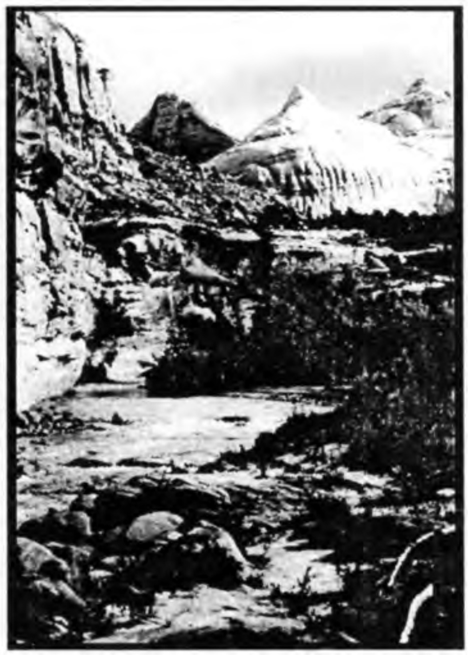
Vascular Flora and Vegetation of Capitol Reef National Park, Utah

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

Technical Report NPS/NAUCARE/NRTR-93/01



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Cooperative Park Studies Unit

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Vascular Flora and Vegetation of Capitol Reef National Park, Utah

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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 (Stanton 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

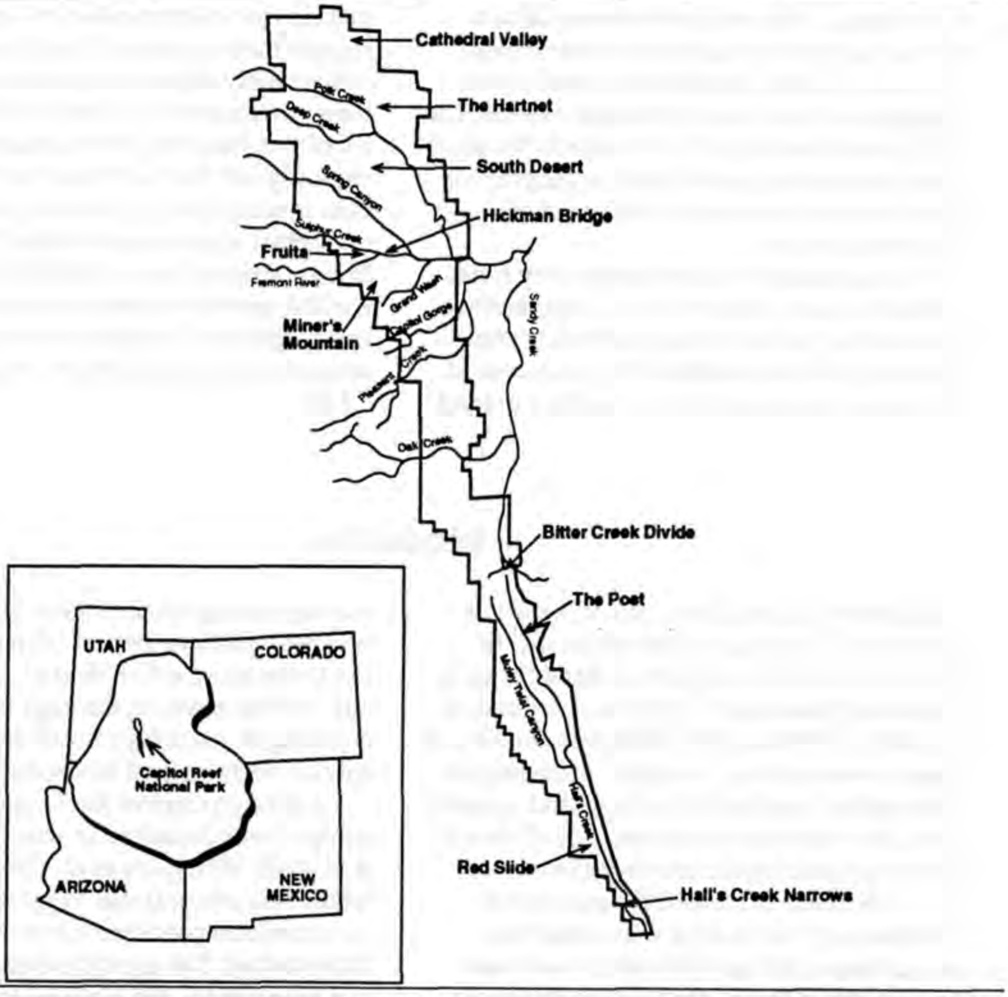

Figure 1. Detailed map of Capitol Reef National Park with inset of location map of Capitol Reef National Park within the Colorado Plateau Physiographic Region.

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 alphanumeric 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 erosiun (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 (*).

Cycladenia humilis var. *jonesii*	(E)	Near Deer Point
Echinocereus triglochidiatus var. *inermis*	(E)*	Paradise Flats
Erigeron maguirei var. *maguirei*	(E)*	Upper Deep Creek
Sclerocactus wrightiae	(E)	Cathedral Valley
Townsendia aprica	(T)	South Desert Overlook
Gilia caespitosa	(1)	Grand Wash; Near Hickman Bridge
Pediocactus winkleri	(1)	The Hartnet
Schoencrambe barnebyi	(1)*	Along Sulfur Creek
Spiranthes diluvialis	(1)*	Along Fremont River
Cymopterus beckii	(2)	Near Hickman Bridge
Dalea flavescens var. *epica*	(2)*	Near The Post
Erigeron maguirei var. *harrisonii*	(2)	Near Hickman Bridge
Habenaria zothecina	(2)*	Halls Narrows
Hymenoxys depressa	(2)*	Waterpocket Fold along Deep Creek
Thelesperma subnuda var. *alpina*	(2)*	Upper Deep Creek
Asclepias ruthiae	(3c)	South Desert
Astragalus barnebyi	(3c)	Along the Caineville Road
Astragalus chamaeluce var. *laccoliticus*	*=	Near The Post
Astragalus consobrinus	(3c)	South Desert Overlook
Astragalus harrisonii	(3c)	Near Hickman Bridge
Astragalus malacoides	(3c)	The Purple Hills; Circle Cliffs
Astragalus pardalinus	(3c)*	Cathedral Valley
Astragalus woodruffii	(3c)*	Fremont River, east entrance
Castilleja scabrida	(3c)	Near Hickman Bridge
Chamaechenactis scaposa	(3c)	The Upper Hartnet
Cryptantha johnstonii	(3c)*	The Hartnet
Erigeron abajoensis	(3c)*	Upper Deep Creek
Eriogonum corymbosum revealianum	(3c)*	Upper Deep Creek
Eriogonum tumulosum	(3c)*	The Hartnet
Geranium marginale	(3c)*	Upper Deep Creek
Lomatium junceum	(3c)	Near Bitter Creek Divide
Nama retorsum	(3c)	Near Hickman Bridge
Parthenium ligulatum	(3c)	The Upper Hartnet
Peteria thompsonii	(3c)*	Cathedral Valley
Physaria acutifolia var. *purpurea*	(3c)*	Upper Deep Creek
Xylorhiza confertifolia	(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 Olson1986).

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 TWINSPAN (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 clasification. 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 *Schoencranbe 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 Waterpocket 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 Summerville 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 communty 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

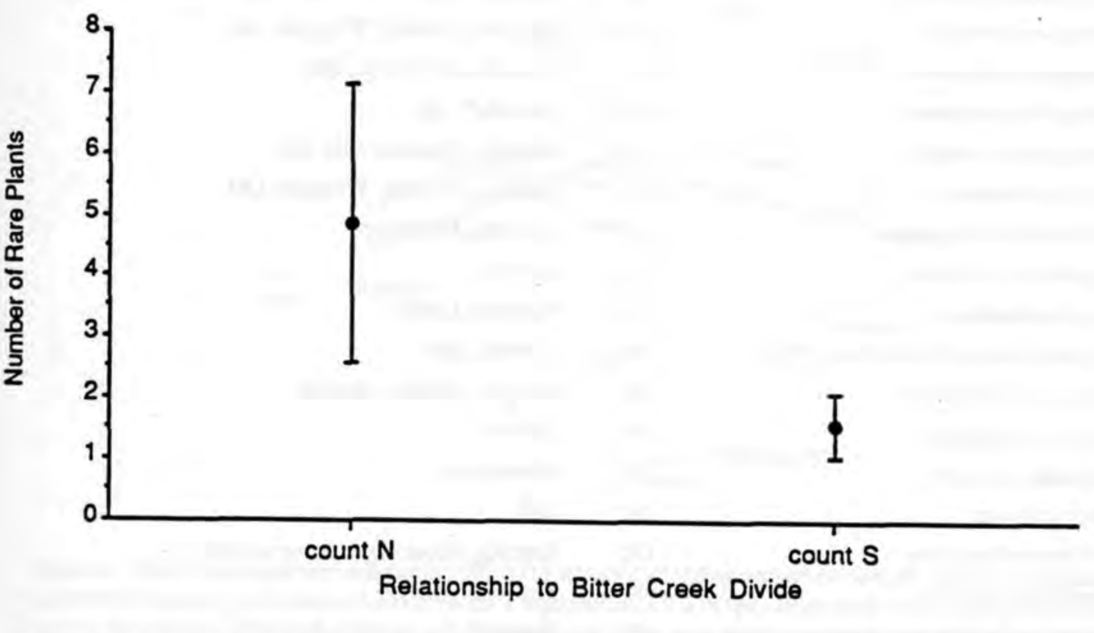

Figure 2. Relative abundance of rare plant taxa north and south of the Bitter Creek Divide in Capitol Reef National Park. Vertical lines are ±1 standard deviation.

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.

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

	Morrison	Curtis	Kaibab	Chinle	Wingate	Mancos	Cutler	Carmel	Kayenta	Navajo	Moenkopi	Summerville	Entrada	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

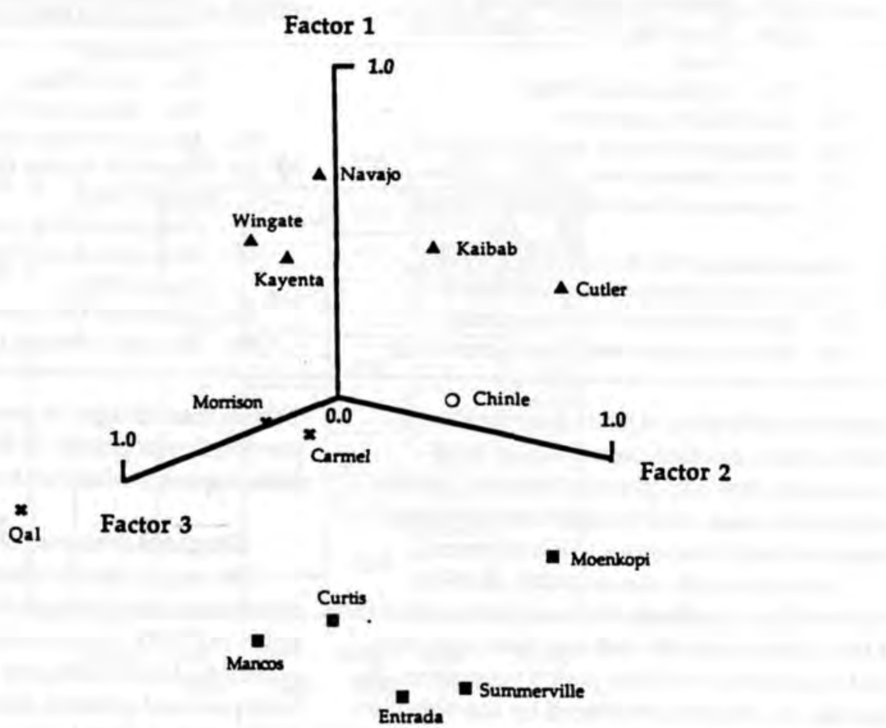

Figure 3. Principal component ordination (PCA) of stands containing rare plant taxa in relation to geologic substrate in Capitol Reef National Park. Factor 1 represents 22.7% of the variance, factor 2 represents 14.8%, and factor 3 represents 13.0% of the variance. Substrates producing coarse textured 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
- A1. Bentonite Badlands Community
- A2. Hopsage Badlands Community
- A3. Mat Saltbush Community
  - A3a. Shrub Phase
  - A3b. Grassland Phase
  - A3c. Buckwheat Phase
- A4. Gypsum Badlands Community

B. Grassland Communities
- B1 Shadscale-Grassland Community
- B2. Eolian Grassland Community
- B3. Mixed Grassland Community

C. Upland Shrub Communities
- C1. Eolian Shrub Community
  - C1a. Blackbrush-Mormon Tea Phase
  - C1b. Sand Sagebrush Phase
- C2. Blackbrush-Rabbitbrush Community
- C3. Intermittent Riparian Shrub Community
  - C3a. Greasewood-Rabbitbrush Phase
  - C3b. Fourwing Saltbush-Rabbitbrush Phase
  - C3c. Big Sagebrush Phase
- C4. Low Shrub Community
- C5. Dry Canyonbottom Shrub Community
- C6. Mesic Canyonbottom Shrub Community
- C7. Sagebrush-Bitterbrush Community

D. Pinyon-Juniper Woodland Communities
- D1. Pinyon-Juniper-Grass Community
- D2. Juniper-Mormon Tea Community
- D3. Pinyon-Juniper-Low Shrub Community
  - D3a. Cushion Plant Phase
  - D3b. Galleta Phase
  - D3c. Pygmy Sagebrush Phase
- D4. Pinyon-Juniper-Tall Shrub Community
- D5. Dwarf Mountain-Mahogany Slickrock Community

E. Upland Forest and Woodland Communities
- E1. Bristlecone Pine-Cushion Plant Community
- E2. Ponderosa Pine-Bitterbrush Woodland Community
  - E2a. Mountain-Mahogany Phase
- E3. Ponderosa Pine-Manzanita Woodland Community
- E4. Mesic Montane Woodland Community
- E5. Aspen Woodland Community

F. Riparian and Wetland Communities
- F1. Cottonwood-Rabbitbrush Woodland Community
- F2. Waterpocket Community
- F3. Cottonwood-Willow Riparian Woodland Community
  - F3a. Reed Phase
  - F3b. Baltic Rush Phase
- F4. Alder-Birch Riparian Community
- F5. Dogwood-Spruce Riparian Woodland Community
- F6. Hanging Garden Community
- F7. Hornbeam-Box Elder-Oak Woodland Community
- F8. Cultivated Orchards and Settlements
- F9. Perennial Wetland 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 reliablility 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

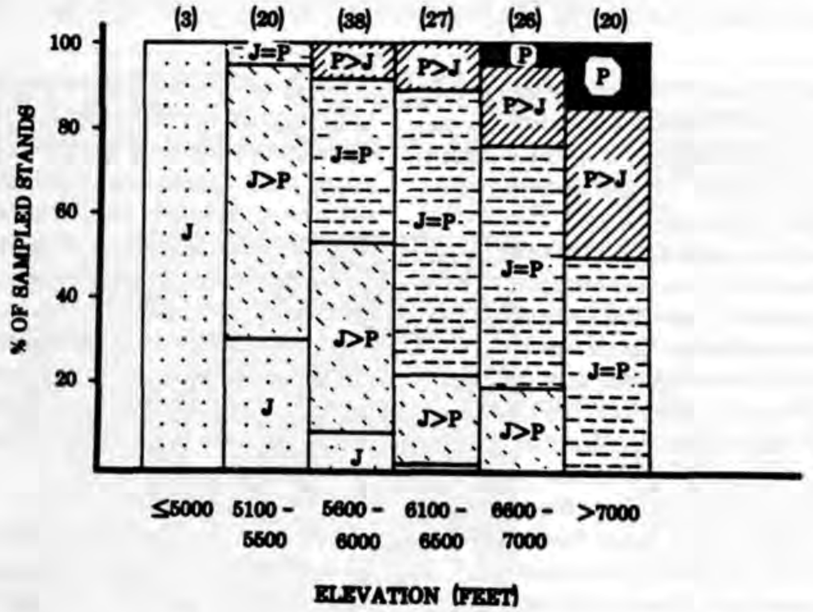

Figure 4. Compositional patterns in pinyon-juniper woodlands in relation to elevation in Capitol Reef National Park. "J" indicates that juniper (*Juniperus osteosperma*) is the only one of the two species present; "J>P" indicates that juniper is more abundant than pinyon (*Pinus edulis*); "J=P" indicates 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.

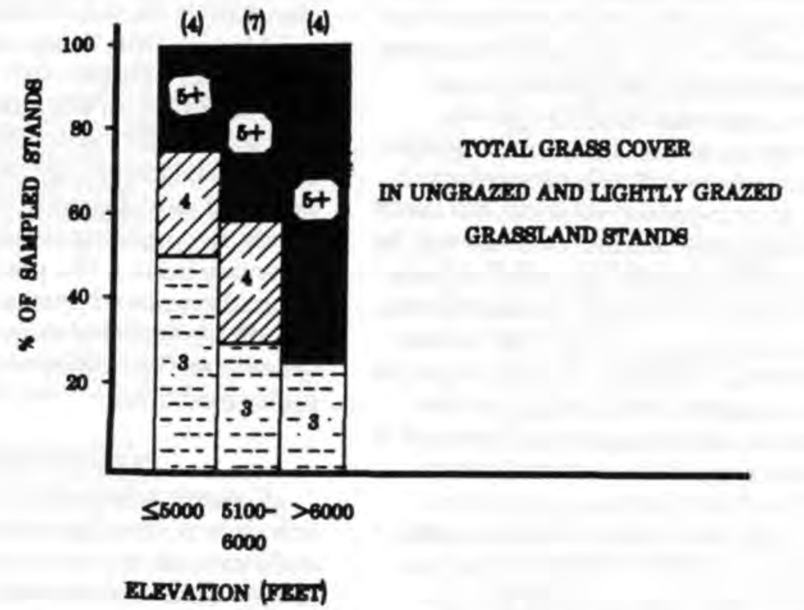

Figure 5. Patterns in minimum total grass cover within grassland stands along an elevational gradient in Capitol Reef National Park. "3" depicts plant cover class 3 (26-50%) in our releve samples; "4" depicts cover class 4 (51-75%); and "5" depicts cover class 5 (76-100%). The numbers in parentheses 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 communities (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

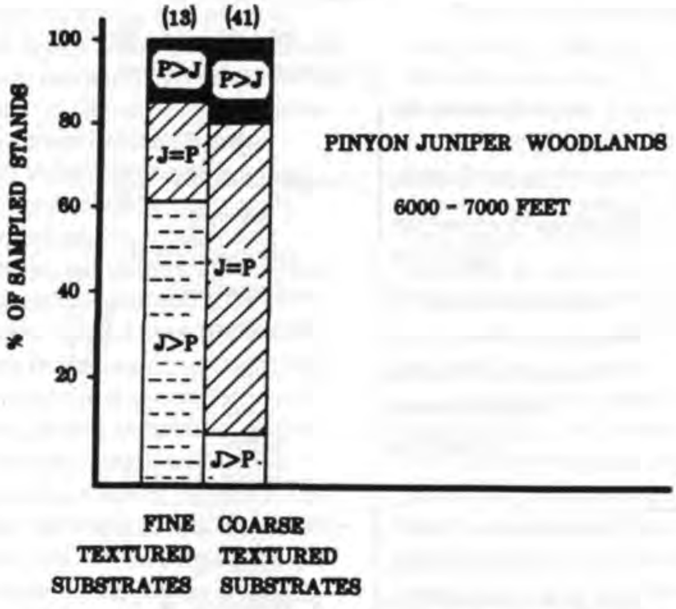

Figure 6. Compositional patterns in pinyon-juniper woodlands in relation to geologic substrate in Capitol Reef National Park. "J" indicates that juniper (*Juniperus osteosperma*) is the only one of the two species present; "J>P" indicates that juniper is more abundant than pinyon (*Pinus edulis*); "J=P" 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.

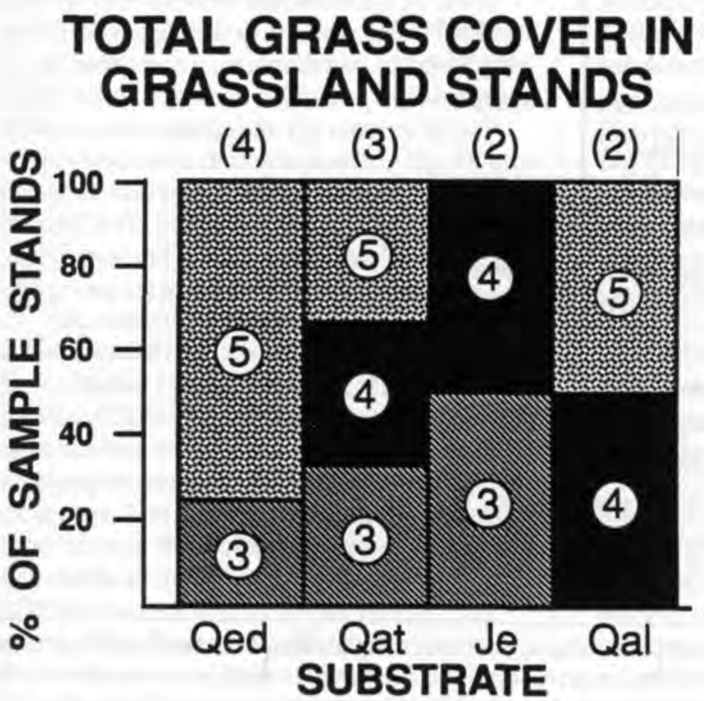

Figure 7. Patterns in minimum total grass cover in relation to geologic substrate in grassland stands in Capitol Reef National Park. "3" depicts plant cover class 3 (26-50%) in our releve samples; "4" depicts cover class 4 (51-75%); and "5" depicts cover class 5 (76-100%). The numbers in parentheses 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.

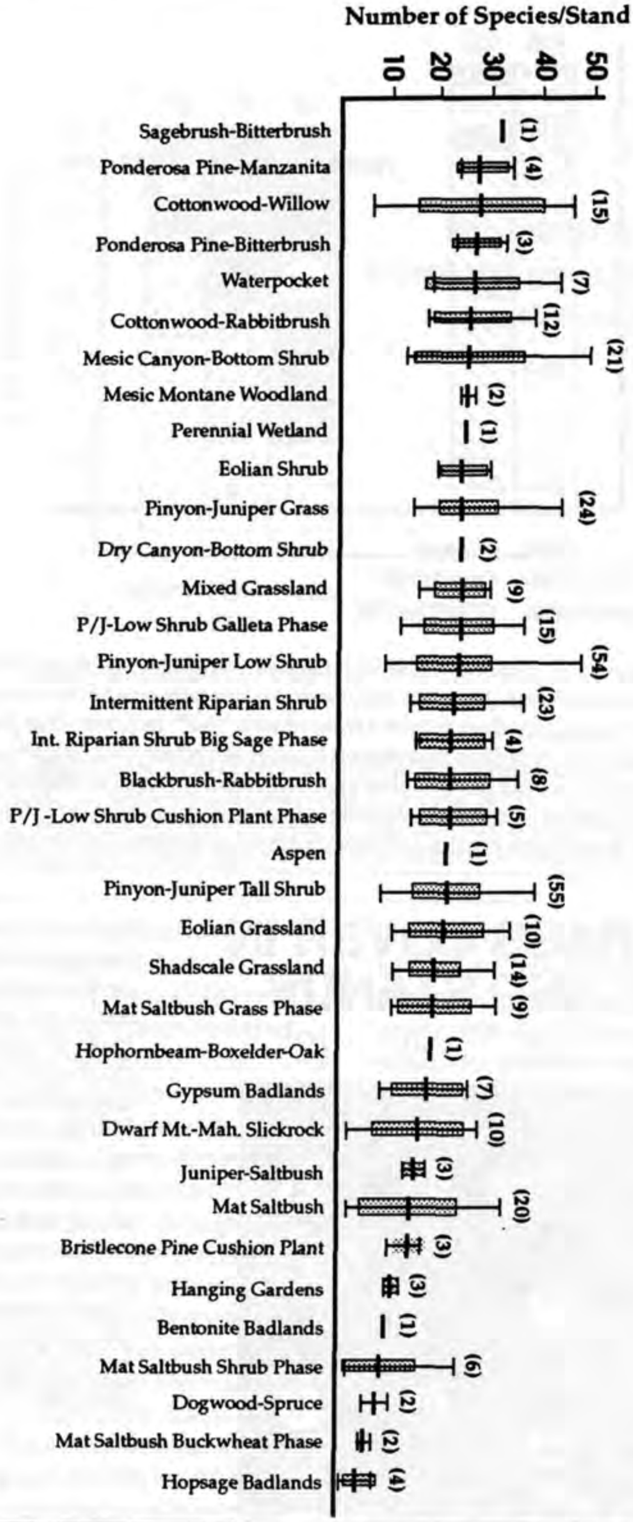

Figure 8. Patterns in species richness among plant community types in Capitol Reef National Park. Horizontal lines represent the mean and range, and shaded areas represent one standard deviation, of the number of vascular plant species recorded in our releve plots of approximately 100 square meters area.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

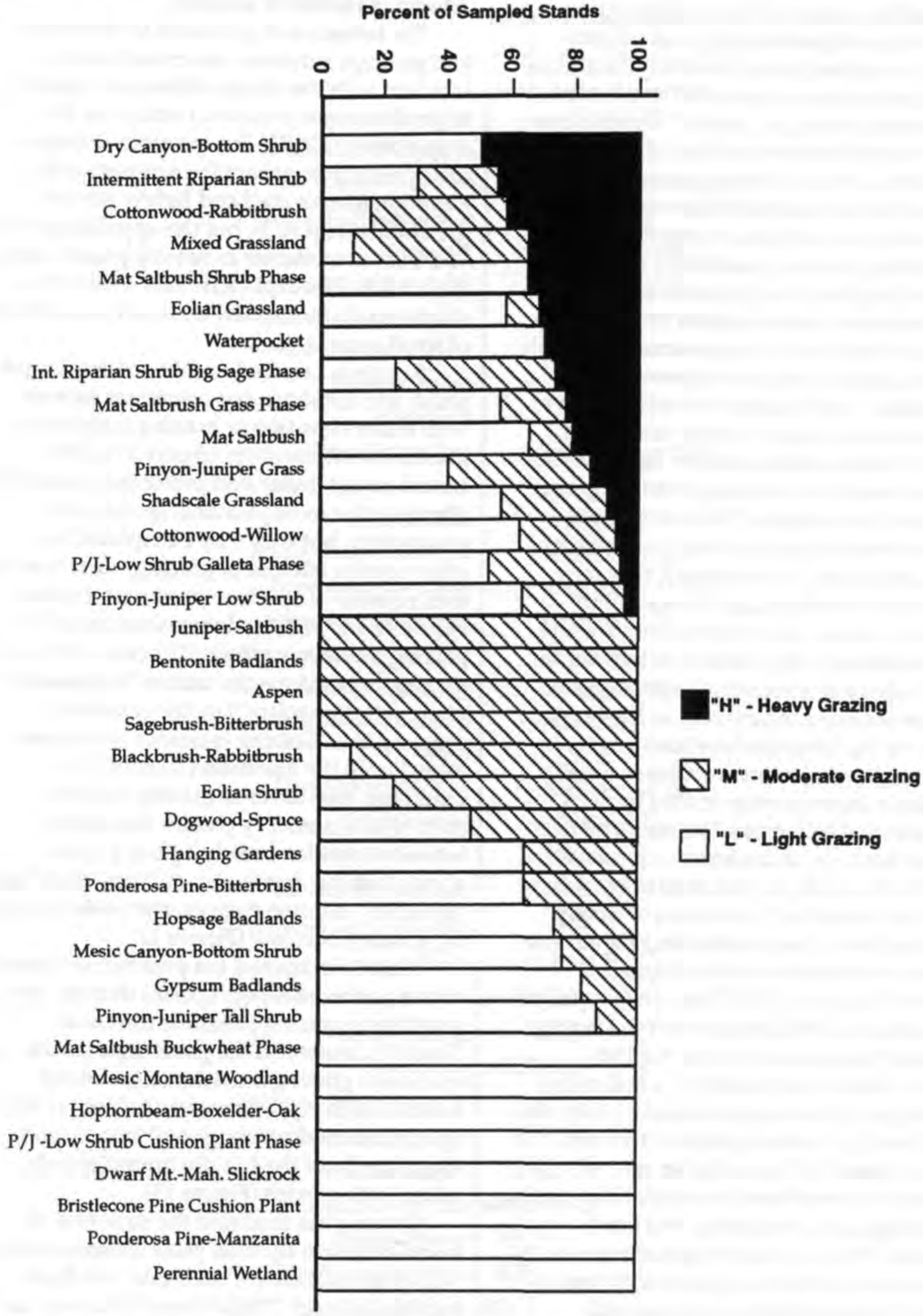

Figure 9. Patterns in grazing intensity among plant community types in Capitol Reef National Park. "H" depicts heavy grazing; "M" depicts moderate grazing; and "L" depicts light or absence of grazing. These are subjective estimates of grazing intensity, made at each sampling site. The numbers at the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

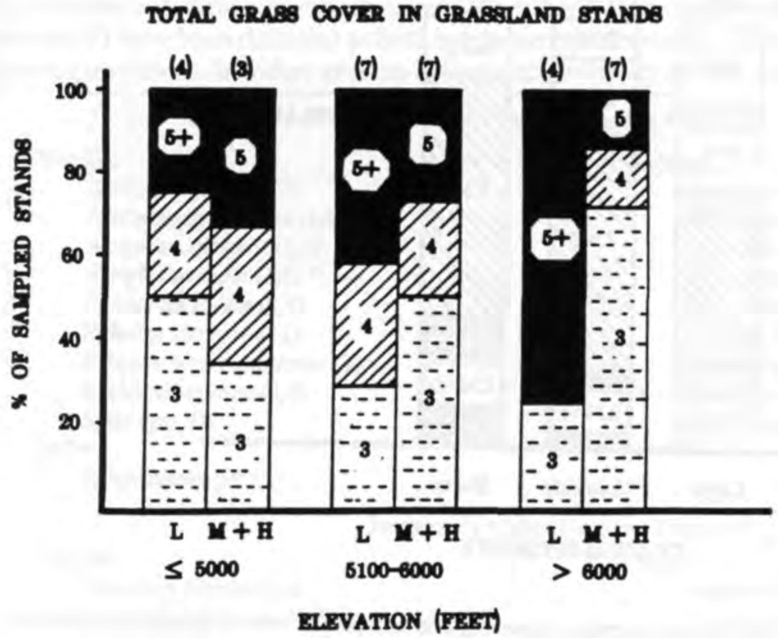

Figure 10. Patterns in minimum total grass cover in relation to elevation and grazing intensity in grassland stands in Capitol Reef National park. "3" depicts plant cover class 3 (26-50%) in our releve samples; "4" depicts cover class 4 (51-75%); and "5" depicts cover class 5 (76-100%). The numbers in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

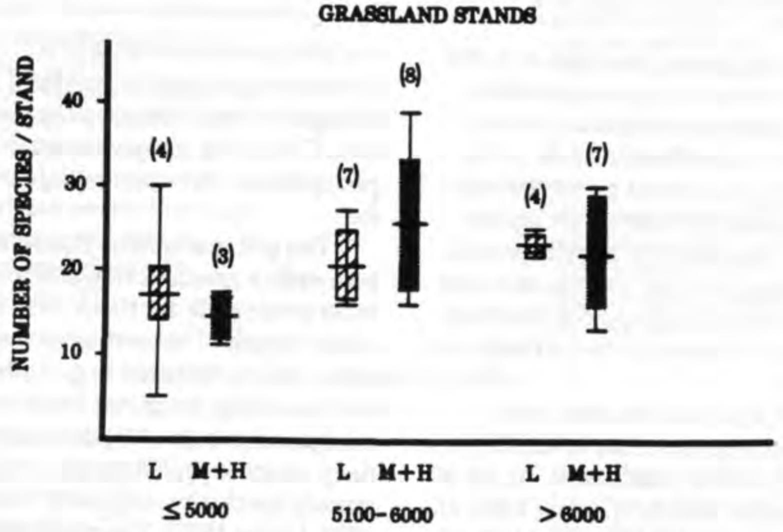

Figure 11. Patterns in species richness of grassland stands in Capitol Reef National Park. Horizontal lines represent the mean and range, and shaded areas represent one standard deviation, of the number of vascular plant species recorded in our releve plots of approximately 100 square meters area. "H" 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.

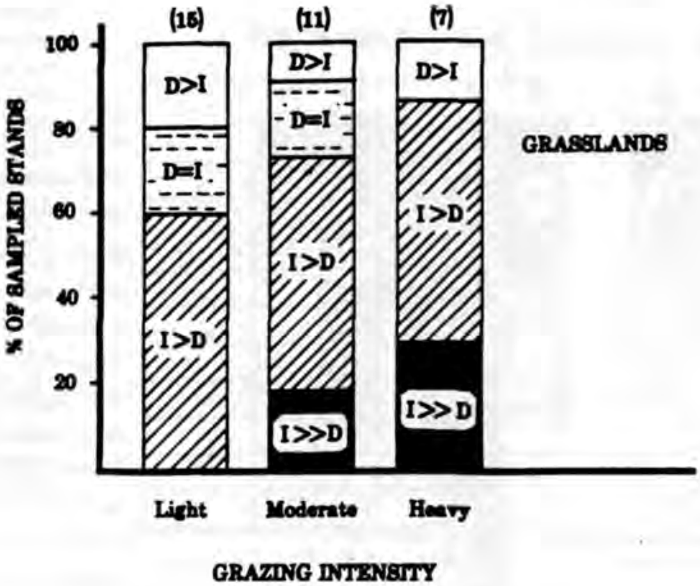

Figure 12. Patterns in relative abundance of increaser (grazing tolerant) and decreaser (grazing intolerant) species (see Table 6) in relation to grazing intensity in grassland stands in Capitol Reef National Park. "D>I" indicates that decreaser species are more abundant (greater total cover) than increaser species; "D=I" indicates that decreasers and increasers are roughly equal in abundance; "I>D" indicates that increasers are more abundant than decreasers; and "I>>D" indicates that increasers are far 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.

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)
- *Vanclevea 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).

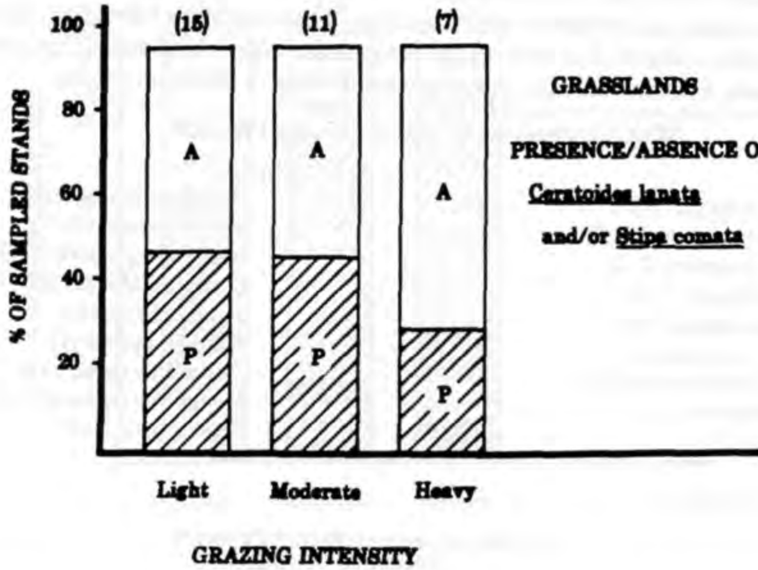

Figure 13. Patterns in presence or absence of two especially sensitive grazing intolerant species (decreasers) in relation to grazing intensity in grassland stands in Capitol Reef National Park. "A" indicates that both winterfat (*Ceratoides lanata*) and needle-and-thread grass (*Stipa comata*) are absent 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.

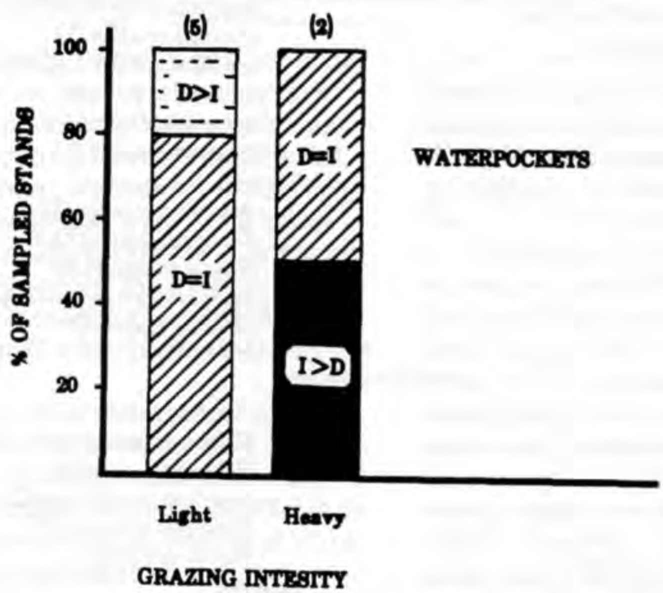

Figure 14. Patterns in relative abundance of increaser (grazing tolerant) and decreaser (grazing intolerant) species (see Table 6) in relation to grazing intensity in waterpocket communities in Capitol Reef National Park. "D>I" indicates that decreaser species are more abundant (greater total cover) 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.

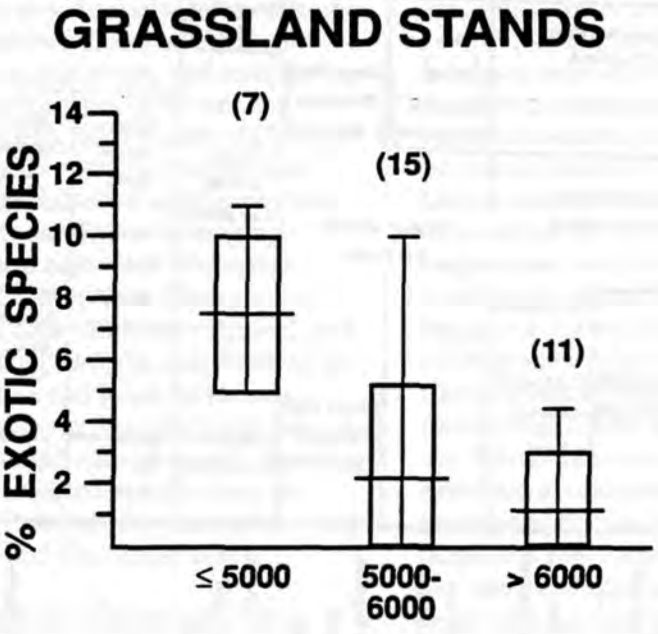

Figure 15. Relative abundance (% of species in a stand) of exotic (non-native) species in relation to elevation in grassland stands in Capitol Reef National Park. Horizontal lines represent the mean and range, and blocked areas represent one standard deviation, of the percent of non-native species among 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).

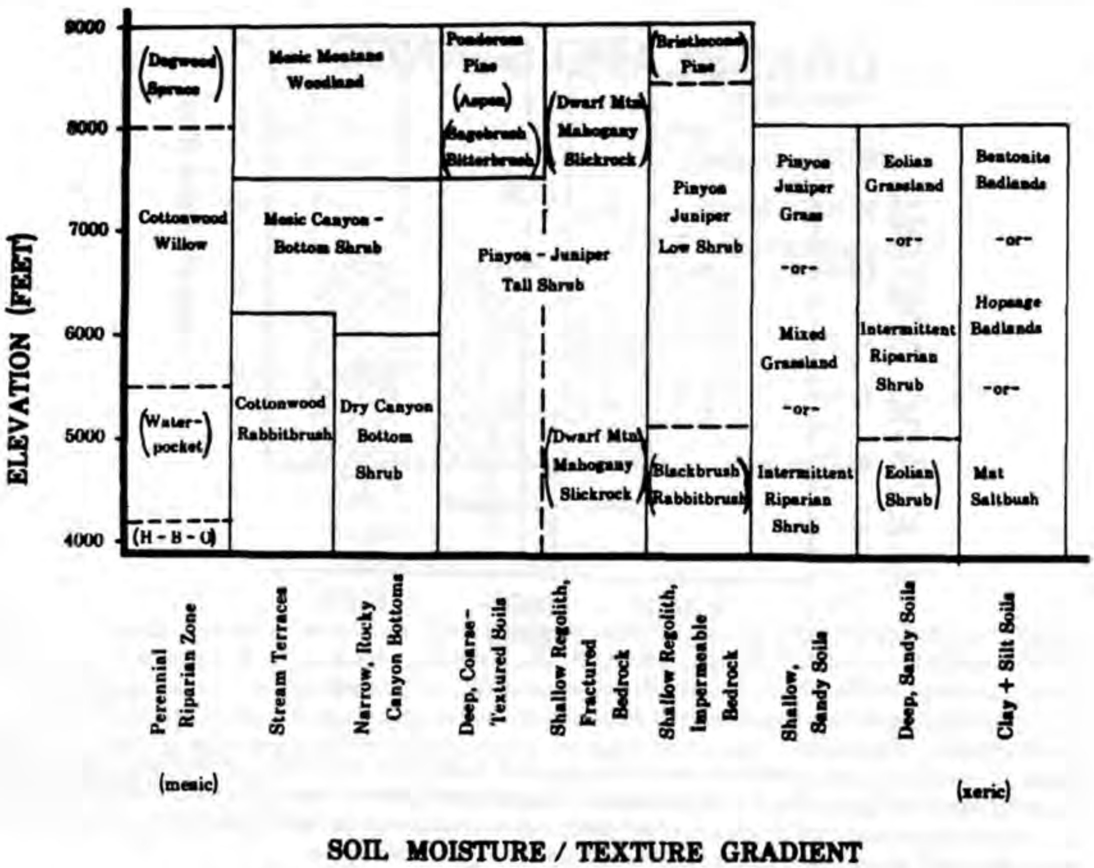

Figure 16. Overall patterns in distribution of plant community types in Capitol Reef National Park in relation to elevation and soil type. The solid vertical and horizontal lines indicate that a particular community type rarely or never extends across the boundary depicted by the line. The community 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 *Schoencrambe 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. *Schoencrambe 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 *Schoencrambe 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, *Schoencrambe 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 *Schoencrambe 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):

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

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

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

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

*Astragalus barnebyi**	*Habenaria zothecina**
Astragalus chamaeleuce var. *laccoliticus**	*Pediocactus winkleri**
*Cymopterus beckii**	*Schoencrambe barnebyi**

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 *Schoencrambe 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 awapensia*, 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 *Chamaechenactis 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 Madro-tertiary (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, *Pteria 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. magnicamporum* (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 discontinous 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, Tangley 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 measureably 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 McCullogh 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 quicky, probably because of the favorable growing conditions that promote reestablishment 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 McCullogh 1988) suggests that overgrazed streamsides 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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Literature Cited

Anderson, J. 1985. Notes on some of the plants of concern at Capitol Reef National Park. Unpublished report. U.S. Fish and Wildlife Service Endangered Species Office, Grand Junction, Colorado.

Arnold, J. F., D. A. Jameson, and E. H. Reid. 1964. The pinyon-juniper type of Arizona: effect of grazing, fire and tree control. USDA Forest Service Production Research Report Number 84.

Axelrod, D. I. 1958. Evolution of the Madro-tertiary geoflora. Botanical Review 24: 433-509.

Barbour, M. G., and W. D. Billings (editors). 1988. North American terrestrial vegetation. Cambridge University Press, New York.

Barnes, F. A. 1978. Canyon country geology for the layman and rockhound. Wasatch Publishers, Inc., Salt Lake City, Utah.

Barth, R. C., and E. J. McCullough. 1988. Livestock grazing impacts on riparian areas within Capitol Reef National Park. Final Report to National Park Service, Contract Number CT1200-4-A065.

Betancourt, J. L. 1990. Late quaternary biogeography of the Colorado Plateau. Pp. 259-293 *in* Betancourt, J. L., T. R. VanDevender, and P. S. Martin (editors), Packrat middens: the last 40,000 years of biotic change. University of Arizona Press, Tucson, Arizona.

Billingsley, G. H., P. W. Huntoon, and W. J. Breed. 1987. Geologic map of Capitol Reef National Park and vicinity, Emery, Garfield, Millard and Wayne Counties, Utah. Utah Geologic and Mineral Survey, Salt Lake City, Utah. (4 maps + key)

Bolin, B., B. R. Doos, J. Jager, and R. A. Warrick (editors). 1986. The greenhouse effect, climate change, and ecosystems. SCOPE Volume 29. John Wiley & Sons, New York.

Bratton, S. P., and P. S. White. 1980. Rare plant management-after preservation what? Rhodora 82:49-75.

Camp, P. A. 1978. Ecological reconnaissance. Halls Creek, Capitol Reef National Park. Unpublished Report. Department of Botany, Utah State University, Logan, Utah. 27 pp + 5 appendices.

Charley, J. L., and N. E. West. 1975. Plant-induced soil chemical patterns in some shrub-dominated semi-desert ecosystems of Utah. Journal of Ecology 63:945-964.

Cole, K. 1982. Late Quaternary zonation of vegetation in the eastern Grand Canyon. Science 217:1142-1145.

Cole, K. L. 1990. Late quaternary vegetation gradients through the Grand Canyon. Pp. 240-258 *in* Betancourt, J. L., T. R. VanDevender, and P. S. Martin (editors), Packrat middens: the last 40,000 years of biotic change. University of Arizona Press, Tucson, Arizona.

Cole, K. L. 1991. A survey of the fossil packrat middens and reconstruction of the pre-grazing vegetation of Capitol Reef National Park. Final Report to National Park Service.

Cooper, C. F. 1960. Changes in vegetation, structure, and growth of southwestern pine forests since white settlement. Ecological Monographs 30:129-164.

Cooper, C. F. 1961. Pattern in ponderosa pine forests. Ecology 42:493-499.

Cronquist, A., A. Holmgren, N. Holmgren and J. Reveal. 1972. Intermountain Flora Vol. 1, Vascular Cryptograms and Gymnosperms. New York Botanical Garden, Hofner Publishing, New York.

Cronquist, A., A. Holmgren, N. Holmgren and P. Holmgren. 1977. Intermountain Flora Vol. 6, The Monocotyledons. New York Botanical Garden, Columbia University Press, New York.

Cronquist, A., A. Holmgren, N. Holmgren and P. Holmgren. 1984. Intermountain Flora Vol. 4, Asteridae (except Asteraceae). New York Botanical Garden, Bronx, New York.

Davis, M. B. 1989. Insights from paleoecology on global change. Bulletin of the Ecological Society of America 70:222-228.

Dickinson, R. E. 1986. The climate system and modelling of future climate. Pp. 207-270 *in* B. Bolin, B. R. Doos, J. Jager, and R. A. Warrick (editors), The greenhouse effect, climate change, and ecosystems. SCOPE Volume 29. John Wiley & Sons, New York.

Dieterich, J. H. 1980. The composite fire interval — a tool for more accurate interpretation of fire history. Pp. 8-18 *in* Stokes, M. A., and J. H. Dieterich (technical coordinators), Proceedings of the fire history workshop. USDA Forest Service General Technical Report RM-81.

Dodge, M. 1972. Forest fuel accumulation — a growing problem. Science 177:139-142.

Everitt, B. L. 1970. A survey of the desert vegetation of the northern Henry Mountains region, Hanksville, Utah. Ph.D. Dissertation, Johns Hopkins University, Geography.

Fenneman, N. M. 1931. Physiography of the western United States. McGraw-Hill Book Co. New York.

Fiedler, P. L. 1985. Heavy metal accumulation and the nature of edaphic endemism in the genus Calochortus (Liliaceae). American Journal of Botany 72:1712-1718.

Fisher, R. F., C. N. Bourn, and W. F. Fisher. 1991. Prehistoric grasslands of Capitol Reef National Park. Draft Final Report to National Park Service.

Forman, R. T. T., and M. Godron. 1986. Landscape ecology. John Wiley & Sons, Inc., New York.

Gauch, H. G. 1981. Multivariate analysis in community ecology. Cambridge University Press, New York.

Gleason H. A. and A. Cronquist. 1964. The natural geography of plants. Columbia University Press. New York.

Goodrich, S. and E. Neese. 1986. Uinta Basin flora. U.S. Forest Service and Bureau of Land Management, U.S. Government Printing Office.

Graham, R. L., M. G. Turner, and V. H. Dale. 1990. How increasing atmospheric CO_2 and climate change affects forests. Bio-Science 40:575-587.

Hansen, J., I. Fung, A. Lacis, et al. 1988. Global climate changes as forecast by the GISS 3-D model. Journal of Geophysical Research 93:9341-9364.

Harris, J. G. 1980. A vascular flora of the San Rafael Swell, Utah. Great Basin Naturalist 43:79-87.

Harrison, B. F., S. L. Welsh, and G. Moore. 1964. Plants of Arches National Monument. Brigham Young University Sci. Bull. Biol. Ser. 5 (1).

Johnsen, T. N., Jr. 1962. One-seed juniper invasion of northern Arizona grasslands. Ecological Monographs 32:187-207.

Loope, W. L. 1977. Relationships of vegetation to environment in Canyonlands National Park. Dissertation, Utah State University, Logan, Utah.

Madany, M. H., and N. E. West. 1983. Livestock grazing - fire interactions within montane forests of Zion National Park, Utah. Ecology 64:661-667.

Malanson, G. P. 1980. Habitat and plant distributions in hanging gardens of the Narrows, Zion National Park, Utah. Great Basin Naturalist 40: 178-182.

Malanson, G. P., and J. Kay. 1980. Flood frequency and the assemblage of dispersal types in hanging gardens of the Narrows, Zion National Park, Utah. Great Basin Naturalist 40:365-371.

Malanson, G. P. 1982. The assembly of hanging gardens: effects of age, area, and location. American Naturalist 119:145-150.

Mason, H. L. 1946a. The edaphic factor in narrow endemism. I. The nature of environmental influences. Madrono 8:209-240.

Mason, H. L. 1946b. The edaphic factor in narrow endemism. II. The geographic occurrence of plants of highly restricted patterns of distribution. Madrono 8:241-257.

McCune, B., and T. F. H. Allen. 1985. Will similar forests develop on similar sites? Canadian Journal of Botany 63:367-376.

McLaughlin, S. P. 1992. Are floristic areas hierarchically arranged? Journal of Biogeography. Volume 19 (in press).

McLaughlin, S. P. 1989. Natural floristic areas of the western United States. Journal of Biogeography 16:239-248.

McLaughlin, S. P. 1986. Floristic analysis of the southwestern United States. Great Basin Naturalist 46:46-65.

Mueggler, W. F., and R. B. Campbell, Jr. 1986. Aspen community types of Utah. USDA Forest Service Research Paper INT-362.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Sons, New York.

Neese, E. J. 1981. A vascular flora of the Henry Mountains, Utah. Unpublished Ph.D. dissertation, Brigham Young University, Provo, Utah.

Neilson, R. P., G. A. King, R. L. DeVelice, J. Lenihan, D. Marks, J. Dolph, B. Campbell, and G. Glick. 1989. Sensitivity of ecological landscapes and regions to global climatic change. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, Oregon.

Olson, V. J. and H. Olson. 1986. Capitol Reef, the story behind the scenery. KC Publication, Las Vegas, Nevada.

Peet, R. K. 1981. Forest vegetation of the Colorado Front Range: composition and dynamics. Vegetatio 37:65-78.

Peters, R. L., and J. D. S. Darling. 1985. The greenhouse effect and nature reserves. BioScience 35:707-735.

Phillips, B. G., A. M. Phillips, III, and M. A. S. Bernzott. 1989. Annotated checklist of vascular plants of Grand Canyon National Park. Grand Canyon Natural History Association Monograph No. 7, Flagstaff, Arizona.

Pieper, R. D., and G. A. Lymbery. 1987. Influence of topographic features on pinyon-juniper vegetation in south-central New Mexico. Pages 53-57 *in* Everett, R. L. (compiler), Proceedings — Pinyon-juniper conference. USDA Forest Service General Technical Report INT-215.

Potter, L. D., R. C. Reynolds, Jr., and E. T. Louderbough. 1985a. Mancos shale and plant community relationships: field observations. Journal of Arid Environments 9:137-145.

Potter, L. D., R. C. Reynolds, Jr., and E. T. Louderbough. 1985b. Mancos shale and plant community relationships: analysis of shale, soil, and vegetation transects. Journal of Arid Environments 9:147-165.

Raven, P. H. 1964. Catastrophic selection and edaphic endemism. Evolution 18:336-338.

Reveal, J. L. 1979. Biogeography of the intermountain region: a speculative appraisal. Mentzelia 4:1-92.

Rominger, J. M. and L. A. Paulik. 1983. A floristic inventory of the plant communities of the San Francisco Peaks research natural area. Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-96.

Romme, W. H., K. D. Heil, J. M. Porter, and R. Fleming. 1993. Plant communities of Capitol Reef National Park, Utah. National Park Service Technical Report NPS/NAUCARE/NRTR-93/02.

Romme, W. H., and D. H. Knight. 1982. Landscape diversity: the concept applied to Yellowstone Park. BioScience 32:664-670.

Romme, W. H., and M. G. Turner. 1991. Implications of global climate change for biogeographic patterns in the greater Yellowstone ecosystem. Conservation Biology 5:373-386.

Sandenberg, R., C. Taylor, and J. S. Hoffman. 1987. Rising carbon dioxide, climate change, and forest management: an overview. Pp. 113-121 *in* W. E. Shands and J. S. Hoffman (editors), The greenhouse effect, climate change, and U.S. forests. The Conservation Foundation, Washington, D.C.

Schlesinger, M., and Z. Zhao. 1988. Seasonal climate changes induced by doubled CO_2 as simulated by the OSU atmospheric GCM/mixed-layer ocean model. Oregon State University Climate Research Institute Report, Corvallis, Oregon.

Sheviak, C. J. 1984. *Spiranthes diluvialis* (Orchidaceae), a new species from the western United States. Brittonia 36:8-14.

Singh, T., and N. E. West. 1971. Comparison of some multivariate analyses of perennial Atriplex vegetation in southeastern Utah. Vegetatio 23:289-313.

Smith, Jr., J. F., L. C. Huff, E. N. Hinrichs, and R. G. Luedke. 1963. Geology of the Capitol Reef area, Wayne and Garfield Counties, Utah. Geological Survey Professional Paper 363. United States Government Printing Office, Washington.

Sparks, S. R., N. E. West, and E. B. Allen. 1990. Changes in vegetation and land use at two townships in Skull Valley, western Utah. Pp. 26-36 *in* Proceedings — symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. USDA Forest Service General Technical Report INT-276.

Stanton, W. D. 1931. A preliminary study of the flora of the Henry Mountains of Utah. Master's Thesis, Brigham Young University, Provo, Utah.

Tangley, L. 1988. Preparing for climate change. BioScience 38:14-18.

Tausch, R. J., N. E. West, and A. A. Nabi. 1981. Tree age and dominance patterns in the Great Basin pinyon-juniper woodlands. Journal of Range Management 34:259-264.

Tueller, P. T., C. D. Beeson, R. J. Tausch, N. E. West, and K. H. Rea. 1979. Pinyon-juniper woodlands of the Great Basin: distribution, flora, vegetal cover. USDA Forest Service Research Paper INT-229.

Tuhy, J. S., and J. A. MacMahon. 1988. Vegetation and relict communities of Glen Canyon National Recreation Area. Final Report for Contract CX1200-6-B076. Unpublished report, Glen Canyon National Recreation Area.

Weber, W. A. 1987. Colorado Flora—Western Slope. Colorado Associated University Press, Boulder, Colorado. 530 pp.

Wein, R. W., and N. E. West. 1972. Physical microclimates of erosion-control structures in a salt desert area. Journal of Applied Ecology 9:703-710.

Welsh, S. L. 1970. Flora of Canyonlands. Great Basin Naturalist 21:26-37.

Welsh, S. L. 1978. Endangered and threatened plants of Utah: A reevaluation. Great Basin Naturalist 38:1-18.

Welsh, S. L. 1983a. A bouquet of daisies (Erigeron, Compositae). Great Basin Naturalist 43:365-368.

Welsh, S. L. 1983b. New taxa in Thelesperma and Townsendia (Compositae) from Utah. Great Basin Naturalist 43:369-370.

Welsh, S. L. 1988. Botanical environmental assessment, Wayne County Water Conservancy District. Fremont River Water Power Project. Prepared for Wayne County Water Conservancy District, Teasdale, Utah.

Welsh, S. L., N. D. Atwood, and J. L. Reveal. 1976. Endangered, threatened, extinct, endemic, and rare or restricted Utah plants. Great Basin Naturalist 35:327-376.

Welsh, S. L., N. D. Atwood, L. C. Higgins, and S. Goodrich. 1987. A Utah Flora. Great Basin Naturalist Mem. No. 9. Brigham Young University, Provo, Utah. 894 pp.

Welsh, S. L., N. D. Atwood, and J. Reveal. 1975. Endangered, threatened, extinct, endemic and rare or restricted Utah vascular plants. Great Basin Naturalist 35:327-376.

Welsh, S. L. and L. M. Chatterley. 1985. Utah's rare plants revisted. Great Basin Naturalist. 45:173-236.

Welsh, S. L., and G. Moore. 1968. Plants of Natural Bridges National Monument. Proceedings of the Utah Academy of Sciences 45:220-248.

Welsh, S. L., and K. H. Thorn. 1978. Illustrated manual of proposed endangered and threatened plants of Utah. U. S. Fish and Wildlife Service publication. 318 pp.

West, N. E. 1983a. Intermountain salt-desert shrubland. Pp. 375-397 *in* West, N. E. (editor), Temperate deserts and semi-deserts. Elsevier Scientific Publishing Company, Amsterdam.

West, N. E. 1983b. Southeastern Utah galleta-threeawn shrub steppe. Pp. 413-421 *in* West, N. E. (editor), Temperate deserts and semi-deserts. Elsevier Scientific Publishing Company, Amsterdam.

West, N. E. 1983c. Great Basin - Colorado Plateau sagebrush semi-desert. Pp. 331-349 *in* West, N. E. (editor), Temperate deserts and semi-deserts. Elsevier Scientific Publishing Company, Amsterdam.

West, N. E. 1988. Intermountain deserts, shrub steppes, and woodlands. Pp. 210-230 *in* Barbour, M. G., and W. D. Billings (editors), North American terrestrial vegetation. Cambridge University Press, New York.

West, N. E. 1990. Structure and function of microphytic soil crusts in wildland ecosystems of arid to semi-arid regions. Advances in Ecological Research 20:179-223.

Wetherald, R. T., and S. Manabe. 1988. Cloud feedback process in a GCM. Journal of Atmospheric Sciences 45:1397-1415.

Whisenant, S. G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. Pages 4-10 *in* Proceedings — symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. USDA Forest Service General Technical Report INT-276.

White, A. S. 1985. Presettlement regeneration patterns in a southwestern USA ponderosa pine (*Pinus ponderosa*) stand. Ecology 66:589-594.

White, P. S. and S. P. Bratton. 1980. After preservation: philosophical and practical problems of change. Biological Conservation 18:241-255.

Whittaker, R. H. 1956. Vegetation of the Great Smoky Mountains. Ecological Monographs 26:1-80.

Whittaker, R. H. 1975. Communities and Ecosystems. Second edition. Macmillan, New York.

Wilken, D. H. 1979. The taxonomic status of *Gilia caespitosa* (Polemoniaceae). Madrono 26:91-95.

Woodin, H. E., and A. A. Lindsey. 1954. Juniper-pinyon east of the Continental Divide as analyzed by the line-strip method. Ecology 35:473-489.

Woolley, R. R. 1947. Utilization of surface-water resources of Sevier Lake Basin, Utah. United States Geological Survey. Water Supply Paper 920.

Youngblood, A. P., and R. L. Mauk. 1985. Coniferous forest habitat types of central and southern Utah. USDA Forest Service General Technical Report INT-187.

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, Waterpocket Fold, Miners Mountain, Cohab and Frying Pan Canyons.

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.

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.

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 throughout 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 community; 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.

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 woodland; 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 crassisepala (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 woodland; 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.

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; HallsNarrows.

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 roadsides; 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 mountains; 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 community; 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 woodland; 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.

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.

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, disturbed 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 canyonbottoms (sandy sites); desert shrub to pinyon-juniper woodland; widespread throughout 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 communities; 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; sagebrush 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 stevioides 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.

Chrysothamnus nauseosus (Pallas) Britt. var. *graveolens* (Nutt.) Piper
W; 3900-7000; bottomland, benches and mesas; desert shurb 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 woodland; Upper Deep Creek.

Chrysothamnus viscidiflorus (Hook.) Nutt. var. *lanceolatus* (Nutt.) Greene
O; 7500-8500; mountains; mixed conifer woodland; 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.

Dyssoidia 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.

Gaillaridia 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.

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 woodland; 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 woodland; 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.

Leucelene 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 shurb 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.) Shinners
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.

Platyschkuhria 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.

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 exscapa (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.

Vanclevea 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) Shinners
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.

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-junipr woodland; 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.

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

Schoencrambe 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.

Thelypodiopsis 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.

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 rafaelensis 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.

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.

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; widepsread throughout the park.

Mirabilis oxybaphoides Gray in Torr.
O; 5000-6000; canyons; pinyon-juniper woodland 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 throughout 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 Jailhouse 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 woodland, 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 woodland; Upper Deep Creek.

Oenothera albicaulis Pursh
O; 5000-6000; upland, bottomland, hills, and mesas; desert shrub to pinyon-juniper woodland; 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 exclosure.

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 subspinosa 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; benhces; pinyon-juniper woodland; Oak Creek.

Erigonum 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.

PORTULACEAE

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.

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.

Clemantis columbiana (Nutt.) T. & G.
O; 7500-8500; mountains; mixed conifer woodland; Upper Deep Creek.

Clemantis 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 hillsides; 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 woodland; Upper Deep Creek.

RHAMNACEAE

Ceanothus fendleri Gray
O; 7000-8000; mountains; mixed conifer woodland; 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 woodland; Upper Deep Creek.

Amelanchier utahensis Koehne
W; 5000-7500; uplands; pinyon-juniper woodland; 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 woodland; Upper Deep Creek.

Cercocarpus montanus Raf.
O; 7500-8500; mountains; mixed conifer woodland; Upper Deep Creek.

Coleogyne ramosissima Torr.
O; 4000-5000; uplands; black brush communities; 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 woodland; 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 woodland; Upper Deep Creek.

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 woodland; 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 hystricina Muhl. ex Willd.
R; 4000; canyon bottoms; riparian; HallsNar-rows.

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 anddisturbed 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 glacum Steud.
O; 5500; bottomlands; disturbed sites; Fruita.

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 oligosanthes 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 monospeliensis (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.

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 ditiches; 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.

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.

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