

*Sphaeralcea* spp. (1)

**Grasses:**

*Bouteloua eriopoda* (1)  
*Hilaria jamesii* (1) \*  
*Muhlenbergia porteri* (1)  
*Oryzopsis hymenoides* (1,4)  
*Poa fendleriana* (1)  
*Sitanion hystrix* (1)  
*Sporobolus airoides* (1)  
*Sporobolus cryptandrus* (1)  
*Stipa comata* (1,4)

**Increasers under Grazing Pressure**

**Shrubs:**

*Artemisia filifolia* (1,4)  
*Artemisia tridentata* (1,2)  
*Atriplex confertifolia* (1,2)  
*Atriplex corrugata* (2)  
*Atriplex cuneata* (2) \*  
*Atriplex falcata* (2)  
*Atriplex gardneri* (2)  
*Chrysothamnus nauseosus* (1,4)  
*Chrysothamnus viscidiflorus* (1,4)  
*Coleogyne ramosissima* (1,4)  
*Ephedra cutleri* (1)  
*Ephedra viridis* var. *viscida* (4)  
*Eriogonum corymbosum* (1)  
*Gutierrezia sarothrae* (1,4)  
*Quercus gambelii* (1)  
*Sarcobatus vermiculatus* (1,4)  
*Tetradymia* spp. (3)  
*Vanclvea stylosa* (1,4)  
*Yucca* spp. (1)

**Trees:**

*Juniperus osteosperma* (1)  
*Pinus edulis* (1)

**Forbs:**

*Astragalus* spp. (1)  
*Caesalpinia repens* (1)  
*Coldenia hispidissima* (1)  
*Cordylanthus* spp. (1)  
*Cryptantha flava* (1)  
*Eriogonum inflatum* (1,4)  
*Lupinus pusillus* (1)  
*Machaeranthera canescens* (4)  
*Opuntia* spp. (1,4)  
*Sphaeralcea* spp. (4) \*  
*Wyethia scabra* (1)

**Grasses:**

*Aristida purpurea* (1)  
*Bouteloua gracilis* (1,4)  
*Hilaria jamesii* (1,4) \*  
*Muhlenbergia pungens* (1,4)  
*Sitanion hystrix* (3) \*

**Invader Species**

**Forbs:**

*Atriplex heterosperma* (2)  
*Atriplex hortensis* (2)  
*Atriplex patula* (2)  
*Atriplex rosea* (2)  
*Ceratocephalus testiculatus* (2)  
*Chenopodium album* (2)  
*Chenopodium botrys* (2)

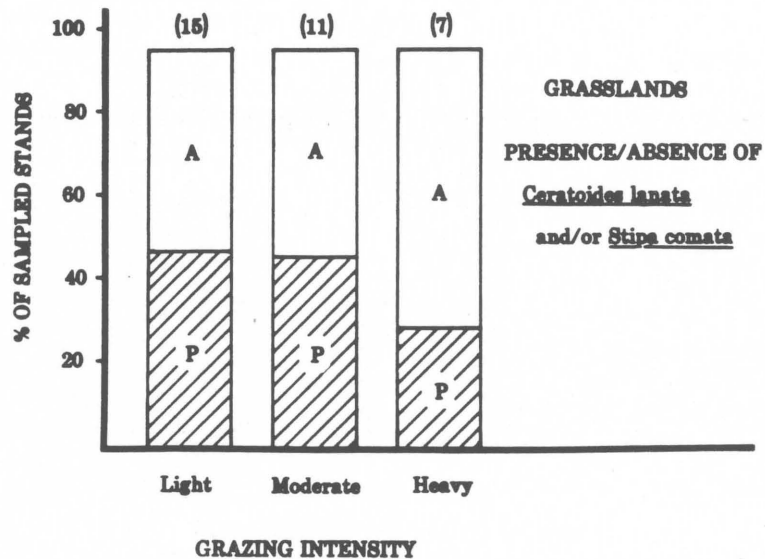
*Halogeton glomeratus* (1,2)  
*Helianthus annuus* (1,4)  
*Lepidium perfoliatum* (2)  
*Malcomia africana* (2)  
*Salsola kali* (1,4)

**Grasses:**

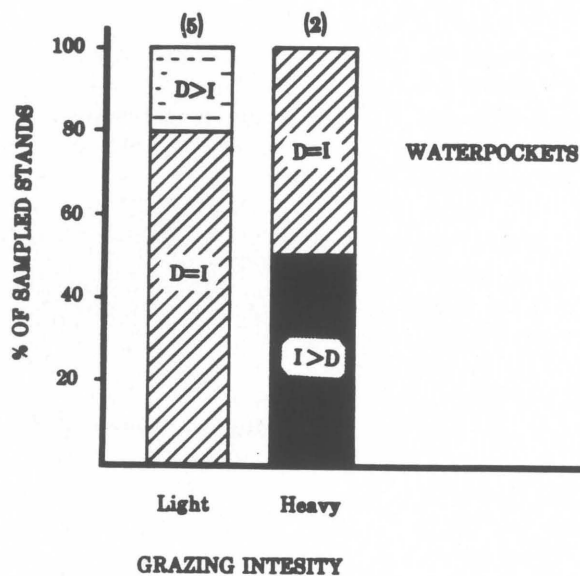
*Bromus rubens* (2)  
*Bromus tectorum* (1,2)

**References:**

- (1) Jarman, T., and H. Swenson. 1984. Ecological Site Descriptions, SCS-BLM Utah, unpublished draft report.
- (2) West (1988), p. 221.
- (3) West (1983c), pp. 341-343.
- (4) Tuhy and MacMahon (1988).

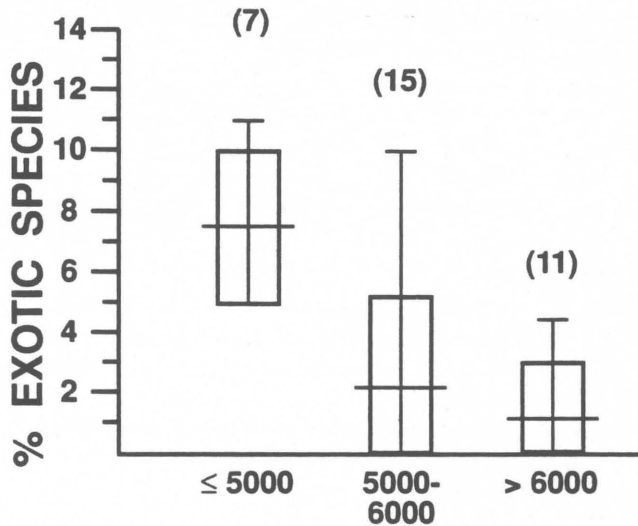


**Figure 13.** Patterns in presence or absence of two especially sensitive grazing intolerant species (decreasers) in relation to grazing intensity in grassland stands in Capitol Reef National Park. "A" indicates that both winterfat (*Ceratoides lanata*) and needle-and-thread grass (*Stipa comata*) are absent from habitats that appear suitable for them. "P" indicates that one or both species are present. Numbers in parentheses at the top indicate the number of sampled stands in each grazing class. Grazing classes are based on subjective estimates of grazing intensity at each sampling site.



**Figure 14.** Patterns in relative abundance of increaser (grazing tolerant) and decreaser (grazing intolerant) species (see Table 6) in relation to grazing intensity in waterpocket communities in Capitol Reef National Park. "D>I" indicates that decreaser species are more abundant (greater total cover) than increaser species; "D=I" indicates that decreasers and increasers are roughly equal in abundance; and "I>D" indicates that increasers are more abundant than decreasers. Numbers in parentheses at the top indicate the number of sampled stands in each grazing class. Grazing classes are based on subjective estimates of grazing intensity at each sampling site.

## GRASSLAND STANDS

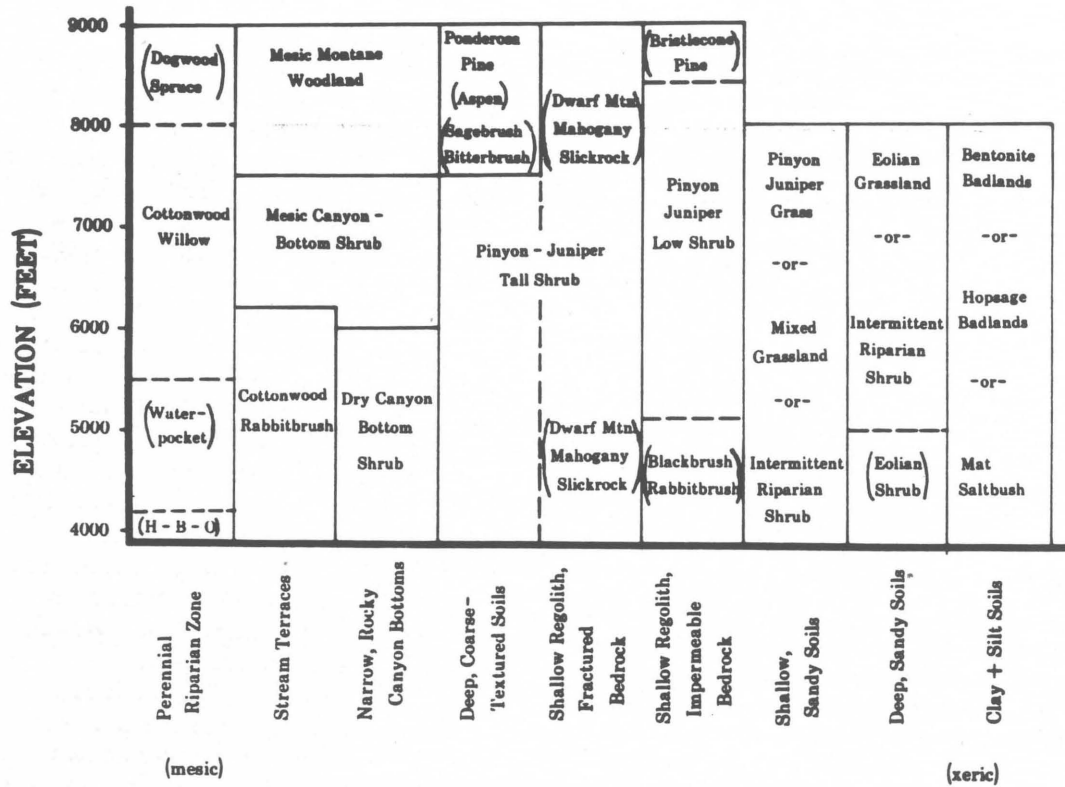


**Figure 15.** Relative abundance (% of species in a stand) of exotic (non-native) species in relation to elevation in grassland stands in Capitol Reef National Park. Horizontal lines represent the mean and range, and blocked areas represent one standard deviation, of the percent of non-native species among all of the vascular plant species recorded in our releve plots of approximately 100 square meters area.

though they extend over a broad range of elevation. Moreover, these soil types are closely correlated with geologic substrate. Topographic position, aspect, and slope generally had far less influence on community type and structure in CARE than did substrate and elevation. Everitt (1970) and Loope (1977) also reported that geologic substrate exerted a powerful control on vegetation patterns in the Henry Mountains and in Canyonlands National Park, respectively.

This powerful control by the geologic substrate may be a general characteristic of desert vegetation, where soils are poorly developed and water is the overwhelmingly limiting resource. By contrast, in regions where precipitation is generally greater, community types appear to occur over a wider range of rock and soil types, and their distribution is controlled more by elevation and topographic position than by geologic substrate (e.g., Whittaker 1956, Peet 1981).





**SOIL MOISTURE / TEXTURE GRADIENT**

Figure 16. Overall patterns in distribution of plant community types in Capitol Reef National Park in relation to elevation and soil type. The solid vertical and horizontal lines indicate that a particular community type rarely or never extends across the boundary depicted by the line. The community types in parentheses are restricted to the areas designated by the broken horizontal lines, but the community types without parentheses may extend across the broken horizontal lines. In portion of the figure where more than one type of community is indicated, the local distribution of communities is controlled by other, more subtle factors not depicted here. "H-B-O" designates the hophornbeam-boxelder-oak riparian woodland community.

**Discussion**

**Vascular Flora**

The flora of Capitol Reef National Park represents one of the largest documented floras of any national park on the Colorado Plateau. This park also contains a greater number of threatened, endangered, and rare taxa than any other park unit in the continental United States.

Two reasons for the large number of plant species in CARE are its great variety of habitats and its strategic location near the intersection of several major biogeographic

regions. CARE's flora includes representatives of the Rocky Mountain, Sierra Madrean, and Great Plains floras, as well as several species endemic to southern Utah or the Colorado Plateau, and cosmopolitan species distributed widely over North America and Eurasia (Barbour and Billings 1988). These biogeographic patterns are discussed further below under threatened and endangered taxa. Habitat diversity in CARE results from the wide variety of geologic substrates and topographic conditions, as well as the broad range in elevation.

Many plant species in CARE are strongly associated with specific geologic formations, and are secondarily influenced by the presence of alluvium, colluvium, and soils having distinctive characteristics of texture and salinity (Welsh et al. 1987, Weber 1987). Some examples of highly restricted taxa include Maidenhair fern (*Adiantum capillus-veneris*), found on Navajo sandstone in hanging gardens; Harrison milkvetch (*Astragalus harrisonii*), Beck cymopterus (*Cymopterus beckii*), Maguire daisy (*Erigeron maguirei*), and the Rabbit Valley gilia (*Gilia caespitosa*), all on Navajo sandstone; and Jones cycladenia (*Cycladenia humilis* var. *jonesii*), found only on Chinle formation. Many of the species having these kinds of restricted distributions are endemic to the Colorado Plateau and the state of Utah (Welsh and Chatterley 1985).

#### Threatened and Endangered Taxa

Although our study was the most thorough inventory of rare plants yet conducted in CARE, the distributional records that we report here probably are still incomplete. The recounted distribution of rare plants in the park is obviously limited by the areas where transects were done. There were many specific locations in the park that we did not sample because of time constraints and the general vegetational and physiographic similarity of these areas to those places that we did sample. This included areas in which rare taxa were expected to occur. For example, we have no doubt that there exist additional undescribed locations of *Erigeron maguirei* var. *maguirei*, *Gilia caespitosa*, *Cymopterus beckii* and *Townsendia aprica* in CARE.

#### Patterns of Rarity in CARE

The rare plants in CARE represent a variety of patterns of rarity. For example, *Sclerocactus wrightiae* is regionally restricted to the Colorado Plateau but occurs at numerous locations both in and out of CARE. We found it at several locations throughout Cathedral Valley, as well as along the Hartnet and in the South Desert. Populations also are known from the Notom area just outside the park, and we expect that it occurs in scattered, small populations from the Hartnet, east of the

Waterpocket Fold, south through the North Blue Hills region to Notom.

By contrast, *Erigeron maguirei* var. *maguirei* is known only within CARE and from two very small populations outside the park. We found it scattered across the Waterpocket Fold on Navajo Sandstone slickrock, from Upper Deep Creek southeast to the Fremont River. The only other known occurrences of *Erigeron maguirei* var. *maguirei* are in the San Rafael Swell just north of CARE. In 1986, before we began our survey, the only known population of *Erigeron maguirei* var. *maguirei* in the world had less than 30 individuals, and the only record from CARE was of *Erigeron maguirei* var. *harrisonii*, an endemic variety apparently restricted to one canyon in the park. Our field inventories have now revealed that var. *maguirei* is more abundant in CARE, and that var. *harrisonii* apparently represents phenotypic response (i.e., plasticity) of individuals growing in shaded, moist canyons.

CARE's population of *Echinocereus triglochidiatus* var. *inermis* shows the greatest geographic disjunction from other known populations. It is found in the park at a single station, on Paradise Flats. The remaining populations are in the Paradox Valley of western Colorado, along the Gunnison and Colorado Rivers in Colorado and in the La Sal Mountains of San Juan County, Utah. Similarly, *Cycladenia humilis* var. *jonesii* is found in CARE at a single location in the southern portion of the park, which fits the general pattern of geographically disjunct populations throughout the entire range of this taxon.

Two of the Federal Candidate Category 1 species, *Gilia caespitosa* and *Pediocactus winkleri*, were found to be more widespread in the park than previous records would indicate. Indeed, the CARE populations of *Gilia caespitosa* represent the greatest concentrations of this species so far discovered, the only other occurrence being near Teasdale, Utah (Wilken 1979). *Gilia caespitosa* is scattered on the Navajo Sandstone formation from Golden Throne to Deep Creek (though the largest populations are north of the Fremont River). *Pediocactus winkleri*, previously known in the park from a single location on the Hartnet, was found scattered from the Hartnet,

through parts of the South Desert, south to the Golden Throne area.

Two additional Federal Candidate Category 1 species, *Spiranthes diluvialis* and *Schoenocrambe barnebyi*, represent significant discoveries in the park. One previously was known only from a single historical record and the other was unknown in CARE. *Spiranthes diluvialis* is a polyploid orchid species known from a very few scattered localities across the Rocky Mountains and Great Basin. Although there is a collection of this species from the park, in the Fremont River Canyon west of the Visitor Center, the location could not be relocated. Indeed, the habitat described on the voucher specimen, Tamarix grove, could not be found at the location cited on the specimen. On the opposite side of the park, two populations (one very small and the other more sizable) were located. *Schoenocrambe barnebyi* was previously known only from two populations of less than 50 individuals in the southern San Rafael Swell (a single record in field notes referred to another location along Pleasant Creek in CARE, which we were unable to relocate). We found this species in the park along the Fremont River and Sulphur Creek. The five populations in CARE now represent the largest populations of this species discovered to date. The Sulphur Creek East population possessed over 200 individuals in 1986-1988.

#### **Critical Areas for Rare Plant Conservation in CARE**

The distribution of rare and endemic taxa throughout the park is not uniform. This is not surprising, considering the great number of geologic formations, and the variation in elevation, drainage patterns and moisture regimes. These various sources of complexity result in considerable edaphic variation, and these edaphic factors may be responsible for the nonrandom distribution of rare taxa, i.e., edaphic endemism (Mason 1946a, 1946b; Raven 1964; Fiedler 1985). One such feature, geologic substrate, is often used as a proxy for more specific edaphic parameters (see, for example, Welsh and Thorn 1978).

The greater abundance of rare taxa in the northern portion of the park (i.e., north of

Bitter Creek Divide; Figure 2) probably results from the higher elevation, the difference in orientation of the Waterpocket Fold, and greater exposure of many of the formations in the north. Several of the locations with exceptionally high numbers of rare taxa, e.g., Upper Deep Creek, Miners Mountain, The Hartnet and above Hickman Bridge (Table 2), are at the higher elevations in the park.

This local variation in the abundance of rare taxa throughout the park suggests that there are critical regions within CARE where disturbance could adversely affect a large number of plants of critical concern. The most notable is the Upper Deep Creek area (Table 2, Figure 1). This high-elevation exposure of Navajo Sandstone and Carmel Formation supports one endangered, one threatened, two federal candidate and four 3C plant species. This concentration of rare plants is likely due in part to the great diversity of habitats, which range from open sagebrush to aspen stands and even bristlecone pine associations. Moisture regimes vary from dry, sandy bench-tops to perennial streams with associated wetlands and seeps. This, coupled with nearly 450 m (1500 ft) of relief, provides an incredible diversity of potential habitats that rare species may inhabit. Upper Deep Creek also supports numerous high-elevation plant species that are not endemic or federally listed, but that occur in the park only in this area. Examples include *Habenaria sparsiflora*, *Fritillaria atropurpurea*, *Pinus longaeva*, and *Zigadenus elegans*.

Other areas supporting high concentrations of rare plant taxa include the Miners Mountain/Fremont Canyon area, the Hartnet, the Hickman Bridge region, and perhaps a large portion of the Waterpocket Fold north of the Fremont River (Table 2, Figure 1). Because of the large number of endemics and rare plants in these areas, it is recommended that these areas be given special management consideration to prevent unnecessary human disturbances. Unfortunately, Upper Deep Creek, the Hartnet, and portions of the Waterpocket Fold still have grazing periodically through the year. In these areas, trampling may have adversely affected some of the federally protected plants that are present.

### Patterns of Endemism

Capitol Reef National Park lies within the Great Basin Floristic Province (Gleason and Cronquist 1964). This province represents the arid region of western North America, composed of plateaus and lesser mountain ranges that lie between the two major mountain chains, the Rocky Mountain Range and the Cascade-Sierra Nevada Ranges, and it corresponds to the Intermountain Floristic Province of McLaughlin (1992). Holmgren, in Cronquist et al. (1972), partitioned much of this floristic province into sixteen sections which represent "natural areas that can be recognized by vegetative, floristic and/or physiographic features" (Cronquist et al. 1972:78). These "floristic sections" are at a much finer scale than the "floristic areas" described by McLaughlin (1986, 1989). These sections are further grouped into four major divisions, one of which is the Colorado Plateau Division, which is nearly identical to McLaughlin's (1992) Northern Colorado Plateau Floristic District and principally conforms to the northwestern portion of Fenneman's (1931) Colorado Plateau physiographic province. It is within this division that Capitol Reef National Park is positioned (Figure 1).

Because the boundaries of Holmgren's floristic province sections are "in part influenced by local regions of species endemism" (Cronquist et al. 1972:78), a feature not included in the multivariate analyses of floristic areas based on species lists from published local floras (McLaughlin 1986, 1989), they may be helpful in evaluating patterns of endemism within the park. According to Cronquist et al. (1972), the three sections, or regions of endemism, which make up the Colorado Plateau Division are the Canyon Lands Section, the Utah Plateaus Section, and the Uintah Basin Section. In a review of endemic plants of Utah by Welsh et al. (1975), four regions of endemism on the Colorado Plateau are recognized. This classification differs only in the recognition of the Colorado River and adjacent areas as a separate region of endemism, in addition to the three recognized by Holmgren.

The geographic location of CARE is significant in that the northern portions of the park are at the interface of the Utah Plateaus

Section and the Canyon Lands Section, while the southern portion of the park extends deep into the the Canyon Lands Section. Moreover, according to Welsh et al. (1975), the park's southern boundary is close to the Colorado River endemic region. Based on its location, then, it would be expected that CARE's endemic and rare plants would have their floristic origins largely in the Utah Plateaus and the Canyon Lands Sections. This indeed is the case: by far the greatest influence on endemic plant species in CARE is from the Canyon Lands Section (Table 7).

A more localized center of endemism is in the San Raphael Swell, located just north of CARE in the northwest corner of the Canyon Lands Section. Harris (1983) recognized eight taxa which he considered endemic to this area. Four of these taxa are also found at CARE: *Cryptantha johnstonii*, *Erigeron maguirei*, *Sclerocactus wrightiae*, and *Schoenocrambe barnebyi*. The occurrence of the first of these species in CARE is not surprising, since the Cathedral Valley portion of the park is rightfully considered as part of the San Rafael Swell. However, the last three species were found farther south, well out of the San Rafael Swell.

One of Harris' San Raphael Swell endemics, *Schoenocrambe barnebyi*, is known from two sites in the San Rafael Swell (Sy's Butte and about three miles east at Bullberry Spring), and from our newly found locations along Sulphur Creek and the Fremont River in CARE. The geologic substrates in the Sulphur Creek/Fremont River area are very similar to those where the populations are found in the southern San Rafael Swell. This geologic setting can be described as extensive areas of Moenkopi Formation associated with steep slopes that expose the Chinle, Wingate, Kayenta, and Navajo Formations as well as canyons that cut through the Kaibab and Coconino/Cutler Formations. Furthermore, this type of habitat is not uncommon in the San Rafael Swell, but *Schoenocrambe barnebyi* is found only at the farthest south point of such a geologic setting in that region. While the populations at CARE are considerably larger, the occurrence of habitat, by comparison, is much less.

These disjunctions between the San Rafael Swell and Capitol Reef are important for



**Table 7.** Plant taxa found in CARE that are considered by Cronquist et al. (1972), by Welsh et al. (1975), and by ourselves to be endemic to the Canyon Lands Section. Those marked with an asterisk are on the U. S. Fish and Wildlife Service threatened and endangered plant species list. Taxa marked by (=) were considered by the compilers to be rare enough to warrant protection whether or not they were formally listed as endangered or threatened.

**A. Endemic taxa compiled by Cronquist et al. (1972):**

<i>Aquilegia micrantha</i>	<i>Eremocrinum albomarginatum</i>
<i>Asclepias ruthiae</i> *	<i>Erigeron abajoensis</i> *
<i>Astragalus coltonii</i> var. <i>coltonii</i>	<i>Erigeron maguirei</i> * (vars. <i>maguirei</i> and <i>harrisonii</i> )
<i>Astragalus desperatus</i> * (variety <i>conspectus</i> = <i>A. barnebyi</i> )	<i>Eriogonum bicolor</i>
<i>Astragalus episcopus</i>	<i>Eriogonum leptocladon</i> var. <i>leptocladon</i>
<i>Astragalus flavus</i> var. <i>argillosus</i>	<i>Gilia caespitosa</i> *
<i>Astragalus harrisonii</i> *	<i>Gilia (Ipomopsis) roseata</i>
<i>Astragalus malacoides</i> *	<i>Gilia subnuda</i>
<i>Astragalus moencoppensis</i>	<i>Mimulus eastwoodiae</i>
<i>Astragalus musiniensis</i>	<i>Camissonia eastwoodiae</i>
<i>Astragalus pardalinus</i> *	<i>Penstemon cyanocaulis</i>
<i>Astragalus woodruffii</i> *	<i>Penstemon marcusii</i>
<i>Atriplex corrugata</i>	<i>Psoralea juncea</i>
<i>Cycladenia humilis</i> var. <i>jonesii</i> *	<i>Sclerocactus parviflorus</i>
<i>Ephedra viridis</i> var. <i>cutleri</i>	<i>Sclerocactus wrightiae</i> *
	<i>Vanclevea stylosa</i>

**B. Endemics compiled by Welch et al. (1975):**

<i>Asclepias labriformis</i>	<i>Hymenoxys depressa</i> *=
<i>Castilleja scabrida</i> *	<i>Lomatium junceum</i> *
<i>Cryptantha johnstonii</i> *=	<i>Nama retorsum</i>
<i>Dalea flavescens</i> var. <i>epica</i> *=	<i>Phacelia rafaensis</i>
<i>Eriogonum corymbosum</i> var. <i>revealianum</i> *=	<i>Xylorhiza confertifolia</i> *=
<i>Gaillardia spathulata</i>	

**C. Additional endemic taxa from the Canyon Lands Section that have been described or reassessed taxonomically since 1975:**

<i>Astragalus barnebyi</i> *	<i>Habenaria zothecina</i> *
<i>Astragalus chamaeleuce</i> var. <i>laccoliticus</i> *	<i>Pediocactus winkleri</i> *
<i>Cymopterus beckii</i> *	<i>Schoenrambe barnebyi</i> *

several reasons. First, given that CARE and the San Rafael Swell are both part of the western extent of the Colorado Plateaus Section, these disjunctions are indicative of an overall floristic similarity between the two areas. Secondly, some of the rare species known from very few localities in the Swell (i.e., *Erigeron maguirei* var. *maguirei*, *Townsendia aprica*, and *Schoenrambe barnebyi*) are now known to be more abundant in CARE than in the San Raphael Swell, suggesting that the populations in the San Rafael Swell may represent dispersals from the actual population

centers farther south. Finally, these disjunctions suggest that other San Rafael Swell endemics are likely to be found in similar habitats in CARE.

Another plant that may fit this category is the newly described *Gilia tenuis*. We searched for it in CARE, but did not find it; however, we think there is a high likelihood of its occurrence on white, limy substrates associated with the Curtis Formation in the Cathedral Valley, Hartnet, and South Desert of CARE, or on light colored sandy substrates associated with the Dakota Formation. These substrates

are similar to the Cedar Mountain Shale on which one population occurs in the San Raphael Swell.

Another important region of endemism in close proximity to CARE is the Utah Plateaus Region (Cronquist et al. 1972). This region comprises the fault-block plateaus which cut across the middle of the state, including the Fish Lake Plateau (Thousand Lakes Mountain), Awapa Plateau and the Aquarius Plateau (Boulder Mountain). A portion of this region lies only a few kilometers west of CARE. Holmgren (in Cronquist et al. 1972) considers this region second only to the Canyon Lands Section in the number of endemic taxa on the Colorado Plateau. Holmgren recognizes 39 endemics to this region. Of these, four are also found at CARE: *Astragalus consobrinus*, *Geranium marginale*, *Penstemon leiophyllus*, and *Townsendia aprica*. In addition, the newly described *Erigeron awapensis*, an endemic of the Awapa Plateau, extends down the Fremont Valley into CARE (Welsh 1983a).

*Townsendia aprica* was mentioned above as a species that occurred in both CARE and the San Rafael Swell; it also was considered by Holmgren as an endemic to the Utah Plateaus region because of the few records of this species available in 1972. Since that time additional records indicate that *T. aprica* is in fact endemic to the eastern Fish Lake Plateau and adjacent San Rafael Swell. A recently described endemic taxon of the Fish Lake (Thousand Lakes Mountain) and Aquarius (Boulder Mountain) Plateaus is *Thelesperma subnuda* var. *alpinum* (Welsh 1983b). This species was found in CARE in the upper Deep Creek area.

The occurrence in CARE of Utah Plateau endemics is to be expected given the high elevation of portions of the park, including areas over 2120 m (7000 ft), and the general similarity of geologic substrates in the two areas. Although most soils on the plateaus are derived from either tufaceous sedimentary rocks and volcanics or quaternary colluvial and boulder deposits, there are some regions with outcrops of Navajo, Kayenta, Wingate, and Entrada Sandstones, similar to what is found in CARE. These substrates also can be

found on nearby Boulder Mountain at elevations of 2240-2485 m (7400-8200 ft) and on Thousand Lakes Mountain at 2210-2730 m (7300-9000 ft). The Utah Plateau endemics that occur in CARE are found at similarly high elevations on Miners Mountain (ca. 2210 m [7300 ft]) and at Upper Deep Creek (2180-2665 m [7200-8800 ft]), as well as in protected, wet canyons nearby. In fact, these high elevation areas of the park may be better considered as the easternmost extent of the Utah Plateaus Section, rather than as a part of the Canyon Lands Section.

Two species found in CARE, *Eriogonum tumulosum* and *Parthenium ligulatum*, were previously considered endemics of the Uintah Basin (Cronquist et al. 1972). It is now clear that these species are not truly endemic to that region. More recent distributional information indicates that *Eriogonum tumulosum* occurs not only at CARE, but it is scattered both north of the Uinta Mountains in Sweetwater County, Wyoming, and south of the Tavaputs Plateau, cutting across the higher elevations of the San Rafael Swell (part of the Canyon Lands Section, as previously noted) to the foot of the Aquarius and Fish Lake Plateaus. It also has been recognized that, in spite of the considerable barriers posed by the Uinta Mountains and the Tavaputs Plateau (Welsh et al. 1976, Reveal 1979), some taxa endemic to the Colorado Plateau cross the Tavaputs Plateau to share the Uinta Basin and the Canyon Lands regions of endemism. Among these species are *Chamaechaenactis scaposa* and *Sclerocactus parviflorus*, which are both found in the park.

A more recently described taxon, *Physaria acutifolia* var. *purpurea*, was previously known only from the southern Uinta Basin. We discovered a small population at Upper Deep Creek, south of Billings Pass, which represents a considerable disjunction. Rather than a disjunction, however, it is possible that the purple (or rightly, maroon) flowered *Physaria* at Upper Deep Creek is in fact an exceptional form of the more common *Physaria acutifolia* var. *acutifolia*. Regardless of which interpretation is correct, this morphologically distinctive population represents a unique gene pool, worthy of protection.

In addition to the regions of endemism discussed above, Welsh et al. (1976) recognized the Colorado River Drainage as a region of endemism; however, they did not cite specific examples to support this claim. There are only a few species in CARE that could be regarded as members of this region, primarily because there is very little area in the park at low enough elevation to be considered as part of the river system (in the narrow sense). The most likely candidate is *Dalea flavescens* var. *epica*, whose type locality is in the low elevation area along the Colorado River in Glen Canyon. It is possible as well that *Sphaeralcea grossulariifolia* var. *moorei*, an endemic of low elevation Colorado and San Juan Rivers, in the Glen Canyon area, could be considered as an endemic of this region. Although not a federal candidate, the Moore Globemallow is quite rare in the park, being restricted to a few waterpocket areas in the south end of CARE.

#### Interpreting Anomalous Plant Distributions in CARE

Regions of endemism are often thought to represent locations where populations of what had been previously a more widespread species have reproduced in isolation from the remaining populations of the "species" from which they were descended. The internment in the isolated areas presumably resulted eventually in divergence and allopatric speciation. If such a scenario is correct, then the present distributions of these taxa at CARE may represent either (1) range extensions from the areas where speciation occurred or (2) the actual region in which speciation occurred. For many of CARE's rare plant species, it is not difficult to interpret the current patterns of distribution as representing in situ speciation, migration, or a combination of the two. However, there are several taxa whose present distributions present difficulties in inferring either in situ speciation or later migration. These difficult taxa are not necessarily restricted to a single region of the Colorado Plateau, but instead may even extend beyond the Colorado Plateau. Three representative taxa whose distributions are more or less anomalous in relation to currently

recognized regions of endemism are discussed below.

The first, *Cycladenia humilis* var. *jonesii*, is found in isolated populations scattered across the Canyon Lands Section: in the northern La Sal Mountains, near Green River, in the San Rafael Swell, in CARE, in Glen Canyon National Recreation Area southwest of CARE, and at least one historical record in Arizona, in the Dixie Corridor Section of the Colorado Plateau. The closest relative of the var. *jonesii* is presumably the polymorphic *C. humilis*, of the Coast Ranges in California. One hypothesis to explain the present distribution of this taxon is that var. *jonesii* may be *Cycladenia humilis* of early origin, possibly even Madrotertiary (Axelrod 1958), and its present distribution represents the remnants of a formerly broader distribution across the western U.S. (i.e., the present distribution is a relictual distribution). If this hypothesis is correct, then speciation would have to have occurred prior to the period when the various populations became isolated from each other.

The second species with an anomalous distribution, *Pteris thompsonii*, is known from Utah, Arizona, Nevada and Idaho, on the Colorado Plateau and in the Great Basin. The present distribution suggests that this species either originated in the southern Great Basin and later migrated along the Colorado River into the Canyon Lands Section, or evolved in the Canyon Lands region and later migrated through the Dixie Corridor into the southern Great Basin (the Idaho disjunction would have to be explained by a dispersal event). Both of these patterns of migration have been suggested for other taxa of the Colorado Plateau (Reveal 1979). Other close relatives of *P. thompsoniae* are *P. scoparia* (southern New Mexico, southwest Texas and Chihuahua), *P. pintorum* (Sonora), and *P. glandulosum* (Mexican Highlands). It is evident that the general pattern of distribution is from the Mexican Highlands northward; however, the present distribution is not particularly helpful in determining if *P. thompsoniae* diverged in the southern Great Basin or on the Colorado Plateau.

The final example of an anomalous distribution pattern is *Spiranthes diluvialis*. This

species is known from scattered locations from the east slope of the Rocky Mountains near Golden, Colorado, to near Salt Lake City, Utah, in the Bonneville Basin Section of the Great Basin, and from near Panaca in Lincoln County, Nevada, in the eastern Tonopah Section of the Great Basin, south to Garfield County, Utah in the Canyon Lands Section of the Colorado Plateau. Although the isolated and widespread nature of the populations is confusing, it is nevertheless possible to infer the origin of *S. diluvialis*. Based on cytological evidence (Sheviak 1984) it is believed that *S. diluvialis* ( $2n=74$ ) is the amphiploid derivative of a hybridization between *S. magnicanporum* ( $2n=30$ ) and *S. romanzoffiana* ( $2n=30$ ). Sheviak (1984) postulated that the hybridization occurred during the Pleistocene, when these two parental taxa potentially could have coexisted. If this scenario is correct, the current pattern of distribution is likely the result of habitat fragmentation, the scarcity of low elevation mesic habitats, and/or multiple, independent hybridization events.

#### Plant Communities of Special Concern

Many of the plant communities in CARE are common and widespread on the Colorado Plateau, and require no special management actions to ensure that they persist into the future. However, four of the community types that we recognized in CARE are rare or vulnerable or both. Managers should be especially careful to protect these communities from unnecessary disturbance.

The first plant community of special concern is the bristlecone pine - cushion plant community, which is restricted to a very small area (ca. 1 ha) on a flat ridgetop formed by the Carmel Formation in the upper Deep Creek area (see Romme et al. [1993] for more details). It is significant both for its rarity and for the extreme age of the trees. Major threats include wildfire, which could kill the trees and consume the ancient dead wood lying on the ground, and recreation, which could involve cutting and burning the ancient wood. Fire may be a minor threat, since fuels are sparse and discontinuous on the ridgetop inhabited by the old bristlecone pine, but uninformed recreational activities could have a serious and

adverse effect on the natural values of this area. The most important step for preserving this community is to keep it remote and inaccessible, as it is presently. New trails, roads, or campgrounds should not be built in the vicinity, and backpacking in the area should not be encouraged.

The second community type of special concern is the waterpocket community (see Romme et al. [1993] for details). This community is rare in the park and the region, and is vulnerable to damage by livestock grazing and recreational use. Livestock effects on waterpockets are discussed below. Recreational damage mainly involves pollution of the water with human wastes and garbage, and disturbance of wildlife dependent on these rare sources of permanent water. People will want to visit these areas, since they are a unique and fascinating component of CARE, but camping, swimming, and extended stays should be discouraged, especially at remote, backcountry waterpockets.

The third community type of special concern is the hanging garden community, which is widely distributed in canyons of the Colorado Plateau, but is everywhere rare and fragmented in its distribution (see Romme et al. [1993] for details). The major threat to hanging gardens is invasion by exotic weeds, such as cheatgrass (*Bromus tectorum*), which could displace the native mesophytic species. We found this weed in several hanging garden sites in CARE. There is no sure control for spread of these exotic weeds, but monitoring of the hanging gardens would be useful to remain aware of the magnitude of the problem.

The final community type of special concern is the hornbeam-boxelder-oak woodland community, which is restricted to a few small, sheltered sites in Halls Creek Narrows (see Romme et al. [1993] for details). The major threats to this community are related to recreational use and damage to the trees from woodcutting and campfire activities. This problem can be minimized by discouraging people from camping within the Narrows, though ordinary hiking through the area should pose no threat. Livestock grazing also could degrade this community, but the known stands are largely inaccessible to livestock.



### **Vegetation Patterns in Capitol Reef National Park**

The vegetation of CARE consists of a complex mosaic of species and communities distributed along two principal environmental gradients. The first major gradient is elevation. As elevation increases, temperatures generally decrease and precipitation increases, resulting in generally more mesic conditions at higher elevations. The park's vegetation strongly reflects this moisture and temperature gradient, changing from semi-desert grasslands and shrublands at low elevations to woodlands and forests in the highest portions of the park.

At any given elevation, temperature and potential evapotranspiration (hence soil moisture conditions) also are influenced by aspect and topographic position, e.g., north-facing exposures generally are more mesic than south-facing exposures. Aspect and topographic position appeared to have a relatively small influence on the composition of upland vegetation in CARE, especially at the lower elevations where soil texture (see below) had an overwhelming influence. Loope (1977) made a similar observation in Canyonlands National Park, although Everitt (1970) stated that slope and aspect were very important in controlling vegetation patterns in the Henry Mountains.

The second major gradient is soil texture, which influences plant distribution and growth primarily through its effects on moisture availability. Moisture-holding capacity generally decreases from deep sandy soils, through rocky loams, to shallow fine-textured clays and silts. Soil texture is determined primarily by geologic substrate. Sandy soils result from the weathering of coarse-textured sandstones, such as the Navajo, and occur also in alluvial and eolian deposits. Fine-textured soils are commonly associated with shales and mudstones, such as the Mancos and Morrison Formations.

Coarse-textured soils generally support communities dominated by woody shrubs or trees, since the deep roots of these species can reach deep sources of water during the long intervals between precipitation events that characterize this semi-arid environment. Fine-textured soils generally support a larger

component of grasses, whose shallow fibrous root systems can effectively absorb the moisture available in surface soil layers immediately after a rain. Soils of intermediate texture commonly support a mix of these two contrasting plant forms.

The chemical composition of the soil also influences the kinds of plants that can grow in that area. For example, the high sodium content and alkalinity of some soils derived from Mancos shale inhibit plant growth (Potter et al. 1985a, b). Both Everitt (1970) in the Henry Mountains and Loope (1977) in Canyonlands National Park reported vegetation patterns related to patterns of soil texture and chemical composition that were similar to the patterns we report here for CARE.

### **Random and Deterministic Patterns in Community Composition**

Although it was possible on the basis of our field observations to predict the general type of plant community present on a site given its elevation and geologic substrate, it frequently was not possible to predict exactly the composition and relative abundance of shrub species making up the community on that site. This was true especially of sites in the various pinyon-juniper community types. We observed enormous variation in relative abundance of the shrub species on sites that appeared to be very similar in terms of habitat conditions.

Three explanations for this observation are possible. First, the distribution of shrub species within the broad zone of pinyon and juniper dominated communities may be controlled in a deterministic fashion by other, possibly subtle, environmental gradients that we did not recognize in this study. Further research into soil chemistry, micrometeorology, local herbivore densities, etc., would be required to rule out this hypothesis. Secondly, many of the stands that we sampled may have been disturbed at various times in the past, and are all converging deterministically into some "climax" community composition. Additional research on disturbance history and succession would be required to address this hypothesis.

The third hypothesis, and the one that we favor, is that there is a large random element

to the distribution of shrub species in the pinyon - juniper community type. There may be numerous species capable of occupying a limited number of micro-sites where growing conditions are suitable for a shrub growth form. Whichever species' propagules reach a suitable site first will be the species occupying that site. Once an individual shrub becomes established on a micro-site, it persists there for a long time, probably decades or centuries. Thus, there are limited opportunities for replacement in a successional sense, and species composition of a stand reflects both the deterministic abiotic characteristics of the site and the more-or-less random events of individual species establishment on that site. Table 8 summarizes the woody species associated with relatively mesic and relatively xeric sites within the pinyon-juniper woodland type. The composition of any particular stand appears to represent a more-or-less random sample of the many species capable of living in that particular habitat.

Investigators in other kinds of communities have suggested this kind of stochastic element of community composition. Malanson (1980, 1982; Malanson and Kay 1980) found that hanging garden communities in Zion National Park showed low floristic similarity despite high habitat similarity. (We observed the same pattern in CARE's hanging gardens.) He concluded that any particular site could support a wide variety of assemblages of mesophytic species, and that species-specific dispersal capabilities and the frequency of disturbance by flooding interacted to control community composition at any particular time and place within the potential habitat of this community type. A similar conclusion was reached by McCune and Allen (1985) who found different species compositions in similar-aged forests occupying essentially identical habitats in a series of deep, isolated canyons in the Bitterroot Range of Montana.

#### **Discrete and Continuous Patterns in Community Composition**

The vegetation in CARE is an interesting mix of stands showing both discrete and continuous compositional patterns. Given the complex geology of this area, there are many

locations where substrates change abruptly, and here one finds abrupt changes in the vegetation as well. For example, sharply tilted sandstone outcroppings at the lower elevations generally support a pinyon-juniper woodland, whereas adjacent shales and mudstones support a mat saltbush or mixed grassland community. Eolian deposits are characterized by a distinctive plant community with usually sharp boundaries that correspond exactly to the boundaries of the underlying sand deposit. Numerous additional examples could be elaborated in which the vegetation changes abruptly with an abrupt change in geologic substrate.

There also are many locations in CARE where environmental conditions change gradually, and here the vegetation varies gradually as well, supporting the continuum concept (Whittaker 1975). For example, the east slope of Miners Mountain in the central part of CARE represents an elevational gradient of several hundred meters over a more or less uniform geologic substrate. The entire slope is covered by a pinyon-juniper community, but pinyon becomes progressively more abundant and juniper less abundant as one moves to higher elevations. On the top of the mountain, ponderosa pine begins to appear. These continuous changes in plant community composition reflect an underlying continuous change in temperature, precipitation, and potential evapotranspiration.

#### **Distribution of Communities along Environmental Gradients**

Although we have described many different types of plant communities in CARE, it must be emphasized that they all overlap to some extent in their characteristic composition and habitat. We have taken several natural patterns of continuous variation and broken them into discrete units for purposes of description and classification.

For example, canyon bottom habitats in CARE represent a gradient in moisture and temperature conditions ranging from relatively dry and hot in shallow canyons at low elevations to relatively moist and cool in deep canyons at high elevations. The three types of canyon bottom communities that we have

identified represent more or less arbitrary divisions of the continuous variation in vegetation associated with this gradient in habitat conditions. The dry canyon bottom shrub community occupies the hot, dry end of the gradient; the mesic canyon bottom shrub community is found in the middle portion; and the mesic montane woodland community occupies the cool, wet end of the gradient.

Similar patterns can be seen across the wide range of soil conditions in CARE. Among sites characterized by coarse textured soils, those with a shallow, poorly developed soil overlying a relatively impermeable bedrock generally are associated with the blackbrush-rabbitbrush or low shrub community. At the other end of the spectrum are deeper, though still coarse textured, soils or shallow soils overlying heavily fractured bedrock. These kinds of sites allow deeper root growth and support the more mesophytic species of the pinyon - juniper - tall shrub community. On intermediate sites one finds the pinyon - juniper - low shrub community, which contains a mix of species from both of the other kinds of communities occupying relatively more xeric and more mesic positions on the soil gradient just described.

Soils having a texture suitable for growth of grasses nevertheless vary continuously across the landscape, and support a range of grass - dominated communities. Deep, sandy soils appear to provide the best growing conditions for grasses, and are associated with eolian grassland, mixed grassland, or pinyon - juniper grassland communities. It is not clear exactly what determines which of these three types of communities will be present on a given site; it may involve historical events (e.g., grazing intensity) as well as environmental factors. As one moves gradually into soils containing more silts and clays, species composition also changes and one finds a grassland phase of the mat saltbush community or a mixed grassland community having a different mix of species than the mixed grassland developing on sandy soils. Where the fine soil particles are mixed with larger pebbles and cobbles, the plant community becomes a shadscale grassland or the galleta phase of the pinyon - juniper - low shrub

community. As coarse soil particles begin to largely replace the fine particles altogether, the plant community becomes dominated more strongly by woody plants, and grasses become a minor component of the community. These kinds of sites may support a low shrub or pinyon - juniper - low shrub community.

### **The Role of Natural Disturbances in the Vegetation of CARE**

The vegetation of any landscape consists of a mosaic of individual stands, some with more or less sharp boundaries, others with very gradual boundaries. The mosaic results from underlying patterns in environmental conditions, e.g., soil type and elevation, as well as historical events such as disturbance and successional processes (Romme and Knight 1982, Forman and Godron 1986). This present study was focused primarily on environmental gradients and their influence on the vegetation patterns in CARE. An important direction for future vegetation research would be to identify the important kinds of natural disturbances that have shaped the various plant communities in the park, and to clarify the role of disturbance and succession in creating and maintaining the striking diversity of plant species and communities in this area.

Our observations suggest that fire has been an important form of natural disturbance in the high elevation ecosystems of the upper Deep Creek portion of the park. We saw lightning scars and fire scars on several large ponderosa pine and Douglas fir trees in this area. One large stump contained five externally visible fire scars. Reconstructions of pre-settlement fire history in ponderosa pine forests elsewhere on the Colorado Plateau have revealed that these kinds of forests burned at intervals ranging from several years to a few decades prior to the onset of fire suppression activities in the twentieth century (Cooper 1960, 1961; Dieterich 1980, Madany and West 1983, White 1985). Periodic, low-intensity fires tended to maintain an open forest structure composed of large, widely spaced canopy trees and a well developed ground layer vegetation of grasses and forbs.

With the greatly reduced frequency of fire during the last century, the canopies of these

kinds of forests generally have become more dense, and the ground layer vegetation has become sparse because of shading by the canopy. Many of the large ponderosa pine and Douglas fir trees in upper Deep Creek were cut many years ago, but the spatial pattern of the stumps suggests that the presettlement forest was more open and contained larger trees than the forest present in this area today. The forest now consists of trees that appear to be mostly less than 100 years of age. In places we saw dying bitterbrush plants in the shade of young pine; the shrubs apparently were being killed by competition from the thickening forest canopy.

Accumulation of dead woody material in the absence of fire also has resulted in fuel conditions in which a fire today is likely to burn more intensely than the typically low-intensity fires of the nineteenth century (Dodge 1972). Thus, fire suppression may have significantly modified the structure and dynamics of high-elevation forests in CARE.

Fire probably has not been important in most of the low elevation communities because fuels generally are not abundant or continuous enough to carry a fire. Grassland communities may be an exception. In the absence of heavy grazing, grassland fuels are abundant and continuous enough to carry a low-intensity, rapidly moving fire. Such fires rarely kill the grasses or forbs, though they may exact heavy mortality in woody plants. Some investigators have suggested that pinyon and juniper are encroaching on southwestern grasslands as a consequence of fire suppression in this century (e.g., Johnsen 1962, Arnold et al. 1964; also see Tausch et al. 1981). However, we are aware of no recent studies addressing this question in the vicinity of CARE.

Other kinds of important natural disturbances in CARE may include periodic floods and landslides. Little research has been done in this area to investigate the possible effects and significance of these disturbances, but it seems likely that they influence the structure and dynamics of riparian communities and communities on steep, unstable slopes. In the course of our fieldwork, we observed waterpockets that had been recently scoured out by

a flood. In these places much of the former plant biomass had been removed, and new individuals were colonizing the exposed ground. As we noted in our discussion of plant communities in CARE, the waterpockets and riparian communities in general are characterized by extremely variable species composition from site to site. A part of this variability may be due to frequent disturbance by floods and subsequent recolonization, such that a stable or climax community never develops. Severe windstorms are a type of disturbance that is at least locally important. We found an area of about half a hectare in upper Deep Creek where all of the large trees had snapped and were lying with their boles pointed in the same direction (northeast).

#### Long Term Stability of Vegetation in CARE

Paleo-ecological research has revealed that the vegetation of the Colorado Plateau has changed during at least the last 25,000 years in response to fluctuating climatic conditions (Cole 1982, 1990; Betancourt 1990). The greatest changes occurred at the end of the Pleistocene some 12,000 - 14,000 years ago.

Two important paleo-ecological studies have been conducted in CARE. One was by Fisher et al. (1991), who examined opal phytoliths in grassland soils, and determined that grasslands in CARE today are different in some respects than they were 200-800 years ago. Grasslands today appear to contain fewer forbs and/or shrubs and fewer cool-season grasses. *Stipa* spp. appear to have decreased in abundance, whereas *Oryzopsis hymenoides* and *Hilaria jamesii* appear to have increased. These changes probably are due mainly to climatic changes since the end of the Little Ice Age some 100-150 years ago. Heavy livestock grazing also may have been involved (see below).

A second important paleo-ecological study was Cole's (1991) analysis of packrat middens in CARE. He reconstructed vegetation over the last 5400 years in the Harnet area of the park (Figure 1), and concluded that the greatest changes in vegetation composition throughout that time were related to overgrazing by livestock during the last 100 years. Plant species that are relatively intolerant of



grazing, such as *Ceratoides lanata* and *Oryzopsis hymenoides*, were more abundant in the older packrat deposits; whereas species that increase in the presence of heavy sustained grazing, such as *Chrysothamnus viscidiflorus* and *Gutierrezia sarothrae*, were more abundant in recent deposits. Cole (1991) also found some packrat middens in the Hall's Narrows area (Figure 1) dating from the Pleistocene. These contained plant species that today are restricted to higher elevations, such as *Pseudotsuga menziesii* and *Juniperus scopulorum*. These two paleo-ecological studies demonstrate that substantial changes have occurred in the vegetation of this area over at least the last 25,000 years, in response both to broad-scale climatic change and to more localized effects of heavy livestock grazing.

As a result of anthropogenic increases in carbon dioxide and other greenhouse gases, another major climatic change is expected to occur over the next century. This change may be comparable in magnitude to that at the end of Pleistocene, but the rate of change will be far greater than previous events (Bolin et al. 1986). Current projections based on global circulation models (e.g., Hansen et al. 1988, Schlesinger and Zhao 1988, Wetherald and Manabe 1988) suggest an average rise in global temperature of 1.5 - 4.5 degrees C (Dickinson 1986). Reduced precipitation and soil moisture at middle latitudes also are predicted, although regional differences in temperature and precipitation changes are likely, and currently beyond the resolving powers of the climate models.

The impending global climate change has far-reaching ramifications for natural areas (Peters and Darling 1985, Tangle 1988, Davis 1989, Graham et al. 1990, Romme and Turner 1991). Potential ranges for species may change more rapidly than populations can migrate to new areas or adapt to new local conditions. Disturbance regimes also are likely to be altered, e.g., fires may become more frequent (Sandenburgh et al. 1987). Managers need to understand the present complex of biotic and abiotic factors, including disturbance, that control the distribution of species and plant communities if they are to anticipate and deal with the substantial changes likely to occur in the coming century (Neilson et al. 1989).

Further research into the interactions between environmental gradients and various kinds of disturbances that shape CARE's vegetation would aid park management and interpretation not only by clarifying the causes of present vegetation patterns but also by helping us to anticipate the potentially devastating effects of global climate change over the next century.

### Effects of Grazing on the Vegetation of CARE

The role of natural disturbances — e.g., fire, floods, landslides, and climatic variation — in shaping the vegetation of CARE has been discussed above. In addition to these natural disturbances, livestock grazing during the last century has profoundly influenced the composition and dynamics of some types of plant communities in CARE. Our research indicates that the most significant grazing effects have occurred in accessible grassland and riparian communities, though nearly all communities have been affected to some extent (Figure 9). Sparks et al. (1990) assessed vegetational changes during the last century in two townships in northern Utah, and reported the greatest livestock-related changes in mid-elevation bench, foothill, and bajada sites — similar to the patterns we found in CARE.

Livestock grazing in CARE's grasslands evidently has had little effect on total cover or number of species, except in very heavily and continuously grazed stands where both of these parameters are reduced (Figure 11). However, our results suggest that even light grazing has produced substantial changes in species composition of grassland communities. The relative abundance of more palatable species (e.g., bunchgrasses) decreases along a gradient of increasing grazing intensity, whereas the abundance of unpalatable species (e.g., *Gutierrezia sarothrae*) shows the opposite pattern (Figure 12). Some of the most preferred plant species, e.g. *Ceratoides lanata* and *Stipa comata*, may have been locally extirpated by grazing (Figure 13).

In addition to changes in species composition, heavy and prolonged livestock grazing appears to have altered the overall structure of some grasslands in CARE. For purposes of comparison, we visited the top of the South



Caineville Butte, approximately 10 km east of CARE, which supports a relatively xeric grassland community comparable to xeric grasslands in CARE. However, the grassland on South Caineville Butte has not been grazed for many years (since the 1950s according to one local landowner; since the 1930s according to another). It probably never was heavily grazed since there are no reliable sources of water. One of the most striking features of the grassland on South Caineville Butte is the large quantity of biomass and litter. There are enormous clumps of *Oryzopsis hymenoides*, for example, with heights of 1 m and diameters of 0.5 m containing a mass of dead leaves and culms accumulated over many years or decades of growth. By contrast, comparable grassland sites in CARE support only small clumps of *Oryzopsis hymenoides* with minimal accumulation of litter as a result of repeated grazing.

These kinds of differences in structure probably are associated with important differences in energy flow and nutrient cycling in grazed and ungrazed grasslands. Net primary productivity may be higher in lightly grazed stands because removal of dead leaves and culms improves light penetration to photosynthetically active tissues. Net primary productivity probably is reduced in heavily grazed stands, however. Wildlife habitat also appears to be quite different in heavily grazed and ungrazed stands. Dave Willey (personal communication, 1989) reported a greater abundance and diversity of breeding songbirds on South Caineville Butte than in heavily grazed but otherwise comparable sites in CARE. He attributed the differences in part to the nesting habitat provided by the large thick clumps of bunchgrasses in the ungrazed area.

Regarding the effects of livestock grazing in riparian areas, our data suggest similar shifts in species composition from dominance by relatively palatable species to dominance by less palatable species. For example, in the series of waterpockets comprising the Willow and Cottonwood Tanks in the southern part of CARE, those waterpockets that are accessible to livestock supported a measurably different flora than the waterpockets that livestock

cannot reach (Figure 14). Ungrazed stands were characterized by relatively high cover of palatable bunchgrasses (*Oryzopsis hymenoides*, *Poa fendleriana*, *Sporobolus cryptandrus*, and *Stipa comata*). These same species were uncommon or absent in the nearby grazed stands. Because all of the waterpockets that we sampled in this area were within 100 m of each other and shared very similar habitats, the differences in vegetation that we detected were probably due primarily to differences in livestock use. Interestingly, both grazed and ungrazed stands contained *Bromus tectorum* and other species associated with disturbed sites, apparently because of frequent disturbance by flooding even in the absence of grazing.

Barth and McCullough (1988) documented similar differences between heavily and lightly grazed streamside communities in CARE. Their data also suggested that prolonged heavy livestock use of riparian areas may prevent reproduction of Fremont cottonwood. An examination of historic photographs further suggested that many of the riparian areas in CARE were severely damaged by the uncontrolled grazing that occurred prior to the Taylor Act and the beginnings of grazing regulation in the late 1930s (Barth and McCullough 1988).

Both grassland and riparian areas are vulnerable to damage by excessive livestock use, but these two kinds of communities probably differ in two important ways in their sensitivity and response to heavy grazing. First, grazing effects are likely to be more widespread in accessible riparian areas, because the presence of water and succulent vegetation makes these areas especially attractive to animals. We noted, for example, that the waterpockets we sampled fell into only two grazing categories: heavily grazed or ungrazed. The latter category occurred only where steep or rocky terrain made it physically impossible for animals to reach the area.

By contrast, we found a variety of grassland stands ranging from heavily grazed to lightly grazed, even in areas where the terrain did not prevent animal access. In grasslands, livestock tend to concentrate around sources

of water; areas remote from reliable water may be lightly used even though livestock numbers are high. Thus, the intensity of livestock grazing appears to be more variable in grassland than in riparian communities.

The second important difference between grasslands and riparian areas relates to the rate and probability of recovery from excessive grazing once the grazing pressure is alleviated. Riparian areas appear to recover relatively quickly, probably because of the favorable growing conditions that promote re-establishment of native plants that had been reduced or even extirpated by grazers. A comparison of photographs from the 1930s and 1940s with the same sites today (Barth and McCulloch 1988) suggests that over-grazed streambanks in CARE have largely recovered from the over-grazing of the early part of this century.

By contrast, reestablishment of native plants in the semi-arid environments that characterize CARE's grasslands probably is far slower and even problematical. Suitable climatic conditions for establishment of new bunchgrasses, for example, may occur only every several decades. Moreover, seed sources may have been eliminated in many local areas, and the well-established exotic species that dominate some sites (e.g., cheatgrass) may competitively exclude seedlings of the native grasses. The depauperate plant communities on some of these arid, heavily over-grazed

sites may have come into equilibrium with the abiotic environment and thus represent new, stable forms of vegetation.

Cheatgrass establishment in many portions of the northern Great Basin also has led to a profound change in the fire regime. Whereas fires formerly occurred infrequently and burned in a patchy fashion because of the discontinuity of the fuels in native sagebrush steppe, the continuous and flammable fuels created by the cheatgrass permit very extensive fires to occur now as frequently as every few years in places (Whisenant 1990). This has led to almost complete destruction of the native perennial shrubs and grasses and their replacement with cheatgrass and other annuals. Such an extreme vegetational conversion does not appear to have occurred in CARE, though it could potentially occur in some areas where cheatgrass is presently very abundant.

It appears, therefore, that even with elimination of livestock grazing, some of CARE's grassland areas may never return to their pre-grazing structure and composition without some form of active intervention. Some arid, over-grazed sites may now be in a new equilibrium with the abiotic environment, and further degradative changes may potentially occur, judging from experiences elsewhere. Additional research in this area is needed if the goal is to restore the vegetation of CARE to its presettlement condition.

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APPENDIX I  
ANNOTATED CHECKLIST OF VASCULAR PLANTS  
CAPITOL REEF NATIONAL PARK, UTAH

Distributional categories used in the checklist are:

- (W)-widespread throughout Capitol Reef National Park;
- (C)-common throughout much of the park or to a particular part of the park;
- (O)-occasional, widely scattered in the park;
- (U)-uncommon, of limited distribution;
- (R) rare, of very limited distribution and only known from one or two locations in the park.

The elevational range is given for each taxon in feet above sea level.

FERN ALLIES

SELAGINELLACEAE

*Selaginella mutica* D. C. Eaton  
U; 5500 to 7500; on rocks in shady sites; slickrock communities; near Hickman Bridge, Water-pocket Fold, Miners Mountain, Cohab and Frying Pan Canyons.

*Notholaena limitanea* Maxon  
R; 5000; canyon bottoms; pinyon-juniper woodland, rock crevices; Muley Twist Canyon.

*Woodsia pregana* D.C. Eaton  
U; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

EQUISETACEAE

*Equisetum arvense* L.  
O; 4000-4500; bottomland; riparian; oxbow of the Fremont River and Halls Creek.

*Equisetum hyemale* L.  
O; 5500-6500; bottomland; riparian; oxbow of the Fremont River, Pleasant Creek, and Spring Canyon.

*Equisetum laevigatum* A. Br.  
R; 4000; bottomland; riparian; Halls Creek.

FERNS

POLYPODIACEAE

*Adiantum capillus-veneris* L.  
U; 3900-4000; moist slickrock sandstone walls; hanging garden community; lower Halls Creek.

*Cheilanthes feei* Moore  
O; 5000-7000; bottomlands, canyons, and benches; sagebrush and pinyon-juniper woodland; Fremont River Valley, Water Canyon, Sulphur Creek and Miners Mountain.

*Cystopteris fragilis* (L.) Bernh. in Schrader  
R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

GYMNOSPERMS

CUPRESSACEAE

*Juniperus communis* L.  
U; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Juniperus osteosperma* (Torr.) Little  
W; 3900-8000; desert shrub to mixed conifer woodland; widespread throughout the park.

*Juniperus scopulorum* Sarg.  
U; 7500-8000; mountains; mixed conifer woodland; Upper Deep Creek.

EPHEDRACEAE

*Ephedra nevadensis* Wats.  
R; 4000; canyon bottoms; desert shrub; Halls Narrows.

*Ephedra torreyana* Wats.  
W; 3900-7000; upland, bottomland, hills, mesas, benches, washes, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Ephedra viridis* Cov.  
W; 3900-7500; upland, bottomland, hills, mesas, benches, washes, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

PINACEAE

*Picea pungens* Engelm.  
U; 8000; mountains; riparian; Upper Deep  
Creek.

*Pinus edulis* Engelm. in Wisliz.  
W; 5000-7500; upland, mesas, hills and benches;  
pinyon-juniper woodland; widespread through-  
out the park.

*Pinus longaeva* D.K. Bailey  
U; 8500; mountain benches; bristlecone pine  
community; Upper Deep Creek.

*Pinus ponderosa* Dougl. ex P. & C. Lawson  
C; 6500-8800; upland, mountains, and canyons;  
mixed conifer woodland; Upper Deep Creek,  
Longleaf Flats, Pleasant Creek, Grand Wash,  
and Spring Canyon.

*Pseudotsuga menziesii* (Mirb.) Franco  
O; 5000-8800; canyons and mountains; moist  
sites and mixed conifer woodland; Pleasant  
Creek, Muley Twist Canyon, Spring Canyon,  
and Upper Deep Creek.

FLOWERING PLANTS  
DICOTYLEDONS

ACERACEAE

*Acer glabrum* Torr.  
O; 7000-8500; mountains and upland canyons;  
riparian; Spring Canyon and Upper Deep Creek.

*Acer negundo* L.  
O; 4000-6500; upland canyons, seeps, springs  
and waterpockets; riparian; Fremont Valley,  
Capitol Wash, Pleasant Creek, Halls Creek,  
Upper Muley Twist, Upper Deep Creek, Cohab-  
Frying Pan, Sulphur Creek, Spring Canyon and  
Grand Wash.

AMARANTHACEAE

*Amaranthus graecizans* L.  
O; 5500; bottomland; disturbed sites; Fremont  
River Valley.

*Amaranthus powellii* Wats.  
O; 5500; bottomland; orchards along the  
Fremont River.

ANACARDIACEAE

*Rhus aromatica* Ait. var. *simplicifolia* (Greene)  
Cronq.  
O; 5000-6000; canyons, canyon bottoms, and  
mesas; pinyon-juniper woodland; Wagon Box  
Mesa and Hickman Bridge.

*Rhus aromatica* Ait. var. *trilobata* (Nutt.) Gray  
W; 4000-7000; upland, bottomland, mesas,  
canyons, benches, and canyon bottoms;  
riparian, and desert shrub to pinyon-juniper  
woodland; widespread throughout the park.

*Toxicodendron rydbergii* (Small) Greene  
O; 4000-5500; bottomland; riparian; oxbow of the  
Fremont River and Halls Creek.

APOCYNACEAE

*Amsonia jonesii* Woodson  
O; 4000-4500; canyon bottoms; desert shrub and  
blackbrush; Halls Creek.

*Apocynum cannabinum* L.  
O; 4500-5500; bottomlands and wet places;  
riparian; Fruita, Halls Creek and The Post.

*Cycladenia humilis* Benth. var. *jonesii* (Eastw.)  
Welsh & Atwood  
R; 6000; hillsides; desert shrub-juniper commu-  
nity; Deer Point.

ASCLEPIADACEAE

*Asclepias asperula* (Decne.) Woodson  
R; 6000; canyons; pinyon-juniper woodland;  
Frying Pan Canyon.

*Asclepias cryptoceras* Wats.  
O; 5500-6500; mesas, benches and hillsides;  
desert shrub to pinyon-juniper woodland;  
Lower Deep Creek, Sulphur Creek, Burr Trail,  
and The Hartnet.

*Asclepias labriformis* Jones  
O; 5000-6000; washes; desert shrub to pinyon-  
juniper woodland; Capitol Gorge, Middle Desert  
Wash, Spring Canyon and Pleasant Creek.

*Asclepias latifolia* (Torr.) Raf.  
R; 4000-5500; hillsides and canyon bottoms;  
desert shrub and pinyon-juniper woodland;  
Fruita and Halls Narrows.



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*Asclepias macrosperma* Eastw.  
R; 5000; hillsides; desert shrub; The Post.

*Asclepias ruthiae* Maguire & Woodson  
U; 5500-6500; bottomland, hills, and benches;  
desert shrub and pinyon-juniper woodland;  
Middle Desert Wash, Cathedral Valley and  
Longleaf Flat.

*Asclepias speciosa* Torr.  
O; 5500-6000; moist sites; riparian; Fruita.

*Asclepias subverticellata* (Gray) Vail  
R; 4000; canyon bottoms; desert shrub; Halls  
Narrows.

BERBERIDACEAE

*Berberis fremontii* Torr.  
C; 4000-5500; canyons, benches, and mesas;  
pinyon-juniper woodland; Halls Creek and  
Circle Cliffs.

*Berberis repens* Lindl.  
O; 6000-8000; mountains and canyon bottoms;  
mixed conifer woodland; Cohab Canyon and  
Upper Deep Creek.

*Berberis vulgaris* L.  
U; 5500; bottomland; orchards; Fruita.

BETULACEAE

*Alnus tenuifolia* Nutt.  
R; 7500-8500; canyon bottoms; mixed conifer  
woodland; Upper Deep Creek.

*Betula occidentalis* Hook.  
O; 5500-8000; uplands and canyon bottoms;  
riparian; Pleasant Creek, Water Canyon, South  
Desert Overlook, and Upper Deep Creek.

*Ostrya knowltonii* Cov.  
R; 4000; canyon bottoms; riparian; Halls  
Narrows.

BORAGINACEAE

*Cryptantha abata* Johnst.  
C; 5000-8000; mesas, benches, mountains, and  
canyon bottoms; desert shrub to mixed conifer  
woodland; Sulphur Spring, Burr Trail, Upper  
Deep Creek and Miners Mountain.

*Cryptantha capitata* (Eastw.) Johnst.  
U; 6000-7000; flats, meadows, and rocky sites;  
sagebrush communities and pinyon-juniper  
woodland; Paradise Flats and Hickman Bridge.  
*Cryptantha cinerea* (Torr.) Cronq.  
W; 5500-8000; bottomland, mesas, benches, and  
washes; desert shrub to mixed conifer wood-  
land; Fremont River Valley, Cathedral Valley,  
South Desert, Upper and Middle Deep Creek,  
and Pleasant Creek.

*Cryptantha circumscissa* (H. & A.) Johnst.  
O; 3900-5500; canyon bottoms; desert shrub;  
Halls Creek and Spring Canyon.

*Cryptantha confertiflora* (Greene) Payson  
C; 4000-6000; hillsides, benches, and canyon  
bottoms; desert shrub to pinyon-juniper  
woodland; Halls Narrows, Burr Trail, and South  
Desert.

*Cryptantha crassisejala* (T. & G.) Greene  
O; 5000-6500; bottomland, mesas, and benches;  
desert shrub to pinyon-juniper woodland; The  
Post and The Hartnet.

*Cryptantha fendleri* (Gray) Greene  
U; 5000-7000; hillsides and canyons; desert  
shrub to pinyon-juniper woodland; Middle  
Deep Creek, Big Thomson Mesa, and Pleasant  
Creek.

*Cryptantha flava* (A. Nels.) Payson  
W; 4000-6500; bottomland, upland, hills, and  
mesas; desert shrub to pinyon-juniper wood-  
land; widespread throughout the park.

*Cryptantha flavoculata* (A. Nels.) Payson  
C; 5000-6500; upland, hillsides and benches;  
desert shrub to pinyon-juniper woodland; Burr  
Trail, Sulphur Creek, Water Canyon, and South  
Desert Overlook.

*Cryptantha fulvocanescens* (Gray) Payson  
W; 5000-6000; bottomland, upland, hills, mesas,  
and benches; desert shrub to pinyon-juniper  
woodland; Fremont River Valley, Chimney  
Rock, Sulphur Creek, and Hickman Bridge.

*Cryptantha gracilis* Osterh.  
C; 4000-6500; upland, hillsides, and benches;  
desert shrub to pinyon-juniper woodland; Red  
Slide, Pleasant Creek, Hickman Bridge, and  
Lower Muley.

*Cryptantha humilis* (Gray) Payson  
O; 8000-8800; mountains; mixed conifer woodland; Upper Deep Creek.

*Cryptantha johnstonii* Higgins  
R; 7500-8500; mountains and washes; mixed conifer woodland (moist sites); Middle and Upper Deep Creek.

*Cryptantha mensana* (Jones) Payson  
O; 5000-6000; upland, hillsides, mesas, and benches; desert shrub to pinyon-juniper woodland; Burr Trail, Fruita, and Deer Point.

*Cryptantha micrantha* (Torr.) Johnst.  
R; 4000-4500; hillsides and benches; desert shrub; Hall Divide.

*Cryptantha pterocarya* (Torr.) Greene  
U; 4000-6000; bottomland and canyon bottoms; desert shrub to pinyon-juniper woodland; Burr Trail and Halls Creek.

*Cryptantha pustulosa* (Rydb.) Payson  
R; 5000-5500; hillsides; desert shrub; The Post.

*Cryptantha recurvata* Cov.  
C; 5000-6000; hills and benches; desert shrub to pinyon-juniper woodland; Burr Trail, Cedar Mesa, Hickman Bridge, and Spring Canyon.

*Cryptantha rollinsii* Johnst.  
O; 5000-6000; mesas and benches; desert shrub to pinyon-juniper woodland; The Hartnet.

*Cryptantha setosissima* (Gray) Payson  
U; 8000; mountains; mixed conifer woodland; Upper Deep Creek.

*Cryptantha tenuis* (Eastw.) Payson  
R; 5000-6000; hills; desert shrub to pinyon-juniper woodland; Burr Trail.

*Lappula occidentalis* (Wats.) Greene  
C; 4000-5500; bottomland; disturbed sites; Fruita, Oyster Shell Reef, Spring Canyon, and Halls Creek.

*Lithospermum incisum* Lehm.  
C; 4000-8500; canyon bottoms, mountains, and benches; desert shrub to mixed conifer woodland; Upper Deep Creek, Halls Creek, and Hickman Bridge.

*Lithospermum multiflorum* T. & G.  
U; 5500-8500; upland and mountains; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek and Sheets Gulch.

*Tiquilia latior* (Johnst.) A. Richards.  
R; hills; desert shrub; Cathedral Valley.

#### CACTACEAE

*Coryphantha vivipara* (Nutt.) Britt. & Rose  
R; 5000-6000; hillsides and benches; pinyon-juniper woodland; Burr Trail.

*Echinocereus triglochidiatus* Engelm. var. *inermis* (K. Schum.) Rowl  
R; 7000; hillsides; pinyon-juniper woodland; Paradise Draw.

*Echinocereus triglochidiatus* Engelm. var. *melanacanthus* (Engelm.) L. Benson  
W; 4500-7000; upland, mesas, hills, benches, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Opuntia basilaris* Engelm. & Bigel. var. *heilii* Welsh & Neese  
R; 5500; benches; desert shrub; Visitor Center.

*Opuntia fragilis* (Nutt.) Haw.  
C; 6500-8500; upland, mesas, and mountains; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek and Pleasant Creek.

*Opuntia phaeacantha* Engelm.  
C; 3900-6500; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Fremont River Valley, Pleasant Creek, Hickman Bridge, Halls Creek and Spring Canyon.

*Opuntia polyacantha* Haw.  
W; 3900-7500; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Pediocactus simpsonii* (Engelm.) L. Benson  
O; 8000; mountains; mixed conifer woodland; Upper Deep Creek.

*Pediocactus winkleri* Heil  
R; 5000-5500; hills and benches; desert shrub to pinyon-juniper woodland; Jailhouse Rock and Ackland Spring.

*Sclerocactus parviflorus* Clover & Jotter  
O; 4000-7000; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Fremont River Valley, Cedar Mesa, Hickman Bridge, Cohab/Frying Pan Canyons, Muley Twist Canyon, and Burr Trail.

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*Sclerocactus wrightiae* L. Benson  
U; 5000-6000; hills and benches; desert shrub to  
pinyon-juniper woodland; Ackland Spring,  
Cathedral Valley, and South Desert.

CAMPANULACEAE

*Campanula parryi* Gray  
R; bottomland; saline soils (riparian); Fremont  
River Valley and Oak Creek.

*Lobelia cardinalis* L.  
R; 3900; canyon bottoms; riparian; Halls Nar-  
rows.

CANNABINACEAE

*Humulus americanus* Nutt.  
U; 5000-5500; bottomland; riparian; Fremont  
River Valley.

CAPPARIDACEAE

*Cleome lutea* Hook.  
O; 4000-6000; bottomland and canyon bottoms;  
desert shrub to mixed conifer; widespread  
throughout the park.

*Cleome serrulata* Pursh  
R; 5000-6000; bottomland; riparian and road-  
sides; Fremont River Valley and Cathedral  
Valley.

*Cleomella palmerana* Jones  
R; 4000; benches; desert shrub; Halls Creek.

CAPRIFOLIACEAE

*Lonicera utahensis* Wats.  
O; 8500; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Sambucus caerulea* Raf.  
O; 8500; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Symphoricarpos longiflorus* Gray  
O; 4500-7000; upland, mesas, benches, and  
canyons; desert shrub to pinyon-juniper  
woodland; occasional throughout the park.

*Symphoricarpos oreophilus* Gray  
O; 5000-8000; upland, bottomland, and moun-  
tains; pinyon-juniper woodland to mixed conifer  
woodland; Upper Deep Creek, South Desert  
Overlook, and the Fremont River Valley.

CARYOPHYLLACEAE

*Arenaria fendleri* Gray var. *eastwoodiae* (Rydb.)  
Welsh  
U; 6000; mesa; pinyon-juniper woodland; The  
Hartnet.

*Arenaria fendleri* Gray var. *glabrescens* Wats.  
O; 7200-8200; hillsides and benches; mixed  
conifer woodland and bristlecone pine commu-  
nity; Miners Mountain and Upper Deep Creek.

*Cerastium nutans* Raf.  
R; 8500; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Lychnis drummondii* (Hook.) Wats.  
R; 8800; mountains; meadows; Upper Deep-  
Creek.

*Paronychia sessiliflora* Nutt.  
O; 7000-8000; mountains and benches; pinyon-  
juniper woodland and mixed conifer woodland;  
Upper Deep Creek and Miners Mountain.

*Saponaria officinalis* L.  
O; 5500; bottomland; riparian; Fremont River  
Valley.

*Silene antirrhina* L.  
U; 4000-5000; canyon bottoms; disturbed sites;  
Willow Tanks and Halls Creek.

*Stellaria longipes* Goldie  
R; 8500; mountains; mixed conifer woodland;  
Upper Deep Creek.

CELESTRACEAE

*Pachystima myrsinites* (Pursh) Raf.  
U; 8000-8800; mountains; mixed conifer wood-  
land; Upper Deep Creek.

CHENOPODIACEAE

*Allenrolfea occidentalis* (Wats.) Kuntze  
R; 5700; saline bottomland; riparian; Lower  
Deep Creek.

*Atriplex argentea* Nutt.  
R; 5500; benches; desert shrub; Chimney Rock.

*Atriplex canescens* (Pursh) Nutt.  
W; 4000-6500; bottomlands, hills, and mesas;  
desert shrub to pinyon-juniper woodland;  
widespread throughout the park.

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*Atriplex confertifolia* (Torr. & Frem.) Wats.  
W; 4000-6500; hillsides, mesas, bottomland, and benches; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Atriplex corrugata* Wats.  
U; 5000-5500; bottomland and hillsides; desert shrub; The Post.

*Atriplex gardneri* (Moq.) D. Dietr. var. *cuneata* (A. Nels.) Welsh  
W; 4000-6500; bottomland, hills, and benches; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Atriplex graciliflora* Jones  
R; 4000; canyon bottoms; riparian; Halls Narrows.

*Atriplex patula* L.  
R; 5500; bottomland; saline soils (riparian) Fremont River Valley.

*Atriplex powellii* Wats.  
U; 5000-5500; bottomland and hillsides; desert shrub; The Post.

*Atriplex rosea* L.  
R; 5500; bottomland; saline soils (riparian); oxbow of the Fremont River.

*Atriplex saccaria* Wats.  
O; 5000-6000; bottomland, washes, and canyon bottoms; desert shrub; Burr Trail, Grand Wash, Ackland Spring.

*Bassia hyssopifolia* (Pallas) Kuntze  
R; bottomland; disturbed sites; Bitter Spring Creek area.

*Ceratoides lanata* (Pursh) J.T. Howell  
W; 5000-6000; upland, mesas, and benches; desert shrub, sagebrush, and pinyon-juniper woodland; Burr Trail, Grand Wash, and Cathedral Valley.

*Chenopodium album* L.  
R; 8500; mountains; disturbed sites in riparian; Upper Deep Creek.

*Chenopodium botrys* L.  
R; 6000; waste places; riparian; Oak Creek.

*Chenopodium fremontii* Wats.  
W; 4000-6500; bottomland; desert shrub, sagebrush, and pinyon-juniper woodland; Halls Creek, Fremont River Valley, and Muley Twist Canyon.

*Chenopodium glaucum* L.  
O; 5500; canyon bottoms; riparian; Fremont River Valley.

*Chenopodium leptophyllum* Nutt. in Wats.  
O; 5000-7000; bottomland, benches, and upland; riparian and pinyon-juniper woodland; Sulphur Creek, Fremont River Valley, and The Hartnet.

*Corispermum villosum* Rydb.  
U; 5000-5500; bottomland; disturbed sites; Fremont River Valley.

*Grayia spinosa* (Hook.) Moq.  
R; 3900; hills, benches, and canyons; desert-shrub; Halls Creek.

*Halogeton glomeratus* C.A. Mey. in Ledeb.  
O; 5000-6000; bottomland; desert shrub; Fremont River Valley and Middle Desert Wash.

*Kochia americana* Wats.  
O; 5000-5500; canyon bottoms; desert shrub to pinyon-juniper woodland; Muley Twist Canyon and Chimney Rock.

*Kochia scoparia* (L.) Schrader  
C; 5000-6500; bottomland; disturbed sites; Fremont River Valley, Spring Canyon, and Pleasant Creek.

*Monolepis nuttalliana* (Schult.) Greene  
U; 5000-6500; bottomland; disturbed sites; Muley Twist Canyon, Burr Trail, and Longleaf Flat.

*Salsola iberica* Sennen & Pau  
W; 4000-7000; bottomland, washes, and canyon bottoms; desert shrub to pinyon-juniper woodland (disturbed sites); widespread throughout the park.

*Sarcobatus vermiculatus* (Hook.) Torr. in Emory  
C; 5000-6000; bottomland; desert shrub; Fremont River Valley, Cedar Mesa, Cathedral Valley, and Spring Canyon.

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*Suaeda calceoliformis* (Hook.) Moq.  
U; 5500; bottomland; riparian; oxbow of the  
Fremont River.

*Suaeda torreyana* Wats.  
C; 4000-6500; bottomland; riparian; Pleasant  
Creek, Sulphur Creek, Brimhall Arch, Halls  
Creek, and Burr Trail.

*Zuckia brandegei* (Gray) Welsh & Stutz var.  
*arizonica* (Standley) Welsh  
R; 5000; hillsides; desert shrub; Jailhouse Rock

*Zuckia brandegei* (Gray) Welsh & Stutz var.  
*brandegei*  
O; 5000-6500; upland, mesas, benches, and  
canyons; desert shrub to pinyon-juniper  
woodland; The Hartnet, Cohab Canyon,  
Fremont River Valley, and Chimney Rock.

CELASTRACEAE

*Forsellsia meionandra* (Koehne) Heller  
O; 5000-8000; bottomland, mountains; upland,  
hills, mesas, and benches; desert shrub to mixed  
conifer woodland; Fremont River Valley, Middle  
and Lower Deep Creek, and Jailhouse Rock.

COMPOSITATE

*Achillea millefolium* L.  
R; 8800; mountains; Aspen community; Upper  
Deep Creek.

*Ambrosia acanthicarpa* Hook.  
W; 5000-6000; bottomland; disturbed sites;  
Fruita, Cathedral Valley, Chimney Rock.

*Antennaria parvifolia* Nutt.  
O; 8000-8800; mountains; mixed conifer forest;  
Upper Deep Creek.

*Antennaria rosea* Rydb.  
R; 8500; mountains; mixed conifer forest; Upper  
Deep Creek.

*Antennaria rosulata* Rydb.  
R; 8500; mountains; mixed conifer forest; Upper  
Deep Creek.

*Arctium minus* (Hill) Bernh.  
O; 5500; bottomland; waste places; Fremont  
River Trail.

*Artemisia bigelovii* Gray  
W; 4500-6500; benches and mesas; pinyon-  
juniper woodland and sagebrush flats;  
widespread throughout the park.

*Artemisia campestris* L.  
O; 5500-8000; canyon bottoms, benches, dis-  
turbed sites, mountains; desert shrub,  
pinyon-juniper woodland, and mixed conifer;  
Cathedral Valley, Upper Deep Creek, and  
Middle Desert Wash.

*Artemisia dracunculus* L.  
W; 5500-8000; canyon bottoms and washes;  
pinyon-juniper to mixed conifer; widespread  
throughout the park.

*Artemisia filifolia* Torr.  
O; 3900-6000; benches, washes and canyon bot-  
toms (sandy sites); desert shrub to  
pinyon-juniper woodland; widespread through-  
out the park.

*Artemisia frigida* Willd.  
R; 8500; canyons; mixed conifer and sagebrush  
flats; Upper Deep Creek.

*Artemisia ludoviciana* Nutt.  
W; 4000-8500; benches, canyon bottoms, washes,  
mesas, mountains; desert shrub to mixed  
conifer; widespread throughout the park.

*Artemisia nova* A. Nels.  
O; 8000-8800; mountains; sagebrush communi-  
ties; Upper Deep Creek.

*Artemisia pygmaea* Gray  
R; 6000-6500; mesas and uplands; sagebrush  
communities and pinyon-juniper woodland; top  
of the Burr Trail and South Desert Overlook.

*Artemisia spinescens* D.C. Eaton in Wats.  
R; 4000; benches; desert shrub; Lower Halls  
Creek.

*Artemisia tridentata* Nutt. var. *tridentata*  
W; 5000-6000; benches; sagebrush communities;  
widespread throughout the park.

*Artemisia tridentata* Nutt. var. *vaseyana* (Rydb.) B.  
Boi.  
O; 7500-8500; benches and mountains; sage-  
brush communities; Upper Deep Creek.

*Aster brachyactis* Blake in Tidestr.  
R; 5500; bottomland; riparian communities;  
Fremont River Valley

*Aster chilensis* Nees  
W; 5000-6000; bottomland and canyon bottoms;  
riparian; Fremont River Valley, Oak Creek, and  
Pleasant Creek.



*Aster foliaceus* Lindl. in DC.

O; 5000-6000; bottomland and canyon bottoms; moist sites; Cathedral Valley, Fremont River Valley and Pleasant Creek.

*Aster frondosus* (Nutt.) T. & G.

R; 6000; canyon bottoms; riparian; Oak Creek.

*Aster glaucodes* Blake

R; 7000-8500; mountains; mixed conifer woodland; Upper and Middle Deep Creek.

*Aster occidentalis* (Nutt.) T. & G.

O; 5500; bottomland; orchards; Fruita.

*Aster pauciflorus* Nutt.

C; 5500-6000; bottomland and canyon bottoms; salt marsh and riparian; Fremont River Valley, Pleasant Creek, and Sulphur Creek.

*Baccharis emoryi* Gray in Torr.

O; 4000; washes and canyon bottoms; riparian; Halls Narrows.

*Baccharis salicina* T. & G.

R; 5000; washes and waterpockets; riparian; Cottonwood Tanks.

*Bahia dissecta* (Gray) Britt.

U; 6000; hillsides and canyons; pinyon-juniper woodland; Pleasant Creek.

*Bidens cernua* L.

O; 5500; bottomland; saline soils (riparian); oxbow of the Fremont River.

*Brickellia atractyloides* Gray

R; 4500-5000; steep hill sides; desert shrub; slopes leading to Halls Creek.

*Brickellia californica* (T. & G.) Gray

C; 5500-7500; canyon bottoms; riparian and desert shrub; Fruita, Paradise Draw, Spring Canyon, and middle Deep Creek.

*Brickellia grandiflora* (Hook.) Nutt.

O; 5500; canyon bottoms; pinyon-juniper woodland and mixed conifer woodland; Fremont River Valley.

*Brickellia longifolia* Wats.

O; 4000-5000; washes; hanging gardens; Lower Muley Twist Canyon and Halls Creek.

*Brickellia microphylla* (Nutt.) Gray var. *scabra* Gray

O; 5000-6500; mesas and benches; slickrock communities; widespread throughout the park.

*Brickellia oblongifolia* Nutt.

O; 5000-6500; hillsides and benches; desert shrub; Burr Trail, Muley Twist Canyon and Deer Point.

*Chaenactis douglasii* (Hook.) H. & A.

O; 7500-8800; mountains; mixed conifer woodland; Upper Deep Creek.

*Chaenactis steviodes* H. & A.

O; 4000-6000; bottomland; desert shrub; Halls Creek and Burr Trail.

*Chamaechaenactis scaposa* (Eastw.) Rydb.

R; 6000; benches and hillsides; pinyon-juniper woodland; South Desert Overlook.

*Chrysothamnus depressus* Nutt.

O; 5500-6500; hillsides and benches; pinyon-juniper woodland; Burr Trail and Muley Twist Canyon.

*Chrysothamnus linifolius* Greene

O; 5000-6000; washes; riparian; Sulphur Creek and Cathedral Valley.

*Chrysothamnus nauseosus* (Pallas) Britt. var. *abbreviata* (Jones) Welsh

O; 6000-7000; mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Frying Pan Canyon, Hickman Bridge, and Wagon Box Mesa.

*Chrysothamnus nauseosus* (Pallas) Britt. var. *albicaulis* (Nutt.) Rydb.

O; 6000-8000; uplands and mountains; pinyon-juniper woodland and mixed conifer woodland; Pleasant Creek and Upper Deep Creek.

*Chrysothamnus nauseosus* (Pallas) Britt. var. *biglovii* (Gray) Hall

U; 6500; ledges; slickrock communities; Pleasant Creek.

*Chrysothamnus nauseosus* (Pallas) Britt. var. *consimilis* (Greene) Hall

O; 5500; bottomland; desert shrub; Cathedral Valley.

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*Chrysothamnus nauseosus* (Pallas) Britt. var.  
*graveolens* (Nutt.) Piper  
W; 3900-7000; bottomland, benches and mesas;  
desert shrub to pinyon-juniper woodland;  
widespread throughout the park.

*Chrysothamnus nauseosus* (Pallas) Britt. var.  
*junceus* (Greene) Hall  
O; 4000-6000; bottomland, mesas, and benches;  
desert shrub to pinyon-juniper; Cathedral  
Valley, Wagon Box Mesa, and Hall Divide.

*Chrysothamnus nauseosus* (Pallas) Britt. ssp.  
*latisquameus* (Gray) Hall & Clem.  
O; 5000-5500; bottomland; disturbed sites;  
Fruita.

*Chrysothamnus nauseosus* (Pallas) Britt. var.  
*leiospermus* (Gray) Hall  
O; 5500-6500; mesas and benches; pinyon-  
juniper woodland; Meeks Mesa and Hickman  
Bridge.

*Chrysothamnus nauseosus* (Pallas) Britt. var.  
*nitidus* L.C. Anderson  
R; 6000-6500; mesas; pinyon-juniper woodland;  
Wagon Box Mesa.

*Chrysothamnus parryi* (Gray) Greene var.  
*attenuatus* (Jones) Kittell in Tidestr. & Kittell  
O; 7500-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Chrysothamnus viscidiflorus* (Hook.) Nutt. var.  
*lanceolatus* (Nutt.) Greene  
O; 7500-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Chrysothamnus viscidiflorus* (Hook.) Nutt. var.  
*puberulus* (D.C. Eaton) Jeps.  
O; 6000-8500; canyon bottoms and mountains;  
pinyon-juniper woodland and mixed conifer  
woodland; Oak Creek and Upper Deep Creek.

*Chrysothamnus viscidiflorus* (Hook.) Nutt. var.  
*stenophyllus* (Gray) Hall  
W; 5000-6500; bottomland, mesas, and benches;  
desert shrub to pinyon-juniper woodland;  
Frying Pan Canyon, Fremont River Valley,  
Wagon Box Mesa, and Brimhall Arch.

*Chrysothamnus viscidiflorus* (Hook.) Nutt. var.  
*viscidiflorus*  
O; 5500; bottomland; riparian; Sulphur Creek  
and Fremont River Valley.

*Cirsium calcareum* (Jones) Woot. & Standl. var.  
*bipinnatum* (Eastw.) Welsh  
R; 6000; benches; pinyon-juniper woodland; Rim  
Overlook Trail.

*Cirsium calcareum* (Jones) Woot. & Standl. var.  
*calcareum*  
W; 6000-8000; washes and canyon bottoms;  
riparian; wide spread throughout the park.

*Cirsium calcareum* (Jones) Woot. & Standl. var.  
*pulchellum* (Greene) Welsh  
O; 5000-6000; benches and canyon bottoms;  
riparian; Burr Trail and Pleasant Creek.

*Cirsium neomexicanum* Gray var. *neomexicanum*  
O; 5000-6000; bottomland and canyon bottoms;  
desert shrub to pinyon-juniper woodland; Burr  
Trail and Sheets Wash.

*Cirsium undulatum* (Nutt.) Spreng  
O; 5500; bottomland and benches; riparian;  
Fremont River Valley.

*Cirsium vulgare* (Savi) Ten  
O; 5500; bottomland; riparian (waste places);  
Fruita.

*Conyza canadensis* (L.) Cronq.  
O; 4000-5500; bottomland and canyon bottoms;  
disturbed sites; Halls Creek and Fremont River  
Valley.

*Crepis runcinata* T. & G.  
O; 4000-6000; bottomland and canyon bottoms;  
riparian; Halls Creek, Fremont River Valley, and  
Pleasant Creek.

*Dicoria brandegei* Gray  
R; 4000; canyon bottoms; desert shrub; Halls  
Creek.

*Dyssodia papposa* (Vent.) A.S. Hitchc.  
U; 5000-5500; bottomland; disturbed sites;  
Fremont River Valley.

*Dyssodia pentachaeta* (DC.) Robins  
O; 3900; canyons and hillsides; desert shrub;  
Halls Creek.

*Eceliopsis nudicaulis* (Gray) A. Nels.  
R; 5000-5500; hillsides; desert shrub; Fremont  
River Valley and Chimney Rock.

*Erigeron abajoensis* Cronq.  
R; 7000-8000; canyon bottoms and benches;  
pinyon-juniper and slickrock communities;  
Upper Deep Creek and Miners Mountain.

*Erigeron aphanactis* (Gray) Greene

R; 5000-5500; hillsides and canyons; desert shrub; Sulphur Creek and Chimney Rock.

*Erigeron awapensis* Welsh

O; 5000-8000; upland, hills, mountains, and canyon bottoms; pinyon-juniper woodland to mixed conifer woodland; Fremont River Valley and Upper Deep Creek.

*Erigeron bellidiastrum* Nutt.

R; 3900; canyon bottoms; desert shrub; Halls Creek.

*Erigeron compactus* Blake

O; 5000-7000; upland, hills, and benches; desert shrub to pinyon-juniper woodland; South Desert and South Desert Overlook.

*Erigeron divergens* T. & G.

W; 4000-6000; canyons, upland, hills, and mesas; riparian, desert shrub, and pinyon-juniper woodland; Halls Creek, Hickman Bridge, The Post, and Burr Trail.

*Erigeron eatonii* Gray

R; 7000-8000; mountains, mesas, and benches; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek and Miners Mountain.

*Erigeron flagellaris* Gray

O; 5500-8000; mountains and bottomland; riparian and mixed conifer woodland; Fruita and Upper Deep Creek.

*Erigeron lonchophyllus* Hook.

O; 5500-6500; bottomland; riparian; Pleasant Creek and oxbow of the Fremont River.

*Erigeron maguirei* Cronq.

U; 5500-8000; canyon walls; slickrock communities; Fremont River Valley, Pine Canyon, Upper Deep Creek, Longleaf Flat, and Meeks Mesa.

*Erigeron pulcherrimus* Heller

O; 5000-8000; mountains, upland, hills, and benches; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek, Grand Wash, and Chimney Rock.

*Erigeron pumilus* Nutt.

W; 5000-8000; upland, hills, mesas, mountains, and benches; desert shrub to mixed conifer woodland; Upper Deep Creek, Fruita, Cottonwood Tanks, Deer Point, Sheets Gulch, and Miner Mountain.

*Erigeron speciosus* (Lindl.) DC.

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Erigeron utahensis* Gray var. *utahensis*

W; 5000-8000; upland, bottomland, hills, mesas, benches, and mountains; desert shrub to mixed conifer woodland; Fruita, Fremont River Valley, Burr Trail, Capitol Gorge, Hickman Bridge, Muley Canyon, and Upper Deep Creek.

*Erigeron utahensis* Gray var. *sparsifolius* (Eastw.)

Cronq.  
R; 4000; canyon bottoms; slickrock communities; Halls Narrows.

*Gaillardia pinnatifida* Torr.

O; 4000-5000; benches; desert shrub; The Post, Burr Trail, and Halls Creek.

*Gaillardia spathulata* Gray

W; 5000-6500; bottomland, mesas, benches, and washes; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Glyptopleura setulosa* Gray

R; 4000; bottomland; desert shrub; Halls Creek.

*Grindelia squarrosa* (Pursh) Dun. in DC.

O; 5000-6500; bottomland; disturbed sites; Fremont River Valley and Pleasant Creek.

*Gutierrezia microcephala* (DC.) Gray

O; 5000-6000; upland, hills, mesas, benches, and washes; desert shrub to pinyon-juniper woodland; Wagon Box Mesa, Fremont River Valley, and Grand Wash.

*Gutierrezia sarothrae* (Pursh) Britt. & Rusby

W; 3900-7500; upland, bottomland, hills, mesas, benches, washes, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Haplopappus acaulis* (Nutt.) Gray

R; 5000-5500; canyon bottoms; slickrock communities; Sheets Gulch

*Haplopappus armerioides* (Nutt.) Gray

O; 5000-6000; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Spring Canyon, Capitol Gorge, Muley Canyon, and Cohab Canyon.

*Haplopappus drummondii* (T. & G.) Blake

R; 4000; desert shrub; along uranium road above the Halls Narrows and Cottonwood Tanks.

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*Helianthella microcephala* (Gray) Gray  
R; 5000-7500; Desert shrub to pinyon-juniper  
woodland; Wagon Box Mesa and top of the Burr  
Trail.

*Helianthella uniflora* (Nutt.) T. & G.  
O; 5500; bottomland; riparian; Fruita.

*Helianthus annuus* L.  
O; 5500-6500; bottomland; disturbed sites;  
Fremont River Valley and Pleasant Creek.

*Helianthus anomalus* Blake  
R; 5000; upland; desert shrub; The Post.

*Helianthus petiolaris* Nutt.  
O; 4000-5500; bottomland; disturbed sites;  
Fremont River Valley and Halls  
Creek.

*Heliomeris multiflora* Nutt.  
R; 8000-8800; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Heterotheca villosa* (Pursh) Shinners  
W; 4000-8000; upland, bottomland, hills, mesas,  
mountains, benches, washes, and canyons;  
desert shrub to mixed conifer woodland;  
widespread throughout the park.

*Hymenopappus filifolius* Hook.  
W; 4000-8000; upland, bottomland, hills, mesas,  
mountains, benches, washes, and canyons;  
desert shrub to mixed conifer woodland;  
widespread throughout the park.

*Hymenoxys acaulis* (Pursh) Parker var. *arizonica*  
(Greene) Parker  
W; 4000-6500; upland, hills, mesas, benches,  
washes, and canyons; desert shrub to pinyon-  
juniper woodland; Longleaf Flat, Chimney Rock,  
The Hartnet, Halls Creek, and Cathedral Valley.

*Hymenoxys acaulis* (Pursh) Parker var. *caespitosa*  
(A. Nels.) Parker  
R; 8500; mountains; bristlecone pine community;  
Upper Deep Creek.

*Hymenoxys acaulis* (Pursh) Parker var. *ivesiana*  
(Greene) Parker  
O; 4000-6500; canyons, upland, hills, mesas, and  
washes; desert shrub to pinyon-juniper wood-  
land; Halls Creek, Pleasant Creek, Capitol  
Gorge, and Grand Wash.

*Hymenoxys depressa* (T. & G.) Welsh & Reveal  
O; 5000-7000; upland, hillsides, and mesas;  
pinyon-juniper woodland; South Desert,  
Fremont River Valley, near Jailhouse Rock, and  
Miners Mountain.

*Hymenoxys richardsonii* (Hook.) Cockerell  
W; 5000-8800; upland, hills, mesas, mountains,  
benches, and canyons; pinyon-juniper woodland  
to mixed conifer woodland; widespread  
throughout the park.

*Iva axillaris* Pursh  
O; 5000-5500; bottomland; riparian; Fremont  
River Valley.

*Iva xanthifolia* Nutt.  
R; 5500; bottomland; riparian; Fremont River  
Valley.

*Lactuca canadensis* L.  
R; 4000; canyon bottoms; riparian; Halls Creek.

*Lactuca serriola* L.  
C; 5000-6500; bottomland; disturbed sites; Fruita  
and Pleasant Creek.

*Leucelele ericoides* (Torr.) Greene  
C; 5000-6000; upland, hills, benches, and mesas;  
desert shrub to pinyon-juniper woodland;  
Capitol Gorge, Hickman Bridge, Cohab/Frying  
Pan Canyons, and Muley Twist Canyon.

*Lygodesmia grandiflora* (Nutt.) T. & G. var.  
*arizonica* (Tomb) Welsh  
O; 5000-6000; upland, mesas, and benches;  
desert shrub; Middle Desert Wash and  
Cathedral Valley.

*Lygodesmia grandiflora* (Nutt.) T. & G. var.  
*grandiflora*  
O; 5000-6500; benches and canyons; sagebrush  
communities and pinyon-juniper woodland;  
Fruita, Sheets Gulch, Cedar Mesa, and Pleasant  
Creek.

*Machaeranthera canescens* (Pursh) Gray var.  
*aristata* (Eastw.) Turner  
O; 5500-6000; bottomland and canyons; desert  
shrub to pinyon-juniper woodland; Fruita and  
Frying Pan Canyon.

*Machaeranthera canescens* (Pursh) Gray var.  
*canescens*  
C; 5000-8000; canyons, canyon bottoms, and  
mountains; desert shrub to mixed conifer  
woodland; Meeks Mesa, Upper Deep Creek,  
Sulphur Creek, and Fremont River Valley.

*Machaeranthera canescens* (Pursh) Gray var. *latifolia* (A. Nels.) Welsh  
U; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Machaeranthera grindelioides* (Nutt.) Shinnery  
O; 5000-6500; benches and canyon bottoms; desert shrub to pinyon-juniper woodland; Burr Trail, Muley Twist Canyon, and Pleasant Creek.

*Machaeranthera tanacetifolia* (H.B.K.) Nees  
C; 4000-6000; benches, canyons, and canyon bottoms; desert shrub to pinyon-juniper woodland; Fremont River Valley, Sulphur Creek, Halls Creek, Cottonwood Tanks, and Capitol Gorge.

*Malacothrix glabrata* Gray  
R; 3900; canyon bottoms; desert shrub; Halls Creek.

*Malacothrix sonchoides* (Nutt.) T. & G.  
O; 5000-5500; canyon bottoms and benches; desert shrub; Middle Desert Wash and The Post.

*Oxytenia acerosa* Nutt.  
O; 4000-5500; bottomland; riparian; Fremont River Valley, Halls Creek, and Spring Canyon.

*Parthenium ligulatum* (Jones) Barneby  
R; 6000; mesas and benches; slickrock communities; South Desert Overlook.

*Petradoria pumila* (Nutt.) Greene  
U; 5000; mesas and hills; desert shrub; Muley Twist Canyon.

*Platyschukhria integrifolia* (Gray) Rydb. var. *desertorum* (Jones) Ellison  
O; 4000-6500; upland, canyons, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; Brimhall Arch, Deer Point, The Hartnet, Halls Creek, and Chimney Rock.

*Psilostrophe sparsiflora* (Gray) A. Nels.  
W; 5000-6500; upland, canyons, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Senecio douglasii* DC. var. *longilobus* (Benth.) L. Benson  
U; 5000-6500; benches, washes, and canyon bottoms; desert shrub to pinyon-juniper woodland; Pleasant Creek, Cathedral Valley, and Muley Twist Canyon.

*Senecio multilobatus* T. & G. ex Gray  
C; 4000-7000; upland, bottomland, hills, mesas, and washes; desert shrub to pinyon-juniper woodland; Danish Hill, Middle Deep Creek, Sulphur Creek, Fremont River Valley, Pleasant Creek, Halls Creek, and Muley Twist Canyon.

*Senecio spartoides* T. & G. var. *spartoides*  
O; 5500-8000; benches and canyon bottoms; desert shrub to mixed conifer woodland; Upper Deep Creek, Oak Creek, Jailhouse Rock, and Longleaf Flat.

*Senecio spartoides* T. & G. var. *multicapitatus* (Greenman) Welsh  
U; 6500; upland; pinyon-juniper woodland; Pleasant Creek.

*Senecio streptanthifolius* Greene  
R; 6000; washes and waterpockets; sagebrush communities; near Burr Trail.

*Solidago canadensis* L.  
C; 5000-6500; bottomland and canyon bottoms; riparian; Fremont River Valley, Pleasant Creek, and Spring Canyon.

*Solidago missouriensis* Nutt.  
R; 4000; canyon bottoms; riparian; Halls Narrows.

*Solidago occidentalis* (Nutt.) T. & G.  
R; 4000; canyon bottoms; riparian; Halls Narrows.

*Solidago sparsiflora* Gray  
O; 4000-5000; canyon bottoms; riparian, hanging gardens; Halls Narrows and Fountain Tanks.

*Solidago spathulata* DC.  
O; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Sonchus asper* (L.) Hill.  
O; 4000-5500; canyon bottoms and bottomland; disturbed sites; Halls Creek and Fremont River Valley.

*Stephanomeria exigua* Nutt.  
C; 4000-6500; canyon bottoms and hillsides; desert shrub to pinyon-juniper woodland; Pleasant Creek, Halls Creek, Fremont River Valley and Muley Twist Canyon.

*Stephanomeria runcinata* Nutt.  
R; 5500; hills; desert shrub; Chimney Rock.



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*Stephanomeria spinosa* (Nutt.) Tomb

U; 6000-8000; mesas and mountains; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek and Wagon Box Mesa.

*Stephanomeria tenuifolia* (Torr.) Hall

C; 4000-6500; upland, bottomland, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; Cohab/Frying Pan Canyons, Longleaf Flat, Fremont River Valley, Cedar Mesa, Pleasant Creek, Muley Twist Canyon, and Halls Creek.

*Tetradymia canescens* DC.

O; 5500-8000; upland, hills, benches, and mountains; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek, Fremont River Valley, and Longleaf Flat.

*Tetradymia glabrata* Gray

O; 5500-6500; upland, bottomland, mesas, and canyons; sagebrush communities and pinyon-juniper woodland; Fremont River Valley, Longleaf Flat, and Cohab/Frying Pan Canyons.

*Tetradymia nuttallii* T. & G.

U; 8000-8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Tetradymia spinosa* H. & A.

R; 6000; hills and washes; pinyon-juniper woodland; The Hartnet.

*Thelesperma subnudum* Gray var. *subnudum*

W; 4000-6500; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Thelesperma subnudum* Gray var. *alpinum* Welsh

R; 8500; benches; bristlecone pine communities; Upper Deep Creek.

*Townsendia annua* Beaman

U; 4000-5500; hills and benches; desert shrub; Brimhall Arch, Cathedral Valley, and The Post.

*Townsendia aprica* Welsh & Reveal

U; 6000-8500; mesas and benches; pinyon-juniper woodland and bristlecone pine communities; South Desert Overlook, Miners Mountain, and Upper Deep Creek.

*Townsendia excapa* (Richards.) T.C. Porter

O; 5000-6000; hills, upland, mesas, and benches; pinyon-juniper woodland; Danish Hill and Fremont River Valley.

*Townsendia incana* Nutt.

C; 4000-6500; upland, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; Fremont River Valley, Capitol Gorge, Pleasant Creek, Hickman Bridge, Muley Twist Canyon, Sulphur Creek, Grand Wash, The Hartnet, and Halls Creek.

*Tragopogon dubius* Scop.

O; 5000-6500; bottomland; disturbed sites; Fremont River Valley and Pleasant Creek.

*Vancleavea stylosa* (Eastw.) Greene

U; 3900-5000; hills and benches; desert shrub; The Post and Halls Creek.

*Vernonia marginata* (Torr.) Raf.

R; 5500; bottomland; disturbed sites; Fremont River Valley.

*Viguiera multiflora* (Nutt.) Blake

U; 8000-8500; mountains; mixed conifer and aspen woodlands; Upper Deep Creek.

*Wyethia scabra* Hook.

C, 4000-5500; hills, benches, canyons, and mesas; desert shrub to pinyon-juniper woodland; Fremont River Valley, Capitol Gorge, Chimney Rock, Muley Twist Canyon, Grand Wash, and Halls Creek.

*Xanthium strumarium* L.

O; 5500-6500; bottomland; disturbed sites; Fruita and Pleasant Creek.

*Xylorhiza confertifolia* (Cronq.) T.J. Watson

R; 5000-6000; hills and benches; desert shrub; Muley Twist Canyon and Sheets Gulch.

*Xylorhiza tortifolia* (T. & G.) Greene

R; 5500-6000; hills, benches, and canyons; desert shrub to pinyon-juniper woodland; Deer Point and Burr Trail.

*Xylorhiza venusta* (Jones) Heller

R; 5000; hills and benches; desert shrub; The Post.

CONVOLVULACEAE

*Convolvulus arvensis* L.

O; 5000-6000; bottomland; disturbed sites; Fruita and Pleasant Creek.

*Evolvulus nuttallianus* Schult. in R. & S.

O; 5000-6000; bottomland, upland, hills, and mesas; slickrock communities; Fremont River Valley and Hickman Bridge.

CORNACEAE

*Cornus stolonifera* Michx.  
O; 5500-8000; bottomland; riparian; Fremont River Valley, Pleasant Creek and Upper Deep Creek.

CRASSULACEAE

*Sedum lanceolatum* Torr.  
U; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

CRUCIFERAE

*Alyssum minus*  
R; 5500; bottomlands; disturbed sites; Fruita.

*Arabis demissa* Greene  
O; 8000-8500; mountains; sagebrush and mixed conifer woodland; Upper Deep Creek.

*Arabis drummondii* Gray  
R; 8500; mountains; sagebrush; Upper Deep Creek.

*Arabis hirsuta* (L.) Bernh.  
O; 8000-8500; mountains; pinyon-juniper, sagebrush and mixed conifer; Upper Deep Creek.

*Arabis holboellii* Hornem.  
R; 8500; mountains; shaded coniferous forest; Upper Deep Creek.

*Arabis microphylla* Nutt. ex T. & G.  
O; 6000-8500; canyon bottoms and mountains; pinyon-juniper, sagebrush, and mixed conifer; Pleasant Creek and Upper Deep Creek.

*Arabis perennans* Wats.  
O; 5000-8000; hillsides, mesas, mountains and benches; pinyon-juniper to mixed conifer; Brimhall Arch, The Post, and Upper Deep Creek.

*Arabis pulchra* Jones  
R; 5000; uplands and benches; desert shrub; Big Thomson Mesa.

*Arabis selbyi* Rydb.  
W; 4000-8500; hillsides, mesas, mountains and benches; desert shrub, pinyon-juniper to mixed conifer woodland; widespread throughout the park.

*Capsella bursa-pastoris* (L.) Medicus  
O; 5000-6000; bottomland; riparian; Fremont River Valley and Pleasant Creek.

*Cardaria draba* (L.) Desv.  
R; 5500; bottomland; riparian; Fremont River Valley.

*Caulanthus crassicaulis* (Torr.) Wats.  
R; 6500; benches; desert shrub; Deer Point.

*Chorispora tenella* (Pallas) DC.  
O; 5500-6000; bottomland; disturbed sites; Fremont River Valley and Pleasant Creek.

*Descurainia californica* (Gray) Schultz  
R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Descurainia pinnata* (Walt.) Britt. var. *filipes* (Gray) Peck  
W; 5500; bottomland, washes and canyon bottoms; riparian; Fremont River Valley.

*Descurainia pinnata* (Walt.) Britt. var. *osmiarum* (Cockerell) Shinnery  
O; 4000-4500; washes and canyon bottoms; disturbed sites; Halls Creek.

*Descurainia richardsonii* (Sweet) Schulz var. *sonnei* (Robins.) C.L.  
Hitchc.  
O; 8500; mountains; mixed conifer woodland and sagebrush communities; Upper Deep Creek.

*Descurainia sophia* (L.) Webb in Engler & Prantl  
W; 5500; bottomland; riparian; Fremont River Valley.

*Dithyrea wislizenii* Engelm. in Wisliz.  
O; 4000-4500; canyon bottoms; desert shrub; Halls Creek.

*Draba cuneifolia* Nutt. ex T. & G.  
O; 5000-5500; hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Sulphur Creek and Big Thomson Mesa.

*Draba stenoloba* Ledeb.  
R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Erysimum asperum* (Nutt.) DC.  
R; 6500; benches; riparian; Pleasant Creek.

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*Erysimum inconspicuum* (Wats.) Macmillan  
O; 5500-8500; mountains and hills; sagebrush  
communities and mixed conifer woodland;  
Upper Deep Creek and Cathedral Valley.

*Hutchinsia procumbens* (L.) Desv.  
R; 4000; canyon bottoms; riparian; Halls  
Narrows.

*Lepidium densiflorum* Schrad. var. *densiflorum*  
O; 4000-6000; upland, hills, mesas, benches,  
washes, and canyons; desert shrub to pinyon-  
juniper woodland; Burr Trail, Spring Canyon,  
and Halls Creek.

*Lepidium densiflorum* Schrad. var. *ramosum* (A.  
Nels.) Thell.  
O; 6000-8000; mesas and mountains; pinyon-  
juniper woodland to mixed conifer woodland;  
The Hartnet and Upper Deep Creek.

*Lepidium montanum* Nutt. in T. & G. var. *jonesii*  
(Rydb.) C.L. Hitchc.  
C; 4000-6000; upland, hills, mesas, benches,  
washes, and canyons; desert shrub to pinyon-  
juniper woodland; Halls Creek, The Hartnet,  
Fremont River Valley, Capitol Gorge, Cedar  
Mesa, Chimney Rock, Muley Twist Canyon,  
Hickman Bridge, and Grand Wash.

*Lepidium perfoliatum* L.  
R; 4000; canyon rims; desert shrub; Big Thomson  
Mesa.

*Lesquerella intermedia* (Wats.) Heller  
W; 5000-8500; upland, hills, mesas, mountains,  
benches, and canyons; desert shrub to mixed  
conifer woodland; widespread throughout the  
park.

*Lesquerella ludoviciana* (Nutt.) Wats.  
O; 4000-8500; upland, mesas, mountains,  
benches, and canyons; desert shrub to mixed  
conifer woodland; Burr Trail, Upper Deep  
Creek, Pleasant Creek, and Halls Creek.

*Lesquerella rectipes* Woot. & Standl.  
W; 4000-6500; upland, mesas, and canyon  
bottoms; desert shrub to pinyon-juniper  
woodland; Halls Narrows; Fremont River  
Valley, Cedar Mesa, Pleasant Creek, Muley  
Twist Canyon, and Sulphur Creek.

*Lesquerella wardii* Wats.  
R; 6500; hills; pinyon-juniper woodland;  
Pleasant Creek.

*Malcomia africana* (L.) R. Br. in Ait.  
U; 5000; roadside; disturbed sites; The Post.

*Nasturtium officinale* R. Br. in Ait.  
R; 5500; moist sites; riparian; oxbow of the  
Fremont River.

*Physaria acutifolia* Rydb. var. *acutifolia*  
C; 4000-6500; upland, mesas, benches, and  
canyons; desert shrub to pinyon-juniper wood-  
land; Muley Twist Canyon, Burr Trail, Halls  
Creek, Cedar Mesa, Chimney Rock, Pleasant  
Creek, and Sulphur Creek.

*Physaria acutifolia* Rydb. var. *purpurea* Welsh and  
Reveal  
R; 8500; mountain benches; bristlecone pine  
community; Upper Deep Creek.

*Physaria newberryi* Gray in Ives  
U; 5000; mesas; desert shrub; Big Thomson  
Mesa.

*Rorippa islandica* (Oed.) Borbas  
O; 6500-8000; bottomland; riparian; Pleasant  
Creek and Upper Deep Creek.

*Rorippa tenerrima* Greene  
O; 5000-5500; bottomland; riparian; Fremont  
River Valley.

*Schoenocrambe barnebyi* (Welsh & Atwood) Rollins  
U; 5500-7000; canyons (talus); desert shrub;  
Fremont River Valley, Sulphur Creek, and  
Miners Mountain.

*Schoenocrambe linifolia* (Nutt.) Greene  
R; 6000-7000; mesas and benches; pinyon-  
juniper woodland; The Hartnet and Miners  
Mountain.

*Sisymbrium altissimum* L.  
C; 5000-5500; bottomland; disturbed sites;  
Fremont River Valley.

*Staneleya pinnata* (Pursh) Britt.  
W; 4000-7500; upland, mesas, and benches;  
desert shrub to pinyon-juniper woodland;  
widespread throughout the park.

*Staneleya viridiflora* Nutt. in T. & G.  
C; 5000-6000; upland, hills, mesas, and benches;  
desert shrub to pinyon-juniper woodland;  
Chimney Rock, Grand Wash, Fremont River  
Valley, Sulphur Creek, and South Desert  
Overlook.

*Streptanthella longirostris* (Wats.) Rydb.  
W; 4000-7000; upland, bottomland, hills, mesas, canyons, and benches; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Streptanthus cordatus* Nutt. ex T. & G.  
U; 5000-6500; upland, hills, mesas, and benches; sagebrush communities and pinyon-juniper woodland; Fremont River Valley, Pleasant Creek, and Cathedral Valley.

*Thelypodopsis divaricata* (Rollins) Welsh & Atwood  
O; 4000-6000; hills, benches, and canyons; desert shrub to pinyon-juniper woodland; Chimney Rock, Halls Creek, Deer Point, and Sulphur Creek.

*Thelypodium integrifolium* (Nutt.) Endl. in Walp.  
O; 4000-6500; bottomland; riparian; Pleasant Creek, Halls Creek, and Fremont River Valley.

#### ELAEAGNACEAE

*Elaeagnus angustifolia* L.  
O; 5000-6000; bottomland; riparian; Fruita and Pleasant Creek.

*Shepherdia canadensis* (L.) Nutt.  
O; 8000-8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Shepherdia rotundifolia* Parry  
W; 4000-7000; upland, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

#### ERICACEAE

*Arctostaphylos patula* Greene  
O; 5000-8000; mesas and mountains; pinyon-juniper and mixed conifer woodland; Burr Trail and Upper Deep Creek.

#### EUPHORBIACEAE

*Euphorbia brachycera* Engelm. in Emory  
R; 5500; bottomland; riparian; Fremont River Valley.

*Euphorbia fendleri* T. & G.  
W; 5000-6500; bottomland, mesas, benches, and washes; desert shrub to pinyon-juniper woodland; Fremont River Valley, Longleaf Flat, and Muley Twist.

*Euphorbia glyptosperma* Engelm. in Torr.  
W; 4000-6000; bottomland and canyon bottoms; waste places; Halls Narrows; Hickman Bridge, and Fruita.

*Euphorbia parryi* Engelm.  
R; 4000; canyon bottoms; desert shrub; Halls Narrows.

*Euphorbia robusta* (Engelm.) Small ex Britt. & Brown  
O; 5500-6500; bottomland and hills; desert shrub to pinyon-juniper woodland.

#### FAGACEAE

*Quercus eastwoodiae* Rydb.  
R; 4000; narrow canyons; riparian; Halls Creek.

*Quercus gambelii* Nutt.  
C; 4000-8000; canyons, mountains, mesas, and benches; desert shrub to pinyon-juniper woodland; Pleasant Creek, Muley Twist Canyon, Upper and Middle Deep Creek, Halls Creek, Oak Creek, and Cottonwood Tanks.

*Quercus undulata* Torr.  
O; 5000-6000; canyons; desert shrub to pinyon-juniper woodland; Burr Trail.

#### FUMARIACEAE

*Corydalis aurea* Willd.  
O; 5000-6000; bottomland and canyon bottoms; riparian; Paradise Draw and Fremont River Valley.

#### GENTIANACEAE

*Centaurium exaltatum* (Griseb.) Wight ex Piper  
R; 5000-6000; bottomlands; saline soils (riparian); Oxbow of the Fremont River and Pleasant Creek.

*Frasera albomarginata* Wats.  
O; 5500-6500; upland, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; Burr Trail and Pleasant Creek.

*Frasera speciosa* Dougl. ex Griseb. in Hook.  
R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Gentiana affinis* Griseb. in Hook.  
R; 8000; mountains; mixed conifer woodland; Upper Deep Creek.

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*Gentianella heterosepala* (Engelm.) Holub  
R; 8000; mountains; mixed conifer woodland;  
Upper Deep Creek.

GERANIACEAE

*Erodium cicutarium* (L.) L'Her in Ait.  
W; 4500-6500; bottomland, washes, and canyon  
bottoms; disturbed sites; The Post, Fremont  
River Valley, and Spring Canyon.

*Geranium caespitosum* James ex Gray  
O; 6500-8000; upland and mountains; pinyon-  
juniper woodland to mixed conifer woodland;  
Pleasant Creek and Upper Deep Creek.

HIPPURIDACEAE

*Hippuris vulgaris* L.  
R; 5500; pond; aquatic; oxbow of the Fremont  
River.

HYDROPHYLLACEAE

*Nama retorsum* J.T. Howell  
U; 5500-6000; upland and hills; pinyon-juniper  
woodland; Hickman Bridge and Longleaf Flat.

*Phacelia crenulata* Torr. in Wats.  
C; 4000-6000; hills, mesas, benches, and canyons;  
desert shrub to pinyon-juniper woodland;  
Spring Canyon, Sulphur Creek, Halls Creek, and  
Burr Trail.

*Phacelia demissa* Gray  
C; 5000; hills and benches of Mancos clay; desert  
shrub; Oyster Shell Reef and The Post.

*Phacelia ivesiana* Torr. in Ives.  
C; 4000-6000; canyon bottoms, mesas, and  
benches; desert shrub to pinyon-juniper  
woodland; Brimhall Arch, The Hartnet, Halls  
Creek, Fremont River Valley, Capitol Gorge, and  
Spring Canyon.

*Phacelia rafaensis* Atwood  
O; 5000-6000; hills, benches, and canyons; desert  
shrub; Fremont River Valley and Chimney Rock.

LABIATAE

*Hedeoma drummondii* Benth.  
O; 5000-5500; bottomland; riparian; Fremont  
River Valley.

*Lycopus asper* Greene  
R; 5500; bottomland; riparian; oxbow of the  
Fremont River.

*Marrubium vulgare* L.  
U; 5000-5500; bottomland and canyon bottoms;  
disturbed sites; Fruita and Sulphur Creek.

*Mentha arvensis* L.  
O; 5000-5500; bottomland; riparian; Fremont  
River Valley.

*Mentha spicata* L.  
O; 5500; bottomland; orchards; Fruita.

*Monardella odoratissima* Benth.  
R; 8500; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Nepeta cataria* L.  
U; 5000-6000; bottomland and canyon bottoms;  
riparian; Cohab Canyon and Fremont  
River Valley.

*Poliomintha incana* (Torr.) Gray  
O; 4500-6000; upland, hills, mesas, benches, and  
canyons; desert shrub to pinyon-juniper  
woodland; Burr Trail, Red Slide, Grand Wash,  
Sulphur Creek, and Hickman Bridge

*Salvia reflexa* Hornem.  
O; 5500; bottomland; riparian; Fruita.

*Scutellaria galericulata* L.  
R; 5500; canyon bottoms; riparian; Fremont  
River Valley.

*Stachys palustris* L.  
R; 5000-5500; bottomland; riparian; Fremont  
River Valley.

LEGUMINOSAE

*Astragalus agrestis* Dougl. ex G. Don  
R; 8500; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Astragalus amphioxys* Gray  
U; 4000-6000; benches and canyon bottoms;  
desert shrub; Halls Creek and Middle Desert  
Wash.

*Astragalus asclepiadoides* Jones  
U; 5000-6000; hillsides; desert shrub; Middle  
Desert Wash and Oyster Shell Reef.



*Astragalus barnebyi* Welsh & Atwood

R; 5000; benches and mesas; desert shrub; Big Thomson Mesa.

*Astragalus brandegei* T.C. Porter in Port. & Coult.

O; 5000-6000; bottomland and hillsides; salt marsh and desert shrub; Fremont River Valley and Upper Cathedral Valley.

*Astragalus calycosus* Torr.

R; 6500; hilltops; pinyon-juniper woodland; Pleasant Creek.

*Astragalus ceramicus* Sheld.

C; 5500-7500; bottomland to mountains; desert shrub to mixed coniferous woodland; Fremont River Valley, Longleaf Flat and Upper Deep Creek.

*Astragalus chamaeleuce* Gray in Ives

R; 5000-6700; hillsides; pinyon-juniper woodland; Burr Trail area.

*Astragalus coltonii* Jones

O; 5500-7500; mountains, mesas, and canyons; mixed conifer woodlands; Upper Deep Creek, South Desert Overlook, and Pleasant Creek.

*Astragalus consobrinus* (Barneby) Welsh

U; 5000-6500; upland, benches and canyons; pinyon-juniper woodland; Danish Hill, Fruita, and Water Canyon.

*Astragalus convallarius* Greene

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Astragalus desperatus* Jones var. *petrophilus* Jones

R; 5600; hillside; desert shrub; Ackland Spring.

*Astragalus episcopus* Wats.

O; 5500-6000; uplands; desert shrub; Middle Desert Wash, Cathedral Valley, and South Desert.

*Astragalus flavus* Nutt. in T. & G. var. *argillosus* (Jones) Barneby

R; 5800; hillsides; desert shrub; Jailhouse Rock.

*Astragalus flavus* Nutt. in T. & G. var. *candicans* Gray

U; 5500-6500; hillsides, washes and bottomland; pinyon-juniper woodland and riparian; Fremont River Valley and The Hartnet.

*Astragalus harrisonii* Barneby

O; 5500-7500; canyons (talus); pinyon-juniper and desert shrub; Fruita, Hickman Bridge, Spring Canyon, and Middle Deep Creek.

*Astragalus kentrophyta* Gray

C; 5500-8500; benches and hillsides; pinyon-juniper woodland and bristlecone pine communities; Fremont River Valley and Upper Deep Creek.

*Astragalus lentiginosus* Dougl. ex Hook.

O; 4000-5500; benches; desert shrub and pinyon-juniper woodland; Brimhall Arch and Sulphur Creek.

*Astragalus lonchocarpus* Torr.

C; 5500-8000; hillsides, benches and canyon bottoms; pinyon-juniper woodland to mixed conifer woodland; Upper and Middle Deep Creek, Sulphur Creek, and Sheets Gulch.

*Astragalus malacoides* Barneby

U; 4000-4500; bottomland and canyon bottoms; desert shrub; Halls Creek and near Brimhall Arch.

*Astragalus miser* Dougl. ex Hook.

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Astragalus moencoppensis* Jones

U; 4500-5500; benches; desert shrub; Brimhall Arch.

*Astragalus mollissimus* Torr. var. *thompsonae* (Wats.) Barneby

C; 4500-6000; benches, hillsides and canyon bottoms; desert shrub and pinyon-juniper woodland; Fremont River Valley, Fruita, Burr Trail and Halls Creek.

*Astragalus musiniensis* Jones

U; 6500; hillsides and talus slopes; pinyon-juniper woodland; Burr Trail and Muley Twist Canyon.

*Astragalus nuttallianus* Nutt.

R; 4000; benches and mesas; desert shrub; Halls Creek.

*Astragalus pardalinus* (Rydb.) Barneby

U; 5500-6000; bottomland; desert shrub; Upper Cathedral Valley and South Desert.

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*Astragalus praelongus* Sheld.

O; 5000-6000; bottomland and hillsides; desert shrub; Burr Trail and Circle Cliffs.

*Astragalus sabulonum* Gray

U; 5000-6000; hills and benches; desert shrub; Cathedral Valley.

*Astragalus sesquiflorus* Wats.

O; 5500-6500; benches; pinyon-juniper woodland; Pleasant Creek, Sheets Gulch and Sulphur Creek.

*Astragalus tenellus* Pursh

O; 7000-8000; mountains; mixed conifer woodland; Upper and Middle Deep Creek.

*Astragalus wardii* Gray

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Astragalus woodruffii* Jones

R; 5500; hillsides; desert shrub; Fremont River Valley.

*Astragalus zionis* Jones

U; 4000-4500; canyons and canyon bottoms; desert shrub; Halls Creek.

*Dalea flavescens* (Wats.) Welsh var. *flavescens*

O; 4000-5500; hillsides; desert shrub; Redslide and Burr Trail.

*Dalea flavescens* (Wats.) Welsh var. *epica* (Welsh) Welsh & Chatterley

R; 5000; hillsides; desert shrub; The Post.

*Dalea oligophylla* (Torr.) Shinn.

O; 4000-5500; hills, canyon bottoms, and washes; desert shrub; Red Slide and Cathedral Valley.

*Glycyrrhiza lapidota* Pursh

O; 5000-5500; bottomland; riparian; Fremont River Valley.

*Hedysarum occidentale* Greene

O; 5000-6000; canyon bottoms; desert shrub to pinyon-juniper woodland; Cathedral Valley, Sulphur Creek, and Upper Muley.

*Lathyrus brachycalyx* Rydb. var. *brachycalyx*

R; 5000; hills; pinyon-juniper woodland; Muley Twist Canyon.

*Lathyrus brachycalyx* Rydb. var. *zionis* (C.L. Hitchc.) Welsh

R; 4000; canyon bottoms; riparian; Halls Narrows.

*Lathyrus pauciflorus* Fern.

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Lupinus argenteus* Pursh var. *argenteus*

O; 5000-5500; upland, canyons, and mesas; desert shrub to pinyon-juniper woodland; Cathedral Valley, Cedar Mesa, and Pleasant Creek.

*Lupinus argenteus* Pursh var. *rubricaulis*

U; 5500-8000; upland and mountains; pinyon-juniper woodland to mixed conifer woodland; The Hartnet and Upper Deep Creek.

*Lupinus brevicaulis* Wats.

U; 4000-4500; washes and canyon bottoms; desert shrub; Red Slide and Brimhall Arch.

*Lupinus pusillus* Pursh

C; 4000-6500; upland, hills, mesas, benches, washes, and canyons; desert shrub to pinyon-juniper woodland; Pleasant Creek, Cottonwood Tanks, Willow Tanks, Cathedral Valley, and Halls Creek.

*Lupinus sericeus* Pursh

O; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Medicago lupulina* L.

U; 5500; bottomland; riparian; oxbow of the Fremont River.

*Medicago sativa* L.

C; 5000-6500; bottomland; riparian; Fruita and Pleasant Creek.

*Melilotus albus* Medicus

C; 5000-6500; bottomland; disturbed sites; Fremont River Valley, Pleasant Creek, and Grand Wash.

*Melilotus officinalis* (L.) Pallas

C; 4000-6500; bottomland and canyon bottoms; disturbed sites; Fremont River Valley, Pleasant Creek, and Halls Creek.

*Oxytropis deflexa* (Pallas) DC.

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Oxytropis lambertii* Pursh

O; 5000-6000; hills and benches; desert shrub to pinyon-juniper woodland; Middle Desert Wash, Ackland Spring, and Cathedral Valley.

*Oxytropis oreophila* Gray var. *juniperina* Welsh

U; 7000-8000; mountains and benches; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek and Miners Mountain.

*Oxytropis viscida* Nutt.

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Peteria thompsonae* Wats.

R; 5000; margins of washes; desert shrub; Cathedral Valley.

*Psoralea juncea* Eastw.

R; 4000; hills and canyons; desert shrub; Halls Divide.

*Psoralea lanceolata* Pursh var. *lanceolata*

C; 4500-5500; bottomland and canyon bottoms; desert shrub to pinyon-juniper woodland; Fruita, Red Slide, and Sulphur Creek.

*Psoralea lanceolata* Pursh var. *stenophylla* (Rydb.)

Toft and Welsh  
R; 4000; canyons and canyon bottoms; desert shrub; Halls Creek.

*Psoreothamnus fremontii* (Torr.) Barneby

O; 4000-5000; bottomland; desert shrub; Halls Creek and Spring Canyon.

*Thermopsis montana* Nutt. in T. & G.

O; 5500-8000; bottomland and canyon bottoms; riparian; Fremont River Valley and Upper Deep Creek.

*Trifolium fragiferum* L.

R; 5000-5500; bottomland; riparian; Fremont River Valley.

*Trifolium pratense* L.

U; 5500; bottomland; riparian; Fremont River Valley.

*Trifolium repens* L.

O; 5000-6500; bottomland; riparian; Fremont River Valley and Pleasant Creek.

*Vicia americana* Muhl. ex Willd.

U; 4000-8000; mountains and canyon bottoms (shady sites); hanging garden communities and mixed conifer woodland; Upper Deep Creek, Halls Narrows, and Pleasant Creek.

#### LENTIBULARIACEAE

*Utricularia vulgaris* L.

C; 5500; pond; aquatic; oxbow of the Fremont River.

#### LINACEAE

*Linum aristatum* Engelm. in Wisliz.

O; 4000-6500; upland, bottomland, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Middle Desert, The Post, Fremont River Valley, Halls Creek, Red Slide, and Pleasant Creek.

*Linum perenne* L.

O; 5000-8000; canyons, mesas, and mountains; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek, Burr Trail, Pleasant Creek, and Muley Twist Canyon.

*Linum puberulum* (Engelm.) Heller

U; 5000-6000; hills and upland; desert shrub to pinyon-juniper woodland; Middle Desert Wash and Fruita.

#### LOASACEAE

*Mentzelia albicaulis* Dougl. in Hook.

W; 4000-6500; bottomland, hills, benches, mesas, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Mentzelia cronquistii* Thompson & Prigge

O; 4000-5000; hillsides and roadsides; disturbed sites; Halls Narrows and The Post.

*Mentzelia multiflora* (Nutt.) Gray

O; 5000-6000; bottomland, hills, benches, and washes; desert shrub; Fremont River Valley, Cathedral Valley, and Chimney Rock.

*Mentzelia pterosperma* Eastw.

O; 4000-5500; upland, hills, mesas, benches, and canyon bottoms; desert shrub; -Middle Desert Wash, Burr Trail, and Halls Creek.

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MALVACEAE

*Sphaeralcea coccinea* (Nutt.) Rydb.  
W; 4000-6500; upland, hills, mesas, benches, and  
canyons; desert shrub to pinyon-juniper  
woodland; widespread throughout the park.

*Sphaeralcea grossulariifolia* (H. & A.) Rydb. var.  
*grossulariifolia*  
O; 5000-5500; benches and hills; desert shrub;  
Cathedral Valley and Spring Canyon.

*Sphaeralcea grossulariifolia* (H. & A.) Rydb. var.  
*moorei* Welsh  
R; 4000; canyon bottoms; riparian; Halls Creek.

*Sphaeralcea parvifolia* A. Nels.  
W; 4000-6500; upland, hills, mesas, benches, and  
canyons; desert shrub to pinyon-juniper  
woodland; widespread throughout the park.

NAJADACEAE

*Najas guadalupensis* (Spreng.) Morong  
R; 6500; slow moving streams; aquatic; Pleasant  
Creek.

NYCTAGINACEAE

*Abronia fragrans* Nutt. ex Hook.  
W; 3900 to 8250; washes, canyon bottoms and  
hillsides; pinyon-juniper and desert shrub;  
widespread throughout the park.

*Abronia nana* Wats.  
R; 5600; hilltops and mesas; pinyon-juniper  
woodland; Danish Hill.

*Allionia incarnata* L.  
O; 4000-5500; Uplands, washes and canyon  
bottoms; desert shrub; Lower Halls, Hickman  
Bridge area, Cohab/Frying Pan and the Fremont  
River Valley.

*Mirabilis linearis* (Pursh) Heimerl var. *decipiens*  
(Standley) Welsh  
R; 8500; mountains; sagebrush community;  
Upper Deep Creek.

*Mirabilis linearis* (Pursh) Heimerl var. *linearis*  
W; 5000-7000; benches, bottomland, and canyon  
bottoms; desert shrub to pinyon-juniper  
woodland; widespread throughout the park.

*Mirabilis multiflora* (Torr.) Gray in Torr.  
W; 4500-7000; mesas, washes, and canyon  
bottoms; pinyon-juniper woodland; widespread  
throughout the park.

*Mirabilis oxybaphoides* Gray in Torr.  
O; 5000-6000; canyons; pinyon-juniper wood-  
land and riparian; Fremont River Valley, Fruita,  
Hickman Bridge, Lower Muley, Grand Wash,  
Cohab and Frying Pan Canyons.

OLEACEAE

*Fraxinus anomala* Torr. in Wats.  
W; 3900-7000; upland, hills, mesas, benches,  
washes, and canyon bottoms; desert shrub to  
pinyon-juniper woodland; widespread through-  
out the park.

ONAGRACEAE

*Calylophus lavandulifolius* (T. & G.) Raven  
O; 5500-7000; benches and hillsides; pinyon-  
juniper woodland; South Desert Overlook and  
Miners Mountain.

*Camissonia eastwoodiae* (Munz) Raven  
O; 4000-5000; bottomland; desert shrub; Halls  
Creek and base of Swap Mesa.

*Camissonia scapoidea* (T. & G.) Raven  
W; 5000-6000; benches and canyon bottoms;  
desert shrub; Fremont River Valley and Jail-  
house Rock.

*Camissonia walkeri* (A. Nels.) Raven  
O; 5000-6000; hillsides; desert shrub to pinyon-  
juniper woodland; Burr Trail and Sulphur  
Creek.

*Epilobium andenocaulon* Hausskn.  
O; 5500-8000; canyon bottoms and bottomland;  
riparian; Upper Deep Creek, Pleasant Creek,  
and oxbow of the Fremont River.

*Epilobium angustifolium* L.  
O; 8000-8500; mountains; mixed conifer wood-  
land, aspen, and sagebrush flats;  
Upper Deep Creek.

*Gaura parviflora* Dougl. ex Hook.  
O; 5500; bottomland; riparian; Fruita.

*Gayophytum ramosissimum* Nutt. in T. & G.  
O; 8000-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Oenothera albicaulis* Pursh  
O; 5000-6000; upland, bottomland, hills, and  
mesas; desert shrub to pinyon-juniper wood-  
land; oxbow of the Fremont River and The Post.

*Oenothera caespitosa* Nutt. var. *marginata* (Nutt.) Munz  
W; 4000-8500; upland, hills, mesas, benches, washes, and mountains; desert shrub to mixed conifer woodland; widespread throughout the park.

*Oenothera caespitosa* Nutt. var. *macroglottis* (Rydb.) Cronq.  
U; 7500; flats, meadows, and hillsides; pinyon-juniper woodland; Paradise Flats.

*Oenothera coronopifolia* T. & G.  
R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Oenothera hookeri* T. & G.  
O; 4000-6500; bottomland and canyon bottoms; riparian; Fremont River Valley, Pleasant Creek and Halls Creek.

*Oenothera howardii* Jones  
R; 5000-6000; hills and benches; pinyon-juniper woodland; Burr Trail and Deer Point.

*Oenothera longissima* Rydb.  
R; 5500; upland and washes; pinyon-juniper woodland (shady sites); Grand Wash.

*Oenothera pallida* Lindl.  
W; 5000-7000; benches, hills, upland, mesas, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

#### ORBANCHACEAE

*Orobanche fasciculata* Nutt.  
O; 5000-5500; upland, hills, mesas, and benches; desert shrub; Middle Desert Wash.

*Orobanche ludoviciana* Nutt.  
O; 5000-6500; bottomland, upland, hills, mesas, and washes; desert shrub to pinyon-juniper woodland; Middle Desert Wash, Fremont River Valley, and Pleasant Creek.

#### PLANTAGINACEAE

*Plantago lanceolata* L.  
O; 5000-5500; bottomland; disturbed sites; Fruita.

*Plantago major* L.  
O; 5500; bottomland; riparian; oxbow of the Fremont River.

*Plantago patagonica* Jacq.  
C; 5000-6000; upland, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; Burr Trail, Capitol Gorge, Hickman Bridge, Sulphur Creek, and Cohab/Frying Canyons.

#### POLEMONIACEAE

*Eriastrum diffusum* (Gray) Mason  
R; 4000-4500; bottomland; desert shrub; south of Brimhall Arch near the enclosure.

*Gilia aggregata* (Pursh) Spreng.  
W; 5000-8000; upland, mesas, mountains, and benches; desert shrub to mixed conifer woodland; widespread throughout the park.

*Gilia caespitosa* Gray  
R; 6000-7000; sides of washes and canyons; slickrock communities; Pine Canyon, Middle Deep Creek, and Longleaf Flat.

*Gilia congesta* Hook.  
O; 6000-6500; canyons; slickrock communities and pinyon-juniper woodland; Burr Trail and Pleasant Creek.

*Gilia gunnisonii* T. & G.  
O; 4000-4500; bottomland; desert shrub; Halls Creek.

*Gilia inconspicua* (J.E. Sm.) Sweet  
W; 4500-6000; hills, benches, and washes; desert shrub; Brimhall Arch, The Post, Big Thomson Mesa, and Burr Trail.

*Gilia latifolia* Wats.  
R; 5500; bottomland; riparian; near the oxbow of the Fremont River.

*Gilia leptomeria* Gray  
W; 4000-6500; upland, hills, mesas, benches, and washes; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Gilia longiflora* (Torr.) G. Don  
O; 5000-6000; washes and canyon bottoms; desert shrub to pinyon-juniper woodland; Sulphur Creek, Pleasant Creek, Hickman Bridge, and Cathedral Valley.

*Gilia polycladon* Torr. in Emory  
O; 4500-6500; upland, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; Brimhall Arch, The Hartnet, Sulphur Creek, and Hickman Bridge.



*Gilia pumila* Nutt.

O; 5000-6500; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Sulphur Creek, Burr Trail, and The Hartnet.

*Gilia roseata* Rydb.

O; 5500-6500; upland and benches; slickrock communities; Pine Canyon, Hickman Bridge, and Spring Canyon.

*Gilia subnuda* Torr. ex Gray

W; 4000-6500; canyon bottoms, upland, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Leptodactylon pungens* (Torr.) Nutt.

O; 4000-6000; upland and canyon bottoms; slickrock communities; Burr Trail, Muley Twist Canyon, and Halls Creek.

*Leptodactylon watsonii* (Gray) Rydb.

R; 5500-8000; canyon walls; slickrock communities; Longleaf Flat, Burr Trail; Upper and Middle Deep Creek.

*Phlox austromontana* Cov. var. *austromontana*

O; 5000-8000; mesas and mountains; pinyon-juniper woodland to mixed conifer woodland; Upper Deep Creek, Cedar Mesa, and Muley Twist Canyon.

*Phlox austromontana* Cov. var. *lutescens* Welsh

R; 7000; hills and benches; blackbrush community; Deer Point.

*Phlox hoodii* Richards

O; 5000-6500; canyons; pinyon-juniper woodland; Fremont River Valley, Pleasant Creek, and Spring Canyon.

*Phlox longifolia* Nutt.

U; 5000-6500; upland and mesas; pinyon-juniper woodland; Cedar Mesa and Cathedral Valley.

*Phlox muscoides* Nutt.

U; 6000-7000; canyons; sagebrush and slickrock communities, and pinyon-juniper woodland; near Jailhouse Rock (in the fold) and South Desert Overlook.

POLYGALACEAE

*Polygala subspinoso* Wats.

O; 5000-6000; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Burr Trail, Red Slide, Grand Wash, Sulphur Creek, and Hickman Bridge.

POLYGONACEAE

*Eriogonum alatum* Torr. in Sitgr.

W; 3900-8000; canyon bottoms, hills, and benches; desert shrub to mixed conifer woodland; Upper Deep Creek, Cathedral Valley, and Halls Creek.

*Eriogonum bicolor* Jones

U; 5000-6500; hillsides, upland, and benches; desert shrub to pinyon-juniper woodland; The Hartnet, Sheets Gulch, and Cedar Mesa.

*Eriogonum cernuum* Nutt.

W; 5000-8500; upland, mountains, hills, mesas, and benches; pinyon-juniper woodland to mixed conifer woodland; widespread throughout the park.

*Eriogonum corymbosum* Benth. var. *aureum* (Jones) Reveal

R; 5500; hills and benches; desert shrub; Chimney Rock and Burr Trail.

*Eriogonum corymbosum* Benth. var. *corymbosum*

W; 5000-7000; upland, hills, benches, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Eriogonum corymbosum* Benth. var. *orbiculatum* (Stokes) Reveal & Brotherson

O; 5000-6500; upland, benches, and canyons; slickrock communities; Muley Twist Canyon, Burr Trail, and Hickman Bridge.

*Eriogonum corymbosum* Benth. var. *revealianum* (Welsh) Reveal

R; 8500; benches; bristlecone pine communities; Upper Deep Creek.

*Eriogonum deflexum* Torr. in Ives

U; 3900-5500; bottomland, washes, and canyon bottoms; desert shrub; oxbow of the Fremont River and Halls Narrows.

*Eriogonum flexum* Jones

C; 4000-5500; upland, hills, benches, washes, and canyons; desert shrub to pinyon-juniper woodland; Brimhall Arch, Grand Wash, and Halls Narrows.

*Eriogonum gordonii* Benth. in DC.

U; 6000-7000; hillsides and canyon bottoms; desert shrub to pinyon-juniper woodland; Meeks Mesa and Middle Deep Creek.

*Eriogonum hookeri* Wats.

C; 5000-6500; bottomland, hills, benches, and washes; desert shrub to pinyon-juniper woodland; oxbow of the Fremont River, Hickman Bridge, Chimney Rock, and Pleasant Creek.

*Eriogonum inflatum* T. & G.

O; 5000-6500; upland, hills, and benches; desert shrub; Fremont River Valley, Pleasant Creek, and The Post.

*Eriogonum leptocladon* T. & G. var. *leptocladon*

U; 5000; upland and hills; desert shrub; Cathedral Valley.

*Eriogonum leptocladon* T. & G. var. *ramosissimum* (Eastw.) Reveal

W; 5000-6000; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Eriogonum microthecum* Nutt. var. *foliosum* (T. & G.) Reveal

W; 4000-6500; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Eriogonum microthecum* Nutt. var. *laxiflorum* Hook.

R; 6000; benches; pinyon-juniper woodland; Oak Creek.

*Eriogonum ovalifolium* Nutt.

O; 5000-6500; hills, mesas, and benches; pinyon-juniper woodland and sagebrush communities; Burr Trail, Capitol Gorge, and Pleasant Creek.

*Eriogonum palmerianum* Reveal in Munz

R; 3900; hillsides; desert shrub; Halls Creek.

*Eriogonum racemosum* Nutt.

U; 8000-8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Eriogonum shockleyi* Wats.

O; 5000-6000; upland, hills, mesas, and benches; desert shrub to pinyon-juniper woodland; Middle Desert Wash, Meeks Mesa, Muley Twist Canyon, and Burr Trail.

*Eriogonum subreniforme* Wats.

U; 4000-5000; bottomland and washes; desert shrub; The Post and Halls Creek.

*Eriogonum tumulosum* (Barneby) Reveal

R; 6500; hills and benches; pinyon-juniper woodland; South Desert Overlook.

*Eriogonum umbellatum* Torr.

U; 6500-7500; canyons and benches; pinyon-juniper woodland; Oak Creek, Miners Mountain, and Pleasant Creek.

*Eriogonum wetherillii* Eastw.

O; 4000-6000; bottomland, washes, and canyon bottoms; desert shrub to pinyon-juniper woodland; Halls Creek, Muley Twist Canyon, and Cohab/Frying Pan Canyons.

*Polygonum aviculare* L.

O; 5500; bottomland; disturbed sites; oxbow of the Fremont River and Fruita.

*Polygonum douglasii* Greene

O; 6000-8500; upland and mountains; pinyon-juniper woodland to mixed conifer woodland; Oak Creek and Upper Deep Creek.

*Polygonum kelloggii* Greene

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Rumex crispus* L.

C; 5000-5500; bottomland; riparian; Fremont River Valley.

*Rumex hymenosepalus* Torr.

O; 4000-4500; washes and canyon bottoms; desert shrub; Halls Creek and the Red Slide.

*Rumex salicifolius* Weinm.

U; 5500; bottomland; riparian; Fremont River Valley.

#### PORTULACACEAE

*Portulaca oleracea* L.

O; 5500; bottomland; disturbed sites; Fruita.

*Talinum brevifolium* Torr.

R; 6000; upland; pinyon-juniper woodland; Longleaf Flat.

#### PRIMULACEAE

*Androsace septentrionalis* L.

U; 8000-8500; mountains; aspen communities and mixed conifer woodland; Upper Deep Creek.

*Glaux maritima* L.

U; 5500; bottomland; riparian; oxbow of the Fremont River.

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PYROLACEAE

*Pterospora andromeda* Nutt.  
U; 8500; mountains; mixed conifer woodland;  
Upper Deep Creek.

RANUNCULACEAE

*Aconitum columbianum* Nutt. in T. & G.  
R; 8800; mountains; shaded coniferous forest;  
Upper Deep Creek.

*Aquilegia caerulea* James in Long  
R; 8800; mountains; shaded coniferous forest;  
Upper Deep Creek.

*Aquilegia micrantha* Eastw.  
R; 4000; canyon walls; hanging gardens; Lower  
Halls Creek.

*Clematis columbiana* (Nutt.) T. & G.  
O; 7500-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Clematis ligusticifolia* Nutt. in T. & G.  
O; 4000-7500; bottomland, washes, canyon  
bottoms; desert shrub to mixed conifer  
woodland; widespread throughout the park.

*Delphinium andersonii* Gray var. *scaposum*  
(Greene) Welsh  
5000-6000; upland, mesas, benches, and hill-  
sides; desert shrub to pinyon-juniper woodland;  
Pleasant Creek, Cathedral Valley, and Spring  
Canyon.

*Ranunculus cymbalaria* Pursh  
O; 5000-6500; bottomland; riparian; oxbow of the  
Fremont River, Pleasant Creek, and a spring at  
South Desert Overlook.

*Ranunculus scleratus* L.  
O; 5000-5500; bottomland; riparian; Fremont  
River Valley.

*Ranunculus testiculatus* Crantz  
R; 5500; bottomland; disturbed sites; Burr Trail.

*Thalictrum fendleri* Engelm. in Gray  
O; 8000-8800; mountains; mixed conifer wood-  
land; Upper Deep Creek.

RHAMNACEAE

*Ceanothus fendleri* Gray  
O; 7000-8000; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Rhamnus betulifolia* Greene  
O; 4000-5000; canyon bottoms; riparian and  
hanging garden communities; Muley Twist  
Canyon and Halls Narrows.

ROSACEAE

*Amelanchier alnifolia* (Nutt.) Nutt.  
O; 7000-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Amelanchier utahensis* Koehne  
W; 5000-7500; uplands; pinyon-juniper wood-  
land; widespread throughout the park.

*Cercocarpus intricatus* Wats.  
W; 4000-6500; uplands, benches, rimrock cliffs  
and slopes (slickrock); widespread throughout  
the park.

*Cercocarpus ledifolius* Nutt.  
O; 8000-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Cercocarpus montanus* Raf.  
O; 7500-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Coleogyne ramosissima* Torr.  
O; 4000-5000; uplands; black brush communi-  
ties; Burr Trail and Halls Creek.

*Fallugia paradoxa* (D. Don) Endl.  
W; 4000-6500; canyons and washes; desert shrub  
to pinyon-juniper woodland; widespread  
throughout the park.

*Fragaria virginiana* Duchesne  
O; 8000; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Holodiscus dumosus* (Nutt.) Heller  
O; 5000-8000; canyons, mountains, mesas,  
benches, and hillsides; pinyon-juniper  
woodland to mixed conifer woodland; Upper  
Deep Creek, Water Canyon, Fruita, Fremont  
River Valley, Capitol Gorge and Pleasant Creek.

*Petrophytum caespitosum* (Nutt.) Rydb.  
O; 5500-7500; upland and canyons; Navajo  
Sanstone rock crevices in the pinyon-juniper  
woodland; in the fold near Jailhouse Rock and  
Upper and Middle Deep Creek.

*Physocarpus alterans* (Jones) J.T. Howell  
U; 5000-8000; canyons; desert shrub to mixed  
conifer woodland; Muley Twist Canyon and  
Upper Deep Creek.

*Potentilla concinna* Richards  
O; 8000-8500; mountains; sagebrush communities and mixed conifer woodland; Upper Deep Creek.

*Potentilla crinita* Gray  
O; 8000-8500; mountains; sagebrush communities; Upper Deep Creek.

*Potentilla diversifolia* Lehm.  
R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Potentilla hippiana* Lehm.  
O; 5500-8000; bottomland and mountains; riparian and mixed conifer woodland; Fremont River Valley and Upper Deep Creek.

*Potentilla pensylvanica* L.  
R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Purshia mexicana* (D. Don) Welsh  
W; 5000-7000; mesas, benches, canyon bottoms, and mountains; pinyon-juniper woodland to mixed conifer woodland; Sulphur Creek, Burr Trail, Upper Deep Creek, and Miners Mountain.

*Purshia tridentata* (Pursh) DC.  
C; 7500-8000; mountains; mixed conifer woodland and sagebrush communities; Upper Deep Creek.

*Rosa woodsii* Lindl.  
C; 5000-8000; canyon bottoms and mountains; riparian; Fremont River Valley, Pleasant Creek, and Upper Deep Creek.

#### RUBIACEAE

*Galium aparine* L.  
O; 4000-8000; mountains and canyon bottoms; hanging gardens and other moist sites; Halls Creek and Upper Deep Creek.

*Galium multiflorum* Kellogg  
O; 4000-6000; canyons; desert shrub to pinyon-juniper woodland; Jailhouse Rock, Lower Muley Twist Canyon, Chimney Rock Canyon, and Pleasant Creek.

*Galium trifidum* L.  
O; 5500; bottomland; riparian; oxbow of the Fremont River.

#### SALICACEAE

*Populus acuminata* Rydb.  
O; 5000-6500; bottomland; riparian; Water Canyon and Pleasant Creek.

*Populus angustifolia* James ex Torr.  
O; 5000-6500; bottomland and canyons; riparian; Cathedral Valley, Pleasant Creek, and Spring Canyon.

*Populus fremontii* Wats.  
W; 3900-7500; bottomland and canyon bottoms; riparian; widespread throughout the park.

*Populus tremuloides* Michx.  
O; 8000-8800; mountains; mixed conifer woodland and aspen communities; Upper Deep Creek.

*Salix amygdaloides* Anderss.  
O; 5000-6500; bottomland; riparian; Fremont River Valley, Pleasant Creek, and Oak Creek.

*Salix exigua* Nutt.  
C; 4000-6500; bottomland and canyon bottoms; riparian; Halls Creek, Fremont River Valley, Pleasant Creek, and Muley Twist Canyon.

*Salix geyeriana* Anderss.  
R; 5500; canyon bottoms; riparian; near Jailhouse Rock in the fold.

*Salix gooddingii* Ball  
U; 4000-5000; bottomland and canyon bottoms; riparian; Cottonwood Tanks and Halls Creek.

*Salix lasiandra* Benth.  
R; 5000; bottomland; riparian; Spring Canyon.

*Salix lasiolepis* Benth.  
U; 5000-5500; canyon bottoms; riparian; Fremont River Valley, Grand Wash, and Spring Canyon.

*Salix lutea* Nutt.  
O; 4000-8000; bottomland and canyon bottoms; riparian; Upper Deep Creek, Hickman Bridge, and Halls Creek.

#### SANTALACEAE

*Comandra umbellata* (L.) Nutt.  
C; 5000-6000; bottomland, mesas, benches, and canyon bottoms; desert shrub to pinyon-juniper woodland; Fremont River Valley and Cathedral Valley.

SAXIFRAGACEAE

*Heuchera parvifolia* Nutt. in T. & G.  
R; 8000; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Parnassia Palustris* L.  
R; 6500-8000; bottomland; riparian; Pleasant  
Creek and Upper Deep Creek.

*Philadelphus microphyllus* Gray  
U; 5000-5500; bottomland; riparian; Fremont  
River Valley.

*Ribes aureum* Pursh  
U; 5000-5500; bottomland; riparian; Fremont  
River Valley.

*Ribes cereum* Dougl.  
O; 5000-8000; canyon bottoms and mountains;  
riparian and mixed conifer woodland; Water  
Canyon, Pleasant Creek, and Upper Deep Creek.

*Ribes inerme* Rydb.  
O; 8000-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

SCROPHULARIACEAE

*Castilleja chromosa* A. Nels.  
W; 4000-6500; uplands, mesas, benches; desert  
shrub to pinyon-juniper woodland; Burr Trail,  
Cedar Mesa, and Halls Creek.

*Castilleja exilis* A. Nels.  
O; 5000-6000; bottom land; riparian; Fremont  
River Valley and Pleasant Creek.

*Castilleja linariifolia* Benth.  
W; 4000-8800; upland, mesas, and mountains;  
desert shrub to mixed conifer woodland; Halls  
Creek, Bitter Spring Creek and Upper Deep  
Creek.

*Castilleja scabrida* Eastw.  
O; 4000-6000; hillsides and benches; slickrock  
communities; Hickman Bridge, Oak Creek,  
Cottonwood Tanks, and Halls Creek.

*Cordylanthus parviflorus* (Ferris) Wiggins  
O; 4000-6500; mesas and canyon bottoms; desert  
shrub to pinyon-juniper woodland; Halls Creek,  
Wagon Box Mesa, and Pleasant Creek.

*Mimulus eastwoodiae* Rydb.  
R; 4000; canyons; hanging gardens; Halls  
Narrows.

*Mimulus glabratus* H.B.K.  
R; 5500; bottomland; riparian; near the oxbow of  
the Fremont River.

*Mimulus guttatus* Fisch. in DC.  
O; 4000-6500; canyons and bottomland; riparian;  
Fremont River Valley, Pleasant Creek, and Halls  
Creek.

*Pedicularis centranthera* Gray in Torr.  
O; 6000-7000; canyons and hills; pinyon-juniper  
woodland; Sheets Gulch, Upper Muley, and  
Miners Mountain.

*Penstemon ambiguus* Torr.  
R; 3900; hills and benches; desert shrub; Halls  
Creek.

*Penstemon angustifolius* Nutt.  
O; 4000-6000; bottomland, canyons, hills, mesas,  
and benches; desert shrub to pinyon-juniper  
woodland; Muley Twist Canyon, Halls Creek,  
and Burr Trail.

*Penstemon barbatus* (Cav.) Roth  
O; 6000-8000; canyons, benches, and mountains;  
pinyon-juniper woodland to mixed conifer  
woodland; Upper Deep Creek, Pleasant Creek,  
and Upper Muley.

*Penstemon caespitosus* Nutt. ex Gray var. *perbrevis*  
Pennell  
R; 7000; upland, hills, and benches; pinyon-  
juniper woodland; Miners Mountain.

*Penstemon carnosus* Pennell in Graham  
O; 5000-5500; hills, mesas, and benches; desert  
shrub to pinyon-juniper woodland; Burr Trail,  
Chimney Rock, and Fruita.

*Penstemon comarrhenus* Gray  
O; 6500-8000; upland, mesas, mountains, and  
benches; pinyon-juniper woodland to mixed  
conifer woodland; Upper Deep Creek, Pleasant  
Creek, and Miners Mountain.

*Penstemon eatonii* Gray  
W; 3900-7000; canyon bottoms, upland, hills,  
mesas, and benches; desert shrub to pinyon-  
juniper woodland; widespread throughout the  
park.

*Penstemon leiophyllus* Pennell  
U; 8000-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.



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*Penstemon moffattii* Eastw.

U; 5000; canyon rims; desert shrub; Big Thomson Mesa.

*Penstemon ophianthus* Pennell

O; 5000-7000; hills, mesas, and benches; desert shrub to pinyon-juniper woodland; South Desert Overlook, Cedar Mesa, and Cathedral Valley.

*Penstemon pachyphyllus* Gray ex Rydb.

U; 6000-8000; mesas, hills, and benches; pinyon-juniper woodland to mixed conifer woodland; South Desert Overlook and Upper Deep Creek.

*Penstemon palmeri* Gray var. *eglandulosus* (Keck) N. Holmgren

O; 5000-6500; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Burr Trail, Capitol Gorge, and Pleasant Creek.

*Penstemon rostriflorus* Kellogg

R; 5000-6500; canyons, benches, and mesas; desert shrub to pinyon-juniper woodland; Pleasant Creek and Muley Twist Canyon.

*Penstemon strictiformis* Rydb.

U; 8000-8500; hillsides; mixed conifer woodland; Upper Deep Creek.

*Penstemon strictus* Benth. in DC.

R; 8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Penstemon utahensis* Eastw.

C; 5000-6500; upland, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Muley Twist Canyon, Burr Trail, Deer Point, Cedar Mesa, Chimney Rock, and Spring Canyon.

*Veronica americana* Schwein. in DC.

U; 5500-6500; bottomland; riparian; near the oxbow of the Fremont River and Pleasant Creek.

*Veronica anagallis-aquatica* L.

O; 5000-8000; bottomland; riparian; Upper Deep Creek, Water Canyon, oxbow of the Fremont River, and Pleasant Creek.

### SOLANACEAE

*Datura meteloides* Dunal in DC.

O; 4500-6000; washes; desert shrub; Fremont River Valley and Halls Creek.

*Nicotiana attenuata* Torr. ex Wats.

O; 5500-7000; bottomland, washes, and mesas; disturbed sites; Fremont River Valley and The Hartnet.

*Physalis longifolia* Nutt.

C; 5000-5500; bottomland; riparian; Fremont River Valley.

*Solanum elaeagnifolium* Cav.

U; 5500; bottomland; disturbed sites; Hickman Bridge parking lot.

*Solanum sarrachoides* Sendt. in Mart.

U; 5500; bottomland; disturbed sites; Fremont River Valley.

*Solanum triflorum* Nutt.

R; 5500; bottomland; disturbed sites; Fremont River Valley.

### TAMARICACEAE

*Tamarix ramosissima* Ledeb.

W; 4000-7000; bottomland and canyon bottoms; riparian; widespread throughout the park.

### ULMACEAE

*Celtis occidentalis* L.

O; 5000-5500; bottomland; orchards; Fruita.

*Celtis reticulata* Torr.

O; 4000-5500; canyon bottoms; sagebrush, desert shrub and pinyon-juniper woodlands; Halls Creek, Cottonwood Tanks, and Grand Wash.

### UMBELLIFERAE

*Anethum graveolens* L.

O; 5500; canyon bottoms; orchards along the Fremont River.

*Cicuta maculata* L.

R; 5500; benches; riparian; Settling pond along the Fremont River.

*Cymopterus beckii* Welsh & Goodrich

U; 5500-6000; bottomland and canyon bottoms; pinyon-juniper woodland; Fremont River Valley, Cohab Canyon, Spring Canyon, and Pine Canyon.

*Cymopterus bulbosus* A. Nels.

U; 5000-5500; hillsides; desert shrub; Burr Trail.

*Cymopterus fendleri* Gray  
U; 5000-8000; hills and mountains; desert shrub  
to mixed conifer woodland; Fremont River  
Valley and Upper Deep Creek.

*Cymopterus lemmonii* (Coult. & Rose) Cronq.  
R; 8000-8500; mountains; mixed conifer wood-  
land; Upper Deep Creek.

*Cymopterus purpurascens* (Gray) Jones  
O; 5000-6000; mesas and canyon bottoms; desert  
shrub to pinyon-juniper woodland; Spring  
Canyon, Brimhall Arch, and Cedar Mesa.

*Cymopterus purpureus* Wats.  
O; 4000-6000; hills, mesas, benches, and canyons;  
desert shrub to pinyon-juniper woodland;  
Muley Twist Canyon, Sulphur Creek, Cedar  
Mesa and Halls Creek.

*Ligusticum porteri* Coult. & Rose  
R; 8800; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Lomatium junceum* Barneby and Holmgren  
U; 5000-5500; upland, benches, and washes;  
desert shrub to pinyon-juniper woodland;  
Meeks Mesa, Chimney Rock and Sheets Gulch.

*Lomatium parryi* (Wats.) Macbr.  
R; 4000; canyon bottoms; desert shrub; Halls  
Creek.

*Lomatium scabrum* (Coult. & Rose) Mathias  
R; 4000-4500; canyon bottoms; desert shrub;  
Halls Creek and Muley Twist Canyon.

*Osmorhiza chilensis* H. & A.  
R; 8800; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Sium suave* Walt.  
U; 5000-5500; bottomland; riparian; Fremont  
River Valley.

#### URTICACEAE

*Urtica dioica* L.  
U; 5000-5500; bottomland; riparian; Fremont  
River Valley.

#### VERBENACEAE

*Verbena bracteata* Lag. & Rodr.  
O; 5000-6500; bottomland; disturbed sites;  
Fremont River Valley and Pleasant Creek.

#### VIOLACEAE

*Viola canadensis* L.  
R; 8800; mountains; mixed conifer woodland;  
Upper Deep Creek.

*Viola nephrophylla* Greene  
R; 5500; bottomland; riparian; oxbow of the  
Fremont River.

#### VISCACEAE

*Arceuthobium campylopodium* Engelm.  
O; 6000-7000; mesas, upland and benches;  
parasite on pinyon pines; Wagon Box Mesa and  
Pleasant Creek.

*Arceuthobium douglasii* Engelm. ex Wheeler  
R; 8500; parasite on douglas-fir; mixed conifer  
woodland; Upper Deep Creek.

*Arceuthobium vaginatum* (H.B.K.) Eichler  
R; 8500; parasite on ponderosa pine; mixed  
conifer woodland; Upper Deep Creek.

*Phoradendron juniperinum* Engelm.  
O; 5000-6500; parasite on junipers; pinyon-  
juniper woodland; Hickman Bridge and  
Cedar Mesa.

#### VITACEAE

*Parthenocissus vitacea* (Knerr) A.S. Hitchc.  
R; 4000-5500; bottomlands and canyon bottoms;  
riparian communities and hanging gardens;  
Fremont River Valley and Halls Narrows.

#### ZYGOPHYLLACEAE

*Tribulus terrestris* L.  
O; 5500; bottomland; disturbed sites; Fruita.

FLOWERING PLANTS-  
MONOCOTYLEDONS

AGAVACEAE

*Yucca anustissima* Engelm. ex Trel.  
O; 4000-5000; upland, hills, mesas, benches, and canyon bottoms; desert shrub to pinyon-juniper woodland; Halls Creek and Muley Twist Canyon.

*Yucca harrimaniae* Trel.  
O; 5000-6000; hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; Capitol Gorge, Chimney Rock, Hickman Bridge Trail, Cohab/Frying Pan Canyons, and Grand Wash.

ALISMACEAE

*Sagittaria cuneata* Sheldon  
R; 5500; bottomland; riparian; Fremont River Valley.

COMMELINACEAE

*Tradescantia occidentalis* (Britt.) Smyth  
R; 4000; canyon bottoms; riparian; Halls Creek.

CYPERACEAE

*Carex aurea* Nutt.  
W; 4000-8000; bottomland; water pockets (riparian); Upper Deep Creek, Cottonwood Tanks; Halls Narrows.

*Carex douglasii* F. Boott in Hook.  
R; bottomland; riparian; oxbow of the Fremont River.

*Carex geophila* Mack.  
U; mountains; mixed conifer woodland; Upper Deep Creek.

*Carex hystericina* Muhl. ex Willd.  
R; 4000; canyon bottoms; riparian; Halls Narrows.

*Carex lanuginosa* Michx.  
C; 4000-5500; bottomland and canyon bottoms; riparian; Fruita, oxbow of the Fremont River, and Halls Narrows.

*Carex microptera* Mack.  
O; 6000-8000; bottomland and canyon bottoms; riparian; Upper Deep Creek, Paradise Draw and Water Canyon.

*Carex nebrascensis* Dewey  
O; 5500; bottomland; riparian; Fruita.

*Carex occidentalis* Bailey  
R; 6500-7000; canyon bottoms; riparian; Middle Deep Creek.

*Carex rossii* F. Boott in Hook.  
O; 6500-8000; mountains and hillsides; mixed conifer woodland; Upper Deep Creek and Miners Mountain.

*Carex stenophylla* Wahl.  
R; 8000-8500; benches of mountains; mixed conifer woodland; Upper Deep Creek.

*Carex vallicola* Dewey  
R; 8000-8500; benches of mountains; mixed conifer woodland; Upper Deep Creek.

*Carex xerantica* Bailey  
R; 7000-7500; canyon bottoms; riparian; Middle Deep Creek.

*Cyperus aristatus* Rottb.  
R; 4000; bottomland; riparian; Halls Creek.

*Eleocharis acicularis* (L.) R. & S.  
C; 5500-6500; bottomland; riparian; Fremont River Valley and Pleasant Creek.

*Eleocharis palustris* (L.) R. & S.  
W; 4000-6500; bottomland and canyon bottoms; riparian; Fremont River Valley, Pleasant Creek, Halls Narrows, and Paradise Draw.

*Eleocharis rostellata* (Torr.) Torr.  
R; 5500; bottomland; riparian; oxbow of the Fremont River.

*Scirpus acutus* Muhl. ex Bigel.  
U; 5500; bottomland; riparian; oxbow of the Fremont River.

*Scirpus maritimus* L.  
R; 5000-5500; bottomland riparian; Fremont River Valley.

*Scirpus pungens* Vahl  
C; 4000-6500; bottomland and canyon bottoms; riparian; Fremont River Valley, Pleasant Creek, Halls Creek, The Harnet, Muley Twist Canyon, and Sulphur Creek.

*Scirpus validus* Vahl  
R; 5000; bottomland; riparian; Oyster Shell Reef.

GRAMINEAE

*Agoseris glauca* (Pursh) Raf.

R; 8000-8500; mountains; meadows; Upper Deep Creek.

*Agropyron cristatum* (L.) Gaertn.

O; 5000-6000; bottomlands; disturbed sites; Fremont Valley and Pleasant Creek.

*Agropyron dasystachyum* (Hook.) Scribn.

U; 8500; mountains; montane meadows; Upper Deep Creek.

*Agropyron intermedium* (Host) Beauv.

R; 7000; canyon valley bottom; riparian; Middle Deep Creek.

*Agropyron repens* (L.) Beauv.

O; 5000-5500; canyon bottoms and bottomlands; riparian; Fruita.

*Agropyron smithii* Rydb.

O; 5000-8500; canyon bottoms, bottomlands and disturbed sites; Fremont Valley and Upper Deep Creek.

*Agropyron spicatum* (Pursh) Scribn. & Sm.

R; 8000-8500; mountains; mixed conifer woodland; Upper Deep Creek.

*Agropyron trachycaulum* (Link) Malte

C; canyon bottoms and bottomlands; desert shrub, sagebrush, riparian; Hickman Bridge area, Fremont River Valley, Spring Canyon and Pleasant Creek.

*Agrostis semiverticillata* (Forsskal) C. Chr.

O; canyon bottoms; riparian; Hickman Bridge area, Fremont River Valley, and lower Halls Creek.

*Agrostis stolonifera* L.

C; 5000-6000; canyon bottoms; riparian; Sulphur Creek, Fremont River Valley, Muley Twist and Deer Point.

*Agrostis tenuis* Sibth.

R; 5000-6000; canyon bottoms and bottomlands; disturbed site; Spring Canyon.

*Alopecurus carolinianus*

R; 6000; canyon bottoms; riparian; Pleasant Creek.

*Andropogon gerardii* Vitman

O; 5500; bottomlands; orchards and riparian sites; Fruita.

*Andropogon glomeratus* (Walt.) B.S.P.

R; 3900; canyon bottom; riparian; Halls Narrows.

*Andropogon hallii* Hackel

R; 3900; sandy benches; desert shrub; Lower Halls Creek.

*Aristida adscensionis* L.

R; 5500; bottomland; disturbed sites; Sulphur Creek.

*Aristida purpurea* Nutt.

W; 4000-7000; disturbed sites, benches, canyon bottoms; desert shrub, sagebrush, and pinyon-juniper woodlands; widespread throughout the park.

*Avena sativa* L.

R; 5500; bottomland; disturbed sites; Fremont River Valley.

*Bouteloua barbata* Lag.

U; 4000-5500; bottomland and canyon bottoms; riparian; Halls Narrows and oxbow of the Fremont River.

*Bouteloua curtipendula* (Michx.) Gray

O; 5500-6000; bottomland and canyon bottoms; disturbed sites; Frying Pan Canyon and Fruita.

*Bouteloua eriopoda* (Torr.) Torr. in Whipple

O; 4000-7000; mesas and canyon bottoms; desert shrub and pinyon-juniper woodlands; Lower Muley Twist Canyon, Halls Narrows, and Longleaf Flat.

*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.

W; 4000-8000; mountains, benches, mesas, canyon bottoms, and hillsides; desert shrub to mixed conifer woodland, and grassland; widespread throughout the Park.

*Bouteloua hirsuta* Lag.

R; 5500; bottomlands; orchards; Fruita.

*Bouteloua trifida* Thurb. in Wats.

O; 5500; bottomlands; disturbed sites; Fruita.

*Bromus carinatus* H. & A.

R; 5500; bottomlands; saline soils (riparian); oxbow of the Fremont River.

*Bromus inermis* Leyss.

W; 5500-8500; bottomlands and mountains; pinyon-juniper woodland and mixed conifer woodland; Fruita and Upper Deep Creek.

*Bromus rubens* L.

O; 3900-4500; canyon bottoms; disturbed sites; Halls Creek.

*Bromus tectorum* L.

W; 3900-8000; upland, bottomlands, hillsides, mesas, mountains, benches, washes, canyon bottoms; desert shrub to mixed conifer woodland; widespread throughout the park.

*Bromus willdenowii* Kunth

O; 5500; bottomlands; orchards; Fruita.

*Calamagrostis scopulorum* Jones

O; 5000-6000; bottomlands and canyon bottoms; hanging gardens, seeps and springs; Middle Deep Creek, Fremont River Valley, Spring Canyon and oxbow of the Fremont River.

*Calamagrostis stricta* (Timm) Koeler

R; 5000; canyons; hanging garden community; Spring Canyon.

*Cenchrus longispinus* (Hackel) Fern.

O; 5500; bottomlands; disturbed sites; Fruita.

*Dactylis glomerata* L.

O; 5000-6500; bottomlands; riparian; Fruita, Fremont River Valley, and Pleasant Creek.

*Dichanthelium lanuginosum* (Ell.) Gould var. *fasciculatum* (Torr.) Spellenberg

R; 4000; canyons; hanging gardens; Halls Narrows.

*Dichanthelium lanuginosum* (Ell.) Gould var. *sericeum* (Schmoll) Spellenberg

R; 4000; canyons; hanging gardens; Halls Narrows.

*Distichlis spicata* (L.) Greene

O; 5500-6500; bottomlands, seeps, and springs; riparian; Fruita, The Hartnet, and Pleasant Creek.

*Echinochloa crus-galli* (L.) Beauv.

R; 5500; bottomlands; riparian; oxbow of the Fremont River.

*Elymus canadensis* L.

O; 4000-6500; bottomlands; riparian; Fremont River Valley, Halls Creek, and Pleasant Creek.

*Elymus glaucus* Buckl.

O; 6500-8500; bottomlands and canyon bottoms; riparian; Upper Deep Creek and Pleasant Creek.

*Elymus junceus* Fisch.

O; 5500; bottomlands; riparian; Fruita.

*Elymus salina* Jones

W; 4000-6500; hillsides, mesas, and benches; desert shrub to pinyon-juniper woodland; Redslide, Spring Canyon, Longleaf Flat, Miners Mountain, Fremont River Valley, and The Hartnet.

*Enneapogon desvauxii* Beauv.

O; 4000-5000; upland and canyon bottoms; desert shrub; Muley Twist Canyon and Halls Creek.

*Eragrostis pectinacea* (Michx.) Nees.

R; 4000; canyon bottoms; riparian; Halls Narrows.

*Erioneuron pilosum* (Buckley) Nash in Small

O; 4000-6000; washes and benches; desert shrub to pinyon-juniper woodland; Sulphur Creek, Ackland Spring, Halls Creek, and Grand Wash.

*Erioneuron pulchellum* (H.B.K.) Tateoka

O; 5000-6000; hills and benches; desert shrub to pinyon-juniper woodland; Halls Creek, Fruita, and Fremont River Valley.

*Festuca arundinacea* Schreb.

O; 5500; bottomlands; disturbed sites; Fruita.

*Festuca ovina* L.

O; 6500-8000; moist sites and mountains; pinyon-juniper woodland to mixed conifer woodland; Pleasant Creek and Upper Deep Creek.

*Festuca elatior* L.

O; 5500; bottomlands; riparian; Fremont River Valley.

*Glyceria striata* (Lam.) A.S. Hitchc.

R; 5500; bottomlands; riparian; oxbow of the Fremont River.

*Hilaria jamesii* (Torr.) Benth.

W; 3900-7000; upland, hills, benches, mesas, and washes; desert shrub to pinyon-juniper woodland, and grassland; widespread throughout the park.

*Hordeum glaucum* Steud.

O; 5500; bottomlands; disturbed sites; Fruita.



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*Hordeum jubatum* L.

W; 5000-6500; bottomlands, canyons, mesas, and benches; desert shrub to pinyon-juniper woodland; Fruita, Sheets Gulch, oxbow of the Fremont River, and Pleasant Creek.

*Hordeum pusillum* Nutt.

R; 5000; hills and benches; desert shrub; Burr Trail.

*Koeleria nitida* Nutt.

R; 8000; mountains; mixed conifer woodland; Upper Deep Creek.

*Lolium perenne* L.

U; 5500-6000; bottomlands and washes; riparian; Fruita and Hickman Bridge.

*Lycurus phleoides* H.B.K.

U; 4000-6500; upland and canyons; slickrock communities; Sheets Gulch, Pleasant Creek, Hickman Bridge, and Halls Creek.

*Muhlenbergia andina* (Nutt.) A.S. Hitchc.

W; 3900-6500; bottomlands and canyon bottoms; water pockets (riparian); Fremont River Valley, Pleasant Creek, Cottonwood Tanks, Spring Canyon, Capitol Gorge, Halls Creek and Sulphur Creek.

*Muhlenbergia asperifolia* (Nees. & Mey.) Parodi

C; 5000-6500; bottomlands; moist disturbed sites (riparian); Burr Trail, Fremont River Valley, Spring Canyon, Pleasant Creek, and Sulphur Creek.

*Muhlenbergia pauciflora* Buckl.

U; 5000-6000; canyons and waterpockets; riparian; Hickman Bridge, Cohab, and Frying Pan Canyons.

*Muhlenbergia pungens* Thurb. in Gray

W; 4000-6000; bottomlands, hills, washes, and canyon bottoms; desert shrub to pinyon-juniper woodland; Hickman Bridge, Fremont River Valley, Capitol Gorge, Muley Twist Canyon, Cohab Canyon, Grand Wash, and Halls Creek.

*Muhlenbergia racemosa* (Michx.) B.S.P.

R; 6000; canyon bottoms; riparian; Cohab Canyon.

*Muhlenbergia thurberi* Rydb.

U; 5000-6000; washes and canyon bottoms; riparian and pinyon-juniper woodland; Hickman Bridge, Capitol Gorge, and Spring Canyon.

*Munroa squarrosa* (Nutt.) Torr. in Whipple

U; 4000-6000; washes; disturbed sites; Halls Creek and Hickman Bridge.

*Oryzopsis hymenoides* (R. & S.) Ricker in Piper

W; 3900-7500; upland, bottomlands, hills, mesas, benches, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Oryzopsis micrantha* (Trin. & Rupr.) Thurb.

U; 5000-6500; bottomlands, benches and canyon bottoms; pinyon-juniper woodland; Fruita, Pine Canyon, and Paradise Draw.

*Panicum capillare* L.

O; 5500; bottomlands; disturbed sites; Fruita.

*Panicum oligosanthos* Schultes

R; 5000; water pockets; riparian; Cottonwood Tanks.

*Panicum virgatum* L.

O; 4000; canyon bottoms; riparian; Halls Narrows.

*Phalaris arundinaceae* L.

U; 5500; bottomlands; riparian; Fremont River Valley.

*Phleum pratense* L.

C; 5000-5500; bottomlands; disturbed and moist sites; Fremont River Valley.

*Phragmites australis* (Cav.) Trin. ex Steud.

C; 4000-6500; bottomlands; riparian; Fremont River Valley, Halls Creek, and Pleasant Creek.

*Poa bigloveii* Vasey & Scribn. in Vasey

R; 4000; canyon bottoms; riparian; Halls Narrows.

*Poa compressa* L.

O; 5000-6500; bottomlands and water pockets; riparian; Pleasant Creek and Cottonwood Tanks.

*Poa curta* Rydb.

R; 5000; bottomlands; riparian; Fremont River Gorge.

*Poa fendleriana* (Steud.) Vasey

W; 5000-8000; upland, mesas, benches, and hillsides; desert shrub to mixed conifer woodland; widespread throughout the park.

*Poa palustris* L.

R; 8000; canyon bottoms; riparian; Upper Deep Creek.

*Poa pratensis* L.

C; 5000-8000; bottomlands, springs, and orchards; riparian and waterpockets; Fremont River Valley, Pleasant Creek, Hickman Bridge, Willow Tanks, and Upper Deep Creek.

*Poa sandbergii* Vasey

U; 5500-6000; upland, mesas, and benches; desert shrub; Burr Trail.

*Polypogon monspeliensis* (L.) Desf.

O; 4000-6500; bottomlands; riparian; oxbow of the Fremont River, Pleasant Creek, Halls Creek, Spring Creek, and Sulphur Creek.

*Puccinellia distans* (L.) Parl.

U; 5000-6500; bottomlands and canyon bottoms; riparian; Cathedral Valley and Pleasant Creek.

*Puccinellia pauciflora* (Presl.) Munz

U; 6500; canyons; riparian; Pleasant Creek.

*Puccinellia nuttalliana* (Schult.) A.S. Hitchc. in Jeps.

U; 5000-5500; bottomlands; riparian; Fremont River Valley.

*Schedonnardus paniculatus* (Nutt.) Trel. in Banner & Coville

U; 5500; bottomlands; disturbed sites; Fruita.

*Schizachne purpurascens* (Torr.) Swallen

R; 6000; canyon bottoms (moist sites); pinyon-juniper woodland; Oak Creek Canyon.

*Schizachyrium scoparium* (Michx.) Nash in Small

U; 3900-6500; hills, benches, and canyon bottoms; desert shrub to pinyon-juniper woodland; Halls Creek and Pleasant Creek.

*Setaria glauca* (L.) Beauv.

C; 5000-5500; bottomlands; disturbed sites; Fremont River Valley.

*Setaria viridis* (L.) Beauv.

C; 5500; bottomlands; disturbed sites; Fruita.

*Sitanion hystrix* (Nutt.) J.G. Sm.

W; 4000-8000; hills, benches, canyons bottoms; upland, mountains, bottomlands, and washes; desert shrub to mixed conifer woodland; widespread throughout the park.

*Spartina gracilis* Trin.

O; bottomlands and canyon bottoms; riparian; Fremont River Valley, Halls Creek, and Spring Canyon.

*Sporobolus airoides* (Torr.) Torr. in Parke

W; 4000-6000; bottomlands, washes and canyon bottoms; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Sporobolus contractus* A.S. Hitchc.

C; 4000-6000; upland and canyon bottoms; desert shrub to pinyon-juniper woodland; Halls Narrows; Frying Pan Canyon, Fremont River Valley, Longleaf Flat, Muley Twist Canyon, and Spring Canyon.

*Sporobolus cryptandrus* (Torr.) Gray

W; 4000-6500; uplands, bottomlands, hills, mesas, and canyons; desert shrub to pinyon-juniper woodland; widespread throughout the park.

*Sporobolus flexuosus* (Thurb.) Rydb.

C; 4000-6500; upland, hills, mesas, benches, and canyon bottoms; desert shrub to pinyon-juniper woodland; Jailhouse Rock, Pleasant Creek, Halls Narrows, and Muley Twist Canyon.

*Sporobolus giganteus* Nash

U; 4000-5000; bottomlands, hills, and canyon bottoms; desert shrub; Halls Narrows and Spring Canyon.

*Stipa arida* Jones

U; 4000-5500; upland, hills, and canyon bottoms; desert shrub to pinyon-juniper woodland; Burr Trail, Capitol Gorge, and Halls Creek.

*Stipa columbiana* Macoun

U; 5500-8000; mesas and mountains; pinyon-juniper woodland to mixed conifer woodland; Frying Pan Canyon and Upper Deep Creek.

*Stipa comata* Trin. & Rupr.

W; 4000-7500; mesas, benches, and upland; desert shrub to mixed conifer woodland, and grassland; widespread throughout the park.

*Stipa coronata* Trin. & Rupr.

R; 5000-6500; hills, mesas, benches, and canyon bottoms; desert shrub to pinyon-juniper woodland; Deer Point and Capitol Gorge.

*Stipa neomexicana* (Thurb.) Scribn.

R; 5000-6000; canyon bottoms, benches, and mesas; desert shrub to pinyon-juniper woodland; Deer Point and Hickman Bridge.

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*Stipa pinetorum* Jones  
U; 6500; hills and mesas; pinyon-juniper  
woodland; The Hartnet.

*Stipa scribneri* Vasey  
U; 5000-8000; upland, mountains, mesas,  
benches, and canyons; desert shrub to mixed  
conifer woodland; Upper Deep Creek, Hickman  
Bridge, Pleasant Creek, and Muley Twist  
Canyon.

*Stipa speciosa* Trin. & Rupr.  
C; 4000-6000; upland and canyon bottoms;  
desert shrub to pinyon-juniper woodland;  
Hickman Bridge, Halls Creek, Fremont River  
Valley, Spring Canyon, Sulphur Creek, and  
Grand Wash.

*Stiporyzopsis bloomeri* (Boland) B.L. Johnson  
R; 5000-5500; canyon bottoms; pinyon-juniper  
woodland; Fremont River Valley.

*Vulpia octoflora* (Walt.) Britt.  
O; 4000-5000; canyon bottoms and upland;  
desert shrub; Halls Creek and Muley Twist  
Canyon.

*Zea mays* L.  
O; 5500; bottomlands; disturbed sites; Fruita.

IRIDACEAE

*Iris missouriensis* Nutt.  
R; 5500; bottomlands; riparian; Fremont River  
Valley.

*Sisyrinchium demissum* Greene  
U; 5500-6500; bottomlands (saline); riparian;  
Fremont River Valley and Pleasant Creek.

JUNCACEAE

*Juncus alpinus* Vill.  
O; 6000-6500; bottomlands; riparian; Pleasant  
Creek.

*Juncus balticus* Willd. var. *mexicanus* Kuntze  
W; 4000-8000; bottomlands and canyon bottoms;  
riparian; Upper Deep Creek, Pleasant Creek,  
and Halls Narrows.

*Juncus balticus* Willd. var. *montanus* Engelm.  
R; 6000-6500; canyon bottoms; riparian; Pleasant  
Creek.

*Juncus bufonius* L.  
O; 5500; bottomlands and canyon bottoms;  
riparian; Fremont River Valley.

*Juncus ensifolius* Wikstr. var. *brunnescens* (Rydb.)  
Cronq.  
O; 5500-6500; bottomlands and canyon bottoms;  
riparian; Pleasant Creek, Sheets Gulch, and  
Spring Canyon.

*Juncus ensifolius* Wikstr. var. *montanus* (Engelm.)  
C.L. Hitchc.  
O; 5500-6500; bottomlands; riparian; oxbow of  
the Fremont River and Pleasant Creek.

*Juncus longistylis* Torr. in Emory  
O; 5500-6500; bottomlands and canyon bottoms;  
riparian; Pleasant Creek and the Fremont River  
Valley.

*Juncus torreyi* Cov.  
O; 5500-6500; bottomlands and canyon bottoms;  
riparian; Pleasant Creek and the Fremont River  
Valley.

JUNCAGINACEAE

*Triglochin maritima* L.  
O; 5000-6000; bottomlands; riparian; oxbow of  
the Fremont River, The Hartnet, and Sulphur  
Creek.

LILIEACEAE

*Allium cernuum* Roth  
O; 6000-8800; mountains and canyons; mixed  
conifer and aspen woodlands; Pleasant Creek,  
Oak Creek and Upper Deep Creek.

*Allium macropetalum* Rydb.  
U; 4000-5000; benches; desert shrub to pinyon-  
juniper woodland; Burr Trail and Upper Halls  
Creek.

*Androstephium breviflorum* Wats.  
R; 4000; benches; desert shrub; Lower Halls  
Creek.

*Asparagus officinalis* L.  
O; 5500; along irrigation ditches; orchards;  
Fruita.

*Calochortus aureus* Wats.  
R; 5000-5500; benches; desert shrub; Oyster Shell  
Reef.

*Calochortus nuttallii* T. & G. in Beckwith  
O; 6000-8000; mesas and hillsides; pinyon-  
juniper woodland and mixed conifer woodland;  
Upper Deep Creek and Cedar Mesa.

*Eremocrynum albomarginatum*  
R; 3900; bottomlands; desert shrub; Halls  
Creek.

*Fritillaria atropurpurea* Nutt.  
R; 8500-8800; mountains; mixed conifer  
woodland and aspen woodlands; Upper Deep  
Creek.

*Smilacina stellata* (L.) Desf.  
O; 4000-8000; canyon bottoms; riparian; Fremont  
River Valley, Upper Deep Creek, and Halls  
Creek.

*Zigadenus elegans* Pursh  
U; 8000; mountains, riparian; Upper Deep  
Creek.

#### ORCHIDACEAE

*Corallorhiza maculata* Raf.  
R; 8800; mountains; mixed conifer and aspen  
woodlands; Upper Deep Creek.

*Epipactis gigantea* Dougl. ex Hook.  
O; 4000-5500; canyon bottoms; riparian; Halls  
Narrows and the Fremont River Valley.

*Habenaria sparsiflora* Wats.  
R; 8000; bottomlands and canyon bottoms;  
riparian; Upper Deep Creek.

*Habenaria zothecina* Higgins and Welsh  
R; 4000; canyon bottoms; riparian; Halls Narrows.

*Spiranthes diluvialis* Shev.  
R; 5500; bottomlands; riparian; Fremont River  
Valley.

#### TYPHACEAE

*Typha domingensis* Pers.  
O; 5000-5500; bottomlands; riparian; Fremont  
River Valley.

*Typha latifolia* L.  
C; 4000-6500; bottomlands and canyon bottoms;  
riparian; Fremont River Valley, Pleasant Creek,  
and Halls Creek.

#### ZANNICHELLIACEAE

*Zannichellia palustris* L.  
O; 5500; ponds; aquatic; oxbow of the Fremont  
River.



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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.