

VASCULAR FLORA
and
VEGETATION CHANGE
at
CANYON DE CHELLY NATIONAL MONUMENT
APACHE COUNTY, ARIZONA

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ABSTRACT

Two hundred and sixty nine previously unrecorded taxa including 70 new genera and 12 new families were documented for Canyon de Chelly National Monument, bringing the total known taxa up to 808. This work was completed as part of a nation-wide inventory and monitoring effort carried out by the National Park Service (NPS) as part of the Natural Resource Challenge, a legislative and administrative mandate for the NPS to learn more about the resources they manage. A significant goal of the effort was to document 90% of the vascular plants occurring within each park unit. Targeted searches were the most productive method for finding new plant records. Though one quarter of the effort was expended in random sampling to model plant species diversity at Canyon de Chelly, not enough data were collected to test the model. Random sampling revealed few new plant records.

Canyon de Chelly harbors twenty-nine sensitive plant taxa; twenty-two that are rare. New discoveries include *Carex chihuahuensis*, *C. specuicola*, and *Zigadenus vaginatus* that are at the edge of their range here. *Astragalus chuskanus*, *Cirsium chellyense*, *Lupinus caudatus* ssp. *cutleri*, and a white-flowered form of *Mertensia oblongifolia* are endemic to the Canyon de Chelly area.

Seventy-nine photographs matched with historical photographs document invasion of uplands by piñon and juniper, and invasion of riparian areas by native trees (cottonwood and willow) and exotic trees (Russian olive and tamarisk) during the last 120 years.

Key Words: biological inventory, Canyon de Chelly, rephotography, biodiversity, plant species diversity, modeling, vegetation, flora.

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INTRODUCTION

Objectives

The Canyon de Chelly inventory project was part of an effort by the National Park Service (NPS) to inventory the botanical resources of the lands they administer (NPS 1995.) Inventory goals were “to help prevent the loss or impairment of natural resources” (NPS 2000/1), which the NPS is mandated to do by law (Lemons and Junker 1996; Shelton and Fox 1994). More specific objectives were “. . . to document the occurrence of 90% of plant species, survey for special status species, and to provide baseline information for park planning and future natural resource monitoring.” (Hiebert *et al.* 2000, p.74).

Researchers chose parks for inventory where less than 90% of their floras were known (Hiebert *et al.* 2000). The inventory plan directs much effort toward the goal of statistically estimating species diversity in each park, to assure that 90% of the species present will have been documented at the end of the project (Hiebert *et al.* 2000). Documentation included field collecting and database searches for existing herbarium specimens previously undocumented by the NPS. My primary goal was to document plants using both targeted and random searches.

This study included goals beyond plant species inventory. The NPS considers Diné use of Canyon de Chelly National Monument to be integral to the NPS mission. Diné use may be diminishing as a result of rapid vegetation community change, change that may be reversed with a more thorough understanding of the influences. In response to this need, I planned to document the last 120 years of vegetation change at Canyon de Chelly using repeat photography. I predicted that this work would help NPS managers assess vegetation change and direct future

restoration efforts. My goal was to compare historical photos with modern photographs to document channel morphology, and riparian and upslope vegetation changes at Canyon de Chelly. Specifically, I questioned whether:

1. These changes were coincident with the regional erosion cycle that began in the late 1800s throughout the Southwest (Hereford 1984, 1986),
2. These changes were coincident (in timing) with tree planting and other management actions designed to control erosion and/or flooding that took place from the 1930s through the 1970s,
3. Riparian vegetation invasion is consistent throughout the canyons and an ongoing process,
4. Cover change and invasion of piñon/juniper woodland are occurring throughout the Monument and ongoing in upland areas.

Where possible, the standards for floras as identified by Palmer *et al.* (1995) were followed for this report.

History

Canyon de Chelly National Monument contains some of the finest examples of prehistoric architecture in the Southwest dating from late Archaic through Pueblo III (0 AD – 1300 AD)(Fall *et al* 1981). Preservation of these ruins was the primary consideration for establishing the National Monument. For details of the prehistory of Canyon de Chelly see De Harport (1959), Grant (1978), Martin and Plog (1973), McGregor (1941), Morris (1986) and/or Wormington (1956).

Diné probably began using the Canyon de Chelly area during the 1700s (Andrews 1985) after 400 years of sporadic Pueblo occupation. Canyon de Chelly has always been an important

community and agricultural area, and it has played an important role as a Diné refuge from both Spanish and American invaders during the late 1700s through the 1800s (Grant 1978). “Canyon de Chelly occupies a special place in both Navajo mythology and Navajo history” (Goodman 1982).

Administration

Canyon de Chelly National Monument was established by presidential proclamation on April 1, 1931 to protect the archeological resources in the canyons. Canyon de Chelly is unique in the National Park Service, both because it has a large resident community and because the land remains in tribal trust for the Navajo Nation. Creation of the National Monument was not intended to alter the rights and privileges of the Navajos (Brugge and Wilson 1974).

The Navajo Nation and the NPS share in the management of Canyon de Chelly, though confusion still exists regarding the role that each is to play. The NPS administers the archaeological resources and “other features of scientific and historical interest” (Brugge and Wilson 1976:17). “The Navajo Nation retains ownership of the land and minerals and is responsible for surface and subsurface use of land, including residential development, agriculture, and grazing” (Westmacott 1992). Chinle, Nazlini, Crystal, Tsaile/Wheatfields, and Sawmill Chapter Houses have jurisdiction within Canyon de Chelly. Numerous private leaseholders (residents) have rights to use specific areas within Canyon de Chelly.

Location

Canyon de Chelly is part of the Navajo Reservation in Apache County, northeastern Arizona ([Figure 1](#)). The boundaries of Canyon de Chelly National Monument are roughly defined as one half mile back from the rims of the entire canyon system (Brugge and Wilson 1976). The boundary is not marked on the ground, nor is there any obvious change in land use at

the boundary. I adopted the boundaries of Canyon de Chelly as shown on US Geological Survey topographic maps for this study. Twelve USGS 7-1/2 minute topographic maps cover Canyon de Chelly: Chinle, Del Muerto, Lower Wheatfields, Mummy Cave Ruins, Red Cornfield Mesa, Sawmill, Sonsela Buttes, Spider Rock, Three Turkey Canyon, Tsaile, White Clay, and White Rock Wash. Canyon de Chelly National Monument encompasses 400 km² (131 mi²) between longitude 109 degrees, 08' and 109 degrees, 33' and between latitude 35 degrees 59' and 36 degrees, 18'.

Access

Paved roads connect the towns of Chinle and Tsaile, and traverse the south rim of Canyon de Chelly from Chinle to the Spider Rock Overlook. Dirt roads requiring a high clearance 4x4 vehicle approach close to the rim along most rim areas. Roads within the canyons are limited to one entry at the canyon mouth, at the western end of Canyon de Chelly. Much of the year, a high clearance 4x4 vehicle can make it to the vicinity of Big Flow Canyon in Canyon del Muerto and to the vicinity of Spider Rock in Canyon de Chelly.

Throughout this report I refer to the lower canyons, defined as those canyon reaches that experience at least occasional vehicle traffic, and the upper canyons, defined as those canyon areas upstream of passable roads. This division occurs in Canyon del Muerto about one mile upstream of Middle Trail Canyon and in Canyon de Chelly at Spider Rock. The Peninsula is the mesa between Canyon de Chelly and Canyon del Muerto. The Junction is the area where Canyon del Muerto joins Canyon de Chelly.

Over one hundred modern trails and ancient routes traverse from canyon bottom to rim (Figure 2). These routes are well distributed in most canyon reaches (Jett 1994, 2001). They vary in difficulty from easy to impossible, due to fallen ladders and erosion of holds (pers. obs.).

Physiographic Environment and Geology

The area of Canyon de Chelly constitutes 0.1 % of the Colorado Plateau physiographic province. The Colorado Plateau is largely composed of nearly flat-lying sedimentary rocks interrupted by occasional monoclines which separate the region into smaller plateaus. Canyon de Chelly and its side canyons are incised into the northern portion of the Defiance Plateau at the western edge of the Chuska Mountains (Barnes 1984).

Canyon rims in the Canyon de Chelly region are primarily composed of shales, coarse sandstones and conglomerates of the Shinarump Conglomerate. The Shinarump forms a resistant cap (Figure 3) over the more easily eroded De Chelly Sandstone and thus is largely responsible for the spectacular cliffs of Canyon de Chelly (Vandiver 1937). Well-sorted sands of the De Chelly Sandstone form most canyon cliffs and slopes (Pierce 1967). Fine-grained Supai Sandstone is exposed at canyon bottoms in mid reach where the canyons have their greatest depth.

The Shinarump Conglomerate and De Chelly Sandstone act as aquifers, storing and transporting water, whereas the Supai Sandstone, with its finer-grained sandstones and shales, acts as an aquiclude, causing water to spring and seep to the surface (Cooley *et al.* 1969). Thus the stratigraphy of the canyons underlies its suitability for agriculture and its attraction for human occupation.

Volcanic basalts and talus cover a small portion of Canyon de Chelly National Monument on slopes east of Coyote Creek. In other areas volcanic rocks intruded very close to the boundaries of Canyon de Chelly. Weathered clasts of volcanic (and very rarely, Precambrian granite) rock occasionally can be found within Canyon de Chelly.

Geomorphology and Hydrology

Channel change throughout the Southwest at the turn of the 19th century is well documented (Cooke and Reeves 1976, Graf 1983; Hereford 1984, Love 1979). Scientific debate over the timing, extent, and causes of erosion ('the arroyo problem') within canyon systems of the Colorado Plateau. . . " (Hereford 1986, p.293) has generated more interest than any single research topic in arid-region geomorphology." Despite this high level of interest, no single widely accepted theory explains these channel changes.

Canyon bottoms at Canyon de Chelly have undergone erosion and deposition cycles for thousands of years (Dolan 1993). These cycles may result from climate change, rates of sediment availability and transport, and/or plant community evolution. Erosion cycles may be exacerbated by human activities such as chaining, logging, woodcutting, grazing, fire, introduction of exotic plant species, tree planting, road building, placement of erosion control features or dams, and agriculture (Hereford 1986).

Canyon de Chelly National Monument ranges 650 m (2,100 ft) in elevation from 1,680 m (5,500 ft) at the mouth of the canyon to 2,320 m (7,600 ft) on slopes, mesas, and ridges of the northern Defiance Plateau. The canyon complex is composed of Canyon de Chelly (to the south) with its major tributary, Canyon del Muerto (to the north) and its smaller tributary, Monument Canyon. Black Rock Canyon is a significant tributary of Canyon del Muerto. The junction of the two main canyons is seven km upstream of the mouth of the canyon, which is close to the western boundary of Canyon de Chelly National Monument ([Figure 4](#)).

The mouth of the canyon appears as a flat sand wash margined with low cliff walls. Canyon bottoms in the lower reaches are flat, sandy, and 0.2 to 1 km in width. Upstream, in much of the canyon system, the slopes and cliff walls attain heights of 250 m (800 ft), though in

a few areas the walls reach heights of up to 350 m (1,200 ft). In the upper canyons, canyon bottoms become increasing U- and then V-shaped and the walls decrease in height until at the heads of the five main tributaries the walls disappear close to the uppermost boundaries of the Monument.

Four main tributaries of Canyon de Chelly drain watersheds that originate in the Chuska Mountains, which attain nearly 3,000 m in elevation. Spring runoff from snowmelt supplies the most dependable flows. Tsaille Creek drains through Canyon del Muerto and is perennial many years to the Draper Ranch, downstream of Big Flow Canyon. Wheatfields, Whiskey, and Crystal Creeks drain into Canyon de Chelly and are perennial most years from where they enter Canyon de Chelly to below the confluence of Wheatfields and Coyote Creeks.

The U.S. Geological Survey installed a gauging station at the mouth of Canyon de Chelly in 1999 ([Figure 5](#)). This short period of record may not be representative of long term average stream flows.

Climate

The Canyon de Chelly visitor center has operated a weather station since 1970 and records a sample of weather conditions for the lower canyons. Unfortunately, weather records for the upper elevations of Canyon de Chelly are problematic to obtain. Records from the nearby Tsaille weather station were unavailable when this report was written. Precipitation records from nearby Lukachukai, which might be used as proximate data for upper elevations of Canyon de Chelly, are unreliable (B. Peterson, NOAA, pers. comm.) Reliable weather stations such as Ganado and Window Rock are over 30 miles away and are in different orographic settings than the upper elevations of Canyon de Chelly National Monument.

Precipitation in the region is extremely variable (Figures 6 and 7). I compared weather records for 1957 and 1961 because they were the only years of complete records at both weather stations. July and August are the highest rainfall months. This rainfall occurs as thunderstorms and cloudbursts that are fickle in their distribution; one area may get a lot of rain while an adjacent area remains dry. This spotty summer rainfall contributes to climate variability at Canyon de Chelly (Green and Sellers 1964, Sellers and Hill 1974).

The gauge at the Canyon de Chelly visitor center has recorded an average of 245mm (9.65 in) of precipitation per year. Two years of complete records from Chinle and Lukachukai indicate the Lukachukai gets more precipitation than Chinle (Figures 8 and 9).

Figure 10 compares average monthly precipitation for the weather station at the Canyon de Chelly visitor center to precipitation observed there during the 2001 and 2002 seasons. Lukachukai precipitation records for 2001/02 are too spotty to characterize patterns of rainfall at the upper elevations of Canyon de Chelly for these years.

During the two summers I experienced at Canyon de Chelly, the upper elevations were significantly wetter than the lower canyons. On several occasions, I was unable to drive on muddy roads adjacent to the upper canyons, but during the same time period at lower elevations, the skies were clear and there had been no precipitation.

This project was conducted during dry years. The spring of 2001 was slightly drier than normal and the 2001 monsoon season was significantly drier than normal. Spring, 2001 collecting trips were fruitful. The year 2002 was the driest on record. Yet, during the summer monsoon period (July – September), precipitation was close to normal. As a result, few herbaceous plants were observed during spring of 2002. However, many plants were observed and collected that hadn't been seen previously. Despite the fact that 2002 was so dry, and most

botanists considered it a poor year for collecting, the rate of finding new plant records remained high, partly due to monsoon and post monsoon collecting. But another, often overlooked, factor is that each year's variation in weather and other events contribute to very different assemblages of plants being observed in different years (McDougall 1967). The herbaceous plants one is likely to see in a given season vary considerably depending on the amount, timing, and intensity of precipitation events and the timing of cold and warm temperatures during the season. Annual plant populations in northwestern New Mexico were found to be spatially and temporally (year to year) variable (Cully & Cully 1989). Juhren *et al.* (1956) found that the greatest total precipitation did not necessarily produce the greatest germination of annuals; and that the amount and duration of precipitation and the temperatures which prevail while the soil is wet, are the principal factors (that they measured) that determine the germination of annuals in any given season. Some plants (cacti) flower primarily during dry years (D. Pinkava, pers. comm.) New records will continue to be found at Canyon de Chelly as herbaceous plants respond to unique weather conditions in future years.

Canyon de Chelly is in US Dept. of Agriculture Climate Zone 6 (USDA 2003 http://www.permed.com/Climate_Zones.htm). Extreme temperatures in the Canyon de Chelly area (Table 1 (Etsitty 1994)) affect plant species that may live in and around the Monument.

Vegetation Communities

Canyon de Chelly vegetation communities range from desert scrub and grassland at lower elevations to ponderosa pine forests and dense stands of sage at upper elevations. Piñon-juniper and riparian vegetation communities thrive within this range (Halse 1973). Douglas fir and aspen forests grow on north aspect slopes within the canyons at elevations as low as 1,830 m

(6,000 ft). Minor communities include hanging gardens; active sand dune; and human impacted agricultural and weedy areas (pers. obs.).

Dennis (1975) and Harlan and Dennis (1976, 1986) mapped the vegetation of Canyon de Chelly into seven plant resource groups related to presumed Anasazi use: (1) Canyon bottom communities, (2) Talus communities, (3) Springs, seeps and other wet places, (4) Piñon-juniper continuum, (5) Low shrub-grassland communities, (6) Sagebrushland community, and (7) Canyon rim, cliffs and ledges.

Harlan and Dennis (1976, 1986) further divided Canyon bottom communities into a lower region below 1,830m (6,000 ft) characterized by a wide streambed and almost no vegetation, and an upper region that was more densely vegetated. Lower canyon bottom communities have changed dramatically since the 1970's (See Recent Vegetation Change, this report, pp.59-80). These areas are now choked with riparian vegetation including *Elaeagnus angustifolia* (Russian olive), introduced in 1964, *Tamarix ramosissima* (tamarisk), introduced in the 1930s (Brugge, 1976, p. 209 and p.64), *Populus deltoides* (plains cottonwood), *Salix* spp. (various willow species), and *Populus deltoides* ssp. *wislizenii*. The upper canyon bottoms are diverse including *Acer negundo* (box elder), *Betula occidentalis* (birch), *Alnus* spp. (alder), *Juniperus scopulorum* (Rocky Mountain juniper), *Quercus gambelii* (Gambel oak), and *Cornus sericea* (redosier dogwood).

Talus communities, the most diverse areas in the canyons, include *Acer negundo*, *Quercus gambelii*, *Philadelphus microphyllus* (mockorange), *Fendlera rupicola* (Fendlerbush), *Juniperus osteosperma* (Utah juniper), *Pinus edulis* (piñon pine) and *Pseudotsuga menziesii* (Douglas fir).

Harlan and Dennis include hanging gardens within their Springs, seeps and other wet places. Most hanging gardens are dominated by either *Adiantum capillus-veneris* (maidenhair fern), most prevalent in the lower canyons; or *Aquilegia micrantha* (columbine) and *Mimulus eastwoodiae* (monkeyflower), prevalent throughout. Several hanging gardens harbor rare plants including *Aletes macdougalii* (MacDougal's aletes), *Zigadenus vaginatus* (death camas, [Figure 11](#)) and *Carex specuicola* (Navajo sedge).

Piñon-juniper continuum covers the most area in Canyon de Chelly National Monument. Cover is sparse at lower elevations and increases with increasing elevation. The ratio of piñon to juniper also increases with increasing elevation.

Low shrub-grassland communities dominate the rims, the upper terraces and the slopes of the lower canyons. *Atriplex* spp. (saltbush), *Ephedra viridis* (Mormon tea), *Gutierrezia sarothrae* (snakeweed), *Opuntia* spp. (prickly pear and cholla cactus), and *Chrysothamnus* spp. (rabbitbrush) are common in this lower community.

Sagebrushland occupied about 9% of the land above 1,900m (6,200 ft) in the 1970s, but much of this community is being invaded by *Pinus edulis* and *Juniperus osteosperma* (pers. obs.)

Canyon rims, cliffs and ledges of the lower canyons support *Amelanchier utahensis* (Utah serviceberry), *Quercus turbinella* (scrub oak), *Pinus edulis*, *Juniperus osteosperma*, *Cercocarpus intricatus* (mountain mahogany), *Purshia stansburiana* (cliffrose), *Yucca angustissima* (narrowleaf yucca), and *Y. baccata* (banana yucca).

Harlan and Dennis (1985) concluded that their “. . . seven category system is inadequate in the upper parts of the canyon system, where Wet Places, Canyon Bottom, Talus and Rim form a continuum.” I agree.

Vegetation History

Wright *et al.* (1973) recovered pollen from sediment cores drilled into four lakes in the Chuska Mountains just east of Canyon de Chelly. Recovered pollen inferred a cool climate from 35,000 BP until post 13,500 BP, during the Wisconsinan glaciation. Wright *et al.* (1973) concluded that vegetation was elevationally depressed, *Artemisia* (sagebrush) was more prevalent, and that *Pinus flexilis* (limber pine), which doesn't grow in the Chuska Mountains today, was present during the Wisconsinan glaciation over 10,000 years ago.

Betancourt and Davis (1984) recovered plant macrofossils from two packrat middens in a rock shelter in lower Canyon del Muerto with dates of 11,900 $\pm$ 330yrs BP and 3120 $\pm$ 110 yrs. BP. They conclude that plant communities changed dramatically between these two periods of time. Fossils in the earlier midden included *Juniperus communis* (common juniper), *Juniperus scopulorum*, *Cornus sericea*, *Picea pungens* (blue spruce), *Pinus flexilis* (limber pine), *Pseudotsuga menziesii*, *Rubus strigosus* (red raspberry), and *Sambucus microbotrys* (red-berried elder), none of which grow close to the site now. *Pseudotsuga menziesii* is the only fossil species included in the later midden that doesn't grow near the site now. The two fossil assemblages share only three species (*Artemisia ludoviciana* (gray sagewort), *Pseudotsuga menziesii*, and *Thalictrum fendleri* (Fendler's meadowrue) out of a total of thirty-eight recorded, which suggests that there was major plant community change between these times. *Pinus ponderosa* (ponderosa pine) and *P. edulis* are conspicuously absent from the earlier midden, suggesting a late arrival for these two species.

Ambrose (1986) reported 16 plant species from the vegetal remains at Antelope House that he did not find growing in the area. Nine of these were found during this survey, leaving seven (*Abies lasiocarpa* (subalpine fir), *Phalaris arundinacea* (reed canarygrass), *Setaria*

leucopila (bristlegrass), *Sporobolus compositus* var. *compositus* (dropseed), *Rumex hymenosepalus* (canaigre), *Shepherdia rotundifolia* (buffaloberry), and *Symphyotrichum* (=Aster) *foliaceum* var. *foliaceum* (alpine leafy-bract aster) still not known from Canyon de Chelly. Of course, people in earlier times may have gathered these plants from outside Canyon de Chelly.

Simpson (1850; pp. 69, 83) traveled along the north rim of Canyon del Muerto and the south rim of Canyon de Chelly in September of 1849. On the north rim he reported, “. . . piñon, yellow pine, and cedar have been the *sylva* . . . of the latter occasionally being dead; the cause not obvious. The artemisia has been the chief *flora*. The cactus, which hitherto has been seen but seldom, to-day was more prevalent.” And while moving up the Defiance Plateau along the south rim, he reports “. . . scrub pine and a species of spruce, thickly interspersed, constituting the *sylva*.” Further up he reports, “. . . scrub oak and yellow pine of large growth have been the *sylva*. Cacti have been frequently seen.” If we presume that his “spruce” is the ‘cedar’ (*Juniperus osteosperma*) he mentions from the north rim, mid 1800s rim vegetation communities were similar to now.

Invasion of piñon and juniper woodland into shrub-steppe, grasslands, and riparian communities has been documented throughout the Southwest (Ernst and Pieper 1996, Miller and Wigand 1994). Anderson *et al* (2001) document “. . . an overall mean increase in tree cover. . .” in the San Francisco volcanic field from 1936 to 1997. Repeat photography shows piñon and juniper invasion at Canyon de Chelly as well.

Andrews (1985) reported two lines of evidence suggesting that the vegetation character of Canyon del Muerto during the last two centuries was different than today. In 1979, she noted four oak stumps, dated to the late 1700s, that had eroded out of the streambed at Antelope House.

Oaks grow on uplands, not in streambeds, which suggests that the shape of the land close to Antelope House was very different in the 1700s. Andrew's informants told her that their elders had told them stories of dense vegetation growing in Canyon del Muerto. One informant told her that Canyon del Muerto used to be "... so thick with vines and trees that travel in the canyon was ... impeded by dense vegetation."

Apparently, upland communities had reached their present composition 3,000 BP at Canyon de Chelly. This contrasts with the riparian vegetation history, which seems to have been rife with change right up to the present.

Many researchers have used repeat photography to document change in the Southwest (Hastings and Turner 1965; Turner and Karpiscak 1980, Rogers 1982; Rogers *et al* 1984, Humphrey 1987, Stephens and Shoemaker 1987, Salamun 1990, McGinnies *et al.* 1991, Gordon *et al* 1992, Webb 1996, Fielder and Marston 1999, Webb *et al.* 2001). The long history of photography at Canyon de Chelly begins with O'Sullivan's visits in 1873 and 1874/5 and Jack Hiller's visits in 1879 and 1882 (Jett, pers. comm.) Hagerty (1996) details the photographic and artistic history of Canyon de Chelly. Rydout (1985) described additional photographic history and annotated a list of 12,000 Canyon de Chelly photographs.

Past Botanical Studies

Early Work

J.F. Hammond, assistant surgeon on the 1849 Washington Expedition to the Canyon de Chelly area, collected plants (Simpson 1850, p.4-5) that may be in the U.S. National Herbarium (US). Both Farmer and Heggie, as part of the "Navajo project" in 1935, collected Canyon de Chelly specimens that are housed at the University of New Mexico Herbarium, Albuquerque (UNM). H. E. Bailey (Bailey no date, Bailey and Bailey 1941) working out of the Jepson

Herbarium (JEPS), University of California, was likely the first to enter Canyon de Chelly with plant documentation as his primary purpose when he worked on the Vegetation Type Map Survey of U.S. National Parks in 1936. Some of Bailey's collections are archived at the Canyon de Chelly herbarium (on loan to Deaver Herbarium (ASC), Northern Arizona University (NAU)). T. Cronyn, Canyon de Chelly National Monument Supervisor in the 1930s, collected plants in association with the Western Museum Laboratories (WML) in Berkeley, CA. H. Cutler, Goodman, and Payson, WML, collected plants in Canyon de Chelly in 1939. In the early 1960s, D. Demaree collected plants that are curated at ARIZ, ASC and UNM. Lindsay and Ranzoni, of Vassar College (VAS) collected plants in 1961, 1962, and 1969. In 1969, N. Hand and J. Rominger, of NAU, collected plants, now curated at ASC. In the early 1970s, R. Hevly, also of NAU, collected plants curated at the University of Arizona Herbarium (ARIZ) and ASC.

The Antelope House Project

The Antelope House Project in the early 1970s supported many studies related to Canyon de Chelly plant life. Richard Halse wrote a key to the plants of Canyon de Chelly and established a reference plant collection to help identify the plant remains recovered during the excavation of Antelope House. He collected Canyon de Chelly plants more extensively than anyone had previously, spending 60 days in the field. Though he walked all of the main canyons at least once, he concentrated most of his collecting close to Antelope House in lower Canyon del Muerto. Halse catalogued his and previous collections from Canyon de Chelly totaling 474 taxa (Halse 1973). Most of Halse's vouchers are curated at the University of Arizona herbarium, Tucson (ARIZ). Additional Halse specimens are curated at ASC.

Harlan and Dennis, NPS, (in Halse 1973) added 44 taxa resulting from their plant geography work at Canyon de Chelly. Their collections are curated at ARIZ. They defined

seven plant resource groups related to prehistoric human exploitation and mapped Canyon de Chelly using these resource groups. They didn't define the resource groups in a strict ecological sense as plant communities, but rather defined them as requiring distinctive methods of exploitation by prehistoric peoples (Dennis 1975, Harlan and Dennis, 1976, 1986). Their effort might serve as a starting point for future vegetation mapping. McDonald (1976, 1981) further analyzed these plant resource groups.

Ambrose (1986) analyzed the vegetal remains found during the excavation of Antelope House and made interpretations from these remains about past climates and vegetation communities. Magers (1975, 1986a, 1986b) analyzed wood, vegetal artifacts, and woven items from Antelope House and concluded that *Gossypium hirsutum* (cotton) was cultivated near there. Hall and Dennis (1986) analyzed cultivated and gathered plant foods recovered from Antelope House. Pollen was analyzed from floor sediment samples (Bryant and Weir 1986) and from human coprolites (Williams-Dean 1986, Williams-Dean and Bryant 1975). Fry and Hall (1986) analyzed plant remains (other than pollen) from human coprolites.

Burgess (1973) inventoried mammals and collected plants at Canyon de Chelly that ARIZ now curates. Schmutz *et al.* (1976) surveyed an isolated flat-topped butte within the canyon to document plant communities undisturbed by human activities. The Western Area Archeological Center (WAAC) at Tucson curates collections from this work. Betancourt and Davis (1983) analyzed plant fragments from packrat middens in lower Canyon del Muerto.

Later Work

Struever (1981) analyzed plant materials recovered during stabilization of Sliding Rock Ruin in Canyon de Chelly. Cook (1994) contrasted vegetation communities of Tsegi Overlook and Tunnel Canyon and listed plants for these areas. Cook (1993) also analyzed factors related

to fungi, and listed fungal species that may be found at Canyon de Chelly. Occasional plant collectors at Canyon de Chelly include V.O. Mayes (Mayes and Rominger 1994), D. Roth of the Navajo Nation Natural Heritage Program, and K. Heil of San Juan College, Farmington, New Mexico. ASC curates Mayes' collections. The Navajo Nation Herbarium (NAVA) in Window Rock curates Roth's collections. The San Juan College herbarium (SJNM) curates Heil's collections. The Canyon de Chelly vertical files include casual plant lists made by other researchers (H.E. Bailey no date, F.V. Ranzoni 1967, V. Trautman no date), the cook for the Canyon del Muerto Survey Project (Travis, personal records, 2001)). [Appendix 2](#) lists taxa on these casual plant lists that have not been vouchered for Canyon de Chelly. K. Heil and S. O'Kane (2003) cataloged the flora of the San Juan drainage.

Many Canyon de Chelly researchers have conducted either focused plant surveys or plant surveys adjunct to other work. Halse's (1973) work stands out for his attempt to document as many taxa as possible, while focusing much of his collecting time close to Antelope House. The project reported here was not so constrained and this made possible a more thorough inventory of the plant resources of Canyon de Chelly.

METHODS

Purposeful Sampling

I explored Canyon de Chelly purposefully, looking for rare, exotic, and new plant records. In order to maximize the number of species encountered I determined it was necessary to:

- Walk over as much terrain as possible.
- Concentrate on areas with suspected high plant diversity. These included
- riparian areas, and canyon slopes and walls.

- Focus on areas with unusual substrates, since these areas often harbor unusual plants. Unusual substrates at Canyon de Chelly include active sand dunes, shale, and limestone and salty areas.
- Concentrate on areas suspected to harbor rare or exotic plants. These areas included hanging gardens, and administrative and other disturbed sites.
- Concentrate on areas known to be less extensively sampled by previous botanists, including slopes, canyon walls, little-visited side canyons, the upper canyons, as well as moving and still waters.
- Explore for plants at times of the year most likely to have the highest diversity of plants in a condition conducive to successful identification.
- Explore during times of the year often under-collected (due to a perception of low plant diversity or lack of time).
- Concentrate on plant families and groups often under-collected (perhaps because their determination is problematical, they are difficult to process, or they are not considered important). These included: Boraginaceae, Cactaceae, Chenopodiaceae, Cyperaceae, Juncaceae, Poaceae, aquatic plants, and horticultural introductions.

I collected plant specimens in good condition for identifying when I was unsure of the plant's identity or I suspected the plant to be a new record. At each collection site, I noted general geomorphic location and, whenever possible, UTM coordinates in North American Datum 27 (NAD27). NAD27 is the most appropriate datum to use in the field because it is the datum used on USGS topographic maps. I also noted associated species, including all recognizable plants in the immediate vicinity, plants suspected of growing close to the edges of their range, and plants of particular interest (either because they were exotic or rare).

The primary assumption for inventory via purposeful collecting was that I would be energetic in carrying out the art of plant exploration in a thorough and effective manner and that I would have enough resources to carry out the inventory intensively enough to get a high level of completeness. Another assumption was that the years chosen for inventory were conducive to getting a high level of completeness.

Estimating Species Diversity

National Park Service researchers (Stuart et al. 2000) guessed that 60% of the plant species in Canyon de Chelly were known when the present survey was initiated. Of course, it is not possible to know that you have a certain percentage of something when you don't know what 100% is. Colorado Plateau Field Station (CPFS) personnel chose to attempt to assess this unknown using statistical probabilities and tabulating species present in computer-generated random plots. At Canyon de Chelly, random plots were assigned within stratified units based on vegetation communities grossly delineated by the GAP Analysis Program (Graham 1995). These were defined as riparian, desert scrub, agricultural, ponderosa pine, piñon-juniper and grassland communities. I visited these random plots twice, once during the spring, and once during the fall, timing my visits for the greatest plant diversity at those points.

The following parameters were used to determine the number of plots required per stratified unit to achieve robust calculations of diversity:

- 1) Number of species estimated to be within an inventoried unit (S),
- 2) Number of species expected to be detected in an individual plot (MS),
- 3) Area of the stratified unit.

The following formula for calculating S was derived from southwestern parks that (were presumed to) have 90% complete species lists:

$$S = 182.9 + 41.7(\text{natural log}[\text{Area(in hectares)} + 1]) * \text{elevation range in km}$$

The area of Canyon de Chelly is 33,929 ha and the elevation range is 0.65 km, which gives a result for S (estimated number of species present at Canyon de Chelly) of 467. This is at least 50 species less than the number known for Canyon de Chelly prior to this study. MS was initially estimated at 30 (based on hectare plots) from the results of field studies at Glen Canyon (J. Spence, pers. comm. to D. Mattson), other areas in the region, and from personal experience (K. Thomas, pers. comm. to D. Mattson).

The number of sample points (*nsp*) was then calculated from the following equation assuming square root decay in the detection of new species:

$$(nsp + 0.5)\underline{0.5} = (S * 0.858)/SM,$$

where SM is the species richness at the first plot in a sequence.

At Canyon de Chelly, it was calculated that 178 plots would be required to estimate S. I gathered data from 30 plots 0.1 hectare in size during the fall of 2001 to get a more accurate MS (estimated number of species per plot). These plots averaged 15 species each. By substituting this new MS (15) in the above equation, we found that I would have to visit 713 sample points to arrive at an estimate of S. Visiting 713 sample points during my remaining field time was not possible, thus I was instructed (D. Mattson, pers. comm.) to choose a number of sample points that I knew I would be able to visit twice in the time I had left. I chose to visit 77 plots.

I used the ICE model available online in the EstimateS software package at <http://viceroy.eeb.uconn.edu/estimates> (Lee and Chao 1994, Colwell 1997) to attempt to estimate species diversity in Canyon de Chelly. ICE models for rare plants by using only species detected in less than ten plots (Nichols *et al.* 1998, Hines *et al.* 1999).

Some of the assumptions inherent in attempting to model overall diversity this way include:

- 1) We can adequately identify and differentiate plants within plots. We need to be able to identify to genus those plants in monospecific genera. We need to be able to identify to species, plants within genera represented by more than one species in the inventory area.
- 2) We have a reasonably accurate estimate of how many species exist in each stratified unit (Hiebert *et al.* 2000).
- 3) We have stratified the vegetation communities well, and at a scale fine enough to detect unique areas of plant diversity.
- 4) We have assigned an appropriate number of plots/stratified unit based on their comparative diversity.

I should point out that in the present NPS inventory effort, researchers decided to experiment with trying to achieve plant inventory goals using methods intended to measure diversity (D. Mattson, pers. comm.) The data collected at Canyon de Chelly plots play an important role in assessing the usefulness of this approach (A. Cully, pers. comm.)

Documenting Vegetation Change

In order to document vegetation community changes, I used a 2-1/4 X 3-1/4 camera to match large format photographs taken by the early western photographers Jack Hillers of the Powell Survey, Timothy O'Sullivan of the Wheeler Survey (late 1800s); Ansel Adams, Edward Curtis and Laura Gilpin (early to mid 1900s); turn of the century archaeologists Ben Wittick and Cosmos Mindeleff; 1950s archaeologist, David DeHarport; and photographs taken by NPS photographers from the 1930s through the 1960s. I used a 35 mm SLR camera to match 35mm photographs taken during the last 50 years by modern landscape photographers.

I matched historic photos that were taken:

- 1) From high viewpoints, because most photo scenes taken at stream level are now obscured by modern riparian vegetation.
- 2) Of different canyon reaches because different canyon reaches often exhibit very different histories.
- 3) Of the same general view during different years so that the progression of change through time could be seen through the resulting sequence of photographs.

I used foreground and parallax (alignments between foreground and background landforms and skyline) to locate my camera as precisely as possible in the position from which the original photographs were taken. I expended considerable effort to locate the precise spot from which the original was taken in order to get the most information from these photo pairs. I tried to take the modern photographs at the season and time of day that the historic photographs were taken because a close match of shadows in photo pairs improves their use for comparison. I took several bracketed exposures of each view to ensure that I would get usable images.

I recorded location, date, time of day, UTM coordinates, azimuth, tilt, lens type, and camera type used at most photo stations so that others may be able to repeat the process more easily. At the time I took the modern photos, I recorded my best estimate of season and time of day of the original photo so that a better match may be made in the future. I recorded differences of cover change; species that had invaded; channel changes; individual plants that had grown, died, or were new; rockfall events; erosion or deposition events; and removal or addition of manmade structures.

RESULTS

Herbaria Searches

Herbaria searches revealed 45 new Canyon de Chelly plant records. I reviewed plant specimens at the University of Arizona (ARIZ), Northern Arizona University (ASC), San Juan College (SJNM), Museum of Northern Arizona (MNA), University of New Mexico (UNM), Western Area Archaeological Center, Tucson (WAAC), and the Canyon de Chelly herbaria. The ARIZ database (50% complete as of March, 2002) includes 497 Canyon de Chelly specimens. Prior to this work, the ASC database (10% complete as of March, 2003) included 28 Canyon de Chelly specimens. The SJC herbarium curates 76 Canyon de Chelly specimens. The MNA herbarium database (75% complete as of February, 2003) includes 22 specimens of Canyon de Chelly plants. The UNM herbarium database (60% complete as of February, 2003) includes five Canyon de Chelly specimens.

WAAC databases about 2500 plant specimens related to Canyon de Chelly, including several plant taxa from Canyon de Chelly not vouchered elsewhere. This collection was designed for identifying plant artifacts from archaeological work, so the plant specimens are dried, but not pressed, and are stored in plastic bags. Most of the specimens were not collected within the boundaries of Canyon de Chelly National Monument, but it is difficult/impossible to ferret specimen provenience out of the WAAC database.

The Canyon de Chelly herbarium curates more than 420 plant specimens, presently (2003) on loan to ASC. I checked the determinations of these specimens. Karen Wright (Bilby Research Center, NAU) annotated the collection to reflect new determinations as well as the latest names. The Canyon de Chelly herbarium and the Navajo Nation herbarium are the only herbaria that have their entire collections of Canyon de Chelly material represented in this flora.

Field Work

I spent 120 days within Canyon de Chelly from April, 2001 through September, 2003; 56 days during 2001, 58 days during 2002, and 5 days during 2003. I spent 68 days purposefully exploring for new plant records, 29 days collecting plant information at random plots, and 9 days matching historic photographs. I spent an additional 13 days at Canyon de Chelly doing administrative or research activities with only incidental plant collecting. I walked every major and secondary side canyon, covered much rim country, and traversed more than one hundred rim to canyon-bottom routes. I sought out and examined every accessible hanging garden. [Table 2](#) and [Figure 12](#) detail how and where my time was spent within Canyon de Chelly.

Plant Identification

I identified plant specimens using numerous manuals including: *Flora of New Mexico* (Martin and Hutchins 2001), *Flora of New Mexico* (Wootton and Standley 1915), *Intermountain Flora* (Cronquist *et al.* 1972 *et seq.*), *Flora of North America, Volumes 1, 2, 3, 22, 23, 26* (1993-2002), *Seed Plants of Northern Arizona* (McDougall 1973), *Arizona Flora* (Kearney and Peebles 1969), *Utah Flora* (Welsh *et al.* 1993), *Colorado Flora* (Weber and Wittman 1987). The identification of specific groups of plants was aided by *Manual of the Grasses of the United States* (Hitchcock 1935), *Grasses of the Southwestern United States* (Gould 1951), *Biosystematic Analysis of the Cirsium arizonicum complex of the Southwestern United States* (Barlow-Irick <http://www.largocanyon.org/science/dissertation/toc.htm>), *Atlas of North American Astragalus* (Barneby 1964) and *The Cruciferae of Continental North America* (Rollins 1993). The identification of cultivated plants was aided by the *Manual of Cultivated Plants* (Bailey 1924) and the *Manual of Cultivated Trees and Shrubs* (Rehder 1987). The reference collection at the Deaver Herbarium (ASC) was crucial.

Experts made determinations of some specimens. *Echinocereus* and *Opuntia* were determined by Marc Baker of Southwest Botanical Research in Chino Valley, Arizona. *Sclerocactus* were determined by Ken Heil of San Juan College (SJNM). *Carex* were determined by Miriam Colson Fritts, Tucson. Ferns were determined by Michael Windham, University of Utah (UT). Lichens were determined by Matt Bowker (Northern Arizona University) and Thomas Nash (ASU). Mosses were determined by John Spence (Glen Canyon NRA) and Lloyd Stark (UNLV). *Salicaceae* were determined by Robert Dorn, Rocky Mountain Herbarium (RM). *Zigadenus* were determined by Stanley Welsh, Brigham Young University (BRY). Tina Ayers, H. David Hammond, and Randy Scott of the Deaver Herbarium (ASC); Nancy Morin of the Flagstaff Arboretum; and Daniela Roth of the Navajo Nation Natural Heritage Program aided in determinations of other Canyon de Chelly plant specimens.

The latest common and scientific plant names; and native vs. exotic status came from the Integrated Taxonomic Information System (ITIS).

Calculating Inventory Completeness

I directed more than 25% of my inventory effort toward an attempt to statistically-calculate the level of inventory completeness. Colorado Plateau Field Station (CPFS) personnel designated 92 random plots within Canyon de Chelly where I compiled species lists and cover estimates. Of the 77 plots I intended to visit during 2002, 4 proved to be inaccessible and were eliminated, leaving 73 plots. Two of the 73 plots proved to be bald rock sites with no vegetation and were only visited during the spring. I visited the other 71 plots in both the spring and the fall of 2002, at a time of the season when I judged, based on seasonal rainfall events, that the most diverse set of plants was likely to be identifiable. At each sample plot, I listed the species I observed and cover estimates for each in a circular area of 100 m².

The 2002 winter was very dry, resulting in few detectable herbaceous plants during spring visits. Precipitation during the summer monsoon was nearly normal, but came late, so I postponed most of the fall visits until September.

One new plant record (*Muhlenbergia arsenei*) for Canyon de Chelly was found within random plots. Ten new plant records were found while traveling to and from random plots. I was able to identify 210 species within the plots.

Figure 13 graphs estimated diversity predicted by the ICE model as each plot was added, averaged over 50 random runs of the data. Because estimates of diversity don't level off toward the right side of the graph, it is clear that information from more random plots would be needed to use this model to theoretically estimate diversity present at Canyon de Chelly.

To gain additional perspective on level of completeness, I graphed taxa accumulation/collecting day (Figure 14) and taxa accumulation/ten plant collections made (Figure 15) for both Halse's and my efforts. Figure 14 shows sharp jumps in taxa accumulation during days spent in the upper canyons of Canyon de Chelly. Both of these figures flatten considerably toward the end of my work. This flattening could result from several factors; 1) my last days in Canyon de Chelly were spent matching historic photos, 2) my last days were during the late fall when fewer plant taxa are notable, and/or 3) there was less diversity to find as the study progressed. I think the flattening is mainly due to the first two factors rather than due to a significant decrease in potential for finding new records. My impression is that most plant taxa at Canyon de Chelly are rare, or at least hard to observe at any given time or place. Evidence supporting this interpretation includes my failure to find nearly 100 of the 571 previously recorded taxa and my observation that 105 of the 266 new records were found only once. Also, each visit in a new

season yields a high number of new records (i.e. my observation of seven new plant records from only 16 incidental collections made during a four-day visit to Canyon de Chelly in June, 2003).

Only 125 of the 805 taxa now known to occur within Canyon de Chelly are trees or shrubby species, easily detectable and identifiable all year long). This leaves 680 herbaceous perennials and annuals that spend much (or most) of their life cycle as undetectable root crowns or seeds. Detectability is a unique difficulty for inventory work in the desert Southwest where floras are dominated by annuals and herbaceous perennials. In other portions of the country, where floras are dominated by woody perennial taxa (pers. obs.), detectability is less of an issue.

Overall Results

I collected 1,335 vascular plant specimens, 15 moss specimens, and five lichen specimens. These vouchers are deposited at ASC, NAVA, UNM and SJNM. The database at www.nau.edu/~deaver/database.htm contains information related to these collections. I vouchered 269 new plant records for Canyon de Chelly National Monument, including four hybrids, nine varieties, eight subspecies, 248 species, in 67 genera, and 12 families. Purposeful collecting accounted for 258 of the 269 new plant taxa found at Canyon de Chelly.

New records were found in each family and group that I concentrated on, as follows: Boraginaceae (3), Cactaceae (4), Chenopodiaceae (7), Cyperaceae (18), Juncaceae (4), Poaceae (54), aquatics (7), horticultural introductions (18). Twenty-three new records were found during April and October, months when botanists don't often explore for plants. Eleven new records were found on unusual substrates, eight in sandy areas, and three in shaley areas. I found 14 new plant records in hanging gardens, 44 new plant records in disturbed areas, 68 new records in little visited side canyons, and 91 new records in riparian areas. I found 90 new plant records during only 12 days of collecting in the uppermost canyons, making these areas the most productive for

finding new taxa. Seven per cent of the new records were exotics, less than the total percentage (10.4) of exotics now known for Canyon de Chelly. [Figure 16](#) shows taxa accumulation from the 1930s through this project.

Summary Statistics

Eight hundred and eight plant taxa are now known for Canyon de Chelly, including 771 species, in 93 families and 379 genera, with eight subspecies, 14 varieties, and five hybrids ([Appendix 1](#)). [Table 3](#) gives a breakdown of these by Division and Class. [Appendix 2](#) lists botanical entities reported for Canyon de Chelly but not vouchered. [Appendix 3](#) lists additional botanical entities likely to be found at Canyon de Chelly National Monument.

Plants of Interest

I use the following species abundance scale developed by Palmer *et al.* (1985) throughout the flora: **5**, Dominant or codominant in one or more common habitats; **4**, Easily seen or found in one or more common habitats but not dominant in any common habitat; **3**, Widely scattered but not difficult to find; **2**, Difficult to find with few individuals or colonies but found in several locations; **1**, Very difficult to find and limited to one or very few locations or uncommon habitats; **0**, Not found but found in a previous survey from the same or similar sites or was otherwise suspected to occur.

Sensitive Plants

[Table 4](#) lists 29 sensitive plant species that have been found at Canyon de Chelly, the agency concerned about them, and their status with that agency. All plants in the cactus, lily, and orchid families have Salvage Protected Status in the State of Arizona and are not included in [Table 4](#). For the Heritage Data Management System, I included plants that have a global or state ranking of 3 or less. This survey discovered new locations for 21 of these taxa. Thirteen of

these were vouchered for the first time within Canyon de Chelly and are marked with an asterisk.

Six species of concern are found exclusively associated with hanging gardens (Table 5).

- *Aletes macdougalii* was occasionally found in the vicinity of hanging gardens and on other steep slopes from 1,700 to 2,150 m (5,600 ft-7,000 ft), but is most common at lower elevations.
- **Carex chihuahuensis* (Chihuahuan sedge) was found at only one site, a small hanging garden on the east wall of Cottonwood Canyon near its mouth. This is likely to be the northernmost record for this sedge, previously known from southeast Arizona and Mexico.
- **Carex meadii* (Mead sedge) was found at only one locality, a hanging garden on a south aspect slope above Coyote Creek in a remote part of the canyon in limey substrate. See note below with *Zigadenus vaginatus*.
- **Carex specuicola* was found at four hanging gardens all within Canyon del Muerto, ranging from 1,700 to 2,150 m, (5,600 ft- 6,800 ft) on west facing walls of the Peninsula. These collections record a range extension for this species, which was previously known only from the area surrounding Navajo Mountain and in the vicinity of Tec Nez Iah, Mexican Water and Rock Point (NNHP 1998).
- *Parnassia palustris* var. *parviflora* (smallflower grass of Parnassus) was found at only one locality, in Wheatfields Canyon about 2-1/2 km upstream of its confluence with Coyote Creek at a dry, north facing hanging garden. Richard Halse collected a specimen of *P. palustris* var. *parviflora* in upper Canyon del Muerto in 1971 or 1972.
- **Zigadenus vaginatus* was found in five hanging garden complexes, all in Canyon de Chelly or close to the Junction. These hanging gardens ranged in elevation from

1,700-2,000 m (5,600 ft to 6,600 ft) on south or west facing walls of the Peninsula between Canyon de Chelly and Canyon del Muerto. Four of the hanging gardens are downstream of Spider Rock and one of them is on a wall upstream of Coyote Creek in a remote part of upper Canyon de Chelly. The latter garden was anomalous for Canyon de Chelly due to its substrate of water-saturated limey soils and an unusual mix of associates including, *Dasiphora floribunda* (shrubby cinquefoil) and *Carex meadii* (the only known locations for these plants within Canyon de Chelly), as well as *Symphiotrichum laeve* var. *laeve* (smooth blue aster)(one of only two known locations for this plant within Canyon de Chelly).

- Thirteen sensitive species are found exclusively in riparian areas.
- *Allium goodingii* (Goodding's onion) was collected by Halse (1973) in upper Canyon del Muerto, with no reports since, despite several targeted search efforts.
- *Almutaster pauciflorus* (alkali marsh aster) was occasional; being collected at four localities within Canyon de Chelly from Blade Rock below the Junction to the heads of the canyons. It seems to be a fairly common aster within Canyon de Chelly riparian areas.
- **Astragalus chuskanus* (San Juan milkvetch) was found at two cattle-disturbed terrace sites in upper Canyon de Chelly at (1980m (6,500 ft) and above. One site was next to Whiskey Creek at 2150m (7,000 ft). The other was next to Coyote Creek about 1 km. downstream of its confluence with Wheatfields Creek. *Astragalus chuskanus* is endemic to the Chuska Mountains and Sonsela Buttes, which lie just east and upstream of my collection localities.

- **Beckmannia syzigache* (slough grass) was found at only one locality, in Wheatfields Canyon about 2 km. upstream from its confluence with Coyote Creek at 2,100 m (6,900 ft) in a mucky place in the creek.
- **Clematis hirsutissima* (hairy clematis) was found at only one locality, in Wheatfields Canyon about 4 km above its confluence with Coyote Creek.
- *Cystopteris utahensis* (Utah bladderfern) was infrequently found hanging on cliffs of De Chelly Sandstone above wet or dry pools usually at elevations above 2,100 m (6,900 ft) in sections of the canyons that are relatively undisturbed. Previously known in Canyon de Chelly only in Canyon del Muerto (Roth 2001), this survey revealed locations in Whiskey Creek, Whiskey Springs, and Monument Canyons, all areas with relatively little disturbance. One site was anomalous because of its high level of disturbance. It is in Canyon de Chelly at 1,770 m (5,800 ft) at the base of a large cliff of De Chelly Sandstone just above a large, disturbed field of weeds that receives heavy grazing.
- *Lupinus caudatus* ssp. *cutleri* (Cutler's spurred lupine) was frequent in the lower part of the upper canyons on upper terraces; not a rare plant in Canyon de Chelly.
- **Opuntia x viridiflora* (rattail cholla) was found at only one locality within Canyon de Chelly, along a fence line on the third terrace next to the road in front of Standing Cow Ruin in Canyon del Muerto. This individual is 1.5 m tall and robust. *Opuntia x viridiflora* is a brightly orange-flowered cholla cactus (contrasting sharply with the common yellow-flowered cholla, *O. whipplei*). Chollas bloom infrequently and this year (2002) was the first time that Sallie Tsosie noticed this plant even though she grew up at Standing Cow and guides in the canyons regularly. *Opuntia x viridiflora*

is endemic to the Rio Grande Valley in New Mexico. Another site where it may occur in Arizona is at an archaeological midden at Betatakin Ruin, Navajo National Monument. It occurs in a few other localities, always associated with humans, which suggests that it may have been imported prehistorically (D. Pinkava, pers. comm.) Modern humans plant *O. x viridiflora* for its colorful blossoms (NMRPTC 1999)

- *Oxyopolis fendleri* (Fendler's cowbane) was collected by Halse (1973) in upper Canyon del Muerto, with no reported sightings since then.
- **Penstemon lentus* (handsome penstemon) was found at only one locality, just upstream of Middle Trail Canyon in Canyon del Muerto at 1,900 m (6,200 ft).
- **Penstemon strictiformis* (Mancos penstemon) was found at only once, on a terrace in lower Bat Canyon.
- *Penstemon virgatus* (upright blue beardtongue) was found at two localities only, in close proximity, in the middle fork of upper Monument Canyon on terraces next to the wash at elevations of 2,160-2,230 m (7,100 ft to 7,300 ft). Halse (1973) found *P. virgatus* in upper Monument Canyon.
- *Phacelia alba* (white phacelia) was found at two localities only, at the head of Whiskey Creek in 2001 and at the head of Wheatfields Creek in 1971 (Halse 1973). *P. alba* is synonymous with *P. neomexicana* var. *alba*.

Eleven sensitive species are found in various habitats.

- **Besseyia arizonica* (Arizona coraldrops) was collected at two localities, one on the mesa above the junction of the two main tributaries to Monument Canyon, and the other in upper Wheatfields Canyon. *Besseyia arizonica* was also seen infrequently at

the heads of the branches of upper Monument Canyon on gentle ponderosa pine forested slopes.

- *Cirsium chellyense* (queen thistle) was occasional below the rims of Canyon de Chelly and frequent in hanging gardens. *Cirsium chellyense* is the most common *Cirsium* in Canyon de Chelly, though often confused with *C. calcareum* (Caineville thistle). I collected *C. chellyense* at four locations from 1,800 to 2,160 m (5,900 ft to 7,100 ft). It is not rare in Canyon de Chelly.
- *Cryptantha cinerea* (bownut cryptantha) was occasional in Canyon de Chelly and collected at five locations from upper terraces and slopes between 1,830 and 2,070 m (6,000 ft and 6,800 ft); not a rare plant in Canyon de Chelly.
- **Ericameria parryi* var. *howardii* (Parry's rabbitbrush) was found by me along the upper part of the White Sands Trail in rocky talus at 1,950 m (6,400 ft) and by Halse (1973) at Battle Cove Ruin.
- **Eriogonum corymbosum* (crispleaf buckwheat) is an abundant to frequent, shrubby buckwheat over much of the Navajo Reservation, but was found at only one locality at the Monument, along the south highway just 0.5 km east of the visitor center in desert scrub.
- *Nama retrorsum* (betatakin fiddleleaf) was collected in the active sand dune field 2 km south of the campground, but it was also infrequently found in sandy areas at lower elevations within Canyon de Chelly.
- **Pediomelum megalanthum* (Intermountain Indian breadroot) was found at only one locality, in a shaley area of desert scrub on the north rim near the mouth of Canyon de Chelly.

- *Penstemon strictus* (Rocky Mountain penstemon) was found at three localities, all at or above 2,130 m (7,000 ft) in the vicinity of Whiskey Creek and on the mesa one km. west of Tsaille Reservoir in *Artemisia tridentata* (big sage) community. T. Cronyn (ARIZ) found *P. strictus* on the south rim of Canyon de Chelly opposite Spider Rock in 1939.

Three sensitive species found by earlier workers were not found during this survey.

- Halse (1973) found *Allium gooddingii* in upper Canyon del Muerto. D. House of the Nature Conservancy and NPS personnel surveyed for *A. gooddingii* in 1985. Navajo Nation Natural Heritage Program botanists surveyed for *A. gooddingii*: B. Hevron, in 1993 (and 1985?), and D. Roth, in 1998 and 2002. I looked for it three times during 2001 and 2002, without success. Despite this intensive effort, no new records have been located. The Chuska Mountains to the east harbor the only two known populations of *A. gooddingii* close to Canyon de Chelly. Many populations grow in wet mountain meadows in the White Mountains of Arizona to the south and in the Gila National Forest of New Mexico (Hevron, 1995).
- Halse (1973) reported *Oreoxis alpina* (alpine oreoxis) in rocky areas in lower parts of the canyons. These records have been annotated to *Aletes macdougalii*. *Oreoxis alpina* is a high mountain meadow or alpine tundra species that grows on granitic soils in Utah and Colorado (Cronquist *et al* 1994; Heil 2001) and is very unlikely to be found in Canyon de Chelly.
- Halse (1973) found *Oxypolis fendleri* in upper Canyon del Muerto. *Oxypolis fendleri* ranges from Wyoming to eastern Arizona and New Mexico.

The following sensitive taxa grow nearby and may still be found in Canyon de Chelly with more searching effort. Most of the following information comes from the Heritage Data Management System (AGFD).

- *Aletes sessiliflorus* (sessileflower Indian parsley), similar to *A. macdougalii*, is known from ledges and crevices in piñon-juniper association 20 miles west of Cuba, New Mexico (Theobald *et al.* 1963).
- *Angelica pinnata* (Angel parsley) grows in wet meadows in the nearby Lukachukai Mountains.
- *Astragalus cottamii* (Cottam milkvetch) grows on sandstone substrates in the piñon-juniper zone in San Juan County, Utah.
- *Astragalus micromerius* (Chaco milkvetch) grows on “dry rocky or sandy areas” at 1,980-2,290 m (6500-7500 ft) in northwestern New Mexico (Martin and Hutchins 2001).
- *Astragalus naturitensis* (Naturita milkvetch) grows on “sandstone ledges and rimrock pavement, in piñon-juniper woodland” at 1,650-2,050 m (5,400-6,725 ft) in the Four Corners Region (Barneby 1989).
- *Astragalus oocalycis* (Arboles milkvetch) grows on “dry hills, plains, and valleys” at 1,670-2,140 m (5,500-7,000 ft) in northwestern New Mexico (Martin and Hutchins 2001).
- *Botrychium echo* (echo moonwort) grows on “grassy mountain slopes, snow fields, road ditches, and sand dunes” at 2,500-3,700m (8,200-12,100 ft) in the Four Corners Region (Flora of North America Editorial Committee 1993, vol.2, p.96).

- *Carex curatorum* (caretaker sedge) grows in hanging gardens in Grand Canyon and the White Mountains.
- *Clematis hirsutissima* var. *arizonica* (Arizona leatherflower) grows in ponderosa pine forests on rocky hillsides.
- *Eremocrinum albomarginatum* (Utah solitaire lily) grows in sandy soil in association with *Coleogyne ramosissima* (blackbrush) in Monument Valley and west of Carrizo.
- *Erigeron kachinensis* (Kachina daisy) grows in seeps and hanging gardens at 1,600-2,250m (5,250-7,400 ft) in southeastern Utah (Cronquist *et al.* 1994).
- *Erigeron rhizomatus* (Zuni fleabane) is associated with the Church Rock and Owl Rock Members of the Chinle Shale in ponderosa pine communities at >2,130 m (7,000 ft) on exposed slopes with little other vegetation in the Chuska Mountains.
- *Erigeron sivinski* (Sivinski's fleabane) grows on steep, barren slopes of the Chinle Shale at 1,860-2,250 m (6,100-7,380 ft) in desert scrub and piñon-juniper communities in the Chuska Mountains.
- *Eriogonum clavellatum* (Comb Wash buckwheat) grows on shales in southeastern Utah and southwestern Colorado (Welsh *et al.* 1993).
- *Grindelia laciniata* (cut-leaf gumweed) grows in dry, open places in southeastern Utah and reputedly as far south as Yavapai County, Arizona (Cronquist *et al.* 1994).
- *Helianthus anomalus* (Hopi sunflower) grows on sandy soil in northern Arizona and southeastern Utah.
- *Hippuris vulgaris* (mare's tail) is an aquatic that grows in still waters at >2,130 m (7,000 ft) in the Lukachukai and the White Mountains.

- *Isoetes bolanderi* (Bolander's quillwort) is an aquatic that grows at >1,500 m (5,000 ft) in the Lukachukai mountains and along the Mogollon Escarpment.
- *Lesquerella navajoensis* grows on the Toldito Limestone in the Chuska Mountains.
- *Lomatium latilobum* (Canyonlands biscuitroot), similar to *Aletes macdougalii*, grows in crevices of sandstone cliffs at 1,400-2,200 m (4,600-7,200 ft) in southeast Utah (Cronquist *et al.* 1972).
- *Ostrya knowltoni* (Knowlton hop hornbean) grows in canyons, on rocky slopes, and in hanging gardens at 1,520-2,150 m (5,000-7,000 ft) in the region surrounding Canyon de Chelly.
- *Penstemon breviculus* (shortstem beardtongue) grows in "sandy, gravelly, or clay soils on open sagebrush hillsides and piñon-juniper woodlands" at 1,600-2,000 m (5,250-6,560 ft) in the Four Corners region (Cronquist *et al.* 1972).
- *Perityle specuicola* (alcove rock daisy) grows along the Colorado River in southeastern Utah (Cronquist *et al.* 1994).
- *Phlox cluteana* (Navajo phlox) grows on conifer forest floors at over 1,800 m (60,00 ft) in the Lukachukai Mountains, Navajo Mountain, and southern Utah.
- *Physocarpus monogynus* (Mountain ninebark) grows at >1,900 m (6,300 ft) in moist, rocky areas in canyons in the Carrizo and Chuska Mountains.
- *Platanthera zothecina* (alcove bog-orchid) grows in hanging gardens in the Navajo Mountain/Tsegi Canyon area.
- *Puccinellia parishii* (Parish's alkali grass) is a widespread but uncommon annual that grows in wet places on salty or alkaline soil from the desert up into the piñon-juniper community.

- *Sclerocactus parviflorus* (Glen Canyon cactus) grows in sandy soils in the region surrounding Canyon de Chelly.
- *Sophora stenophylla* (narrowleaf mescal bean) grows in dunes in the region surrounding Canyon de Chelly.
- *Trifolium neurophyllum* (White Mountains clover) grows along wet meadows, springs, and along streams above 6500' in the White and Mogollon Mountains of Arizona and New Mexico.
- *Zigadenus virescens* (green death camas) grows on moist, shady slopes in canyons above 1,980 m (6,500 ft) in the White and San Francisco Mountains.

Sensitive plants known from more distant localities and more dissimilar habitats may be found at Canyon de Chelly, but the ones listed above are among the most likely to be found.

Invasive Plants

Table 6 lists 40 invasive plants found at Canyon de Chelly that are being tracked by various agencies (Backer 2003). Many exotic and native plants invade newly disturbed areas as a natural strategy. Thirty of the 41 invasive plants being tracked are exotics and eleven are native plants. These plants are listed below with notes on their occurrence within Canyon de Chelly as I found them during 2001/02. The five species with an asterisk are new records for Canyon de Chelly that may have invaded recently. *Sisymbrium altissimum* (tumble mustard) is an exotic invasive that was found for the first time during this survey, but is not being tracked by an agency. *Echinochloa crus-galli* (barnyard grass), *Erysimum repandum* (repand wallflower), and *Sonchus asper* (prickly sowthistle) were reported by Halse (1973), but not found within Canyon de Chelly during this survey. *Solanum rostratum* (buffalobur), probably an invasive from the Great Plains (Parker 1958), is not on an agency list, but is notable because it is often

confused with *Centaurea solstitialis* (yellow star thistle), which hasn't been found at Canyon de Chelly. *Solanum rostratum* is frequent along paved roads and occasional in heavily grazed or agricultural areas. For now, it doesn't seem to be invading beyond these places.

Eighty-five of the 805 taxa known for Canyon de Chelly are exotic, representing 10.5% of the flora. This figure is the median among other areas of the Colorado Plateau (Table 7). The common presumption of Canyon de Chelly as a weedy place may be true in terms of percent cover, but is not accurate when considered as a percentage of the flora. Only seven percent of the new records for Canyon de Chelly are exotic.

Floristic Relationships

Some Canyon de Chelly plants demonstrate a floristic relationship with the flora of the Rocky Mountains. **Cardamine cordifolia* (heartleaf bittercress), found at only one locality (Wheatfields Canyon), is a Rocky Mountain and Great Basin species that is found sporadically south into Arizona in the White Mountains, along the Mogollon Rim, and on the San Francisco Peaks (McDougall 1973, Rollins 1993). **Dasiphora floribunda*, found at only one locality (see note with *Zigadenus vaginatus* above), is a widespread northern species, normally found in more mountainous environments. **Hedysarum boreale* (northern sweetvetch), infrequent in side canyons of the upper canyons, ranges from southern Canada and to northern Arizona. **Polemonium foliosissimum* var. *foliosissimum* (towering jacob's ladder), found at only one locality (along upper Wheatfields Creek), ranges from the southern Rocky Mountains to the Colorado Plateau.

Some species demonstrate a floristic relationship with southeastern Arizona. *Brickellia brachyphylla* (Brach brickellbush), occasional on slopes throughout the canyons, ranges from eastern Arizona to Texas. **Carex chihuahuense*, found at one hanging garden within Canyon de

Chelly, is normally found in southeastern Arizona and northern Mexico. This record represents a significant range extension for this plant. **Draba petrophila* var. *petrophila* (Santa Rita Mountain draba), found at only one locality (on a steep, north slope along a horse trail in upper Canyon de Chelly), is endemic to mountain ranges in southeastern Arizona (Rollins 1993). This record represents a significant range extension for this plant. *Geranium lentum* (Mogollon geranium), occasional on upper terraces of the upper canyons, ranges from eastern Arizona to western Texas.

Some species demonstrate a floristic relationship with southern Utah. **Carex specuicola* and **Zigadenus vaginatus*, found in hanging gardens within Canyon de Chelly, are at the southern limit of their known range here.

Other species are endemic to Canyon de Chelly, or Canyon de Chelly and the immediately surrounding area. **Astragalus chuskanus*, endemic to the Chuska Mountains and the Sonsela Buttes, is now known also to grow within the boundaries of Canyon de Chelly. *Cirsium chellyense*, the most common thistle found within, and immediately around Canyon de Chelly, is not found elsewhere. **Mertensia oblongifolia* (oblong bluebells), infrequent in the uppermost canyons and north facing slopes of Canyon de Chelly, is a widespread and variable bluebell (Warfa 1998). The unusual white-flowered variety of *M. oblongifolia* is endemic to the Chuska Mountains area. “The striking thing about the early-flowering bluebells of the Chuska Mountains is that they are consistently white.” (R. Sivinski, pers. comm.)

Humans probably introduced some species prehistorically. *Juglans major* (black walnut), occasional to infrequent in the lower canyons and rare over the rest of the Navajo Reservation, is an occasional riparian native tree along the Mogollon Rim in central Arizona. It was probably imported for its edible nuts. *Nolina microcarpa* (beargrass), found at only one locality, at the

base of Face Rock, is occasional 100 miles to the south, west, and east of Canyon de Chelly.

Traditional Hopi people were aware of and probably imported *Nolina* for making fibrous articles (Whiting 1939). Southern Arizona native people wove sleeping mats and baskets of *Nolina* (Rea 1997). Other Southwestern groups made use of *Nolina* for weaving (Bell and Castetter 1941).

**Proboscidea parviflora* (devil's claw), found in several disturbed areas of the lower canyons, is more common in southern Arizona, but has been found at scattered localities throughout northern Arizona. The abundant population on terraces upstream of Tse Taa Ruins in Canyon de Chelly was in full bloom and fruiting in late September 2002. Hopi people used devil's claw for ceremonial purposes (Whiting 1939). Pima people cultivate devil's claw to weave with the black fibers from the fruits, to use it medicinally, to eat the seeds, and for children to make toys of the fruits (Rea 1997). **Opuntia x viridiflora*, found at Standing Cow, was probably introduced for its unique and beautiful flowers.

The floras of the two main canyon systems (Canyon de Chelly and Canyon del Muerto, [Figure 4](#)) are generally similar; however, I have identified 80 taxa that within Canyon de Chelly have only been found in Canyon de Chelly and its tributaries, and are not found in Canyon del Muerto. An additional 60 taxa have only been found in the Canyon del Muerto system. No doubt, with more intensive collecting, some of these taxa would be found in canyons other than where they have been collected so far. But many of them stand out as notable taxa that likely are endemic within Canyon de Chelly to one canyon or the other. Of those apparently limited to the Canyon de Chelly system, the following are the most notable: *Woodsia neomexicana* (New Mexico cliff fern), *Aralia racemosa* (American spikenard), *Ratibida columnifera* (prairie coneflower), *Senecio wootonii* (Wooton's ragwort), *Astragalus chuskanus*, *Menodora scabra* (rough menodora), *Parnassia palustris* var. *parviflora*, *Besseyia arizonica*, *Penstemon virgatus*,

Echeandia flavescens (Torrey's crag lily), and *Sorghastrum nutans* (Indiangrass). *Mertensia oblongifolia* would be on this list except for its occurrence in Black Rock Canyon, a southern tributary to Canyon del Muerto. *Zigadenus vaginatus* would also be on this list except for its occurrence about one mile upstream of Canyon de Chelly in Canyon del Muerto. Of those apparently limited to the Canyon del Muerto system, the following are most notable: *Picea pungens*, *Chamaechaenactis scaposa* (fullstem), *Ranunculus longirostris* (longbeak buttercup), *R. macounii* (Macoun's buttercup), *Carex specuicola*, *Allium bisceptrum* var. *palmeri* (aspen onion), *A. goodingii*, and *Torreyochloa pallida* (pale false mannagrass). I cannot account for these differences.

Hanging gardens are unusual habitats and odd plants often show up in them. *Dasiphora floribunda* and *Campanula parryi* (harebell) normally grow in high mountain meadows. *Campanula parryi* occurs in meadows over 7,000' at Canyon de Chelly. I was surprised to find both of these plants in high elevation >1,980 m (6,500 ft) hanging gardens at Canyon de Chelly.

Recent Vegetation Change

From May 2001 through October 2002, I photographed 79 scenes in Canyon de Chelly that were originally photographed in the 1870s through the 1990s. [Table 8](#) contains brief notes on these photos. [Figure 17](#) shows the locations of the photo matches that appear as [Figures 18 through 29](#) in this report. Eighteen of the historic vantage points were impossible to precisely replicate due to erosion and vegetation invasion, 13 due to riparian vegetation invasion and five due to piñon-juniper invasion.

Native cottonwood and willow, and exotic tamarisk and Russian olive have invaded riparian areas in all 68 photo matches that show riparian areas. Historical photographs taken of the lower canyons of Canyon de Chelly at the turn of the 19th century show canyon bottoms

filled nearly from wall to wall with braided depositional streambeds. No deep channels and little to no streamside vegetation existed. Today, many areas are deeply eroded with one to four terraces exposed. Many of the terrace surfaces and newly exposed areas are now covered with riparian forests of both native and exotic vegetation. The latest cycle of erosion at Canyon de Chelly could correlate with a major erosion event that began in the late 1800s throughout the Southwest. There is still no consensus on the cause(s) of this erosional event even though this has been the most studied geomorphology issue in the Southwest. Researchers variously blame climate change, grazing, and changes in the fire regime for the erosion that progressed rapidly during the late 1800s and early 1900s (Hereford 1986). Alternatively, the erosion at Canyon de Chelly could be a direct result of the erosion and flood control efforts of the NPS and Soil Conservation Service during the 1930s through the 1960s when they planted thousands of trees (both indigenous and exotic) and built many engineered erosion control features within the canyons. These efforts were designed to reduce flood damage to Navajo fields and archaeological resources (ruins). Riparian vegetation invasion is more extensive in Canyon de Chelly than in Canyon del Muerto, perhaps due to more tree planting and erosion control efforts conducted in Canyon de Chelly. Another consideration is the construction of twenty m tall Tsale Dam at the head of Canyon del Muerto in 1963 (Brugge and Wilson 1976). Tsale Dam moderates stream flow and thereby influences vegetation within Canyon de Chelly National Monument. Matched photos show a timing concurrence of tree planting and construction of erosion control features with vegetation and stream channel morphology change. The O'Sullivan photo match (25a and 25b) in Monument Canyon points toward the involvement of other, unknown, factors. Robert Webb (USGS pers. comm.) has found increased riparian vegetation in many Southwestern streams, where neither tree planting nor damming were factors.

Piñon-juniper woodlands have invaded terraces and uplands in 39 of 43 photo matches of piñon-juniper woodland. The remaining four photo matches of piñon-juniper woodlands show that piñon-juniper cover has increased due to growth of individuals, with no evident recruitment. Thus, all 43 matched photographs of piñon-juniper woodland show an increase in cover for these trees in the modern photos. This result concurs with the results of similar studies in the Southwest (Fielder and Marston 1999). Researchers have suggested various theories (fire control, cattle grazing) for this historical increase in piñon-juniper cover, but have not reached a consensus yet (Anderson *et al.* 2001, Cole *et al.* 1997, Ernst and Pieper 1996, Miller and Wigand 1994, Soulé and Knapp 1999, Yorks *et al.* 1994).

Recent photo pairs show that vegetation invasion and channel change are on-going processes, at least into the 1990s. Vegetation invasion and channel change will continue into the foreseeable future.

Disturbance History

Natural Disturbance

Climate change and changes in fire regime could be important disturbance elements at Canyon de Chelly National Monument, but little is known about their effects. Beaver live in both canyons. A sizable beaver dam was constructed near the confluence of Coyote and Wheatfields Creeks between April and June of 2001 ([Figure 30](#)). Beaver are often active in the vicinity of Twin Trails in Canyon del Muerto. Beaver dams create unique habitats for plants. No Canyon de Chelly sensitive species were found in these habitats.

The canyons also support a healthy population of bears. Bears disturb vegetation in their search for food. They also disperse the exotic tree, Russian olive, as evidenced by Russian olive

pits dominating bear scat during much of the year. Horses also eat and disperse Russian olive pits (pers. obs.)

Heavy rains during the summer monsoon period often flood the canyons. These floods knock out beaver and human dams, and disturb streamside habitats important to plant species (including the sensitive *Almutaster pauciflorus*) that thrive in these frequently disturbed places.

Rockfalls disturb vegetation on steep areas of Canyon de Chelly. These rockfalls contribute to disturbed habitat important for plant species (such as *Thelypodium wrightii* (Wright's thelypody)) that thrive in these places.

Human Disturbance

Prehistoric

Canyon de Chelly has a long history of human disturbance. Corn and *Cleome* (Rocky Mountain bee plant) pollen found in a 3,120 B.P. packrat midden near the junction of Canyon del Muerto and Canyon de Chelly suggests an early arrival of agricultural practices in the canyons (Betancourt and Davis 1984), along with its concomitant disturbance to natural plant communities. Humans likely used and/or occupied the Canyon de Chelly area prior to these first suggestions of early agricultural use. Such uses and disturbances included gathering, and perhaps, propagation of wild plants (including introduction of exotics), hunting, wood gathering for both fuel and construction purposes. Human disturbance has been nearly continuous for the last 1,500 years, with Diné use likely beginning during the late 1700s (Grant 1978, p81). Magers (1976) documented Diné prehistory at Canyon de Chelly. Andrews (1985) addressed historic Diné use of Canyon de Chelly.

Historic

Agriculture, grazing, tree planting, erosion control features, motor vehicle travel, and tourism have severely impacted canyon bottoms in the lower canyons. These impacts are less severe to nonexistent in the upper canyons. Human settlement, logging, grazing, fuel wood gathering, and a small amount of agriculture have disturbed rim areas.

The Resources Committee of the Navajo Tribal Council created Resolution RCS-51-85 which delineated a protection zone within the confines of Canyon de Chelly National Monument and in a buffer zone along the south and north main roads at a distance of 600 m (1,000 ft) away from the canyon rim extending from the west entrance to the park to the Diné College turnoff on the north rim and the Spider Rock turnoff on the south rim (Resources Committee 1985).

Within this protection zone, Resolution RCS-51-85 prohibits adverse impacts from the following activities: development of house trailers; two story houses; hogans, corrals, or other traditional structures, fences; roads; trails; chaining; wood cutting in highly sensitive areas; or timbering.

None-the-less, many of these types of development and resource use continue within the Monument (pers. obs.).

Local Population

Small, but rapidly growing communities surround Canyon de Chelly (Goodman 1982). The town of Chinle spreads around the mouth of Canyon de Chelly with a population of over 5000 (U.S. Census Bureau 1996). Approximately 34,000 people use Chinle as their trading center (ADOC, 2001), which gives some idea of the population in the surrounding area. More than 1600 people live in or near smaller centers of population surrounding Canyon de Chelly including Del Muerto on the north rim of Canyon del Muerto, Tsaile (home of Diné College) at the northeastern border of Canyon de Chelly National Monument, Lower Wheatfields at the

eastern border, and White Clay in the area between Canyon de Chelly and Monument Canyon (DinehCoops@aol.com 2003). Many dispersed residential areas border on, and exist within, the boundaries of Canyon de Chelly National Monument (pers. obs.)

Westmacott (1992, 2:14) found that few people were “year-round residents in the canyon.” During my field seasons (2001-03) Diné typically used the canyon during the growing season for one to three day stays, primarily during weekends. The leaseholder at Antelope House maintained a nearly continuous presence there during the tourist season, and one or two old-timers (Frank Draper and Chee B. Teller) may have spent much of their time at canyon bottom farms during the summer (pers. obs.)

Agriculture

Simpson (1850, p. 73-75) reported “a belt of probably half a mile in breadth being planted in corn” in the Chinle Valley at the mouth of the canyons in 1849. He also reported corn, melons, pumpkins and squash growing in Cottonwood Canyon and several peach orchards in the first nine miles of Canyon de Chelly. Walker and Shepard (1964, as cited in Andrews 1985:138) reported abundant corn and occasional wheat fields in 1859. In 1864, Captain Thompson’s troops cut down 3200 mature peach trees in the canyons in the following areas: Monument Canyon, 200 trees; Canyon de Chelly, near Sliding Rock Ruin, 350 trees; Canyon de Chelly, near White House Trail, 1450 trees; Canyon de Chelly, below Blade Rock, 500 trees; Canyon del Muerto, middle reaches, 700 trees. The troops also destroyed 11 acres of corn and beans (Jett, 1974).

Hill (1938) reports that Navajos began growing pumpkins and potatoes after their return from Fort Sumner in 1868. Alfalfa began to be grown in the 1900s (Andrews 1985: 145). Hill

reported the following crops in the early 1900s: corn, 2 kinds of melon, muskmelon, two kinds of squash, and five kinds of beans.

Andrews (1985:167-173) reported that corn, squash, pumpkins, melons, watermelons, peaches, apples, pears, plums, apricots, tomatoes, and other vegetables were grown in the canyons during the 1970s and 1980s. In addition to canyon farms, some leaseholders continue to dry farm on the mesas surrounding Canyon de Chelly National Monument. The amount of area farmed has fluctuated over the last two thousand years, declining during the last few decades (Andrews 1985).

Hydrologic Projects

Tsaile Reservoir, built at the head of Canyon del Muerto in 1963, submerges portions of the National Monument and alters the flow regime of Tsaile Creek (Brugge and Wilson 1976). The diversion for Wheatfields Lake alters the flow regime of Wheatfields Creek above Canyon de Chelly. Dams and diversions reduce the annual downstream water yield, reduce hydrograph peaks and sometimes allow low flows to last longer.

Ditch agriculture dates at least from the mid 1800s (Jett and Spencer 1981, Hill 1938), and continues to be used in the lower canyons. Floods destroy the diversion dams almost yearly. All were in poor shape during my field seasons. Numerous small-scale concrete and rock dams and diversions that seem to have no function have been installed in some of the side canyons (Figure 31). They were probably built to control headward erosion, but may have diverted water for agriculture. Modern farmers have built shallow ditches at the base of many of the cliffs in the lower canyons, which serve to catch water for agriculture. Locals have augmented many small rock pools with small hand-built dams on the bald rock mesas surrounding the canyons (pers. obs.)

Grazing

Grazing arrived at Canyon de Chelly with the first Diné. Simpson (1850, p.70) reported “innumerable signs of stock, principally of sheep, have been seen” along his route on the north rim of Canyon del Muerto. He went on to report that Navajo stock consisted of “mainly sheep and horses; mules and cattle forming but an inconsiderable portion...haven’t seen a drove of mules or cattle” (Simpson 1850; p.79).

The lower canyons are most impacted by unconfined grazing, which is common throughout Canyon de Chelly National Monument. Two short canyon reaches show no indications of being grazed. One is in Black Rock Canyon, from the waterfall downstream 1.5 km to a section of canyon bottom jumbled with large boulders. The other is in the upper west arm of Monument Canyon below the waterfall for a short distance, where dense vegetation likely discourages upstream travel. Many rim areas with healthy cryptobiotic crusts are available for grazing, but are not grazed perhaps due to a lack of grasses (pers. obs.)

Sheep and goats still graze many areas of the National Monument ([Figure 32](#)), though Westmacott (1992) and Travis (no date) report a shift away from raising sheep to raising cattle. This shift will result in reduced vegetation impacts on steep slopes because sheep and goats are better climbers than horses and cattle.

Wood Gathering

Locals gather wood for both construction and fuel on canyon rims where the growth of *Pinus edulis* and *Juniperus osteosperma* is most dense. Unplanned roads, clearly marked with discarded plastic oil bottles and pop cans, criss-cross many square miles within Canyon de Chelly National Monument. These roads are caused by fuel wood gathering, as evidenced by cut stumps and brush ([Figure 33](#)). Rim areas upstream of Middle Trail Canyon on the Canyon del

Muerto side and within a few km of Spider Rock above Canyon de Chelly and Monument Canyon are most impacted.

Logging

Ponderosa pine timber was harvested within Canyon de Chelly National Monument in 1959, 1960, in the early 1970s, and perhaps in the late 1990s (Canyon de Chelly National Monument resource files). During the 1970s timber was harvested on the rims above Monument Canyon upstream of where Monument Canyon splits into many smaller canyons as well as adjacent to Coyote Creek west of the Sonsela Buttes (Figure 34 & 35). In the late 1990s, timber was harvested on the north rim of Canyon de Chelly north of its confluence with Wheatfields Canyon downstream to the area just east of Black Rock. Harvests seem likely to occur in the future.

Chaining

Chaining (the 'improvement' of rangeland for grazing animals via the massive destruction of piñon-juniper woodland usually by dragging a heavy chain between two large, tracked vehicles) is a management tool that has been employed at Canyon de Chelly National Monument. By 1981 thousands of acres of east of Middle Trail Canyon on both rims of Canyon del Muerto, between Twin Trails and Pine Tree Canyon on the north rim of Canyon del Muerto, between Bat and Monument Canyon, and between Monument Canyon and Canyon de Chelly had been chained (Figures 36-40).

Tree Planting and Jetty Construction

Locals have grown fruit in orchards within Canyon de Chelly National Monument since the early 1700s (Jett 1974, 1977, 1979). Indigenous people probably introduced *Juglans major* (Arizona black walnut) (Jett, pers. comm.) and it is somewhat naturalized now. Diné probably

introduced pecan trees in historic time. Since 1985, Trees for Mother Earth (now known as Diné Trees of Life) has planted thousands of apple, peach, pear, cherry, and apricot trees within the canyons (J. Mishke, W. Clark, pers. comm. 2002). See Jett (1979, p.307) for a map of orchards in the Canyon de Chelly system.

From the 1930s to the present, thousands of riparian trees, including native willow (*Salix* spp.) and cottonwood (*Populus* spp.), as well as exotic *Tamarix* spp. and Russian olive (*Elaeagnus angustifolia*), were, and continue to be planted in the canyon bottoms to reduce erosion at archeological sites and to alter channel geomorphology to increase the size of arable areas. [Table 9](#) gives a general impression of the scale of tree planting, other plantings, and erosion control work conducted during the 1940s to the 1960s (Brugge and Wilson 1976). In addition, Andrews (1985) reported that Australian tamarisks were planted in 1936; 10,000 willow and *Phragmites* (common reed) were planted in 1946; and 16,300 Russian olives, golden leaf willows, and cottonwood seedlings were planted in 1963.

Tree plantings and erosion control efforts have severely altered the hydrologic and geomorphic regime of the canyon bottoms and resulted in a rapid transformation of the riparian community that continues to this day. These impacts include:

- 1) Reduction of visibility, primarily from the canyon bottoms, but also from the rim.
(Riparian trees that blocked the view of White House Ruin from White House Overlook were removed by the Park Service).
- 2) Reduction of water availability for farmers, due to both lowered water table and transpiration from the new riparian vegetation ([Figure 18](#)).
- 3) Shading and stabilization of the canyon bottoms, which may allow other exotics (plants, artropods, and birds) to become established.

See previous section for additional discussion of these changes.

Refuse Dumping

People occasionally dump refuse into the canyons as a convenient landfill (Figure 41).

Tourism

Canyon de Chelly is the third most visited park in the region, after Grand Canyon National Park and Glen Canyon National Recreation Area (Etsitty 1994). Table 10 lists visitation rates and activities for the years 2001 and 2002 (Canyon de Chelly National Monument monthly use reports.). Tourism severely impacts park administrative areas, including the campground, so that these areas support the densest stands of exotic herbaceous plants in the Monument. Within the canyons, the areas surrounding White House Ruin, Antelope House Ruin, and Mummy Cave Ruin (the three most-visited tourist sites) are most severely trampled and compacted. The roads to these sites exhibit high levels of disturbance and exotic plants. Tourists sometimes camp on resident lands, where their impact is slight since these areas have a long history of severe impacts from agriculture, grazing, and other uses (pers. obs.).

RESOURCES, IMPACTS, and MANAGEMENT CONSIDERATIONS

Sensitive Plants

Nineteen of the 28 sensitive plant species at Canyon de Chelly National Monument are only found in either riparian or hanging garden habitats. Of the 19, six (*Aletes macdougallii*, *Carex chihuahuensis*, *C. meadii*, *C. specuicola*, *Zigadenus vaginatus*, and *Parnassia*) are found exclusively in hanging gardens and 13 (*Allium gooddingii*, *Almutaster pauciflorus*, *Astragalus chuskanus*, *Beckmannia syzigache*, *Clematis hirsutissima*, *Cystopteris utahensis*, *Lupinus caudatus* ssp. *cutleri*, *Opuntia* x *viridiflora*, *Oxypolis fendleri*, *Penstemon lentus*, *P. strictiformis*, *P. virgatus*, and *Phacelia neomexicana*) are found exclusively in riparian habitats. This makes

hanging gardens (Table 5) and riparian areas the most critical habitats for Canyon de Chelly sensitive plants. The 13 riparian sensitive species are found almost exclusively in the upper canyons, where grazing impacts are less than in the lower canyons. Grazing does not impact hanging gardens much. The greatest threat to hanging gardens is from well drilling and water development on the Peninsula and other areas adjacent to, and upstream of the Monument.

Of the nine species not associated with water, *Besseyia arizonica*, *Chrysothamnus parryi* ssp. *howardii* and *Nama retrorsum* are the only three that may be rare. *Besseyia arizonica* has a dispersed distribution in ponderosa pine forest, and should be looked for, and mitigated for, prior to large forest disturbances such as logging. *Chrysothamnus parryi* ssp. *howardii* has a widespread distribution in the Rocky Mountain West but is likely rare in northern Arizona. *Nama retrorsum* grows in disturbed, sandy habitats. We should note where these last two potentially sensitive species grow, and look for them, and mitigate for them prior to development in the areas where they may be found.

Invasive Plants

Many agencies are in the process of developing plans to assess and eliminate invasive plants. As these plans get up and running, better information related to the noxiousness, invasiveness, ecosystem impacts, and methods for eliminating invasive plants will become available.

The following exotics presently have a limited range within Canyon de Chelly National Monument, but may be in the process of expanding, and should be early targets for eradication. *Acroptilon repens* (Russian knapweed) is common along roads and in administrative areas, but in time may invade more pristine areas of the Monument as well. *Carduus nutans* (musk thistle), a native of southern Europe and western Asia, ". . . was introduced to the U.S. in the early part of

the century." (Whitson 1992). It is a tall spiny thistle that forms dense stands and may be in the beginning stages of a significant invasion. *Chloris virgata* (feather windmill grass), a weed from South America, was only found in the campground and may be a recent arrival at Canyon de Chelly. *Chorispora tenella* (blue mustard), probably native to Russia or southwestern Asia (Whitson 1992) is a low blue-flowered mustard that is infrequent at Canyon de Chelly, but forms dense stands in the lower canyons. *Cirsium vulgare* (bull thistle), a native of Eurasia, is widespread in North America, but very limited in its distribution at Canyon de Chelly. *Cynodon dactylon* (Bermuda grass), probably introduced from Africa, is infrequent in the lower canyons. *Lactuca serriola* (wild lettuce), a native of Europe, is infrequent throughout the National Monument. *Medicago polymorpha* (bur clover) was found in only one location, in lower Canyon del Muerto. *Setaria viridis* (bottle grass), native to Eurasia, was only found in park administrative areas around the visitor center, in the campground, and at Thunderbird Lodge. *Tamarix parviflora* (saltcedar), introduced from southern Europe (Whitson 1992) has a limited range within the National Monument and efforts to eradicate it may be worthwhile, depending on its prevalence along adjacent areas of Chinle Wash. *Carduus nutans*, *Cirsium vulgare*, and *Setaria viridis* in particular should be monitored for expansion and removed at every opportunity. Any of these plants should be removed if they start invading areas with rare plants.

Exotics with potentially significant ecological impacts that exist throughout the Monument and which would be very difficult and costly to eradicate or control include *Bromus* spp. (brome), *Convolvulus*, *Elaeagnus*, *Hordeum* (barley), *Marrubium*, *Polypogon* (rabbitsfoot grass), *Salsola* spp. (Russian thistle), *Tamarix chinensis*, and *Tribulus terrestris* (puncture vine). *Elaeagnus angustifolia* and *Tamarix chinensis* will be costly to eliminate or control, but this effort may be undertaken depending on NPS and Navajo management goals (which are being

developed now) and funding availability. *Convolvulus* should be a candidate for eradication due to its negative impact on farming. Machinery used in areas with *Convolvulus* or *Marrubium* should be cleaned prior to moving to other areas to reduce the spread of these nasty weeds.

Capsella bursa-pastoris (shepherd's purse), *Erodium cicutarium* (filaree), *Kochia scoparia* (kochia), *Melilotus* spp. (sweetclover), *Rumex crispus* (curly dock) and *Tragopogon* spp. (goat's beard) are not particularly noxious, and efforts to eliminate them might not be well rewarded with ecosystem benefits.

Amaranthus palmeri (Palmer amaranth), *Cenchrus spinifex* (field sandbur), *Cicuta douglasii* (water hemlock), *Conyza canadensis* (Canada horseweed), *Descurainia* spp. (tansymustard), *Helianthus annuus* (annual sunflower), *Phragmites australis*, and *Xanthium strumarium* (Canada cocklebur) are native invasive plants and should not be considered for control efforts.

Agriculture

Residents sometimes clear their lease holdings of weedy species including cacti (pers. obs.) All cacti in the State of Arizona have exclusive protections that involve the use of salvage permits, tags and seals, as provided by state law (ADA 2003) and their Salvage Restricted Status. Technically, when leaseholders clear their land of cacti (a rare event), under state law, they would be required to get permits to remove and salvage those plants (ARS 2003). Realistically, none of the cacti within Canyon de Chelly are highly safeguarded or in danger of extinction.

Hydrologic Projects

It is hard to generalize about how hydrologic alterations may impact native plants and vegetation communities. Fluctuating water tables in the park due to activities inside the park, and changes in water usage outside park boundaries all have the potential to impact species

dependent upon on surface water or nearby water tables. The NPS must manage riparian habitats wisely since most sensitive plants within the National Monument grow in these areas.

Grazing

Grazing increases the rates of introduction and spread of exotic plant species. Trampling and soil compaction reduce productivity. Grazed areas in Canyon de Chelly support sensitive plant species, specifically: *Aletes macdougallii*, *Allium gooddingii*, *Astragalus chuskanus*, *Beckmannia syzigache*, *Besseyia arizonica*, *Cirsium chellyense*, *Clematis hirsutissima*, *Oxypolis fendleri*, *Penstemon lentus*, *P. strictiformis*, *P. strictus*, *P. virgatus*, and *Phacelia neomexicana* that could be negatively impacted, even eradicated, by grazing.

Fuel Wood Gathering

Fuel wood gathering impacts vegetation by trampling, increased fire risk, possible introduction of exotic plant species, destruction of herbaceous cover, and reducing the target species, *Pinus edulis* and *Juniperus* ssp. No sensitive species occur in piñon-juniper woodland.

Increased fire ignition risk from fuel wood gathering may be acceptable during much of the year, but not appropriate during seasons when fires can spread rapidly.

Exotic plants (*Acroptilon repens*, *Solanum rostratum*) that have been present within Canyon de Chelly for at least thirty years remain prevalent only along heavily used roads. As these plants adapt to local conditions, they may invade less disturbed areas, such as fuel wood gathering roads as these roads become more heavily used.

Betancourt and Samuels (1982) modeled prolonged fuel harvesting and its impact on piñon-juniper woodlands and applied their model to prehistoric fuelwood use at nearby Chaco Canyon, New Mexico. They concluded that the prehistoric population completely depleted the local woodland within two hundred years during the 900s through the 1100s AD. At present

rates of population increase in the Canyon de Chelly area, fuel wood gathering may become a significant impact in the next twenty years.

Potential management objectives such as conversion of piñon-juniper woodland to grassland or big sage could be sought by confining fuel wood gathering to limited times of the year and/or by concentrating the impacts within limited areas.

Logging

National Park Service concerns related to logging activities include increased erosion, sedimentation, and changes in natural fire frequency and intensity (Canyon de Chelly letter to Wilson Barber, BIA Area Director, Sept. 17, 1985). Impacts to herbaceous vegetation from associated activities such as road building and use, log skidding, traffic and the resulting increase in opportunity for exotic plant establishment can also be significant. Increased water yield and erosion can impact downstream plant resources.

Chaining

Impacts to vegetation from chaining impacts are tremendous, converting an area from one community type to another, and probably facilitating the introduction and spread of exotics. Cacti are the only sensitive plants that grow in these areas and are protected by Arizona native plant laws (ARS 2003).

Tree Planting

Revegetation plans should involve a qualified botanist to check the appropriateness and identifications of intended plant introductions. Nurseries cannot be depended on for accurate information.

Dumping

Dumping has immediate impacts on vegetation that is buried. Dumping also introduces toxins and exotic plants and should be discouraged.

Tourism

Canyon de Chelly visitors and their conveyances can be vectors for exotic plant introduction and spread. The time may come when vehicles and shoes will be routinely washed prior to entering the canyons.

Recent Vegetation Change

Both upland and riparian plant communities within Canyon de Chelly have changed dramatically in the last 100 years, negatively impacting traditional farming in the canyons.

Vegetation invasion and erosion of channels reduce agricultural potential in several ways:

- 1) Eroded, channelized stream reaches have lowered water tables. Depth to ground water is directly related to depth of channelization, so that the water table is out of reach for crop plants in reaches with deeper modern channels (Westmacott 1992). See [Figure 18](#).
- 2) Larger and therefore less frequent floods are required to bring water directly to crops along stream reaches that are eroded and channelized.
- 3) Less water is available to crop plants because it is being removed from the water table via transpiration of new, abundant riparian vegetation (Culler *et al.* 1982).
- 4) As fields are abandoned, Russian olive (an exotic tree introduced in the early part of the century to control erosion) invades and often forms a closed forest canopy in just a few years, further exacerbating transpiration water loss. See [Figures 19a-d](#) and [20](#).
- 5) Invading piñon and juniper trees take up moisture and space that might otherwise be occupied by grasses that could support sheep, cattle and horses.

Canyon de Chelly is considered a “heartland to the Navajo people” (Andrews 1976) largely due to its historical roles as a farming region and as a refuge. Modern resident Navajo families still farm in and around the canyons, with older folks passing Navajo culture on to the next generation by working on the land with younger folks (Andrews 1985). Nonresident Navajo families continue to visit the canyons for spiritual renewal and to get reconnected to Navajo culture.

Canyon de Chelly is a unique unit in the NPS system in that agricultural and other Navajo use of the canyons is accepted and encouraged by the NPS. In fact, the NPS considers continuing Navajo use of the canyons a necessary component for preservation of the area (Canyon de Chelly Superintendent S. Travis, pers. comm. 2002.) Traditional Navajo farmers and the NPS are worried that this traditional modern use is declining now, impacting Navajos ability to pass their culture on to the next generation. This decline is partly due to dramatic riparian vegetation invasion and channel erosion during the last century which has made canyon farms less arable (suitable for growing crops). The NPS is building a consensus among the five local Navajo Chapter Houses, the U.S. Fish and Wildlife Service, and the Soil Conservation Service to start management actions aimed at improving arability of fields within the canyons to benefit Navajo farmers (S. Travis, pers. comm. 2002.) "This is the primary mission of the Park Service (at Canyon de Chelly National Monument) now. . . what's at stake is the future of the canyon community" (S. Travis, pers. comm. 2003). Management actions will likely entail mechanical removal or poisoning of riparian vegetation. Prior to embarking on a stream restoration plan, NPS managers should carefully consider possible correlations between past management actions and the results of those actions. In particular, planning should include the input of a qualified exotic plant specialist, who will be knowledgeable in the mitigation of the

spread of exotics, including precautions such as thoroughly cleaning all equipment prior to moving from one work area to another to avoid spreading exotic plant propagules. Research, monitoring, and an adaptive management plan should be part of the program.

Inventory Protocols

Random Sampling for Inventory

Both inventory and monitoring efforts in parks are likely to continue for several years, reflecting substantial effort, so it is important to assess the efficacy of inventory protocols for meeting NPS objectives.

First, we need to accept that it is virtually impossible to complete a plant inventory with 100% confidence for an area in the Southwest the size of Canyon de Chelly National Monument. Plant detectability is susceptible to the vagaries of weather and climate, constantly fluctuating ranges, and other factors that affect their appearance and disappearance at various locations during different years. We will always be stuck with imperfect results.

I found one new record within random plots and only 10 new records while traveling to and from random plots. I found 486 more taxa during purposeful collecting than during random sampling. Four reasons contributed to finding few new records during random sampling:

- 1) Purposeful collection sites were in more varied geomorphic locations with more specialized habitat niches, which have greater plant diversity (Harner and Harper 1976.)
- 2) At the outset, I suspected that random sampling would not be productive at producing new records, and accordingly invested about two-thirds of my time in purposeful sampling and only 1/4 of my time in random sampling.
- 3) Most random sampling was done during 2002, an extremely dry year, when fewer herbaceous plants were notable and identifiable.

4) I added many new records during 2001, prior to most random sampling.

The random approach misses plant records because it requires sampling twice during the year, but only at times of perceived greatest plant diversity. The random sampling effort could be expanded to include other times of year as well, but it is clear that the effort/reward ratio would be great (Stuart et al. 2000.) Because the intent of purposeful collecting is to add new records to known floras, collecting at times other than the perceived time of optimum diversity is justified. Purposeful collecting also justifies focusing on areas of occurrence of plant groups often overlooked. The random approach doesn't accommodate this type of focus.

Random sampling is inefficient toward the goal of thorough inventory because collecting, identifying, and associated effort is invested regardless of whether new diversity is found. Purposeful work is efficient (Stuart et al. 2000) because this work is only invested when new diversity is found or suspected.

Only two species found during random sampling are also in [Table 4](#), the list of sensitive species of conservation concern. Purposeful plant exploration revealed new localities and range extensions for 26 sensitive plant species including *Aletes macdougalii*, *Almutaster pauciflorus*, *Astragalus chuskanus*, *Beckmannia syzigachne*, *Carex chihuahuense*, *C. meadii*, *C. specuicola*, *Ericameria parryi* var. *howardii*, *Clematis hirsutissima*, *Cryptantha cinerea*, *Cystopteris utahensis*, *Lupinus caudatus* ssp. *cutleri*, *Nama retrorsum*, *Parnassia parviflorus*, *Penstemon lentus*, *P. strictiformis*, *P. strictus*, *P. virgatus*, *Phacelia neomexicana*, and *Zigadenus vaginatus*. I looked for, but did not find, another sensitive plant, *Allium gooddingii*, previously found in the 1970s. Random sampling has not revealed any comparable information and is expected to be poor at finding new plant localities or verifying the absence of previously recorded plants (Stuart et al. 2000).

The riparian community is the only vegetation community defined for random sampling that has an abundance of sensitive plants of interest in Canyon de Chelly National Monument (Table 4). But the riparian community was not sampled extensively in the random sampling scheme because it does not occupy much area within the National Monument. Some vegetation communities, such as piñon-juniper with low plant diversity and few sensitive plants, were sampled extensively because they cover a large area within the National Monument.

Random Sampling as a Diversity Indicator

In the course of 119 days observing plants and plant communities in Canyon de Chelly, I developed reservations about the random sampling approach for estimating diversity. I realized that the assumptions inherent in the model were unavoidably violated. Specifically:

- 1) *We can adequately identify and differentiate plants within plots. We need to be able to identify to genus those plants in monospecific genera. We need to be able to identify to species, plants within genera represented by more than one species in the inventory area.*

Due to lack of flowering or fruiting parts, I could not adequately identify many of the herbaceous plants found in the random plots. Nearly 85% of the known plants at Canyon de Chelly are herbaceous, meaning that they spend much (or most) of their life cycle as an undetectable root crown, or seed. Problems with plant identification plague all inventory methods. Random sampling protocol requires identification of every plant found within a sample plot when it is sampled. Due to phenology, it is difficult and time consuming or even impossible to identify with certainty, many of the plants in the plots, even though the botanist is sampling at the optimal time of year for diversity. Much effort is spent attempting to identify random scraps of common plants that don't have diagnostic features (flowers or fruits). In contrast, purposeful sampling allows the

botanist the latitude to collect or not, weighing the potential difficulties of identification against the potential for adding new records. Purposeful sampling doesn't require the identification of poor specimens of common plants, so time and energy are not expended wastefully in this way, as they are with random sampling.

- 2) *We have a reasonably accurate estimate of how many species exist in each stratified unit.*

I have not assessed the validity of this assumption.

- 3) *We have stratified the vegetation communities well, and at a scale fine enough to detect unique areas of plant diversity.* Of the random plots that I visited twice during 2002, only 28 of 71 (39.4%) were within the vegetation communities as prescribed by the model. Apparently the stratification units were not delineated well. Problems with stratification included:

- 1) Stratification units didn't identify smaller community elements. Because the number of stratification units is limited by practical considerations, unique plant communities small in area with significant diversity, or unique plant resources, were overlooked by the random method. Overlooked communities included Douglas fir, aspen, Gambel oak thickets, hanging gardens, sand dune areas, as well as weedy areas around homes and park administration buildings.
- 2) Stratification units did not identify important community elements. The big sage community may cover as much area as the ponderosa pine community in the National Monument, but big sage was not identified as one of the stratification units.
- 3) GAP drew the boundaries of plant communities in this area as much as two km. away from their actual location. The fact that most of the plots were not in the vegetation

communities prescribed by GAP indicates that the gains made by choosing to stratify may have been negligible.

- 4) *We have assigned an appropriate number of plots/stratified unit based on their comparative diversity.* The riparian community has high diversity, but is small in area, so it was under-sampled by the random plots.

My results were not adequate for estimating diversity at Canyon de Chelly. If I had sampled the prescribed 713 random plots, budgetary constraints would have required me to abandon all purposeful sampling, which would have resulted in much less qualitative information being made available to NPS managers. Random statistical methods are appropriate for finding common things, but they are not adequate or appropriate for finding unusual things like plants that don't occur commonly.

Summary

Reasonable and appropriate goals of the current NPS inventory effort should be to document exotic and rare species, and changes in regional vegetation communities. Random sampling methods can augment these goals by:

- 1) Requiring the botanist to search carefully for plants in a small area, increasing the likelihood of finding new records that way.
- 2) Serving as a much needed field check on GAP vegetation community mapping.
- 3) Identifying plant communities at a finer scale, as well as assessing the impacts of grazing and other human activities (Heil *et al* 1993.)
- 4) Serving as starting points for monitoring work to come.

Cully (pers. comm.) has proposed that random work could be useful for comparing diversity values across the Southwest. My feeling is that the number of plants identified in a plot

(in one or two visits) is too dependent on recent weather and expertise of the sampler, so that these methods poorly estimate the actual diversity present, resulting in misleading comparisons.

The random sampling scheme used in the present inventory provided little in the way of conservation biology objectives, at great expense. Random sampling schemes are poor at finding new populations of rare or exotic species. Much more effort would be needed for this program to be tested for its efficacy at predicting diversity. This effort would be at the expense of purposeful surveying, a proven method of adding knowledge that is important to land managers. This finding should be carefully considered prior to continuing with the program.

Future Inventory Work

I analyzed the results of Halse's (1973) and my work to determine strategies that were highly productive for inventory. Halse found 123 of his 275 new plant records in the upper canyons during only eight of the 70 days he spent at Canyon de Chelly. I found 90 of 267 new plant records in the upper canyons during only 12 of the 119 days I spent at Canyon de Chelly. The upper canyons, with their slopes and side canyons, probably have the greatest diversity of unknown plants because botanists still haven't explored these areas as thoroughly as the lower canyons. Also, the upper canyons offer greater overall diversity because the terrain is wetter, and less disturbed. Future inventory efforts aimed at documenting diversity should focus on the upper canyons.

Monitoring Needs

Plant communities at Canyon de Chelly should be monitored for changes in abundances and ranges of both exotic and sensitive plants. Monitoring of exotics may help NPS managers prioritize removal efforts. Most of the sensitive plants at Canyon de Chelly ([Table 4](#)) grow in the small areas of hanging gardens and riparian areas. The direct impacts at hanging gardens are

few, but the potential exists for negative impacts from well drilling and ground water removal at some distance from Canyon de Chelly. Riparian areas are some of the most highly impacted areas in Canyon de Chelly. Monitoring these relatively small areas would give managers early warning of threats and impacts.

Due to the major riparian vegetation changes at Canyon de Chelly, and their impacts on local culture, these areas should be monitored for on-going changes. As NPS vegetation removal projects get underway, these experiments will need to be monitored to see how well they function at realizing their intended goals, and to assess how these plans may be altered to improve their results.

RECOMMENDATIONS FOR INVENTORY and MONITORING

- 1) Future inventory work at Canyon de Chelly should target the upper, less-visited canyons and side canyons, especially steep slopes and riparian areas.
- 2) Testing the random approach to inventory will require an effort (budget) five to ten times greater than that used for this project, and should be viewed as the experiment it is.
- 3) Identifying plants that are not in flowering or fruiting condition in random plots requires a high level of training and background for the botanists involved.
- 4) For the random inventory approach to work well, areas need to be more finely and accurately stratified. Sampling needs to be more appropriately allotted to stratification units according to their expected diversity.
- 5) Vegetation removal and introduction projects should be closely monitored. Monitoring should include taxa beyond plants, especially arthropods, birds, mammals, reptiles, soil crust, and mycorrhizae. An adaptive management plan would improve the chances that

these efforts may succeed in achieving goals that need to be agreed upon by all the stakeholders.

- 6) Riparian areas and hanging gardens should be monitored for change since these areas harbor most of the sensitive plant species found at Canyon de Chelly.

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Table 1. Extreme temperatures (°F) in the Canyon de Chelly area.

	<u>High</u>	<u>Low</u>
Chinle	104	-32
Fort Defiance	98	-30
Lukachukai	98	-25
Window Rock	99	-29

Table 2. Brief notes on investigator's time spent in Canyon de Chelly

Key:

Yr=year, **Mo**=month, **Day**=day of month, **Intent** of trip; m=photo matching; p=purposeful collecting; r=random sampling, **No.**=number of collections as related to intent

Area=area surveyed; a=above, A=Aspen Trail, AH=Antelope House, b=below, B=Baby Trail, BF=Big Flow, Bh=Beehive, BR=Black Rock, Bt=Bat Trail, BT=Bad Trail, C=Cottonwood, CC=Coyote Creek, CdC=Canyon de Chelly, CdM= Canyon del Muerto, Ch=Cherry, Cr=Creek, CT=Crack Trail, D=Draper, E=Elephant Grass Canyon, F=Face, FS=Far Spiral, FT=Fir Tree, G=Gopher, GC=Giant Canyon, H=Hanging Ladder, Ht=Horse Trail, J=Junction, K=Kiva, l=lower, lo=loop, LC=Last Canyon, LW=Lady White Trail, m=middle, M=Many, MS=Many Skulls, Mu=Mummy, MC=Monument Canyon, nr=north rim road, O=Overlook, P=Peninsula, PT=Pine Tree, r=r rim, Rc=Red Clay, RO=Red Ochre, sr=south rim road, S=Selah Springs Route, SC=Spring Canyon, SP= Sheep Point Canyon, SR=Spider Rock, ST=Spanish Trail, T=Tunnel, TB= Thunderbird Lodge, TC=Tsaile Creek, Tr=Trail, u=upper, VC=Visitor Center, w=window, W=Windpipe, Wc=White Clay, WH= White House, Wi=Wilson, Wk=Wheatfields, Wf=Wheatfields, WR=White Rock, Z=Zuni Trail

Loc.=location; geomorphic location; b=canyon bottom; d=dunes; r=canyon rim

Mode of transportation; d=drive; h=hike; r=river ducky

Purp.=purpose; lvsc=lesser visited side canyons; p#=number of photos matched; r=random; rip=riparian; sd=short day; VC=Visitor Center

Comm.=communities sampled; d=disturbed; ds=desert scrub; du=dune;h=horticultural; hg=hanging garden; p=ponderosa pine; pj=pinon-juniper woodland; r=riparian; s=sage

Coll. No. my collection numbers, **NR**=number of new records for that day

Yr.	Mo.	Day	Intent	No.	Area	Loc.	Mode	Purp.	Comm.	Coll. No.	NR
1	4	24	p	16	uCDC	r,b	r	rip	r	151-169a	7
1	4	25	p	11	uCDC	b	r	rip	r	170-180	2
1	4	26	p	16	ICDC	b	r	rip	r	181-195	6
1	5	3	p	13	bJ	r	h	lvsc	ds	200-213	1
1	5	4	p	22	bJ, T-Ridge lo	b,r	h	p2	hg	214-236	5
1	5	5	p	27	ICDC, WH, P	b,r	h	p4	hg	237-263	5
1	5	6	p	15	m& ICDC, C	r,b	d/h	p4	pj,ds	264-278	2
1	5	7	p	20	ICDM, B & CT Tr lo	r,b	h	p1	pj,r	279-297	6
1	5	8	p	1	Campground	r				300	1
1	5	14	p	8	bJ, dunes	r,d	d/h	sd	du	301-308	
1	5	15	p	11	mCDM, Mu	b	d/h	p3	pj,r	309-319	1
1	5	16	p	18	mCDM, Mu-BFlo	r,b	h	lvsc	pj,r	320-338	3
1	5	17	p	26	uCDM, PI-BFlo	r,b	h	lvsc	pj,r	339-365	7
1	5	18	p	17	mCDM, m-PT Cyn lo	r,b	h	lvsc	hg,pj,r	366-383	2
1	5	19	p	3	mCDM, upstreamof m	r,b	h	lvsc	hg,pj,r	384-387	2
1	5	20	p	5	mCDM, GC-Mu lo	r,b	h	lvsc	pj,r	388-392	1
1	5	21	p	15	ICDM, MCh-Twin Tr lo	r,b	h	lvsc	hg,pj,r	393-408	3
1	5	22	p	10	ICDM, ML-AH Tr lo	r,b	h	lvsc	hg,pj,r	409-418	1
1	5	23	p	11	uCDM, TC	r,b	d	rip	r	419-429	1
1	5	24	p	20	uBR	r,b	h	lvsc	pj,r	430-449	6
1	5	25	p	13	uCDC, Rc-BR Tr lo	r,b	h	VC	pj,r	450-464	1
1	5	26	p	8	mCDC, Bh-CT Tr lo	r,b	h	lvsc	hg,pj,r,ds	465-473	1
1	5	27	p	5	MC, Sm.Twin-Ht lo	b,r	h	lvsc	hg,pj,r	474-478	
1	5	28	p	4	MC, IBT, E	b	h	lvsc	r	479-482	1
1	5	29	p	18	ICDC/dunes/uMC.	b,r	d/h	lvsc	du,ds,pj,r,p	483-500	6
1	5	30	p	32	SE arm, MC	b,r	h	lvsc	hg,pj,r,p	501-537	8
1	5	31	p	10	uMC, uJ	b,r	d/h	lvsc	pj,r,p	538-549	1
1	6	1	p	30	uCDC, CC-X-tal-Wk	b,r	h	lvsc	pj,r,p	550-579	6
1	6	2	p	17	uCDC, CC-J Ht lo	b,r	h	lvsc	pj,r,p	580-597	2
1	6	15	p	47	uCDM, TC	b,r	h		pj,r	598-643b	11

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Yr.	Mo.	Day	Intent	No.	Area	Loc.	Mode	Purp.	Comm.	Coll. No.	NR
1	6	16	p	18	uCDM, TC	b,r	h		pj,r	644-661	2
1	6	17	p	29	uCDC, Wk Cr	b,r	h	lvsc	hg,pj,r	662-691	7
1	7	12	p	32	B Tr, White S&s-Z lo	r,b	h	lvsc	du,r,pj	692-724	3
1	7	13	p	33	uCDM, TC	b,r	h	lvsc	pj,r	725-756	4
1	7	19	p	18	ICDM, Bear-B lo	b,r	h		hg,r,pj,ds	757-774	4
1	7	20	p	8	m CDM, Twin-MS	b,r	h	lvsc	pj,r	775-782a	3
1	7	31	p	10	bJ, visitor center	r	d	VC	ds,d	782b-791	4
1	8	1	p	19	TC	b	d	p1	r,pj	792-810	1
1	8	2	p	52	uCDC, uWf	b,r	h	lvsc	r,pj	811-865	16
1	8	3	p	30	uCDC, IWf	b,r	h	lvsc	rn,pj	866-894	12
1	8	4	p	7	uMC	r,b	h	lvsc	pj,r,p	900-906	
1	8	5	p	13	uMC	b	h	lvsc	hg,r,pj,p	907-919	2
1	8	6	p	8	IMC-BT	b,r	h		pj,rip.	920-928	1
1	8	7	p	5	BT Cyn-BT Tr lo	b,r	h	lvsc	pj,rip.	929-935	
1	8	16	p	22	VC/uMC	r,b	d/h	lvsc	ds,pj,r,p	936-958	6
1	8	17	p	19	uMC./TC/PT	b,r	d/h	lvsc	hg,r,pj,ds	959-978	6
1	8	18	p	31	uCDM, TC	b,r	h		pj,r	979-1010	6
1	8	19	p	17	m CD,SC-Wild Ch lo	b,r	h	lvsc	hg	1011-1027	1
1	9	14	r	0	bJ, visitor center	r	d		ds		
1	9	15	r	31	uCDC,mesa N. of Wf	r	d/h	r	p,pj,s	1028-1056	3
1	9	16	r	20	uCDC,mesa Wf-Wk	r	d/h	r	s,pj	1057-1080	3
1	10	13	p/r	11	uBR	b,r	h	lvsc	pj,r	1081-1090	
1	10	14	p	8	ICDM, AH-Ridge Tr	b,r	h	lvsc	pj,ds,r	1091-1098	
1	11	3	p/r	8	mCDM, H-Mu	b,r	h	p2	pj,r	1099-1106	2
1	11	4	p	7	mCDM, Mu-Twin	b	h	p1	pj,r	1107-1113	
2	5	9	p	1	bJ	r	d/h	r	ds	1121-1122	1
2	5	10	r	14	bJ	r	d/h	r	ds	1123-1135	3
2	5	11	r	1	mCDC, SCCyn	r,b	h	r	hg,ds	1136	
2	5	12	r	4	ICDM, ra AH	r	d/h	r	pj	1137-1141b	2
2	5	13	r	4	IBR, AH-BR lo	r,b	h	r	pj,r	1142-1146	1
2	5	14	r	2	mCDM, CT Tr	r,b	h	r	pj,ds	1147	
2	5	15	r	1	IP	r,b	h	r	pj,r	1149	
2	5	20	r	6	mCDC, Wi Tr- GClo	r,b	h	r	hg,r,pj	1150-1158	
2	5	21	p	23	bJ, T, cyn nr. CT	b	d/h	lvsc	hg,r,ds,pj	1159-1186	1
2	5	22	r	7	uCDM, ST	b,r	h	r	pj,r	1187-1193	2
2	5	23	p/r	7	mCDM/ ICDC,SP	b,r	h	lvsc/p3	hg,pj,r	1194-1200	
2	5	24	r	16	IMC/SRTr-Wind Tr	b,r	h	lvsc	pj,r	1202-1217	1
2	5	31	p	5	AH O, CG,	b,r	d/h	lvsc	pj,d	1218-1219	1
2	6	1	r	2	mCDM, m Tr	b	h	lvsc	pj,r	1220-1224	
2	6	2	r	3	uCDM, D Tr	b,r	h	lvsc	pj,r	1225-1227	
2	6	3	p	2	mCDM, PT Cyn. Tr	b,r	h	lvsc	hg,pj,r	1228-1229	
2	6	4	r	3	VC/uMC	r	d/h	r	ds,pj,p	1230-1232	
2	6	5	p/r	14/2	uCDC, Mule-Wc Tr lo	b,r	h	lvsc	pj,r	1233-1251	2
2	6	6	r	5	uCDC, Wk Cr	r	d/h	r	pj,s	1252-1256	1
2	6	7	r	4	uCDC, Wk-Wf	r	d/h	r	p,s,pj	1257-1260	
2	6	8	p	28	BRSpr/TC/bJ	b,r	d/h	rip	r	1261-1289	4
2	6	9	p	9	l& mCDM	b	d	p7	hg,r	1290-1292	2
2	6	10	p	3	TB	r	d	sd	h	1293-1295	1
2	7	1	p	1	mCDC, SCCyn	b,r	h	sd	hg,pj	1296	
2	7	2	p	22	uCDC, Wk-CC lo	b,r	h	lvsc	hg,pj,r	1297-1319	8
2	7	3	p	20	uCDC, Wf-CDC lo	b,r	h	lvsc	hg,pj,r	1320-1342	4
2	7	4	p	10	uCDM, TC & b	b	h		r	1343-1352	1
2	7	5	p	4	uCDM	b,r	d/h	lvsc	pj,r	1353-1356	2
2	7	20	p	20	bJ/uCDC	b	d/h		hg,ds,pj,r,p	1357-1377	4
2	7	21	p	7	uCDC,WR-K lo	b,r	h	lvsc	hg,pj,p,r	1378-1384	

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Yr.	Mo.	Day	Intent	No.	Area	Loc.	Mode	Purp.	Comm.	Coll. No.	NR
2	8	3	p/r	2	uCDC, A-RO lo	b,r	h	lvsc	pj,r	1385-1386	
2	8	4	p	16	mCDC,Bh-S-F-BR Tr	b,r	h	lvsc	hg,pj,r	1387-1403	2
2	8	5	p	1	TB	r	d	sd	h	1404	1
2	9	5	r	18	CDC, VC, BT-Er	r	d/h	p1	ds,pj,r	1405-1422	11
2	9	6	r	11	uCDC, MC-CDC	r	d/h	r	p,r,s	1423-1434	1
2	9	7	r	23	uCDC, Wk	r	d/h	r	s,pj	1436-1456	2
2	9	8	r	8	uCDC/mCDM/bJ	r	d/h	r	s,pj	1457-1465	2
2	9	9	r	10	IP, LW	b,r	h/d	r	hg,pj,r	1466-1475	2
2	9	13	r/p	9	uCDM/TC	b,r	d/h		pj,r	1476-1485	3
2	9	14	r	2	P, CDM-Wf	r	d/h	r	pj	1486-1487	1
2	9	15	r	14	uCDC, Wf r	r	d/h	r	p,s,ds,r	1488-1503	1
2	9	16	r	7	CDM, S.D-ST lo	b,r	h/d	p1	pj,r,ds	1504-1508b	2
2	9	19	r	1	mCDM, nr	r	d	p4	ds,pj	1509	
2	9	20	p	4	bJ, FT Tr-Ch lo	b	h/d	p2	rip,pj	1510-1513	2
2	9	21	p	6	mCDM, BT-PT lo	b,r	h	lvsc	hg,pj,r	1514-1519	2
2	9	22	p/r	2	mCDC, w	b	h	p3	rip,ds,pj,r	1520-1521	1
2	9	23	p	4	ICDM, AH Tr	b	h/d	p1	hg,pj,r	1522-1525	
2	9	26	m	1	mCDC, sr	r	d	p4	pj,ds	1526	
2	9	27	p	8	bJ,W-T,ICdM	b,r	h	p1/lvsc	hg,ds,r	1527-1534	2
2	9	28	r/p	3	uCDC/ICDM, FS	b	h	p1	hg,pj,ds,r	1536-1541	1
2	9	29	p	2	bJ, C	b	h	sd	ds,r	1542-1543	
2	10	4	r	14	bJ,WH Tr	b,r	d	p4	ds,pj,r	1544-1557	3
2	10	5	p/r	12	TB, SRO	r	d	p2	h,ds,pj	1558-1570	5
2	10	19	m	2	bJ, sr	r	d	p4	ds,pj	1571-1572	
2	10	25	m/r	1	mCDC, WHO	r	d	p4	ds,pj	1573-1574	
2	10	26	m	2	CDC, SR	b	d	p14	r,pj	1575-1576	
2	10	27	m	1	CDC, SR	b	d	p3	r,pj	1577	
2	11	16	p	0	uCDC, LC-K lo	b,r	h	lvsc	r,pj		
2	11	17	p	1	uCDC, C-G lo	b,r	h	lvsc	r,pj,hg	1578	

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Table 3. Results by Division and Class

Taxonomic Group	Families	Genera	Species		Total
			Native	Exotic	
Pteridophyta	5	8	15	0	15
Pinophyta	3	6	10	2	12
Magnoliophyta					
Magnoliopsida	75	290	486	74	560
Liliopsida	10	76	150	33	183
Total	93	380	661	109	770

Table 4. Twenty-nine sensitive plant species that have been found at Canyon de Chelly, the agency concerned about them, and their status with that agency.

Key

AG&F Global Record = Arizona Game and Fish Department Heritage Data Management System; Global Rank: priority ranking (1 to 5) based on the number of occurrences throughout the entire range of the element; G1 = Very Rare: 1 to 5 occurrences or very few individuals or acres; G2 = Rare: 6 to 20 occurrences or few individuals or acres; G3 = Uncommon or Restricted: 21 to 100 occurrences, rather rare throughout a fairly wide range, or fairly common in a rather restricted range; G4 = Apparently Secure: more than 100 occurrences, though it could be quite rare in some parts of its range; G5 = Demonstrably Secure: more than 100 occurrences; G#T# = Subspecies: numeric designations based on same criteria as those for global ranks; G#?= Uncertain: insufficient information to give a definitive ranking; confidence of numeric rank is plus or minus one rank.

EOS = Element occurrence record filed with the Navajo Nation

ESA = Endangered Species Act; **LT** = Listed Threatened; **SC** = Species of Concern

GR Found = Glenn Rink found at CACH

Habitat; d = dune; ds = desert scrub; hg = hanging garden; rip = riparian; s = sage; tal = talus; v = various

HDMS AZ Rank; Heritage Data Management System, Arizona State Rank: priority ranking (1 to 5) based on the number of occurrences of an element within the state; S1 = Very Rare: 1 to 5 occurrences in the state or very few individuals or acres within the state; S2 = Rare: 6 to 20 occurrences in the state or few individuals or acres within the state; S3 = Uncommon or Restricted: 21 to 50 occurrences in the state, either rather rare throughout a fairly wide range, or fairly common in a rather restricted range within the State; S3S4 = Fairly Common: 51 to 100 occurrences and found over a rather wide range within the state; S4 = Apparently Secure: more than 100 occurrences within the state, though it could be quite rare in some parts of the state; S5 = Demonstrably Secure: more than 100 occurrences within the state; **SR** = State Reported: reported from the state, but without persuasive evidence to either accept or reject the report.

New Record = Previously unknown

NNHPETL = Navajo Natural Heritage Program Element Tracking List

NESL = Navajo endangered species list; G-3 = A species or subspecies whose prospects of survival or recruitment are in jeopardy; G-4 = Any species or subspecies for which the Navajo Nation Department of Fish And Wildlife (NNDFWL) does not currently have sufficient information to support being listed in G2 or G3 but has reason to consider them.

NM RED Code (New Mexico R = rarity, E = endangerment, D = Distribution Code)

R (rarity): 1 = rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low for the foreseeable future; 2 = occurrence confined to several populations of to one extended population; 3 = occurrence limited to one or a few highly restricted populations, or present in such small numbers that it is seldom reported.

E (endangerment); 1 = not endangered; 2 = endangered in a portion of its range; 3 = endangered throughout its range.

D (distribution); 1 = more or less widespread outside New Mexico; 2 = rare outside New Mexico; 3 = endemic to New Mexico.

NPL = Arizona Native Plant Law (ADA, 2003); **HS** = Highly Safeguarded, no collection allowed; **SR** = Salvage Restricted, salvage permit required

USFS = U.S. Forest Service; **S** = Sensitive

Utah Status Categories, plants known from San Juan County; **R** = Rare, plants with known or suspected range wide viability concern; **W** = Watch, plants regionally endemic, but without range wide viability concern.

<u>PLANT</u>	<u>FAMILY</u>	<u>GR</u> <u>Found</u>	<u>New</u> <u>Record</u>	<u>EOS</u>	<u>NESL</u>	<u>AG&F</u> <u>Global</u> <u>Record</u>	<u>HDMS</u> <u>AZ</u> <u>Rank</u>	<u>NM</u> <u>RED</u>	<u>UT</u>	<u>NHP</u>	<u>ESA</u>	<u>USFS</u>	<u>NPL</u>	<u>NNHP</u> <u>ETL</u>	<u>HABITAT</u>
<i>Aletes macdougalii</i>	Apiaceae	x	x	x		G3	S2							x	hg
<i>Allium gooddingii</i>	Liliaceae				G-3	G4	S3S4				SC	S	HS		rip
<i>Almutaster pauciflorus</i>	Asteraceae	x	x			G4	S1								rip
<i>Astragalus chuskanus</i>	Fabaceae	x	x	x		G3	S3	2-1-2						x	rip
<i>Beckmannia syzigachne</i>	Poaceae	x	x			G5	S1								rip
<i>Besseyia arizonica</i>	Scrophulariaceae	x	x											x	p
<i>Carex chihuahuensis</i>	Cyperaceae	x	x	x		G3G4	S2S3					S			hg
<i>Carex meadii</i>	Cyperaceae	x	x			G4G5	S3								hg
<i>Carex specuicola</i>	Cyperaceae	x	x	x	G-3	G2	S2		R		LT		HS		hg
<i>Cirsium chellyense</i>	Asteraceae	x													v
<i>Clematis hirsutissima</i>	Ranunculaceae	x	x		G-4	G4	S2								rip
<i>Cryptantha cinerea</i>	Boraginaceae	x	x			G5	S1								v
<i>Cystopteris utahensis</i>	Dryopteridaceae	x		x	G-4	G3?	S?								rip cliffs
<i>Ericameria parryi</i>	Asteraceae	x	x	x		G5T5	S1								ds, tal
var. <i>howardii</i>															
<i>Eriogonum corymbosum</i>	Polygonaceae	x	x			G5	S3								ds, tal
<i>Lupinus caudatus</i>	Fabaceae					G5T2	S2								rip
ssp. <i>cutleri</i>															
<i>Nama retrorsum</i>	Polemoniaceae	x	x	x		G3	S2								d

<u>PLANT</u>	<u>FAMILY</u>	<u>GR</u> <u>Found</u>	<u>New</u> <u>Record</u>	<u>EOS</u>	<u>NESL</u>	<u>AG&F</u> <u>Global</u> <u>Record</u>	<u>HDMS</u> <u>AZ</u> <u>Rank</u>	<u>NM</u> <u>RED</u>	<u>UT</u>	<u>NHP</u>	<u>ESA</u>	<u>USFS</u>	<u>NPL</u>	<u>NNHP</u> <u>ETL</u>	<u>HABITAT</u>
<i>Nolina microcarpa</i>	Liliaceae	x		x											P-J, tal
<i>Opuntia viridiflora</i>	Cactaceae	x	x					3-3-3					SP		rip
<i>Oxypolis fendleri</i>	Apiaceae					G4	S2								rip
<i>Parnassia palustris</i>	Saxifragaceae	x		x		G4	S1								hg
var. <i>parviflora</i>															
<i>Pedimelum megalanthum</i>	Fabaceae	x	x			G4	SR?								ds, tal
<i>Penstemon lentus</i>	Scrophulariaceae	x	x	x				1-1-2							rip
<i>Penstemon strictiformis</i>	Scrophulariaceae	x	x							W					rip
<i>Penstemon strictus</i>	Scrophulariaceae	x	x			G5	S3S4								s
<i>Penstemon virgatus</i>	Scrophulariaceae	x		x		G4	S3S4								rip
<i>Phacelia neomexicana</i>	Hydrophyllaceae					x									rip
<i>Proboscidea parviflora</i>	Martyniaceae	x	x	x		G4G5	S?								dist.
<i>Zigadenus vaginatus</i>	Liliaceae	x	x	x						R				x	hg
	all Cactaceae												SP		v
	all Liliaceae												SP		v
	all Orchidaceae												SP		hg

Table 5. Some hanging gardens at Canyon de Chelly National Monument

All UTMs in NAD27, 12S; elevations in feet large=large and multilevel
 Key: Cs=Carex specuicola, Zv=Zigadenus vaginatus, Eg=Epipactis gigantea, Am=Aletes mcdougallii,
 Am=Aquilegia micrantha, Me=Mimulus eastwoodiae, Ca=Carex aurea, Ac=Adiantum capillus-veneris,
 Cc=Cirsium chellyense

Location	Easting	Northing	Elev.	Size	Aspect	Collection	Plants observed									
						Nos.	Cs	Zv	Eg	Am	Am	Me	Ca	Ac	Cc	
Junction	636474	4001119	5700	large	west	257-258,1365-1369	x	x		x	x	x			x	
Mummy	647234	4008563	6200	small	nw	318-319					x					
Pine Tree	648750	4014787	6900	large	var.	376-380		x					x		x	
Pine Tree	648320	4014124	6700	small	west	381-383						x				
Massacre	648000	4012000	6800	large	west	none					x	x				
Middle Tr.	651000	4013300	6700	large	var.	none					x	x				
Many Cherries	644000	4004000	6500	small	north	396										
Twin Trail Cyn.	647312	4004489	5850	small		405		x		x	x	x	x		x	
A. H. Trail	639675	4001733	6050	large	west	417		x	x	x	x					
Black Rock Cyn.	647100	4000950	6860	small	west	448					x	x				
Beehive	643800	3997800	6300	small	sw	none					x					
W of Beehive	643300	3987600	6000	large	south	467-470		x		x	x		x	x		
Monument	657489	3986341	7000	small		513-515		x		x						
Whiskey Spring	666600	3998100	7040	small		none								x		
Whiskey Creek	666050	3999092	6860	small		675-681,1298							x		x	
Coyote	665137	3999614	6700	small	south	589-592,688					x		x		x	

Table 6. Exotic and invasive plants tracked within Canyon de Chelly National Monument

Key:

N= Native; I = Introduced (source http://plants.usda.gov/cgi_bin/invasive_all.cgi)

AZ-EXT = Arizona Invasive Weeds. AZ Cooperative Extension, by Howery and Ramos

AZ-NWL = Arizona State Noxious Weed List, (<http://agriculture.state.az.us/PSD/Quarantine2.htm>; P = prohibited, Reg = regulated, Rst = restricted, Prop = proposed)

SDERP = Sonoran Desert Ecoregional Plan, April 2000 (<http://agriculture.state.az.us/psd/quarantine2.htm>)

FedNWL = Federal Noxious Weedlist (<http://www.usgs.nau.edu/SWEPIC/asp/swemp/list.asp?status=Federal>)

SDM = Sonoran Desert

ADOT = Arizona Department of Transportation; incomplete; current ADOT list came from ADOT Natural Resources Dave Evans in IPM-SD

IPM-SD = A Resource guide: Invasive plant management in the Sonoran Desert, Chambers and Hall 2001

IPSD - Plants of the Sonoran Desert: A field guide, Chambers and Hawkins

Scientific Name	Common Name	Native or Exotic	USDA Code	Reference for Listing in Arizona	Arizona Noxious Listing	SWEMP	SWEPIC	NPS-AZ Tracking
<i>Acroptilon repens</i>	Russian knapweed	E	ACRE3	IPM-SD, ADOT, AZ-NWL, AZ-EXT	P,Rst	SWEMP	SWEPIC	
<i>Amaranthus palmeri</i>	Palmer amaranth	N	AMPA					NPS
<i>Bromus rubens</i>	red brome	E	BRRU2	SD				NPS
<i>Bromus tectorum</i>	cheat grass	E	BRTE	IPM-SD, ADOT, AZ-NWL, AZ-EXT		SWEMP	SWEPIC	NPS
<i>Capsella bursa-pastoris</i>	shepherd's purse	E	CABU2				SWEPIC	
<i>Carduus nutans</i>	musk thistle	E	CANU4	ADOT	Prop	SWEMP	SWEPIC	
<i>Cenchrus spinifex</i>	field sandbur	N	CESP4	AZ-NWL, AZ-EXT	P, Reg	SWEMP		
<i>Chloris virgata</i>	fingergrass	N	CHVI4	SDERP				NPS
<i>Chorispora tenella</i>	blue mustard	E	CHTE2			SWEMP	SWEPIC	
<i>Cicuta douglasii</i>	hemlock	N	CIDO			SWEMP	SWEPIC	

Scientific Name	Common Name	Native or Exotic	USDA Code	Reference for Listing in Arizona	Arizona Noxious Listing	SWEMP	SWEPIC	NPS-AZ Tracking
<i>Cirsium vulgare</i>	bull thistle	E	CIVU	IPM-SD, ADOT, AZ-NWL, AZ-EXT	Prop	SWEMP	SWEPIC	
<i>Convolvulus arvensis</i>	field bindweed	E	COAR4	AZ-NWL, AZ-EXT	P, Reg	SWEMP	SWEPIC	
<i>Conyza canadensis</i>	horseweed	N	COCA5			SWEMP	SWEPIC	NPS
<i>Cynodon dactylon</i>	Bermuda grass	E	CYDA	SD			SWEPIC	NPS
<i>Descurainia sophia</i>	flixweed	N	DESO2			SWEMP	SWEPIC	NPS
<i>Echinochloa crus-galli</i>	barnyard grass	E	ECCR					NPS
<i>Elaeagnus angustifolia</i>	Russian olive	E	ELAN	AZ-NWL, IPM-SD	Prop	SWEMP	SWEPIC	
<i>Erodium cicutarium</i>	filaree	E	ERIC6	IPSD, SDERP		SWEMP	SWEPIC	NPS
<i>Helianthus annuus</i>	common sunflower	N	HEAN3					NPS
<i>Hordeum murinum</i> ssp.glaucum	wild barley	E	HOMU	ADOT				NPS
<i>Kochia scoparia</i>	kochia	E	KOSC			SWEMP	SWEPIC	
<i>Lactuca serriola</i>	prickly lettuce	E	LASE					NPS
<i>Marrubium vulgare</i>	horehound	E	MAVU			SWEMP	SWEPIC	NPS
<i>Medicago polymorpha</i>	burclover	E	MEPO3 MEAL1	AZ-NWL	P, Reg	SWEMP	SWEPIC	
<i>Melilotus alba</i>	white sweetclover	E	2	ADOT, IPM-SC,		SWEMP	SWEPIC	NPS
<i>Melilotus officinalis</i>	yellow sweetclover	E	MEOF			SWEMP	SWEPIC	NPS
<i>Phragmites australis</i>	Phragmites	N	PHAU7	IPM-SD				
<i>Polypogon viridis</i>	rabbit's foot grass	E		SDERP				
<i>Portulaca oleracea</i>	common purslane	N	POOL	AZ-NWL	P, Reg	SWEMP	SWEPIC	
<i>Rumex crispus</i>	dock	E						NPS
<i>Salsola kali</i>	Russian thistle	E	SAKA			SWEMP	SWEPIC	NPS

Scientific Name	Common Name	Native or Exotic	USDA Code	Reference for Listing in Arizona	Arizona Noxious Listing	SWEMP	SWEPIC	NPS-AZ Tracking
<i>Salsola tragus</i>	Russian thistle	E	SATR12	ADOT				
<i>Setaria viridis</i>	green foxtail	E	SEVI4			SWEMP	SWEPIC	NPS
<i>Solanum elaeagnifolium</i>	silverleaf nightshade	N	SOEL			SWEMP	SWEPIC	
<i>Tamarix chinensis</i>	saltcedar	E	2	IPM-SD	Prop	SWEMP	SWEPIC	NPS
<i>Tamarix parviflora</i>	saltcedar	E	2	IPM-SD	Prop	SWEMP	SWEPIC	NPS
<i>Tragopogon pratensis</i>	goatsbeard	E					SWEPIC	
<i>Tribulus terrestris</i>	puncturevine	E	TRTE	AZ-NWL, IPM-SD	P, Reg	SWEMP	SWEPIC	NPS
<i>Ulmus pumila</i>	Siberian elm	E	ULPU	IPM-SD			SWEPIC	
<i>Xanthium strumarium</i>	cocklebur	N	XAST			SWEMP	SWEPIC	NPS

Table 7. Percentage of known exotic plants in some other areas on the Colorado Plateau.

Arches National Park (Schelz, pers. comm.)	8%
Canyonlands National Park (Schelz, pers. comm.)	7%
Canyon de Chelly National Monument	10.5%
Capitol Reef National Park (Clark, pers. comm.)	13%
Dinosaur National Monument (Naumann, pers. comm.)	10%
Glen Canyon National Recreation Area (Spence, pers comm.)	9%
Greater Sedona Area (Licher, pers. comm.)	14%
Hubbell Trading Post (Roth, pers. comm.)	13%
Natural Bridges National Monument (Schelz, pers. comm.)	8%
Petrified Forest National Park (Hansen, <i>et al.</i> , 2003)	13%
Zion National Park (Louie, pers. comm.)	11%

Table 8. Brief notes on photos matched during this study at Canyon de Chelly.

Key

GR = Glenn Rink photo number

BK-PG = book and page of my field notes

Date = date of match

Film = color; or black and white film?

Camera = camera used

Lens = lens used

Previous = historic photo date

Shooter = historic photographer

Location = location; AH=Antelope House Ruin; AHO=Antelope House Overlook;
BR=Black Rock Canyon; CdC=Canyon de Chelly; CdM=Canyon del Muerto;
CR=Crack-in-Rock Trail; ds=downstream view; FR=Face Rock;
FRO=Face Rock Overlook; SR=Spider Rock; Jct=Junction; HR=Hand Rock;
LR=Lightning Rock; MC=Monument Canyon; O=Overlook;
SRO=Spider Rock Overlook; TO=Tsegi Overlook; TT=Twin Trails;
us=upstream view; WH=White House; WHO=White House Overlook

Qual. = quality of comparison; do the images show riparian invasion (r.i)?

GR #	Bk-Pg	Date	Film	Camera	Lens	Previous	Shooter	Location	Qual.
1	1-9	4-May-01	b/w	35mm	50mm	1897	Cosmos	1st Ruin	fair
2	1-11	4-May-01	b/w	35mm		1897	Cosmos	ruin #16	poor
3- 4	1-14	5-May-01	b/w	35mm		1897	Cosmos	WH	poor
4- 3	1-15	5-May-01	b/w	35mm		1897	Cosmos	WH	fair
5	1-15	5-May-01	c	35mm	35mm	pre4/59	Davis	WH	fair
6	1-16	5-May-01	c	35mm	45mm	pre10/65	Manley	WH	fair
7	1-20	6-May-01	c	35mm	35mm	pre10/65	Manley	SRO	good
8	1-21	6-May-01	c	35mm	35mm	pre4/59	Davis	SRO	good
9	1-22	6-May-01	c	35mm	70mm	pre11/69	Muench	JTN O	good
10	1-23	6-May-01	c	35mm	40mm	pre10/65	Manley	Ist Over.	good
11-								CdM/BR	
12	1-27	7-May-01	c	35mm	40mm	pre4/59	Davis	Jct	r.i.
12-								CdM/BR	
11	1-27	15-May-01	c	35mm	28mm	pre4/59	Davis	Jct	r.i.
13	1-34	15-May-01	c	35mm	35mm	pre10/65	Manley	Mummy	poor
14	1-35	15-May-01	b/w	35mm	40mm	1897	Cosmos	Mummy	fair
15	1-129	1-Aug-01	c	35mm	35mm	1989	Bob Rink	CR	fair
16	2-45	3-Nov-01	c	35mm	35mm	1989	Bob Rink	mid CdM	fair
17	2-46	3-Nov-01	b/w	70mm	70mm		Wisherd	Mummy	poor
18a	2-48	4-Nov-01	c	35mm	35mm	Nov-86	Bob Rink	TT	fair
18b	2-70	23-May-02	b/w	35mm	50mm	1879-	Hillers	WHO ds	
18c	2-70	23-May-02	b/w	35mm	40mm	1879-	Hillers	WHO us	
18d	2-71	23-May-02	c	35mm	35mm	pre10/65	Manley	WHO ds	
19	2-94	9-Jun-02	c	35mm	45mm	pre10/65	Manley	below Jct	poor
20	2-94	9-Jun-02	c	35mm	28mm	pre10/65	Manley	S's sister	good

GR #	Bk-Pg	Date	Film	Camera	Lens	Previous	Shooter	Location	Qual.
21	2-95	9-Jun-02	c	35mm	40mm	pre10/65	Manley	lower CdM	fair
22	2-95	9-Jun-02	c	35mm	50mm	Az Hwys	Muench	AH	fair
23	2-96	9-Jun-02	b/w	35mm		30s-40s	Gilpin	SC	fair
24	2-97	9-Jun-02	b/w	35mm		expl cyn of death	Wisherd	TT	poor
25	2-97	9-Jun-02	c	35mm		pre10/65	Manley	TT	fair
26	2-113	5-Sep-02	c	35mm			Bandini	LR	good
27	2-141	16-Sep-02	b/w	2 1/4		1940	Grant	Mummy	good
28a	2-142	19-Sep-02	b/w	2 1/4		30s-40s	Gilpin	DW hogan	fair
28b	2-142	19-Sep-02	b/w	2 1/4			Hamilton	Massacre	fair
28c	2-142	19-Sep-02	b/w	2 1/4			Hamilton	Mummy up	fair
29	2-143	19-Sep-02	c	35mm		pre8/79	Davis	AHO	good
30	3-1	20-Sep-02	b/w	2 1/4				nr. Giant	good
31	3-2	21-Sep-02	b/w		45mm	pre4/59	Davis	Mummy	
32	3-4	22-Sep-02	c	35mm		pre10/65	Manley	Zuni area	r.i.
33	3-5	22-Sep-02	b/w	2 1/4			Curtis?	mid CdC	r.i.
34	3-5	22-Sep-02	c	35mm	40mm	pre10/65	Manley	Window	good
35	3-5	22-Sep-02	b/w	2 1/4		1940		Window	good
36	3-7	23-Sep-02	b/w	2 1/4				AH	good
37	3-7	26-Sep-02		2 1/4		1949	DeHarport	FRO	good
38	3-8	26-Sep-02		2 1/4		1949	DeHarport	FRO	good
39	3-8	26-Sep-02	b/w	2 1/4		Oct-59	Hamilton	Jct Over.	fair
40-									
41	3-9	26-Sep-02	b/w	35mm	26mm	30s-40s	Gilpin	Jct Over.	fair
41-									
40	3-9	26-Sep-02	c					Jct Over.	good
42-									
43	3-10	27-Sep-02	b/w	2 1/4			NPS	Tse Taa	r.i.
43-									
42	3-10	27-Sep-02	c	35mm	40mm		NPS	Tse Taa	r.i.
44a	3-11	28-Sep-02	b/w	2 1/4	80mm	1879	Hillers	SR	good
44b	3-11	28-Sep-02	c	35mm			Hopkins	CdC us	r.i.
45-									
46	3-13	4-Oct-02	b/w	2 1/4		Apr-64	NPS	WH	fair
46-									
45	3-13	4-Oct-02	c	35mm	40mm	Apr-64	NPS	WH	fair
47	3-13	4-Oct-02	b/w	2 1/4	90mm	Apr-53	Hamilton	WH	fair
48	3-14	4-Oct-02	b/w	2 1/4		Sep-53	Hamilton	WH	good
49	3-15	4-Oct-02	b/w	2 1/4	80mm	41 or '42	A. Adams	WH	good

GR #	Bk-Pg	Date	Film	Camera	Lens	Previous	Shooter	Location	Qual.
50	3-17	5-Oct-02	b/w	2 1/4	90mm		DeHarport	SR	good
51	3-18	5-Oct-02	c	35mm	30mm	Dec-86	Bob Rink	SR	good
52	3-19	19-Oct-02	both	2 1/4				TO	good
53	3-19	19-Oct-02	b/w	2 1/4	45mm	Mar-56	Hamilton	TO	good
54	3-20	19-Oct-02	c	35mm	35mm	30s-40s	Gilpin	TO	good
55	3-20	19-Oct-02	b/w	2 1/4		1949	DeHarport	TO	good
56	3-21	25-Oct-02	b/w	2 1/4	70mm	Oct-55	Hamilton	WH	good
57	3-21	25-Oct-02	b/w	2 1/4	100mm	1949	DeHarport	mid CdC	good
58	3-22	25-Oct-02	b/w			30s-40s	Gilpin	WH	good
59	3-22	25-Oct-02	b/w	2 1/4		1965	NPS	Bridge	good
60	3-23	26-Oct-02	b/w	2 1/4	90mm	1949	DeHarport	SR	good
61	3-23	26-Oct-02	c	digital		1984	Bob Rink	FR	r.i.
62	3-23	26-Oct-02	c	digital			Bob Rink	SR	good
63	3-24	26-Oct-02	b/w	2 1/4		1879	Hillers	HR	good
64	3-24	26-Oct-02	b/w	2 1/4	85mm	1873	O'Sullivan	HR	good
65	3-25	26-Oct-02	c	digital			Bob Rink	Bat	fair
				dig.,35m					
66	3-25	26-Oct-02	c	m	35mm	Oct-79	G.Rink	SR	fair
67	3-25	26-Oct-02	c			Oct-79	G.Rink	Bat	r.i.
68	3-25	26-Oct-02	c			Oct-79	G.Rink	Bat	r.i.
69	3-26	26-Oct-02	b/w	2 1/4	80mm	Feb-05	O'Sullivan	MC	good
70	3-26	26-Oct-02	b/w	2 1/4		1879	Hillers	SR	r.i.
71	3-27	26-Oct-02	b/w	2 1/4		1879	Hillers	SR	fair
72	3-27	26-Oct-02	b/w	2 1/4		1879	Hillers	SR	fair
73	3-27	26-Oct-02	c	digital		pre10/65	Manley	SR	fair
74	3-28	27-Oct-02	b/w	2 1/4	45mm	1879	Hillers	FR dn	fair
75	3-28	27-Oct-02	b/w	2 1/4	45mm	1879	Hillers	FR up	fair
76	3-29	27-Oct-02	b/w	2 1/4		1879	Hillers	SR up	fair
A			c	35mm		pre4/59	Davis	WH	good
B			c	35mm		pre4/59	Davis	Mummy	fair

Table 9. Some of the tree (and other) planting and erosion control work conducted at Canyon de Chelly National Monument from the 1940s through the 1960s. This gives an idea of the intensity of these projects.

<u>Year</u>	<u>Work</u>	<u>Where</u>
1947	willow planting	White House and Antelope House
1948	Peach leaf willow planting	White House and Antelope House
1949	1000 trees planted	canyon mouth
	7000 willows planted	White House
1950	4000 willows planted	Tse Ta'a
	200 jetties built	Twin Trails
	300 jetties built	above White House
1952	150 Russian olive and Chinese elms planted	Headquarters area
	3000 pounds of grass seed planted	
	350 jetties built	
1953	2500 pounds of grass seed planted	
1954	removal of trees	White House
1956	removal of trees	White House
1958	240 jetties built	Standing Cow Ruins
	160 jetties built	Antelope House
	240 jetties built	Tse Ta'a
1963	5000 trees planted	
	147 jetties built	Twin Trails
1964	16,300 Russian olive, golden leaf willow, and cottonwood seedlings planted	
1965	15,000 seedlings planted 5000 willow cuttings planted	

Table 10. Visitation rates and activities at Canyon de Chelly National Monument during 2001 and 2002 (Canyon de Chelly National Monument monthly use reports).

	<u>2001</u>	<u>2002</u>
Canyon de Chelly visitation	2,032,740	1,890,878
Concession vehicles entering canyons	23,853	18,736
Private tour vehicles entering canyons	13,606	16,088
NPS campground overnight stays	32,400	26,514
Inner canyon overnight stays	1,148	1,246
Horse trips	4,100	3,983

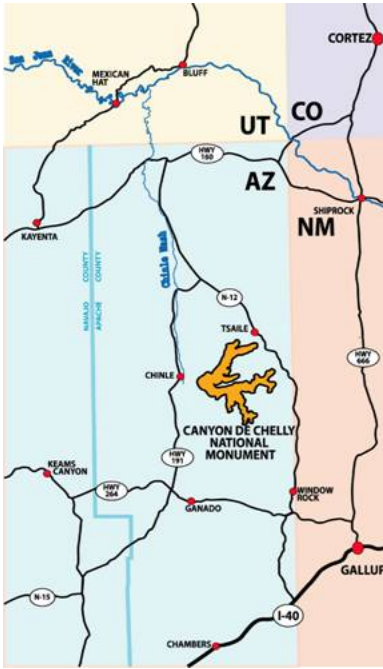


Figure 1. Canyon de Chelly region.

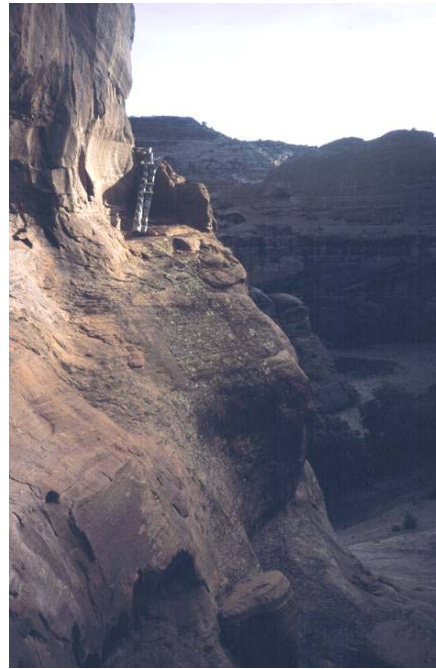


Figure 2. Along the Baby Trail, Canyon del Muerto.

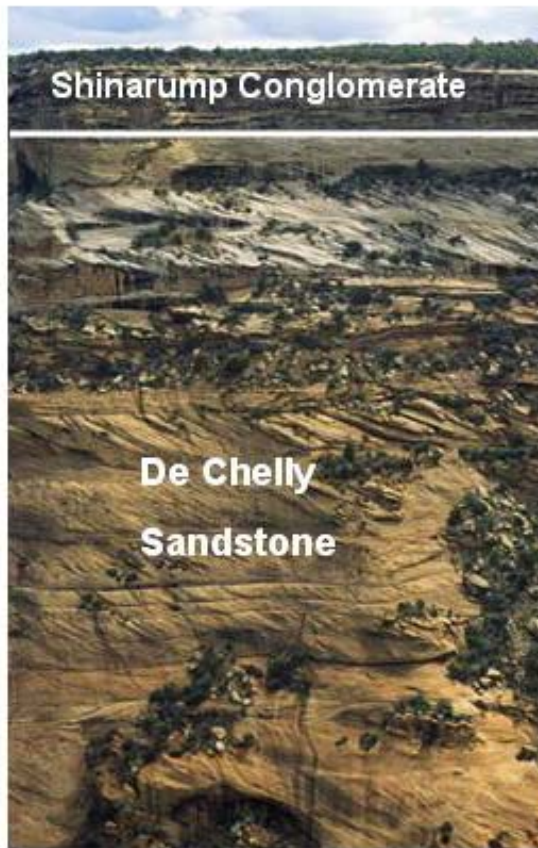


Figure 3. Stratigraphy of Canyon de Chelly. Massive cross-bedded De Chelly Sandstone overlain by thin layer of dark, resistant Shinarump Conglomerate.

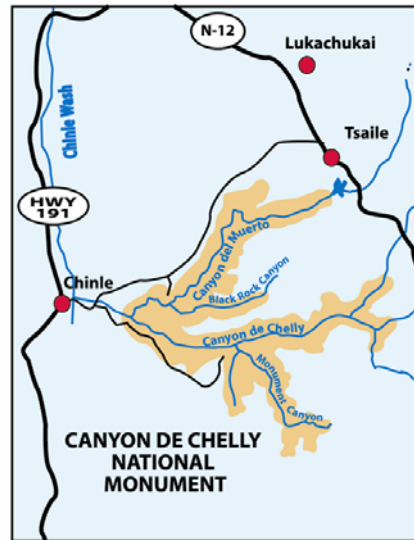


Figure 4. The canyon system at Canyon de Chelly National Monument.

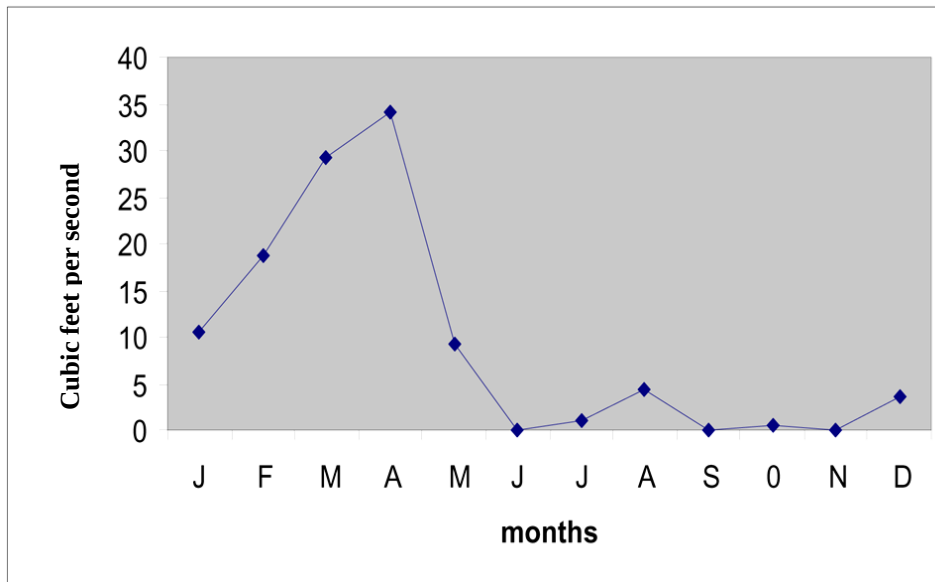


Figure 5. Chinle Wash monthly mean streamflow at the mouth of Canyon de Chelly in cubic feet per second for period December, 1999 to September, 2001 (USGS, 2003).

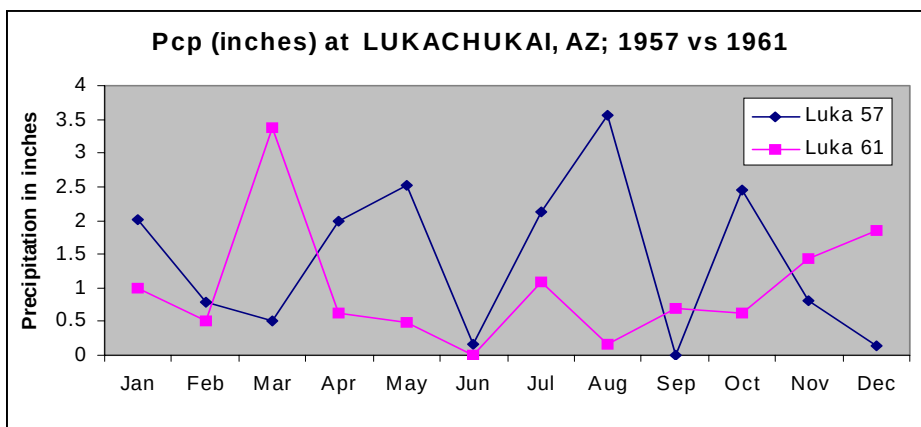


Figure 6. Precipitation at Lukachukai. Precipitation is highly variable at Lukachukai, a good model for the precipitation pattern in the upper elevations of Canyon de Chelly.

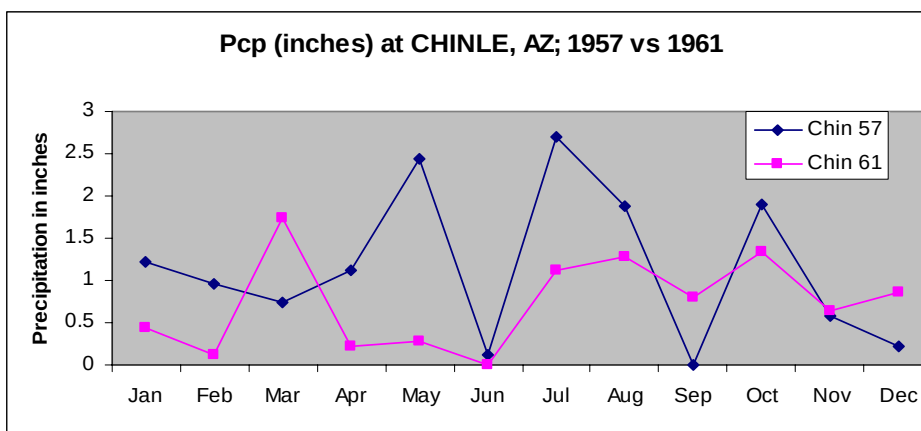


Figure 7. Precipitation at Chinle. Precipitation is highly variable at Chinle, a good model for the precipitation pattern in the lower elevations of Canyon de Chelly.

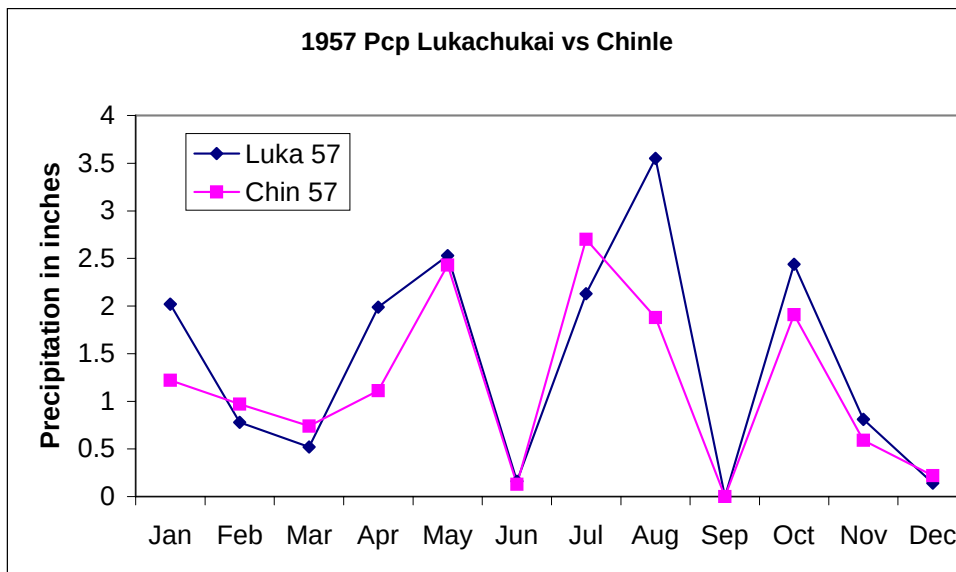


Figure 8. Comparison of Average Monthly Precipitation at Lukachukai (high elevation) and Chinle (lower elevation) during 1957.

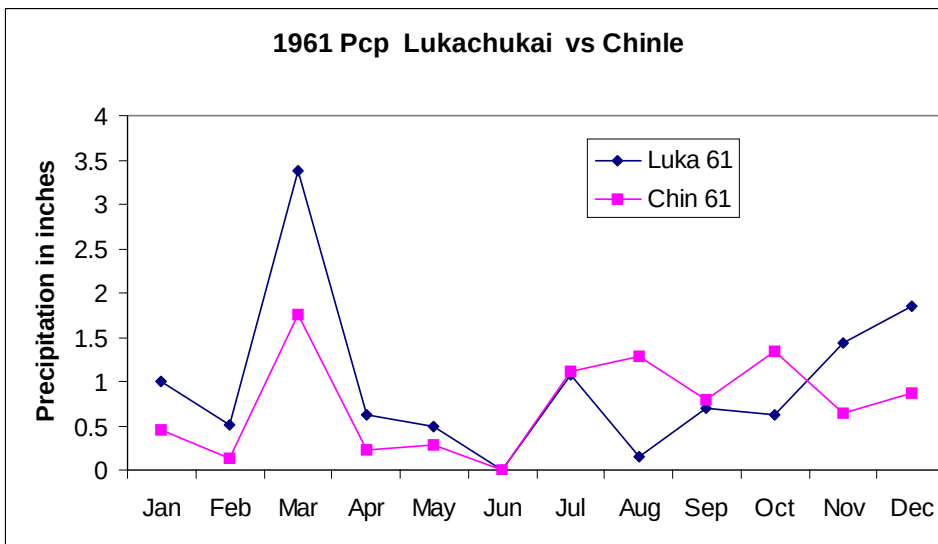


Figure 9. Comparison of Average Monthly Precipitation at Lukachukai and Chinle during 1961. 1957 and 1961 were compared because they were the only two years of complete records for both weather stations. Lukachukai averages slightly more precipitation than Chinle.

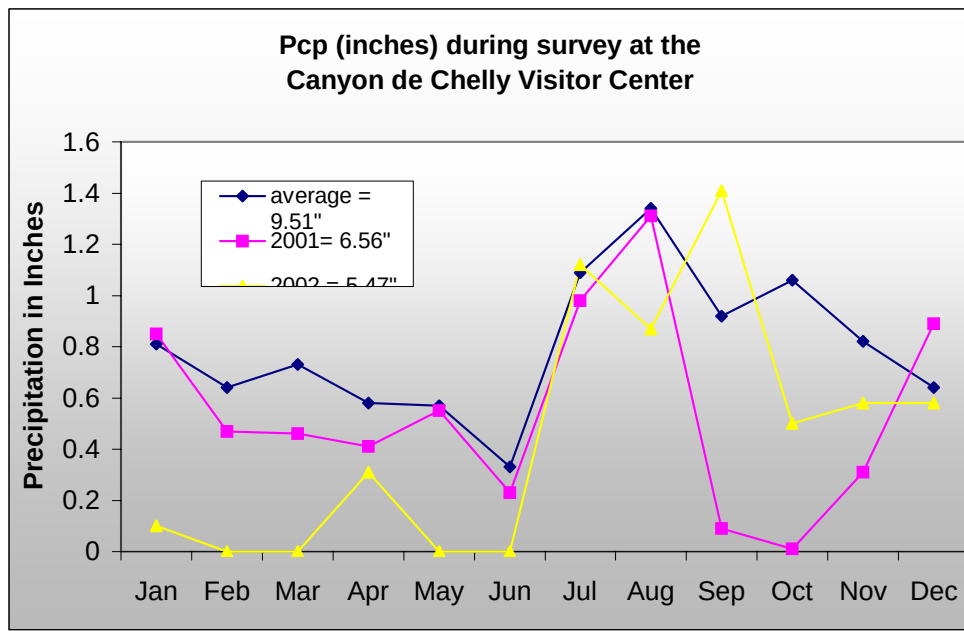


Figure 10. Precipitation monthly averages for the two years of study compared to the monthly average (for the period of record) at the Canyon de Chelly Visitor Center. Spring, 2001 precipitation was slightly below average, but fall, 2001 precipitation was far below average. Spring, 2002 precipitation was far below average, but fall, 2002 precipitation was only slightly below average.



Figure 11. *Zigadenus vaginatus*, death camas.
Canyon de Chelly hanging gardens harbor the southernmost populations of these plants.

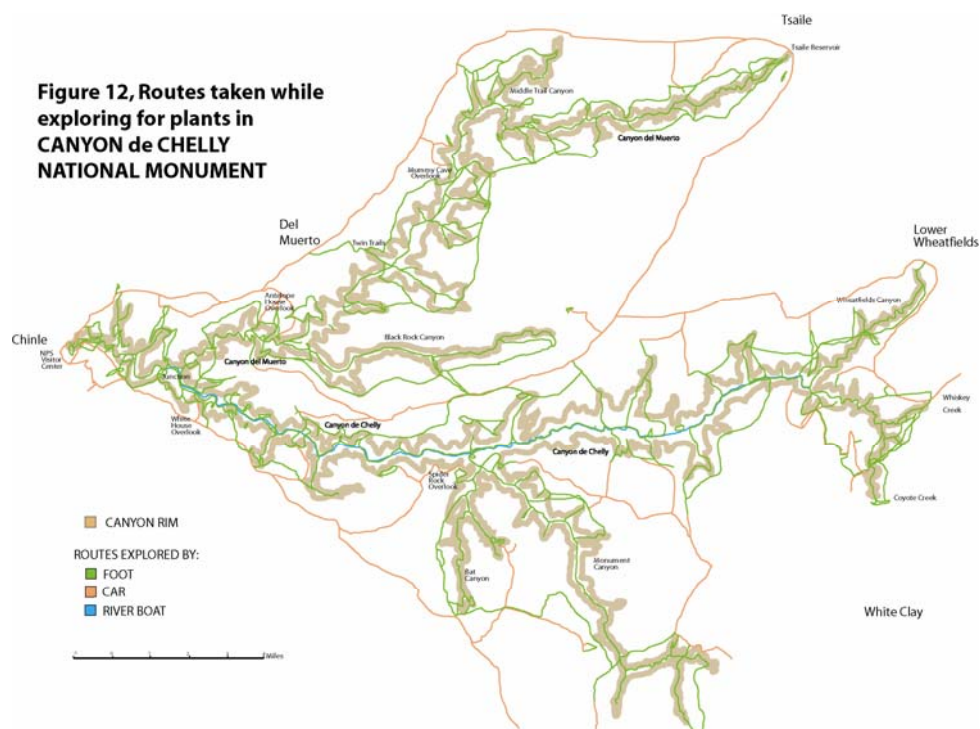


Figure 12. Routes taken while exploring for plants at Canyon de Chelly National Monument.

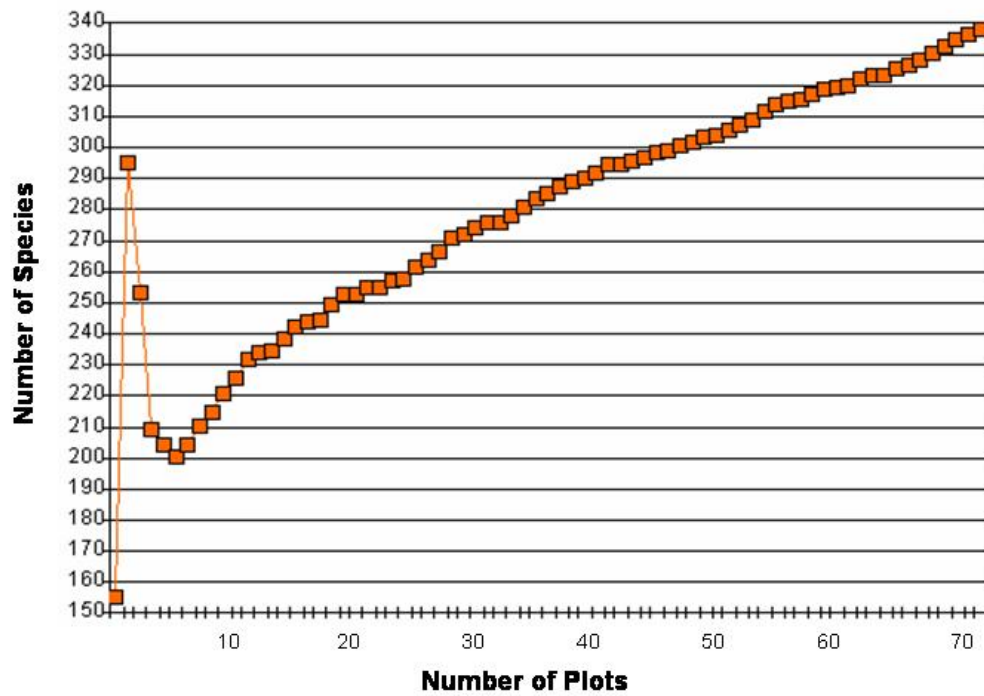


Figure 13. ICE model of estimated species diversity. Number of plots is on the x-axis ($n = 72$). Number of species is on the y-axis. Estimated species diversity increases with each added plot from the left side of the graph to the right side of the graph. Many more random plots would be needed to estimate theoretical plant diversity at Canyon de Chelly using this model.

Halse + Rink sub-generic taxa accumulation/day

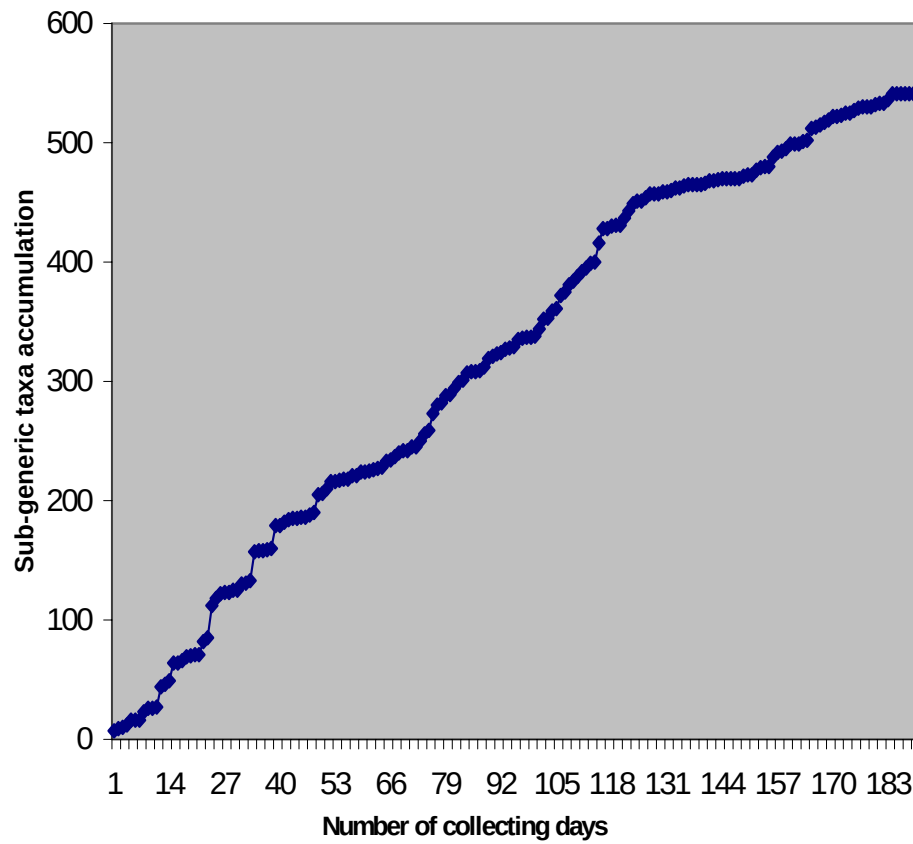


Figure 14. Halse and Rink sub-generic taxa (species, sub-species, varieties, and hybrids) accumulation per day.

Halse and Rink sub-generic taxa accumulation/10 collections

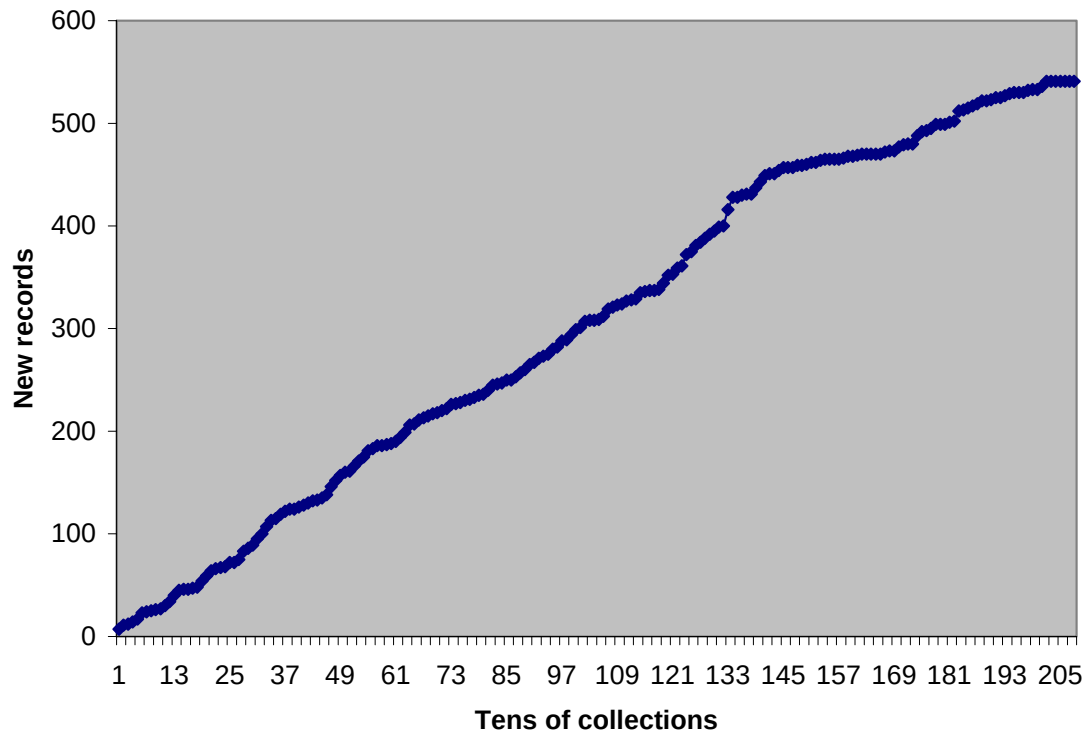


Figure 15. Halse and Rink sub-generic taxa (species, sub-species, varieties, and hybrids) accumulation per 10 collections.

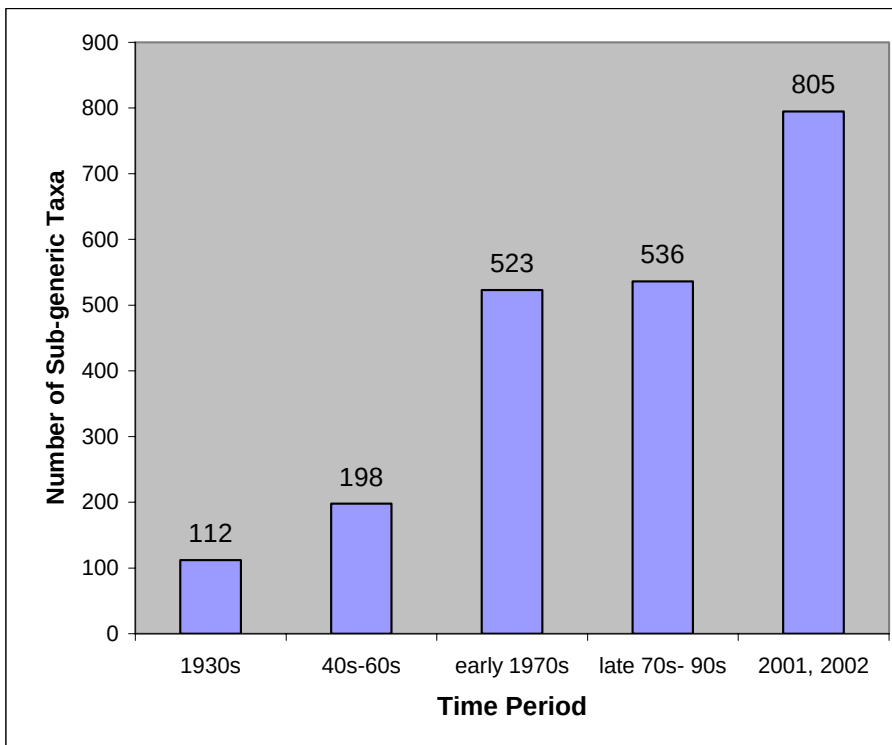


Figure 16. Sub-generic taxa accumulation from the 1930s through 2002.

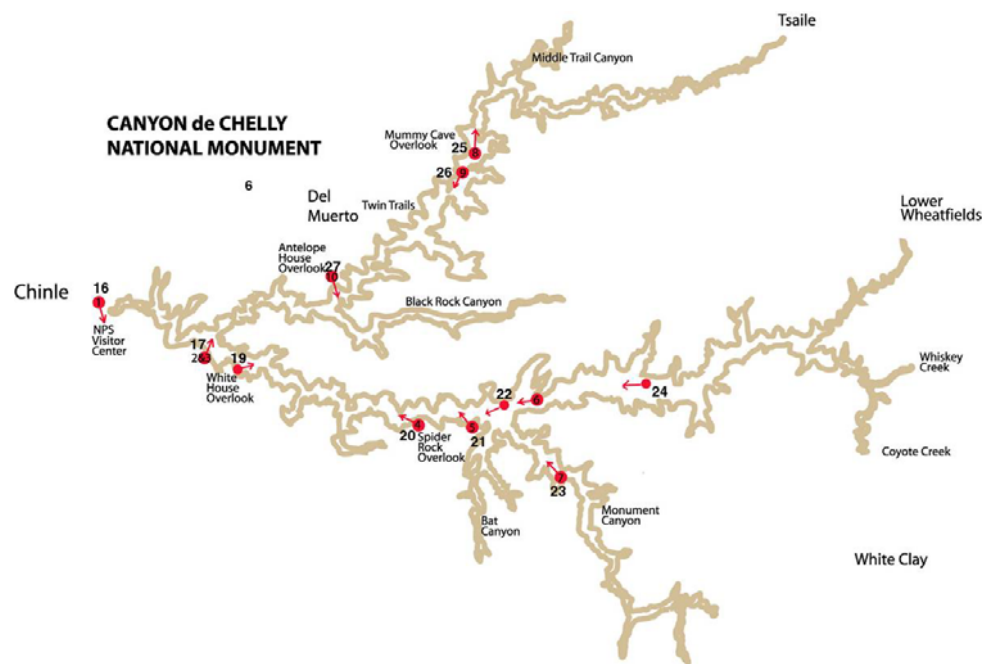


Figure 17. Locations of Canyon de Chelly photo matches: Figures 16 -17 and 19 - 27.



Figure 18a and 18b. National Park Service photo (top) and replicate photo (bottom) at the bridge over Chinle Wash.

An NPS photographer captured the bridge under construction near the Visitor Center in 1965 (Courtesy of the National Park Service, Image Catalog #CDC-535.) I was able to make a very close replicate (#59) on October 25, 2002 based on foreground rocks barely visible in the older photograph (bottom). Riparian vegetation invasion by cottonwood, Russian olive, and tamarisk is obvious. Not so obvious is the increased vegetation around the Visitor Center and more cottonwoods in the campground behind the Visitor Center. The small shadscale (*Atriplex confertifolia*) shrub in the right foreground of the old photo is still there, though smaller and in bad shape. The shrub on the left in the old photo is now gone.

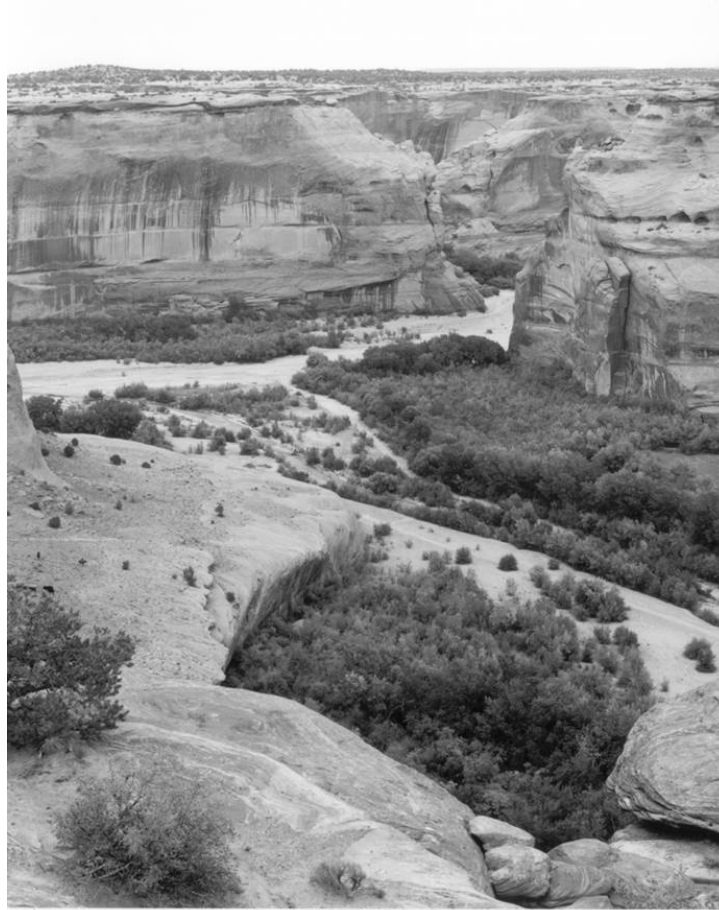
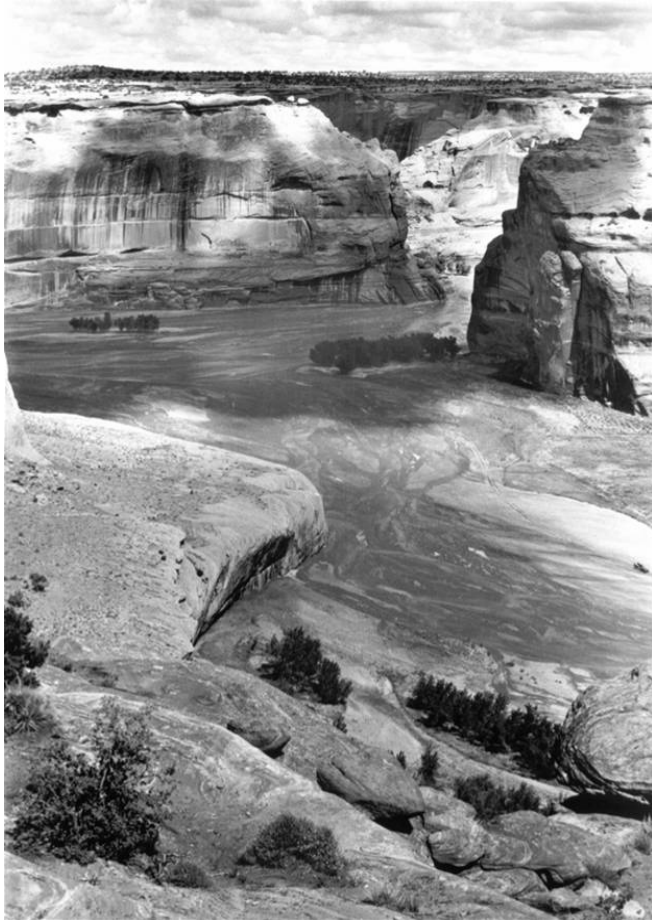
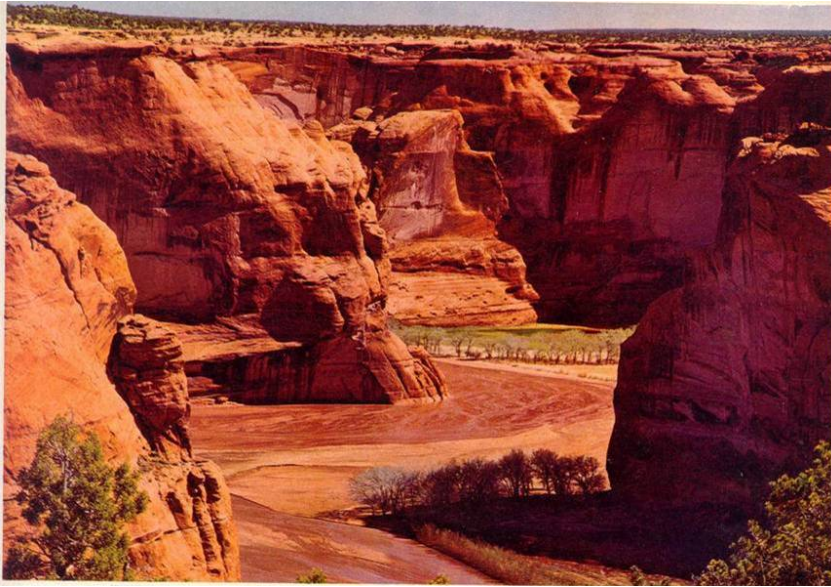


Figure 19a and 19b. Match of Gilpin photo at the Junction. This pair and the next pair of photographs exemplify riparian vegetation invasion at Canyon de Chelly National Monument.

In these four photographs of the junction of Canyon del Muerto and Canyon de Chelly (Fig. 19a-19d), Canyon del Muerto comes in from the distance, Canyon de Chelly comes in from the right, and they continue downstream to the left.

Laura Gilpin, a well-known western photographer, made this gelatin silver print (left, below) titled *Junction Overlook, Canyon del Muerto Joins Canyon de Chelly* (©1979, Amon Carter Museum, Ft. Worth, Texas, Bequest of the artist, P1979.128.126) in the 1950s. My September 26th, 2002 exposure (right, above) is a very close match based on foreground objects. Two large rocks in Gilpin's foreground, which must have measured 1-2 meters in diameter, are now gone.

Cottonwood trees are the only recognizable riparian vegetation in the old photo, whereas the modern channel is lined with cottonwood, Russian olive, willow, and tamarisk. The small field up against the far wall at the extreme right hand edge of Gilpin's photo has been abandoned and is now dominated by Russian olive. In the 1950s, this field was only a foot or two above the broad floodplain, so crop plants were close to the water table, but the field would have been susceptible to frequent flooding. Since the 50s, the channel has deepened and become more constricted.



Figures 19c and 19d. Josef Muench photo (top) and replicate photo (bottom) at the Junction. Muench's photo, taken prior to 1969, shows the transition from the earlier Gilpin photograph to the modern scene. I replicated Muench's scene on May 6, 2001 (photo #9).

In the Muench photo, the small field has been expanded and was then protected from the stream by lines of planted(?) willow(?) and tamarisk trees, as well as the cottonwood trees that were present in the earlier Gilpin photo. These trees constricted the channel and probably caused the channel to deepen, allowing terraces to begin forming. A deeper channel may have resulted in a lowered water table. The field may have been abandoned because crop plants were unable to access the water table, which was lowered due to channel deepening. A low band of vegetation in front of the cottonwoods in Canyon del Muerto was replaced with a band of Russian olive. The field behind the row of cottonwoods is in the process of being invaded by Russian olive.

Gilpin's photograph shows the canyon bottom as one terrace from wall to wall. Two distinct terraces can be differentiated in the Muench photo. In the modern scene, the riparian zone can be easily differentiated into three distinct terraces. Water flows regularly on the lowest (1st) terrace. The middle (2nd) terrace floods occasionally and is somewhat vegetated with tamarisk, willow, Russian olive and herbaceous plants. The upper (3rd) terrace rarely floods and is thickly vegetated with cottonwood and Russian olive. These three terraces can be recognized throughout much of Canyon de Chelly National Monument today.

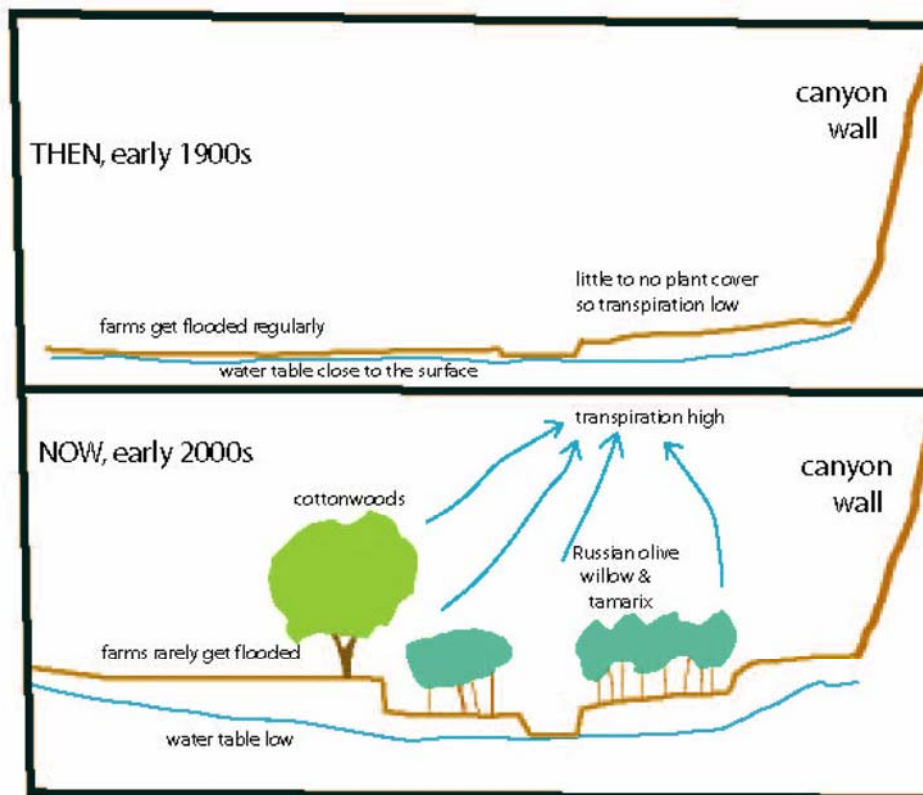


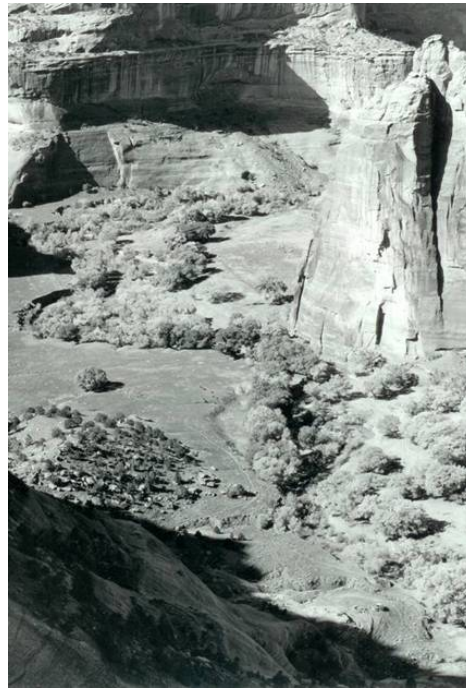
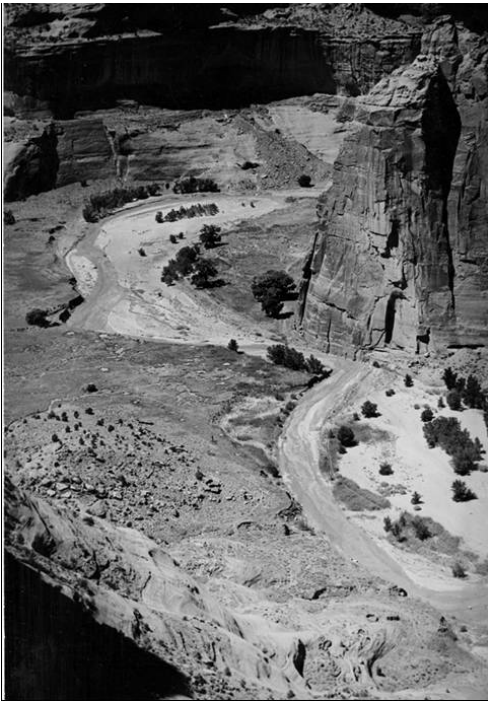
Figure 20. Schematic of historic riparian changes. These changes may reduce the water availability to local farmers, by increased water loss due to transpiration, lowered water tables due to entrenchment, and reduced flooding of terraces, also due to entrenchment. (Culler, 1982).



Figure 21a and 21b. Ansel Adams photo (top) and replicate photo (bottom) from the top of the White House Trail.

Adams photographed this well-known scene during an afternoon in October of 1941 (Courtesy of the National Archives (NWDNS-79-AA-C02), and he noted that his photo was a close match to an earlier O'Sullivan photograph (Stillman and Turnage, 1992). I replicated Adams' photo on October 4, 2002 (photo #49).

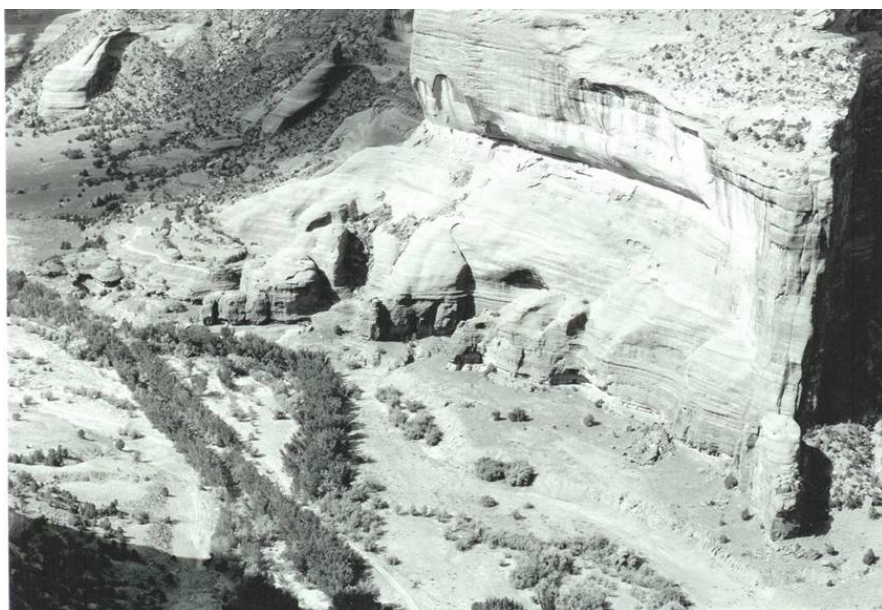
New terraces have formed and many new tamarisk, Russian olive, willow and cottonwood trees have invaded the riparian zone. The channel is much more constricted (and likely deepened) now. Piñon and juniper cover on foreground slopes has increased due to both recruitment and growth.



Figures 22a and 22b. David DeHarport photo (left) and replicate photo (right) of canyon floor near the Window.

DeHarport, a mid 1900s archaeologist, photographed this view in the summer of 1949, about noon (Courtesy of the National Park Service, Image Catalog #917.1 (CDC), 58.764). I replicated DeHarport's photo on October 25, 2002 (photo #57).

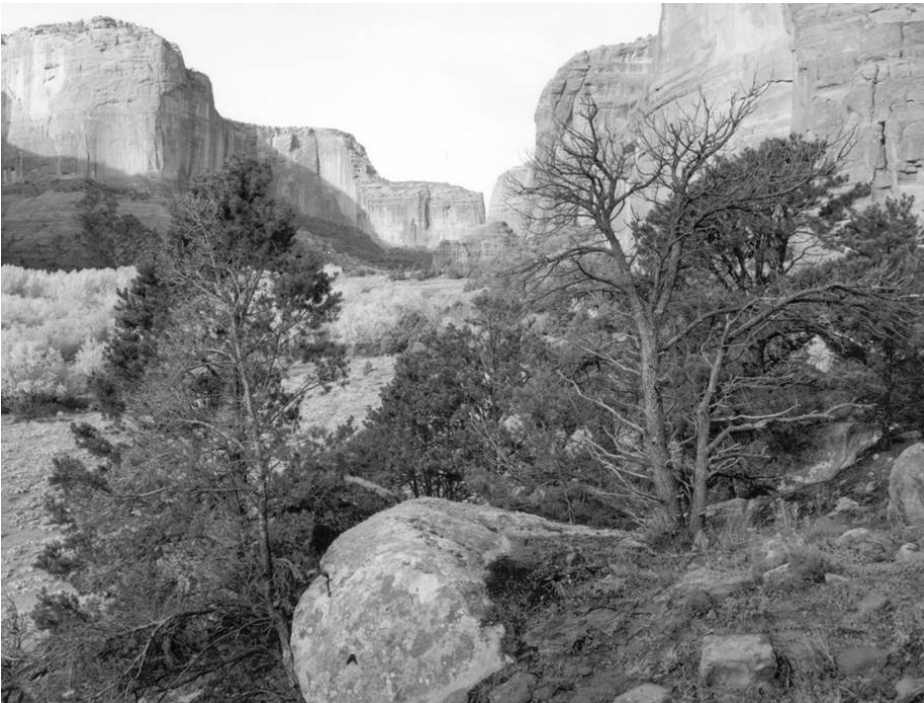
This photo pair illustrates both riparian invasion, and encroachment and cover increase of piñon and juniper. The first right bend of the channel is meandering, constricted, and incised about 5' now. The second right bend has cut extensively into the left side terrace. Russian olive trees have invaded the first terrace and cottonwoods have invaded the second terrace. Near and far talus slopes have more piñon-juniper cover.



Figures 23a and 23b. David DeHarport photo (top) and replicate photo (bottom) from near Face Rock Overlook.

DeHarport took the upper photo during the summer of 1949, about 3-4 pm (Courtesy of the National Park Service, Image Catalog #917.1 (CDC) 58.760). I replicated the scene on September 26, 2002, but had a hard time precisely matching DeHarport's position because of the lack of foreground or other good markers (photo #37).

The channels and terraces have moved in the last 50 years. The gullies on the left side and the edge of the third terrace on right side are more subdued. The main channel has shifted left and cut deeper. Cottonwood and Russian olive now line the banks of the modern channel. Piñon trees have grown and invaded upper terraces and slopes.



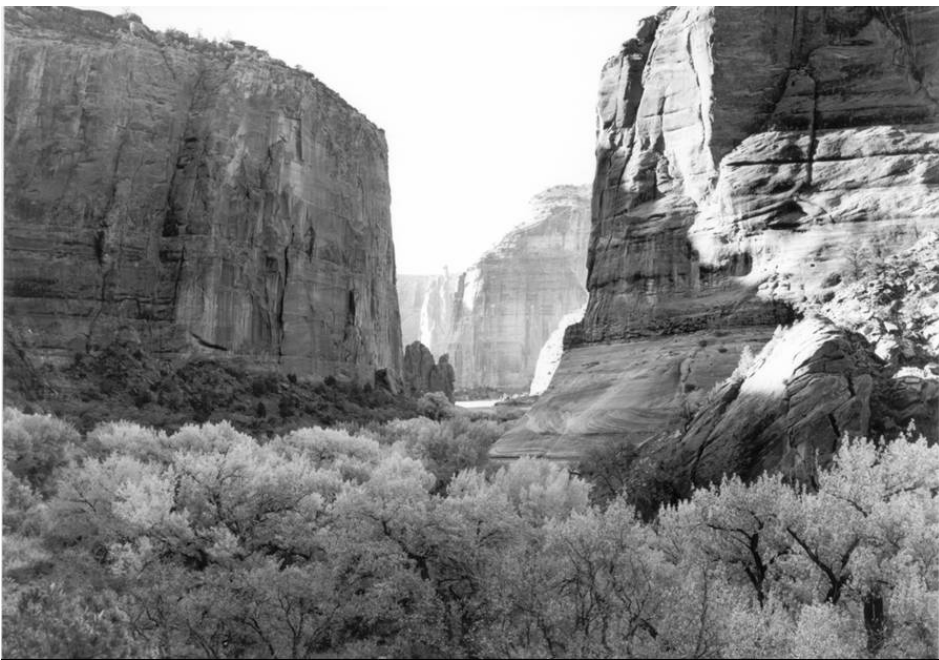
Figures 24a and 24b. Jack Hillers photo (top) and replicate photo (bottom) from near Spider Rock.

Hillers, a well-known late 19th century western photographer, took the top view looking downstream from the base of Face Rock in 1879 (Courtesy National Archives (NWDNS-57-PS-85, Canyon de Chelly)). I captured the modern replicate that was close to, but not on the site of the original photo (note the foreground rocks), on October 27, 2002 (photo #74). The original view, which was taken from about 1 meter down and to the left of my modern match, is now obscured by piñon trees.

Cottonwood and Russian olive trees in the middle ground of the modern scene form a continuous sea of riparian vegetation where the left side of the old, broad channel used to be. Prickly pear cacti cover a new third terrace to the right of the riparian trees.

A comparison of the foreground illustrates invasion of piñon-juniper woodland that has occurred throughout much of Canyon de Chelly National Monument. The slopes in the background also show increased piñon and juniper cover.

Cottonwood and Russian olive trees in the middle ground of the modern scene form a continuous sea of riparian vegetation where the left side of the old, broad channel used to be. Prickly pear cacti cover a new third terrace to the right of the riparian trees.



Figures 25a and 25b. Match of O'Sullivan photo of Monument Canyon.

Timothy O'Sullivan, of the Wheeler Survey, photographed the top view looking downstream in Monument Canyon in 1874. Face Rock is visible in the far distance. I matched the scene on the 26th of October, 2002 (bottom).

Piñon and juniper have invaded the canyon slopes since O'Sullivan took his photo. But the most striking change is the increase in cottonwood cover. I have found no records of tree planting, nor erosion control activities during the 1930s through the 1970s extending this far upstream. Both native and exotic riparian tree cover has increased even without tree planting or erosion control efforts in this reach.

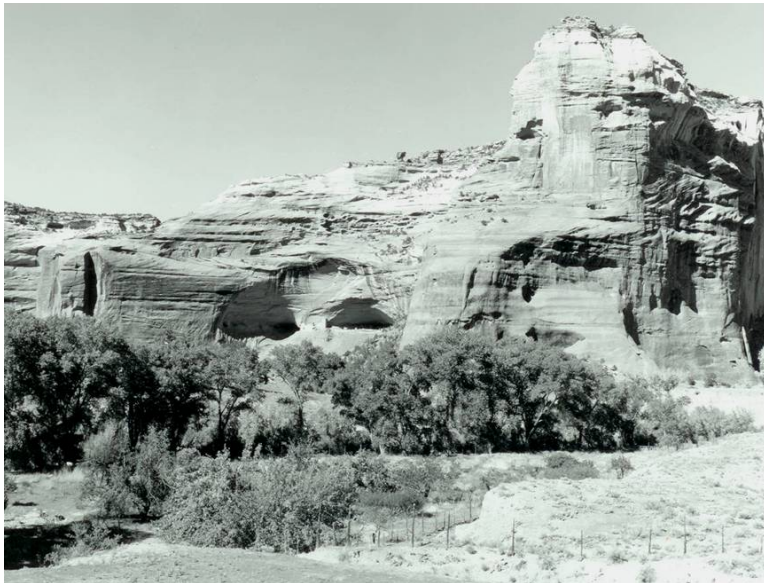
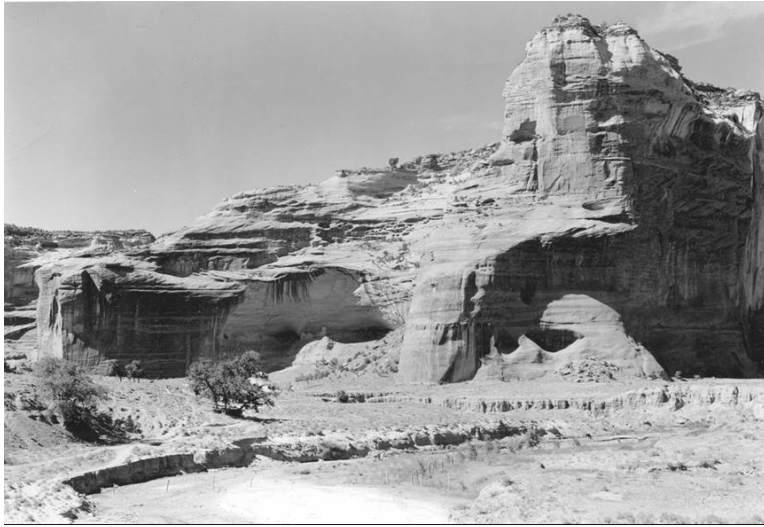


Figures 26a and 26b. Match of Hiller's photo upstream of Spider Rock.

Jack Hillers took the top photograph in 1879 from a point about two miles upstream of Spider Rock. It shows Wide Rock Butte, Spider Rock, and Face Rock from left to right in the far background. Hillers took his photograph from a spot where the view is now obscured by piñon

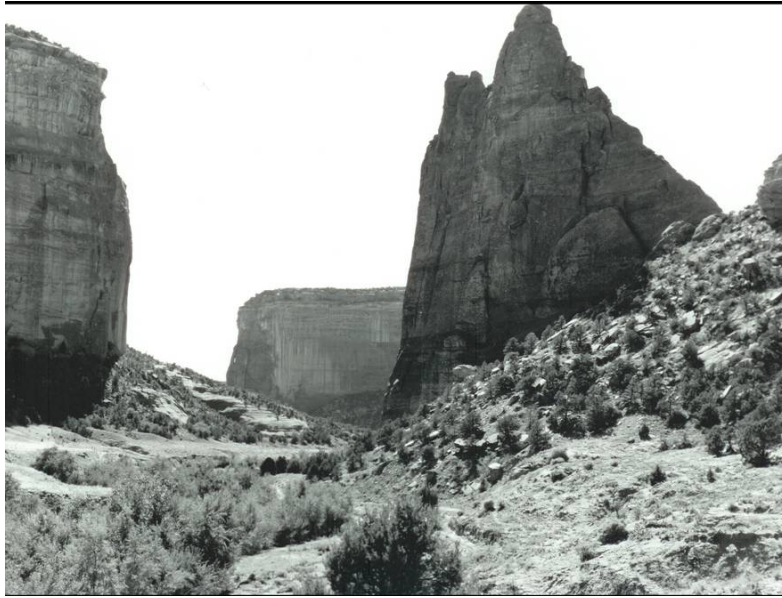
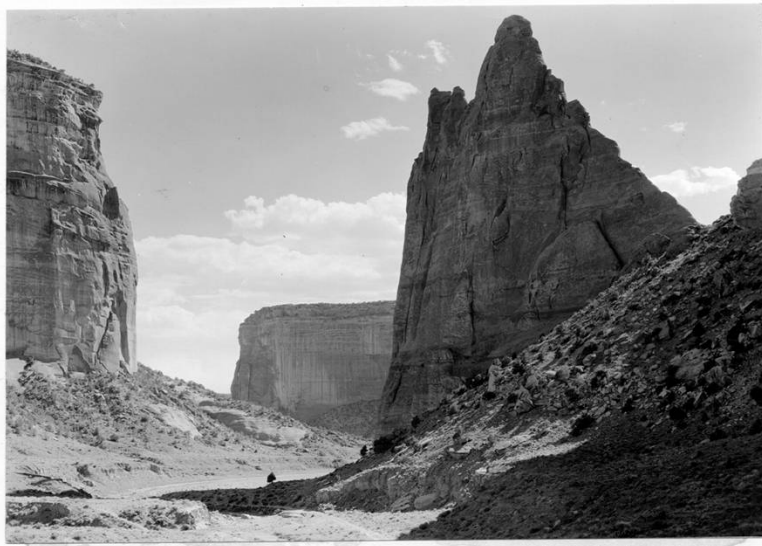
trees, so I went upslope to capture the modern scene on September 28th, 2002. Note that the immediate foreground does not match because the two photographs were not taken from precisely the same spot.

There are now about three times as many piñon trees on the foreground terrace and much more piñon and juniper cover on the slopes in the background. The channel has shifted to the right and the second terrace is now covered with a continuous stand of Russian olive and cottonwood trees. Like the previous photo pair, I have found no records of tree planting or erosion control efforts in this reach.

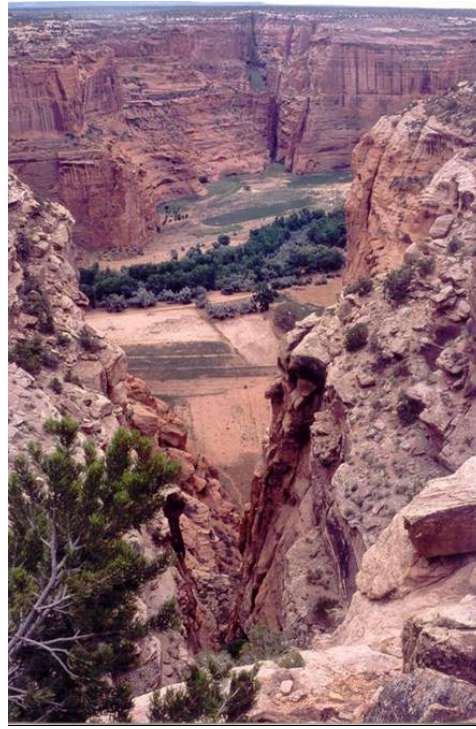
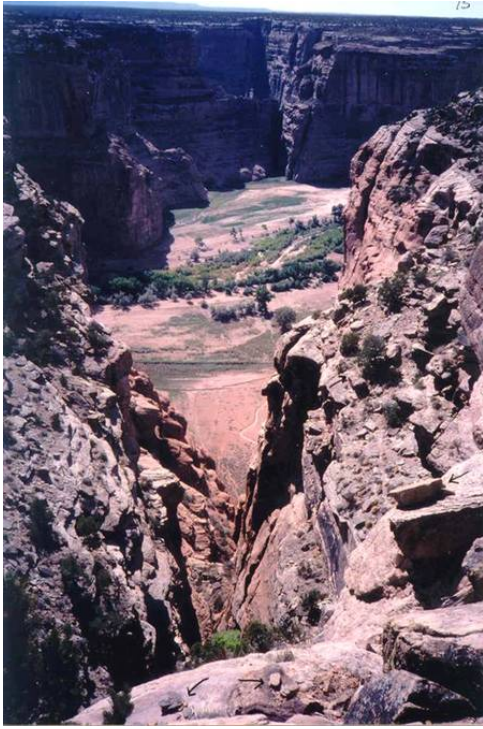


Figures 27a and 27b. George Grant photo (top) and replicate photo (bottom) of Mummy Cave. Grant, a National Park Service photographer, took the top view of Mummy Cave about 2pm, on June 16, 1940 (Courtesy of the National Park Service, Image Catalog #3709). My September 16, 2002 replicate (#27) is a close match, based on the intersections of background objects, even though the foreground fences and terraces don't line up well. These features may have been altered by humans and/or erosion of terraces.

Many cottonwoods and Russian olive now line the channel in the foreground. Piñon-juniper cover on the slopes below Mummy Cave may have tripled.



Figures 28a and 28b. National Park Service photo (top) and replicate photo (bottom) in the middle portion of Canyon del Muerto. This downstream view was taken during mid summer, (1940?) about 3pm (Courtesy of the National Park Service, Image Catalog #228). I replicated the scene on September 20, 2002 (photo #30). The cut bank at the bottom of photo is now gone. Riparian trees (dominated by Russian olive and some cottonwoods) now cover much of the 2nd and 3rd terraces. There is a new juniper tree in the center foreground and much more piñon and juniper cover on the talus slopes on both sides of the canyon.



Figures 29a and 29b. Bob Rink photo (left) and replicate photo (right) from near the top of the Crack Trail. Bob Rink, my brother, took the photograph on the left looking down the upper part of the Crack Trail in Canyon del Muerto in 1989 (Courtesy of Bob Rink Photography). I was able to make a very close replicate based on foreground rocks on August 1, 2001 (photo #15).

Russian olive, tamarisk, willow and cottonwood cover in the riparian zone has increased, evidence that riparian invasion continued into the 1990s. Farms dominate more of the canyon bottom now and an orchard has grown or been added on the opposite side of the canyon. Piñon and juniper cover have increased since Bob took his photo, even with little to no recruitment of piñon or juniper trees (note foreground piñon tree obscuring a portion of the foreground now.) Rocks in the foreground (arrows) have moved or fallen off the cliff.



Figure 30. Beaver dam constructed at the confluence of Coyote and Wheatfields Creeks during the spring of 2001.



Figure 31, Small, old concrete dam near the mouth of Spring Canyon, Canyon de Chelly.



Figure 32, Sheep grazing in upper Wheatfields Canyon.



Figure 33, Signs of recent woodcutting on the rim of Monument Canyon.

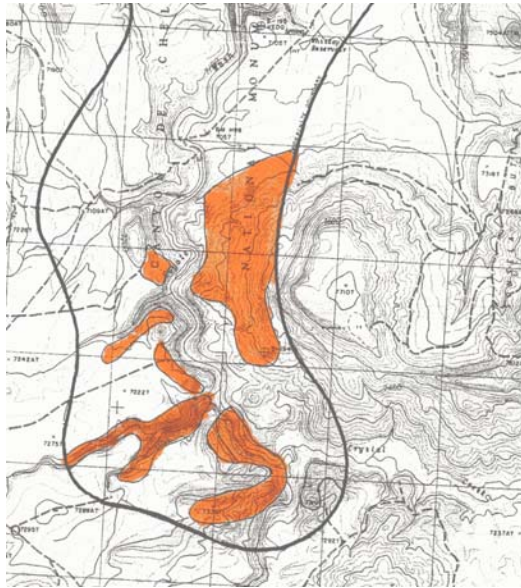


Figure 34. Areas adjacent to Coyote Creek within Canyon de Chelly National Monument and mostly logged in the 1970s, Scale 1:62,500 (Canyon de Chelly National Monument resource files).

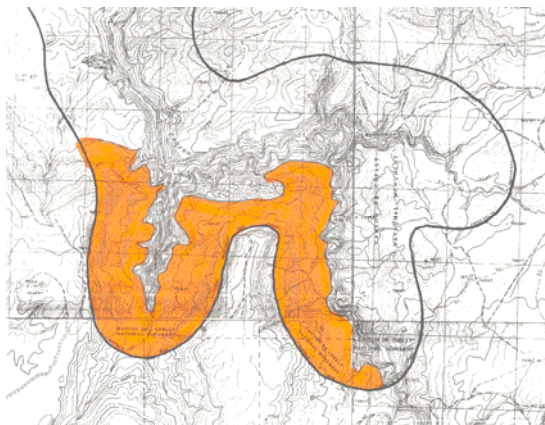


Figure 35. Logged areas on the south rim of Monument Canyon within Canyon de Chelly National Monument, Scale 1:62,500 (Canyon de Chelly National Monument resource files).



Figure 36. Pile of chained material on the south rim of Canyon de Chelly

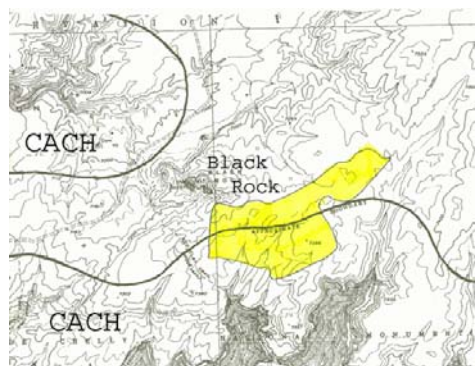


Figure 37. Chained areas close to Black Rock, on the north side of Canyon de Chelly (Canyon de Chelly National Monument resource files). Dark lines are the approximate boundary of the National Monument. CACH = Canyon de Chelly National Monument.

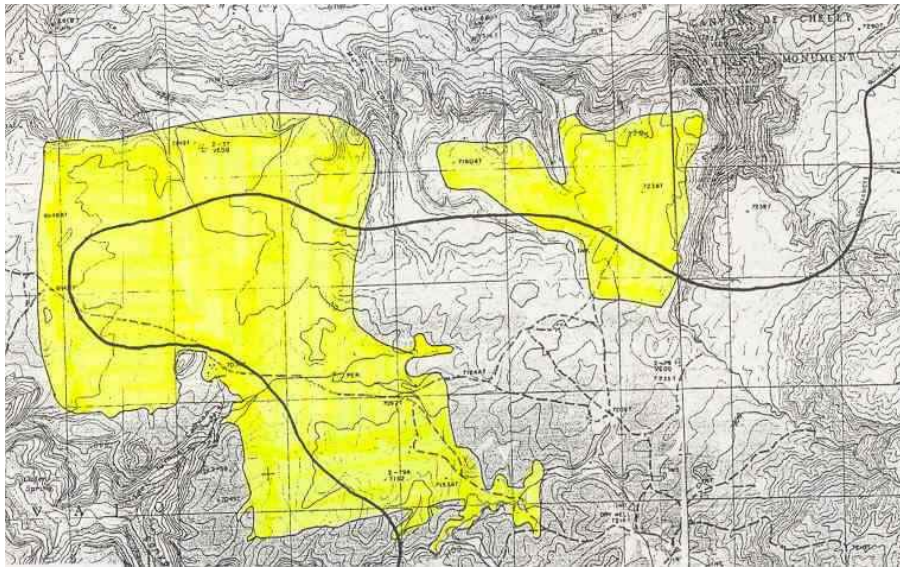


Figure 38. Chained areas on the peninsula between Canyon de Chelly and Monument Canyon (Canyon de Chelly National Monument resource files). Dark line is the approximate National Monument boundary.

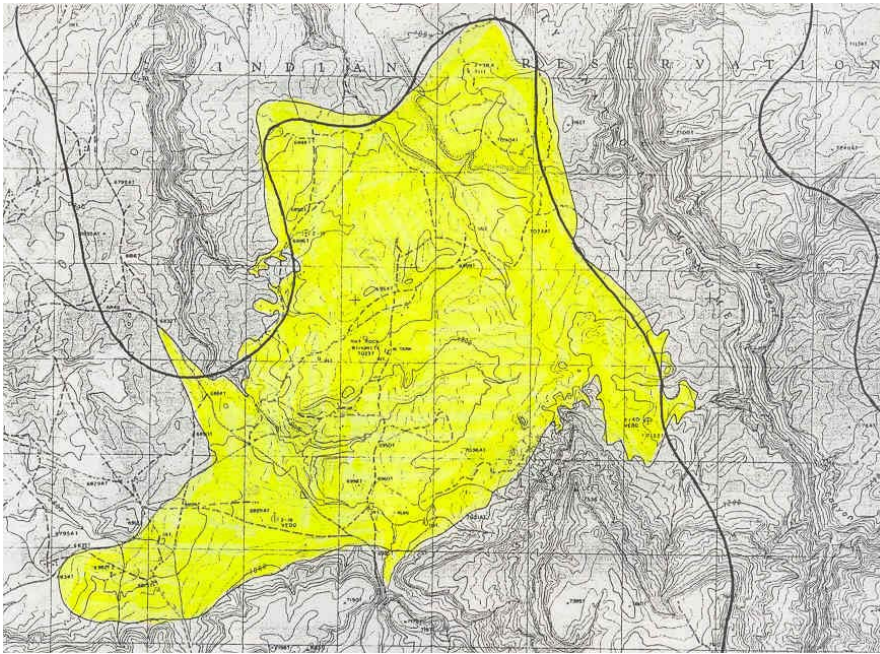


Figure 39. Chained areas on the peninsula between Bat (left) and Monument (right) Canyons (Canyon de Chelly National Monument resource files). Dark line is the approximate National Monument boundary according to USGS maps. Note that the boundary of the chained area approximates the National Monument boundary.

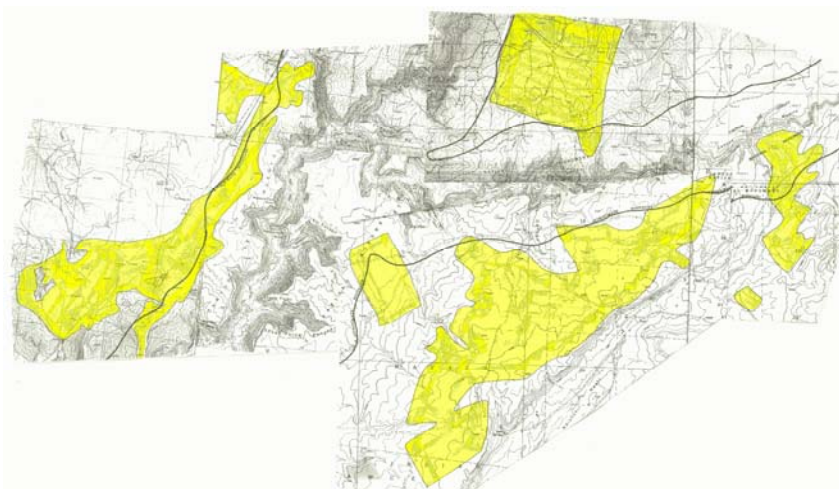


Figure 40. Chained areas within and adjacent to Canyon de Chelly National Monument on the rims of Canyon del Muerto, Scale 1:62,500 (Canyon de Chelly National Monument resource files).



Figure 41, Refuse dumped over the canyon rim.

APPENDIX 1. Vascular Flora of Canyon de Chelly National Monument

Family	Latest name w/ authority (from ITIS,	Native (N) vs exotic (E)? (ITIS) horticultural intro (H)? (pers. obs.),
<i>previous family</i>	unless otherwise noted)	abundance scale (0-5), distribution in CACH; cyn=canyon,
<i>name</i>	previous synonym for; or previously determined as; common name (from ITIS, unless otherwise noted)	CdM=Cyn del Muerto, CdC=Cyn de Chelly, hg=hanging garden, h rep= Halse reported, jct= confluence of CdC & CdM, MC=Monument Canyon, T= Thunderbird Lodge, VC= NPS visitor center, WH=White House Collectors ; B=Bailey, Ba=Barr, Bu=Burgess, C=Cronyn, Cu=Cutler, Goodman, & Payson, D=Dennis, De=Demaree, F=Farmer, Fl=Fladager, h=Halse, Ha=Hand, H =Heggie, <i>H</i> =Heil, H=Hevly, He=Hevron, K=King, L=Lindsay, M =Mason, m=Mayes, M=Miranda, P=Payson, R=Ranzoni, r=Rink, R =Roth, W=Western Area Archeological Center (collector unknown. WAAC specimen labels often don't include collector name.) Collector number follows.
Aspleniaceae	Asplenium resiliens Kunze blackstem spleenwort	N, 2, rock crannies, lower canyons r271 h11, 799
Dryopteridaceae	Cystopteris fragilis (L.) Bernh brittle bladderfern	N, 0, cracks in walls of upper CdM h 329, 475, 879
	Cystopteris reevesiana Lellinger	N, 1, cliffs above pool in upper MC

	Reeve's bladderfern	r505
	<i>Cystopteris tennesseensis</i> Shaver	N, 0, Tse Taa Ruins, upper CdM
	Tennessee bladderfern	h
	<i>Cystopteris tenuis</i> (Michx.) Desv.	N, 1, rim of Elephant Grass Spring Cyn
	brittle bladderfern	r1422
	<i>Cystopteris tenuis x utahensis</i> (Michx.) Desv.	N, 1, near top of Wild Cherry Cyn near pool
	Windham & Haufler	r1026
	<i>Cystopteris utahensis</i> Windham & Haufler	N, 2, cliffs above pools in upper canyons
	Utah bladderfern	r516, 572, 576, 625, 664, 1067, 1349, 1393 R
	<i>Dryopteris filix-mas</i> (L.) Schott.	N, 2, cracks in cliffs, lower canyons
	male fern	r711, 721 h 284, 439
	<i>Woodsia neomexicana</i> Windham	N, 2, uppermost tributaries to CdC
	New Mexico cliff fern	r595, 825, 838, 847, 1071
Equisetaceae	<i>Equisetum arvense</i> L.	N, 3, upper cyns & rims
	western horsetail	r610, 613, 1331 Bu781 h192, 935
	<i>Equisetum hyemale</i> L.	N, 1, Black Rock Cyn
	<i>E. hiemale</i>	h193
	horsetail	
	<i>Equisetum laevigatum</i> A. Braun	N, 0, h rep as common thru-out
	horsetail	h92, 179, 212, 221, 336 Ha Ra B356
	<i>Equisetum variegatum</i> Schleich.	N, 1, dry sandy areas

	ex F. Weber & D.M.H. Mohr	r1127, 1193				
	variegated horsetail					
Pteridaceae	Adiantum capillus-veneris L.	N, 3, seeps in lower cys				
	maidenhair fern	r469		h 411		
	Cheilanthes feei T. Moore	N, 3, dry cliffs	r259, 378	D	h8, 443, 575	B225
	slender lipfern					
Selaginellaceae	Selaginella mutica D.C. Eat.	N, 3, dry cliffs & slopes				
	ex Underwood	r357, 1090		h574, 841, D H		
	bluntleaf spikemoss					
Cupressaceae	Juniperus osteosperma (Torr.) Little	N, 5, thru-out				
	Utah juniper	r1961	Bu729	h6, 507, 835	H R129	B237
	Juniperus monosperma (Engelm.) Sarg.	N, 2, perhaps common thru-out				
	one-seed juniper				m	
	Juniperus scopulorum Sarg.	N, 4, upper cys				
	Rocky Mountain juniper	r1561		h 787, 827		
	Juniperus scopulorum var. viridiflora	H, 1, T				
	D. Hill ref. from Rehder (1987)	r1563				
	western red cedar					
	Platycladus orientale (L.) Franco	H, 1, T				
	Thuja orientalis	r1559				
	oriental arborvitae					
Ephedraceae	Ephedra cutleri Peebles	N, 3, probably common at sandy sites				

	prev. det. as <i>E. viridis</i>	r1137	B
	Cutler's ephedra		
	<i>Ephedra torreyana</i> S.Wats.	N, 0, perhaps common, undercollected	
	torrey ephedra	h343, Bu743, R22, B234	
	<i>Ephedra viridis</i> Coville.	N, 4, lower cyns & rims	
	Mormon tea	r1137 h83, 94, 292, 404, 414 B247	
Pinaceae	<i>Picea engelmannii</i> Parry ex Engelm.	H, 1, T-bird Lodge	
	Engelmann spruce	r1955	
	<i>Picea pungens</i> Engelm.	N, 1, upper CdM	
	blue spruce	r623 h 755, Bu784	
	<i>Pinus edulis</i> Engelm.	N, 5, thru-out	
	pinyon pine	r1286 h48, 825, 832 Bu725 R128 B236	
	<i>Pinus ponderosa</i> P. & C. Lawson	N, 5, middle cyns & upper cyns & rims	
	ponderosa pine	h 349	
	<i>Pseudotsuga menziesii</i> (Mirbel) Franco	N, 5, upper & middle cyns	
	Douglas fir	r162 h194, 828 B235	
Aceraceae	<i>Acer glabrum</i> Torr.	N, 3, upper cyns	
	rocky mountain maple	r496, 585, 587, 657, 918	
	<i>Acer negundo</i> L.	N, 5, thru-out	
	box elder	h10, 120, 577, 606	
Amaranthaceae	<i>Amaranthus albus</i> L.	N, 2, disturbed sites	
	<i>A. graecizans</i>	r1550 H h749	

	pigweed	
	Amaranthus blitoides S. Wats.	E, 3, disturbed sites thru-out
	A. graecizans	r1110, 1323, 1348 h 114, 225, 260, 552, 556
	prostate pigweed	
	Amaranthus hybridus L.	N, 0, h rep as common on cyn floor
	smooth amaranth	h 690, 690, 719, 740, 751
	Amaranthus palmeri S. Wats.	N, ?, probably common, upper CdM
	Palmer amaranth	r1001
	Amaranthus powellii S. Wats.	N, 0, Wheatfields Canyon
	Powell amaranth	H h539
	Amaranthus retroflexus L.	E, 2, dist. sites, upper cyns & rims
	redroot amaranth	r 885, 1085, 1492, 1500
Anacardiaceae	Rhus trilobata Nutt.	N, 3, thru-out
	skunk bush	h22, 43, 72, 151 B322
	Toxicodendron rydbergii (Small)	N, 3, thru-out cyns
	Greene	
	Rhus radicans	h68a, 68b, 166, 438 B361
	poison ivy	
Apiaceae	Aletes macdougalii Coult. & Rose	N, 3, <6500', hg and ledges
	MacDougal's aletes	r257, 1172, 1235, 1285 h46
	Cicuta douglasii (DC.) Coult. & Rose	N, 0, h rep. as common in upper CdM
	water hemlock	h465a, 668

Conioselinum scopulorum (Gray)	N, 0, h rep. as common in upper CdM
Coult. And Rose	h675
Rocky Mountain hemlock parsley	
Cymopterus acaulis var. fendleri	N, 3, lower cyns and rims
(Gray) Goodrich	r176, 201, 249 h34, 759, 779, 844, 863 D C
C. fendleri	
Fendler's spring parsley	
Cymopterus bulbosus A. Nels.	N, 2, rim of MC and near T
bulbous spring parsley	r195, 533
Cymopterus purpurascens (Gray)	N, 1, upper cyns & rims >6000'
M.E. Jones	
Utah spring parsley	r170 h768, 783, 830 C
Cymopterus purpureus S. Wats.	N, 2, upper rims >7000'
purple spring parsley	r364, 420, 534
Ligusticum porteri Coult. & Rose	N, 1, upper cyns, h reported as common
Porter's ligusticum	r634, 994 h270, 305, 465b
Lomatium nevadense var. nevadense	N, 2, upper CdM & CdC
(Wats.) Coult. & Rose	r153, 324, 367
Nevada biscuitroot	
Lomatium nevadense var. parishii	N, 0, upper rims
(Coult. & Rose) Jepson	h773, 829 C
Parish biscuitroot	

	Oxypolis fendleri (Gray) Heller	N, 0, upper CdM		
	Fendler's cowbane	h465		
	Pseudocymopterus montanus	N, 2, upper slopes and cyns		
	(Gray) Coult. & Rose	r353, 451, 567, 678	h929	H
	False spring parsley			
Apocynaceae	Apocynum cannabinum L.	N, 2, upper cyns		
	A. suksdorfii	r686	h 674	
	dogbane			
Araliaceae	Aralia racemosa L.	N, 2, upper CdC & Black Rock Cyn.		
	American spikenard	r882, 1082, 1232, 1342		
Asclepiadaceae	Asclepias asperula ssp. asperula	N, 2, lower cyns & rims		
	(Decne.) Woods.	r488, 1216	h87, 167, 399, 167	R132
	prev. det. as A. a. var. decumbens			B 305
	antelope horns			
	Asclepias asperula ssp. capricornu	N, 0, lower cyns & rims		
	(Woods.) Woodson			
	A. asperula var. decumbens			R
	antelope horns			
	Asclepias engelmannii Woodson	N, 0, Baby Trail, lower CdM		
	Engelmann's milkweed	h 424, 502		
	Asclepias involucrata Engelm.	N, 1, rims >7000'		
	dwarf milkweed	r1257	h898	D

Asteraceae	Asclepias subverticillata (Gray) Vail	N, 3, thru-out			
	whorled milkweed	r724, 924, 1073, 1394, 1554	h377, 417, 434, 557, 573, 657	De	
	Asclepias tuberosa L.	N, 2, upper CdM & upper MC			
	butterflyweed	r915, 1226	h280		
	Achillea millefolium var. occidentalis	N, 4, >6000'			
	DC.				
	A. millefolium var. lanulosa	r989	h		
	A. lanulosa				
	yarrow				
	Acroptilon repens (L.) DC.	E, 5, disturbed sites thru-out			
	Centaurea repens	r704	D	h264	R13 H
	Russian knapweed				
	Ageratina herbacea (Gray)	N, 2, upper cyn slopes			
	King & H.E. Robins.				
	Eupatorium herbaceum	r905, 1504		h706	
	fragrant snakeroot				
	Agoseris glauca (Pursh) Raf.	N, 1, rims >7200'			
	pale dandelion	r542, 556			
	Almutaster pauciflorus (Nutt.)	N, 3, riparian			
	A.& D. Love				
	alkali marsh aster	r1055, 1480, 1501, 1537			

Ambrosia acanthicarpa Hook.	N, 3, disturbed sites thru-out		
bursage	r821, 1013, 1096, 1105	h726, 744	
Ambrosia artemisiifolia L.	N, 1, CdC		
ragweed	r1023, 1051		
Antennaria marginata Greene	N, 2, rocky slopes thru-out		
white margin pussytoes	r329, 521	h122	
Antennaria parvifolia Nutt.	N, 2, slopes >6000'		
A. aprica	r522, 1185	h930	
little leaf pussytoes			
Antennaria rosulata Rydb.	N, 3, sage flats >7000'		
Kaibab pussytoes	r502, 552	h359	
Arnica chamissonis var. andina	N, 1, upper CdM		
(Nutt.) Ediger & Barkl.			
A. foliosa	r1345	h477	
chamisso arnica			
Artemisia arbuscula Nutt.	N, 4, rims >7000'		
low sagebrush	r1426, 1491		
Artemisia biennis Willd.	E, 1, shore of Whiskey Reservoir		
biennial wormwood	r1440		
Artemisia bigelovii Gray	N, 4, thru-out		
Bigelow sage	r703, 1043, 1070, 1098, 1102, 408, 1464	h743	R10
Artemisia campestris var. scouleriana	N, 0, upper MC		

(Hook.) Cronq.	
A. pacifica	r727, 956, 1440 h639
field sagewort	
Artemisia carruthii Wood ex Carruth.	N, 2, upper cyns & rims >7000'
Carruth's sagewort	r820, 1006, 1058
Artemisia dracunculus L.	N, 1, base of Many Skulls Tr
A. dracunculoides	
false tarragon	r781
Artemisia filifolia Torr.	N, 1, dunes at mouth of Cottonwood Cyn
sand sagebrush	r1362
Artemisia frigida Willd.	N, 3, thru-out
fringed sagebrush	r289, 574, 1008, 1056 h936 D
Artemisia ludoviciana ssp. ludoviciana	N, 0, lower cyns
Nutt.	H
white sagebrush	
Artemisia ludoviciana ssp. mexicana	N, 4, thru-out cyns
(Willd. ex Spreng.) Keck	h699 B226
A. ludoviciana	
Mexican sagewort	
Artemisia tridentata Nutt.	N, 5, esp >6000'
big sage	r1101 Bu754 h707, 754, 826 M B256, 257, 384
Baccharis wrightii Gray	N, 1, nr VC

Wright baccharis	r1951		
Bahia dissecta (Gray) Britt.	N, 2, >7000		
ragleaf bahia	r953, 1450	W	
Bidens cernua L.	N, 1, Tsaile Lake		
bur marigold	r792, 1477		
Brickellia brachyphylla (Gray) Gray	N, 4, slopes thru-out		
Brach brickellbush	r751, 764, 881	h 613, 737	
Brickellia californica (Torr. & Gray)	N, 3, slopes thru-out		
Gray	r1433	W	
California brickellbush			
Brickellia grandiflora (Hook.) Nutt.	N, 3, slopes thru-out		
mountain brickellbush	r1454	h604, 660, 683, 732	
Brickellia microphylla var. scabra Gray	N, 4, <6500'		
B. scabra	r1571	h709, 739	L12 B243
rough brickellbush			
Brickellia oblongifolia Nutt.	N, 0, SW of the VC		
narrowleaf brickellbush		h854, 941	R139
Carduus nutans L.	E, 2, next to roads and riparian areas thru-out		
musk thistle	r747, 1087, 1296, 1359	h479	R475
Chaenactis stevioides Hook. & Arn.	N, 2, lower rims		
Steve's pincushion	r212	h848	D
Chaetopappa ericioides (Torr.) Nesom	N, 4, thru-out		

Leucelene ericioides, Aster hirtifolius			
smallflower aster	h61, 93, 163	D R19, 481	C B214
Chamaechaenactis scaposa (Eastw.) Rydb.	N, 1, CdM rim, Mummy Overlook-Middle Tr.		
fullstem	r374	D	
Chrysothamnus depressus Nutt.	N, 4, sage flats >6800'		
dwarf rabbitbrush	r691, 754, 839, 1004, 1033, 1037, 1041	R	
Chrysothamnus greenei (Gray) Greene	N, 4, thru-out		
C. greenei var. filifolius	r695, 865, 939	h521 R140 L15 De B101	
Greene's rabbitbrush			
Chrysothamnus viscidiflorus (Hook.) Nutt.	N, 3, thru-out, probably includes var. stenophyllus		
yellow rabbitbrush	r1106	h	
Chrysothamnus viscidiflorus	N, 0, S rim CdC, included in above taxon by Cronquist et al (1994)		
var. stenophyllus (Gray) Hall	h426, 727, 753	L16	
yellow rabbitbrush			
Cirsium calcareum (M.E. Jones) Woot. & Standl.	N, 2, hg W of Refuge Rock		
C. pulchellum, C. bipinnatum	r1370	h448, 505	H
Cainville thistle			
Cirsium chellyense Moore & Frankton	N, 3, hg thru-out, endemic to CACH area		

prev. det. as <i>C. calcareum</i> , <i>C. chuskaense</i>			
queen thistle	r759, 949, 1317, 1398	h	
<i>Cirsium rothrockii</i> (Gray) Petrak	N, 1, above Mummy Cave		
Rothrock's thistle			W
<i>Cirsium undulatum</i> var. <i>tracyi</i> (Rydb.)	N, 1, Whiskey Reservoir area		
Welsh	r1439, 1451		
<i>C. tracyi</i>			
Tracy's thistle			
<i>Cirsium vulgare</i> (Savi) Ten.	E, 2, thru-out		
bull thistle	r1453, 1482, 1529	h 667	
<i>Cirsium wheeleri</i> (Gray) Petrak	N, 1, Wheatfields Cyn area		
Wheeler thistle	r870, 890		
<i>Conyza canadensis</i> (L.) Cronq.	N, 2, riparian thru-out		
<i>Erigeron canadensis</i>	r748	h 548, 578	
Canada horseweed			
<i>Crepis occidentalis</i> Nutt.	N, 2, rims >7100'		
western hawksbeard	r363, 689	h 324	
<i>Dicoria canescens</i> Gray	N, 0, lower CdC		
<i>D. oblongifolia</i>			M213
desert twinbugs			
<i>Dicoria canescens</i> ssp. <i>brandegei</i> (Gray)	N, 3, near Jct.		
Kartesz, comb. nov. ined.	r1475	h 810	

D. brandegei
 desert twinbugs
 Dyssodia papposa (Vent.) A.S. Hitchc. N, 1, thru-out
 fetid marigold r941, 1425, 1539
 Ericameria nauseosa (Pallas ex Pursh) N, 4, thru-out B
 Nesom & Baird
 goldenbush
 Ericameria nauseosa var. bigelovii N, 4, lower rims
 (Gray) Nesom & Baird h750 Bu736 R141 B246, 374
 Chrysothamnus nauseosus var. bigelovii
 rubber rabbitbrush
 Ericameria nauseosa var. glabrata N, 4, lower rims and cyn
 (Gray) Nesom & Baird r1570 h752 L14
 Chrysothamnus nauseosus ssp. nauseosa
 var. glabrata, C. nauseosus var. graveolens
 rubber rabbitbrush
 Ericameria nauseosa var. hololeuca N, 0, Battle Cove Ruins
 (Gray) Nesom & Baird h 721
 Chrysothamnus nauseosus
 var. gnaphaloides
 rubber rabbitbrush
 Ericameria nauseosa var. oreophila N, 4, lower rims

(A. Nels.) Nesom & Baird	r975, 1434			
Chrysothamnus nauseosus var. oreophila				
rubber rabbitbrush				
Ericameria parryi var. howardii	N, 2, lower slopes			
(Parry ex Gray) Nesom & Baird	r710	h		
Chrysothamnus parryi ssp. howardii				
Parry's rabbitbrush				
Erigeron aphanactis (A. Gray) Greene	N, 0, Battle Cove Ruin			
E. concinnus var. aphanactis		h 909		
beach daisy				
Erigeron colomexicanus A. Nelson	N, 4, thru-out			
E. divergens var. cinereus	r315, 342, 423, 596, 597, 636, 740, 864	h		
running daisy				
Erigeron concinnus var. concinnus	N, 3, thru-out			
(Hook. & Arn.) Torr. & Gray	r421, 549	h30, 911	B209	
Navajo daisy				
Erigeron divergens Torr.& Gray	N, 4, thru-out			
spreading daisy	r246, 449, 648, 737, 810, 912, 1074, 1092, 1148			
Erigeron flagellaris Gray	N, 4, thru-out			
trailing daisy	r206, 240, 331, 349, 530, 814	h 117	B203, 327	
Erigeron formosissimus	N, 1, upper MC, riparian			
var. formosissimus Greene	r957			

beautiful fleabane		
Erigeron lonchophyllus Hook.	N, 1, upper CdM	
Trimorpha lonchophylla	r805, 997	
spearleaf daisy		
Erigeron pumilus Nutt.	N, 2, mid cyns	
low daisy	r389, 395	
Erigeron speciosus var. macranthus	N, 3, upper cyns, riparian	
(Nutt.) Cronq.	r750, 850	h 473, 672, 689
E. macranthus		
aspen daisy		
Erigeron speciosus var. speciosus	N, 3, upper cyns, riparian	
(Lindl.) DC.	r725, 888, 1382	
aspen daisy		
Eurybia radulina (Gray) Nesom	H, 1, T	
roughleaf aster	r1404	
Gaillardia pinnatifida Torr.	N, 3, lower cyns & rims	
blanketflower	r338, 546	h 188, 215, 388, 884
Gnaphalium exilifolium A. Nels.	N, 0, Tsaile Lake spillway	
G. grayi		W

slender cudweed					
Gnaphalium palustre Nutt.	N, 1, riparian thru-out				
cudweed	r873, 1281				
Grindelia nuda var. aphanactis	N, 3, thru-out				
(Rydb.) Nesom	r1436	h419, 498	L17	R474	H B350
G. aphanactis					
rayless gumweed					
Grindelia squarrosa var. serrulata	N, 0, near Antelope House Ruin				
(Rydb.) Steyermark					
G. squarrosa var. serrulata		h 654			
curlycup gumweed					
Gutierrezia microcephala (DC.) Gray	N, 0, Spider Rock Overlook				
G. lucida		h		R480	
threadleaf snakeweed					
Gutierrezia sarothrae (Pursh)	N, 5, thru-out				
Britt. & Rusby		h585, 659, 723	L18		De
broom snakeweed					
Helianthella microcephala (Gray) Gray	N, 4, thru-out				
purpledisk helianthella	r723, 891	h 716			
Helianthus annuus L.	N, 2, disturbed sites thru-out				
annual sunflower	r782, 853	h550			
Helianthus petiolaris Nutt.	N, 2, disturbed sites thru-out				

prairie sunflower	r769	h 569, 588, 597, 730
<i>Heliomeris multiflora</i> Nutt.	N, 2, >6500'	
showy goldeneye	r730, 900, 1505	
<i>Heterotheca villosa</i> (Pursh) Shinnars	N, 5, thru-out	
<i>Chrysopsis villosa</i>	r719, 807 Bu728	h75, 157, 500 Ha R137, 479 L39 B310, 335
hairy goldenaster		
<i>Hymenopappus filifolius</i> var. <i>lugens</i>	N, 5, thru-out	
(Greene) Jepson	r1441, 1445	h 204, 246, 527, 895
<i>H. lugens</i>		
yellow cutleaf		
<i>Hymenopappus mexicanus</i> Gray	N, 1, upper MC	
Mexican woollywhite	r958	
<i>Hymenoxys richardsonii</i> var. <i>floribunda</i>	N, 5, thru-out	
(Gray) Parker	r599, 649, 705, 808	h295, 390, 431, 454, 592 D R143, 478 De
Colorado rubberweed		
<i>Isocoma rusbyi</i> E. Greene	N, 3, lower rims	
<i>Haplopappus rusbyi</i>	r694, 936	h 497, 554, 696 L8 R473
anno. from <i>H. drummondii</i>		
anno. from <i>H. acradenia</i>		
Rusby goldenbush		
<i>Iva xanthifolia</i> Nutt.	N, 0, near Antelope House Ruin	
horseweed		h 725

Lactuca serriola L.	E, 2, thru-out	
wild lettuce	r1075	h 559, 591, 731
Lactuca tatarica var. pulchella (Pursh) Breitung	N, 0, upper CdC	
L. pulchella		h 514
blue lettuce		
Lygodesmia arizonica S. Tomb	N, 1, dunes 2km. S of VC	
Arizona skeletonplant	r487	
Lygodesmia grandiflora (Nutt.) T. & G.	N, 0, lower rims	
Largeflower skeletonplant		h899 D
Lygodesmia juncea (Pursh)	N, 1, Draper Trail, CdM	
D. Don ex Hook.	r1506	
rush skeletonplant		
Machaeranthera canescens (Pursh) Gray	N, 4?, thru-out	
Aster canescens	r863, 978, 1109	
purple aster		
Machaeranthera canescens	N, 3?, Tsail Lake	
var. ambigua B. L. Turner	r806	
hoary tansy aster		
Machaeranthera canescens var. aristata	N, 3?, thruout?	
(Eastw.) B.L. Turner	r780 H	h599 L11
M. canescens ssp. glabra var. aristata,		
M. rigida, Aster cichoreaceus		

hoary tansy aster					
Machaeranthera grindelioides	N, 3, lower cnns & slopes				
(Nutt.) Shinnery	r366, 1465				
Haplopappus nuttallii					
rayless aster					
Machaeranthera parviflora Gray	N, 1?, lower cnn				
small flower tansy aster			<i>H</i>		
Malacothrix sonchoides	N, 2, lower cyns & rims				
(Nutt.) Torr. & Gray	r248		h 869, 902, 942		
sowthistle desert dandelion					
Microseris nutans	N, 1, disturbed areas				
(Hook.) Schultz-Bip.	r1958				
nodding microseris					
Packera hartiana (Heller)	N, 2, hg, upper cyns				
W.A. Weber & A. Löve	r590, 680		h 201		
Senecio hartiana					
Hart's ragwort					
Packera multilobata	N, 4, lower elevs.				
(Torr.& Gray ex Gray) W.A. Weber & A. Love					
Senecio multilobatus	r318, 330, 372, 1130		h77, 132, 155, 850	D C	B216, 326
lobeleaf groundsel					
Packera neomexicana	N, 4, upper elevs				

var. neomexicana (Gray) W.A. Weber & A. Löve		
Senecio neomexicana	r163, 373, 442, 452, 503, 1214	h 299, 544
New Mexico groundsel		
Pericome caudata Gray	N, 1, upper CdM	
mountain leaftail	r799	h 816
Petradoria pumila ssp. graminea	N, 3, thru-out, esp. lower cyn rims	
(Woot. & Standl.) L.C. Anders.	r706, 758, 1494	h398 D R144
Solidago graminea		
giant rockgoldenrod		
Pseudognaphalium canescens	N, 1, north slope, upper CdM	
ssp. canescens (DC.) W.A. Weber		
Gnaphalium canescens	r1476	
Wright's cudweed		
Pseudognaphalium stramineum (Kunth) N, 1, upper CdM		
W.A. Weber		
Gnaphalium chilense	r1351	h 666
annual cudweed		
Ratibida columnifera (Nutt.)	N, 1, upper MC	
Woot. & Standl.	r895, 959	h 626
R. columnaris var. pulcherrima		
Prairie coneflower		
Rudbeckia laciniata L.	N, 3, upper cyps, riparian	

cutleaf coneflower	r645	h 331, 489, 678	Bu777	
Sanvitalia abertii Gray	N, 1, upper cyns & rims			
Abert creeping zinnia	r930, 1390			
Schkuhria multiflora Hook. & Arn.	N, 1, upper cyns & rims			
Bahia neomexicana	r1447, 1513			W
manyflower false threadleaf				
Senecio flaccidus var. douglasii (DC.)	N, 0, ?			
B.L. Turner & T.M. Barkl.				B
Douglas groundsel				
Senecio flaccidus var. flaccidus Less.	N, 4, lower cyns & rims			
S. douglasii var. longilobus, S. longilobus, S. douglasii var. jamesii				
threadleaf groundsel	r241, 699 Bu716	h84, 236		L20 B340
Senecio spartioides var. multicapitatus	N, 0, h rep as scattered thru-out cyns			
(Greenm. ex Rydb.) Welsh				
S. multicapitatus		h 480, 589		
broomlike ragwort				
Senecio spartioides var. spartioides	N, 2, upper CdC & rims			
Torr. & Gray	r832, 1452			
broomlike ragwort				
Senecio wootonii Greene	N, 2, upper MC			
Wooton's ragwort	r489, 547			
Solidago simplex var. spatulata	N, 1, upper MCrim			

(DC.) Cronq.	r952	
<i>S. spathulata</i>		
Mt. Albert goldenrod		
<i>Solidago velutina</i> DC.	N, 3, thru-out	
<i>S. sparsiflora</i>	r871, 1373	h 394, 433, 646 Bu776
sparse goldenrod		
<i>Sonchus asper</i> (L.) Hill	E, 0, lower cyns	
prickly sowthistle		h867 B
<i>Stenotus armerioides</i> Nutt.	N, 3, lower rims	
<i>Haplopappus armerioides</i>	r254, 278	h96 D B348
thrift mock goldenweed		
<i>Stephanomeria exigua</i> Nutt.	N, 1, WH Ruin	
small wirelettuce		h217, 257, 385, 418a, 586 Ha
<i>Stephanomeria minor</i> var. <i>minor</i>	N, 3, slopes thru-out	
(Hook.) Nutt.		
<i>S. tenuifolia</i>	r916, 1011	h 370, 509
narrowleaf wirelettuce		
<i>Stephanomeria pauciflora</i>	N, 2, upper rims	
(Torr.) A. Nels.	r1064, 1448	
brownplume wirelettuce		
<i>Symphotrichum ascendens</i>	N, 1, upper CdM	
(Lindl.) Nesom	r737, 983	

Aster ascendens			
western aster			
Symphyotrichum falcatum	N, 0, upper MC		
var. crassulum (Rydb.) Nesom			
Aster commutatus var. crassulus		h 628	
white prairie aster			
Symphyotrichum falcatum	N, 3, thru-out		
var. falcatum (Lindl.) Nesom	r981, 1022, 1028, 1499	H	
Aster falcatus			
white prairie aster			
Symphyotrichum laeve var. laeve (L.)	N, 1, upper cyns		
A. & D. Löve	r1314		
Aster laevis			
smooth blue aster			
Symphyotrichum lanceolatum	N, 3, mid –upper cyn		
var. hesperium (Gray) Nesom	r779, 802, 982, 1050, 1481	H	h
Aster hesperius			
white panicle aster			
Symphyotrichum praeltum	N, 0, ?		
var. praeltum (Poir.) Nesom			
Aster coerulescens		h450, 542, 671	
willowleaf aster			

Taraxacum laevigatum (Willd.) DC	E, 4, thru-out		
rock dandelion		h 28, 184, 220, 775	
Taraxacum officinale Weber	N, 0, Battle Cove Ruin		
dandelion		h 692	
Tetradymia canescens DC	N, 2, upper cyn slopes		
gray horsebrush	r823	D	
Tetranneuris ivesiana Greene	N, 3, rims thru-out		
Hymenoxys acaulis var. ivesiana	r255, 375, 398, 537	h239, 344, 616, 894	B249
anno. from H. acaulis var. arizonica			
Ives' four-nerve-daisy			
Thelesperma megapotamicum	N, 2, mid-lower cyns thru-out		
(Spreng.) Kuntz.	r715, 908	h 392, 885	
Hopi tea greenthread			
Thelesperma subnudum Gray	N, 2, mid-lower cyns and rims		
Navajo tea	r302, 412, 913	h348, 893	D R484
Townsendia exscapa (Richards.) Porter	N, 0, ?		
stemless Townsend daisy		m	
Townsendia incana Nutt.	N, 3, lower cyns and rims		
hoary Townsend daisy	r226, 305, 319, 778, 1223	h49, 119, 159	M B210
Townsendia strigosa Nutt.	N, 0, dunes near VC		
hoary Townsend daisy		h 781, 864	

	Tragopogon dubius Scop.	E, 2, thru-out, h rep as common at head of CdM	
	prev. det. as Tragopogon pratense		
	goat's beard	r1963	h 267, 340
	Verbesina encelioides ssp. exauriculata	E, 2, thru-out	
	(Robins. & Greenm.) J.R. Coleman	r886, 1084, 1097, 1530	h814, 868 R477 C
	V. encelioides		
	golden crownbeard		
	Verbesina microptera DC.	N, ?	W 49057
	Texas crownbeard		
	Wyethia scabra Hook.	N, 1, mesa top	R482
	mules-ears		
	Xanthium strumarium var. canadense	N, 4, thru-out, riparian	
	(P. Mill.) Torr. & Gray		
	X. saccharatum		h 409, 684, 694, 722
	Canada cocklebur		
Berberidaceae	Mahonia repens (Lindl.) G. Don	N, 3, thru-out, high slopes	
	Berberis repens		h7, 131, 268, 306, 531
	creeping barberry		
Betulaceae	Alnus incana ssp. tenuifolia	N, 2, upper cys, riparian	
	(Nutt.) Breitung	r577, 1237	
	thinleaf alder		
	Alnus oblongifolia Torr.	N, 2, upper cys, riparian	

	Arizona alder	r171	h 272, 341		
	Betula occidentalis Hook.	N, 3, upper cys, riparian			
	water birch	r586, 1384	h 272b		
Bignoniaceae	Catalpa bignonioides Walt.	H, 1, Draper Ranch, end of road in CdM			
	southern catalpa	r1187 1225	B36		
Boraginaceae	Cryptantha bakeri (Greene) Payson	N, 2, upper cyn rims >6900', h rep as common thru-out			
	Baker catseye	r264, 564, 618 h, 112, 937 D			
	Cryptantha cinerea var. cinerea	N, 3, rky slopes & rip, upper cys			
	(Greene) Cronq.	r320, 464, 884, 1211, 1244	H		
	bownut cryptantha				
	Cryptantha cinerea var. jamesii Cronq.	N, perhaps mis IDed, Cronquist <i>et al.</i> (1984) say var. jamesii			
	C. jamesii	doesn't occur here			
	James catseye	h887	H 887		
	Cryptantha confertiflora (Greene) Payson	N, 2, lower cyn rims			
	Basin yellow cryptantha	r394			
	Cryptantha crassisepala	N, 2, lower cys			
	(Torr. & Gray) Greene	r174, 186, 203, 223 h56, 252, 761, 857, 1196	D	B319	
	deertongue				
	Cryptantha fendleri (Gray) Greene	N, 1, Wheatfields Cr.			
	Fendler's cryptantha	r830			

Cryptantha flava (Nels.) Payson	N, 2, lower sandy rims			
plateau yellow catseye	r394		K	
Cryptantha fulvocanescens (Wats.) Pays.	N, 2, lower rims			
tawny catseye	r200, 1125	h80, 112, 242, 937	B215	
Cryptantha gracilis Osterh.	N, 3, lower cyns & rims			
narrowstem catseye	r209, 213, 237, 267, 401	D		
Cryptantha pterocarya (Torr.) Greene	N, 2, mid-lower cyns			
wingnut cryptantha	r173, 285, 314	h 133	D	
Lappula occidentalis var. cupulata	N, 0, NPS housing area			
(Gray) Higgins				
L. texana		h 56a, 855	D	
flat-spine sheepburr				
Lappula occidentalis var. occidentalis	N, 3, thru-out			
(S. Wats.) Greene				
L. redowski	r573, 650, 670	h27, 488, 793	R133	C B318
desert stickseed				
Lithospermum incisum Lehm.	N, 2, lower cyns			
fringed puccoon	r390	h 5, 26, 871, 927	D	
Lithospermum multiflorum	N, 2, thru-out			
Torr. ex Gray	r339, 566, 869, 1176	h 318		
manyflowered stoneseed				

	Mertensia oblongifolia (Nutt.) G. Don	N, 2, Whiskey Cr, Black Rock Cyn, white-flowered form is endemic to
	M. lanceolata, M. fusiformis	Chuska Mtns/ CACH area
	oblongleaf bluebells	r435, 675, 1449
Brassicaceae	Alyssum alyssoides (L.) L.	E, 0, NPS housing area
	pale alyssum	h 50
<i>used to be</i>	Alyssum minus (L.) Rothm.	E, 3, thru-out
	alyssum	r183, 1265
Cruciferae	Arabis fendleri (S. Wats.) Greene	N, 3, thru-out
	Fendler's rockcress	r158, 265, 506
	Arabis perennans S. Wats.	N, 0, thru-out, Arabis is in revision, A. fendleri & A. perennans are often confused. Some of H's A. perennans specimens at UA may have been annotated to an unknown taxon (Jenkins, pers comm)
	perennial rockcress	h 4, 39,149, 833, 839 D
	Arabis pulchra var. pallens M. E. Jones	N, 1, Battle Cove Ruin
	pale rockcress	r290
	Camelina microcarpa Andrzej.	E, 2, thru-out
	false flax	r189, 336, 424, 668 D
	Capsella bursa-pastoris (L.) Medic.	E, 2, lower cyn, h rep. as thru-out
	shepherd's purse	r192 h 880 D
	Cardamine cordifolia Gray	N, 1, Wheatfields Cr
	heartleaf bittercress	r1328
	Chorispora tenella (Pallas) DC.	E, 3, disturbed sites, lower cyns

blue mustard	r187	h 218, 790, 796	
Descurainia incana ssp. viscosa (Rydb.) N, 0, upper CdM			
Kartesz & Gandhi			
D. richardsonii ssp. viscosa		h 486	
mountain tansy mustard			
Descurainia pinnata ssp. halictorum	N, 3, disturbed sites, lower cyns		
(Cockerell) Detling	r190	B	
western tansymustard			
Descurainia pinnata ssp. ochroleuca	N, 3, lower cyns, probably same taxon as ssp. halictorum		
(Woot.) Detling		D h15, 36, 37	B341
western tansymustard			
Descurainia sophia (L.) Webb ex Prantl	N, 3, mid-lower cyns		
flaxweed tansy mustard	r191, 459	h 16, 51, 65a	
Dimorphocarpa wislizeni (Engelm.)	N, 2, sandy areas, lower cyns		
Rollins	r275		
Dithyrea wislizenii			
spectaclepod			
Draba cuneifolia var. cuneifolia	N, 3, thru-out		
Nutt. ex Torr. & Gray	r167	h 19, 777, 794, 831	
wedgeleaf draba			
Draba nemorosa L.	N, 2, upper Black Rock and MC		
woodland draba	r437, 494, 515		

<i>Draba petrophila</i> var. <i>petrophila</i> Greene	N, 1, horse trail into Coyote/Wheatfields confluence		
Santa Rita Mountain draba	r594		
<i>Erysimum capitatum</i>	N, 2, thru-out cys, riparian		
(Dougl. ex Hook.) Greene	r180, 286	h529, 637, 883	D
western wallflower			
<i>Erysimum repandum</i> L.	E, 0, NPS housing area		
repand wallflower		h778	
<i>Lepidium densiflorum</i> Schrad.	N, 3, mid-lower cys		
pepperweed	r388, 1204	h23, 798	B317
<i>Lepidium montanum</i> Nutt.	N, 0, lower cys, probably var. <i>jonesii</i>		
mountain pepperweed		h 1, 275	D
<i>Lepidium montanum</i> var. <i>jonesii</i>	N, 2, lower cys		
(Rydb.) C.L. Hitchc.	r281		
Jones pepperweed			
<i>Lepidium perfoliatum</i> L.	E, 2, lower cys		
clasping pepperweed	r1171	h 378	
<i>Lesquerella intermedia</i>	N, 0, Tsaille Lake		
(S. Wats.) Heller		h 915	
Santa Fe bladderpod			
<i>Lesquerella rectipes</i> Woot. & Standl.	N, 3, thru-out		
straight bladderpod	r279, 1324	h18, 140, 208, 213, 786	C B355
<i>Physaria newberryi</i> Gray	N, 1, below Two Hole Ruin, CdC		

Newberry's twinpod	r168		
Rorippa sinuata (Nutt.) Hitchcock	N, 1, dry cattle tanks nr. park housing		
spreading yellowcress	r1959		
Rorippa sphaerocarpa (Gray) Britt.	N, 1, upper CdM and MC		
roundfruit yellowcress	r617, 654	h 633	
Rorippa tenerrima Greene	N, 1, lower Wheatfields		
Modoc yellowcress	r872		
Rorippa teres (Michx.) R. Stuckey	N, 0, H rep as common in upper cyns		
R. obtusa		h 468, 517	
southern marsh yellowcress			
Sisymbrium altissimum L.	E, 3, lower cyns		
tumble mustard	r284	h17, 65	Ha
Stanleya pinnata (Pursh) Britt.	N, 1, mid CdC		
desert prince'splume	r1401	h 888	
Streptanthella longirostris (Wats.) Rydb.	N, 3, lower cyns & rims		
longbeak fiddle mustard	r181, 308	h 38, 45, 108, 758	
Streptanthus cordatus Nutt.	N, 3, lower cyns & rims		
heartleaf twistflower	r166, 1138	h 42, 82, 444	D
Thelypodium wrightii Gray	N, 2, MC and lower CdC		
Wright's thelypody	r906, 909	h 600, 705	
Thlaspi montanum var. montanum L.	N, 2, upper cyns		
T. fendleri	r151, 348, 354	h 313, 788	

	alpine pennycress	
Cactaceae	Echinocereus coccineus Engelm.	N, 0, Sliding House Overlook
	scarlet hedgehog cactus	<i>H</i>
	Echinocereus fendleri (Engelm.) F. Seitz	N, 2, rims thru-out
	Fendler hedgehog cactus	r1044, 1194, 1256 h 248
	Echinocereus triglochidiatus Engelm.	N, 3, rims thru-out, likely var. mojavenis
	claretcup hedgehog	r904 h103, 171, 842 Bu760
	Echinocereus triglochidiatus	N, 3, rims thru-out
	var. mojavenis	r385, 1150, 1151, 1195, 1206, 1213
	(Engelm. & Bigelow) L. Benson	
	Mohave hedgehog cactus	
	Escobaria vivipara var. vivipara	N, 3, rims >6800'
	(Nutt.) Buxbaum	r404, 536, 902 h 822, 913
	Coryphantha vivipara var. arizonica	
	spiny star	
	Opuntia erinacea	N, 4, lower cys
	Engelm. & Bigelow ex Engelm.	r310
	grizzly bear prickly pear	
	Opuntia fragilis (Nutt.) Haw.	N, 2, upper cys & rims
	fragile cactus	r1045
	Opuntia macrorhiza Engelm.	N, 1, upper cys
	grassland prickly pear	r403, 1338 h 820

	Opuntia phaeacantha Engelm.	N, 4, lower cyns
	brownspine pricklypear	r1169 h 374 Bu763
	Opuntia polyacantha	N, 3, lower cyns
	var. polyacantha Haw.	r303, 466 h256, 402, 819, 824 B373
	O. erinacea var. hystricina	
	hairspine pricklypear	
	Opuntia whipplei Engelm. & Bigelow	N, 4, thru-out
	Whipple's cholla	r640, 1220, 1289 <i>H</i> h255, 365, 403, 823 B116
	Opuntia x viridiflora	H?, 1, fenceline at Standing Cow Ruin, CdM
	Britt. & Rose (pro sp.)	r1290
	rattail cholla	
	Sclerocactus whipplei	N, 2, lower cyns & rims
	(Engelm. & Bigelow) Britton	r251, 1027, 1126 h 808, 821 Bu761
	Whipple's fishhook cactus	
Campanulaceae	Campanula parryi Gray	N, 3, uppermost cyns and hgs
	harebell	r666, 681, 812, 1298 h 460, 818
Cannabaceae	Humulus lupulus var. lupuloides	N, 2, lower cyns
	H. americanus	h 481, 685
	Arizona hops	
Capparaceae	Cleome serrulata Pursh.	N, 4, lower cyns
	Rocky Mountain beeplant	h66, 741 L2 C B274
Caprifoliaceae	Lonicera korolkowii Stapf	H, 1, T

	blueleaf honeysuckle	r1141, 1954	
	Symphoricarpos oreophilus Gray	N, 3, slopes, upper cys	
	mountain snowberry	r392	h 934
Caryophyllaceae	Arenaria eastwoodiae var. adenophora	N, 0, Battle Cove Ruin	
	Kearney & Peebles		h 116
	Eastwood sandwort		
	Arenaria eastwoodiae	N, 2, sandy soils, lower slopes	
	var. eastwoodiae Rydb.	r239	h116a Ha
	Eastwood sandwort		
	Arenaria fendleri var. brevifolia	N, 3, slopes thru-out	
	(Maguire) Maguire	r528, 414	h357
	Fendler's sandwort		
	Arenaria fendleri var. fendleri Gray	N, 2, upper cys	
	Fendler's sandwort	r837	
	Arenaria lanuginosa ssp. saxosa	N, 2, cys thru-out	
	(Gray) Maguire	r628, 826, 988, 1066, 1287, 1392	W
	A. lanuginosa		
	spreading sandwort		
	Arenaria serpyllifolia L.	E, 0, near Sliding House Overlook	
	thymeleaf sandwort	H	
	Cerastium beeringianum	N, 1, upper CdM	
	Cham. & Schlecht.		

	chickweed	r1355		
	<i>Cerastium fontanum</i> ssp. <i>vulgare</i>	E, 2, CdM		
	(Hartman) Greuter & Burdet	r639, 995	h290	
	<i>C. vulgatum</i>			
	big chickweed			
	<i>Cerastium glomeratum</i> Thuill	E, 1, upper CdM		
	sticky chickweed	r631		
	<i>Pseudostellaria jamesii</i> (Torr.)	N, 2, upper cyns		
	W.A. Weber & R.L. Hartman	r490, 629	h 274	
	<i>Stellaria jamesii</i>			
	sticky starwort			
	<i>Silene antirrhina</i> L.	N, 1, Wheatfields Cyn		
	catchfly	r856		
	<i>Silene laciniata</i> Cav.	N, 2, upper cyns		
	cardinal catchfly	r846	h 515, 629	
	<i>Silene menziesii</i> Hook.	N, 2, upper cyns		
	Menzie's catchfly	r499, 630		
	<i>Spergularia salina</i> J.& K. Presl	N, 1, WH Ruins & cyn mouth		
	<i>S. marina</i> , prev. det. as <i>S. media</i>	r1282	h B325	
	salt sandspurry			
Celastraceae	<i>Paxistima myrsinites</i> (Pursh) Raf.	N, 1, Nest Mtn.		
	boxleaf	r535		

Ceratophyllaceae	Ceratophyllum demersum L. common hornwort	N, 2, upper CdM & MC, aquatic r524, 1343
Chenopodiaceae	Atriplex argentea Nutt. silverscale saltbush	N, 0, ? h858, 943 De42795
	Atriplex canescens (Pursh) Nutt. fourwing saltbush	N, 4, lower cyns & rims Bu753 h78, 161, 447 R134
	Atriplex confertifolia (Torr. & Frem.) S. Wats. A. jonesii shadscale	N, 4, lower cyns & rims Bu739, 741 h58 L3 B349
	Atriplex obovata Moq. prev. det. as A. jonesii mound saltbush	N, 0, lower cyns & rims h 602, 697
	Atriplex rosea L. redscale saltbush	E, 0, h rep as common at mouth of Far Spiral Cyn h738
	Bassia hyssopifolia (Pallas) Kuntz smother weed	E, 1, below jct. H
	Chenopodium album L. lambsquarters	N, 2?, Bat Cyn above falls r923
	Chenopodium berlandieri Moq. netseed lambsquarters	N, 2, thru-out r782, 920, 1438 h 130, 525, 571, 612
	Chenopodium botrys L.	E, 1, below jct.

Dysphania botrys	r789	
Jerusalem oak		
Chenopodium fremontii S. Wats.	N, 2, thru-out	
Fremont goosefoot	r736, 783, 1455, 1545	
Chenopodium glaucum L.	E, 0, Wheatfields Cyn	
oak-leaf goosefoot	h 528	
Chenopodium graveolens Willd.	N, 2, thru-out	
Dysphania graveolens	r1000	W
fetid goosefoot		
Chenopodium leptophyllum (Moq.)	N, 3, thru-out	
Nutt. ex S. Wats.	r787, 1007, 1009	
narrowleaf goosefoot		
Chenopodium rubrum L.	N, 2, lower cyns	
red goosefoot	H	
Corispermum americanum	N, 3, lower cyns	
var. americanum (Nutt.) Nutt.	r1474, 1528	
C. orientale		
American bugseed		
Cycloloma atriplicifolium (Spreng.)	N, 2, lower cyns	
Coult.	r788	
winged pigweed		
Kochia scoparia (L.) Schrad.	E, 3, disturbed sites, lower cyns	

	kochia	r784, 933, 1540, 1548 h584, 593, 704, 717 R4
	Krascheninnikovia lanata (Pursh)	N, 3, lower cyns
	A.D.J. Meeuse & Smit	r714, 1574 D R135
	Ceratoides lanata, Eurotia lanata	
	winterfat	
	Monolepis nuttalliana (Schult.) Greene	N, 2, thru-out
	Nuttall's poverty weed	r172, 568 h 881, 921
	Salsola kali L.	E, 4, thru-out
	Russian thistle	h420, 496, 560, 663, 748 R5 B338
	Salsola tragus L.	E, 1, upper MC, probably same as S. kali above
	S. kali ssp. tragus	r901
	prickly Russian thistle	
	Sarcobatus vermiculatus (Hook.) Torr.	N, 3, lower cyns
	greasewood	r261, 1527, 1549 h254, 590, 718 Bu738 H L6 B347
	Suaeda moquinii (Torr.) Greene	N, 0, south of NPS housing area, White House Ruins
	S. torreyana	r1957 h601 L7
	alkali seepweed	
Clusiaceae	Hypericum scouleri Hook.	N, 0, upper CdM
<i>used to be Guttiferae</i>	H. formosum	h 462
	Scouler St. Johnswort	

Convolvulaceae	<i>Calystegia macounii</i> (Greene) Brummitt	N, 0, upper CdM		
	anno. from <i>Convolvulus sepium</i>		h 485	
	Macoun's false bindweed			
	<i>Convolvulus arvensis</i> L.	E, 3, disturbed sites thru-out		
	field bindweed	r739	h 52	
	<i>Evolvulus nuttallianus</i> J.A. Schultes	N, 0, Black Rock Cyn & talus slopes nr. Spider Rock		
	<i>E. pilosus</i>		h197, 891	R146
	prostrate <i>evolvulus</i>			
	<i>Ipomoea costellata</i> Torr.	N, 1, S Rim Dr .5 mile E of VC		
	crestrub morningglory	r1406		
Cornaceae	<i>Cornus sericea</i> L.	N, 3, upper cys		
	<i>C. stolonifera</i>	r493	h 191	
	redosier dogwood			
Cucurbitaceae	<i>Cucurbita foetidissima</i> Kunth	N, 3, lower cys		
	buffalo gourd	r1019	h 565	
	<i>Cucurbita moschata</i> (Duchesne ex Lam.) H, 1, S Rim Dr, W of Tunnel Tr.			
	Duchesne ex Poir.	r1531		
	crookneck squash			
	<i>Citrullus lanatus</i> var. <i>lanatus</i> (Thunb.)	H, 0, Antelope House Ruin		
	Matsumura & Nakai			
	<i>Cucurbita vulgaris</i>		h 610	
	wild watermelon			

Elaeagnaceae	Elaeagnus angustifolia L.	H, 5, thru-out, riparian, mainly lower cyns
	Russian olive	h172 L21 H
Euphorbiaceae	Chamaesyce fendleri (Torr. & Gray)	N, 3, lower cyns & rims
	Small	
	Euphorbia fendleri	r693, 976, 1458 h 53, 238, 405, 508, 939
	Fendler's sandmat	
	Chamaesyce glyptosperma (Engelm)	N, 3, lower cyns
	Small	r1113 h 511, 595, 605
	Euphorbia glyptosperma	
	rib-seed sandmat	
	Chamaesyce serpyllifolia (Pers.) Small	N, 3, thru-out
	Euphorbia serpyllifolia	r744, 922, 976, 1048, 1435 h 545, 562, 605a, 631, 700
	thyme-leaf sandmat	
	Croton texensis (Klotzsch) Muell.- Arg.	N, 4, lower cyns & rims
	Texas croton	r484, 696, 1104, 1107 h258, 407, 553, 747 D R25, 148
Fabaceae	Euphorbia brachycera Engelm.	N, 2, upper CdC and Whiskey Cr area
	E. lurida	r570, 1319 h524
	horned spurge	
	Tragia ramosa Torr.	N, 3, slopes, lower cyns
	T. stylaris	r207, 1215 H h 90, 153, 183
	noseburn	
	Astragalus amphioxys var. modestus	N, 2?, upper CdC & MC, known from NW AZ (Barneby, 1989) Barneby

	Crescent milkvetch	r532, 1246	
<i>used to be</i>	Astragalus brandegei Porter	N, 1, Whiskey Res. shoreline	
	Brandegee's milkvetch	r571	
<i>Leguminosae</i>	Astragalus calycosus Torr. ex S. Wats.	N, 2?, lower rims	
	Torrey's milkvetch	r263	B217
	Astragalus ceramicus Sheldon	N, 2, sandy areas, lower cyns & rims	
	painted milkvetch	r214, 225, 447	
	Astragalus chuskanus	N, 1, Whiskey Cr & upper CdC, endemic to Chuska and Tunitcha Mtns	
	Barneby & Spellenberg	r671, 889	
	San Juan milkvetch		
	Astragalus humistratus var. humivagans	N, 1, upper Wheatfields	
	(Rydb.) Barneby	r860	
	groundcover milkvetch		
	Astragalus kentrophyta var. elatus	N, 2, slopes, mid cyns	
	S. Wats.	r1403	h395 Cu
	A. impensus, A. kentrophyta		
	tall spiny milkvetch		
	Astragalus lentiginosus	N, probably var. diphysus	
	Dougl. ex Hook.	r238, 593	h
	freckled milkvetch		
	Astragalus lentiginosus var. diphysus	N, 3, thru-out	
	(Gray) M.E. Jones	r234	h13, 33, 101, 200, 219, 765 Ha B220, 221, 213

A. diphyus			
freckled milkvetch			
Astragalus lonchocarpus Torr.	N, 2, slopes & rims thru-out		
rushy milkvetch	r397, 402, 565		
Astragalus mollissimus Torr.	N, 0, probably var. as below		
A. thompsoniae			
wooly locoweed			
Astragalus mollissimus	N, 3, thru-out		
var. thompsoniae (S. Wats.) Barneby			
A. thompsoniae	r182, 233	h 14, 76, 774, 886	B218
Thompson's wooly milkvetch			
Astragalus nuttallianus DC.	N, 2, mid cyn bottoms		
Nuttall milkvetch	r177, 1197	h 797, 904	
Astragalus scopulorum T.C. Porter	N, 1, upper CdM		
Rocky Mountain milkvetch	r350		
Astragalus wingatanus S. Wats.	N, 2, upper rims		
Fort Wingate milkvetch	r323, 419		
Calliandra humilis Benth.	N, 1, rim above MC		
mountain calliandra	r961		
Dalea candida var. oligophylla	N, 2, lower cyns		
(Torr.) Shinnery	r720	h396	R468
Petalostemon candidum			

white prairie clover				
<i>Gleditsia triacanthos</i> L.	H, 1, bottom of Twin Trail & T			
var. <i>inermis</i> Willd.	r1292, 1565			
honeylocust				
<i>Glycyrrhiza lepidota</i> Pursh.	N, 2, mid-lower cys & rims			
licorice	r409	h205, 291		Ba
<i>Hedysarum boreale</i> Nutt.	N, 2, slopes, mid cys			
northern sweetvetch	r368, 453			
<i>Lathyrus eucosmus</i> Butters & St. John	N, 2, mid-upper cys			
bush peavine	r369, 1209	h 210		
<i>Lathyrus graminifolius</i> (S. Wats.) White	N, 0, Antelope House Trail Cyn			
grassleaf peavine		h 137		
<i>Lotus plebeius</i> (Brand) Barneby	N, 1, upper CdM			
long-bract bird's-foot-trefoil	r351			
<i>Lotus wrightii</i> (Gray) Greene	N, 2, upper cys			
Wright's deervetch	r1335, 1381	h 316		
<i>Lupinus brevicaulis</i> S.Wats.	N, 2, sage flats mid-upper rims			
shortstem lupine	r410, 555	h 847		
<i>Lupinus caudatus</i> ssp. <i>cutleri</i> (Eastw.)	N, 3, upper terraces, mid cys			
Hess & D. Dunn	r347	h 271		
L. <i>cutleri</i>				

Cutler's spurred lupine			
Lupinus kingii S. Wats.	N, 2, upper cys & rims >7000'		
King's lupine	r817, 1005, 1046		
Medicago lupulina L.	E, 4, thru-out		
black medic	r242, 343	h74, 115, 143	R152 Ha
Medicago polymorpha L.	E, 1, upstream of Baby Tr, CdM		
bur clover	r283		
Medicago sativa L.	H, 4, thru-out		
alfalfa	r768	h 499	
Melilotus alba Desr.	E, 3, thru-out		
anno. from Melilotus indicus	r673, 1391	h 361, 380, 416	B
white sweetclover			
Melilotus officinalis (L.) Lam.	E, 3, thru-out, may have been introduced as a crop for making hay		
yellow sweetclover		h207, 310	B303
Oxytropis lambertii Pursh	N, 1, upper CdC >6900'		
Lambert locoweed	r835, 1456		
Parryella filifolia Torr. & Gray ex Gray	N, 1, bottom of Tseh Ya Kin Cyn		
dune broom	r1512		
Pedimelum megalanthum	N,1, shaly slope, head of Yellow Coyote Wash		
(Woot. & Stand.) Rydb.	r211		
Intermountain Indian breadroot			
Psoraleidum lanceolatum (Pursh) Rydb.	N, 3, upper terraces, mid cys		

	Psoralea lanceolata	r340, 457, 741	h 249, 259, 391
	dune scurfpea		
	Psoralidium tenuiflorum (Pursh) Rydb.	N, 1, Wheatfields Cr. & slopes east of Coyote Cr	
	scurfpea	r841	
	Robinia pseudo-acacia Linnaeus	H, 1, Draper Ranch, end of road in CdM	
	black locust	r1189	
	Spartium junceum L.	H, 1, T	
	Spanish broom	r1294, 1953	
	Trifolium longipes Nutt.	N, 3, mid-upper cyns, riparian	
	longstalk clover	r341, 655, 1192	
	Trifolium repens L.	E, 3, cyns thru-out	
	white clover	r562, 655, 1242	h358 Ha
	Vicia americana Muhl. ex Willd.	N, 2, upper cyns	
	American deervetch	r438, 1299	h 210a, 277, 334
Fagaceae	Quercus gambelii Nutt.	N, 5, thru-out	
	Gambel oak		h102, 800 L26
	Quercus turbinella Greene	N, 4, lower cyns & rims	
	scrub oak	r235 Bu727, 751	h234, 386, 435 L27 B244
	Quercus x pauciloba Rydb. (pro sp.)	N, 2, lower cyns & rims	
	Q. undulata		h401 D B380
	wavyleaf oak		

Fumariaceae	Corydalis curvisiliqua ssp. occidentalis	N, 2, thru-out		
used to be	(Engelm. ex Gray) W.A. Weber			
Papaveraceae	Corydalis aurea		h41	B365
	curvepod fumewort			
Gentianaceae	Centaurium calycosum (Buckl.) Fern.	N, 0, lower cyps, riparian		
	Arizona centaury	H	H	L28 R467
	Frasera paniculata Torr.	N, 1, north rim road		
	Swertia paniculata		W	
	Utah elkweed			
	Frasera speciosa Dougl. ex Griseb.	N, 2, thru-out		
	Swertia utahensis	r840	h 896	D
	deers ears			
	Gentianella amarella ssp. acuta (Michx.)	N, 1, Whiskey Cr		
	J. Gillett	r1054		
	autumn dwarf gentian			
Geraniaceae	Erodium cicutarium (L.) L'Her. ex Ait.	E, 4, thru-out		
	filaree		h2, 661	R149 B342
	Geranium caespitosum	N, 2, upper cyps		
	var. caespitosum James	r735	h635, 679	
	pineywoods geranium			
	Geranium lentum Woot. & Standl.	N, 3, upper cyps		

	Mogollon geranium	r626, 914, 990	h 338, 483, 677
	Geranium richardsonii Fisch. & Trautv.	N, 2, upper cyns	
	Richardson's geranium	r511	h 338a
Grossulariaceae	Ribes cereum Dougl.	N, 2, upper CdC>6900'	
	wax currant	r550, 1069, 1297	
	Ribes leptanthum Gray	N, 3, thru-out	
	trumpet gooseberry	r288, 627, 942, 951, 966, 1210, 1224	h 9, 139
Haloragaceae	Myriophyllum sibiricum Komarov	N, 3, upper CdM, aquatic	
	milfoil	r603, 979	
Hydrangeaceae	Fendlera rupicola Gray	N, 3, slopes, lower cyns	
	<i>used to be</i> fendlerbush	D	h69, 126, 156, 801 B223
Saxifragaceae	Philadelphus microphyllus Gray	N, 3, slopes, thru-out	
	littleleaf mockorange	r322, 635	He h223, 865 Cu
Hydrophyllaceae	Nama dichotomum (Ruiz & Pavón)	N, 2, upper cyns & rims	
	Choisy	r1413, 1575	
	wishbone fiddleleaf		
	Nama retrorsum J.T. Howell	N, 2, sandy areas, lower cyns & rims	
	betatakin fiddleleaf	r697	h 563
	Phacelia alba Rydb.	N, 1, Whiskey	Cr
	P. neomexicana var. alba, P. neomexicana		
	white phacelia	r663	h 516
	Phacelia crenulata var. corrugata	N, 3, lowermost rims	

	(A. Nels.) Brand.	r188	h55, 856, 940
	P. corrugata		
	caterpillarweed		
	Phacelia ivesiana Torr.	N, 2, lower rims <6500'	
	Ives' phacelia	r247, 282, 400	h 135 D
Juglandaceae	Carya illinoensis (Wangenh.) K. Koch	H, 1, Draper Ranch, end of road in CdM	
	C. pecan	r1190	
	pecan		
	Juglans major (Torr.) Heller	H, 2, lower cyns	
	Arizona black walnut	r243	h 105, 875
Lamiaceae	Agastache pallidiflora (Heller) Rydb.	N, 0, probably ssp as below	
	Bill William hyssop		h 634
	Agastache pallidiflora ssp. neomexicana	N, 2, upper CdC>7000'	
	(Briq.) Lint & Epling	r818, 851, 954	
	New Mexican giant hyssop		
	Dracocephalum parviflorum Nutt.	N, 2, mid cyns	
	Moldavica parviflora	r481	h B
	American dragonhead		
	Hedeoma drummondii Benth.	N, 3, thru-out	
	Drummond's false pennyroyal	r470, 1245	h91, 368 R458 L33 B354
	Hedeoma oblongifolia (Gray) Heller	N, 1, west slopes of Pine Tree Cyn, could use another look	
	false pennyroyal		W

	Marrubium vulgare L.	E, 3, lower cyns	
	horehound	h 466, 512	De
	Mentha arvensis L.	N, 2, Tsaille Lake to mouth of cyns	
	field mint	r731, 786, 796, 800 h470 L34	
	Monarda fistulosa var. menthifolia	N, 3, upper cyns	
	(Graham) Fern.	r632, 734, 929 h 474	
	M. menthifolia		
	wildbergamot beebalm		
	Perovskia atriplicifolia Benth.	H, 1, T-bird Lodge	
		r1295	
	Poliomintha incana (Torr.) Gray	N, 2, sandy sites, lower cyns	
	rosemary mint	r227	
	Prunella vulgaris L.	N, 2, upper cyns	
	selfheal	r604 h 276, 315, 469	
	Salvia reflexa Hornem.	N, 2, Tsaille Lake to confluence	
	blue sage	r1479, 1523	
	Stachys rothrockii Gray	N, 2, upper CdC	
	Rothrock's hedgenettle	r845 h 530, 623	
Lemnaceae	Lemna minor L.	N, 3, upper CdM, aquatic	
	common duckweed	r965, 992	
Linaceae	Linum aristatum Engelm.	N, 0, rim, upper CdM	
	bristle flax	h339, W	

	Linum australe Heller	N, 2, thru-out
	southern flax	r559, 1024
	Linum lewisii Pursh	N, 2, upper cyns & rims >6500'
	blue flax	r440, 545 h 917, W
	Linum puberulum (Engelm.) Heller	N, 2, lower cyns & rims
	desert flax	r202 h 224, 903 D
Loasaceae	Mentzelia albicaulis Dougl.	N, 2, rims thru-out
	white blazingstar	r210, 365, 445 h 900
	Mentzelia multiflora (Nutt.) Gray	N, 2, sandy sites, lower cyns
	desert blazingstar	r276
	Mentzelia pumila Nutt. ex Torr. & Gray	N, 2, sandy sites, lower rims
	dwarf blazingstar	r698 h 63, 250
	Mentzelia rusbyi Woot.	N, 1, NE of Whiskey Res.
	Rusby's blazingstar	r1080
Malvaceae	Malva neglecta Wallr.	E, 2, lower cyns & slopes
	cheeseweed	r274, 775 W
	Sphaeralcea ambigua Gray	N, 0, WH Ruin
	desert globemallow	B
	Sphaeralcea coccinea (Pursh) Rydb.	N, 3, lower cyns & rims
	S. coccinea var. dissecta	r269, 1960 h251, 317, 410 R153 B204
	copper mallow	
	Sphaeralcea fendleri Gray	N, 3, mid-lower cyns & rims

	Fendler's globemallow	r1497, 1524	h415, 422	H C	B276
	Sphaeralcea hastulata Gray	N, 0, NPS housing area			
	S. subhastata		h 59, 695		
	spreading globemallow				
	Sphaeralcea incana Torr. ex Gray	N, 1, White Sands Tr			
	gray globemallow	r717			
	Sphaeralcea leptophylla (Gray) Rydb.	N, 2, dunes south of VC			
	scaly globemallow	r307, 483, 702	h406, 501	R154	
	Sphaeralcea parvifolia A. Nelson	N, 2, lower cyns			
	smallflower globemallow	r272	h232, 253	L35	
Monotropaceae	Pterospora andromedea Nutt.	N, 1, spring at top of TR124, upper CdC			
	woodland pinedrops	r1379			
Moraceae	Morus alba L.	H, 1, Sliding Rock & Antelope House Ruins			
	prev. det. as M. microphylla	r1145	h 876, 878		
	white mulberry				
Nyctaginaceae	Abronia elliptica A. Nels.	N, 2, sandy sites, lower cyns			
	fragrant white sand verbena	r224	h387, 418, 762, 780, 866	R155	B336
	Abronia fragrans Nutt. ex Hook.	N, 1, sandy sites, Cottonwood Cyn			
	sweet sandverbena	r277			
	Boerhavia spicata Choisy	N, 3, lower cyns & rims			

	B. torreyana	r1462, 1469, 1521	h 658
	creeping spiderling		
	Mirabilis decipiens (Standl.) Standl.	N, 2, upper cys	
	broadleaf four-o'clock	r963	
	Mirabilis linearis (Pursh) Heimerl	N, 2, thru-out	
	Oxybaphus linearis	r716, 1057	h 491, 518, 598
	narrowleaf four-o'clock		
	Mirabilis multiflora (Torr.) Gray	N, 2, thru-out	
	Colorado four o'clock	r1468	h95 D H L36 R466
	Mirabilis oxybaphoides (Gray) Gray	N, 2, cys thru-out	
	spreading four-o'clock	r987, 1018, 1519 h	
	Tripterocalyx carnea var. wootonii	N, 2, sandy sites, lower cys	
	(Standl.) L.A. Gal.	r1177	D h263, 555, 579, 698 R465 B315
	T. wootonii		
	Wooton sandpuffs		
Oleaceae	Forestiera pubescens var. pubescens Nutt.	N, 3, thru-out, T	
	F. neomexicana	r208, 1567	h100 DB228
	desert olive		
	Fraxinus anomala Torr. ex S. Wats.	N, 1, S Rim road .5 km east of VC & WH Tr	
	singleleaf ash	r1122 h383, 764 L37 C B321	B
	Fraxinus sp. L.	H, 1, T	
	ash	r1966	

Onagraceae	Ligustrum sp.	H, 1, T	
	privet	r1566	
	Menodora scabra Gray	N, 2, upper CdC & rim above Whiskey Cr	
	rough menodora	r456, 1061	
	Calylophus lavandulifolius	N, 2, lower south rim	
	(Torr. & Gray) Raven	r228, 232, 411	B208
	Oenothera lavandulifolius		
	lavender calylophus		
	Epilobium ciliatum Raf.	N, 3, cyns thru-out, riparian	
	E. californicum	r733, 801?, 996, 1305, 1334, 1376, 1385	h 463
	fringed willow herb		
	Gaura coccinea Nutt. ex Pursh	N, 2, sage flats above CdC >7000'	
	scarlet gaura	r662, 862, 1078	
	Gaura hexandra ssp. gracilis	N, 0, upper MC	
	(Woot. & Standl.) Raven & Gregory		
	G. gracilis		h 644
	harlequin bush		
	Gaura mollis James	N, 2, lower cyns & rims	
	G. parviflora	r785, 1291, 1543	h 408, 428, 566, 662
	velvetweed		
	Gayophytum diffusum ssp. parviflorum	N, 1, upper Wheatfields Cyn	

Lewis & Szweykowski	r836		
spreading groundsmoke			
Gayophytum ramosissimum	N, 1, near head of Black Rock Cyn		
Torr. & Gray	r429		
pinyon groundsmoke			
Oenothera albicaulis Pursh.	N, 3, mid-lower cyns & rims		
prev. det. as O. speciosa	r252, 461, 1198	D	B 273
white-stem evening primrose			
Oenothera caespitosa ssp. caespitosa Nutt.	N, 0, lower cyns		
O. caespitosa var. montana		h 372	B274
tufted evening primrose			
Oenothera caespitosa ssp. marginata	N, 2, mid cyns		
(Nutt. ex Hook. & Arn.) Munz	r474	h	B
tufted evening primrose			
Oenothera caespitosa ssp. navajoensis	N, 0, base of Spider Rock		
W.L. Wagner, Stockhouse & Klein			
prev. det. as O. c. var. montana		h 214	
Navajo evening-primrose			
Oenothera coronopifolia Torr. & Gray	N, 2, Wheatfields & Coyote Creeks		
crownleaf evening primrose	r558, 813		
Oenothera elata ssp. hookeri	N, 2, upper CdM		
(Torr. & Gray) W. Dietr. & W.L. Wagner			

	O. hookeri	r986	h 490, 551, 643, 664
	Hooker's evening-primrose		
	Oenothera flava (A. Nels.) Garrett	N, 3, upper cyns & rims	
	yellow evening-primrose	r430, 501, 531, 538, 984 h630	B325
	Oenothera pallida Lindl.	N, ?, likely ssp. runcinata or trichocalyx	
	pale evening primrose	h181, 265, 670	Ha
	Oenothera pallida ssp. runcinata	N, 0, WH Tr	
	(Engelm.) Munz & W. Klein	Ha	
	pale evening primrose		
	Oenothera pallida ssp. trichocalyx	N, 2, dunes 1 mile south of VC	
	(Nutt.) Munz & W. Klein	r306, 701	
	pale evening primrose		
Orobanchaceae	Orobanche fasciculata Nutt.	N, 1, rim of MC, h rep common on rims thru-out	
	purple broomrape	r529	h 908 D C
	Orobanche ludoviciana ssp. multiflora	N, 1, rims thru-out	
	(Nutt.) Collins, comb. nov. ined.	r1072	h 897 D
	O. multiflora		
	manyflowered broomrape		
Oxalidaceae	Oxalis decaphylla Kunth	N, 2, thru-out	
	O. grayi	r866, 1388	
	tenleaf woodsorrel		
Pedaliaceae	Proboscidea parviflora (Woot.)	N, 2, lower cyns	

	Woot. & Standl.	r1108			
	Devil's claw				
Plantaginaceae	Plantago argyrea Morris	N, 2, mid-upper cyns			
	saltmeadow plantain	r317, 669, 857, 945	h543		
	Plantago eriopoda Torr.	N, 2, mid-lower cyns			
	alkali plantain	r1238, 1268	h379	Ha	R157 Ba
	Plantago lanceolata L.	N, 3, thru-out cyns, riparian			
	lanceleaf plantain	r425, 605, 803	h320, 376, 482	L38	
	Plantago major L.	N, 3, thru-out cyns, riparian			
	broadleaf plantain	r660, 1014, 1302	h476, 532, 611, 682	He	
	Plantago patagonica Jacq.	N, 3, upper terraces, mid-lower cyns			
	P. purshii	r458	h64, 859		B313
	wooly plantain				
Polemoniaceae	Eriastrum diffusum (Gray) Mason	N, 1, sandy site, lower peninsula			
	diffuse eriastrum	r250			
	Gilia inconspicua Sm. (Sweet)	N, 3, thru-out			
	shy gilia	r164, 266, 476			
	Gilia leptomeria Gray	N, 0, between NPS housing & dunes			
	sand gilia		h 384, 861	D	
	Gilia ophthalmoides Brand	N, 0, lower cyns			
	eyed gilia		h 125, 148, 209, 802		
	Gilia sinuata Dougl.	N, 0, lower cyns			

rosy gilia	h125, 148, 209, 384, 784, 802	D125
<i>Ipomopsis aggregata</i> (Pursh) V. Grant	N, 3, lower cyns & slopes	
Gilia aggregata	h79, 164, 235	R160 C B36, 202
scarlet gilia		
<i>Ipomopsis gunnisonii</i> (T. & G.) V. Grant	N, 0, sandy sites, lower cyns & rims	
Gilia gunnisonii		D
sand-dune skyrocket		
<i>Ipomopsis longiflora</i> (Torr.) V. Grant	N, 2, sandy sites, lower cyns	
Gilia longiflora	r236, 311 H h199, 734, 742	Cu
whiteflowered gilia		
<i>Ipomopsis multiflora</i> (Nutt.) V. Grant	N, 2, upper cyns & rims	r815
Gilia multiflora	h 817	
manyflowered gilia		
<i>Ipomopsis polycladon</i> (Torr.) V. Grant	N, 2, sandy sites, lower south rim	
Gilia polycladon	r215 h 861	D
sprawling skyrocket		
<i>Ipomopsis pumila</i> (Nutt.) V. Grant	N, 0, lower rims	
Gilia pumila	h 861a, 901	D
dwarf gilia		
<i>Leptodactylon pungens</i> Torr.)	N, 3, lower cyns & slopes	
Torr. ex Nutt.	h852	D B222
common pricklygilia		

	Phlox austromontana Coville	N, 3, slopes, lower cys	
	P. austromontana ssp. densa	r178, 287	h 35, 147 F
	desert phlox		
	Phlox gracilis (Dougl.) Greene	N, 2, upper cys	
	Microsteris gracilis	r161	h 198, 924
	slender phlox		
	Phlox hoodii Richards.	N, 1, Navajo Fortress	
	Hood's phlox		W
	Phlox longifolia ssp. brevifolia	N, 0, near Spider Rock Overlook	
	(Gray) Mason		
	P. grayi		h 771
	longleaf phlox		
	Phlox longifolia ssp. longifolia Nutt.	N, 2, mid cys	
	longleaf phlox	r175	h 907, 726 C
	Polemonium foliosissimum	N, 1, upper Wheatfields Cr	
	var. foliosissimum Gray	r829	
	towering jacobs ladder		
Polygonaceae	Eriogonum alatum Torr.	N, 3, rims thru-out	
	winged buckwheat	r478, 707, 774 D	h397, 520, 618, 736 C
	Eriogonum cernuum Nutt.	N, 2, upper cys & rims	
	nodding buckwheat	r743, 1047, 1538	h910
	Eriogonum corymbosum Benth.	N, 1, S Rim Dr 1 km east of VC	

crispleaf buckwheat	r1405		
Eriogonum microthecum Nutt.	N, 3, rims & slopes thru-out		
E. m. var. simpsonii	r708	h541, 733	R159
E. simpsonii			
slender buckwheat, Simpson buckwheat			
Eriogonum racemosum Nutt.	N, 3, upper cyns & rims >6500'		
redroot buckwheat	r728, 756	h 519, 931	
Eriogonum shockleyi S. Wats.	N, 1, floor of CdC		
Shockley's buckwheat		R463	
Eriogonum umbellatum var. cognatum	N, I have found no reference separating this from var. subaridum below (Greene) Reveal		
E. cognatum		h 522	
sulphur-flower buckwheat			
Eriogonum umbellatum var. subaridum	N, 2, upper cyns & rims		
S. Stokes	r677, 753		
sulphur-flower buckwheat			
Polygonum aviculare L.	E, 2, cyns thru-out		
prostrate knotweed		h 129, 510, 534	
Polygonum convolvulus L.	E, 1, upper CdM		
black bindweed	r998		
Polygonum douglasii ssp. johnstonii	N, 2, upper cyns and rims		

	(Munz) Hickman	r446, 729		
	P. douglasii var. johnstonii			
	Johnston knotweed			
	Polygonum lapathifolium L.	N, 1, Tsaile Lake discharge area		
	smartweed	r970		
	Polygonum ramosissimum Michx.	N, 1, Wheatfields Cyn		
	tall knotweed	r842, 1030		
	Rumex aquaticus var. fenestratus	N, 1, thru-out CdM		
	(Greene) Dorn	r292, 616		
	western dock			
	Rumex crispus L.	E, 3, thru-out		
	curly dock	r793, 1483, 1553 h173, 187, 226, 261, 455	Ha	B368
	Rumex salicifolius var. mexicanus	N, 2, upper CdC & Black Rock Cyn		
	(Meisn.) C.L. Hitchc.	r1052, 1088		
	Mexican dock			
Portulacaceae	Portulaca halimoides L.	N, 2, thru-out		
	silk-cotton purslane	r1415, 1542		
	Portulaca oleracea L.	E, 2, thru-out		
	P. retusa	r907, 921, 1389, 1516	H	h 715
	common purslane			
	Talinum brevifolium Torr.	N, 2, rims <6800'		
	pygmy fameflower	r229, 1387	h 815	

	Talinum confertiflorum Greene	N, 2, upper rims >6800'
	New Mexican fameflower	r946, 1003, 1386, 1414, 1427
Primulaceae	Androsace occidentalis Pursh	N, 1, rim near head of Poison Ivy Cyn
	western rock jasmine	r360
	Androsace septentrionalis ssp. subulifera	N, 3, thru-out
	(Gray) G.T. Robbins	r160, 433, 498 h 918 D
	A. septentrionalis var. subulifera	
	pigmyflower rockjasmine	
Ranunculaceae	Actaea rubra ssp. arguta (Nutt.) Hultén	N, 0, upper MC
	A. arguta	h 636
	red baneberry	
	Aquilegia chrysantha Gray	H, 1, T-bird Lodge
	golden columbine	r1952
	Aquilegia elegantula Greene	N, 1, upper east arm of MC
	western red columbine	r509
	Aquilegia micrantha Eastw.	N, 3, hg thru-out
	Mancos columbine	r467, 687, 1316, 1339 h 245
	Ceratocephala testiculata (Crantz) Bess. E, 4, thru-out	
	Ranunculus testiculatus	h 756 776, 791, 803, 843
	bur buttercup	
	Clematis columbiana (Nutt.)	N, 1, steep, forested slope in Poison Ivy Cyn
	Torr. & Gray	r355

rock clematis

Clematis hirsutissima var. hirsutissima	N, 1, Wheatfields Creek		
Pursh.	r855		
hairy clematis			
Clematis ligusticifolia Nutt.	N, 3, cys & slopes thru-out		
virgins bower	r722, 928, 960, 1012, 1233, 1364	h533, 624, 693	B382, 385
Delphinium nuttallianum Pritz. ex Walp.	N, 3, mid-upper cys & rims	>6500	
D. nelsonii	r268, 352, 543	h933	B201
low larkspur			
Delphinium scaposum Greene	N, 3, lower cys & rims	<6000'	
barestem larkspur	r316, 407, 454	D	h 845, 906
Myosurus apetalus var. borealis	N, 1, upper cys & rims		
Whittemore			
M. aristatus	r575	h 769	
bristly mousetail			
Myosurus cupulatus S.Wats.	N, 0, rim of upper CdM		
Arizona mousetail		h 922	
Ranunculus aquatilis L.	N, 0, upper cys, aquatic		
water buttercup		h 302, 487	
Ranunculus cymbalaria Pursh	N, 3, cys thru-out		
R. cymbalaria var. saximontanus		h124 L39	B277

	alkali buttercup			
	Ranunculus longirostris Godr.	N, 3, upper CdM, aquatic		
	R. aquatilis var. longirostris,	r602, 612, 980		
	R. aquatilis var. diffusus			
	longbeak buttercup			
	Ranunculus macounii Britt.	N, 2, upper CdM & near cyn mouth		
	Macoun's buttercup	r606, 1168, 1271, 1344	h 86, 278, 303	
	Ranunculus sceleratus var. multifidus	N, 2, cys thru-out		
	Nutt.	r1141b, 1283, 1375		
	blister buttercup			
	Thalictrum dasycarpum Fisch.& Avé-Lall.	N, 0, S Rim Dr ¼ mi ESE of T		
	purple meadowrue	<i>H</i>		
	Thalictrum fendleri Engelm. ex Gray	N, 3, cys thru-out		
	Fendler's meadow-rue	r1356	h337, 446	B323
Rhamnaceae	Ceanothus fendleri Gray	N, 1, upper cys & rims		
	Fendler's ceanothus	r892, 1337		
Rosaceae	Agrimonia striata Michx.	N, 0, upper MC		
	roadside agrimony		h 625	
	Amelanchier alnifolia var. alnifolia	N, 2, upper cys		
	(Nutt.) Nutt. ex M. Roemer	r1231		
	Saskatoon serviceberry			
	Amelanchier utahensis var. utahensis	N, 4, thru-out		

Koehne	r179, 260, 1186, 1231	Bu758	h99, 168, 757, 766, 767	B241	C
<i>A. bakeri</i>					
Utah serviceberry					
<i>Argentea anserina</i> (L.) Rydb.	N, 2, cyns thru-out				
<i>Potentilla anserina</i>	r561, 1170				
silverweed cinquefoil					
<i>Cercocarpus intricatus</i> S. Wats.	N, 4, rims and slopes <6500'				
<i>C. lediflorus</i> var. <i>intricatus</i>	h44, 104			B252	
littleleaf mountain mahogany					
<i>Cercocarpus ledifolius</i>	N, 2, lower rims and slopes <6400'				
var. <i>intermontanus</i> N. Holmgren	r692, 1128, 1218				
curl leaf mountain mahogany					
<i>Cercocarpus montanus</i> Raf.	N, 4, thru-out				
mountain mahogany	r321, 1124	h97, 196	Bu759	B239, 245	
<i>Cotoneaster horizontalis</i> Dcne.	H, 1, T				
rockspray cotoneaster	r1564				
<i>Dasiphora floribunda</i> (Pursh)	N, 1, hg on N side of Coyote Cr.				
Kartesz, comb. nov. ined.	r1309				
<i>Potentilla fruticosa</i>					
shrubby cinquefoil					
<i>Fallugia paradoxa</i> (D. Don) Endl. ex Torr.	H, 1, T				
Apache plume	r1293				

Fragaria virginiana ssp. glauca (S. Wats.)	N, 2, upper SW arm of MC		
Staudt		r491, 495	
Virginia strawberry			
Holodiscus dumosus (Nutt. ex Hook.)	N, 2, cyns thru-out >6200'		
Heller			
H. discolor			
H. dumosus var. australis		r919, 1083	h 464, 938
rock spirea			
Malus pumila Mill.	H, 4, lower cyns		
Common apple		r1470	h 807
Potentilla crinita Gray	N, 1, upper CdC		
bearded cinquefoil		r844	h352, 547
Potentilla pensylvanica L.	N, 2, upper CdC		
prairie cinquefoil		r665, 827	
Prunus armeniaca L.	H, 3, lower cyns		
apricot		r1183, 1560	
Prunus persica (L.) Batsch	H, 4, lower cyns		
peach		r1184	h 806
Prunus virginiana L.	N, 3, upper cyns		
chokecherry		r325, 370, 588	h 309, 356
Purshia stansburiana (Torr.) Henrickson	N, 4, thru-out		

	Cowania mexicana var. stansburiana,				
	C. stansburiana	r985, 1129, 1234, 1259, 1573	h169, 190, 881	R161 C	B224
	Stansbury cliffrose				
	Purshia tridentata (Pursh) DC.	N, 1, Whiskey Cr.			
	antelope bitterbrush	r674			
	Rosa woodsii var. ultramontana	N, 3, thru-out			
	(S. Wats.) Jepson	r1180	h 189, 322		
	R. arizonica				
	Wood's rose				
	Rubus idaeus ssp. strigosus (Michx.)	N, 2, upper cys			
	Focke				
	R. strigosus	r880	h 484		
	red raspberry				
	Rubus parviflorus Nutt.	N, 1, upper CdM			
	thimbleberry	r656			
Rubiaceae	Galium boreale L.	N, 1, upper CdM, h rep as common			
	northern bedstraw	r653	h308, 458		
	Galium triflorum Michx.	N, 1, hg, Whiskey Creek			
	fragrant bedstraw	r1303	h 332		
	Galium wrightii Gray	N, 4, thru-out			
	G. wrightii var. rothrockii	r651, 712, 776, 947, 977, 1017, 1304, 1350, 1380			
	Wright bedstraw		h237, 288, 296, 354, 67, 427	D R40	Ba 61

Salicaceae	Populus alba L.	H, 1, Draper Ranch, end of road in CdM		
	white poplar	r1188	B	
	Populus angustifolia James	N, 2, cys >6200'		
	narrowleaf cottonwood	r441, 523	B	
	Populus deltoides ssp. wislizeni	N, 5, cys thru-out		
	(S. Wats) Eckenwalder	r598, 1133, 1144, 1341	h25, 421	B376
	P. wislizeni, P. fremontii			
	Rio Grande cottonwood			
	Populus fremontii S. Wats.	H, 1, T		
	Fremont cottonwood	r1558		
	Populus nigra L.	H, 1, Campground and VC		
	Lombardy poplar	r1219, 1230		
	Populus tremuloides Michx.	N, 3, cys >6500'		
	quaking aspen	r1228	h 355	
	Populus x acuminata Rydberg	N, 2, mid cys		
	P. acuminata	r999, 1089	h 195, 393	
	lanceleaf cottonwood			
	Salix amygdaloides Anderss.	N, 4, mid-lower cys		
	peachleaf willow	r344, 746	h129, 228	B352
	Salix bebbiana Sarg.	N, 1, upper CdM		
	Bebb's willow	r620		
	Salix exigua Nutt.	N, 5, cys thru-out		

	coyote willow	r184, 658 h88, 229, 804 H L, 43 R464 B338
	<i>Salix gooddingii</i> Ball	N, 2, lower cyns
	Goodding willow	r217, 393 B
	<i>Salix laevigata</i> Bebb.	N, 2, thru-out
	red willow	r1165 Cu
	<i>Salix lasiolepis</i> Benth.	N, 2, mid-upper cyns >6200'
	arroyo willow	r156, 431, 443
Santalaceae	<i>Comandra umbellata</i> ssp. <i>pallida</i> (A. DC.) Piehl	N, 2, thru-out?
	<i>C. pallida</i>	h 240
	bastard toadflax	
Saururaceae	<i>Anemopsis californica</i> (Nutt.) Hook. & Arn.	N, 3, cyn bottoms below Jct r1159, 1361 H h381 R41
	yerba mansa	
Saxifragaceae	<i>Heuchera parvifolia</i> var. <i>flavescens</i> (Rydb.) Rosendahl, Butters & Lakela	N, 2, upper slopes
	littleflower alumroot	r358, 371, 584 h 279
	<i>Heuchera rubescens</i> var. <i>versicolor</i> (Greene) M.G. Stewart	N, 1, hg in lower Wheatfields Cr r877
	pink alumroot	
	<i>Lithophragma tenellum</i> Nutt.	N, 1, SE arm of MC
	slender woodlandstar	r520

Parnassia palustris var. parviflora	N, 1, hg in lower Wheatfields Cr
(DC.) Boivin	r878 h 451, 676
P. parviflora	
smallflower grass of Parnassus	
Scrophulariaceae Besseyia arizonica Pennell	N, 2, rims above upper CdC under ponderosa pine
Arizona coraldrops	r500, 848 <i>H</i>
Castilleja applegatei ssp. martinii	N, 2?, thru-out
(Abrams) Chuang & Heckard	r304, 391 C B211, 212
C. chromosa	
desert Indian paintbrush	
Castilleja angustifolia (Nutt.) G. Don	N, 0, lower cyns
prev det as C. chromosa	h165, 241a, 763, 805, 836
northwestern paintbrush	
Castilleja integra Gray	N, 2, upper rims >6800'
squawfeather	r1076 h 294, 351, 916
Castilleja linariifolia Benth.	N, 2, cyns thru-out
Wyoming paintbrush	r887, 1091, 1357 h206, 241b, 369, 467 H L45
Castilleja minor (Gray) Gray	N, 0, near WH Ruin
alkali Indian paintbrush	h870 Ha R44, 162, 472
Cordylanthus wrightii Gray	N, 2, rims >6400'
Wright bird's-beak	r709, 861 R163
Mimulus eastwoodiae Rydb.	N, 3, hg thru-out

crimson monkeyflower	r448	h243	B
Mimulus glabratus Kunth	N, 2, upper Cyns		
round-leaf monkey-flower	r688, 795, 1346		
Mimulus guttatus DC.	N, 2, upper cyns		
seep monkeyflower	r879, 1307	h449, 526	R164
Mimulus rubellus Gray	N, 1, rim above Black Rock Cyn		
little redstem monkeyflower	r444		
Orthocarpus luteus Nutt.	N, 0, head of MC		
yellow owlclover		h549	
Orthocarpus purpureoalbus	N, 3, upper rims & cyns		
Gray ex S. Wats.	r642, 749		
purple owlclover			
Pedicularis centranthera Gray	N, 2, lower rims		
dwarf lousewort	r280, 413	h 837	
Penstemon barbatus ssp. trichander	N, 2, thru-out		
(Gray) Keck	r633, 757	h273, 287, 362	D Ha R165 C
P. barbatus			
beardlip penstemon			
Penstemon comarrhenus Gray	N, 1, rim above CdM		
dusty penstemon	r752	h 461	
Penstemon lentus Pennell	N, 1, CdM upstream of Middle Trail Cyn		
handsome penstemon	r384		

Penstemon linarioides Gray	N, 3, mid-upper cys & rims
creeping penstemon	r337 h 266, 323, 350, 890, 925
Penstemon ophianthus Pennell	N, 3, cys & rims >6000'
P. jamesii var. ophianthus	r399, 465, 479 h 333, 846, 889, 914
Arizona beardtongue	
Penstemon strictiformis Rydb,	N, 1, lower Bat Cyn
Mancos penstemon	r480
Penstemon strictus Benth.	N, 2, sage flats >7000'
Rocky Mountain penstemon	r641, 672, 690 C
Penstemon virgatus Gray	N, 1, uppermost MC >7000'
upright blue beardtongue	r948, 955 h621
Veronica americana Schwein. ex Benth.	N, 2, thru-out cys
American speedwell	r334, 1306, 1336, 1353 h314a R166
Veronica anagallis-aquatica L.	N, 3, thru-out cys
water speedwell	r291, 335, 482, 794 <i>H</i> h 70, 142, 314
Veronica peregrina L.	N, probably ssp xalapensis
neckweed	h141 D
Veronica peregrina ssp. xalapensis	
(Kunth) Pennell	N, 2, thru-out >6000'
neckweed	r230, 510, 1247, 1322, 1326
Veronica serpyllifolia L.	N, 1, upper CdM
thymeleaf speedwell	r661

Solanaceae	Chamaesaracha coronopus (Dunal) Gray	N, 2, thru-out		
	green false nightshade	r940	h538, 561	R167
	Datura wrightii Regel	N, 2, lower cyns		
	D. meteloides	r1360	h230, 282, 503	D B370
	sacred datura			
	Lycium pallidum Miers	N, 2, lower cyns		
	pale wolfberry	r194	h89, 371, 504	L46 B308
	Nicotiana attenuata Torr. ex S. Wats.	N, 0, thru-out cyns		
	coyote tobacco		h567, 582, 640	R47
	Nicotiana obtusifolia var. obtusifolia	N, 2, lower cyns		
	Mertens & Galeotti	r216	h 655	
	N. trigonophylla			
	desert tobacco			
	Physalis hederifolia var. fendleri	N, 2, lower CdC		
	(Gray) Cronq.			
	P. fendleri	r718, 1020	h222, 364, 570, 587, 609	R48
	Fendler groundcherry			
	Physalis hederifolia var. hederifolia	Gray N, 1, upper Bat Cyn, Tunnel Cyn		
	ivy leaf ground cherry	r927, 1178		
	Physalis longifolia Nutt.	N, 0, in field near Twin Tr, CdM		
	common groundcherry		Mayes (ASC)	
	Solanum elaeagnifolium Cav.	E, 3, disturbed sites, esp. lower cyns & rims		

	white horsenettle	h 54, 71, 366, 568, 746 R168 H
	Solanum jamesii Torr.	N, 2, thru-out
	wild potato	r931, 999, 1443 h 724
	Solanum rostratum Dunal.	N, 3, disturbed sites, thru-out
	buffalobur	r601, 770 h513, 576 R470
	Solanum triflorum Nutt.	N, 2, upper cyns & rims
	cutleaf nightshade	r1079, 1442 R
Tamaricaceae	Tamarix chinensis Lour.	E, 5, thru-out
	T. pentandra	r1275, 1965 h73 R469 L49
	saltcedar	
	Tamarix parviflora DC.	E, 5, only at canyon mouth
	saltcedar	r1121
Ulmaceae	Celtis laevigata var. reticulata (Torr.)	N, 3, lower cyns
	L. Benson	
	C. reticulata	H h170 B334
	netleaf hackberry	
	Ulmus americana L.	N, 0, CdC near mouth of Wild Cherry Cyn
	American elm	h 877
	Ulmus pumila L.	E, 3, thru-out
	Siberian elm	r273 B
Urticaceae	Parietaria pensylvanica Muhl. ex Willd.	N, 2, rock overhangs, upper Cyns
	Pennsylvania pellitory	r831 W

	Pennsylvania pellitory				
	Urtica dioica ssp. gracilis (Ait.) Seland.	N, 2, cyns thru-out			
	U. gracilis	r1964	h 437		
	stinging nettle				
Valerianaceae	Valeriana acutiloba Rydb.	N, 1, upper slopes & rims			
	cordilleran valerian	r152			
Verbenaceae	Caryopteris X clandonensis	H, 1, T			
	hort. ex Rehd.	r1569			
	caryopteris				
	Verbena bracteata Lag. & Rodr.	N, 3, disturbed sites lower cyns			
	prostrate verbena	r485 Bu748 h154, 231, 286 R169	R		
	Verbena macdougallii Heller	N, 2, disturbed sites, upper cyns & rims			
	MacDougal verbena	r1498	h 472, 641		
Violaceae	Viola sororia Willd.	N, 1, upper CdM & MC			
	prev. det. as V. nephrophylla	r512	h321		
	common blue violet				
Viscaceae	Arceuthobium divaricatum Engelm.	N, 2?, middle rims			
	A. campylopodum forma divaricatum				
	pinyon dwarf mistletoe	r1099	h 321, 703	B250	
	Phoradendron juniperinum	N, 0, thru-out			
	Engelm.ex Gray		h247, 702, 735, H	B233	
	juniper mistletoe				

Vitaceae	Parthenocissus vitacea (Knerr)	N, 3, thru-out	
	A.S. Hitchc.	r297	h293, 373, 430 B358
	anno. from P. inserta & P. quinquefolia		
	Virginia creeper		
Zygophyllaceae	Vitis arizonica Engelm.	N, 3, cyns thru-out	
	Arizona grape	r1182	h67 B
	Kallstroemia californica (Wats.) Vail	N, 0, CdM downstream of Antelope House Ruin	
	California caltrop		h 653, 812
Agavaceae	Tribulus terrestris L.	E, 3, disturbed sites, lower cyns, h rep in NPS housing area	
	puncturevine		h701, 712
	Yucca angustissima Engelm. ex Trel.	N, 4, thru-out	
	narrowleaf yucca	r1123, 1136, 1179	h 121 Bu726
Commelinaceae	Yucca baccata Torr.	N, 4, thru-out	
	banana yucca	r1149	h98 B219
	Tradescantia occidentalis	N, 2, lower cyns	
	var. occidentalis (Britt.) Smyth	r777	h873 R462
Cyperaceae	prairie spiderwort		
	Tradescantia pinetorum Greene	N, 1?, upper rims>7000'	
	pinewoods spiderwort	r944	h 638
	Carex aurea Nutt.	N, 3, hg thru-out	
	golden sedge	r377, 405, 592, 679, 974, 1518, 1533	
	Carex chihuahuensis MacKenzie	N, 1, hg, mouth of Cottonwood Cyn	

Chihuahuan sedge	r1358	
Carex duriuscola C. A. Mey.	N, 3, cys thru-out	
C. eleocharis, C. stenophyla var. eleocharis		
needleleaf sedge	r332, 362, 560, 742, 1167, 1264	
Carex filifolia Nutt.	N, 1, Wide Rock Butte	
C. filifolius	W	
threadleaf sedge		
Carex foenea var. foenea Willd.	N, 2, riparian sites thru-out	
C. siccata, C. simulata	r760, 1093, 1254	h24, 127, 177 B369
dryspike sedge		
Carex geophila Mackenzie	N, 1, upper CdC	
White Mountain sedge	r154	
Carex interior Bailey	N, 1?, upper Black Rock Cyn	
inland sedge	r436	
Carex meadii Dewey	N, 1, hg above Coyote Cr.	
Mead sedge	r1315	
Carex microptera MacKenzie	N, 0, upper CdM	
ovalhead sedge	h 326	
Carex nebrascensis Dewey	N, 1, where road crosses Coyote Cr	
Nebraska sedge	r1255	
Carex occidentalis Bailey	N, 2, cys thru-out	
western sedge	r326, 525, 926, 1181	h185

Carex pachystachya Cham. ex Steud.	N, 1, upper CdM
chamisso sedge	r615
Carex pellita Muhl ex Willd.	N, 2, mid-upper cyps >6200'
C. lanuginosa	r580, 1333, 1399 h 327
woolly sedge	
Carex praegracilis W. Boott	N, 2, cyps thru-out
slim sedge	r1163, 1260, 1264
Carex specuicola J.T. Howell	N, 2, 4 hgs in CdM
Navajo sedge	r258, 1154, 1200, 1365, 1522
Carex vallicola Dewey	N, 1, upper cyps
valley sedge	r346, 436
Cyperus fendlerianus Boeckl.	N, 1, rocky S slope in upper Wheatfields Cr.
Fendler's flatsedge	r858
Cyperus schweinitzii Torr.	N, 1, E rim of Elephant Spring Cyn
sand flat sedge	r1421
Cyperus squarrosus L.	N, 1, rim above jct of MC and CdC
C. aristatus	r1428
awned flat sedge	
Eleocharis engelmannii Steud.	N, 1, upper CdC
Engelmann's spikerush	r185
Eleocharis palustris (L.)	N, 3, thru-out cyps

Roemer & J.A. Schultes		
E. macrostachya	r293, 526, 563, 579, 619, 624, 1243	h 176, 342
common spikerush		
Schoenoplectus acutus var. acutus	N, 1, 1 km below Tsaile Dam in CdM	
(Muhl. ex Bigelow) A.& D. Löve	r614	
Scirpus acutis		
hardstem bulrush		
Schoenoplectus americanus (Pers.)	N, 3, thru-out cyps	
Volk. Ex Schinz & R. Keller	r293, 527, 578, 1241	h85, 144, 175, 319 R147 H
Scirpus americanus		
American bulrush		
Schoenoplectus pungens var. pungens	N, 2, thru-out cyps	
(Vahl) Palla	r387, 426, 563, 581, 798, 973	
Scirpus pungens		
common threesquare		
Scirpus microcarpus J. & K. Presl	N, 2, upper CdM & at spring at top of Tr 124 in CdC	
panicled bulrush	r1378	h325
Scirpus pallidus (Britt.) Fern.	N, 1, Wheatfields Cyn	
pale bulrush	r1340	
Iridaceae		
Iris missouriensis Nutt.	N, 2, rim above upper MC	
Rocky Mountain iris	r541, 544	
Sisyrinchium demissum Greene	N, 2, wet places, upper cyps	

	dwarf blue-eyed grass	r685	h 281, 459
Juncaceae	<i>Juncus balticus</i> var. <i>montanus</i> Engelm.	N, 0, lower CdC	
	mountain rush		h136, 174, 186 Ha
	<i>Juncus bufonius</i> L.	N, 2, thru-out cyns	
	toad rush	r1249, 1280	h 145, 413
	<i>Juncus ensifolius</i> Wikstr.	N, 2, CdM	
	<i>J. tracyi</i>	r804, 969	h 186a W
	swordleaf rush		
	<i>Juncus interior</i> Wieg.	N, 2?, Pine Tree Cyn, CdM	
	inland rush		W
	<i>Juncus longistylis</i> Torr.	N, 2, upper cyns	
	longstyle rush	r345, 582, 2540	
	<i>Juncus mexicanus</i>	N, 2, rims and cyns >5900'	
	Willd. ex J.A. & J.H. Schultes	r231, 427, 475, 583	
	Mexican rush		
	<i>Juncus saximontanus</i> A. Nels.	N, 1, Antelope House Tr	
	<i>J. ensifolius</i> var. <i>brunnescens</i>	r416, 1400, 2539	h186a
	prev. det. as <i>J. tracyi</i>		
	Rocky Mountain rush		
	<i>Juncus tenuis</i> Willd.	N, 2, rims and cyns >6200'	
	field rush	r991, 1094, 1430	
	<i>Juncus torreyi</i> Coville	N, 2, Tsaille Dam discharge area & hg in side cyn below WH Ruin	

	Torrey rush	r971, 1485, 1534	W
Liliaceae	<i>Allium bisceptrum</i> var. <i>palmeri</i>	N, 2, upper CdM	
	(S. Wats.) Cronq.	r638, 652	h 920, 932
	<i>A. palmeri</i>		
	aspen onion		
	<i>Allium cernuum</i> var. <i>obtusum</i>	N, 2, upper cyns & rims >7000	
	Cockerell ex J.F. Macbr.	r755, 819, 852	h 546, 620a
	nodding onion		
	<i>Allium geeyeri</i> Wats.	N, 2, upper CdC & rims >7000	
	Geyer's onion	r854, 868, 894	h620
	<i>Allium gooddingii</i> Ownbey	N, 0, upper CdM	
	Goodding's onion		h471
	<i>Allium macropetalum</i> Rydb.	N, 1, above pour-off on rim of Elephant Spring Cyn	
	largeflower onion	r1419	
	<i>Asparagus officinalis</i> L.	E, 1, disturbed sites, lower cyns	
	asparagus	r1546	h 138
Liliaceae	<i>Calochortus aureus</i> S. Wats.	N, 3, rims thru-out	
	<i>C. nuttallii</i> var. <i>aureus</i>	r301	h 311, 360, 849, 905 D
	sego lily		
	<i>Calochortus gunnisonii</i> S. Wats.	N, 2, rim above CdM	
	Gunnison's mariposa lily	r643	h 311a
Liliaceae	<i>Disporum trachycarpum</i> (S. Wats.)	N, 0, upper CdM	

	Benth. & Hook. f.	h 269
	roughfruit fairybells	
	Echeandia flavescens	N, 2, P-J rims above CdC
	(J.A. & J.H. Schultes) Cruden	r1416, 1429
	Anthericum torreyi	
	Torrey's craglily	
	Maianthemum racemosum (L.) Link	N, 2, mid cyn side cyns
	Smilacina racemosum	r327, 548, 903 h300, 457, 523
	Western Solomon's-seal	
	Maianthemum stellatum (L.) Link	N, 2, mid cyn side cyns
	Smilacina stellata	r359, 589 h 211
	false Solomon's-seal	
	Nolina microcarpa Wats.	H, 1, base of Face Rock
	sacahuista	r1577 h 892
	Zigadenus paniculatus (Nutt.) S. Wats.	N, 2, upper CdM & rims above CdM
	foothill deathcamas	r361 H h312, 912
	Zigadenus vaginatus (Rydb.) Macbr.	N, 2, 4 hgs in CdC & at Jct
	sheathed deathcamas	r1312, 1366, 1371, 1396, 1466
Orchidaceae	Epipactis gigantea Dougl. ex Hook.	N, 3, hgs thru-out
	stream orchid	r761, 1313, 1383 h 244 Bu717
Poaceae	Achnatherum lettermanii (Vasey)	N, 1, Gopher Spring area, MC
<i>used to be</i>	Barkworth	r910

Gramineae

Letterman needlegrass				
Achnatherum hymenoides	N, 3, lower cyns & rims			
(Roemer & J.A. Schultes) Barkworth				
Oryzopsis hymenoides	h57, 118, 160 Bu 745 Ha			B254
Indian rice grass				
Achnatherum scribneri (Trin. & Rupr.)	N, 1, mesa above Wheatfields Cyn			
Barkworth	r890			
Stipa scribneri				
Scribner needlegrass				
Achnatherum speciosum (Trin. & Rupr.)	N, 2, lower CdM			
Barkworth	r396	D		
Stipa speciosa				
desert needlegrass				
Agropyron desertorum	E, 2, rims >6900			
(Fisch. ex Link) J.A. Schultes	r422, 477	h330		
desert wheatgrass				
Agrostis exarata Trin.	N, 0, upper CdM			
spike bentgrass		h 492		
Agrostis gigantea Roth	E, 2, thru-out			

A. alba	r732, 745, 790, 797, 875, 1053	h 535, 537, 642a, Bu779	
redtop			
Agrostis scabra Willd.	N, 0, upper MC		
rough bentgrass		h 627	
Agrostis stolonifera L.	N, 2, near cyn mouth		
redtop	r1354		
Alopecurus aequalis Sobol.	N, 2, upper CdM >6800'		
short foxtail	r1266, 1320, 1347	h 310	
Apera interrupta (L.) Beauv.	E, 2, thru-out cyns		
silky bentgrass	r245, 418, 1222		
Aristida purpurea var. fendleriana	N, 3, lower rims		
(Steud.) Vasey	r1062	D, Bu730	B300
A. fendleriana			
fendler 3-awn			
Aristida purpurea var. longiseta	N, 3, lower cyns & rims		
(Steud.) Vasey		Bu735, D, h202, 216, 227, 708, R460	Cu B386
A. longiseta			
fendler 3-awn			
Aristida schiedeana var. orcuttiana (Vasey)			
Allred & Valdés-Reyna	N, 2, lower cyns <6500'		
Orcutt's 3-awn	r772, 1015, 1212, 1467		
Avena fatua L.	E, 2, lower cyns		

wild oats	r1956		
Beckmannia syzigache (Steud.) Fern.	N, 1, Wheatfields Creek		
slough grass	r1325		
Blepharoneuron tricholepis (Torr.) Nash	N, 2, rims>6800'		
pine dropseed	r943, 1065, 1417		
Bothriochloa barbinodis (Lag.) Herter	N, 2, lower cyns		
cane bluestem	r1395, 1459, 1510	h 506	
Bouteloua aristidoides (Kunth) Griseb.	N, 2, lower cyns		
needle grama	r1472		
Bouteloua barbata Lag.	N, 2, lower cyns<6000'		
sixweeks grama	r937, 1112		
Bouteloua curtipendula (Michx.) Torr.	N, 3, thru-out		
side oats grama	<i>H</i>	h564, 572, 581, 594, 617, 711 D	L29
Bouteloua eriopoda (Torr.) Torr.	N, 2, mid cyns		
black grama	r1103		
Bouteloua gracilis (Willd. ex Kunth)	N, 5, thru-out		
Lag. ex Griffiths	<i>H</i>	h645, 714	B206
blue grama			
Bromus anomalus Rupr. ex Fourn.	N, 1, Wheatfields Cr.		
nodding brome	r822		
Bromus arvensis L.	E, 0, lower cyns		

field brome	h	Ha
<i>Bromus carinatus</i> Hook. & Arn.	N, 1, Crack in Rock Tr, CdM	
mountain brome	r296	
<i>Bromus ciliatus</i> L.	N, 2, MC	
fringed brome	r1578	h 619
<i>Bromus commutatus</i> Schrad.	E, 2, upper CdM	
hairy chess	r646, 967	
<i>Bromus frondosus</i> (Shear)	N, 0, upper CdC	
Woot. & Standl.	h 540	
weeping brome		
<i>Bromus inermis</i> Leyss.	N, 2, Whiskey Cr	
smooth brome	r676	
<i>Bromus japonicus</i> Thunb. ex Murr.	E, 2, lower cyns	
Japanese brome	r766	h 182, 375, 445, D
<i>Bromus marginatus</i> Nees ex Steud.	N, 0, Far Spiral Cyn	
mountain brome	h 583	
<i>Bromus racemosus</i> L.	E, 1, near mouth of cyn	
bald brome	r1272	
<i>Bromus rigidus</i> Roth	E, 4, lower cyns, H rep at Antelope House Ruin	
ripgut brome	r218, 471	h723
<i>Bromus rubens</i> L.	E, 1, lower cyns	
red brome	r765	F (UNM)

Bromus tectorum L.	E, 4, thru-out
cheat grass	h20, 60, 106, 113, 436, B 344
Calamagrostis stricta ssp. stricta	N, 1, Whiskey Cr
(Timm.) Koel.	r683
slimstem reedgrass	
Cenchrus longispinus (Hack.) Fern.	N, 0, lower cyns
burgrass	H h
Cenchrus spinifex Cav.	N, 2, disturbed sites lower cyns
C. pauciflorus	r934, 1471 h729, 813 L30
field sandbur	
Chloris verticillata Nutt.	N, 2, lower cyns
windmillgrass	r1473 Bu720 h432 R461 B364
Chloris virgata Sw.	E, 1, campground
feather windmill grass	r1552
Cynodon dactylon (L.) Pers.	E, 2, disturbed sites, lower cyns; h rep as common
Bermudagrass	r1525 h 162
Dactylis glomerata L.	E, 2, thru-out
orchardgrass	r309 D
Dichanthelium acuminatum	N, 2, thru-out cyns
var. fasciculatum (Torr.) Freckmann	
Panicum lanuginosum	r684, 1173, 1310

western panicgrass				
<i>Distichlis spicata</i> (L.) Greene	N, 3, below Jct			
saltgrass	r771	h180	H	L31
<i>Echinochloa crus-galli</i> (L.) Beauv.	E, 0, h rep as very common thru-out			
barnyard grass		h 536		
<i>Elymus canadensis</i> L.	N, 2, thru-out cys			
Canada wildrye	r1086	h412	Bu780	
<i>Elymus elymoides</i> ssp. <i>brevifolius</i>	N, 3, thru-out			
(J.G. Sm.) Barkworth, comb. nov. ined.				
prev. det. as <i>E. elymoides</i> & <i>Sitanion hystrix</i>				
squirreltail	r219	h62, 158	Ha	B205, 251
<i>Elymus trachycaulus</i> ssp. <i>trachycaulus</i>	N, 2, thru-out			
(Link) Gould ex Shinnars	r462, 876, 1131	h123, 152	Bu722	B
<i>E. pauciflorus</i> ssp. <i>pseudorepens</i>				
prev. det. as <i>E. x pseudorepens</i>				
slender wheatgrass				
<i>Enneapogon desvauxii</i> Desv. ex Beauv.	N, 1, lower rims			
feather pappusgrass	r1463			
<i>Eragrostis cilianensis</i> (All.)	E, 2, cys thru-out			
Vign. ex Janchen	r1095, 1111, 1536		W	
lovegrass				
<i>Eragrostis mexicana</i> (Hornem.) Link	N, 2, lower cys & rims			

Mexican lovegrass	r1406, 1508
Eragrostis pectinacea (Michx.) Nees ex Steud.	N, 2, lower cyns & rims <6800' r791, 938, 1460, 1515, 1576 <i>H</i>
purple lovegrass	
Eremopyrum triticeum (Gaertn.) Nevski	E, 1, campground
annual wheatgrass	r193
Erioneuron pilosum (Buckl.) Nash	N, 0, S Rim near Wild Cherry Cyn
Triodia pilosa, Tridens pilosus	B377
hairy tridens	
Glyceria striata (Lam.) A.S. Hitchc.	N, 2, upper cyns >6500'
fowl mannagrass	r621, 647, 883, 1229 h307, 452a, 642
Hesperostipa comata ssp. comata (Trin. & Rupr.) Barkworth	N, 2, thru-out h 853 DB
Stipa comata	
needle and thread	
Hesperostipa neomexicana (Thurb. ex Coult.) Barkworth	N, 2, thru-out
Stipa neomexicana	h 882 Ha B299
New Mexico needlegrass	
Hordeum jubatum L.	N, 2, disturbed sites, lower cyns
little barley	r1556 D h335, 495, 919 Ha
Hordeum murinum ssp. glaucum	E, 3, disturbed sites, lower cyns

(Steud.) Tzvelev	r300	
H. glaucum	ssp. glaucum & ssp. leporinum are nearly impossible to tell apart!	
smooth barley		
Hordeum murinum ssp. leporinum	E, 0, H rep as common in lower cyns	
(Link) Arcang.	h 40, 107, 285	
H. leporinum		
lepor barley		
Hordeum pusillum Nutt.	N, 3, lower cyns	
hare barley	r312	B298
Koeleria macrantha (Ledeb.)	N, 3, upper rims>7000'	
J.A. Schultes		
K. cristata	r504, 553, 1005	h304, 923
june grass		
Leptochloa fusca ssp. fascicularis	N, 1, Campground; stock pond above Pine Tree Cyn	
(Lam.) N. Snow	r1514, 1555	
bearded sprangletop		
Lolium arundinaceum (Schreb.)	E, 2, thru-out	
S.J. Darbyshire		
Festuca arundinacea	r428, 608, 622, 1025	h
tall fescue		
Lolium pratense (Huds.)	E, 2, upper cyns	
S.J. Darbyshire		

Festuca pratense, F. elatior meadow fescue	r611, 874 He h 328, 493, 494a
Lycurus phleoides Kunth wolftail	N, 2, lower rims <6000' r763, 1407, 1509 H
Monroa squarrosa (Nutt.) Torr. false buffalograss	N, 2, rims thru-out r1031, 1409 D h 874 W
Muhlenbergia andina (Nutt.) A.S. Hitchc. foxtail muhly	N, 2, hg in lower cyns r381, 1541
Muhlenbergia arsenei A.S. Hitchc. Navajo muhly	N, 1, rim above Elephant Spring Cyn r1420
Muhlenbergia asperifolia (Nees & Mey.) Parodi alkali muhly	N, 2, thru-out r1049, 1199, 1418 h 128
Muhlenbergia curtifolia Scribn. low muhly	N, 3, hg <6000' r762, 1016, 1367 h 614
Muhlenbergia depauperata Scribn. sixweeks muhly	N, 2, middle rims r1412
Muhlenbergia filiformis (Thurb. ex S. Wats.) Rydb. pullup muhly	N 1, Coyote Cr. r1300
Muhlenbergia minutissima (Steud.) Swallen	N, 2, thru-out? r1444, 1489

annual muhly			
Muhlenbergia montana (Nutt.) Hitchc.	N, 2, rims >6800'		
mountain muhly	r859, 1488, 1526		
Muhlenbergia pauciflora Buckl.	N, 3, slopes <6500'		
New Mexico muhly	r415, 767, 1147, 1208, 1284		
Muhlenbergia peruviana (Beauv.) Steud.	N, 0, mouth of Black Rock Cyn		
M. pulcherrima	h 442		
Peruvian muhly			
Muhlenbergia porteri Scribn. ex Beal	N, 1, lower CdC, likely more common		
bush muhly	r1520		
Muhlenbergia pungens Thurb.	N, 0, lower rims		
sandhill muhly	Bu733 h713	R732	
Muhlenbergia racemosa (Michx.) B.S.P.	N, 3, mid cyns		
green muhly	r439, 925, 1081	h 681	
Muhlenbergia repens (J. Presl)	N, 1, upper CdC		
A.S. Hitchc.	r165		
creeping muhly			
Muhlenbergia thurberi Rydb.	N, 2, hg, mid cyns		
Thurber muhly	r917, 1308		
Muhlenbergia wrightii Vasey ex Coult.	N, 3, sage flats >7000'		
spike muhly	r1010, 1029	h 632	
Nassella viridula (Trin.) Barkworth	N, 1, head of Whiskey Cr		

green needlegrass	r1318	
<i>Panicum bulbosum</i> Kunth	N, 1, CdC & its rims	
bulb panicgrass	r911, 1432	
<i>Panicum capillare</i> L.	N, 2, thru-out	
witchgrass	r1301, 1547	H h 608, 687
<i>Panicum obtusum</i> Kunth	N, 1, lower CdM	
vine mesquite	r1532	
<i>Pascopyrum smithii</i> (Rydb.) A. Löve	N, 3, thru-out	
<i>Agropyron smithii</i>	r1321	h 203, 425 D
western wheatgrass		
<i>Phragmites australis</i> (Cav.)	N&H, 3, lower cyns	
Trin. ex Steud.	r1021	H (UNM)
common reed		
<i>Piptatherum micranthum</i>	N, 2, slopes >7000'	
(Trin. & Rupr.) Barkworth	r507, 644, 824, 849	W, D
<i>Oryzopsis micranthum</i>		
littleseed ricegrass		
<i>Pleuraphis jamesii</i> Torr.	N, 3, thru-out	
<i>Hilaria jamesii</i>		h345, 860 Bu746 D Ha
galleta		
<i>Poa annua</i> L.	E, 1, SE arm of Monument Cyn	
annual blue grass	r514	

Poa bulbosa L.	E, 1, lower cyns		
bulbous blue grass	r244, 1134		
Poa compressa L.	N, 3, cyns thru-out		
	r376, 607, 738, 1164, 1262, 1273	h 109, 297, 441, 452, 494, 928	
Poa fendleriana (Steud.) Vasey	N, 4, thru-out		
mutton grass	r1135, 1142, 1191, 1203, 1207, 1217	Bu750 h 3, 21, 760, 792, 834, 840	
Poa glauca Vahl	N, 0, fence at Newspaper Rock		
prev. det. as P. pratensis	h 183		
glaucous bluegrass			
Poa nemoralis L.	N, 1, upper Black Rock Cyn		
P. interior	r434		
forest blue grass			
Poa pratensis L.	N&E, 3, thru-out		
Kentucky bluegrass	r270, 294, 609, 809, 1221	D	
Poa secunda J. Presl	N, 0, near mouth of cyn		
big bluegrass	H		
Polypogon interruptus Kunth	E, 3, lower cyns		
ditch polypogon	r220, 417, 468, 1160, 1277	H h110, 146	B309
Polypogon monspeliensis (L.) Desf.	E, 2, lower cyns		
rabbit'sfootgrass	r1276, 1377	H Bu719 h146a, 289, 382	Ha
Polypogon viridis (Gouan) Breistr.	E, 2, thru-out CdM		
Agrostis semiverticillata	r968, 1277, 1352	h 423, W	

water bentgrass		
<i>Puccinellia distans</i> (Jacq.) Parl.	N, 3, mid-lower cyns	
spreading alkali grass	r295, 313, 333, 463, 1263, 1269	h
<i>Puccinellia fasciculata</i> (Torr.) Bickn.	N, 1, lower cyns	
saltgrass alkaligrass	r1132	
<i>Puccinellia nuttalliana</i> (J. A. Schultes)	N, 2, lower cyns	
Hitch.		
<i>P. airoides</i>	r1162, 1279, 1288	h 131
Nuttall alkaligrass		
<i>Schedonnardus paniculatus</i> (Nutt.) Trel.	N, 1, sage flats above Wheatfields Cyn	
tumble grass	r1032	
<i>Schizachyrium scoparium</i> (Michx.) Nash	N, 3, thru-out	
little bluestem	r773, 867	h 558, 615
<i>Setaria macrostachys</i> H. B. K.	N, 1, Crack in Rock Tr	
<i>S. macrostachya</i>	r472	
<i>Setaria viridis</i> (L.) Beauv.	E, 2, VC, CG, & T-bird Lodge	
bottle grass	r1544, 1551, 1568	W
<i>Sorghastrum nutans</i> (L.) Nash	N, 1, hgs in CdC >6200'	
Indiangrass	r1311, 1397	
<i>Sphenopholis obtusata</i> (Michx.) Scribn.	N, 0, seep at top of Antelope House Tr.	
prairie wedgegrass		h 363
<i>Sporobolus airoides</i> (Torr.) Torr.	N, 3, lower cyns & rims	

alkali sacaton	r486, 1557	h262, 691	Bu747 D	Ha	B
<i>Sporobolus contractus</i> A.S. Hitchc.	N, 2, mid-lower cyns				
spike dropseed	r1372, 1572				
<i>Sporobolus cryptandrus</i> (Torr.) Gray	N, 2, upper slopes & rims				
sand dropseed	r1042, 1060	D		Cu	
<i>Sporobolus flexuosus</i>	N, 2, lower cyns				
(Thurb. ex Vasey) Rydb.	r1461				
mesa dropseed					
<i>Sporobolus giganteus</i> Nash	N, 1, sandy site at mouth of Cottonwood Cyn				
giant dropseed	r1363				
<i>Stipa lettermannii</i> Vasey	N, 1, rim above upper CdC				
	r1251				
<i>Thinopyrum intermedium</i> (Host)	E, 1, Tsaille Lake discharge area				
Barkworth & D.R. Dewey	r1484				
<i>Agropyron intermedium</i>					
intermediate wheatgrass					
<i>Thinopyrum ponticum</i> (Podp.)	E, 1, Tsaille Lake discharge area				
Z.-W. Liu & R.-C. Wang					
<i>Agropyron elongatum</i>	r972				W
rush wheatgrass					
<i>Torreyochloa pallida</i> var. <i>pauciflora</i>	N, 1, Tsaille Lake discharge area				
(J. Presl) J.I. Davis	r1267				

	T. pallida		
	pale false mannagrass		
	Vulpia myuros (L.) K.C. Gmel.	E, 2, thru-out	
	V. melin forma megalura	r1278, 1374	
	foxtail fescue		
	Vulpia octoflora var. hirtella (Piper) Henr.	N, 2, thru-out	
	Festuca octoflora var. hirtella	r205, 222, 460, 1327	h 111, 150, 223, 838 D
	six-weeks fescue		
	Zea mays L.	H, 5, lower cyns & rims	
	corn	W	
Potamogetonaceae	Potamogeton foliosus Raf.	N, 1, Tsaili Lake discharge area	
	leafy pondweed	r1478, 2541	
Typhaceae	Typha angustifolia L.	E, 0, end of road in Black Rock Cyn	
	narrowleaf cattail		F (CACH)
	Typha latifolia L.	N, 2, cyns thru-out	
	broadleaf cattail	r2538	h 453

APPENDIX 2. *Taxa reported, but no voucher; reference, and annotations related to its likelihood of being found at Canyon de Chelly National Monument.*

Acer grandidentatum (Trautman); not reported for Apache County.

A. negundo var. *interius* (Bailey as *A. n.* var. *interior*)

Abronia ammophila (Bailey as *A. fendleri*); not reported for Apache County.

Ceanothus greggii (Trautman); not reported for Apache County.

Cercocarpus montanus var. *glaber* (Bailey as *C. betuloides*)

Chaenactis douglasii (Bailey); reported for Apache County.

Cichorium intybus (Trautman); reported for Apache County.

Cirsium arizonicum var. *nidulum* (Bailey as *C. nidulum*); not reported for Apache County.

Conopholis alpina var. *mexicana* (NP species list); not reported for Apache County.

Cryptantha angustifolia (Bailey); not reported for Apache County.

Cymopterus newberryi (NP species list); one Apache County report from near Ganado. I suspect it was misidentified.

Echinochloa frumentacea (NP species list); commonly used in birdseed mixes, probably not persistent, (Barkworth *et al*, 2003, p.400).

Ephedra trifurca (Bailey); not reported for Apache County.

Fallugia paradoxa (Travis' cook's list); a recent horticultural introduction (pers. obs.) at Thunderbird Lodge. I find it surprising that *F. paradoxa* does not occur as a native plant at Canyon de Chelly. I suspect Travis' cook would not have recorded horticultural plants, and I don't believe that *F. paradoxa* was at Thunderbird when the cook's flora was compiled.

Heterotheca villosa var. *hispida* (Bailey as *Chrysopsis hispida*); reported for Apache County.

Lepidium thurberi (Bailey); not reported for Apache County.

Lesquerella montana (Bailey); not reported for Arizona, but known in nearby southwestern Colorado.

Mahonia fremontii (Travis' cook's list); reported for Apache County.

Melilotus indica (Bailey); not reported for Apache County.

Mimulus cardinalis (Travis' cook's list); reported for Apache County.

M. glabratus var. *jamesii* (NP species list); not reported for Apache County.

Mirabilis glabrus (as *Oxybaphus glabrus* on Travis' cook's list); not reported for Apache County.

Nama demissum (Trautman); not reported for Apache County.

Oenothera fascicula (Trautman, not in ITIS); not reported for Apache County.

O. speciosa (Bailey); not reported for Apache County.

Opuntia erinacea var. *hystricina* (Bailey as *O. hystricina*); not reported for Apache County.

O. imbricata (Trautman); not reported for Apache County.

O. polyacantha var. *rufispina* (NP species list); not reported for Apache County.

Penstemon eatoni (Travis' cook's list); reported for Apache County.

P. secundiflorus (Travis' cook's list); not reported for Apache County.

Phlox viridis ssp. *compacta* (Bailey as *P. longifolia* ssp. *compacta*); not reported for Apache County.

Physalis virginiana (Travis' cook's list); not reported for Apache County.

Polanisia trachysperma (Travis' cook's list, reported on a PII mound near Big Cave, Canyon del Muerto); reported for Apache County.

Prosopis velutina (Halse as *P. juliflora*); There was a *P. velutina* specimen in the Canyon de Chelly herbarium amongst other specimens labeled as an ethnobotanical collection. There was no collection information associated with the specimen. Halse (1973) reported one introduced tree growing between Tse Taa Ruins and White House Ruins in Canyon de Chelly. I looked for this tree on several occasions without success. This area is densely vegetated now, making a single tree hard to find.

Prunus armeniaca (Jett, 1977)

P. domestica (Jett, 1977)

P. persica var. *nectarina* (Jett, 1977)

Pyrus communis (Jett, 1977)

Quercus dunni (Bailey as *Q. palmeri*); not reported for Apache County.

Ranunculus trichophyllus var. *trichophyllus* (NP species list); widespread & likely for Canyon de Chelly, though not reported for Apache County.

Tradescantia occidentalis var. *scopulorum* (Ranzoni); reported for Apache County.

Viguiera helianthoides (Bailey, not in ITIS); not reported for Apache County, Bailey may have seen *Viguiera dentata*, reported for southern and central Arizona, including southern Apache County.

APPENDIX 3. *Taxa found close to, or likely to be found at, Canyon de Chelly National Monument.*

Halse's (1973) *Eriogonum subreniform* plant record was found outside the boundaries of Canyon de Chelly National Monument and it has yet to be found within the Monument. Other species on the following list were found close to the boundaries of Canyon de Chelly during this survey but have not been found in the Monument yet.

<i>Eriogonum subreniforme</i> , in Beautiful Valley.	h720
<i>Frasera albomarginata</i> , next to north rim road.	r3462
<i>Mentzelia nuda</i> , rim above Wheatfields Cyn.	r1496
<i>Monarda pectinata</i> , settlement of Wheatfields.	r811
<i>Potamogeton nodosus</i> , in a stock tank south of Black Rock Canyon.	r1487

APPENDIX 4. MOSSES OF CANYON DE CHELLY

Name	Rink Collection #	Location
<i>Bryum gemmiparum</i> De Not.	406	Twin Trail Cyn., hanging garden
<i>Ceratodon purpureus</i> (Hedw.) Brid.	539, 540	ponderosa forest, head of Monument Canyon
<i>Funaria hygrometrica</i> Hedw.	221	hanging garden below Jct.
<i>Grimmia anodon</i> Bruch. & Schimp. in B.S.G.	1140	hanging gardens near Antelope House parking lot
<i>Homalothecium nevadensis</i> (Lesq.) Ren. & Card.	659	bouldery creek bottom 2 miles below Tsaille Dam
<i>Hygroamblystegium tenax</i> (Hedw.) Jenn.	551	under dry overhang in upper Coyote Creek
<i>Hymenostylium recurvirostrum</i> (Hedw.) Dix.	379, 1330	hanging off cliffs in cool areas, upper canyons
<i>Hypnum lindbergii</i> Mitt.	356, 508	base of cliffs, upper canyons
<i>Lescurea arizonae</i> (Williams) P. Wils. & Norris	1329	lower Wheatfields Creek
<i>Marchantia polymorpha</i> L.	513	muddy spring area, upper Monument Canyon
<i>Syntrichia ruralis</i> (Hedw.) Web. & Mohr	380	hanging garden in upper Pine Tree Canyon
<i>Timmia megapolitana</i> Hedw. var. <i>bavarica</i> (Hessl.) Brid.	328	bouldery bottom of Big Flow Canyon